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T3.3 Business Use Cases for Innovative System Services

D3.3

EU-SysFlex

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DOCUMENT GLOSSARY

A (Role)	Aggregator (see ANNEX II)
aFRR	automatic Frequency Restoration Reserve
AO(Role)	Asset Operator(see ANNEX II)
BRP(Role)	Balance Responsible Party(see ANNEX II)
Business Case	An explanation or set of reasons describing how a business decision will improve a business, product, … and how it will affect costs, profits and attract investments [SOURCE IEC/TS62913-1]
Business Use Case (BUC)	Business Use Cases describe how Business Roles of a given system interact to execute a business process. These processes are derived from services, i.e. business transactions, which have previously been identified. [SOURCE IEC/TS62913-1]
Business Role	A Business role describes a finite set of responsibilities that is assumed by a party(organisations, organisational entities or physical persons) [SOURCE IEC/TS62913-1]
DN_FP(Role)	Distribution Network Flexibility Provider (see ANNEX II)
DS_O(Role)	Distribution System Operator (see ANNEX II)
EA	Enterprise Architect UML Modelling tool from Sparx Systems. http://www.sparxsystems.com.au
FCP(Role)	Forecast Provider(see ANNEX II)
FCR	Frequency Containment Reserves
FRR	Frequency Restoration Reserve
G(Role)	Generator (see ANNEX II)
GA(Role)	Generation Aggregator (see ANNEX II)
G_O(Role)	Generator asset Operator (see ANNEX II)
MDC Tool	Market Design Challenge Tool.
MDO(Role)	Metered Data Operator (see ANNEX II)
mFRR	manual Frequency Restoration Reserve
MO(Role)	Market Operator (see ANNEX II)
MO_D(Role)	Market Operator in Distribution (see ANNEX II)
MO_T(Role)	Market Operator in Transmission (see ANNEX II)
Modsarus®	EDF Freeware plugin of Enterprise Architect UML modelling tool from Sparx Systems. ***MOD**elling **S**martGrid **Ar**chitecture **U**nified **S**olution*
OLTC	On-Load Tap-Changer
RR	Replacement Reserve
Stakeholder	Stakeholder is an individual, team, or organization (or classes thereof) with interests in, or concerns relative to, a system (source: ISO/IEC 42010:2007)
System Role	A System Role describes a finite set of functionalities that is assumed by an entity (devices, information system, equipment) [SOURCE IEC/TS62913-1]
System Use Case (SUC)	System Use Cases describe how System and/or Business Roles of a given system interact to perform a Smart Grid Function required to enable / facilitate the business processes described in Business Use Cases. Their purpose is to detail the execution of those processes from an Information System perspective. Since a Smart Grid Function can be used to enable / facilitate more than one business process, a System Use Case can be linked to more than one Business Use Case.

<table>
<tr><td></td><td>
<table>
<tr><th>Type of Use Case</th><th>Description</th><th>Actors involved</th></tr>
<tr><td>Business Use Cases (BUC)</td><td>A business process implementing a service</td><td>Business Roles (organisations, organisational entities or physical persons)</td></tr>
<tr><td>System Use Cases (SUC)</td><td>A function or sub-function supporting one or several business processes</td><td>Business Roles and System Roles (Devices, Information System)</td></tr>
</table>
[SOURCE IEC/TS62913-1]</td></tr>
<tr><td>TN_FP(Role)</td><td>Transmission Network Flexibility Provider(see ANNEX II)</td></tr>
<tr><td>TS_O(Role)</td><td>Transmission System Operator(see ANNEX II)</td></tr>
<tr><td>Unified Modelling Language (UML)</td><td>[SOURCE OMG Specification] https://www.omg.org/spec/UML/About-UML/</td></tr>
<tr><td>Use Case</td><td>specification of a set of actions performed by a system, which yields an observable result that is, typically, of value for one or more actors or other stakeholders of the system
[SOURCE: SG-CG/M490/E:2012-12]</td></tr>
</table>

EXECUTIVE SUMMARY

The EU-SysFlex H2020 project aims at a large-scale deployment of solutions, including technical options, system control and a novel market design to integrate a large share of renewable electricity, maintaining the security and reliability of the European power system. The project results will contribute to enhancing system flexibility, resorting both to existing assets and new technologies in an integrated manner, based on seven European large scale demonstrations (WP 6, 7, 8 and 9). Work Package 3 (WP3) is dedicated to the regulatory and market aspects of this transition of the power system. As a starting point to the studies and simulations, which will take place all through the project in this WP, the first deliverable of WP3, D3.3, describes the Use Cases, which will be tested in the demonstrations of the project, from a service to the system point of view.

The main objective of the task, T3.3, was to produce specifications of the business processes in terms of Business Use Cases (BUC), of the system services identified in WP2, and tested in the different project demonstrators. Out of the 7 demonstrations of the project, WP9 focuses on the data exchanges aspect only, and WP8 on the technical capability only, so they were considered out of the scope of T3.3 work.
Within the scope of T3.3, there are the other 5 industrial scale demontrators in the following countries: Finland, Germany, Italy and Portugal. They demonstrate innovative services to the power system with high share of variable Renewable Energy Sources (RES). These services are related to frequency control, voltage control, congestion management and improved information management. Each demonstrator uses different means of flexibilities, to provide active and reactive power to support these system services, using different sets of assets connected to the grid at different voltage levels, and also different market assumptions and organisations.

In order to facilitate harmonisation across the BUCs, the standardised IEC use case modelling method was applied (IEC62559) and the use cases were modelled in Unified Modelling Language (UML) with the support of the EDF Modsarus® tool. Moreover a harmonized list of business roles was created and used in the BUC descriptions in order to rely on replicable responsibilities independent from the country specific market layers. It is based on existing role models and has been updated to cover the needs of the project. This activity will be further continued in the project in particular when building business models for innovative services. In addition, each BUC uses a common structure of four main building blocks to describe the process parts of the service: prequalification, bidding/selection, delivery and settlement. The BUCs detail the interactions between business roles involved in the service, including the relevant information exchanges, without detailing the behaviours between system roles (information systems, devices) which will be covered by SUCs (System Use Case) defined in the demonstrators WPs. For each BUC, the involved assets to provide the service, the roles and the market mechanism are described. Furthermore, the relevant regulatory context has been explored and, when applicable, modifications to the current regulatory framework were described.

Figure 1 provides an overview of the BUCs described in task 3.3 for the relevant countries[1].

	Services						
	Active power management					Reactive power management	Information management
	Frequency control				Congestion management	Voltage control	
DEMO countries	FCR	aFRR	mFRR	RR			
Finland	✓		✓	✓		✓	
Italy			✓	✓	✓(1)	✓	
Germany					✓(1)	✓	
Portugal		✓(3)	✓	✓	✓(2)(4)	✓(4)	✓(4)

(1) for transmission & distribution; (2) for transmission only; (3) VPP demo only; (4) FlexHub demo only

FIGURE 1: OVERVIEW OF DEMO SERVICES

During several months of remote collaborative activities and four physical workshops, the BUCs were developed with the task partners, associating partners leading the experimental demonstrations, as well as partners experts in energy market and regulation, and finally partners skilled in BUC modelling. Attention was paid to consult with the system operators of the project consortium, in order to ensure the relevancy and replicability of the BUCs.
A list of 12 BUCs emerged, several per demonstration, describing their service processes step by step following the standardized BUC modelling method. These BUCs are summarized in the main part of this deliverable, the full description in Word is in Annex, and a full repository in UML is available for all the partners to use for updates, or for System Use Cases modelling basis in their following activities in the project.

The BUC approach used in this task will serve as a standardized specification of the business processes for the services to be demonstrated in the project. This deliverable will provide input for the other tasks in WP3, in particular for studying, at European level, evolutions in energy policy and market design, as it provides a basis for building replicable business models for innovative system services.

Therefore, a cross-analysis of the BUCs has been carried out in order to start and identify similarities across BUCs and reveal specific regulatory or technical evolutions, which will be studied in the next steps of the project. Following elements were detailed for the cross-analysis: the assets used to provide the service, the market design proposed for the service and possible regulatory barriers in the context of the delivery of the service. The cross-analysis showed that the different demonstrators consider a variety of flexibilities in generation, consumption loads and storage assets, connected to either transmission or distribution grid, at various voltage levels. The way to use them, for most services tested in these demonstrations, considers the need for aggregation of these decentralized assets, in different configurations (VPP, DSR).

[1] There is one demonstration per country except in Portugal where there are two different demonstrators VPP and FlexHub.

In terms of market design, the same service could be organized considering different market concepts (i.e. regulated market, local market or centralized market). Even the detailed characteristics within a certain market concept can be diverse in terms of gate closure and pricing mechanism. With respect to the regulatory assessment, the regulatory barriers observed for the different use cases are small. One regulatory gap relevant for several BUCs was the need to organize local markets of flexibility in distribution.

In most BUCs, the flexibility sources (renewable energy sources, load, storage, grid assets) are connected to the distribution grid, therefore different roles and services are appearing to involve the Distribution System Operator (DSO) in the operation of flexibilities. Several BUCs use a power schedule at the transmission-distribution interface, the specifications of which will be further tested in the demonstrators. It also shows the relation between system operators and how each system operator is involved in the process of the service. In some BUCs, no role is foreseen for the DSO while in other BUCs, the DSO plays a key role in the prequalification of assets or even in the organization of a local market. The processes, as described within each BUC, make assumptions about which system operator should have priority to use a specific flexibility resource. The cross-analysis points out potential consequences related to choices made for the services. This analysis will feed in and be extended in the next steps of Work Package 3.

1. INTRODUCTION

1.1 WP3 OBJECTIVES

The main objectives of WP3 are the development of innovations for existing and new system services on the one hand and the analysis of different options for market design on the other hand. The assessment of product characteristics and corresponding market design will be supported by advanced modelling techniques. In addition, roles and interactions of both regulated and deregulated stakeholders will be examined in the context of the provision of system services. For the different market design options, the regulatory framework is analysed for a selection of relevant countries. Within Work Package 3, generic functional specifications in terms of business use cases are provided for the services tested by the different demonstrators within EU-SysFlex.

1.2 OBJECTIVE OF T3.3 AND RELATIONSHIP WITH OTHER TASKS

The main objective of T3.3 is to produce functional specifications in terms of Business Use Cases (BUC), compliant with the standardized use case methodology IEC62559, of the system services identified and tested by different national demonstrators (WP6 and WP7). Within the scope of task 3.3, there are 5 industrial scale demontrators in Finland, Germany, Italy and Portugal (2 demonstrators), demonstrating innovative services to the power system with high share of Renewable Energy Sources (RES) that should support several system needs mapped with the technical scarcities as determined in WP2.

The BUCs contain the definition of the business processes for the interactions (information exchanges) between stakeholders as business roles participating in the provision of the service.

These Business Use Cases aim to be generic, in the sense that they share common business roles with independent, replicable responsibilities from the Demo market layers and they aim to be neutral about the technical implementation of the system service.

The set of Business Use Cases will hence materialize a specification of Demo tested services, which will be implemented by the demonstrators in WP6 and WP7.

BUCs are described using the standardized Use Case approach IEC62559 and UML graphical standardized modelling language. This use case approach benefits from several years of best practices in IEC and recent EU smart grid projects. This choice was made in EU-SysFlex to facilitate the cross analysis between BUCs on the one hand and to support the harmonisation and replicability of the results on the other hand.

In order to facilitate the application of the IEC use case methodology, a freeware modelling tool Modsarus® (developed by EDF R&D) is used: this tool is already in use for standardizing the smart grid use cases within IEC (IEC62913 standard series) in a compliant way with IEC62259.

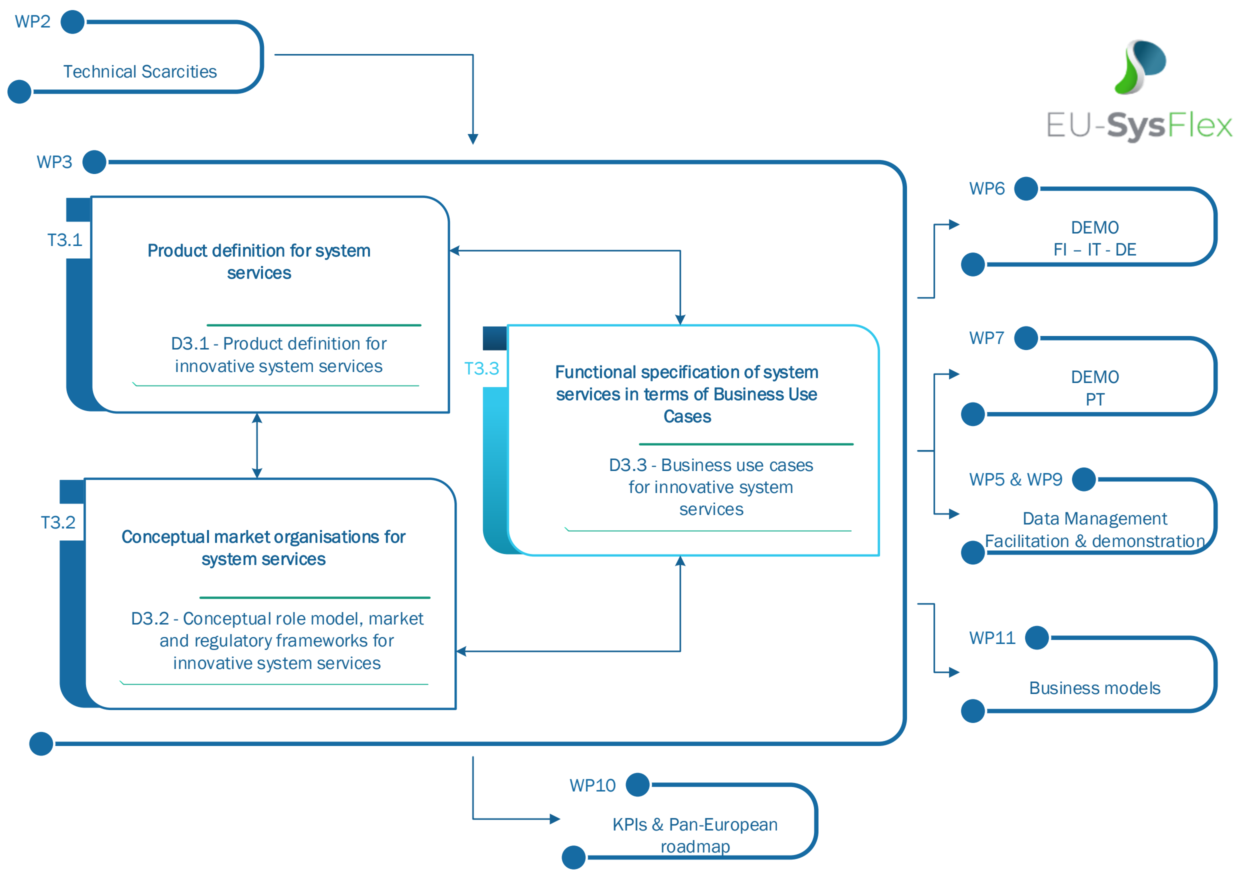

FIGURE 2 : RELATIONSHIPS BETWEEN WP3 TASKS AND OTHER WORK PACKAGES

As shown in Figure 2, T3.3 closely works with the WPs of the demos, T3.1 (for the product definition for innovative system services) and T3.2 (for the description and the definition of market organisations and the implicated business roles within the demos services (see §2)).

T3.2 will continue the work to produce a conceptual role model and market / regulatory framework for innovative system services.

The results of T3.3 will be an input for :

- The WPs of the demonstrators to elaborate System Use Cases (SUCs) for the tested services
- WP9-WP5 as a starting point to describe the data exchange processes in term of SUCs
- WP11 to elaborate business models based on the BUCs of the Demonstrators
- WP10 for KPI definitions

1.3 OVERVIEW OF SERVICES VS DEMONSTRATIONS IN THE SCOPE OF BUC DESCRIPTION

Within the scope of task 3.3, there are 5 industrial scale demonstrations (or demonstrators) in the following countries: Finland (1), Germany (1), Italy (1), Portugal (2), covering several system services, i.e. frequency control, voltage control, congestion management and information services.

	Services						
	Active power management					Reactive power management	Information management
	Frequency control				Congestion management	Voltage control	
DEMO countries	FCR	aFRR	mFRR	RR			
Finland	✓		✓	✓		✓	
Italy			✓	✓	✓ (1)	✓	
Germany					✓ (1)	✓	
Portugal		✓ (3)	✓	✓	✓ (2)(4)	✓ (4)	✓ (4)

(1) for transmission & distribution; (2) for transmission only; (3) VPP demo only; (4) FlexHub demo only

FIGURE 3: OVERVIEW OF DEMO SERVICES

Figure 3 illustrates the mapping between the demonstrators and the services to be tested (including the relevant products), with one per country except in Portugal where there are two: FlexHub[2] and VPP.

In EU-SysFlex, two demonstrators are out of scope for T3.3 BUC description:

- WP8 (French Demo) : WP8 focuses on testing at a reduced scale in EDF's laboratory distribution grid several innovative products or different existing services but provided by new assets (e.g. from variable renewable generations). Some of these products do not exist in the current ancillary services market but could be required by the future grid codes, as their procurement will help to meet future European system needs at high renewable penetration rates. At this stage, specific processes of those services from the "market" perspective cannot be fixed yet and detailed BUC description taking into account the regulatory framework and roles of stakeholders cannot be described and should be further explored during project execution.
- WP5 & WP9: Those WPs are dealing with use cases description for the management of the data (IT support) while WP3 T3.3 is dealing only with use cases for services to the system.. Moreover WP5 is describing SUCs (use cases for IT components, devices, information system) while WP3 is focused on BUCs only.

12 BUCs have been defined for the 5 demonstrators based on the nature of the managed flexibility (active or reactive power) and the service delivered by the demonstrator.

Table 1 gives the complete list of BUCs with identifiers and long names[3]. This document will then always refer to the BUCs identifiers instead of the long names.

[2] The information service category is only used in the Portuguese FlexHub demonstrator for a BUC which specifies how the DSO provides a dynamic grid model to the TSO.

[3] The names of BUCs have been normalized with the following scheme :

Manage [Means of Flexibility] to support [service] in the [Country] demo

Manage [P, Q, VPP Flexibilities] to support [congestion management, voltage control, Freq Control] in the [FI, DE, PT, IT] demo

WP	Demo	BUC ID	BUC name
WP6	Germany	DE-AP	Manage active power flexibility to support congestion management and voltage control in the German demo
WP6	Germany	DE-RP	Manage reactive power flexibility to support voltage control and congestion management in the German demo
WP6	Italy	IT-AP	Manage active power flexibility to support mFRR/RR and congestion management in the Italian demo
WP6	Italy	IT-RP	Manage reactive power flexibility to support voltage control and congestion management in the Italian demo
WP6	Finland	FI-AP1	Manage active power flexibility to support FCRn in the Finnish demo
WP6	Finland	FI-AP2	Manage active power flexibility to support mFRR/RR in the Finnish demo
WP6	Finland	FI-RP	Manage reactive power flexibility to support voltage control in the Finnish demo
WP7	Portugal	PT-FxH-RP	Manage reactive power flexibility to support voltage control and congestion management in the FlexHub Portuguese demo
WP7	Portugal	PT-FxH-AP	Manage active power flexibility to support mFRR/RR and congestion management in the FlexHub Portuguese demo
WP7	Portugal	PT-FxH-DM	Provide active distribution grid dynamic model for transmission operator in the FlexHub Portuguese demo
WP7	Portugal	PT-VPP-AP1	Manage VPP active power flexibility to support aFRR in VPP Portuguese demo
WP7	Portugal	PT-VPP-AP2	Manage VPP active power flexibility to support mFRR/RR in VPP Portuguese demo

TABLE 1 LIST OF BUCS PER DEMO WITH IDENTIFIERS AND LONG NAMES

Note: Both flexible active power and reactive power could be used for multiple services. For example, reactive power flexibility could be used to support both voltage control and congestion management. The effective use will depend on the operational strategy of the TSO or DSO.

In the different demonstrators, the active and reactive flexibility provision will be tested using different sets of assets connected to the grid.

Table 2 provides an overview of the assets used for the delivery of the different services in the demonstrators. The assets are grouped in four categories: generation, consumers, storage and network assets.

Demo	BUC ID	Services	Generation	Consumers	Storage	Network assets
Finland (WP6)	**FI-AP1**	Frequency control (FCRn)		Distributed EV stations, homes with smart electric heating installation	Medium-size Battery Distributed batteries	
	FI-AP2	Frequency control (mFRR/RR)		homes with smart electric heating installation	Medium-size Battery Distributed batteries	
	FI-RP	Voltage control	PV		Medium-size Battery	
Italy (WP6)	**IT-AP**	Frequency control (mFRR/RR) and congestion management	RES	Consumers	Battery (DSO owned)	OLTC
	IT-RP	Voltage control and congestion management	PV		Battery (DSO owned)	STATCOM, OLTC
Germany (WP6)	**DE-AP**	Congestion management and voltage control	Wind Farms + PV			
	DE-RP	Voltage control and Congestion management	RES + conventional			
Portugal (WP7) FlexHub	**PT-FxH-AP**	Frequency control mFRR/(RR) and congestion management	Wind Farms			
	PT-FxH-RP	Voltage control and congestion management	Wind Farms			Capacitor banks, OLTC
Portugal (WP7) VPP	**PT-VPP-AP1**	Frequency control (aFRR)	Large-scale generation and RES power plants		Large-scale storage (variable speed pumped storage power plant)	
	PT-VPP-AP2	Frequency control (mFRR/RR)				

TABLE 2 ASSETS USED TO PROVDE THE FLEXIBILITY IN THE DEMONSTRATORS

1.4 ORGANISATION OF THE WORK

The work in T3.3 was organized according to following activities :

1. Small test case to illustrate the method on a simplified example before applying it to all demonstrators.
2. Design and definition of common business roles for all BUCs.
3. Description of the BUCs for all demonstrators.
4. Cross analysis of BUCs to identify the regulatory or technical issues and similarities regarding the tested services and regulations.
5. Validation of the BUCs content.

In order to define the BUCs, the contributions of the partners have been organized in 3 sub-teams:

- **one sub-team per demonstrator** responsible for the writing and modelling of the different BUCs of this demonstrator combining knowledge on demo tested services and expertise on IEC62559 use case approach and UML.
- **a role definition sub-team** to define a common role model to be used in the description of the BUCS.
- **a validation sub-team** to discuss the issues, similarities of the BUCs across different demonstrators in coordination with other tasks and WPs. The validation team includes key representatives from the Demo Leaders, from T3.3 (use case for the demo services), T3.2 (market design) as well as T3.1 (innovative products and services).

The sub teams worked in parallel in an iterative way with many remote meetings as well as 4 workshops:

- **Workshop 1**: Presentation of the demo tested services and the related market organisations along with the identified responsibilities of business roles
- **Workshop 2**: Consolidation of a shared business role list used by the demos and IEC62559 use case (with UML tutorial) learning session
- **Workshop 3**: Consolidation of the detailed workflow of information exchanges between roles for each BUC
- **Workshop 4**: Finalisation of BUCs, presentation of the cross analysis and validation of the BUCs content

2. BUC MODELLING FRAMEWORK : METHODS AND TOOLS

2.1 BUC MODELLING METHOD PRESENTATION

2.1.1 METHOD

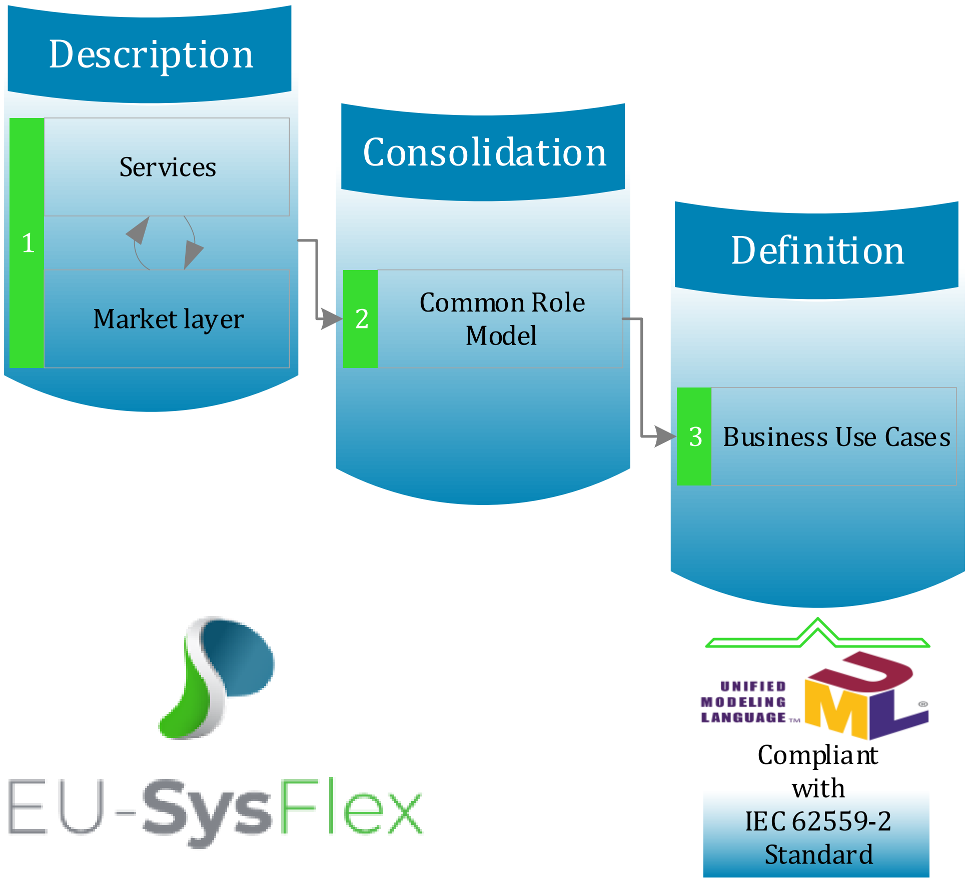

FIGURE 4: METHOD FOR BUC MODELLING

The methodology to describe the BUCs per demo contains 3 main steps :

- **Step 1: description of the service / market Layer** : for each demo and service, the market environment is described as well as a short narrative description of the service demonstrated within this market environment.
- **Step 2: Consolidation of a common Role Model**: For each demo and service, the implicated roles described in step 1 are consolidated in single common role model.
- **Step 3: Definition of the Business Use Cases**: For each service, the BUCs are modelled in UML by detailing the workflow of activities in term of information exchanges between roles. The word document compliant with the standardized use case methodology IEC62559-2 is generated automatically from the UML model.

2.1.2 USED TOOLS AND TEMPLATES

The used tools and templates are :

- MDC Tool owned by EDF. This is a collaborative website of knowledge management
  - URL: https://mdctool.ardans.fr/EUSYSFLEX/listHomePage.do.
  - Used in step 1 and 2
  - Contains a list of available roles (see section §2.3) and allows sharing of the described textual market layers per service between partners

- The standardized IEC62559-2 use case textual template enhanced in the context of EU-SysFlex project (see section §ANNEX I) with prefilled information and indications, in particular for the market assumptions and descriptions of the service phases (see §2.2.2). It harmonises, for EU-SysFlex, the structures for the description of the BUCs which facilitates the cross analysis and the identification of issues/barriers to be studied further into detail in the project.
  - Used in Step 1, Step 2 and Step 3
  - Used for drafting textual market layers per service in relation with the approved implicated business roles and generated automatically for the final results from the UML modelling in step3.

- Modsarus®: a freeware developed by EDF R&D as a plugin of the UML modelling tool Enterprise Architect from Sparx Systems. In particular, Modsarus® brings to EA a model-driven approach to specify unambiguous, interoperable and vendor-independent smart energy systems through use case modelling and automates the generation of the IEC62559-2 compliant use case template as a paper document.
  - URL : http://www.sparxsystems.com.au/products/3rdparty/frameworks.html#modsarus
  - Contact : Modsarus@edf.fr
  - Used in step 3
  - Used to model in UML the use cases and automate the generation of the textual use case template compliant with IEC62559-2

In the following sections, the different steps from the method will be further detailed.

2.2 STEP 1: DESCRIPTION OF THE SERVICE / MARKET LAYER

2.2.1 ELEMENTS DESCRIBED

The purpose of this step is to analyse and produce a narrative description of the service tested by the demonstrator within its market environment. This step contains the following elements :

- Service description
  - Name of the service
  - Short description of the service

- Short description of the scope and objectives of the BUC
- The needs of the system covered by the provision of the service
- Complete description of each phase (when applicable) of the service within a certain market context (Prequalification, Bidding / Selection, Delivery, Settlement). The description of the phases corresponds to narrative description of process parts by detailing :
    - The implicated business roles
    - The main activities under the responsibility of the implicated roles leading to interactions with other roles
- Market design related to the service : assumptions and prerequisites regarding the market environment and local choices in the specific context of the Demo WP.

In order to facilitate the description of service phases and assumptions, a common structure has been proposed. The definition of the common phases and assumptions/prerequisites is detailed in the next section.

2.2.2 COMMON STRUCTURE FOR THE DESCRIPTION OF PHASES, ASSUMPTIONS AND PREREQUISITES

The IEC62559-2 default template easily maps the market layer description for the services. In order to facilitate the description of service phases and assumptions, prefilled common structures have been proposed and are described in this section.

2.2.2.1 PHASES DEFINITIONS

There are 4 phases for the description of the BUCs :

- **<u>Phase 1: Prequalification</u>**
    - The Prequalification phase deals with the certification and registration of all assets participating to the flexibility service. The prequalification phase can include processes regarding the certification of existing assets (periodic tests to extend the certification) and the certification of new resources (which arrive after the demo beginning).
    - End of Prequalification Phase : Resources are registered and allowed to participate to the procurement processes for the delivery of the service.

- **<u>Phase 2: Bidding / Selection (of resources)</u>**
    - The Bidding / Selection phase deals with the procurement process of a certain service, i.e. bidding of flexibility offers and the clearing of the market. We consider that there is a market if the participation of the flexible resource happens on a voluntary base at a free price. In case there is no market, there are still interactions between stakeholders for the selection of resources.
    - End of Bidding/Selection Phase : final set points are sent to the resources (before the delivery)

- **<u>Phase 3: Delivery</u>**
    - The Delivery phase deals with the supply of flexibility services and the activation of the flexibility resources

- End of Delivery phase : the provision of the service is finished, including measurements

- **Phase 4: Settlement**
  - The Settlement phase deals with the management of invoices between stakeholders
  - Beginning of Settlement phase : the measured data is sent (to the role in charge of consolidation of data)
  - In this phase, one may find the following activities: aggregation of the measured data, calculation of deviations, sending of invoices.

2.2.2.2 ASSUMPTIONS / PREREQUISITES

In addition, categories of assumptions and prerequisites have been proposed to guide the description of the market design, including the current regulatory framework and the technical context of the individual demo :

- ***Assumptions (elements related to the market environment on top of the service)***:
  - rules relevant for the service (market and regulation)
  - limitations due to the regulatory and market environment (In case of assumptions regarding future market environments and regulation, this includes the differences with the today's market environment and regulation)
- ***Prerequisites (elements related to the service in the context of the demo):***
  - choices for the delivery of the service
  - choices regarding the level of detail and the scope for the description of the BUC
  - limitations in the context of the demo

Table 3 below gives examples of assumptions and prerequisites taken for the Finnish demo (FI-AP1):

	Assumptions
1	Rules relevant for the service (market & regulation): • Existing market • All the market participants have registered themselves to the MO • The FCRn results from the yearly market are known for the following day
2	Limitations due to the regulatory and market environment: • Bids cannot be linked to each other, except for aggregated bids. • The aggregator is also the retailer of the consumers and resources it controls (according to the regulation)
	Prerequisites
1	Choices for the delivery of the service:

	• The contractual interactions between the homes/buildings with smart heating, the building owners and the home automation provider have been sorted out so that the aggregator needs to interact only with the interface of the automation system
2	Choices regarding the level of detail, the scope for the description of the BUC : • The public EV charging stations are considered as loads (consumption) only. The vehicles behind and the relationships between the station operator and the vehicle users are ignored • The parties responsible for the balance of the aggregators do not need to be included

TABLE 3 EXAMPLE OF ASSUMPTIONS AND PREREQUISITES BASED ON THE FINNISH DEMO

2.3 STEP 2: CONSOLIDATION OF A COMMON ROLE MODEL

Attention was paid to stakeholders involved in the provision of services per demo, the roles they play and the responsibilities they endorse.

T3.3 focuses on the interactions between stakeholders in term of exchanges of information between business roles (set of responsibilities). It means that interactions between system roles (set of functionalities) such as devices or information systems are not included. Defining such level of detail will be provided by each demo in their own WPs.

Step 2 aims at consolidating a common role model shared between demos in order for the BUCs to use a list of common business roles (e.g. Aggregator). It gives a generic description of BUCs independent from the specific stakeholders playing the business roles in the context of a demo WP or a specific market environment in a country. The Role Model used within EU-SysFlex is based on existing role models (ex: ENTSO-e) adapted to the needs of the services to be described for the project.

In order to facilitate the definition of business roles, the following rules are used in EU-SysFlex:

- A role is composed of a unique set of responsibilities.
- A role is entirely assumed by a stakeholder. A stakeholder can play several roles. The same role may be adopted by several stakeholders.
- A role model describes the roles and the main interactions between roles in a given context (services in a market environment).

The Role Definition sub-team consolidated a list of Business Roles along with their responsibilities and made this specific for the EU-SysFlex project by making the necessary adaptations to existing roles or by incorporating specific roles needed for the BUCs descriptions.

The work initiated by the Role Definition sub-team will continue in Task 3.2 of the project.

The list of business roles (along with their definition) built in the fast track and used in the BUCs is available in section §ANNEX II.

Also, section §3 shows how the roles are implicated in the different BUCs.

2.4 STEP 3 : DEFINITION OF THE BUSINESS USE CASE PER SERVICE

Step 3 starts when the implicated business roles and the description of service phases are finalized.

It provides a detailed description of sections 1 to 3 of the textual descriptions from the IEC62559-2 Use Case template (see §ANNEX I).

For each service, the BUC is described in UML focusing on detailed workflows of information exchange between roles for each phase.

The outcome of step 3 corresponds to the deliverable of WP3 T3.3 and takes the form of:

- A single UML use case repository containing all BUCs along with a common business role model.
- Exported BUCs (in word format with Modsarus®) compliant with IEC62559-2 use case templates

3. BUSINESS USE CASES DESCRIPTION FOR THE SERVICES TESTED

3.1 SHARED ROLES LIST INVOLVED IN THE FAST TRACK FOR THE BUCS DESCRIPTION

This section gives an overview of the business roles involved in the BUCs description for the services tested in the demonstrators and the section §ANNEX II gives a complete definition of each role in terms of set of responsibilities. Note: the set of involved roles in the BUCs is a subset of the complete final role model, limited to the roles needed for the BUC description of the demonstrators services. The complete role model will be available in D3.2.

The role model identifies two categories of business roles (Generic and Specific):

- Generic roles (for example: Generator, Transmission System Operator, Distribution System Operator, Market Operator, Aggregator) are identified, in order to cover the essential responsibilities within the electricity system.
- For some generic roles, several specific roles are identified. Specific roles enable to describe in a BUC the variations of the process when it depends effectively on the specific role (the generic role is relevant when a common process is applied to its specific roles). For example, It is the case for the generic role Generator G and its specific asset operator G_O and also for the generic role Aggregator A and its specific GA for Generation Aggregator.

The set of involved roles, in the BUCs, is:

- Resources roles:
    - the generic role Asset Operator AO operating a set of assets connected to the distribution grid which may cover generation, consumption and storage assets.
    - the generic Generator G and its specific asset operator G_O
    - Flexibility Provider for distribution DN_FP or transmission TN_FP, relying on any kind of assets connected to the corresponding distribution or transmission network .
- Aggregator roles: the generic role Aggregator A of flexibilities is declined into specific roles for aggregating generation or consumption flexibilities (note that only the generation specific role GA is used in the BUCs).
- Role for distribution system operation: the DS_O role (Distribution System Operator) for operating the distribution system.
- Roles of transmission system operation: the TS_O role (Transmission System Operator) for operating the transmission system covering power system balance and network management.
- Balance Responsible Party BRP
- The Market Operator MO organizes auctions of electricity products and clears the market. The MO is declined into the specific roles MO_T and MO_D when it is dedicated specifically to the transmission or distribution resources.
- Metered Data Operator MDO role
- Forecast Provider FCP for forecasting generation and consumption.

Table 4 below shows an overview of the involved roles for each BUC while the following sub sections show their implications for each phase of the BUC process.

Roles		Finland			Germany		Italy		Portugal - FlexHub			Portugal-VPP	
Roles ID	**Roles name**	FI-AP1	FI-AP2	FI-RP	DE-AP	DE-RP	IT-AP	IT-RP	PT-FxH-AP	PT-FxH-RP	PT-FxH-DM	PT-VPP-AP1	PT-VPP-AP2
AO	Asset Operator	X	X	X							X		
G	Generator											X	X
G_O	Generation asset Operator				X	X	X	X					
DN_FP	Distribution Network Flexibility Provider								X	X			
TN_FP	Transmission Network Flexibility Provider								X				
A	Aggregator	X	X	X			X	X	X	X	X		
GA	Generation Aggregator				X	X						X	X
BRP	Balance Responsible Party		X										
DS_O	Distribution System Operator			X	X	X	X	X	X	X	X		
TS_O	Transmission System Operator	X	X	X	X	X		X	X	X	X	X	X
MO	Market Operator	X	X	X			X		X	X			
MDO	Metered Data Operator	X		X	X	X	X	X	X	X			
FCP	Forecast Provider				X	X							

TABLE 4 OVERVIEW OF INVOLDED BUSINESS ROLES IN BUCS

3.2 BUCS OVERVIEW

The following section provides tables summarizing the key characteristics of the BUCs for each demo. These tables highlight information related to the service tested in the demo, the assets, the main roles and market mechanism involved. In addition, a visual representation is provided that illustrates how the business roles within each BUC are interacting with each other for the delivery of a specific service.

Note 1: The definition of phases is explained in section §2.2.2.
Note 2: Compared to the full standardized description of the BUCs, this simplified representation in the following figures gives a simple overview per BUCs/phase without being exhaustive and facilitates the cross analysis (see section §4).

3.2.1 SIMPLIFIED DIAGRAMS PRINCIPLES

The diagrams are organized in this way :

- 4 columns per phase
- Horizontal lanes for the BUCs with Roles involvement and the supporting services. When common roles are for 2 BUCs, the lane at the middle is containing those common roles.

3.2.2 SIMPLIFIED DIAGRAMS PER BUC/PHASE

In all the tables per Demonstration and per BUC below, the product exchanged is capacity or energy, that is:

- capacity in active power or active energy if the BUC manages active power
- capacity in reactive power or reactive energy if the BUC manages reactive power

3.2.2.1 FINNISH DEMO

BUC ID	FI-AP1
BUC Name	Manage active power flexibility to support FCRn in the Finnish demo
Services	Frequency control (FCRn)
New mechanism in the demo (even if the service already exists)	Introduction of small scale distributed assets to an existing market
Assets used	Medium-size battery, distributed batteries, distributed EV stations and homes with smart electric heating installation
Product	Capacity
Market mechanism	Centralised

BUC ID	FI-AP2
BUC Name	Manage active power flexibility to support mFRR/RR in the Finnish demo
Services	Frequency control (mFRR/RR)
New mechanism in the demo (even if the service already exists) ?	Introduction of small scale distributed assets to an existing market, use of AMR-controlled loads for mFRR/RR
Assets used	Medium-size battery, distributed batteries, homes with smart electric heating
Product	Capacity
Market mechanism	Centralised

BUC ID	FI-RP
BUC Name	Manage reactive power flexibility to support voltage control in the Finnish demo
Services	Voltage control
New mechanism in the demo (even if the service already exists) ?	Opening of the service provision to a new market instead of only bilateral contracts
Assets used	Medium size battery (BESS), PV plant
Product	Capacity
Market mechanism	bilateral agreement + local market

FIGURE 5: FINNISH DEMO SIMPLIFIED KEY POINTS TABLE

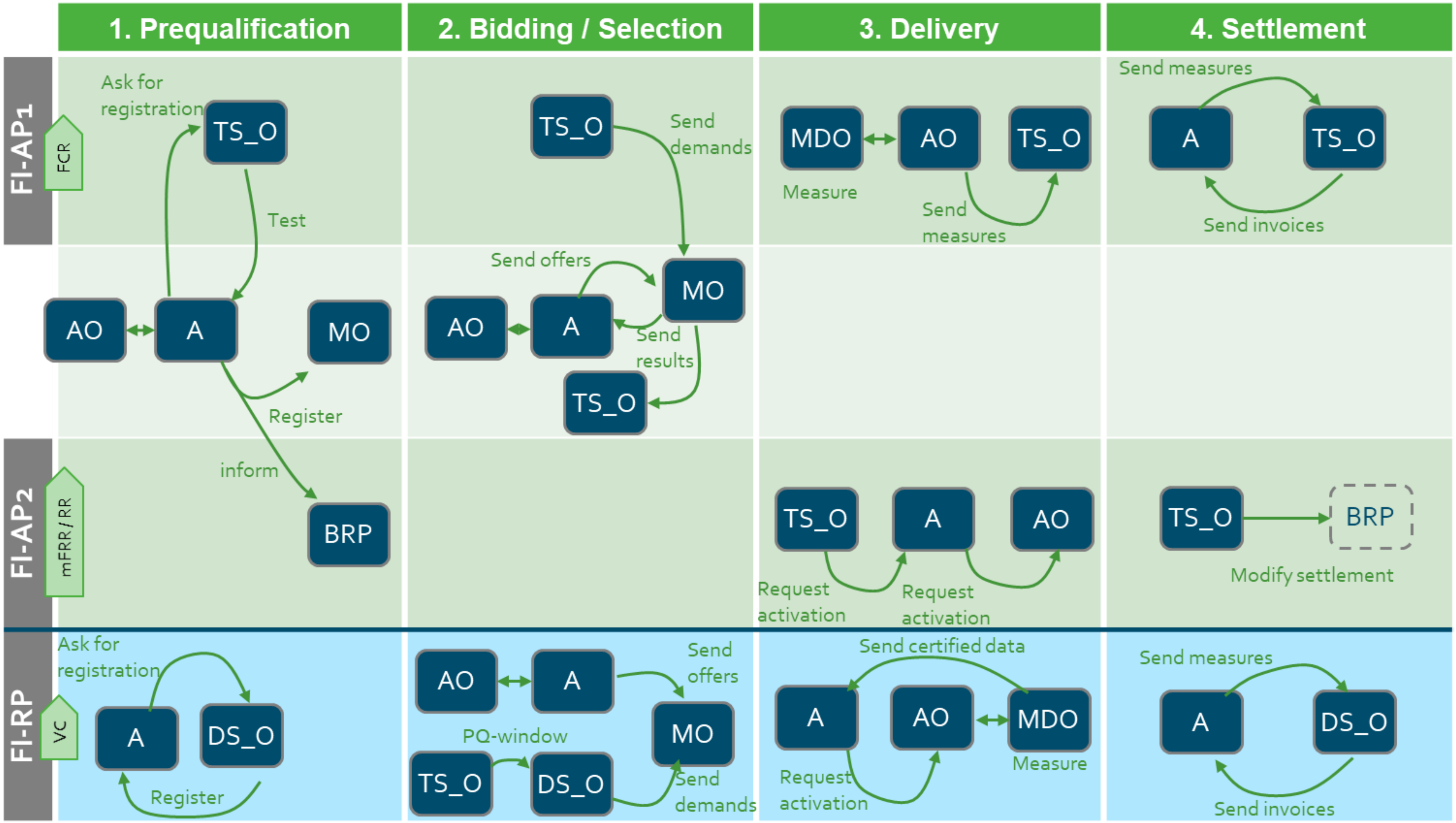

FIGURE 6: FINNISH BUCS SIMPLIFIED OVERVIEW DIAGRAM

3.2.2.2 ITALIAN DEMO

BUC ID	IT-AP
BUC Name	Manage active power flexibility to support mFRR/RR and congestion management in the Italian demo
Services	Frequency control (mFRR/RR), Congestion management
New mechanism in the demo (even if the service already exists) ?	Local flexibility market and aggregation of flexibilities coming from DERs.
Assets used	Consumers, local RES, Battery Energy Storage System (DSO owned), OLTC. The tests will be done in a simulation environment due to the unavailability of flexible active power RES in the physical demo
Product	Energy
Market mechanism	Local

BUC ID	IT-RP
BUC Name	Manage reactive power flexibility to support voltage control and congestion management in the Italian demo
Services	Voltage control and congestion management
New mechanism in the demo (even if the service already exists) ?	Participation of DSO in a service of reactive power flexibility and aggregation of reactive power flexibilities coming from DERs.
Assets used	PV plants, Battery Energy Storage System (DSO owned), STATCOM, OLTC
Product	Capacity
Market mechanism	No market: long-term agreement,

FIGURE 7: ITALIAN DEMO SIMPLIFIED KEY POINTS TABLE

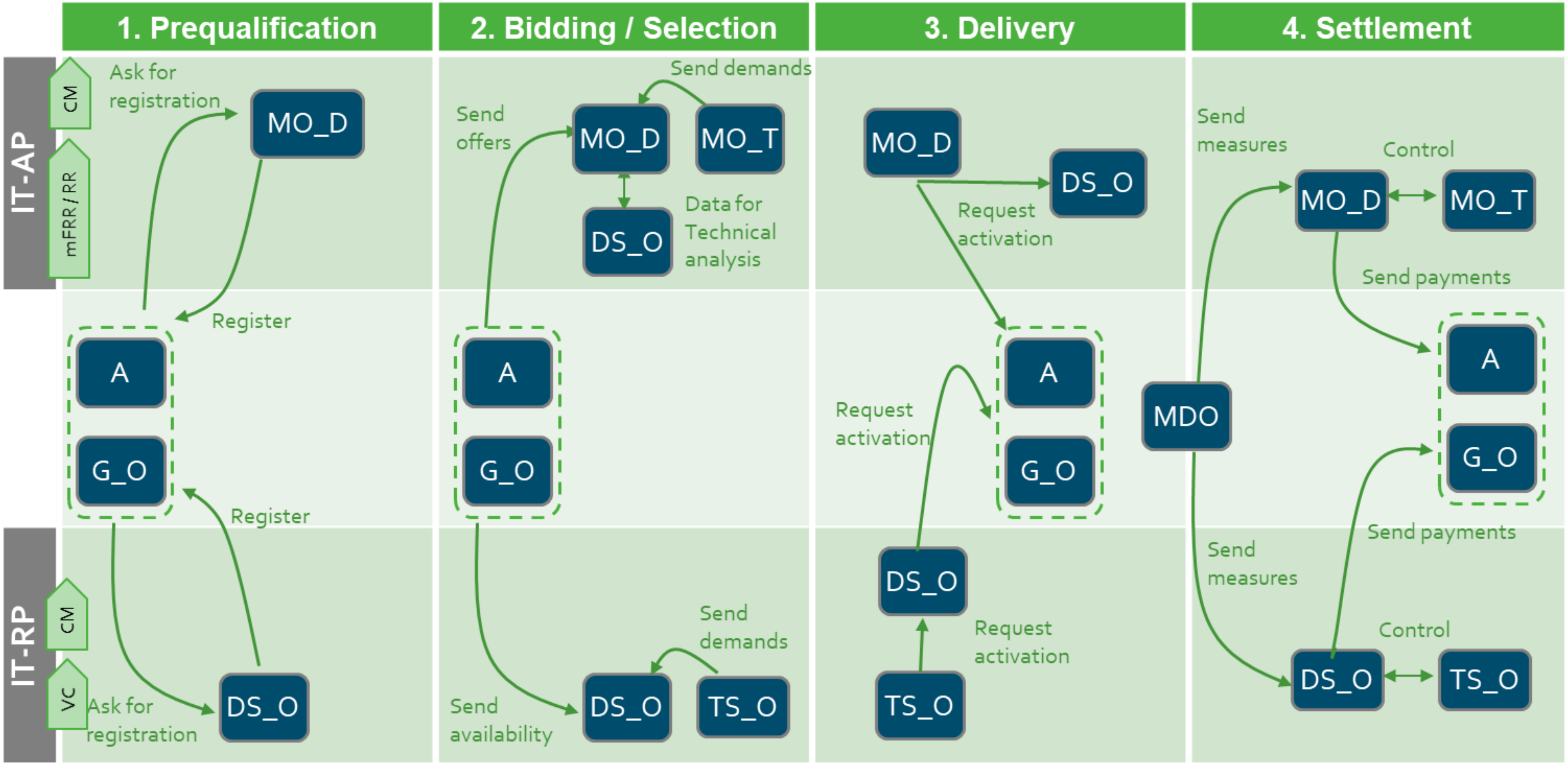

FIGURE 8: ITALIAN BUCS SIMPLIFIED OVERVIEW DIAGRAM

3.2.2.3 GERMAN DEMO[4]

BUC ID	DE-AP
BUC Name	Manage active power flexibility to support congestion management and voltage control in the German demo
Services	Congestion management and voltage control
New mechanism in the demo (even if the service already exists) ?	The coordination mechanism for redispatch between DSO and TSO is new, but the redispatch process already exists in Germany and is enhanced with RES
Assets used	All generators (in demonstrator focus on RES)
Product	Energy
Market mechanism	No market (RES must offer flexibility in a mandatory way, DSO/TSO select flexibility in a Merit Order List)

BUC ID	DE-RP
BUC Name	Manage reactive power flexibility to support voltage control and congestion management in the German demo
Services	Voltage control and congestion management
New mechanism in the demo (even if the service already exists) ?	Coordination process for dynamic reactive power management between DSO and TSO
Assets used	All connected generators (in demonstrator focus on RES)
Product	Capacity
Market mechanism	No market (reactive power potential is set in grid connection contract/grid code)

FIGURE 9: GERMAN DEMO SIMPLIFIED KEY POINTS TABLE

[4] Note about use case assumptions: In the German use cases, the same stakeholder is playing both GA and BRP roles. For this stakeholder, the German use cases focus on the GA involvement

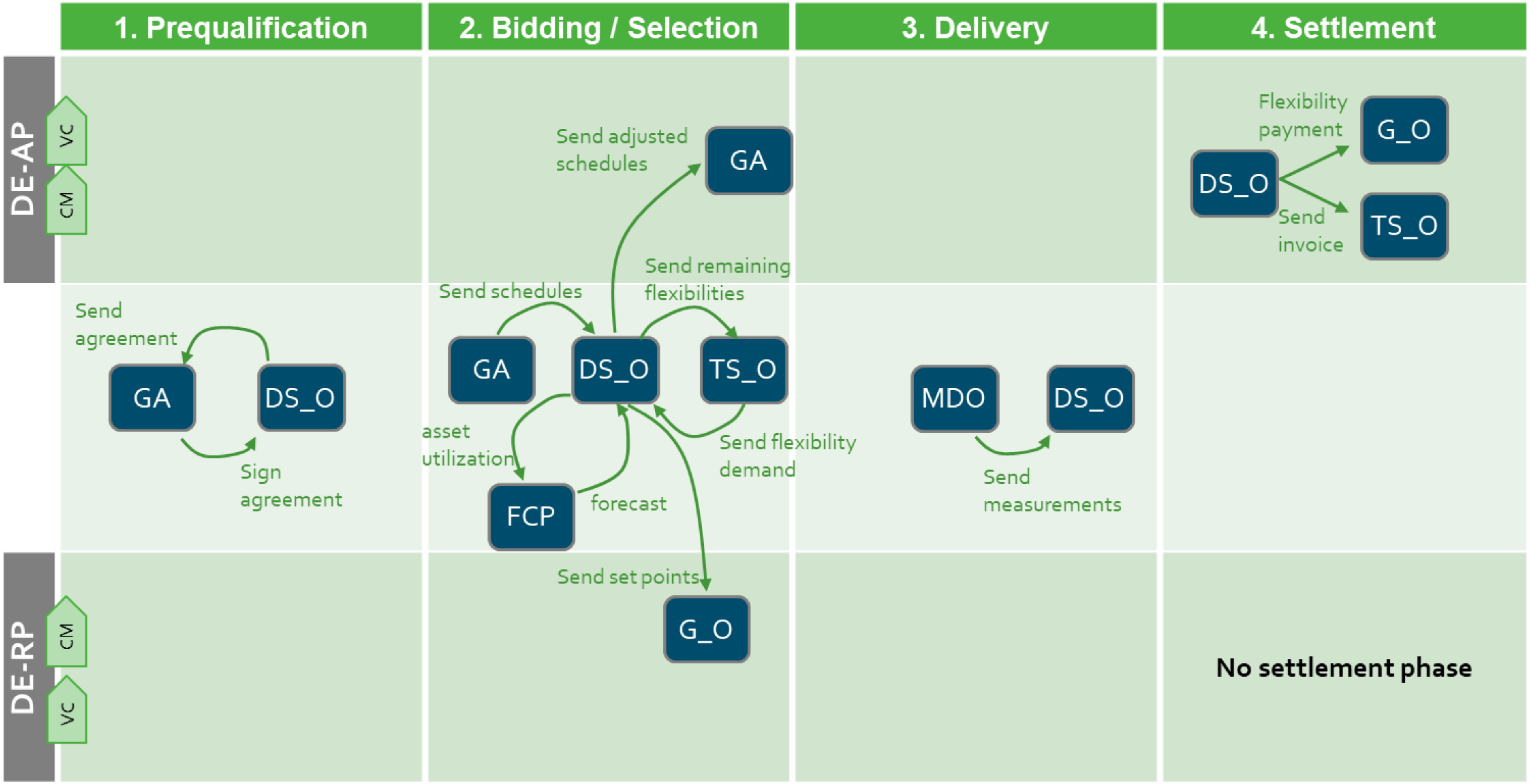

FIGURE 10: GERMAN BUCS SIMPLIFIED OVERVIEW DIAGRAM

3.2.2.4 PORTUGUESE FLEXHUB DEMO

BUC ID	PT FxH-RP
BUC Name	Manage reactive power flexibility to support voltage control and congestion management in the FlexHub Portuguese demo
Services	Voltage control and congestion management
New mechanism in the demo (even if the service already exists) ?	Yes, to provide to the TSO a non-null reactive power exchanged value at the TSO-DSO interface.
Assets used	Capacitor banks, OLTC (on load tap changers), inverters connecting wind farms
Product	Energy
Market mechanism	Local

BUC ID	PT FxH-AP
BUC Name	Manage active power flexibility to support mFRR/RR and congestion management in the FlexHub Portuguese demo
Services	Frequency control (mFRR/RR) and congestion management
New mechanism in the demo (even if the service already exists) ?	Yes (restoration reserve service adapted)
Assets used	Inverters connecting wind farms
Product	Energy
Market mechanism	Centralised

BUC ID	PT FxH-DM
BUC Name	Provide active distribution grid dynamic model for transmission operator in the FlexHub Portuguese demo
Services	Information exchange
New mechanism in the demo (even if the service already exists) ?	Yes, the DSO provides a simplified dynamic model of its grid to the TSO
Assets used	None
Product	Dynamic model (information exchange)
Market mechanism	No market

FIGURE 11: PORTUGUESE FLEXHUB DEMO SIMPLIFIED KEY POINTS TABLE

Note: the Portuguese use case PT-FxH-DM providing dynamic model is not shown on the simplified diagrams, as it is not providing flexibility services as other BUCs, that can be split in phases.

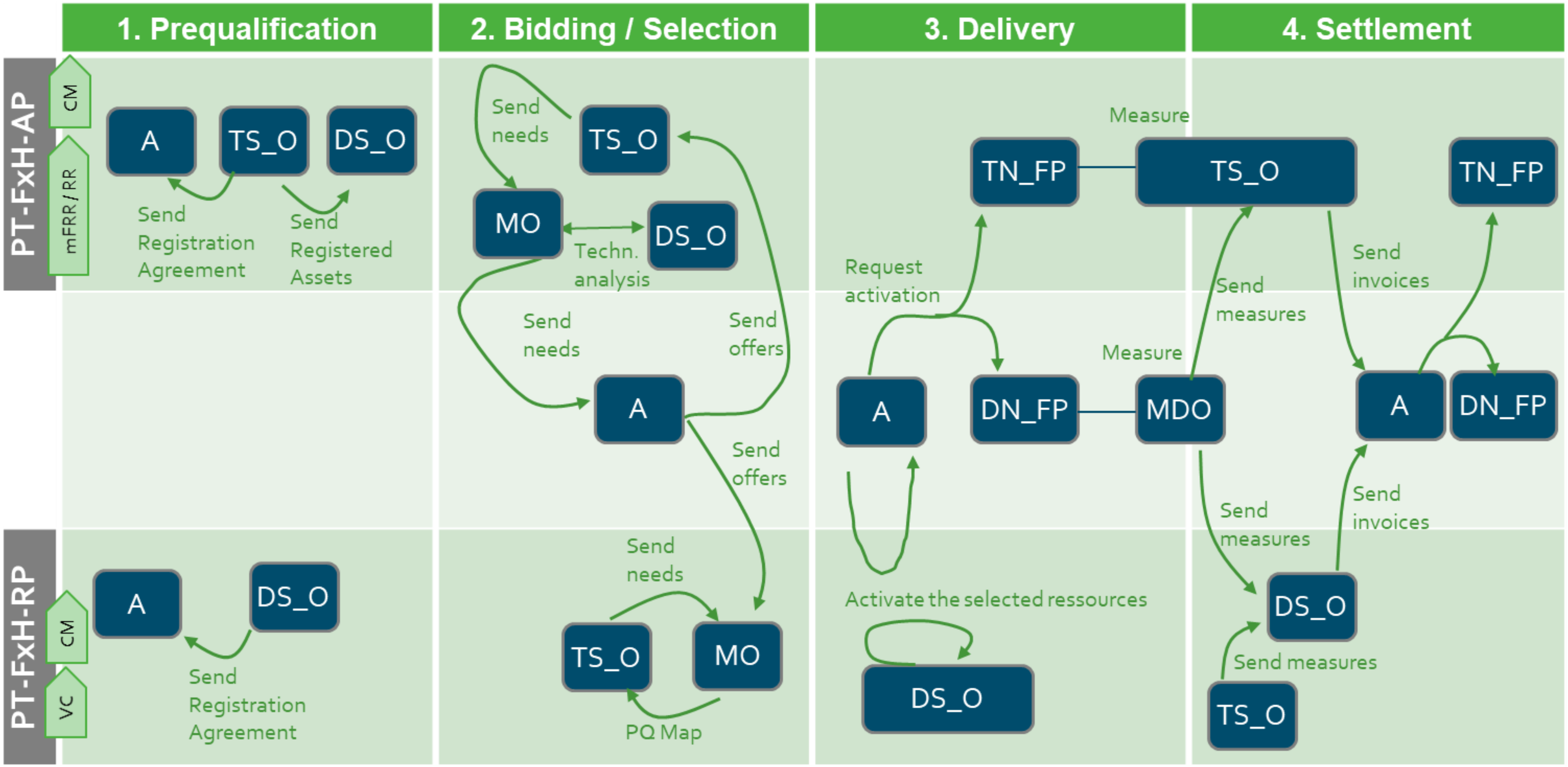

FIGURE 12: PORTUGUESE FLEXHUB BUCS SIMPLIFIED OVERVIEW DIAGRAM

3.2.2.5 PORTUGUESE VPP DEMO[5]

BUC ID	PT VPP-AP1
BUC Name	Manage VPP active power flexibility to support aFRR in VPP Portuguese demo
Services	Frequency control (aFRR)
New mechanism in the demo (even if the service already exists) ?	The service enables the participation of a mixed portfolio of the traditional and the new generation RES, through their aggregation and by managing directly the TSO's requests within its generation portfolio, (without the TSO directly acting on the generators).
Assets used	Only assets connected to TSO: large-scale generation, large-scale storage (variable speed pumped storage power plant) and RES power plants
Product	Capacity
Market mechanism	Centralised

BUC ID	PT-VPP-AP2
BUC Name	Manage VPP active power flexibility to support mFRR/RR in VPP Portuguese demo
Services	Frequency control (mFRR/RR)
New mechanism in the demo (even if the service already exists) ?	"Forgetting" the balancing area concept and allowing the aggregation of a mixed portfolio of traditional and new generation RES. This will grant access to the energy market to those generators that in the future will lose the feed-in tariffs.
Assets used	Only assets connected to TSO: large-scale generation, large-scale storage (variable speed pumped storage power plant) and RES power plants
Product	Energy
Market mechanism	Centralised

FIGURE 13: PORTUGUESE VPP DEMO SIMPLIFIED KEY POINTS TABLE

[5] Note about use case assumptions: In the Portuguese VPP use cases:
- the same stakeholder is playing both GA and BRP roles. For this stakeholder, the VPP use cases focus on the GA involvement
- as the flexibility resources participation to the service is mandatory, there is no involvement of the Market Operator role.

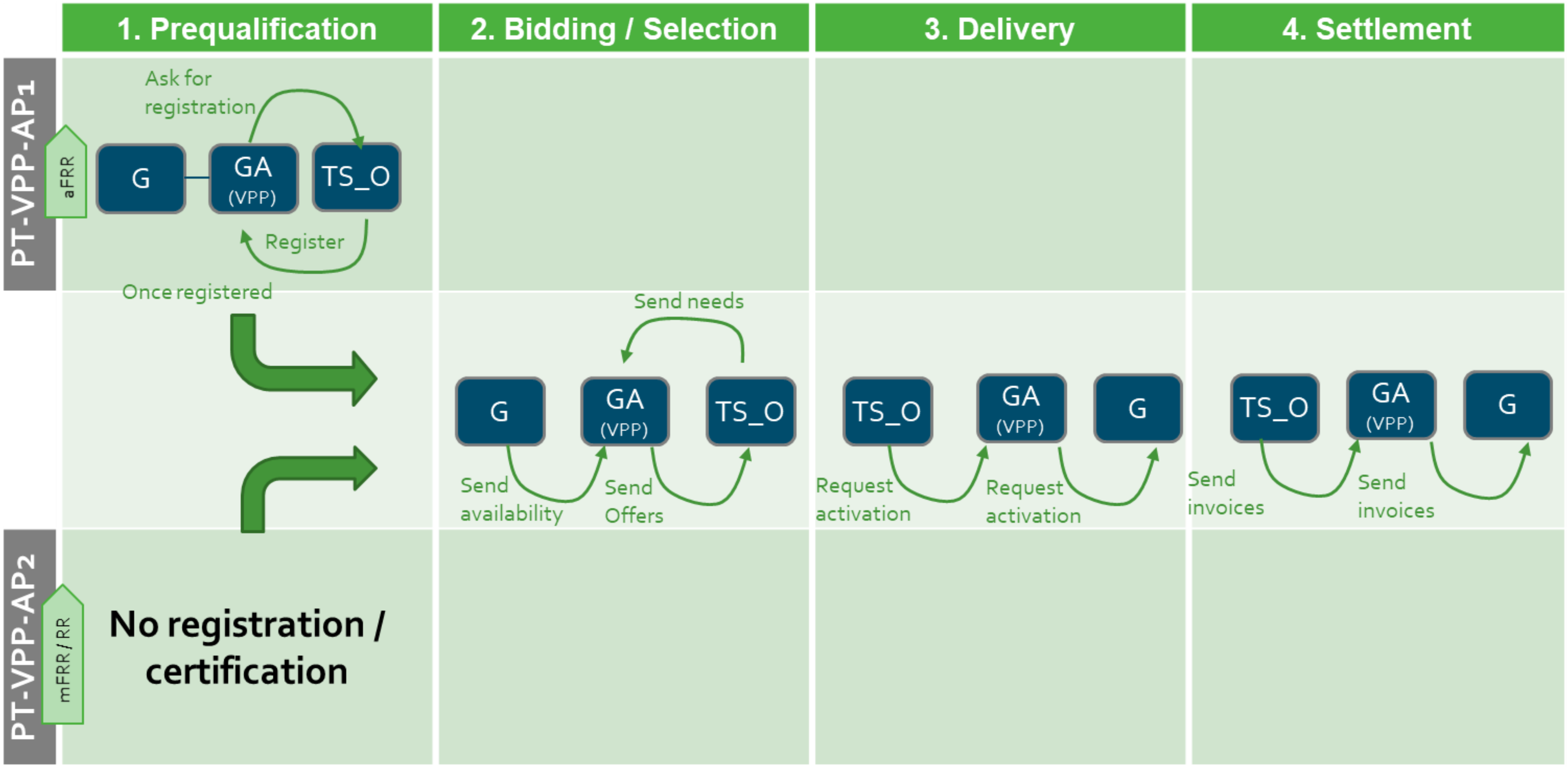

FIGURE 14: PORTUGUESE VPP BUCS SIMPLIFIED OVERVIEW DIAGRAM

3.3 FULL DESCRIPTION OF BUCS PER DEMO COMPLIANT WITH IEC62559-2 USE CASE TEMPLATE

For readability, the full description of each BUC is available in ANNEX III in the form of the use case IEC62559-2 template.

4. CROSS ANALYSIS OF BUSINESS USE CASES

4.1 GOAL

Based on the tables shown in the previous chapter, a cross analysis was made in order to identify:

- the similarities regarding the tested services, and regulation with respect to interactions between roles, market mechanisms involved and the type of information exchanged.
- the regulatory or technical issues, that could arise when the service is delivered according to the process described in the BUC

Moreover, the cross analysis gives an input for the next steps of WP3, which will further analyse regulatory or market barriers in the context of the provision of flexibility services.

4.2 SIMILARITIES ABOUT SERVICES AND REGULATION

4.2.1 MAIN TYPES OF SERVICES

The services provided and demonstrated have been presented in 1.3. Many BUCs deliver a service (e.g. provision of active or reactive power flexibility) that answers multiple needs of the system.
When a BUC supports several services, that does not imply that several services will be delivered at the same time; here we do not prejudge the economic additivity of a multi-service BUC.

4.2.2 REMUNERATION OF FLEXIBILITY

Table 5 below provides an overview by BUC on:

- the existence of a market: is a market effectively used, is it local or centralized?
- the product exchanged: capacity or energy in active or reactive power depending on the type of flexibility managed in the BUC
- the mechanism of pricing
- the time frame of delivery of the service

BUC ID	Market mechanism	Product	Pricing	Time frame
FI-AP1	Centralised	Capacity	Pay as clear + capacity fee	Day ahead
FI-AP2	Centralised	Capacity	Pay as clear + optional pay-as-bid capacity fee	Intraday (up to 45 min before the delivery
FI-RP	bilateral agreement + local market	Capacity	Pay as clear	Monthly
IT-AP	Local	Energy	Pay as bid	Real time
IT-RP	No market, long-term agreement	Capacity	No remuneration (reduction on grid fees for the participating resources)	Real time / intraday (6 hours)
DE-AP	No market (mandatory provision)	Energy	Regulated costs for curtailment of RES	Day-ahead and Intraday
DE-RP	No market (mandatory provision)	Capacity	Reactive power delivery within limits set in connection agreement is free of charge	Real time for activation
PT-FxH-AP	Centralised	Energy	Pay as clear	Intraday (15 min time periods)
PT-FxH-RP	Local	Energy	Pay as clear	Intraday (15 min time periods)
PT-FxH-DM	No market	Dynamic model (information exchange)	Regulated DSO task, thus remunerated as an operational cost of the DSO	Yearly (for planning)
PT-VPP-AP1	Centralised	Capacity	Pay as clear	Day ahead
PT-VPP-AP2	Centralised	Energy	Pay as clear	Day ahead, intraday

TABLE 5 MARKET DESIGN CHARATERISTICS OF BUCS

Most services are contracted close to real time, i.e. in day-ahead or intraday, and activated in real time. Although the contracting period is relatively similar across the various BUCs, the market mechanisms, which organize the procurement process are different and depend on the service itself, the regulatory framework in the country or the particular choices of the demonstrator. Some demonstrators consider a more centralized market design, where all flexibilities are offered and selected in a centralized way by the system operators. In other demonstrators, the emergence of local markets is assumed, where local flexibilities from the distribution grid are processed before they are made available for services to the transmission grid. In some cases, there is even no market and the provision of the service is mandatory (e.g. the BUCs for the German demonstrator) or the remuneration of the service is regulated (examples: the BUCs DE-AP in Germany and IT-RP in Italy: note that in this latest case, the service is new for the DSO). Although most services can be provided both via centralized market and local market concepts, it shows from the set-up of the demos that the provision of reactive power, due to the importance of locality, is organized by a local market concept or even treated outside the market.

The pricing mechanisms are diverse (market or regulated fee, pay as bid or pay as clear, remunerated quantities). When the flexibility offers participate in a market, the price is in general pay as clear (exception: pay as bid in Italy). The remunerated quantity is sometimes active or reactive energy, sometimes active or reactive capacity.
In some cases, the market introduced by the demonstrator will coexist with an existing operational market. For example, in Finland Fi-AP1, where the action is frequency control FCRn, the capacity market of the demonstrator will determine the capacity price , but the existing energy market determines an energy price.

4.2.3 REGULATORY ASSUMPTIONS AND EVOLUTION

There are few barriers listed that hinder the realization of the services described by the BUCs according to the processes to be tested in the demonstrators. The evolutions needed to organize the use cases are limited. The most frequently mentioned evolution is that the regulation should foresee the possibility of a local market of flexibility in distribution, to manage active or reactive power. In order to define the expression “local market”, a standard list of functions of the local market could be defined.

The main evolutions per demo are:

- Italy: the present regulation organizes a centralized ancillary services market model. The evolution consists in organizing a local market of flexibility in the BUC about active power
- Germany : the present regulation authorizes re-dispatching, curtailment (mandatory provision) and reactive power provision. The two BUCs do not need new regulation, but only agreements between actors to follow the process of the BUC. Nevertheless, a regulatory change could enlarge the scope of the use cases by allowing the load to participate to a ‘local market’ instead of the present mandatory design where only generation can participate.
- Finland: no new regulation is needed. The two BUCs use a centralized market. Note that the aggregator is the retailer.

- Portugal:
  - Reactive power: the regulation shall introduce the possibility of a local market in distribution networks
  - Active power: the regulation shall suppress the balancing zone constraint and allow other types of resources to participate in the service
  - Dynamic model: no specific regulation exists, this service is an information exchange and is compatible with the present regulation.

4.2.4 NECESSARY INVOLVEMENT OF THE DSO

With an increasing share of renewable electricity in the system, a major amount of flexibility sources needed by the TSO are connected to the distribution grid. In order to be able to have access to them, the DSO needs to be involved, in order to manage the consequences with respect to possible voltage constraints or congestions on its own grid.

There is an exception in the Finnish demo (FI-AP1 and FI-AP2 for respectively frequency control FCRn and mFRR/RR): the DSO is not involved and the TSO contracts resources directly from the distribution grid, but this is limited to an early phase of deployment of the service, and the BUC could be extended to include the DSO as a stakeholder. At present, as no congestions occur in the Finnish grid, there is no need for the scope of the demo to include a process that checks possible local congestions in the case of activation of resources connected to the distribution grid by the TSO.

4.2.5 PRIORITY BETWEEN TSO AND DSO TO USE DISTRIBUTED FLEXIBILITY

In all BUCs, there is interaction between the TSO and the DSO. Only in the two Finnish BUCs, the DSO does not participate actively in the procurement of ancillary services from distributed resources due to the low DER penetration. For the 5 BUCs for which it is the case, the DSO has de facto priority to use resources connected to its own grid. The DSO studies its constraints and if some appear, solves them with the flexibility available before offering the remaining flexibility to the TSO:

1. Germany (DE-AP, DE-RP)
2. Italy IT-AP
3. Portugal PT FxH-RP
4. Portugal PT FxH-AP: here the DSO gives to the TSO a traffic light qualification for the bids including distributed resources, but it does not change that the DSO has a factual priority to use distributed flexibility.

This use of priority is not limited to the TSO/DSO interaction; it can be generalized to any combination of different system operators, who operate the system by intervals of voltage, whatever the voltage limits, using flexibilities in another SO's network. For instance it could also apply when two TSOs or several DSOs operate different intervals of voltage in the same area.

From an economic point of view, the access to the flexibility resources connected on a lower voltage network, between the different system operators from downstream to upstream, is a question of optimization, taking into account the economics and the security of the whole electric system, for all the voltage levels. The optimization could distinguish normal and emergency situations.

The comparison of the economic interest of flexibility, for instance in reduction of outage time or grid investments, between the TSO and DSO, could be country specific. Following the country, it could therefore be more interesting economically to use a given flexibility resource for the TSO, or for the DSO.

To enable access to distributed flexibilities, a complementary solution could be to include, in the prequalification phase of the flexibility resources, a detection of the means which have a high risk to create network constraints. However, it must be analyzed, to which extent this process would limit the offering of flexibility more often than the dynamic, time-dependent, priority use of flexibility by the system operator. Especially in meshed grids, volume and direction of constraints highly depend on power flows so that flexibilities can have positive and negative sensitivities on different grid nodes at the same time.

The BUCs written here have underlined the concern of DSOs to be involved in the activation of flexibilities connected to their network. The market designs and options to take this concern into account will be further discussed in the long track of WP3.

4.2.6 THE POWER SCHEDULE AT THE TRANSMISSION/DISTRIBUTION INTERFACE

This objective of reaching a power schedule at the TSO/DSO interface appears in several BUCs. Within EU-SysFlex, the efficiency of this schedule at the TSO/DSO interface will be further analyzed and tested in the demonstrators. In particular, attention will be given to the liquidity related to resources on the one hand and operational specificities on the other hand.

4.2.7 RISK OF COMPETITION BETWEEN REGULATED AND DEREGULATED PLAYERS

In some BUCs assets owned both by the DSO and by actors of the competitive field can provide the same service:

- In IT-RP, the DSO can use its own assets in his balancing responsibility
- In PT-FxH-RP, the DSO will be the market operator and will also be able to offer his own resources (capacitor banks, on load tap changers), which could be in competition with actors of the competitive field.

To avoid issues with respect to DSO assets competing with deregulated assets, the following transitory solutions are foreseen:

- Italy: for provision of mFRR/RR, the DSO uses his storage asset twofold:
  - the DSO uses his storage for the TSO (at zero cost) if a private bid, placed in the local market, cannot be fully exploited due to grid constraints
  - the DSO uses his storage asset to balance the DSO grid in case the DSO activates resources for local congestion management, which could create an imbalance at system level.

- Portugal (PT-FxH-RP):
  - for the provision of voltage control, the DSO uses first its own flexibility resources. Then the reactive energy needed by the TSO, but not supplied by the DSO-owned resources, is requested to the market
  - another transitory improvement is that DSO assets could be managed by independent market agents to avoid any possible market distortions. This solution is more complex and probably the first solution is preferable.

These organizations are considered as transitory and limited to the demos.

5. CONCLUSION

This Deliverable D3.3 describes the specifications of 12 BUCs for 5 demonstrators of the EU-SysFlex project. Each BUC describes the process of a service (by means of active or reactive power flexibility management) to the power system, including the assumed roles of stakeholders, the market design and the interactions (including the necessary information exchange).

The description of the BUCs follows the standardized IEC 62559 method and a common template in UML graphical language. In addition, a generic role model was used to describe all the BUCs in order to guarantee harmonization across BUCs on the one hand, and an easy comparison between BUCs on the other hand. The common list of roles used for the BUC description is based on existing role models, that will be further discussed and elaborated within EU-SysFlex in other tasks of this work package.

The deliverable's main part summarizes the key points for each BUC. The complete 12 BUCs are available in textual format compliant with IEC62559-2 in Annex III. This format was generated from a UML use case repository modelled with the EDF Modsarus® tool, which is available to all partners for further activity, on the project's SharePoint.

In addition to further analysis and simulations on the market and regulation aspects in WP3, the BUCs are a useful starting point for the demonstrators of the EU-SysFlex project to detail and standardize the services tested. They will be used to describe the relevant corresponding SUCs in the demonstration WPs. WP11 will continue the work on business models, also using the BUCs as a starting point.

The cross analysis of the BUCs showed that a large variety of complementary cases will be tested within EU-SysFlex with respect to services, market design options, pricing mechanisms and products. The cross analysis pointed out some adaptations necessary to allow the BUC mechanisms from a regulatory point of view. Although few regulatory barriers were mentioned, the consideration of local markets of flexibility is something new, which was observed in several BUCs.

Moreover, with schemes to be further studied and tested, the DSO shall be largely involved in the mechanism, in particular to manage the consequences of flexibility activation in congestions and voltages problems on his own grid.

6. COPYRIGHT

Changes in this document will be notified and approved by the PMB. This document will be approved by the PMB.

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ANNEX I. EMPTY IEC USE CASE TEMPLATE ENHANCED FOR THE PURPOSE OF EUSYSFLEX

Use Case Template

1. DESCRIPTION OF THE USE CASE

1.1 NAME OF USE CASE

Use case identification		
ID	***Area(s)/Domain(s)/Zone(s)***	***Name of use case***
	Country market layer	Name of the service

1.2 VERSION MANAGEMENT

Version management				
Version No.	***Date***	***Name of author(s)***	***Changes***	***Approval status***

1.3 SCOPE AND OBJECTIVES OF USE CASE

Scope and objectives of use case	
Scope	Short description, a few sentences
Objective(s)	Objective1: Objective2:
Related business case(s)	Frequency Control Voltage Control Congestion Management

1.4 NARRATIVE OF USE CASE

Narrative of use case
Short description
Need:. Short description, a few sentences **Service** *(short description of how the service meets the objectives):* Short description, a few sentences
Complete description
The complete description is focused on the narrative descriptions of each phase of the service. Each phase is linked to a scenario in the use case template.

Definition of services phases (= scenarios)

- **Phase 1: Prequalification**
  - The Prequalification phase deals with the certification and registration of all assets participating to the flexibility service. The prequalification phase can include processes regarding the certification of existing assets (periodic tests to extend the certification) and the certification of new resources (which arrive after the demo beginning).
  - End of Prequalification Phase : Resources are registered and allowed to participate to the procurement processes for the delivery of the service.

- **Phase 2: Bidding / Selection (of resources)**
  - The Bidding / Selection phase deals with the procurement process of a certain service, i.e. bidding of flexibility offers and the clearing of the market. We consider that there is a market if the participation of the flexible resource happens on a voluntary base at a free price. In case there is no market, there are still interactions between stakeholders for the selection of resources.
  - End of Bidding/Selection Phase : final set points are sent to the resources (before the delivery)

- **Phase 3: Delivery**
  - The Delivery phase deals with the supply of flexibility services and the activation of the flexibility resources
  - End of Delivery phase : the provision of the service is finished, including measurements

- **Phase 4: Settlement**
  - The Settlement phase deals with the management of invoices between stakeholders
  - Beginning of Settlement phase : the measured data is sent (to the role in charge of consolidation of data)

o In this phase, one may find the following activities: aggregation of the measured data, calculation of deviations, sending of invoices.

1.5 KEY PERFORMANCE INDICATORS (KPI)

Note: out of scope in the fast track. To be refined later within WP10 activities.

Key performance indicators			
ID	***Name***	***Description***	***Reference to mentioned use case objectives***
1	PKI1		Objective1
2	PKI2		Objective 2

1.6 USE CASE CONDITIONS

Note: to facilitate the description in the context of EUSysFlex T3.3 services, categories are proposed as examples for each assumptions and prerequisites.

- ***Assumptions (elements related to the market environment on top of the service)***:

  - rules relevant for the service (market and regulation)
  - limitations due to the regulatory and market environment (In case of assumptions regarding future market environments and regulation, this includes the differences with the today's market environment and regulation)
- ***Prerequisites (elements related to the service in the context of the demo):***
  - choices for the delivery of the service
  - choices regarding the level of detail and the scope for the description of the BUC
  - limitations in the context of the demo

Use case conditions	
Assumptions	
1	rules relevant for the service (market and regulation) • assumptions 1 • assumptions 2 • …
2	limitations due to the regulatory and market environment • … • … • …
Prerequisites	
1	choices for the delivery of the service • … • ….
2	choices regarding the level of detail and the scope for the description of the BUC • … • … • …
3	limitations in the context of the demo • … • … • …

1.7 FURTHER INFORMATION TO THE USE CASE FOR CLASSIFICATION/MAPPING

Classification information
Relation to other use cases
Level of depth
BUC for Country XXX EU-SysFlex Demo WPX
Prioritisation
Generic, regional or national relation
National Country XXX Market Environment
Nature of use case
BUC
Further keywords for classification

1.8 GENERAL REMARKS

General remarks

2. DIAGRAMS OF USE CASE

Diagram(s) of use case
UML diagrams are preferable. Use Modsarus to automate the insert of such UML diagrams

3. TECHNICAL DETAILS

3.1 ACTORS

Note: use consolidated EU-SysFlex Role Model within the UML Repository of EU-SysFlex Project

Actors			
Grouping		***Group description***	
Actor name	***Actor type***	***Actor description***	***Further information specific to this use case***
	Business		
	Business		

3.2 REFERENCES

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

4. STEP BY STEP ANALYSIS OF USE CASE

4.1 OVERVIEW OF SCENARIOS

Scenario conditions						
No.	***Scenario name***	***Scenario description***	***Primary actor***	***Triggering event***	***Pre-condition***	***Post-condition***
1	Prequalification					
2	Bidding / Selection					
3	Delivery					
4	Settlement					

4.2 STEPS – SCENARIOS

Note:

- Produce such section for each scenario.
- Use Modsarus to add UML Figures showing workflow of information exchange between Business Roles

Scenario								
Scenario name	Prequalification							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***

5. INFORMATION EXCHANGED

Information exchanged			
Information exchanged, ID	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***

6. REQUIREMENTS (OPTIONAL)

Requirements (optional)		
Categories ID	***Category name for requirements***	***Category description***
Requirement R-ID	***Requirement name***	***Requirement description***

7. COMMON TERMS AND DEFINITIONS

Common terms and definitions	
Term	***Definition***

8. CUSTOM INFORMATION (OPTIONAL)

Custom information (optional)		
Key	***Value***	***Refers to section***

ANNEX II. CONSOLIDATED BUSINESS ROLES LIST

Disclaimer: The following business roles list is a limited sub-set of the complete final role model, limited to the roles needed for the BUC description of the demonstrators services and based on an initial assessment. The complete role model, including final definitions will be available in D3.2

Roles ID	Roles name	Responsibilities
AO	Asset Operator	Operate a set of assets connected to distribution grid which may cover consumption, storage or generation assets.
G	Generator	Invest in, maintain and operate the asset(s) Select the contractual framework with relevant stakeholders related to the energy contract and the provision of flexibility/other system services
G_O	Generation asset Operator	Operate one or several generation asset(s)
DN_FP	Distribution Network Flexibility Provider	Provide flexibility by assets connected to the distribution network
TN_FP	Transmission Network Flexibility Provider	Provide flexibility by assets connected to the transmission network
A	Aggregator	Aggregate and maximise value of portfolio(s) of resources
GA	Generation Aggregator	Aggregate and maximize value of generation portfolio resources Provide flexibility by generation assets to the system operators
BRP	Balance Responsible Party	Manage Operational planning of imbalances within its perimeter Ensure financial liability for imbalance between realized energy injection/withdrawal
DS_O	Distribution System Operator	Elaborate network development plan (including defining system needs for distribution) Ensure a transparent and non-discriminatory access to the distribution network for each user Operate the distribution grid over a specific region in a secure, reliable and efficient way Optimize system operation distribution grid from planning to real-time, using available levers (grid expansion, flexibility activation,...) Assess network status of the distribution grid and broadcast selected information of the network status to eligible actors (e.g. aggregators, other system operators)

		Support the Transmission System Operator in carrying out its responsibilities (including load shedding) and coordinate measures if necessary
TS_O	Transmission System Operator	Elaborate network development plan (including defining system needs for transmission) Ensure a transparent and non-discriminatory access to the transmission network for each user Operate the transmission grid over a specific region in a secure, reliable and efficient way Secure and manage in real time the physical generation-consumption balance on a geographical perimeter, including ensuring the frequency control service Optimize transmission system operation from planning to real-time, using available levers (grid expansion, flexibility activation,...) Assess network status of the transmission grid and broadcast selected information of the network status to eligible actors (e.g. aggregators, other system operators) Provide data to the interconnection capacity market operator for the management of cross border transactions In critical situations, implement dedicated actions and deliver alerts during stress events If necessary, implement emergency measures (e.g. system defence plan) including load shedding
MO_D	Market Operator in Distribution	Organize auctions (continuous auction, discrete auctions, call for tenders) between buyers and sellers of electricity-related products in the markets, and more generally publish the corresponding prices, for assets connected to distribution grid Manage/operate the platform for trading (where bids and offers are collected) Clear the market and communicate results
MO_T	Market Operator in Transmission	Organize auctions (continuous auction, discrete auctions, call for tenders) between buyers and sellers of electricity-related products in the markets, and more generally publish the corresponding prices, for assets connected to transmission grid Manage/operate the platform for trading (where bids and offers are collected) Clear the market and communicate results

MO	Market Operator	Organize auctions (continuous auction, discrete auctions, call for tenders) between buyers and sellers of electricity-related products in the markets, and more generally publish the corresponding prices, for assets connected to transmission or distribution grid Manage/operate the platform for trading (where bids and offers are collected) Clear the market and communicate results
MDO	Metered Data Operator	Provide metered data to authorized users in a transparent and non-discriminatory manner
FCP	Forecast Provider	Provide forecasts of RES, small generation and consumption load based on different data (e.g. weather data and historical load flow) to other roles

FIGURE 15: LIST OF BUSINESS ROLES INVOLVED IN THE FAST TRACK

EU-SysFlex

ANNEX III. BUSINESS USE CASES OF T3.3 COMPLIANT WITH THE IEC62559-2 TEMPLATE

Manage active power flexibility to support FCRn in the Finnish demo

Based on IEC 62559-2 edition 1
Generated from UML Use Case Repository with Modsarus® (EDF R&D Tool)

1. DESCRIPTION OF THE USE CASE

1.1 NAME OF USE CASE

Use case identification		
ID	***Area(s)/Domain(s)/Zone(s)***	***Name of use case***
FI-AP1	Finland	Manage active power flexibility to support FCRn in the Finnish demo

1.2 VERSION MANAGEMENT

Version management				
Version No.	***Date***	***Name of author(s)***	***Changes***	***Approval status***
1	2018-03-08	Cyril Effantin	intial draft from KM Tool based on Finland Demo inputs done by Corentin Evens	
2	2018-05-31	Corentin Evens	Proposed version from demo	
3	2018-06-11	Cyril Effantin	Consolidation in a common UC repository	
4	2018-06-26	Corentin Evens	Modifications from June review	
5	2018-08-29	Cyril Effantin	UML fixes	
6	2018-10-25	Cyril Effantin	Updates on role model and UML use case impacted parts	

1.1. SCOPE AND OBJECTIVES OF USE CASE

Scope and objectives of use case	
Scope	Use of distributed batteries, one large battery unit (BESS), distributed EV charging stations and distributed buildings equipped with adequate home automation to participate to the hourly market for Frequency Containment Reserves for Normal operation in Finland.

	The FCRn market in Finland is a combination of a yearly capacity market (out of scope of the demo) and a day-ahead, single buyer market cleared on an hourly basis. The energy settlement is made according through the usual balance settlement of the associated BRPs.
Objective(s)	Stabilize frequency: The main objective of the use case is for the TSO to stabilize the frequency in response to deviations occurring due to the normal variations in production and consumption. Increased revenues: The aggregator aims at increasing the revenue associated to the operation of its resources. In the case of the demo, this means increasing the income from the operation of the battery systems and of the distributed controllable heating loads.
Related business case(s)	Frequency Control

1.2. NARRATIVE OF USE CASE

Narrative of use case
Short description
Need: Automatic activation of resources on the electricity network in order to prevent the frequency from deviating from its set-point of 50Hz. The purpose of these reserves is to be used for the fine tuning during normal operation, other reserves kick in in cases of large disturbances on the network. **Service:** Helen, acting as a flexibility aggregator wishes to increase the revenue generated by its large battery unit, distributed batteries, aggregated EV stations and homes with the Optiwatti smart electric heating installation by offering them on the existing market operated by Fingrid.
Complete description
Prequalification phase: - The aggregator gets access to the flexibility of the various resources (by owning them itself or by agreement with the resources operators and/or owners as described in the prerequisites. - The aggregator registers itself as a reserves provider to the TSO. - The aggregator must perform regulation tests when the service is agreed upon as well as when there are changes to the installations which could lead to changes in the behaviour, or after maintenance or repairs, or at least every 10 years. During a test: A step change in frequency is subsituted to the local measurements. The reaction of the resources is measured and logged.

The reaction is sent to the TSO for validation.

- The TSO also contracts resources on a yearly basis with specific capacity reserved for specific times.

Bidding:

- The asset operators send their schedules to the aggregator for the following day based on the results of the day-ahead market and their estimated availability (optional)
- All the market participants assess their availability and create their bids for the following day.
- The bids are sent to the MO before 18.00.
- The demand on the market comes from the TSO and is based on their estimates for the need and the results from the yearly market.
- The MO determines the resources that should reserve the capacity from their bid based on the offer bids and the demand from the TSO. The reserves contracted under the yearly market are used first. The remaining needs are selected in price order, the cheapest first.
- All the activated reserves providers recalculate the operational set-points of their controllable resources based on the results from the market.

Delivery phase:

- The delivery is realized by the different resources based on local frequency measurements.
- The aggregator sends "real-time" (with a 0.1MW accuracy) data to the TSO at least every 3 minutes. This data consists of the available reserves capacity, the ID of the aggregators considered and time stamps.

Settlement phase:

- The aggregator sends the invoicing data to the TSO. It should include: unit-specific hourly average power, unit-specific hourly maximum power and the volume of frequency controlled reserves activated during the hour.
- The payment includes the capacity fee (14€/MW,h) and the energy fee based on market clearing.
- In case of failure to deliver the capacity fee and the energy fee based on the market clearing are charged by the TSO from the A.

Summary of use case

- **Prequalification**
  Description:
    - Choose Aggregator
      Description: The asset operators choose the aggregator that will get access to their flexibility in order to bid it on the selected market

- Select suitable markets
  Description: Taking into account the resources it has access to, the aggregator selects the markets they choose to participate to.

- Select suitable markets
  Description: Taking into account the resources it has access to, the aggregator selects the markets they choose to participate to.

- Process registration request
  Description: The system operator has received a request from an aggregator to become a service provider

- Run performance test
  Description: Under the monitoring of the TS_O, the aggregator simulates a step change in the frequency measurements. The response of the resources is measured and analyzed by the aggregator and the TS_O. The test is deemed successful if the changes in production or consumption correspond to the claims from the aggregator.

- Register to market
  Description: With records of a successful performance test, the aggregator sends the final information in order to register themselves to the market.

- Update participant list
  Description: Add, remove or modify the information about the actors participating to a specific market.

- **Selection/Bidding**
  Description:

  - Send Resource availability for day-ahead
    Description: Forecasting of the available capacity of the resources under the control of the asset operator.

  - Create Bids for Day ahead
    Description: This includes forecasting of the assets that didn't forecast themselves and calculation of the availability of the ones that didn't send it.

  - Register bids
    Description: The market operator receives and collects the bids in its database.

  - Send Demands for day ahead
    Description: Based on the requirements agreed upon with the neighbouring TS_Os and on updated operational forecasts the TS_O determines the amount of FCRn reserves that are required for the time period considered.

  - Do Market Clearing
    Description: The MO subtracts the reserves previously contracted on the yearly market from the TS_O needs and allocates the remaining to the aggregators with the cheapest bids. The TS_O also receives a copy of the accepted bids.

  - Do Market Clearing
    Description: The MO subtracts the reserves previously contracted on the yearly market from

the TS_O needs and allocates the remaining to the aggregators with the cheapest bids. The TS_O also receives a copy of the accepted bids.

- Inform market clearing result to corresponding resources
  Description: The aggregators send the set-points for frequency-based response to the selected resources.

- Recalculate the operational set-points
  Description: The set-points (active power response to deviations in the frequency measurements) of the flexible assets are adjusted so that the service can be provided with no further interactions required.

- **Delivery**
  Description:

  - Observe frequency deviation
    Description: A frequency deviation is measured locally.

  - Change energy balance
    Description: The production or consumption is adjusted according to the set-points adjusted during the market clearing process and on locally measured values.

  - Certify power measurement
    Description: The MDO guarantees that the measured data is accurate and reliable.

  - Aggregate certified metered data
    Description: The metered data is aggregated and packaged in the format expected by the TS_O.

  - Save data for future verification
    Description: The TS_O stores the measurement data received in real time in order to have it available later for the settlement phase.

- **Settlement**
  Description: Monetary settlement for delivered capacity

  - Aggregate the metered data for invoicing
    Description: The measured data recorded over one month is aggregated and made ready to be sent to the TS_O.

  - Prepare invoice for capacity
    Description: The aggregator prepares the invoice to the TS_O for the capacity maintained.

  - Calculate the payment for the delivery of the contracted capacity.
    Description: Check if the capacity that was promised has been delivered and either add or substract the capacity price to the aggregator's saldo

  - Prepare the payment
    Description: The TS_O sends the payment for the balance between provided and not provided capacities.

  - Prepare the invoice
    Description: The TS_O prepares the invoice for the balance between provided and not provided capacities.

1.3. KEY PERFORMANCE INDICATORS (KPI)

1.4. USE CASE CONDITIONS

Use case conditions	
Assumptions	
1	Rules relevant for the service (market & regulation): • Existing market • All the market participants have registered themselves to the MO • The FCRn results from the yearly market are known for the following day • The aggregator must keep the "real-time" data about its resources, along with their local measurements of frequency, for at least 4 days. • The invoicing data must be sent by the providers to the TSO within 10 days of the delivery of the service
2	Limitations due to the regulatory and market environment: • Bids are to be submitted for the whole day on the day-ahead before 6PM • The bid size must be between 0.1 and 5MW • The precision of a bid is 0.1MW • Bids cannot be linked to each other, except for aggregated bids. • The aggregator is also the retailer of the consumers and resources it controls (according to the regulation) • The activation of a bid has to be realized in a linear band of width ±10% going from -100% at 49.9Hz and +100% at 50.1Hz
Prerequisites	
1	Choices for the delivery of the service: • The contractual interactions between the homes/buildings with smart heating, the building owners and the home automation provider have been sorted out so that the FA needs to interact only with the interface of the automation system
2	Choices regarding the level of detail, the scope for the description of the BUC : • The public EV charging stations are considered as loads (consumption) only. The vehicles behind and the relationships between the station operator and the vehicle users are ignored • Single generation, storage and consumption units acting directly on the market are considered to be their own aggregator • The distinction between operator/owner etc. of resource is made only in the cases involving the demo directly • The parties responsible for the balance of the aggregators do not need to be included • The situation on the distribution networks considered is in a condition where congestions do not need to be considered as a limiting factor for the activation of resources

- The MO and the TSO is the same stakeholder. The interactions with one or the other or among them may sometimes be slightly inaccurate.
- The aggregator and retailer are the same stakeholder.
- The BESS and the EV charging infrastructure are owned by the aggregator.
- The aggregator has an agreement with the operators of the distributed battery units to control them within set limits.
- For larger units the MDO responsibility is assumed by the aggregator. For smaller units the aggregator collects the measurement data from the DSO

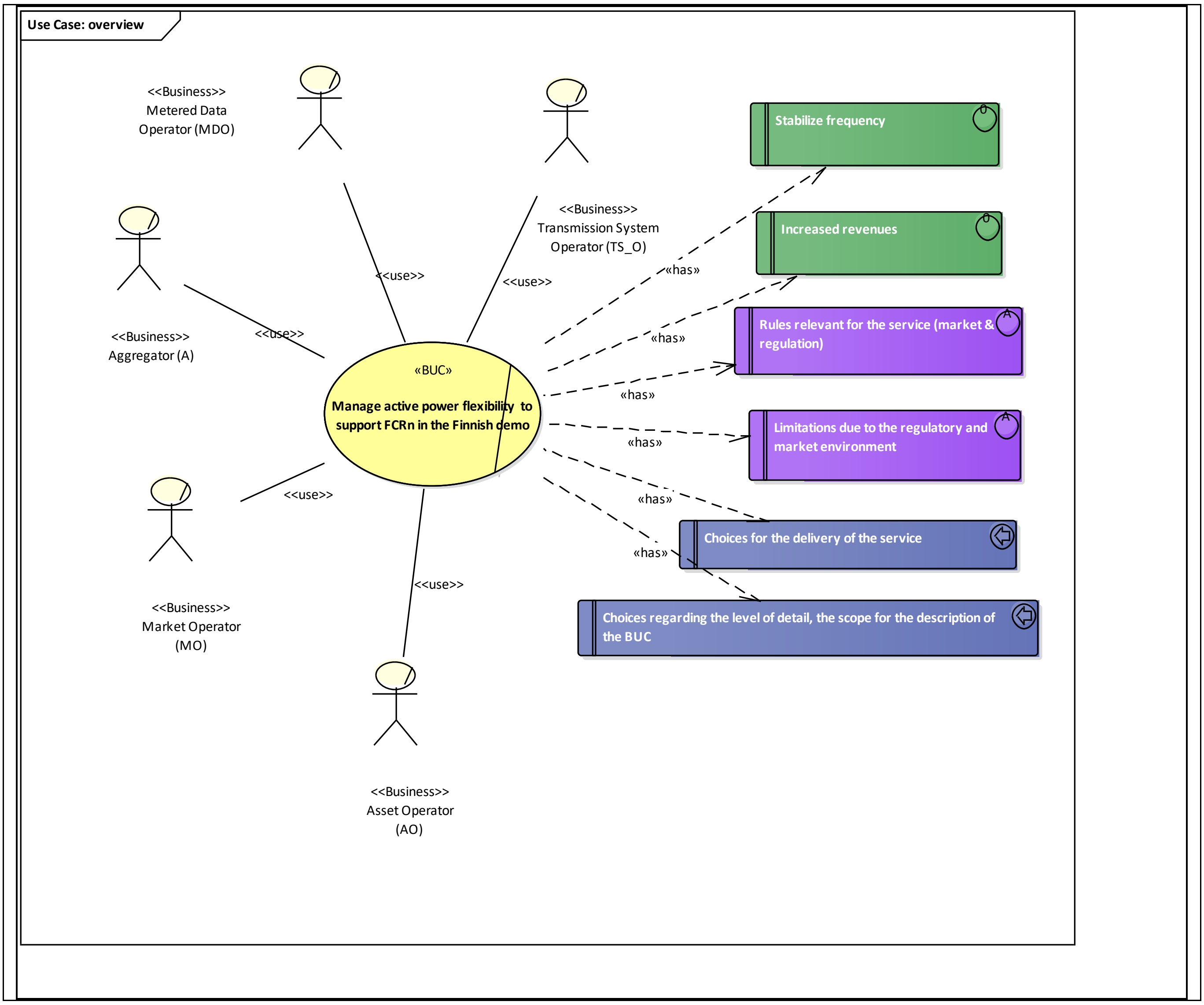
1.5. FURTHER INFORMATION TO THE USE CASE FOR CLASSIFICATION/MAPPING

Classification information
Relation to other use cases
Level of depth
BUC for Finland EuSysFlex Demo WP6
Prioritisation
Generic, regional or national relation
National Finland Market Environment
Nature of the use case
BUC
Further keywords for classification

1.6. GENERAL REMARKS

2. DIAGRAMS OF USE CASE

Diagram(s) of use case


Use Case: overview
<<Business>>
Metered Data Operator (MDO)
<<Business>>
Transmission System Operator (TS_O)
<<Business>>
Aggregator (A)
<<Business>>
Market Operator (MO)
<<Business>>
Asset Operator (AO)
<<use>>
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«BUC»
Manage active power flexibility to support FCRn in the Finnish demo
«has»
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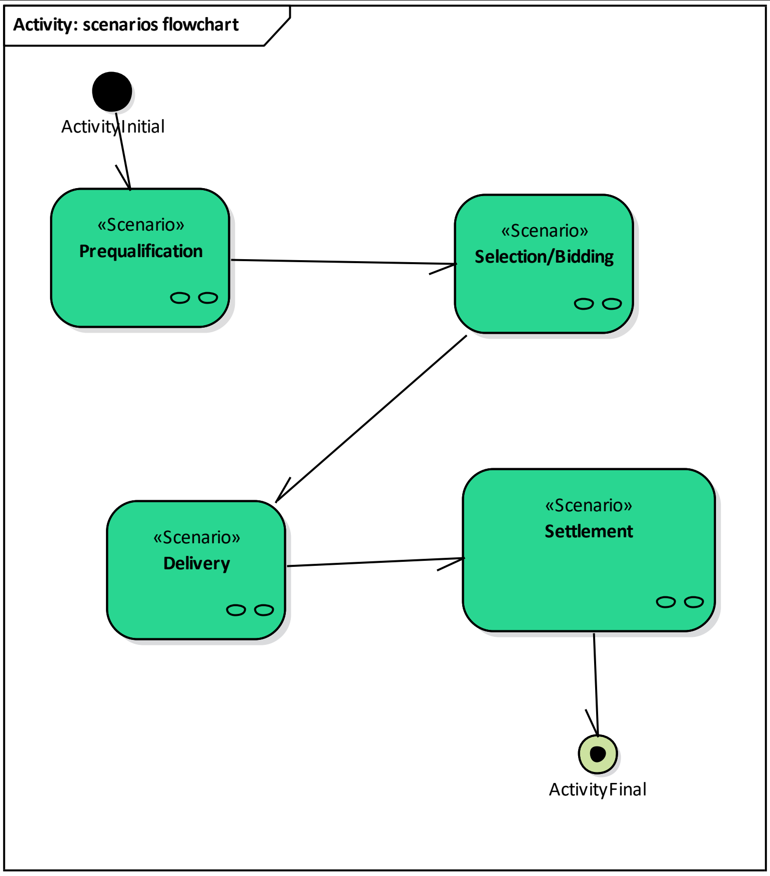
«has»
Stabilize frequency
Increased revenues
Rules relevant for the service (market & regulation)
Limitations due to the regulatory and market environment
Choices for the delivery of the service
Choices regarding the level of detail, the scope for the description of the BUC



3. TECHNICAL DETAILS

3.1 ACTORS

Actors			
Grouping (e.g. domains, zones)		***Group description***	
Actor name	***Actor type***	***Actor description***	***Further information specific to this use case***
Aggregator (A)	Business	Aggregate and maximise value of portfolio(s) of resources	
Market Operator (MO)	Business	Organize auctions (continuous auction, discrete auctions, call for tenders) between buyers and sellers of electricity-related products in the markets, and more generally publish the corresponding prices, for assets connected to transmission or distribution grid Manage/operate the platform for trading (where bids and offers are collected) Clear the market and communicate results	

Metered Data Operator (MDO)	Business	Provide metered data to authorized users in a transparent and non-discriminatory manner	
Transmission System Operator (TS_O)	Business	Elaborate network development plan (including defining system needs for transmission) Ensure a transparent and non-discriminatory access to the transmission network for each user Operate the transmission grid over a specific region in a secure, reliable and efficient way Secure and manage in real time the physical generation-consumption balance on a geographical perimeter, including ensuring the frequency control service Optimize transmission system operation from planning to real-time, using available levers (grid expansion, flexibility activation,...) Assess network status of the transmission grid and broadcast selected information of the network status to eligible actors (e.g. aggregators, other system operators) Provide data to the interconnection capacity market operator for the management of cross border transactions In critical situations, implement dedicated actions and deliver alerts during stress events If necessary, implement emergency measures (e.g. system defence plan) including load shedding	
Asset Operator (AO)	Business	Operate a set of assets connected to distribution grid which may cover consumption, storage or generation assets.	Includes Generation (G_O), Consumption (C_O) and Storage (S_O) Operators for clarity in some cases.

3.2 REFERENCES

4. STEP BY STEP ANALYSIS OF USE CASE

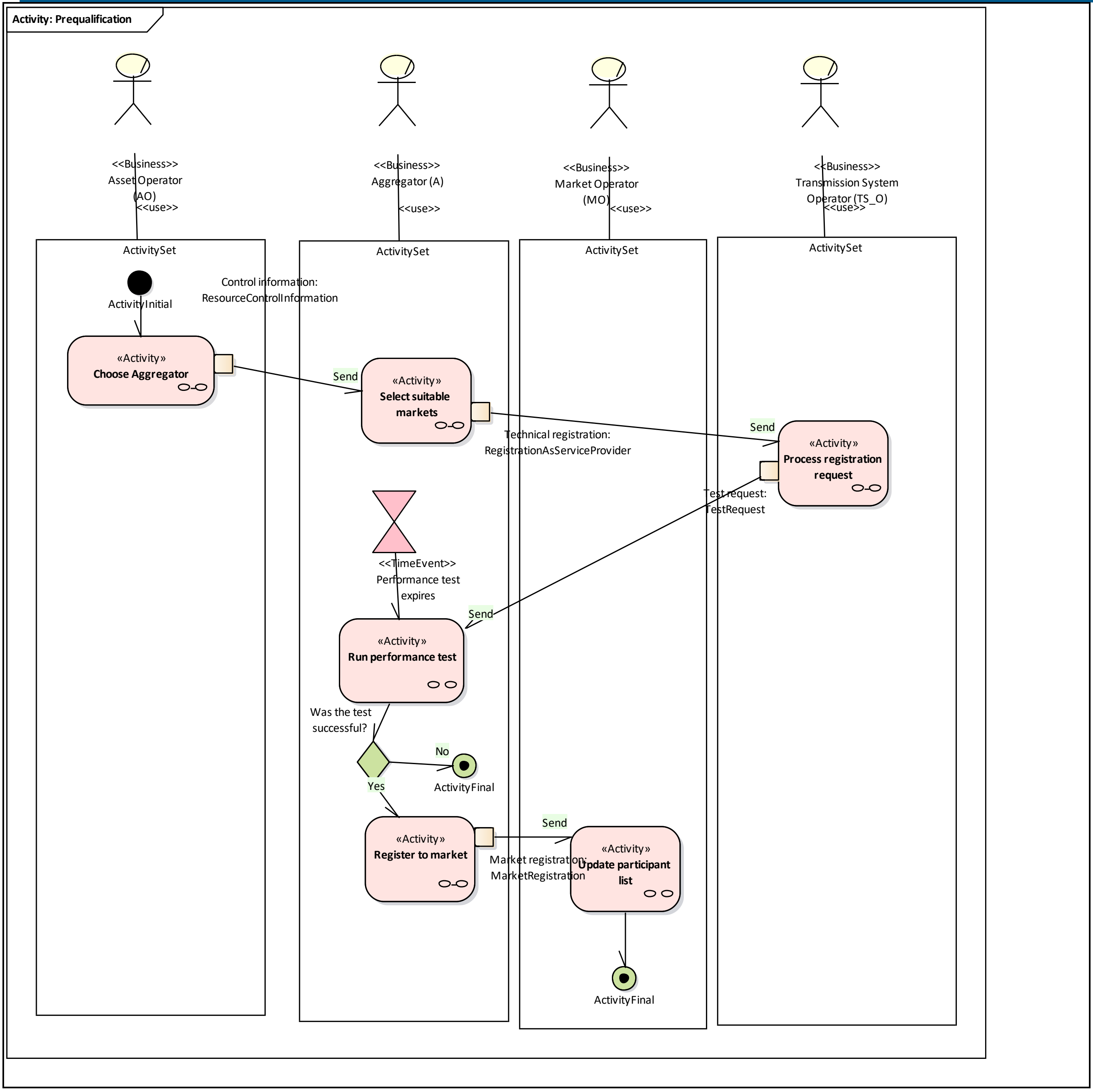
4.1 OVERVIEW OF SCENARIOS

Scenario conditions						
No.	***Scenario name***	***Scenario description***	***Primary actor***	***Triggering event***	***Pre-condition***	***Post-condition***
1	Prequalification					
2	Selection/Bidding					

3	Delivery					
4	Settlement	Monetary settlement for delivered capacity			Settlement Frequency: The settlement phase is executed once a month.	

4.2 STEPS - SCENARIOS

4.2.1 PREQUALIFICATION



Scenario step by step analysis

Scenario

Scenario name	Prequalification							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
1.1		Choose Aggregator	The asset operators choose the aggregator that will get access to their flexibility in order to bid it on the selected market	Send	Asset Operator (AO)	Aggregator (A)	Info1-ResourceControlInformation	
1.2		Select suitable markets	Taking into account the resources it has access to, the aggregator selects the markets they choose to participate to.	Send	Aggregator (A)	Market Operator (MO)	Info2-MarketRegistration	
1.3		Select suitable markets	Taking into account the resources it has access to, the aggregator selects the markets they choose to participate to.	Send	Aggregator (A)	Transmission System Operator (TS O)	Info3-RegistrationAsServiceProvider	
1.4		Process registration request	The system operator has received a request from	Send	Transmission System Operator (TS O)	Aggregator (A)	Info4-TestRequest	

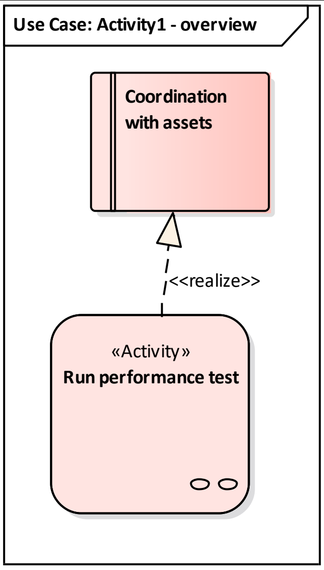
			an aggregator to become a service provider					
1.5		Run performance test	Under the monitoring of the TS_O, the aggregator simulates a step change in the frequency measurements. The response of the resources is measured and analyzed by the aggregator and the TS_O. The test is deemed successful if the changes in production or consumption correspond to the claims from the aggregator.		Aggregator (A)			Cat1.Req1
1.6		Register to market	With records of a successful performance test, the aggregator sends the final information in order to register	Send	Aggregator (A)	Market Operator (MO)	Info2-MarketRegistration	

			themselves to the market.					
1.7		Update participant list	Add, remove or modify the information about the actors participating to a specific market.		Market Operator (MO)			

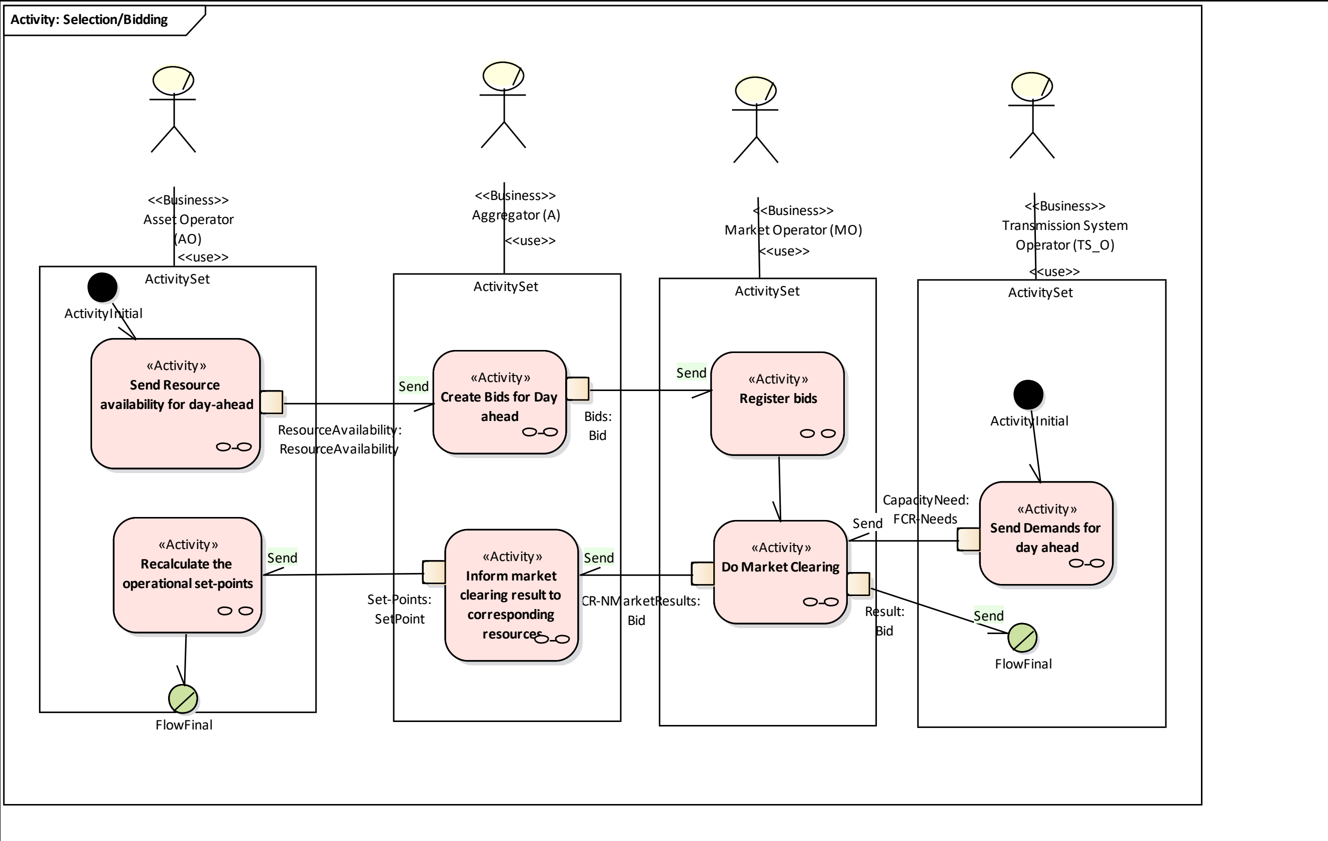
- ## 1.5. Run performance test

Business section: Prequalification/Run performance test

Under the monitoring of the TS_O, the aggregator simulates a step change in the frequency measurements. The response of the resources is measured and analyzed by the aggregator and the TS_O. The test is deemed successful if the changes in production or consumption correspond to the claims from the aggregator.



4.2.2 SELECTION/BIDDING



Scenario step by step analysis

Scenario								
Scenario name	Selection/Bidding							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
2.1		Send Resource availability for day-ahead	Forecasting of the available capacity of the resources under the control of the asset operator.	Send	Asset Operator (AO)	Aggregator (A)	Info5-ResourceAvailability	
2.2		Create Bids for Day ahead	This includes forecasting of the assets that didn't forecast	Send	Aggregator (A)	Market Operator (MO)	Info6-Bid	Cat2.Req2, Cat3.Req3

			themselves and calculation of the availability of the ones that didn't send it.					
2.3		Register bids	The market operator receives and collects the bids in its database.		Market Operator (MO)			
2.4		Send Demands for day ahead	Based on the requirements agreed upon with the neighbouring TS_Os and on updated operational forecasts the TS_O determines the amount of FCRn reserves that are required for the time period considered.	Send	Transmission System Operator (TS_O)	Market Operator (MO)	Info7-FCR-Needs	
2.5		Do Market Clearing	The MO subtracts the reserves previously contracted on the yearly market from the TS_O needs and allocates the remaining to the aggregators with the	Send	Market Operator (MO)	Aggregator (A)	Info6-Bid	

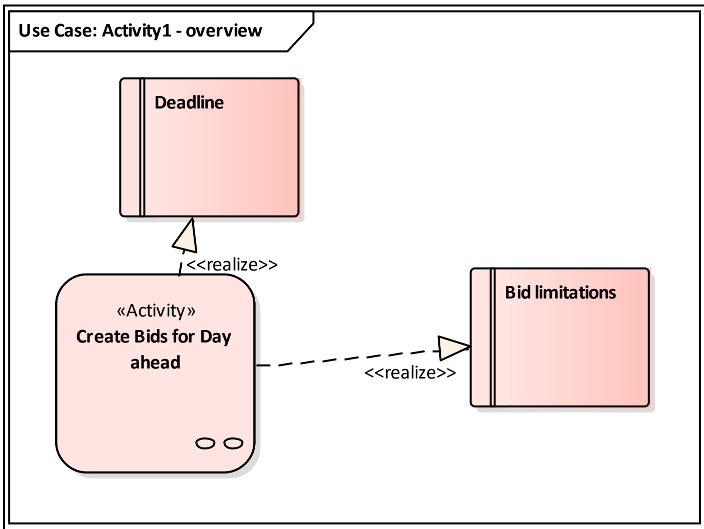
			cheapest bids. The TS_O also receives a copy of the accepted bids.					
2.6		Do Market Clearing	The MO subtracts the reserves previously contracted on the yearly market from the TS_O needs and allocates the remaining to the aggregators with the cheapest bids. The TS_O also receives a copy of the accepted bids.	Send	Market Operator (MO)	Transmission System Operator (TS_O)	Info6-Bid	
2.7		Inform market clearing result to corresponding resources	The aggregators send the set-points for frequency-based response to the selected resources.	Send	Aggregator (A)	Asset Operator (AO)	Info8-SetPoint	
2.8		Recalculate the operational set-points	The set-points (active power response to deviations in the frequency measurements) of the flexible assets are		Asset Operator (AO)			

			adjusted so that the service can be provided with no further interactions required.					

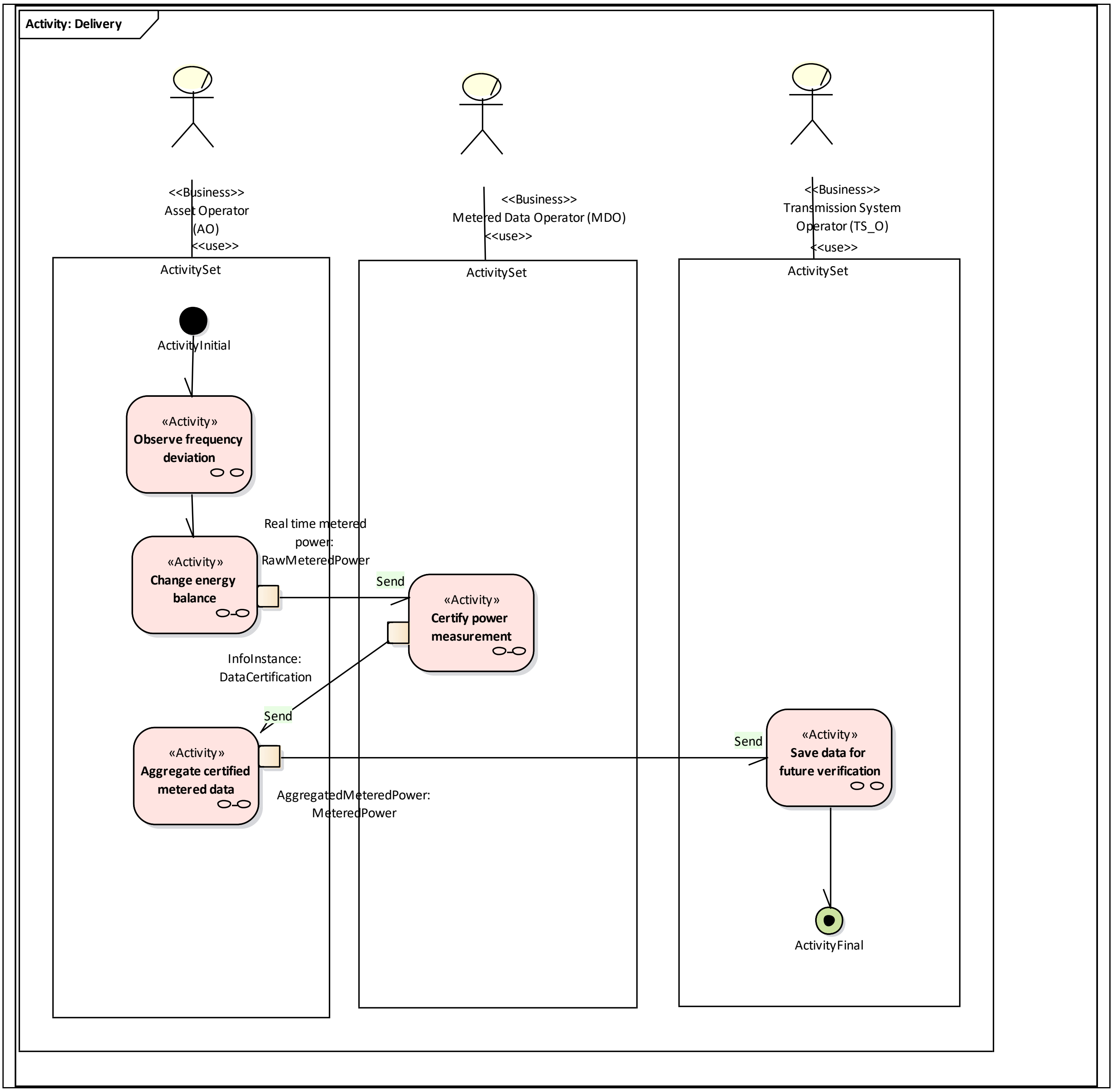
- <u>2.2. Create Bids for Day ahead</u>

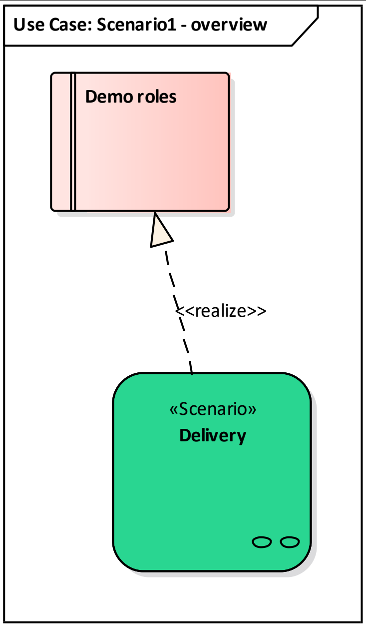
<u>Business section: Selection/Bidding/Create Bids for Day ahead</u>

This includes forecasting of the assets that didn't forecast themselves and calculation of the availability of the ones that didn't send it.



4.2.3 DELIVERY


Activity: Delivery
<<Business>>
Asset Operator
(AO)
<<use>>
<<Business>>
Metered Data Operator (MDO)
<<use>>
<<Business>>
Transmission System
Operator (TS_O)
<<use>>
ActivitySet
ActivitySet
ActivitySet
ActivityInitial
«Activity»
Observe frequency
deviation
Real time metered
power:
RawMeteredPower
«Activity»
Change energy
balance
Send
«Activity»
Certify power
measurement
InfoInstance:
DataCertification
Send
«Activity»
Aggregate certified
metered data
AggregatedMeteredPower:
MeteredPower
Send
«Activity»
Save data for
future verification
ActivityFinal



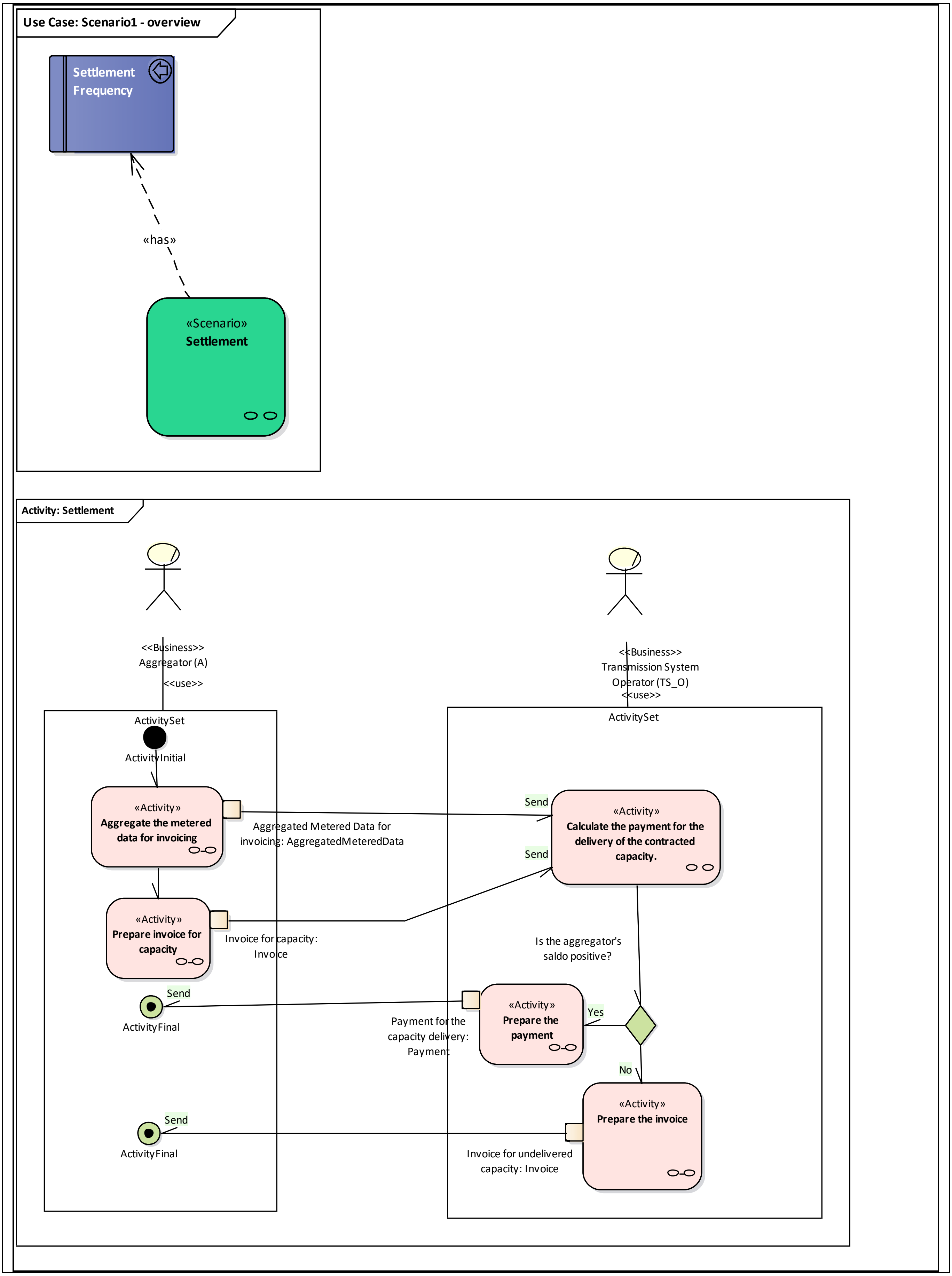
Scenario step by step analysis

Scenario								
Scenario name	Delivery							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
3.1		Observe frequency deviation	A frequency deviation is measured locally.		Asset Operator (AO)			
3.2		Change energy balance	The production or consumption is adjusted according to the set-points adjusted during the market clearing process and on locally measured values.	Send	Asset Operator (AO)	Metered Data Operator (MDO)	Info9-RawMeteredPower	

3.3		Certify power measurement	The MDO guarantees that the measured data is accurate and reliable.	Send	Metered Data Operator (MDO)	Asset Operator (AO)	Info10-DataCertification	
3.4		Aggregate certified metered data	The metered data is aggregated and packaged in the format expected by the TS_O.	Send	Asset Operator (AO)	Transmission System Operator (TS_O)	Info11-MeteredPower	
3.5		Save data for future verification	The TS_O stores the measurement data received in real time in order to have it available later for the settlement phase.		Transmission System Operator (TS_O)			

4.2.4 SETTLEMENT

Monetary settlement for delivered capacity


Use Case: Scenario1 - overview
Settlement Frequency
«has»
«Scenario»
Settlement
Activity: Settlement
<<Business>>
Aggregator (A)
<<use>>
<<Business>>
Transmission System Operator (TS_O)
<<use>>
ActivitySet
ActivitySet
ActivityInitial
«Activity»
Aggregate the metered data for invoicing
Aggregated Metered Data for invoicing: AggregatedMeteredData
Send
«Activity»
Calculate the payment for the delivery of the contracted capacity.
Send
«Activity»
Prepare invoice for capacity
Invoice for capacity: Invoice
Is the aggregator's saldo positive?
Send
ActivityFinal
Payment for the capacity delivery: Payment
«Activity»
Prepare the payment
Yes
No
«Activity»
Prepare the invoice
Send
ActivityFinal
Invoice for undelivered capacity: Invoice

Scenario step by step analysis

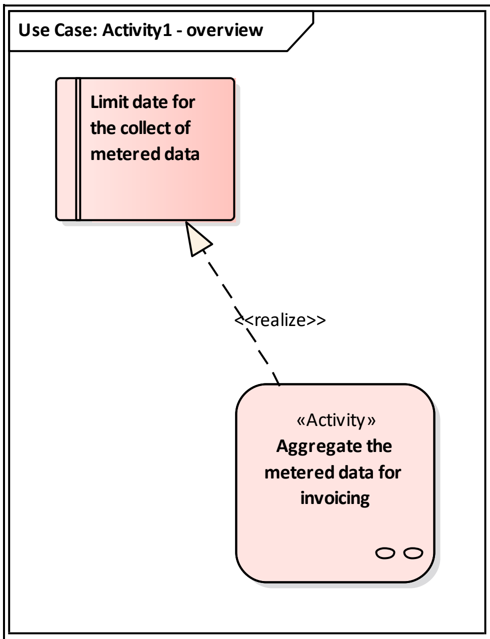
Scenario								
Scenario name	Settlement							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
4.1		Aggregate the metered data for invoicing	The measured data recorded over one month is aggregated and made ready to be sent to the TS_O.	Send	Aggregator (A)	Transmission System Operator (TS_O)	Info12-AggregatedMeteredData	Cat2.Req5
4.2		Prepare invoice for capacity	The aggregator prepares the invoice to the TS_O for the capacity maintained.	Send	Aggregator (A)	Transmission System Operator (TS_O)	Info13-Invoice	Cat2.Req6
4.3		Calculate the payment for the delivery of the contracted capacity.	Check if the capacity that was promised has been delivered and either add or substract the capacity price to the aggregator's saldo		Transmission System Operator (TS_O)			
4.4		Prepare the payment	The TS_O sends the payment for the balance	Send	Transmission System Operator (TS_O)	Aggregator (A)	Info14-Payment	Cat2.Req7

				between provided and not provided capacities.					
4.5		Prepare the invoice		The TS_O prepares the invoice for the balance between provided and not provided capacities.	Send	Transmission System Operator (TS_O)	Aggregator (A)	Info13-Invoice	Cat2.Req8

- ## 4.1. Aggregate the metered data for invoicing

Business section: Settlement/Aggregate the metered data for invoicing

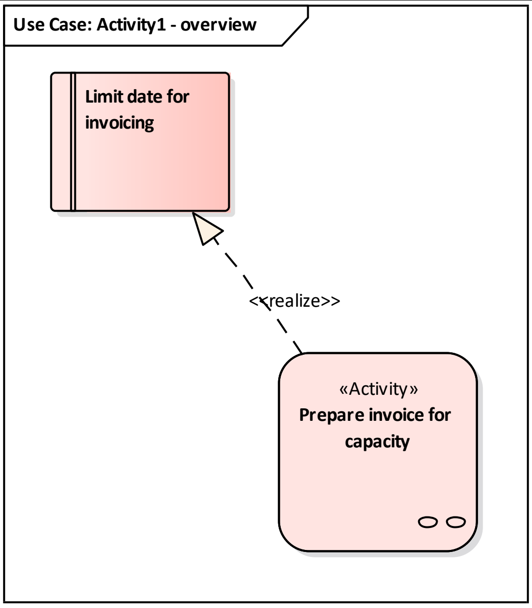
The measured data recorded over one month is aggregated and made ready to be sent to the TS_O.



- ## 4.2. Prepare invoice for capacity

Business section: Settlement/Prepare invoice for capacity

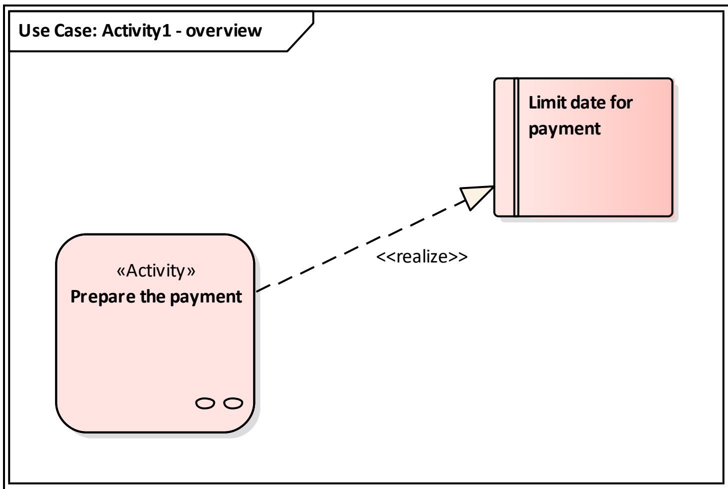
The aggregator prepares the invoice to the TS_O for the capacity maintained.



- ## 4.4. Prepare the payment

Business section: Settlement/Prepare the payment

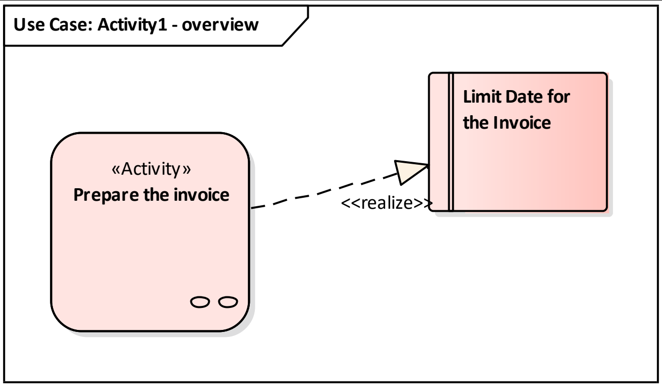
The TS_O sends the payment for the balance between provided and not provided capacities.



- ## 4.5. Prepare the invoice

Business section: Settlement/Prepare the invoice

The TS_O prepares the invoice for the balance between provided and not provided capacities.



5. INFORMATION EXCHANGED

Information exchanged			
Information exchanged, ID	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
Info1	ResourceControlInformation	Information needed for a market actor to evaluate and activate flexible resources. It may include the following pieces of information: - Location of the resource on the network - Information on how to communicate with the devices: address, protocols, possible inputs and outputs, etc. - Technical capabilities - Remuneration scheme and price	
Info2	MarketRegistration	The market participant registers as such to the market operator. This is accomplished by signing the appropriate contracts, establishing the communication links and possibly creating the required accounts on the online trading platform.	
Info3	RegistrationAsServiceProvider	The service provider requests a registration as such to the actor requiring the service. The information may contain the following: - Location of the resources - Technical capabilities of the resources - ID of the service provider	
Info4	TestRequest	An actor needing a service requests a potential provider to perform a test in order to prove its ability to provide the service.	
Info5	ResourceAvailability	Availability of the resources to be used during the required time period: - Time interval - Resource ID - Normal state of the resource (MW or kva	

		if no signal is exchanged) - Capacities up and down with their associated prices: MW and €/MW or kva and €/kva	
Info6	Bid	It should include the following information: • Bid ID • Product name • Aggregator ID • Capacity (MW) • Activation price (€/MW,h) • Hour	
Info7	FCR-Needs	Should include: - time intervals - capacity for each time interval - (optional) area where the capacity is needed	
Info8	SetPoint	Technical references that dictate how the outputs of the resources should vary based on an input signals (frequency measurements for FCR)	
Info9	RawMeteredPower	- ID - Time interval - Active power produced or consumed	
Info10	DataCertification	- Data ID - ID of the MDO - Certification status	
Info11	MeteredPower	- available reserves capacity (with a 0.1MW accuracy) - ID of the aggregator - time interval	
Info12	AggregatedMeteredData	For a period of month, includes: - unit-specific hourly average power - unit-specific hourly maximum power - the volume of frequency controlled reserves activated during each hour	
Info13	Invoice	The invoice must contain : • object of the invoice • justification • name of recipient • amount • due date • bank account	
Info14	Payment	The payment must contain :	

		• Object and justification of the payment • name of recipient • amount • date	

6. REQUIREMENTS (OPTIONAL)

Requirements (optional)		
Categories ID	***Category name for requirements***	***Category description***
Cat1	Out of scope	Inputs or organization aspects that are taken care of in other use cases and out of the scope of these BUC.
Requirement R-ID	***Requirement name***	***Requirement description***
Req1	Coordination with assets	The aggregator needs to activate and coordinate the resources behind the asset operator. The details of how it is done are not included here as it could vary based on the agreements with the asset operators and it is not the focus of this BUC.

Requirements (optional)		
Categories ID	***Category name for requirements***	***Category description***
Cat2	Deadlines	Requirements related to deadlines and timing of information exchanges.
Requirement R-ID	***Requirement name***	***Requirement description***
Req2	Deadline	The bids must be ready and sent by 18:00.
Req5	Limit date for the collect of metered data	The aggregated metered data are aggregating for invoicing maximum 10 days after delivery.
Req6	Limit date for invoicing	The invoice must be sent by the 10th day of the following month, or on the following first work day
Req7	Limit date for payment	The limit date for the payment is at the latest 14 days after the date the invoice was sent.
Req8	Limit Date for the Invoice	The limit date for the invoice is 14 days after the first invoice was received.

Requirements (optional)		
Categories ID	***Category name for requirements***	***Category description***
Cat3	Value limitations	Bounds and granularity of the possible values that can be assigned to information items.
Requirement R-ID	***Requirement name***	***Requirement description***
Req3	Bid limitations	- Bid size between 0.1 and 5MW - Bid precision: 0.1MW - Bids can not be linked to each other

Requirements (optional)		
Categories ID	***Category name for requirements***	***Category description***
Cat4	Roles and actors	Precision, in the context of the demo, of actors assuming several roles.
Requirement R-ID	***Requirement name***	***Requirement description***
Req4	Demo roles	In the case of the demo: - The A is acting as MDO after the measurement system has been verified during the procurement phase.

TABLE 6 BUC FI-AP1

Manage active power flexibility to support mFRR/RR in the Finnish demo

Based on IEC 62559-2 edition 1
Generated from UML Use Case Repository with Modsarus® (EDF R&D Tool)

1. DESCRIPTION OF THE USE CASE

1.1 NAME OF USE CASE

Use case identification		
ID	***Area(s)/Domain(s)/Zone(s)***	***Name of use case***
FI-AP2	Finland	Manage active power flexibility to support mFRR/RR in the Finnish demo

1.2 VERSION MANAGEMENT

Version management				
Version No.	***Date***	***Name of author(s)***	***Changes***	***Approval status***
1	2018-05-31	Corentin Evens	Proposed version from demo	
2	2018-06-11	Cyril Effantin	Consolidation in a common UC repository	
3	2018-06-26	Corentin Evens	Modifications from June review	
4	2018-08-02	Cyril Effantin	UML Fixes	
5	2018-10-25	Cyril Effantin	Updates on role model and UML use case impacted parts	

1.3 SCOPE AND OBJECTIVES OF USE CASE

Scope and objectives of use case	
Scope	The aggregator (Helen) uses distributed resources to participate to the manual balancing power market (mFRR/RR) of the TSO (Fingrid).
Objective(s)	Bring the frequency back to the required value: The system frequency after the resources activation should be back within the values defined in the regulation. Increased revenue: The Aggregator wishes to improve its revenue by better utilizing the resources it has available.
Related business case(s)	Frequency Control

1.4 NARRATIVE OF USE CASE

Narrative of use case
Short description
Need: Activation of resources on the electricity network in order to bring the frequency back to its set-point of 50Hz. The process is a market where capacity is offered. However the activation and settlement is based on the energy required at the time by the TSO **Service:** Helen, acting as a flexibility aggregator wishes to increase its revenue by offering the flexibility of its assets on the existing market operated by Fingrid. **Assets:** A medium-size battery unit (BESS) owned and operated by Helen. Distributed small-size battery units owned by third parties, but operated by Helen. Houses with electric heating. They are owned by a third party, but Helen can operate them through the AMR by utilizing the DSO's (Helen SV) communication infrastructure
Complete description
Prequalification phase: The aggregator secures its access to the flexible resources it is going to utilize. The aggregator then registers as a participant to the market operator and informs its BRP. **Bidding:** The MO opens the market for energy bids and logs them in until the market closure. The service providers assess their availability and place bids. After the market closure the market operator puts the bids in an ordered list and sends it to the TSO.

Delivery phase:

The TSO measures a deviation in frequency and sends the appropriate signals to the resources based on the bid list from the bidding phase. The asset operators have 15 minutes to provide the promised variations in production/consumption.

Settlement phase:

The delivery is measured and assessed at the same time as the resource provider's energy balance. The monetary result is included in the balancing fees and paid through the regular channels.

Summary of use case

- **Prequalification**
  Description: - The aggregator gets access to the flexibility of the various resources (by owning them itself or by agreement with the resources operators and/or owners as described in the prerequisites.
  - The aggregator registers itself as a reserves provider to the TSO, i.e. makes a mFRR/RR contract with the TSO.
  - The aggregator registers itself as a reserves provider to the actor responsible for its resources balance

  Optional:
  - The aggregator submits an offer on the capacity market.
  - The MO puts the offers in merit order and contracts the required amount of capacity.
  - On the day-ahead (before 1pm) as well as during the delivery day, at least the contracted capacity is required to be submitted as bids to the mFRR/RR market (in the bidding phase).

  - Choose aggregator
    Description: The asset operator, with the permission of the owner, chooses an aggregator and give them the possibility, technically and contractually, to use their resources for this use case.

  - Select suitable markets
    Description: Taking into account the resources it has access to, the aggregator selects the markets they choose to participate to.

  - Select suitable markets
    Description: Taking into account the resources it has access to, the aggregator selects the markets they choose to participate to.

  - Update resources database
    Description: The BRP updates the status of the resources it is responsible for in its database.

  - Update list of participants
    Description: Add, remove or modify the information about the actors participating to a specific market.
- **Selection/Bidding**
  Description: - The resources/resource operators send their schedule for the following day and following hours based on the results of the day-ahead and intra-day market and their estimated availability (optional)

- All the market participants, except the TSO, assess their availability and create their bids (Power MW, price €/MWh, production/consumption, transmission area, type of resource).
- The MO ranks put the bids in merit order, based on their price.
- The MO provides the list of bids to the TSO after the gate closure.

  - Send resource availability
    Description: Based on its own forecasts the asset operator calculates the availability of its resources for the upcoming mFRR/RR market.

  - Create mFRR/RR bids
    Description: The aggregator creates bids for the mFRR/RR market based on the forecasted availability of the assets it can control.

  - Sort bids
    Description: The MO sorts the bids in price order.

  - Receive bid list
    Description: The TS_O receives a sorted list of bids for each control zone and for each time period.

- **Delivery**
  Description: - A stable frequency deviation is measured by the TSO.
  - The TSO calculates the volume of reserves that needs to be activated.
  - The TSO sends the orders for activation to the bidders (aggregators) based on the merit order and the needed volume.
  - The aggregators relay the activation order to the resource (G, C and S) operators.
  - The resource operators realize the product delivery. The full activation needs to be achieved within 15 minutes of the reception of the TSO signal.

  - Detect frequency deviation
    Description: The TS_O detects a sustained frequency deviation and determines a need to activate mFRR/RR resources to restore the frequency to the desired level.

  - Select resources
    Description: Based on the merit order list from the bidding phase, the TS_O determines which aggregators should be contacted to provide mFRR/RR products.

  - Select resources to activate
    Description: The aggregator receives a request for activation of its resources. It can allocate the activation signals to the different assets based on updated forecasts.

  - Change the power production or consumption
    Description: Change the production or consumption of the units according to the received request and the resources availability.

- **Settlement**
  Description: - The delivery is measured and assessed at the same time as the resource provider's energy balance.
  - If the aggregator had been selected previously on the capacity market, a pay-as-bid capacity fee is added.
  - If the aggregator is its own BRP, the payment is added/removed in the regular balancing fees and paid through the same channels. Otherwise the TSO sends a bill to the aggregator within 6 weeks of the delivery, to be paid 2 weeks after reception.

  - Modify the settlement for the BRP
    Description: The settlement from the FRR market is added or removed from the balancing fees

	incurred by the BRP. The billing itself is made through the usual channels and is out of the scope of this BUC.

1.5 KEY PERFORMANCE INDICATORS (KPI)

1.6 USE CASE CONDITIONS

	Use case conditions
	Assumptions
1	rules relevant for the service (market & regulation): - Existing market
2	limitations due to the regulatory and market environment: - Bids are to be submitted up to 45 min. before the delivery hour - The bid size must be at least 5MW for electronically controlled devices, 10MW otherwise. - The precision of a bid is 1MW. - The aggregator is also the retailer of the consumers and resources it controls (according to the regulation) - For cross-border and area balancing purposes TSO (Fingrid) forwards mFRR/RR bids to be used for all other TSOs (Stattnett, Svenska Kraftnet, Elnett) in the synchronized Nordic common grid area. This results in common Nordic merit order list for all up- and down-regulation bids. - Bids can be aggregated from several different resources or units as long as all aggregated units are under the same BRP (Balance Responsible Party, usually same as the electricity retailer) and in the same balancing area (Finland consists of two balancing areas “top-half, bottom-half”) - Reserve providers’ BRP must be informed of the actions their assets bid ad perform on the mFRR/RR market - Units from different balancing groups (G,C) can be aggregated - Up-regulation has a price limit of 5000 € /MWh
	Prerequisites
1	choices for the delivery of the service
2	Choices regarding the level of detail, the scope for the description of the BUC : - Single G, S and C acting directly on the market are considered to be their own aggregator (A) - The situation on the distribution networks considered is in a condition where congestions do not need to be considered as a limiting factor for the activation of resources - The MO and the TSO is the same entity (demo specific). The interactions with one or the other or among them may sometimes be slightly inaccurate. - The BESS is owned by the aggregator (demo specific). - The aggregator, the retailer and the BRP are the same entity (demo specific)

1.7 FURTHER INFORMATION TO THE USE CASE FOR CLASSIFICATION/MAPPING

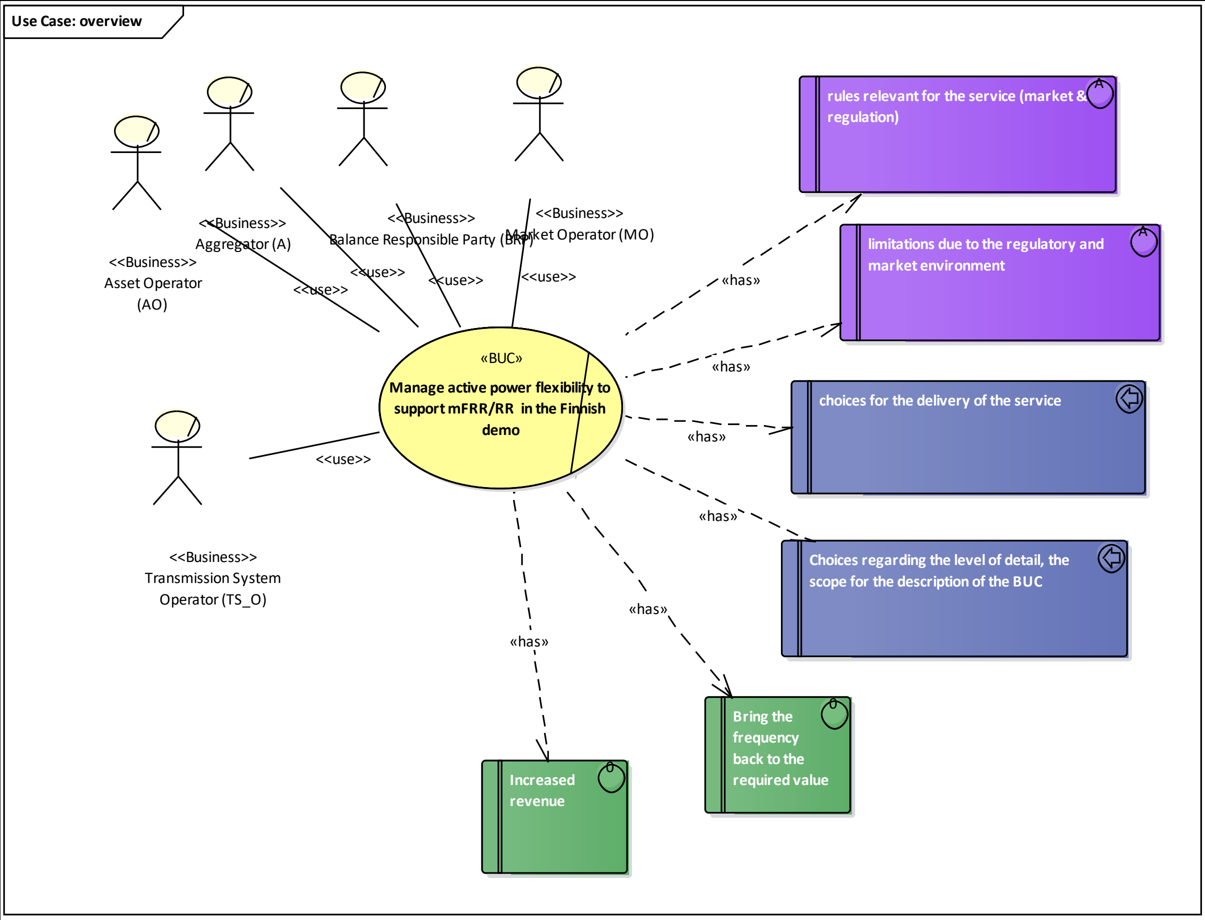
Classification information
Relation to other use cases
Level of depth

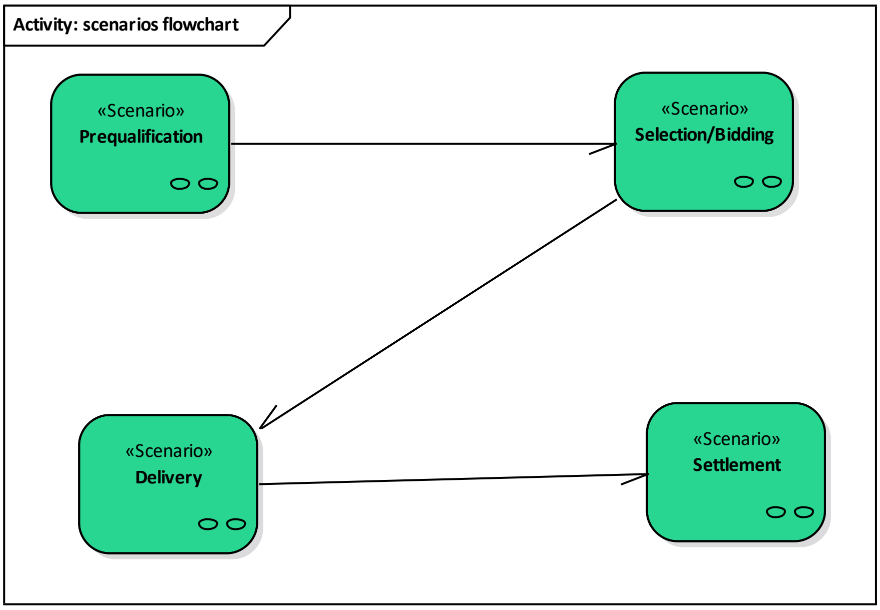
BUC for Finland EuSysFlex Demo WP7
Prioritisation
Generic, regional or national relation
National Finland Market Environment
Nature of the use case
BUC
Further keywords for classification

1.8 GENERAL REMARKS

2. DIAGRAMS OF USE CASE

Diagram(s) of use case





3. TECHNICAL DETAILS

3.1 ACTORS

Actors

Grouping (e.g. domains, zones)		***Group description***	
Actor name	***Actor type***	***Actor description***	***Further information specific to this use case***
Asset Operator (AO)	Business	Operate a set of assets connected to distribution grid which may cover consumption, storage or generation assets.	Includes Generation (G_O), Consumption (C_O) and Storage (S_O) Operators for clarity in some cases.
Aggregator (A)	Business	Aggregate and maximise value of portfolio(s) of resources	
Balance Responsible Party (BRP)	Business	Manage Operational planning of imbalances within its perimeter Ensure financial liability for imbalance between realized energy injection/withdrawal	
Market Operator (MO)	Business	Organize auctions (continuous auction, discrete auctions, call for tenders) between buyers and sellers of electricity-related products in the markets, and more generally publish the corresponding prices, for assets connected to transmission or distribution grid Manage/operate the platform for trading (where bids and offers are collected) Clear the market and communicate results	
Transmission System Operator (TS_O)	Business	Elaborate network development plan (including defining system needs for transmission) Ensure a transparent and non-discriminatory access to the transmission network for each user Operate the transmission grid over a specific region in a secure, reliable and efficient way Secure and manage in real time the physical generation-consumption balance on a geographical perimeter, including ensuring the frequency control service Optimize transmission system operation from planning to real-time, using available levers (grid expansion, flexibility activation,...) Assess network status of the transmission grid and broadcast selected information of the network status to eligible actors (e.g. aggregators, other system operators) Provide data to the interconnection capacity market	

		operator for the management of cross border transactions In critical situations, implement dedicated actions and deliver alerts during stress events If necessary, implement emergency measures (e.g. system defence plan) including load shedding	

3.2 REFERENCES

4. STEP BY STEP ANALYSIS OF USE CASE

4.1 OVERVIEW OF SCENARIOS

Scenario conditions						
No.	***Scenario name***	***Scenario description***	***Primary actor***	***Triggering event***	***Pre-condition***	***Post-condition***
1	Prequalification	- The aggregator gets access to the flexibility of the various resources (by owning them itself or by agreement with the resources operators and/or owners as described in the prerequisites. - The aggregator registers itself as a reserves provider to the TSO, i.e. makes a mFRR/RR contract with the TSO. - The aggregator registers itself as a reserves provider to the actor responsible for its resources balance Optional: - The aggregator submits an offer on the capacity market. - The MO puts the offers in merit order and contracts the required amount of capacity. - On the day-ahead (before 1pm) as well as during the delivery day, at least the contracted capacity is required to be submitted as bids to the mFRR/RR market (in the bidding phase).				
2	Selection/Bidding	- The resources/resource operators send their schedule for the following day and following hours based on the results of the day-ahead and intra-day market and their estimated availability (optional) - All the market participants, except the TSO, assess their availability and create their bids (Power MW, price €/MWh, production/consumption, transmission				

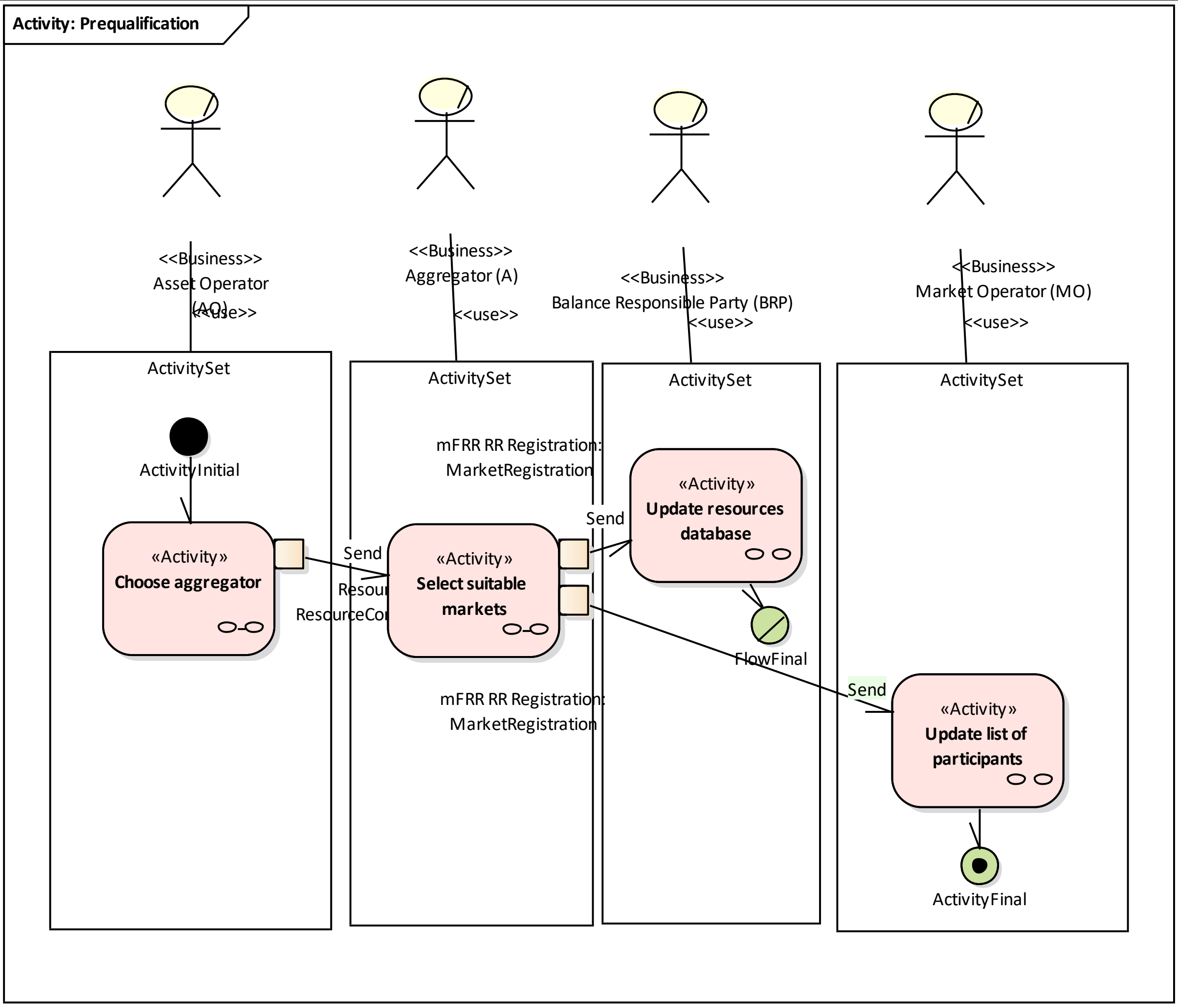
		area, type of resource). - The MO ranks put the bids in merit order, based on their price. - The MO provides the list of bids to the TSO after the gate closure.				
3	Delivery	- A stable frequency deviation is measured by the TSO. - The TSO calculates the volume of reserves that needs to be activated. - The TSO sends the orders for activation to the bidders (aggregators) based on the merit order and the needed volume. - The aggregators relay the activation order to the resource (G, C and S) operators. - The resource operators realize the product delivery. The full activation needs to be achieved within 15 minutes of the reception of the TSO signal.				
4	Settlement	- The delivery is measured and assessed at the same time as the resource provider's energy balance. - If the aggregator had been selected previously on the capacity market, a pay-as-bid capacity fee is added. - If the aggregator is its own BRP, the payment is added/removed in the regular balancing fees and paid through the same channels. Otherwise the TSO sends a bill to the aggregator within 6 weeks of the delivery, to be paid 2 weeks after reception.				

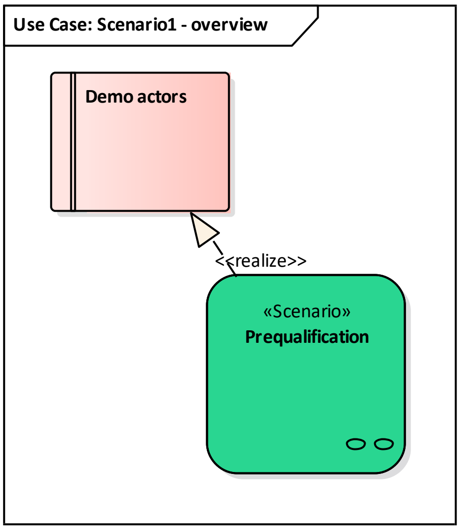
4.2 STEPS - SCENARIOS

4.2.1 PREQUALIFICATION

- The aggregator gets access to the flexibility of the various resources (by owning them itself or by agreement with the resources operators and/or owners as described in the prerequisites.
- The aggregator registers itself as a reserves provider to the TSO, i.e. makes a mFRR/RR contract with the TSO.
- The aggregator registers itself as a reserves provider to the actor responsible for its resources balance

Optional:
- The aggregator submits an offer on the capacity market.
- The MO puts the offers in merit order and contracts the required amount of capacity.
- On the day-ahead (before 1pm) as well as during the delivery day, at least the contracted capacity is required to be submitted as bids to the mFRR/RR market (in the bidding phase).





Scenario step by step analysis

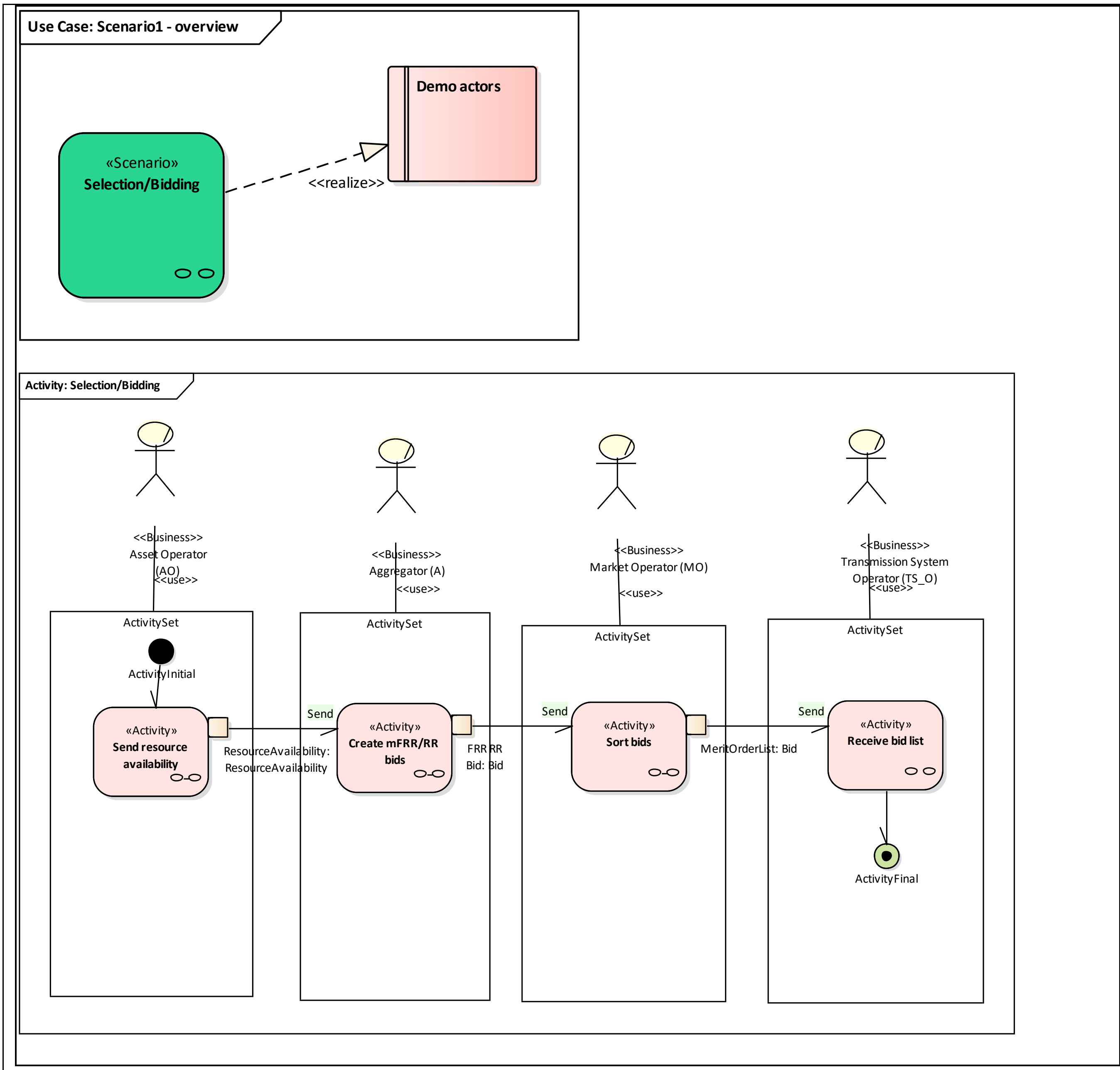
Scenario

Scenario name	Prequalification							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
1.1		Choose aggregator	The asset operator, with the permission of the owner, chooses an aggregator and give them the possibility, technically and contractually, to use their resources for this use case.	Send	Asset Operator (AO)	Aggregator (A)	Info1-ResourceControlInformation	
1.2		Select suitable markets	Taking into account the resources it has access to, the aggregator selects the markets they choose to participate to.	Send	Aggregator (A)	Balance Responsible Party (BRP)	Info2-MarketRegistration	
1.3		Select suitable markets	Taking into account the resources it has access to, the aggregator selects the markets they choose to participate to.	Send	Aggregator (A)	Market Operator (MO)	Info2-MarketRegistration	

1.4		Update resources database	The BRP updates the status of the resources it is responsible for in its database.		Balance Responsible Party (BRP)				
1.5		Update list of participants	Add, remove or modify the information about the actors participating to a specific market.		Market Operator (MO)				

4.2.2 SELECTION/BIDDING

- The resources/resource operators send their schedule for the following day and following hours based on the results of the day-ahead and intra-day market and their estimated availability (optional)
- All the market participants, except the TSO, assess their availability and create their bids (Power MW, price €/MWh, production/consumption, transmission area, type of resource).
- The MO ranks put the bids in merit order, based on their price.
- The MO provides the list of bids to the TSO after the gate closure.



Scenario step by step analysis

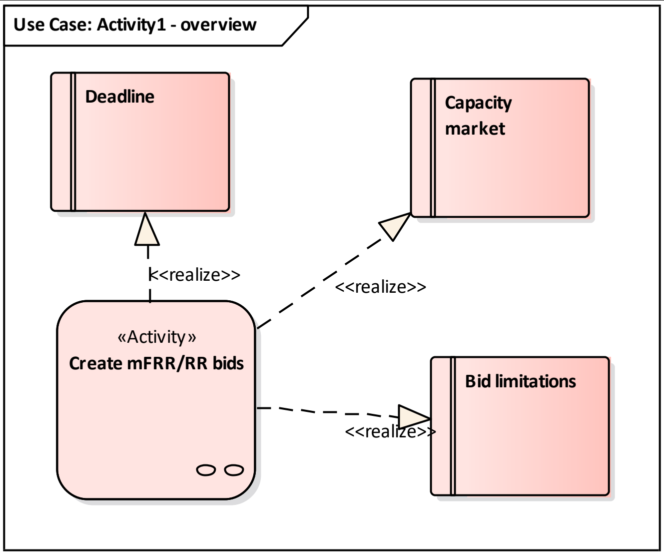
Scenario								
Scenario name	Selection/Bidding							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
2.1		Send resource availability	Based on its own forecasts the asset	Send	Asset Operator (AO)	Aggregator (A)	Info3-ResourceAvailability	

			operator calculates the availability of its resources for the upcoming mFRR/RR market.					
2.2		Create mFRR/RR bids	The aggregator creates bids for the mFRR/RR market based on the forecasted availability of the assets it can control.	Send	Aggregator (A)	Market Operator (MO)	Info4-Bid	Cat2.Req3, Cat3.Req4, Cat4.Req5
2.3		Sort bids	The MO sorts the bids in price order.	Send	Market Operator (MO)	Transmission System Operator (TS_O)	Info4-Bid	
2.4		Receive bid list	The TS_O receives a sorted list of bids for each control zone and for each time period.		Transmission System Operator (TS_O)			

- 2.2. Create mFRR/RR bids

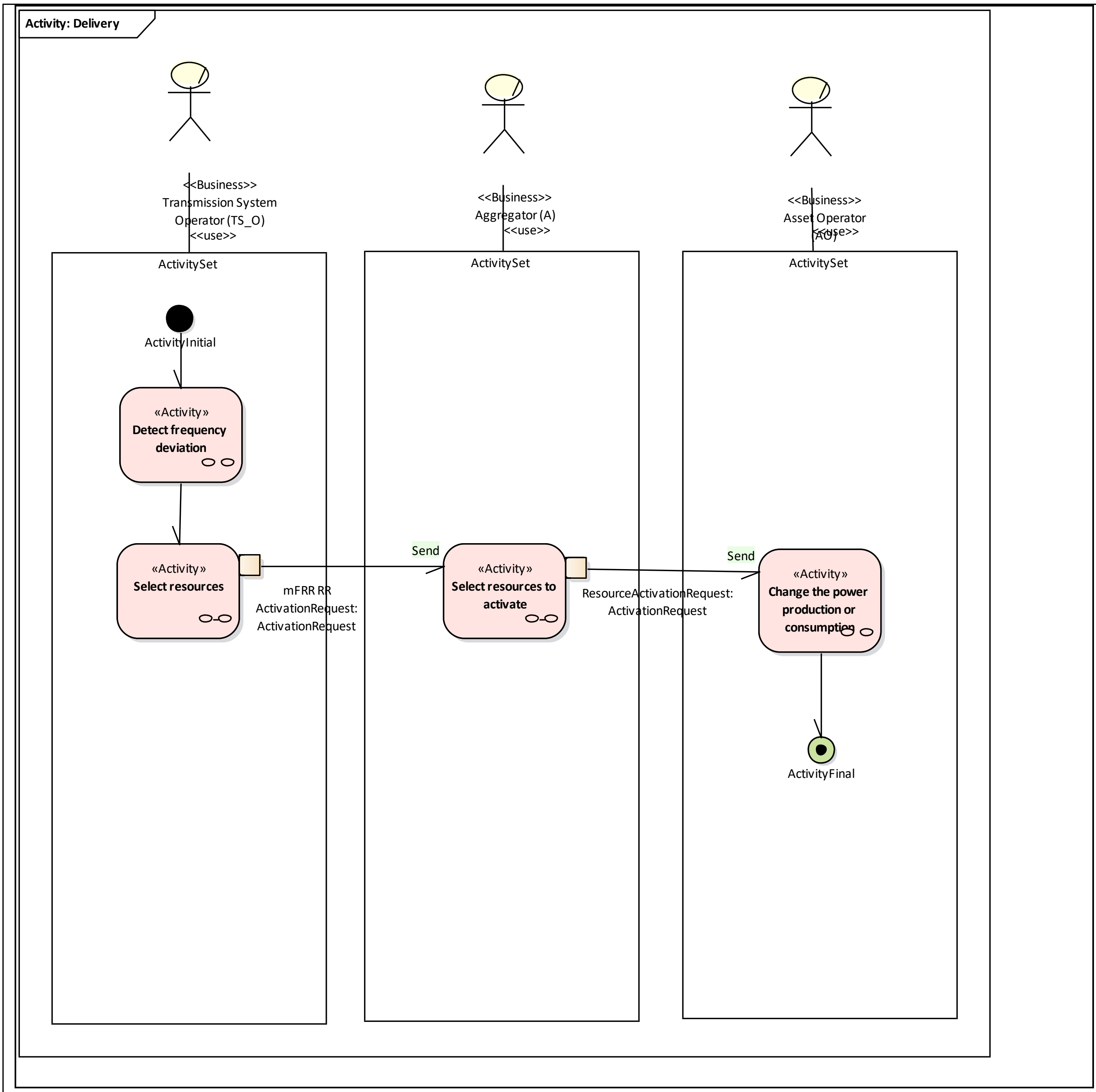
Business section: Selection/Bidding/Create mFRR/RR bids

The aggregator creates bids for the mFRR/RR market based on the forecasted availability of the assets it can control.



4.2.3 DELIVERY

- A stable frequency deviation is measured by the TSO.
- The TSO calculates the volume of reserves that needs to be activated.
- The TSO sends the orders for activation to the bidders (aggregators) based on the merit order and the needed volume.
- The aggregators relay the activation order to the resource (G, C and S) operators.
- The resource operators realize the product delivery. The full activation needs to be achieved within 15 minutes of the reception of the TSO signal.



Scenario step by step analysis

Scenario								
Scenario name	Delivery							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***

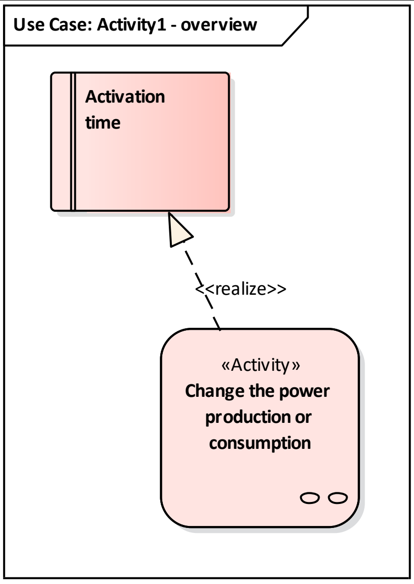
3.1		Detect frequency deviation	The TS_O detects a sustained frequency deviation and determines a need to activate mFRR/RR resources to restore the frequency to the desired level.		Transmission System Operator (TS_O)				
3.2		Select resources	Based on the merit order list from the bidding phase, the TS_O determines which aggregators should be contacted to provide mFRR/RR products.	Send	Transmission System Operator (TS_O)	Aggregator (A)	Info5-ActivationRequest		
3.3		Select resources to activate	The aggregator receives a request for activation of its resources. It can allocate the activation signals to the different assets based on updated forecasts.	Send	Aggregator (A)	Asset Operator (AO)	Info5-ActivationRequest		

3.4		Change the power production or consumption	Change the production or consumption of the units according to the received request and the resources availability.		Asset Operator (AO)		Info6-RawMeteredPower	Cat2.Req6

- 3.4. Change the power production or consumption

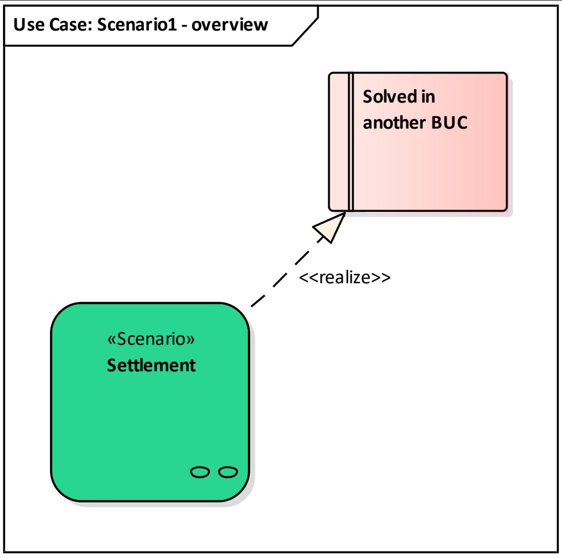
Business section: Delivery/Change the power production or consumption

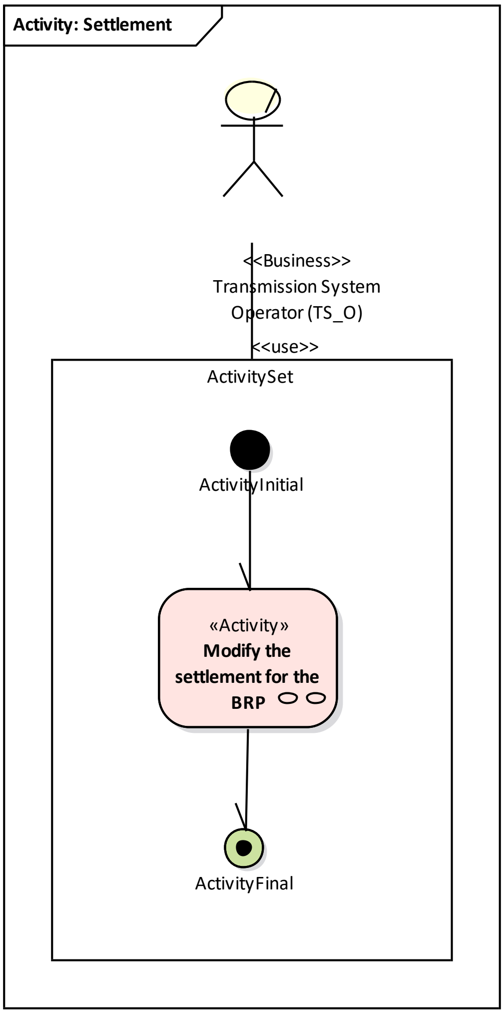
Change the production or consumption of the units according to the received request and the resources availability.



4.2.4 SETTLEMENT

- The delivery is measured and assessed at the same time as the resource provider's energy balance.
- If the aggregator had been selected previously on the capacity market, a pay-as-bid capacity fee is added.
- If the aggregator is its own BRP, the payment is added/removed in the regular balancing fees and paid through the same channels. Otherwise the TSO sends a bill to the aggregator within 6 weeks of the delivery, to be paid 2 weeks after reception.





Scenario step by step analysis

Scenario

Scenario name	Settlement							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
4.1		Modify the settlement for the BRP	The settlement from the FRR market is added or removed from the balancing fees incurred by the BRP. The billing itself is made through the usual channels and is out of the scope of this BUC.		Transmission System Operator (TS O)			

5. INFORMATION EXCHANGED

Information exchanged			
Information exchanged, ID	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
Info1	ResourceControlInformation	Information needed for a market actor to evaluate and activate flexible resources. It may include the following pieces of information: - Location of the resource on the network - Information on how to communicate with the devices: address, protocols, possible inputs and outputs, etc. - Technical capabilities - Remuneration scheme and price	
Info2	MarketRegistration	The market participant registers as such to the market operator. This is accomplished by signing the appropriate contracts, establishing the communication links and possibly creating the required accounts on the online trading platform.	
Info3	ResourceAvailability	Availability of the resources to be used during the required time period: - Time interval - Resource ID - Normal state of the resource (MW or kva if no signal is exchanged)	

		- Capacities up and down with their associated prices: MW and €/MW or kva and €/kva	
Info4	Bid	It should include the following information: • Bid ID • Product name • Aggregator ID • Capacity (MW) • Activation price (€/MW,h) • Hour	
Info5	ActivationRequest	The aggregator or resource operator receives a signal to activate resources that had been previously committed. It should include: - ID of the service - ID of the aggregator or resources - Volume - Time	
Info6	RawMeteredPower	- ID - Time interval - Active power produced or consumed	

6. REQUIREMENTS (OPTIONAL)

Requirements (optional)		
Categories ID	***Category name for requirements***	***Category description***
Cat1	Roles and actors	Precision, in the context of the demo, of actors assuming several roles.
Requirement R-ID	***Requirement name***	***Requirement description***
Req1	Demo actors	In the case of the demo: - The A and the asset operator are the same stakeholder - The TSO and the MO are the same stakeholder - The DSO is involved in the operation of some assets (by providing the control signals and interface to the heating loads controlled through the AMR)
Req2	Demo actors	In the case of the demo: - The A is also the asset operator - The TSO is also the MO

Requirements (optional)		
Categories ID	***Category name for requirements***	***Category description***
Cat2	Deadlines	Requirements related to deadlines and timing of information exchanges.
Requirement R-ID	***Requirement name***	***Requirement description***

Req3	Deadline	The bids must be submitted more than 45 min before the time of the delivery.
Req6	Activation time	The change in resource production/consumption has to be effective within 15 minutes of the reception by the aggregator of the activation signal from the TSO.
Requirements (optional)		
Categories ID	***Category name for requirements***	***Category description***
Cat3	Out of scope	Inputs or organization aspects that are taken care of in other use cases and out of the scope of these BUC.
Requirement R-ID	***Requirement name***	***Requirement description***
Req4	Capacity market	Accepted bids on the optional capacity market give a minimum power that the aggregator needs to bid at the agreed times.
Req7	Solved in another BUC	Based on the measurements approved by the MDO, the settlement is included in the BRP's balance and the money is exchanged along with the rest of the balancing fees. It is thus part of the balancing BUC (not in the scope of this project) and this is why we do not develop this phase in this BUC.
Requirements (optional)		
Categories ID	***Category name for requirements***	***Category description***
Cat4	Value limitations	Bounds and granularity of the possible values that can be assigned to information items.
Requirement R-ID	***Requirement name***	***Requirement description***
Req5	Bid limitations	- Bid size is at least 5MW for electronically controlled devices, 10Mw otherwise. - Bid precision is 1MW. - Up-regulation has a price limit of 5000 € /MWh

TABLE 7 BUC FI-AP2

Manage reactive power flexibility to support voltage control in the Finnish demo

Based on IEC 62559-2 edition 1
Generated from UML Use Case Repository with Modsarus® (EDF R&D Tool)

1. DESCRIPTION OF THE USE CASE

1.1 NAME OF USE CASE

Use case identification		
ID	***Area(s)/Domain(s)/Zone(s)***	***Name of use case***
FI-RP	Finland	Manage reactive power flexibility to support voltage control in the Finnish demo

1.2 VERSION MANAGEMENT

Version management				
Version No.	***Date***	***Name of author(s)***	***Changes***	***Approval status***
1	2018-05-31	Corentin Evens	Proposed version from demo	
2	2018-06-11	Cyril Effantin	Consolidation in a common UC repository	
3	2018-06-26	Corentin Evens	Modifications from June review	
4	2018-08-02	Cyril Effantin	UML fixes	
5	2018-10-25	Cyril Effantin	Updates on role model and UML use case impacted parts	

1.3 SCOPE AND OBJECTIVES OF USE CASE

Scope and objectives of use case	
Scope	Creation of a new market for reactive power at the distribution level. The market is operated by the DSO and would be open to all the resources connected to the network which satisfy to the requirements. In the demonstration however, only one aggregator will be participating to the market.
Objective(s)	Avoid penalties : The DSO wants to avoid penalties for reactive power exchanges being outside of the allowed PQ-window determined by the TSO Increase revenue: The Aggregator wishes to increase the revenue it gets from operating its resources by providing reactive power services to the DSO
Related business case(s)	Voltage Control

1.4 NARRATIVE OF USE CASE

Narrative of use case
Short description

<u>Need:</u> The TSO gives a reactive to active power window (PQ-window) to each DSO. Deviations from the window cause the DSO to pay extra fees. The DSO needs resources with reactive power control capabilities to help in avoiding those costs. **<u>Service:</u>** Helen, acting as a flexibility aggregator wishes to increase the revenue generated by providing reactive power from their PV plant and from their medium scale battery system (BESS). Helen-SV, acting as DSO sets up a bilateral contracts system and completes it with a monthly reactive power capacity market.
Complete description
<u>Prequalification phase:</u> - All the resource operators wishing to participate have registered themselves to the Flexibility Aggregator. - The aggregator gets access to the flexibility of the various resources (by owning them itself or by agreement). - The aggregator registers itself as a reserves provider to the market operator. - The Flexibility aggregator runs a performance test required by the DSO. In addition, the DSO analyses the local applicability of the local resources and states approvements of them. Only after that the flexibility resource can be registered to the market. - If they choose to do so, the aggregator and the DSO sign a bilateral contract for long-term reserves provision. **<u>Bidding:</u>** - The Asset Operators send the schedule for the availability of their resources for the following month. This is done every 15. day of the month. The data should cover the next month. The data is hourly based data. - The aggregators assess the availability of the flexible resources and create their bids for the following month to the Market Operator. This is done every 15. day of the month. The bid should cover the next month. - The bid size must be between x? to xx? kvar (TBD?). The precision of a bid is xxx? kvar (TBD?) - The DSO sends demands of the next month for the Market Operator. This is done every 15. day of the month for the next month. The demand from the DSO and is based on their estimates and forecasts for parts of their network. - The MO determines the resources that should reserve the capacity from their bid based on the offer bids and the demand from the DSO, selecting the cheapest offers first. As a result of the monthly market clearing, approved bids are informed to the Flexibity Aggregator. ***<u>Delivery phase:</u>*** - Based on the schedule resulting from the market and on their resource availability, the flexibility aggregator dispatches the control to their different resources.

Settlement phase:

- The aggregator sends the invoicing data to the DSO. It should include the unit-specific hourly reactive power provided.
- The DSO computes how much the different aggregators should pay or receive for the RPM operations and include it with the rest of the network connection fees.

Summary of use case

- **Prequalification**
  Description:
  - Wish for bilateral agreement
    Description: The DS_O assesses its future needs for reactive power and decides if it wishes to contact resources providers and ask them if they would be interested in a bilateral contract. This step is optional. The aggregators can also express their interest and suggest the contract themselves.
  - Initiate bilateral agreement
    Description: The aggregator takes the decision to initiate the bilateral contract process. This decision can be prompted by a request from the DS_O, but it can also be started directly by the Aggregator.
  - Bilateral agreement evaluation
    Description: The DS_O takes into consideration its needs, its existing bilateral contracts and the suggestion from the aggregator and decides if the offer should be included in its portfolio. If the DS_O had sent an interest request and if the contract request matches it, the contract should be accepted right away.
  - Performance test
    Description:
  - Update resource database
    Description: The DS_O updates the database of resources that can be used for reactive power control provision
- **Selection/Bidding**
  Description:
  - Set PQ-windows
    Description: The TS_O sets the PQ window values for the following month and sends them to the DS_O.
  - Send resource availability
    Description: The asset operator determines its resources availability for this market during the considered time period (the following month)

- Create bid
  Description: The aggregator creates bids based on the availability of the resources it has access to.

- Wait for market gate closure
  Description: The market operator collects the bids, asaves them and pre-processes them until the gate closure

- Send bilateral contract information
  Description: The DS_O informs the MO of the status of the running bilateral contracts

- Send needs for reactive power
  Description: The DS_O asesses how much reactive power is needed for the following month.

- Do market clearing
  Description: The MO clears the market based on the bids, the needs and the existing bilateral contracts. The results are the accepted and rejected bids as well as the bilateral contracts that are not needed and will be disactivated for the following month.

- Do market clearing
  Description: The MO clears the market based on the bids, the needs and the existing bilateral contracts. The results are the accepted and rejected bids as well as the bilateral contracts that are not needed and will be disactivated for the following month.

- Disable bilateral contracts
  Description: As a result of the market clearing, some bilateral contracts for the following month are not to be used. The DS_O registers which ones and informs the concerned aggregators.

- Register market results
  Description: The aggregator registers the expected reactive power exchanges for the month cleared by the market.

- **Delivery**
  Description: This phase is still under discussion.

  - Forecast assets availability
    Description: The forecasts for the availability of the resources is updated on a regular basis or when new weather information is received.

  - Dispatch reactive power
    Description: The aggregator has the reactive power production and consumption schedules from the RPM and the forecasted availability and prices for the different resources. It can dispatch the required exchanges between the different resources.

  - Update schedules
    Description: The asset operator changes the schedule of its resources in order to produce or consume the expected reactive power at the right times.

  - Measure reactive power exchanges
    Description: The physical exchanges of reactive power take place and are measured.

  - Certify the data
    Description: The MDO certifies the measurement data

- Measurement data aggregation
  Description: The aggregator gathers the certified measurement data.
- **Settlement**
  Description:
  - Aggregate measurement data for invoicing
    Description: The aggregator prepares the measurement data for the invoice and sends it to the DS_O
  - Calculate payment
    Description: The DS_O calculates the payment or the fee for the aggregator's reactive power production and consumption.

    The result is added or removed from the aggregator's connection fees.
  - Prepare the invoice
    Description: An invoice is sent to the aggregator.
  - Prepare the payment
    Description: The payment amount is computed and sent to the aggregator.

1.5 KEY PERFORMANCE INDICATORS (KPI)

1.6 USE CASE CONDITIONS

Use case conditions	
Assumptions	
1	rules relevant for the service (market & regulation): - Non-existing market. Its structure is likely to change significantly during its development. - The Balancing Power market (mFRR) is a continuous energy-based market. Bids can be submitted earliest one month in advance. Market closure is 45 minutes before the particular delivery hour and bids can be changed freely before that. After market closure the bids become binding for the bidder. - Some reserves providers may have previously committed themselves to provide down- or up-regulation on a mFRR power-based capacity market (which is an extension to the energy-based mFRR) . In that case they are bound to submit mFRR bids for the same time period they're participating the mRR capacity market. The energy mFRR bids linked to the capacity mFRR market must be submitted day-ahead before 1pm. - The activation and settlement are based on the energy provided, although the bids are made in the form of capacity. - The invoicing data must be sent by the providers to the TSO within 14 days of the delivery of the service. - In case the reserves provider is the same actor as the BRP, the invoicing is made directly in the balancing settlement.
2	limitations due to the regulatory and market environment: - Bids are to be submitted by the 15th of the previous month. - The bid size is yet to be defined according to the DSO needs

	- The precision of a bid is still to be defined. - Units from different balancing groups (G, C, S) can be aggregated
	Prerequisites
1	choices for the delivery of the service
2	Choices regarding the level of detail, the scope for the description of the BUC : - Single G, S and C acting directly on the market are considered to be their own Aggregator - The MO and the DSO is the same actor. The interactions with one or the other or among them may sometimes be slightly inaccurate. - The BESS is owned by the aggregator (demo specific). - The aggregator, the retailer and the asset operator are the same actor (demo specific)

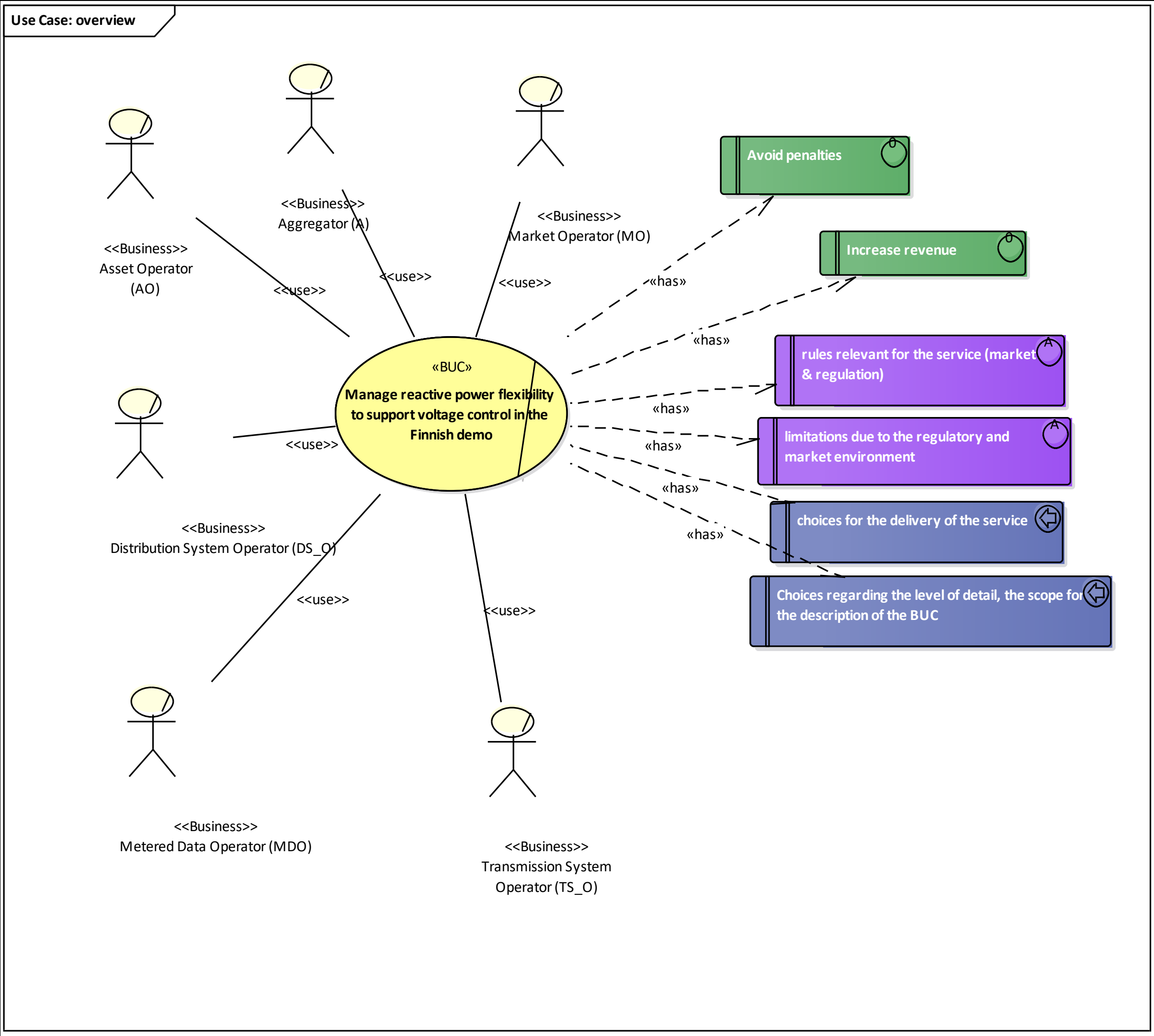
1.7 FURTHER INFORMATION TO THE USE CASE FOR CLASSIFICATION/MAPPING

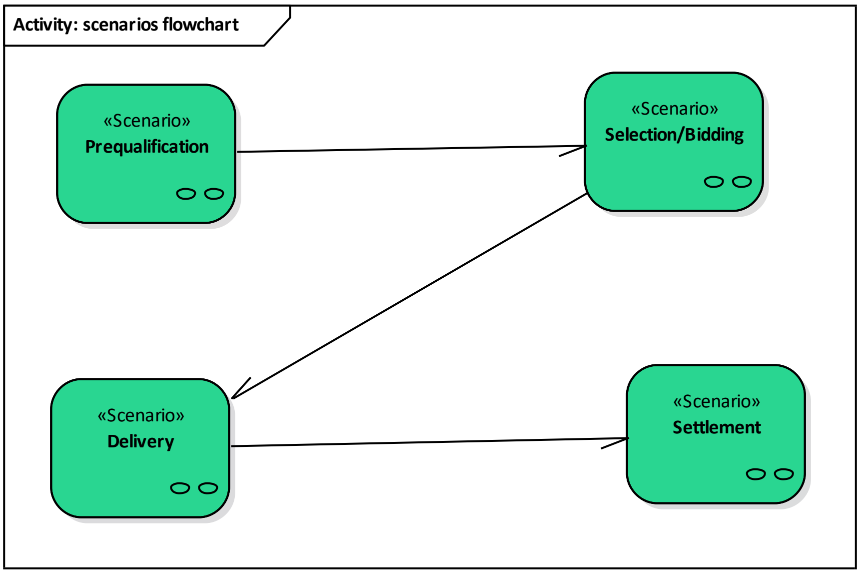
Classification information
Relation to other use cases
Level of depth
BUC for Finland EuSysFlex Demo WP6
Prioritisation
Generic, regional or national relation
Regional, DSO level (Helen-SV)
Nature of the use case
BUC
Further keywords for classification

1.8 GENERAL REMARKS

2. DIAGRAMS OF USE CASE

Diagram(s) of use case


Use Case: overview
<<Business>>
Asset Operator
(AO)
<<Business>>
Aggregator (A)
<<Business>>
Market Operator (MO)
<<use>>
<<use>>
<<use>>
«has»
«has»
Avoid penalties
Increase revenue
«BUC»
Manage reactive power flexibility to support voltage control in the Finnish demo
rules relevant for the service (market & regulation)
limitations due to the regulatory and market environment
choices for the delivery of the service
Choices regarding the level of detail, the scope for the description of the BUC
«has»
«has»
«has»
«has»
<<use>>
<<Business>>
Distribution System Operator (DS_O)
<<use>>
<<use>>
<<Business>>
Metered Data Operator (MDO)
<<Business>>
Transmission System
Operator (TS_O)


Activity: scenarios flowchart
«Scenario»
Prequalification
«Scenario»
Selection/Bidding
«Scenario»
Delivery
«Scenario»
Settlement

3. TECHNICAL DETAILS

3.1 ACTORS

Actors			
Grouping (e.g. domains, zones)		*Group description*	
Actor name	*Actor type*	*Actor description*	*Further information specific to this use case*
Metered Data Operator (MDO)	Business	Provide metered data to authorized users in a transparent and non-discriminatory manner	
Distribution System Operator (DS_O)	Business	Elaborate network development plan (including defining system needs for distribution) Ensure a transparent and non-discriminatory access to the distribution network for each user Operate the distribution grid over a specific region in a secure, reliable and efficient way Optimize system operation distribution grid from planning to real-time, using available levers (grid expansion, flexibility activation,...) Assess network status of the distribution grid and broadcast selected information of the network status to eligible actors (e.g. aggregators, other system operators) Support the Transmission System Operator in carrying out its responsibilities (including load shedding) and coordinate measures if necessary	
Aggregator (A)	Business	Aggregate and maximise value of portfolio(s) of resources	
Market Operator (MO)	Business	Organize auctions (continuous auction, discrete auctions, call for tenders) between buyers and sellers of electricity-related products in the markets, and more generally publish the corresponding prices, for assets connected to transmission or distribution grid Manage/operate the platform for trading (where bids and offers are collected) Clear the market and communicate results	
Transmission System Operator (TS_O)	Business	Elaborate network development plan (including defining system needs for transmission) Ensure a transparent and non-discriminatory access to	

		the transmission network for each user Operate the transmission grid over a specific region in a secure, reliable and efficient way Secure and manage in real time the physical generation-consumption balance on a geographical perimeter, including ensuring the frequency control service Optimize transmission system operation from planning to real-time, using available levers (grid expansion, flexibility activation,...) Assess network status of the transmission grid and broadcast selected information of the network status to eligible actors (e.g. aggregators, other system operators) Provide data to the interconnection capacity market operator for the management of cross border transactions In critical situations, implement dedicated actions and deliver alerts during stress events If necessary, implement emergency measures (e.g. system defence plan) including load shedding	
Asset Operator (AO)	Business	Operate a set of assets connected to distribution grid which may cover consumption, storage or generation assets.	Includes Generation (G_O), Consumption (C_O) and Storage (S_O) Operators for clarity in some cases.

3.2 REFERENCES

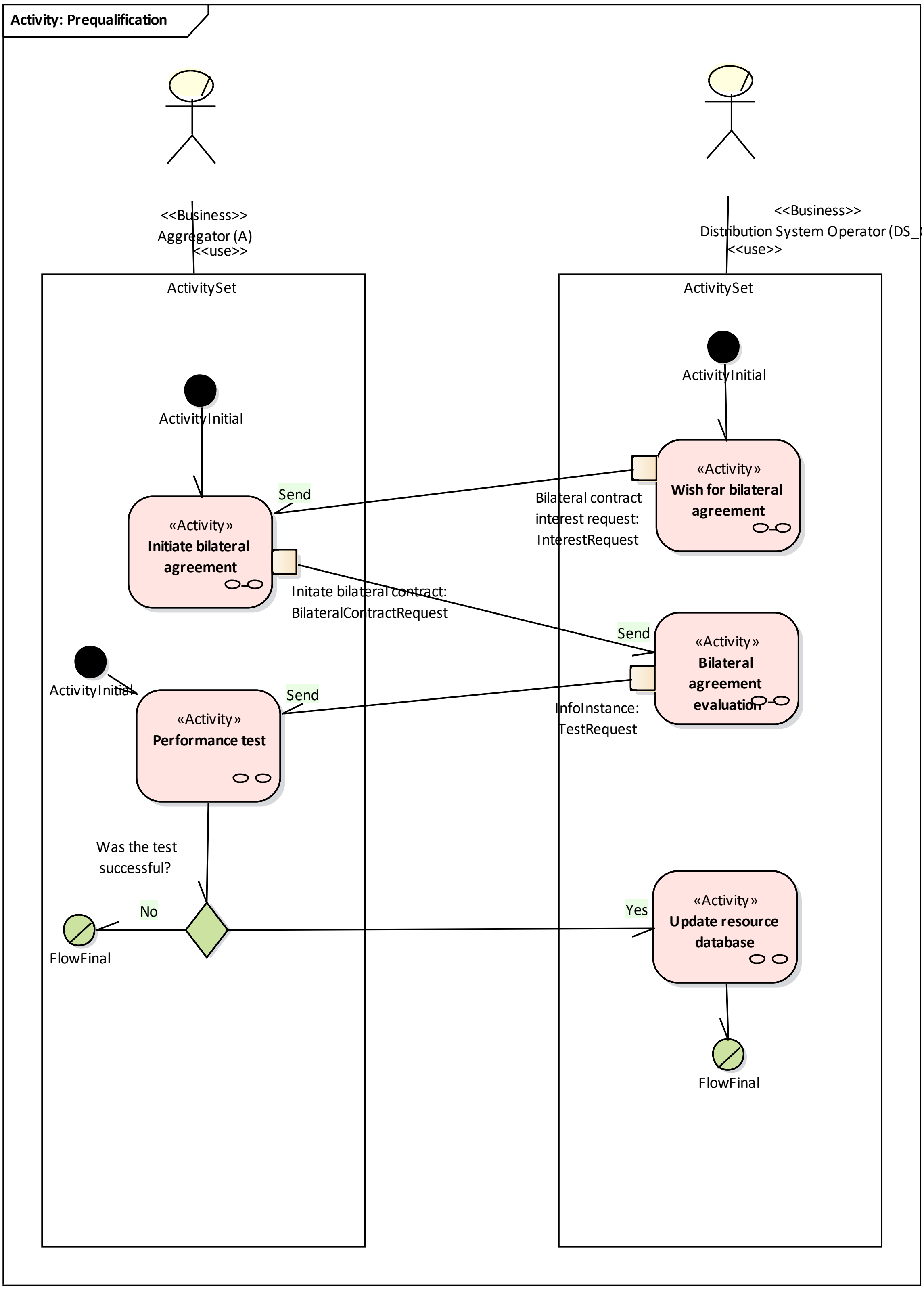
4. STEP BY STEP ANALYSIS OF USE CASE

4.1 OVERVIEW OF SCENARIOS

Scenario conditions						
No.	***Scenario name***	***Scenario description***	***Primary actor***	***Triggering event***	***Pre-condition***	***Post-condition***
1	Prequalification					
2	Selection/Bidding					
3	Delivery	This phase is still under discussion.				
4	Settlement					

4.2 STEPS - SCENARIOS

4.2.1 PREQUALIFICATION



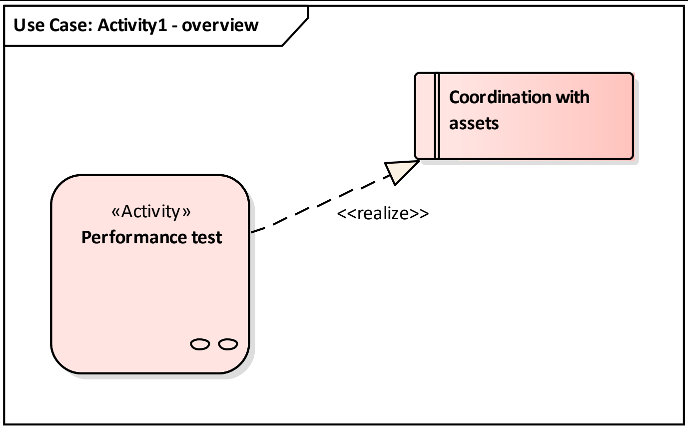
<u>Scenario step by step analysis</u>

Scenario								
Scenario name	Prequalification							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
1.1		Wish for bilateral agreement	The DS_O assesses its future needs for reactive power and decides if it wishes to contact resources providers and ask them if they would be interested in a bilateral contract. This step is optional. The aggregators can also express their interest and suggest the contract themselves.	Send	Distribution System Operator (DS_O)	Aggregator (A)	Info1-InterestRequest	
1.2		Initiate bilateral agreement	The aggregator takes the decision to initiate the bilateral contract process. This decision can be prompted by a	Send	Aggregator (A)	Distribution System Operator (DS_O)	Info2-BilateralContractRequest	

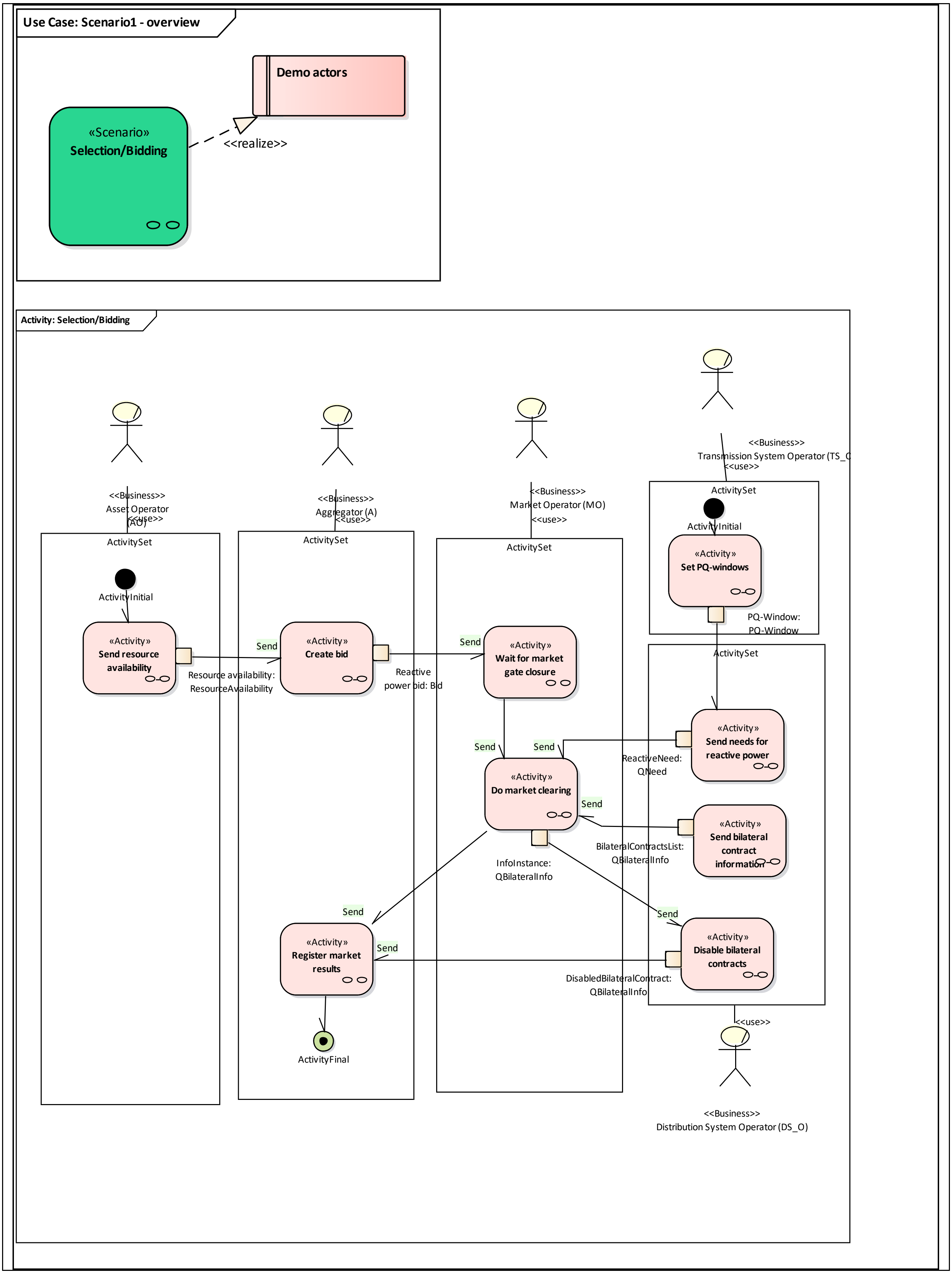
			request from the DS_O, but it can also be started directly by the Aggregator.					
1.3		Bilateral agreement evaluation	The DS_O takes into consideration its needs, its existing bilateral contracts and the suggestion from the aggregator and decides if the offer should be included in its portfolio. If the DS_O had sent an interest request and if the contract request matches it, the contract should be accepted right away.	Send	Distribution System Operator (DS_O)	Aggregator (A)	Info3-TestRequest	
1.4		Performance test			Aggregator (A)			Cat1.Req1
1.5		Update resource database	The DS_O updates the database of resources that can be used for reactive power control provision		Distribution System Operator (DS_O)			

- 1.4. Performance test

Business section: Prequalification/Performance test



4.2.2 SELECTION/BIDDING


Use Case: Scenario1 - overview
Demo actors
«Scenario»
Selection/Bidding
<<realize>>
Activity: Selection/Bidding
<<Business>>
Asset Operator (AO)
<<use>>
ActivitySet
ActivityInitial
«Activity»
Send resource availability
Resource availability: ResourceAvailability
<<Business>>
Aggregator (A)
<<use>>
Send
«Activity»
Create bid
Reactive power bid: Bid
<<Business>>
Market Operator (MO)
«Activity»
Wait for market gate closure
«Activity»
Do market clearing
InfoInstance: QBilateralInfo
<<Business>>
Transmission System Operator (TS_O
«Activity»
Set PQ-windows
PQ-Window: PQ-Window
«Activity»
Send needs for reactive power
ReactiveNeed: QNeed
«Activity»
Send bilateral contract information
BilateralContractsList: QBilateralInfo
«Activity»
Disable bilateral contracts
DisabledBilateralContract: QBilateralInfo
«Activity»
Register market results
ActivityFinal
<<Business>>
Distribution System Operator (DS_O)

Scenario step by step analysis

Scenario								
Scenario name	Selection/Bidding							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
2.1		Set PQ-windows	The TS_O sets the PQ window values for the following month and sends them to the DS_O.		Transmission System Operator (TS_O)	Distribution System Operator (DS_O)	Info4-PQ-Window	
2.2		Send resource availability	The asset operator determines its resources availability for this market during the considered time period (the following month)	Send	Asset Operator (AO)	Aggregator (A)	Info5-ResourceAvailability	
2.3		Create bid	The aggregator creates bids based on the availability of the resources it has access to.	Send	Aggregator (A)	Market Operator (MO)	Info6-Bid	
2.4		Wait for market gate closure	The market operator collects the bids, asaves them and pre-processes them		Market Operator (MO)			Cat3.Req3

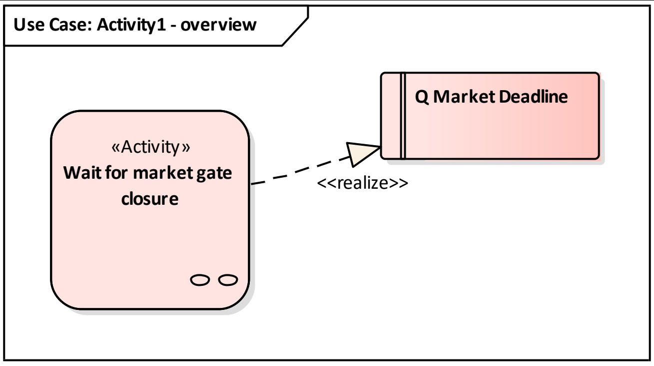
			until the gate closure					
2.5		Send bilateral contract information	The DS_O informs the MO of the status of the running bilateral contracts	Send	Distribution System Operator (DS_O)	Market Operator (MO)	Info7-QBilateralInfo	
2.6		Send needs for reactive power	The DS_O asesses how much reactive power is needed for the following month.	Send	Distribution System Operator (DS_O)	Market Operator (MO)	Info8-QNeed	
2.7		Do market clearing	The MO clears the market based on the bids, the needs and the existing bilateral contracts. The results are the accepted and rejected bids as well as the bilateral contracts that are not needed and will be disactivated for the following month.	Send	Market Operator (MO)	Distribution System Operator (DS_O)	Info7-QBilateralInfo	
2.8		Do market clearing	The MO clears the market based on the bids, the needs and the existing bilateral		Market Operator (MO)			

			contracts. The results are the accepted and rejected bids as well as the bilateral contracts that are not needed and will be disactivated for the following month.					
2.9		Disable bilateral contracts	As a result of the market clearing, some bilateral contracts for the following month are not to be used. The DS_O registers which ones and informs the concerned aggregators.	Send	Distribution System Operator (DS_O)	Aggregator (A)	Info7-QBilateralInfo	
2.10		Register market results	The aggregator registers the expected reactive power exchanges for the month cleared by the market.		Aggregator (A)			

- 2.4. Wait for market gate closure

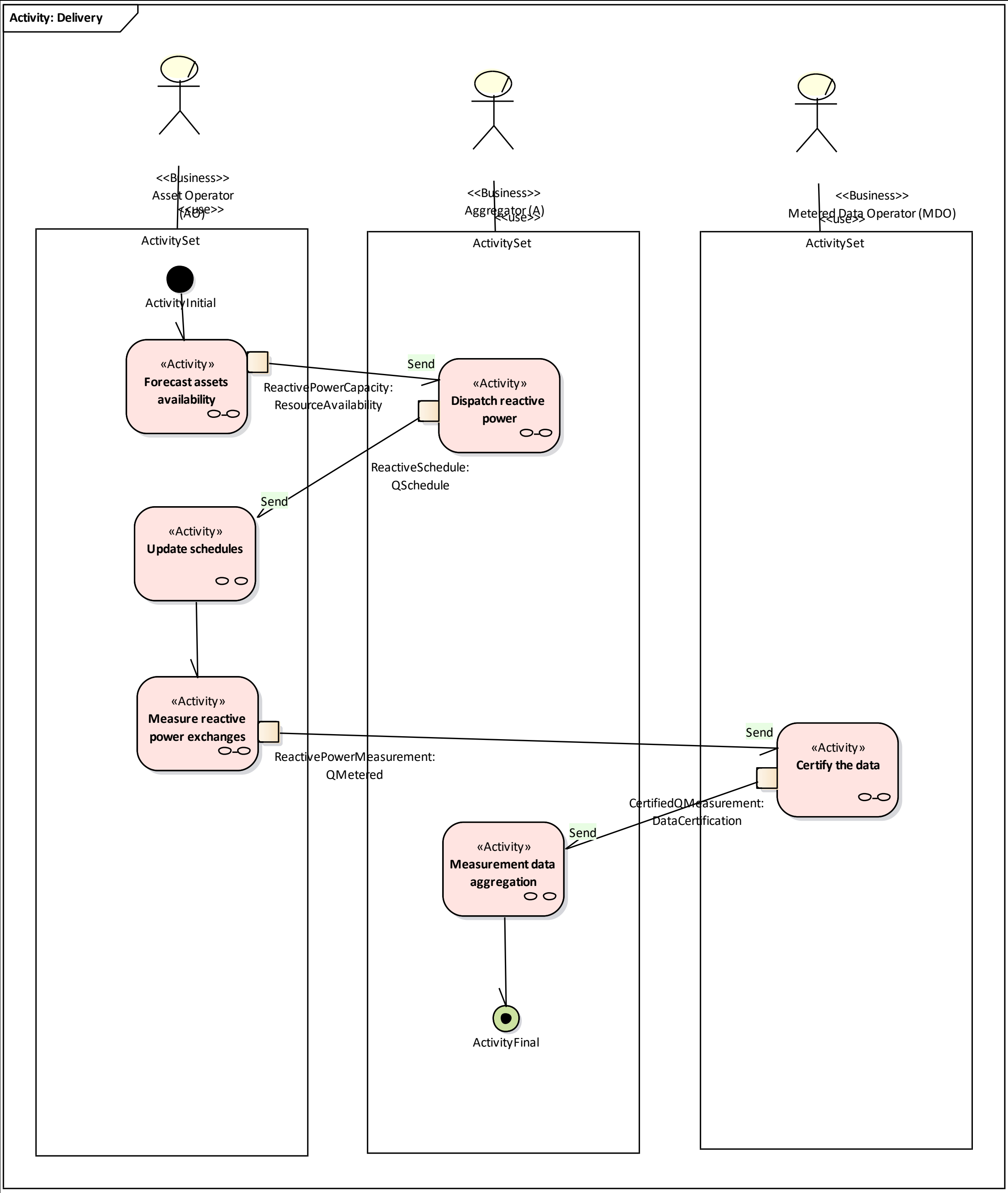
Business section: Selection/Bidding/Wait for market gate closure

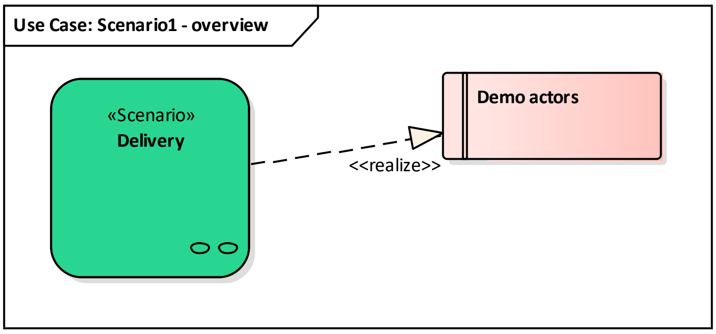
The market operator collects the bids, asaves them and pre-processes them until the gate closure



4.2.3 DELIVERY

This phase is still under discussion.


Activity: Delivery
<<Business>>
Asset Operator (AO)
<<use>>
<<Business>>
Aggregator (A)
<<use>>
<<Business>>
Metered Data Operator (MDO)
<<use>>
ActivitySet
ActivitySet
ActivitySet
ActivityInitial
«Activity»
Forecast assets availability
Send
ReactivePowerCapacity:
ResourceAvailability
«Activity»
Dispatch reactive power
ReactiveSchedule:
QSchedule
Send
«Activity»
Update schedules
«Activity»
Measure reactive power exchanges
ReactivePowerMeasurement:
QMetered
Send
«Activity»
Certify the data
CertifiedQMeasurement:
DataCertification
Send
«Activity»
Measurement data aggregation
ActivityFinal

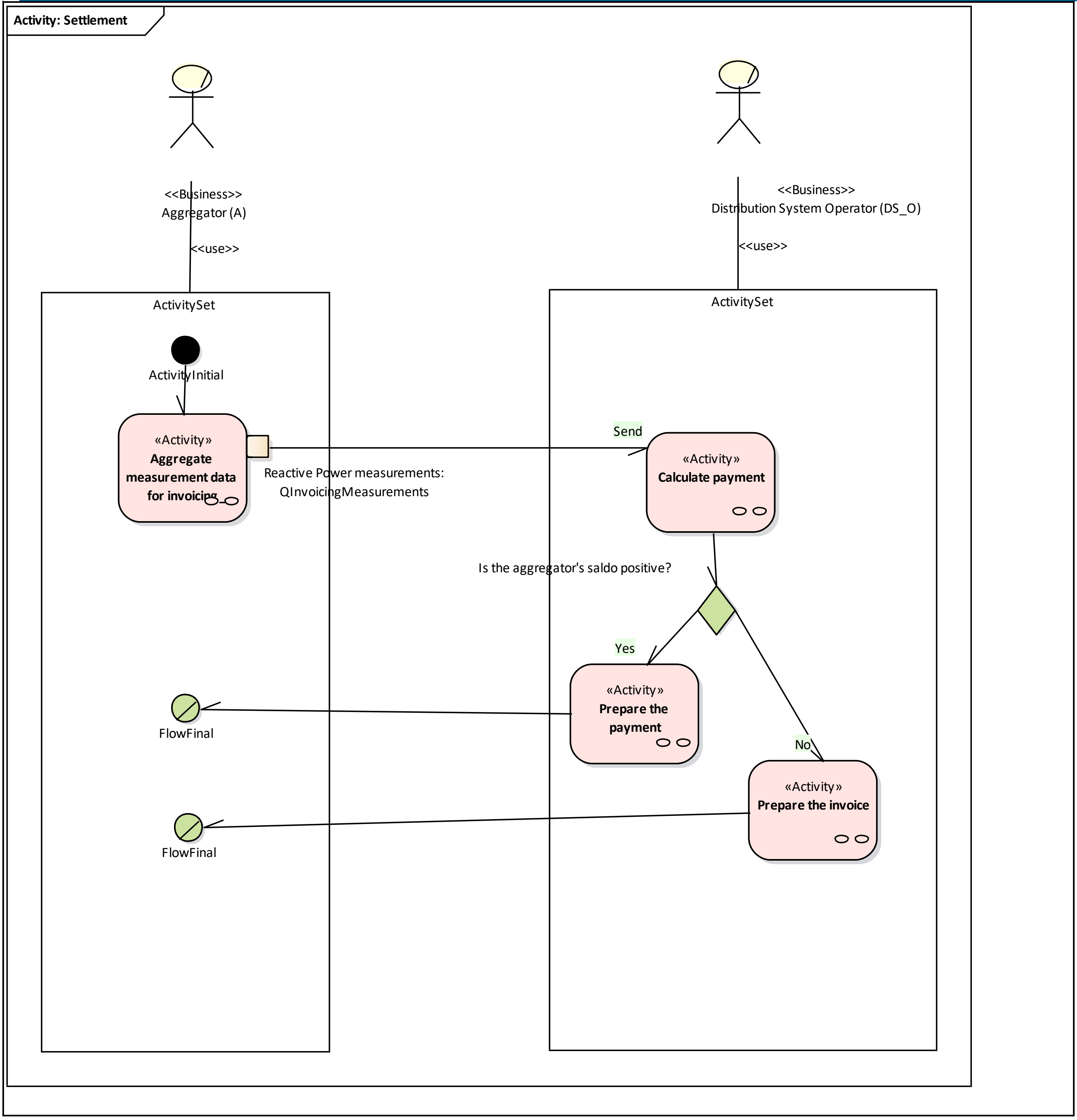

Use Case: Scenario1 - overview
«Scenario»
Delivery
<<realize>>
Demo actors

Scenario step by step analysis

Scenario								
Scenario name	Delivery							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
3.1		Forecast assets availability	The forecasts for the availability of the resources is updated on a regular basis or when new weather information is received.	Send	Asset Operator (AO)	Aggregator (A)	Info5-ResourceAvailability	
3.2		Dispatch reactive power	The aggregator has the reactive power production and consumption schedules from the RPM and the forecasted availability and prices for the different resources. It can dispatch the required exchanges between the different resources.	Send	Aggregator (A)	Asset Operator (AO)	Info9-QSchedule	

3.3		Update schedules	The asset operator changes the schedule of its resources in order to produce or consume the expected reactive power at the right times.		Asset Operator (AO)			
3.4		Measure reactive power exchanges	The physical exchanges of reactive power take place and are measured.	Send	Asset Operator (AO)	Metered Data Operator (MDO)	Info10-QMetered	
3.5		Certify the data	The MDO certifies the measurement data	Send	Metered Data Operator (MDO)	Aggregator (A)	Info11-DataCertification	
3.6		Measurement data aggregation	The aggregator gathers the certified measurement data.		Aggregator (A)			

4.2.4 SETTLEMENT



Scenario step by step analysis

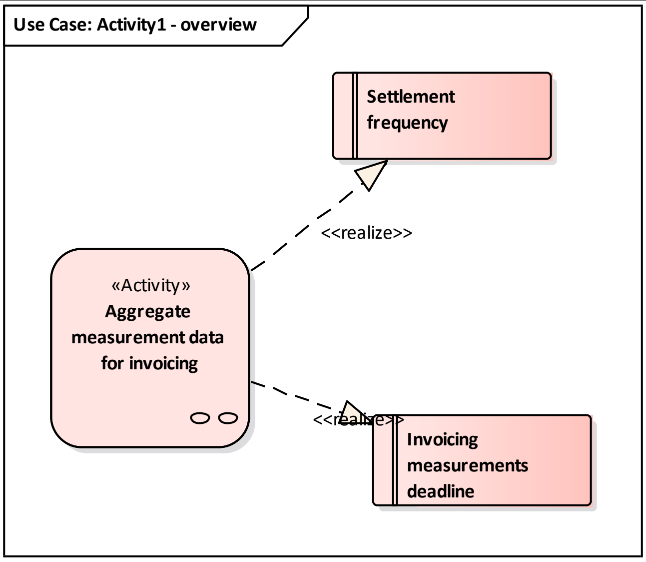
Scenario								
Scenario name	Settlement							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***

4.1		Aggregate measurement data for invoicing	The aggregator prepares the measurement data for the invoice and sends it to the DS_O	Send	Aggregator (A)	Distribution System Operator (DS_O)	Info12-QInvoicingMeasurements	Cat3.Req5, Cat3.Req6
4.2		Calculate payment	The DS_O calculates the payment or the fee for the aggregator's reactive power production and consumption. The result is added or removed from the aggregator's connection fees.		Distribution System Operator (DS_O)			Cat3.Req7
4.3		Prepare the invoice	An invoice is sent to the aggregator.		Distribution System Operator (DS_O)			
4.4		Prepare the payment	The payment amount is computed and sent to the aggregator.		Distribution System Operator (DS_O)			

- 4.1. Aggregate measurement data for invoicing

Business section: Settlement/Aggregate measurement data for invoicing

The aggregator prepares the measurement data for the invoice and sends it to the DS_O

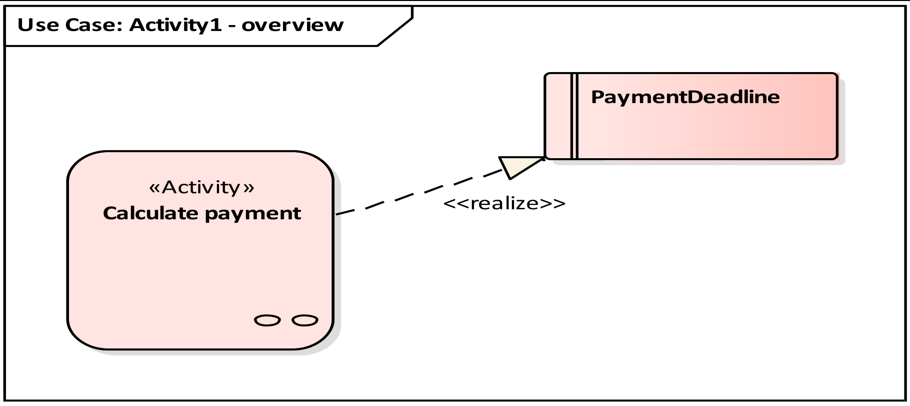


- 4.2. Calculate payment

Business section: Settlement/Calculate payment

The DS_O calculates the payment or the fee for the aggregator's reactive power production and consumption.

The result is added or removed from the aggregator's connection fees.



5. INFORMATION EXCHANGED

Information exchanged			
Information exchanged, ID	*Name of information*	*Description of information exchanged*	*Requirement, R-IDs*
Info1	InterestRequest	- Market ID or specifications - Deadline for response	
Info2	BilateralContractRequest	- Market or transaction ID - Specification of the assets	

Info3	TestRequest	An actor needing a service requests a potential provider to perform a test in order to prove its ability to provide the service.	
Info4	PQ-Window	Window including an area of the PQ-plane (active and reactive power plot) in which the DSO is allowed to operate. Deviations from this window will result in fees to be paid.	
Info5	ResourceAvailability	Availability of the resources to be used during the required time period: - Time interval - Resource ID - Normal state of the resource (MW or kva if no signal is exchanged) - Capacities up and down with their associated prices: MW and €/MW or kva and €/kva	
Info6	Bid	It should include the following information: • Bid ID • Product name • Aggregator ID • Capacity (MW) • Activation price (€/MW,h) • Hour	
Info7	QBilateralInfo	List of bilateral contracts for reactive power: - Contract ID - Aggregator ID - Market area - Time periods - Quantity (kvar) - Price (€/kvar)	
Info8	QNeed	- Market area - Time interval (or time of start) - Reactive power (kvar)	
Info9	QSchedule	Schedule for reactive power: - ID of the asset - Time interval - Reactive power production or consumption (kvar)	
Info10	QMetered	- ID - Time interval - Reactive power produced or consumed	
Info11	DataCertification	- Data ID - ID of the MDO - Certification status	
Info12	QInvoicingMeasurements	- ID of the units - Hourly average reactive power consumed or produced	

6. REQUIREMENTS (OPTIONAL)

Requirements (optional)		
Categories ID	***Category name for requirements***	***Category description***
Cat1	Out of scope	Inputs or organization aspects that are taken care of in other use cases and out of the scope of these BUC.
Requirement R-ID	***Requirement name***	***Requirement description***
Req1	Coordination with assets	The aggregator needs to activate and coordinate the resources behind the asset operator. The details of how it is done are not included here as it could vary based on the agreements with the asset operators and it is not the focus of this BUC.
Requirements (optional)		
Categories ID	***Category name for requirements***	***Category description***
Cat2	Roles and actors	Precision, in the context of the demo, of actors assuming several roles.
Requirement R-ID	***Requirement name***	***Requirement description***
Req2	Demo actors	In the case of the demo: - The DSO is the MO - The aggregator is the Asset Operator
Req4	Demo actors	The Aggregator and the asset operator is the same actor (demo specific)
Requirements (optional)		
Categories ID	***Category name for requirements***	***Category description***
Cat3	Deadlines	Requirements related to deadlines and timing of information exchanges.
Requirement R-ID	***Requirement name***	***Requirement description***
Req3	Q Market Deadline	The market closure happens on the 15th of the previous month.
Req5	Settlement frequency	The reactive power market results are settled once a month.
Req6	Invoicing measurements deadline	The measurement data must be sent at the latest on the 14th of the month following the delivery.
Req7	PaymentDeadline	The payment or invoice must be sent to the aggregator within 14 days of the reception of the measurement data.

TABLE 8 BUC FI-RP

Manage active power flexibility to support congestion management and voltage control in the German demo

Based on IEC 62559-2 edition 1
Generated from UML Use Case Repository with Modsarus® (EDF R&D Tool)

1. DESCRIPTION OF THE USE CASE

1.1 NAME OF USE CASE

Use case identification		
ID	***Area(s)/Domain(s)/Zone(s)***	***Name of use case***
DE-AP	Germany	Manage active power flexibility to support congestion management and voltage control in the German demo

1.2 VERSION MANAGEMENT

Version management				
Version No.	***Date***	***Name of author(s)***	***Changes***	***Approval status***
1	2017-11-12	MS	First draft	
2	2017-11-12	MS	Improvement of description	
3	2018-03-16	MS	Completion of process	
4	2018-04-27	MS, JB	Adding details for understanding	
5	2018-05-30	FD, LGT	Integration with EA and added scenarios with activities diagrams	
6	2018-06-04	JB	Proposed version from demo	
7	2018-06-11	Cyril Effantin	Consolidation in a common UC repository	
8	2018-06-20	JB	Editorial improvements	
9	2018-06-26	FD	Textual modifications, Images added	
10	2018-07-26	Cyril Effantin	Minor UML fixes.	

11	2018-10-22	Cyril Effantin	Changes in role model and UML related parts.	

1.3 SCOPE AND OBJECTIVES OF USE CASE

Scope and objectives of use case	
Scope	This use case will explain how active power flexibilities from distribution grids can be used to solve congestions in transmission grids, while respecting distribution grid constraints on the one hand and solving congestions in distribution grids on the other hand. The timing of this use case lasts from day ahead to intraday. Active power flexibilities are activated on the basis of schedules.
Objective(s)	• Reducing counteractions by TSOs and DSOs: Establishing a coordination process on a schedule basis to reduce counteractions. Therefore, frequency reserve activations by TSOs (caused by DSO's realtime curtailments) and DSO's counteractions (due to TSO's frequency reserve activation or ReDispatch) are reduced • Improving TSOs flexibility selection process: Offering further flexibility options for active power management to TSO by activating flexibilities in the distribution grid under consideration of sensitivities. Therefore, the TSO's congestion management costs can be reduced.
Related business case(s)	Voltage Control Congestion Management

1.4 NARRATIVE OF USE CASE

Narrative of use case
Short description
The BUC addresses the need of enhancing congestion management coordination between TSOs and DSOs in order to optimize the flexibility use regarding constraints in distribution and transmission grid and therefore reduce the overall system costs. Nowadays, TSOs and DSOs perform congestion management independently without a strong coordination mechanism. Therefore, flexibilities can be activated by TSOs in distribution grids in realtime, which can cause counteractions by the DSOs. Assets prequalified for frequency reserve are known to DSOs, but their contracted power for certain time periods is not. Additionally, RES are not included in todays planned day ahead ReDispatch process so that their curtailment can cause frequency reserve activations by TSOs. Therefore, this BUC describes the optimization of flexibility usage in distribution grids and aggregation of residual flexibilities for TSOs on a schedule basis in order to reduce total flexibility activation and thus system costs. In this BUC, the TSO uses different resources for active power management, such as flexibilities in the distribution grid. Generation units that have to indicate their available flexibility when submitting generation schedules day ahead to the DSO provide these flexibilities. These flexibilities are collected and transferred by the DSO to the TSO. The DSO will guarantee that no congestion in its distribution grid remains and no additional congestion in its distribution grid occurs when the TSO activates flexibilities for reactive and active power management or

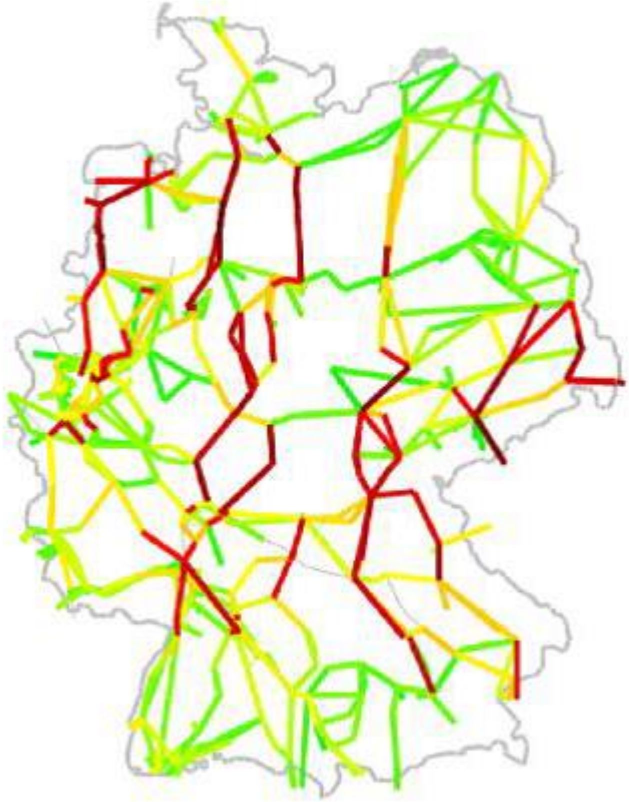
frequency reserve. The day ahead process will be continued in an intraday timeline to react on faults or forecast deviations.

The BUC for reactive power management is described separately although there are strong links in the technical part of the process. The used optimization algorithm uses active and reactive power at the same time based on prices/costs and effectiveness for congestion management or voltage control.

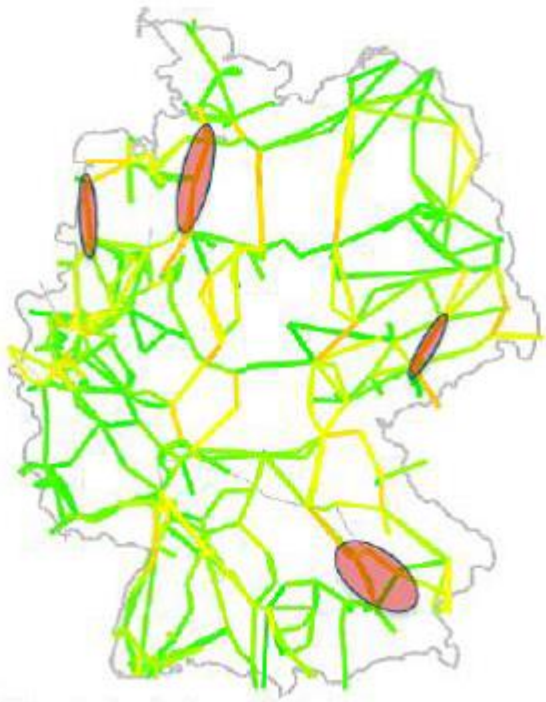
The main innovations of the BUC are:
· DSO improves knowledge of TSO about interdependencies between TSO/DSO grid interconnection points when using flexibilities in the distribution grid
· DSO receives day ahead schedules of generators (RES and conventional) connected to his grid
· DSO informs TSO about aggregated available active power flexibilities in distribution grid in day-ahead planning, considering grid asset utilization
· DSO updates information on available active power flexibilities in intraday planning
· DSO considers in own congestion management possible activation of frequency products directly contracted by TSO
· DSO ensures that no constraints are violated in distribution grid if TSO activates flexibilities in distribution grid
· DSO activates units if TSO wants to activate flexibilities in the distribution grid

Complete description

1. Problem statement
In 2030, an increasing share of RES is expected. This increasing share makes more efficient congestion management processes for both TSOs and DSOs necessary. Also today, events occur that cause congestions in the transmission and distribution grid. For example, the use of conventional power plants in distribution grids for reserve requirements (frequency control or frequency restoration) carried out by TSOs can cause congestions in the respective distribution grids. Therefore, if TSOs and DSOs do not coordinate their actions, DSOs must solve these kind of congestions by reducing e.g. the production of RES in the distribution grid, counteracting the action done by the TSO.
Due to the already high share of wind power in the northern and eastern part of Germany, substantial ReDispatch (schedule adjustments) measures are necessary. The first image shows grid congestions in the German transmission grid (red lines), if ReDispatch measures would not have been undertaken – meaning that generators would feed in as originally traded without intervention of system operators.



After performing Redispatch at transmission level, there are still some lines with more than 100% use of capacity (red bubbles). If RES in distribution grids could be used, the load on each line would be lower than 100%. If the load is under 65%, the n-1 criteria will always be assured. The following BUC is designed to use all possible generator flexibilities in the distribution grid in order to solve congestions in the transmission and distribution grid in the most cost-efficient way. However, in the demonstration phase, the focus will be on RES as most probable reason of congestions in the testing area.



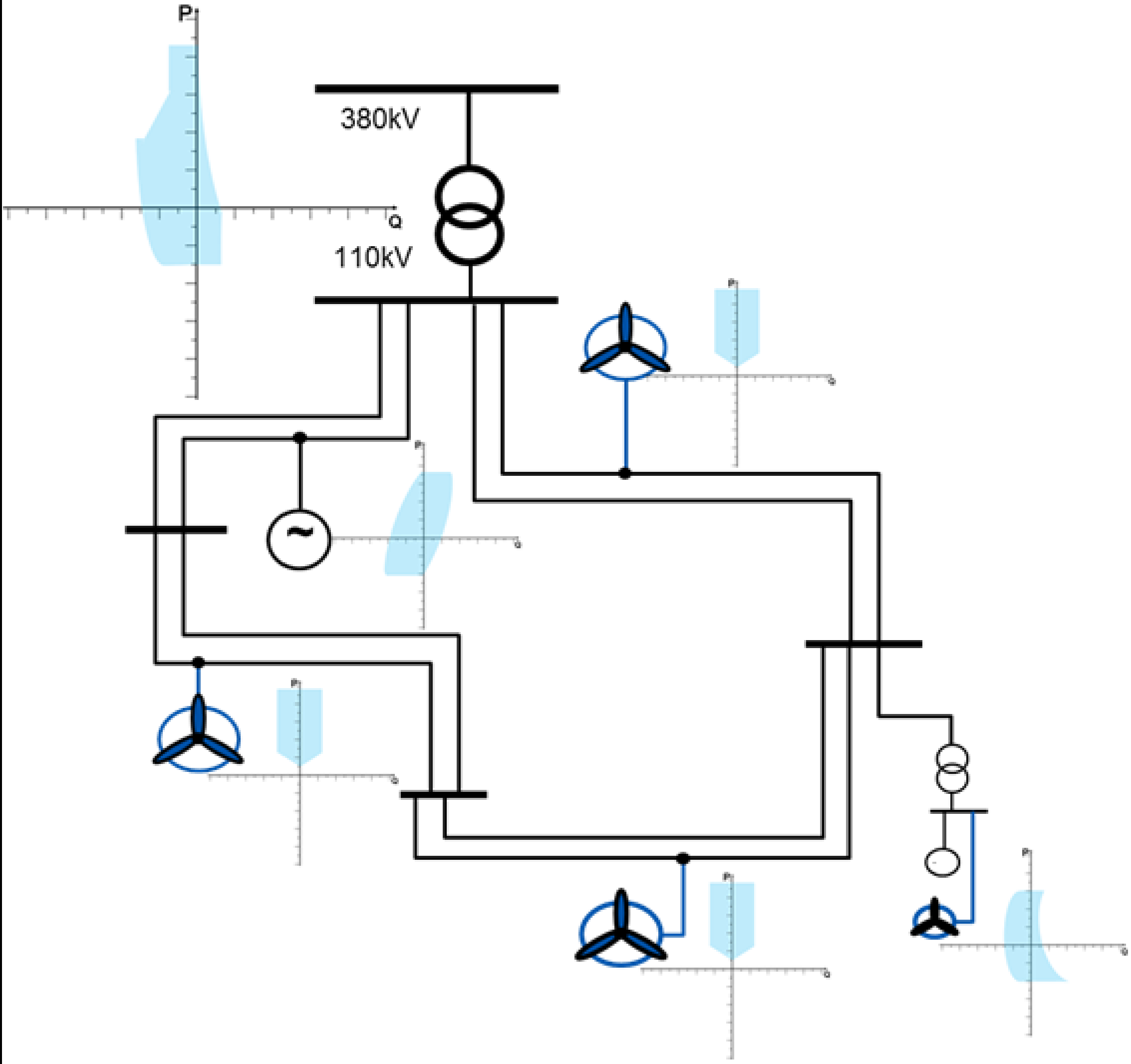
Source of pictures: BNetzA, German Regulatory Authority, 2017

2. Goal of the use case

This use case enables TSOs to react on active power needs for congestion management with a known flexibility at DSO-TSO interface. Hence, the TSO can include the potential of units in distribution grid to its own power flow analysis.

The aggregation of active power flexibility at TSO-DSO-interface depends on physical constraints in the distribution grid. It also depends on the transmission ability of the grid considering active and reactive power flows. Therefore the needs of reactive power management has to be included in the calculation of congestion management. Consequently, reactive power management also supports the transmission ability of the grid. This implies a strong link between the BUCs of active and reactive power management. Thus the used optimization algorithm uses offered flexibilities in active and reactive power equally considering costs and effectiveness for solving congestions. The result is a P/Q-map of set points and flexibility ranges at the TSO-DSO-interface.

An example of the aggregation of different flexibilities in active and reactive operating ranges towards the P/Q flexibility potential at the TSO-DSO-interface is shown in the following picture:



3. Current underlying German electricity market design
- Generally, system operators must curtail conventional generators before RES and CHP.
- Conventional generators > 10 MW at >= 110kV have to send schedules to TSO two days ahead.
- TSOs can adjust schedules of conventional generators one day ahead of delivery for congestion management (ReDispatch). The generators receive a compensation for their opportunity costs (lost revenue – reduced costs + higher costs).
- If congestions in the transmission grid are not solved, the TSO can curtail any generators in its own and in the distribution grid (realtime). RES and CHP operators receive a compensation for their opportunity costs. RES and CHP curtailment is routed from the TSO over the DSO to the units. The RES or CHP unit operator has to be informed as soon as possible about the planned curtailment (where possible, day-ahead). Imbalances in the balance group are not compensated.
- DSOs can also curtail generators in case of congestion management in real time. The same rules as for TSOs apply.
- The compensation for curtailment of RES and CHP (accord. to §15 EEG) is paid by the connected network operator. However, the network operator which needed the flexibility for congestion management (e.g. TSO) has to compensate the connected network operator (§15 (2) EEG).
- The TSO* can procure frequency reserve flexibility from generators in any grid . The TSO pays for the option to activate (capacity) and for the activation itself (energy, only for secondary and tertiary reserve). The activation is carried out directly without any interference of the DSO. The DSO knows which generators are prequalified to sell frequency reserve to the TSO, but doesn't know the procured options at a certain timeframe
*In Germay, the TSO takes over the role as TSO and PSO, being responsible for maintaining the frequency and procuring respective frequency products.

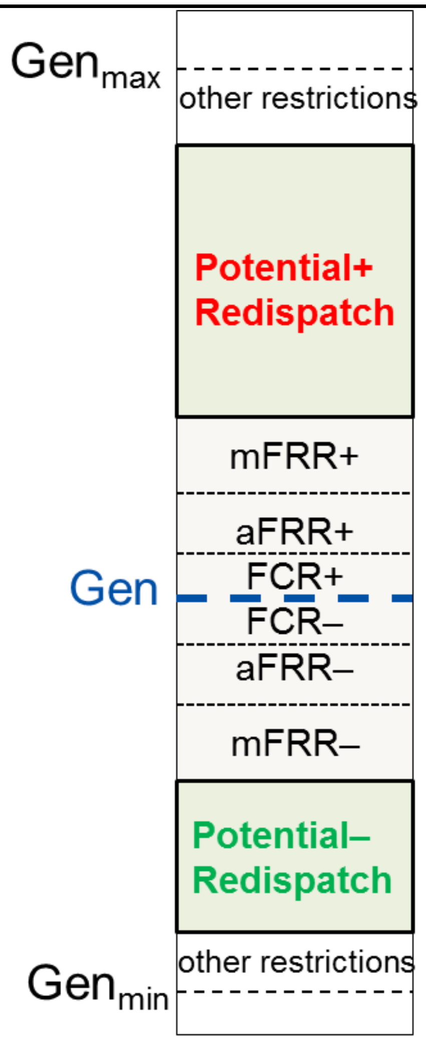
4. Necessary modifications of the German market design for the BUC.
For fulfilling the objectives of the BUC, no regulatory modifications are necessary. However, certain agreements between different actors are necessary, which are stated in section "1.6 use case conditions".

5. Possible developments in the long track, making adaptions of market design necessary
a) Market mechanism for load flexibility
b) If a market mechanism is introduced, also including load flexibility, cost recognition by the NRA must be ensured and the Averch-Johnsen-effect (tendency of SO towards CAPEX investment instead of OPEX) has to be addressed. c) There might be introduced cost sharing principles between TSOs and DSOs for flexibilities which help both network operators in reducing congestions.

Summary of phases:

· Prequalification phase

Generation Aggregator (GA) and Distribution Network Operator (DSO) sign an agreement that the GA sends schedules of planned generation, contracted frequency reserve, flexibility potential and flexibility costs day ahead so that the DSO can adjust these schedules also day ahead (compared to realtime nowadays). · Bidding/Selection phase Day ahead, the different GA submit their generation schedules, containing data about the planned generation, contracted frequency reserve capacity as well as the residual flexibility/ReDispatch potential and its flexibility price. For small units without a schedule (small RES, household loads, etc.), forecasts will be used to predict their generation/consumption. The DSO aggregates the different flexibilities day ahead after gate closure of the day ahead markets. The DSO performs a load flow analysis based on the individual schedules of generation units and industrial loads and the forecasted aggregated schedules of small generation and loads. If congestions or voltage range deviations** are forecasted, the DSO selects available flexibilities (based on a price and sensitivity decision) to solve these limit violations in its own grid. In a next step, the DSO submits the remaining flexibility potential to the TSO at each TSO-DSO interconnection point. The DSO guarantees that the remaining flexibilities will not violate any distribution grid constraints. Therefore, an optimization of conditions in the distribution grid is necessary. DSO and TSO determine which flexibilities shall be activated based on physical location and price, e.g. if resources from the distribution grid are selected, the TSO sends an adjusted aggregated schedule to the DSO (aggregated at the level of the TSO-DSO interface) and the DSO sends the activation signals (activation of active power flexibilities is carried out as schedule) to the generation units providing the flexibility.



** In Section 4.2 ("Steps – Scenarios"), "congestions" refer to violations of both voltage and current limits. However, active power flexibility is mostly used to prevent violations of current limits.

· Delivery phase
The delivery of flexibility is proven by metered data sent from the Metered Data Operator (MDO) to the DSO.

· Settlement phase
The DSO pays the Generator Operator for the flexibility delivery (credit note) and sends an invoice to the TSO for its specific flexibility usage.
Concluding this use case, it enables TSO to react on congestions and operation reserve needs with known and available flexibilities (including flexibilities in distribution grid).

<u>Summary of use case</u>

- **<u>Prequalification</u>**
  <u>Description</u>:
  - Create framework agreement with schedule delivery requirements
    <u>Description</u>: Schedules: planned generation, flexibility potential and opportunity costs

- Sign framework agreement
  Description:

- **Selection/Bidding**
  Description:

  - **Day ahead process**
    Description:

    - **DS_O receives day ahead schedules from GA and FCP**
      Description:

      - Create day ahead operation schedule (planned energy trading) and potential flexibilities
        Description: Schedules: planned generation per grid connection node incl. contracted frequency reserve, flexibility potential and opportunity costs

      - Create planned grid asset utilization
        Description: FCP needs planned grid asset utilization data for improved forecast

      - Forecast small generation and load
        Description: Small generation: with fixed feed-in tariff

    - **DS_O predicts schedule adjustments for own congestions and sends Merit Order List (MOL) to TS_O**
      Description:

      - Predict congestions in DS_O grid
        Description: from load flow, generation (day-ahead schedule and forecast), state estimation and asset utilization

      - Solve congestions in DS_O grid with available flexibilities
        Description: Adjusting schedules and if necessary limiting remaining flexibilities of generators

      - Aggregate schedules and remaining flexibilities per DS_O-TS_O grid node
        Description: Including physical and cost sensitivity (enhanced merit order list: (e.g. an activation of 50 MW can have a physical impact of only 30 MW at TSO-DSO-interface, although incurring costs for 50 MW))

    - **TS_O congestion management: use of offered flexibilities (in own grid or from DS_O's aggregated MOL)**
      Description:

      - TS_O congestion management
        Description: European coordination process, predicting congestions in own grid

      - Solve congestions in TS_O grid with available flexibilities
        Description: Adjusting schedules and if necessary limiting remaining flexibilities of generators

- **DS_O verifies schedule and sends it to GA**
  Description:
  - Segregate adjusted schedules
    Description: For each plant in DS_O grid
  - Verify feasibility of grid to perform received schedules
    Description: DS_O executes simulation, if received adjustments cause congestions (repetition of 2.1.2.1)
  - Adjust schedules, if needed
    Description: Repetition of 2.1.2.2

- **Intraday process**
  Description:
  - **Update process if TS_O changes its already adjusted schedule**
    Description:
    - Update aggregated schedules
      Description: If deviations in need of DS_O's flexibilities occur
    - Segregate schedules
      Description: For each plant in DS_O grid
    - Verify feasibility of grid to perform received schedules
      Description: Simulation if received adjustments cause congestions (repetition of 2.1.2.1)
    - Adjust schedules, if needed
      Description: Repetition of 2.1.2.2
  - **Update process in case of deviations in DS_O grid**
    Description: Deviations: forecasts, GA's schedules, state estimation
    - Update forecast due to deviation
      Description:
    - Update schedules
      Description:
    - Update DS_O asset utilization
      Description:
    - Predict congestions in DS_O grid
      Description: Repetition of 2.1.2.1
    - Solve congestions in DS_O grid with available flexibilities
      Description: Repetition of 2.1.2.2.
    - Aggregate schedules and remaining flexibilities per DS_O-TS_O grid node
      Description: Send, if threshold exceeded

- TS_O congestion management
  Description: Repetition of 2.1.3.1., but without European coordination process
- Solve congestions in TS_O grid with available flexibilities
  Description: Repetition of 2.1.3.2.
- Segregate adjusted schedules
  Description: DS_O. Repetition of 2.1.4.1.
- Verify feasibility of received schedules
  Description: Repetition of 2.1.4.2.
- Adjust schedules, if needed
  Description: Repetition of 2.1.4.3.

- **Delivery**
  Description:
  - Measure delivered flexibility
    Description:
- **Settlement**
  Description:
  - Create payment instruction for generator
    Description: According to regulation (different procedures for calculation of payment might apply, see Bundesnetzagentur: "Leitfaden zum EEG-Einspeisemanagement")
  - Create invoice for flexibility usage by TS_O
    Description: Including analysis which flexibilities the TS_O activated

1.5 KEY PERFORMANCE INDICATORS (KPI)

1.6 USE CASE CONDITIONS

	Use case conditions
	Assumptions
1	The roles Generation Aggregator (GA) and the Balance Responsible Person (BRP) are performed by the same stakeholder.
2	Regulatory framework stays the same: • ReDispatch (§13 (1) EnWG, §13a EnWG), including time framework and schedule delivery of conventional generators => 10 MW • Curtailment methodology according to §13 (2) EnWG: compensation schemes for RES, CHP with fixed tariff (§13 (3) EnWG), GA/BRP responsible for caused imbalance due to curtailment, necessity of informing GA day-ahead of curtailment • Loads do not have to send schedules with flexibility potential and costs in ReDispatch process, compensation of these costs is not secured by National Regulation Agency. Therefore, loads are not included in the BUC.
3	No procurement of options necessary due to DSO/TSO's right of curtailment (§ 13 (1,2) EnWG). Therefore, only energy is procured.

Prerequisites	
1	Communication process is fixed with defined information paths
2	Schedules per grid connection point: Generation Aggregators (GA) with units in the distribution grid agree with DSO to send schedules, flexibility potential and opportunity costs day ahead. In return, the DSO sends the curtailment signals to the GA day ahead so that the GA has time to optimize the balance group.
3	Relevance thresholds for sending updated data has to be agreed with TSO
4	Grid data calculation (e.g. state estimation): It will be updated continuously for load flow calculation and sensitivity analysis.
5	Flexibility aggregation: DSO aggregates the available flexibility, considering the sensitivity of the flexibility at the TSO-DSO-interface and submits the merit order list of the flexibilities to the TSO (therefore no commercial activity, only data routing/aggregation/evaluation).
6	Assets used: The demonstrator focuses on RES flexibilities at 110 kV level. Potential assets: The demonstrator is technically designed for all kind of generators and loads at every voltage level. For loads, changes in market design are necessary (see assumptions).
7	TSO/DSO coordination mechanism: TSO agrees with DSO to activate flexibilities for congestion management (i.e. frequency reserve methodology is not changed) using Merit Order List at the TSO-DSO-interface in order to avoid pushing each other in congestions.
8	Wrong schedules: It has to be discussed with TSO, if penalties for wrong schedules are used in the ReDispatch process.

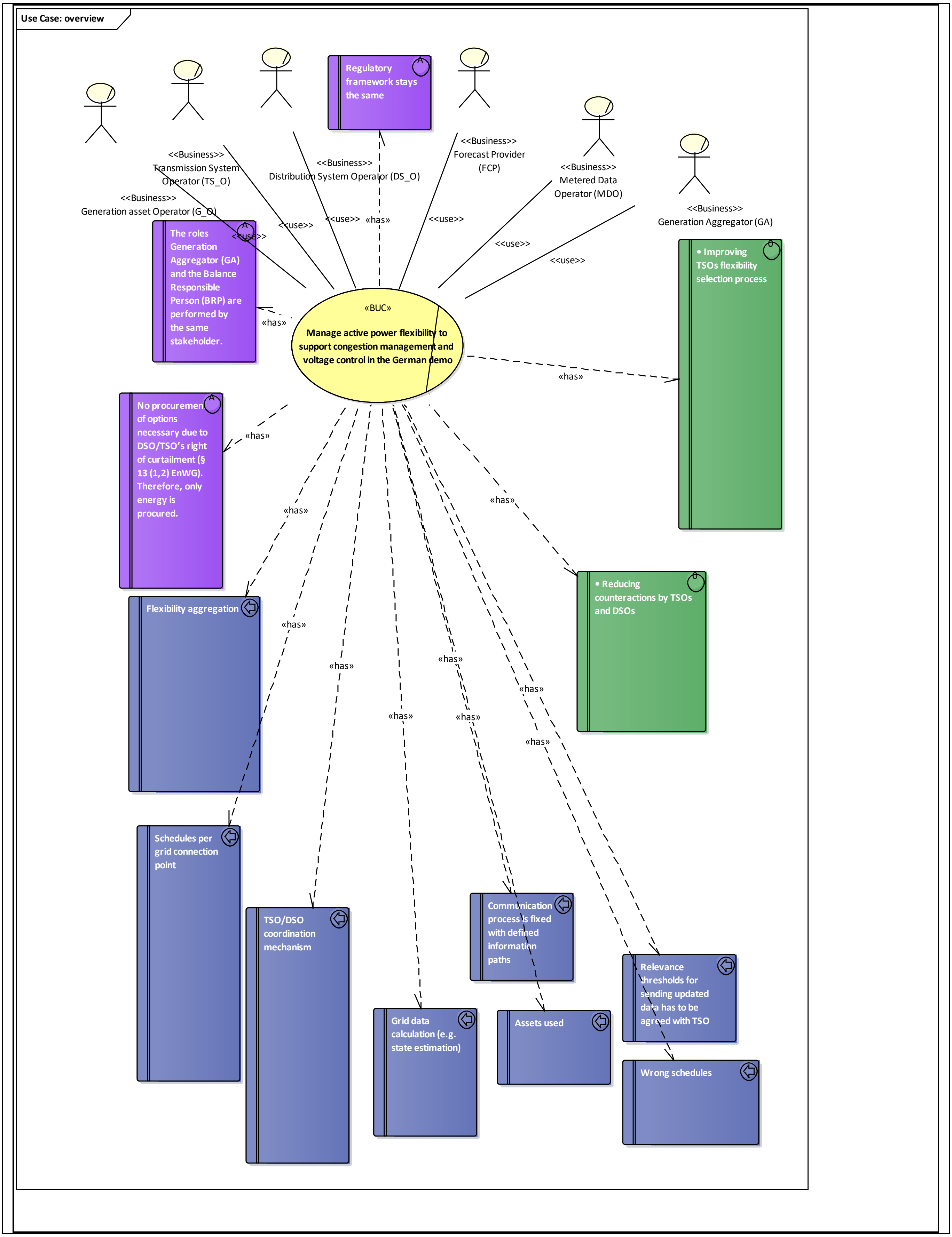
1.7 FURTHER INFORMATION TO THE USE CASE FOR CLASSIFICATION/MAPPING

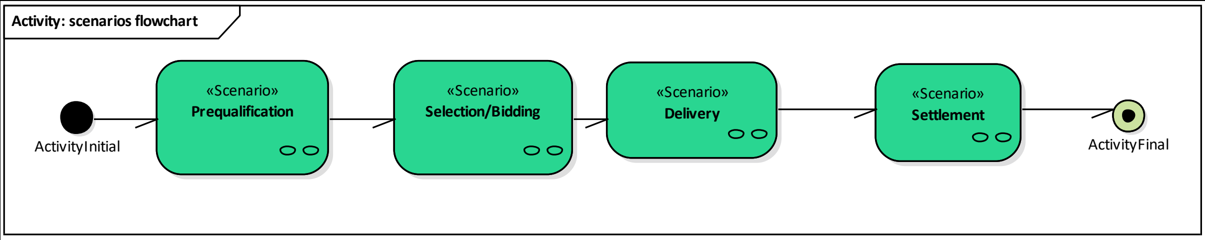
Classification information
Relation to other use cases
Level of depth
BUC for German Demo WP6
Prioritisation
Generic, regional or national relation
solving regional problems, European deployment
Nature of the use case
BUC
Further keywords for classification

1.8 GENERAL REMARKS

General remarks
GeneralRemarks1: This use case supports the TSO with flexibilities from distribution grid. The DSO aggregates predicted available flexibilities per grid node as support. Consequently, cooperation of TSO and DSO is necessary.

2. DIAGRAMS OF USE CASE
Diagram(s) of use case


Use Case: overview
<<Business>> Transmission System Operator (TS_O)
<<Business>> Generation asset Operator (G_O)
<<Business>> Distribution System Operator (DS_O)
Regulatory framework stays the same
<<Business>> Forecast Provider (FCP)
<<Business>> Metered Data Operator (MDO)
<<Business>> Generation Aggregator (GA)
The roles Generation Aggregator (GA) and the Balance Responsible Person (BRP) are performed by the same stakeholder.
«BUC» Manage active power flexibility to support congestion management and voltage control in the German demo
Improving TSOs flexibility selection process
No procurement of options necessary due to DSO/TSO's right of curtailment (§ 13 (1,2) EnWG). Therefore, only energy is procured.
Reducing counteractions by TSOs and DSOs
Flexibility aggregation
Schedules per grid connection point
TSO/DSO coordination mechanism
Grid data calculation (e.g. state estimation)
Communication process is fixed with defined information paths
Assets used
Relevance thresholds for sending updated data has to be agreed with TSO
Wrong schedules
<<use>>
«has»



3. TECHNICAL DETAILS

3.1 ACTORS

Actors			
Grouping (e.g. domains, zones)	***Group description***		
Actor name	***Actor type***	***Actor description***	***Further information specific to this use case***
Metered Data Operator (MDO)	Business	Provide metered data to authorized users in a transparent and non-discriminatory manner	
Distribution System Operator (DS_O)	Business	Elaborate network development plan (including defining system needs for distribution) Ensure a transparent and non-discriminatory access to the distribution network for each user Operate the distribution grid over a specific region in a secure, reliable and efficient way Optimize system operation distribution grid from planning to real-time, using available levers (grid expansion, flexibility activation,...) Assess network status of the distribution grid and broadcast selected information of the network status to eligible actors (e.g. aggregators, other system operators) Support the Transmission System Operator in carrying out its responsibilities (including load shedding) and coordinate measures if necessary	Technical aggregation (MW, €, sensitivity) of residual flexibility potential towards TSO

Generation Aggregator (GA)	Business	Aggregate and maximize value of generation portfolio resources Provide flexibility by generation assets to the system operators	Takes over BRP responsibility. Role is taken over by TSO for small RES and CHP generation with fixed feed-in tariff.
Generation asset Operator (G_O)	Business	Operate one or several generation asset(s)	Receives flexibility cost compensation by DSO
Transmission System Operator (TS_O)	Business	Elaborate network development plan (including defining system needs for transmission) Ensure a transparent and non-discriminatory access to the transmission network for each user Operate the transmission grid over a specific region in a secure, reliable and efficient way Secure and manage in real time the physical generation-consumption balance on a geographical perimeter, including ensuring the frequency control service Optimize transmission system operation from planning to real-time, using available levers (grid expansion, flexibility activation,...) Assess network status of the transmission grid and broadcast selected information of the network status to eligible actors (e.g. aggregators, other system operators) Provide data to the interconnection capacity market operator for the management of cross border transactions In critical situations, implement dedicated actions and deliver alerts during stress events If necessary, implement emergency measures (e.g. system defence plan) including load shedding	Uses interface to DSO to select flexibilities at DSO grid for own congestion management

Forecast Provider (FCP)	Business	Provide forecasts of RES, small generation and consumption load based on different data (e.g. weather data and historical load flow) to other roles	Forecasts small RES (which don't need a schedule due to fixed tariff), small generation and consumption load based on different data (e.g. weather data and historical load flow)

3.2 REFERENCES

References						
No.	***Reference Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***
1	Law	Generation and Load Data Provision Methodology	active	Data exchange procedures	European Commission	
2	Law	EnWG, EEG, ARegV	active	Flexibility usage, coordination TSO/DSO, compensation for flexibility towards G_O, cost recognition for TSO and DSO	German legislation	
3	Guideline	UCTE Operation Handbook	active	ReDispatch Process, Coordination European grid operators, applicable standards for grid operation	ENTSO-E	
4	Guideline	System Operation Guideline	in development	Data exchange procedures	European Commission	
5	Standard	ISO 27019	active	Information security management for energy grids	International Organization for Standardization	
6	Guideline	Leitfaden zum Einspeisemanagement 2.1	active	Methodology for calculation of flexibility cost compensation towards G_O	German Regulation Agency (Bundesnetzagentur)	

4. STEP BY STEP ANALYSIS OF USE CASE

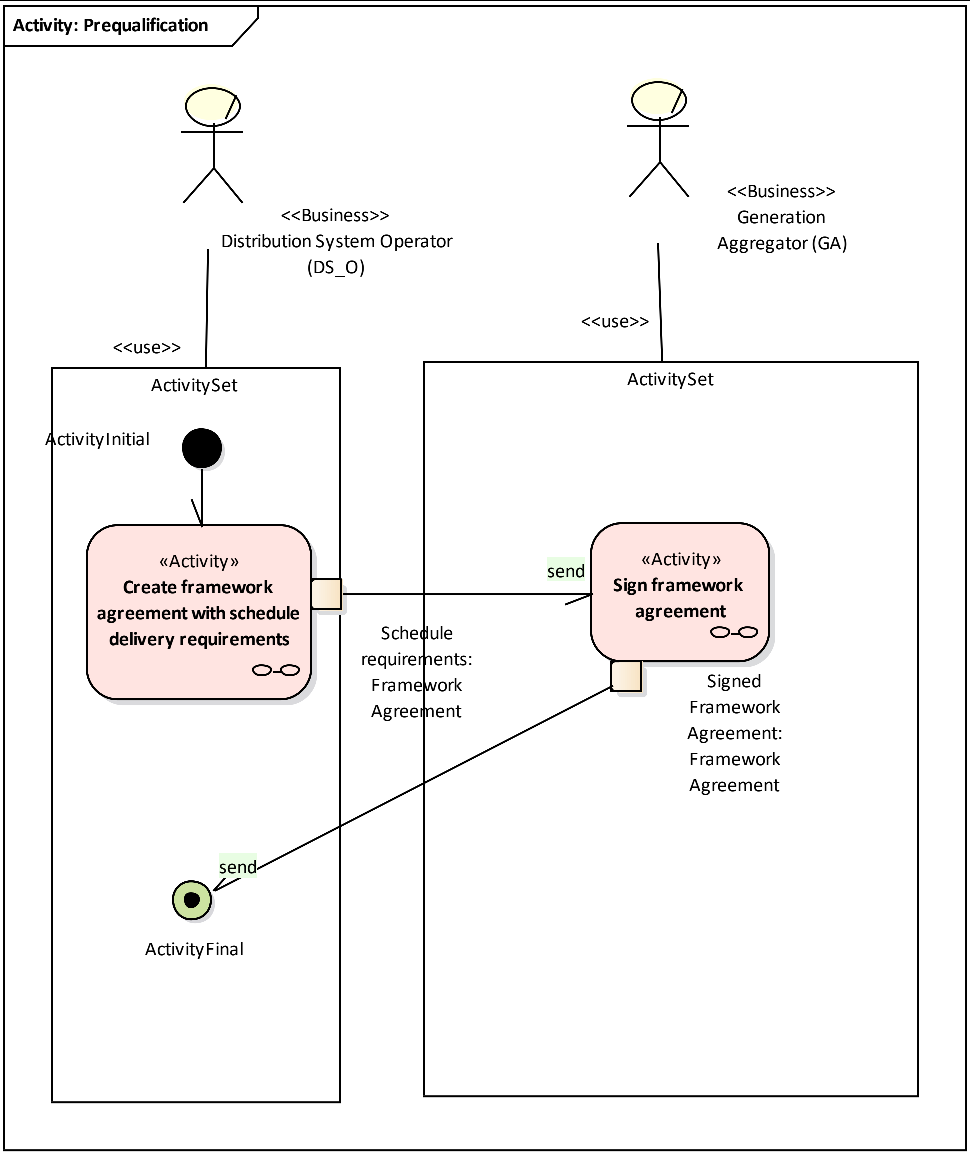
4.1 OVERVIEW OF SCENARIOS

Scenario conditions						
No.	***Scenario name***	***Scenario description***	***Primary actor***	***Triggering event***	***Pre-condition***	***Post-condition***
1	Prequalification					
2	Selection/Bidding					
3	Delivery					

4	Settlement					

4.2 STEPS - SCENARIOS

4.2.1 PREQUALIFICATION

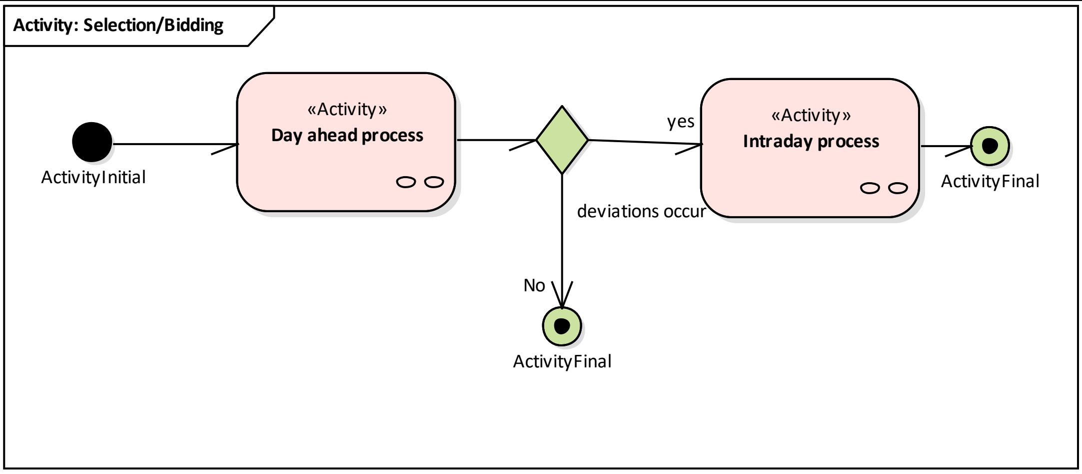


Scenario step by step analysis

Scenario								
Scenario name	Prequalification							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***

1.1		Create framework agreement with schedule delivery requirements	Schedules: planned generation, flexibility potential and opportunity costs	send	Distribution System Operator (DS_O)	Generation Aggregator (GA)	Info1-Framework Agreement	
1.2		Sign framework agreement		send	Generation Aggregator (GA)	Distribution System Operator (DS_O)	Info1-Framework Agreement	

4.2.2 SELECTION/BIDDING

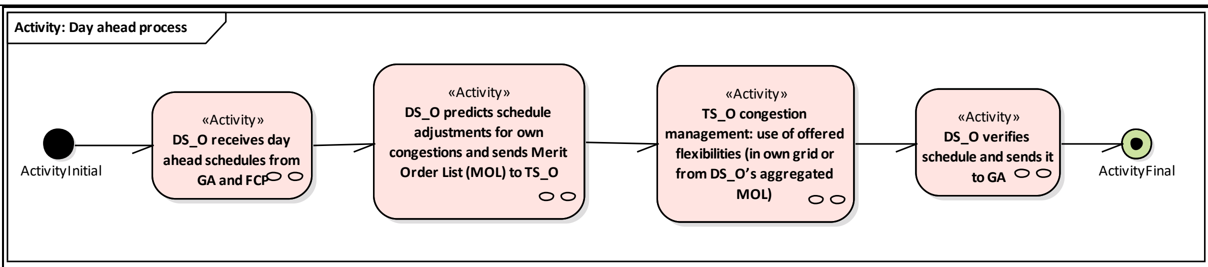


Scenario step by step analysis

Scenario								
Scenario name	Selection/Bidding							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
2.1		Day ahead process						
2.2		Intraday process						

- 2.1. Day ahead process

Business section: Selection/Bidding/Day ahead process

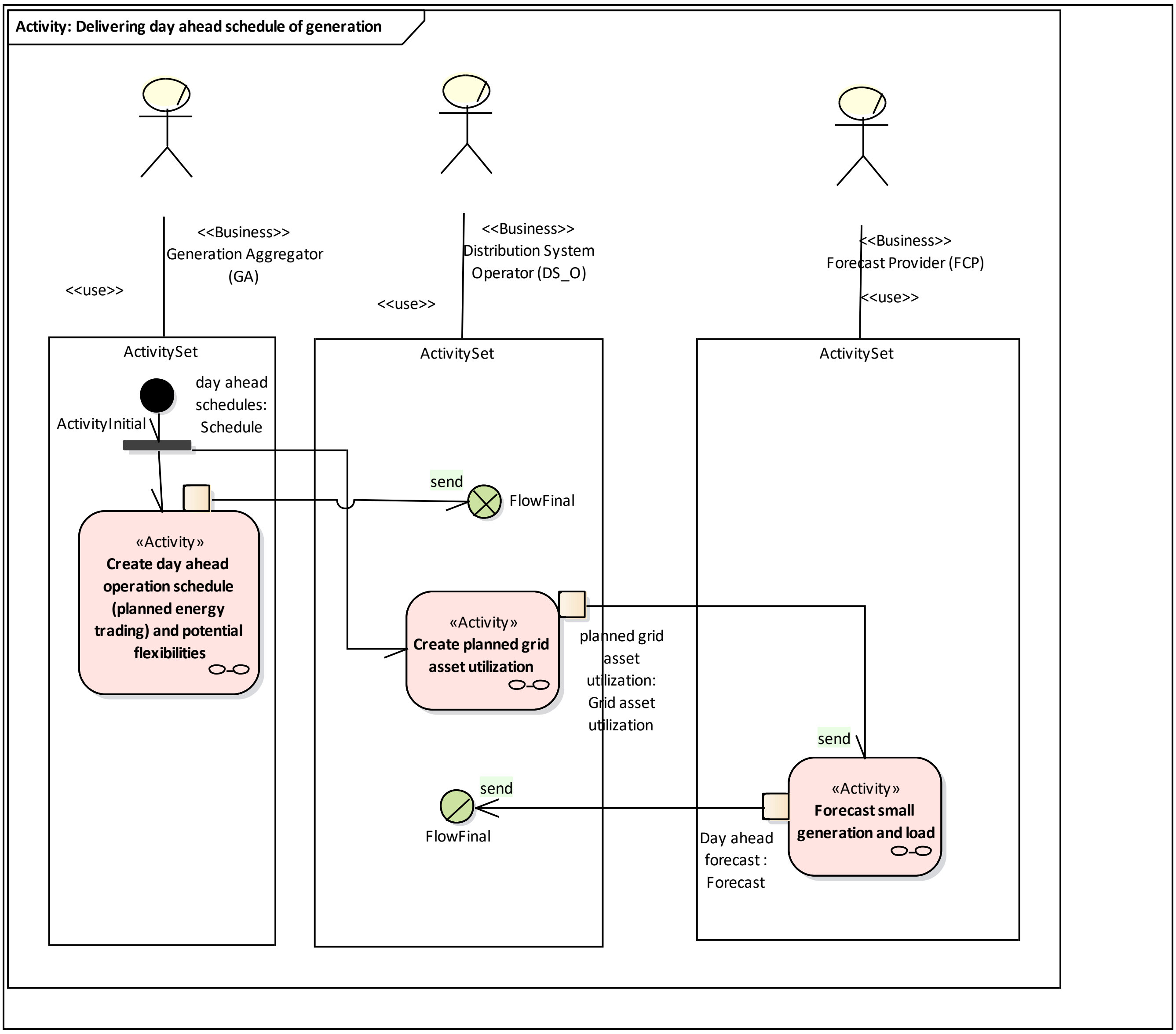


Activity step by step analysis

Scenario								
Scenario name	Selection/Bidding							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
2.1.1		DS_O receives day ahead schedules from GA and FCP						
2.1.2		DS_O predicts schedule adjustments for own congestions and sends Merit Order List (MOL) to TS_O						
2.1.3		TS_O congestion management: use of offered flexibilities (in own grid or from DS_O's aggregated MOL)						
2.1.4		DS_O verifies schedule and sends it to GA						

- 2.1.1. DS_O receives day ahead schedules from GA and FCP

Business section: Selection/Bidding/Day ahead process/DS_O receives day ahead schedules from GA and FCP



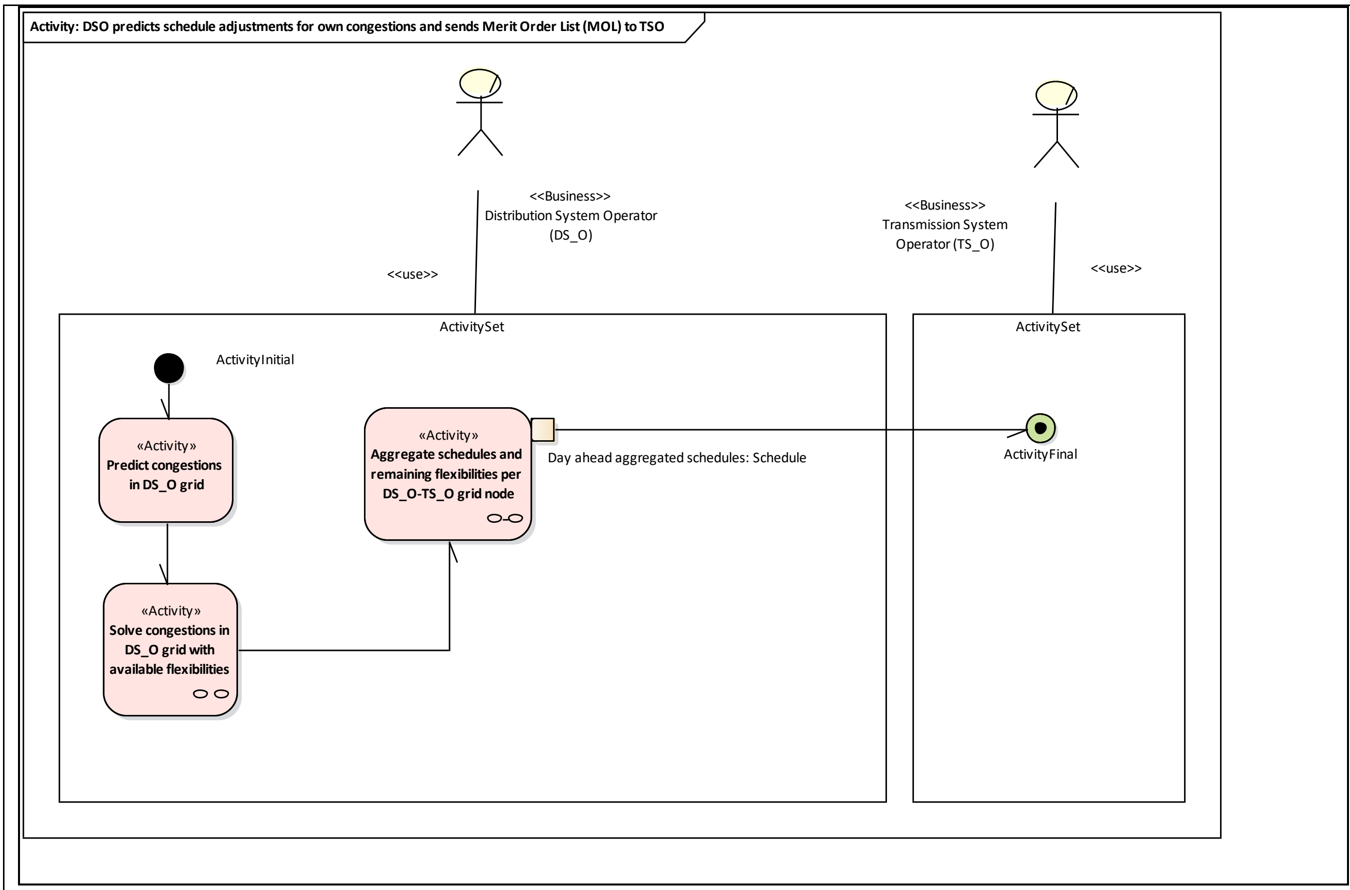
Activity step by step analysis

Scenario								
Scenario name	Selection/Bidding							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
2.1.1.1		Create day ahead operation schedule	Schedules: planned generation per	send	Generation Aggregator (GA)	Distribution System	Info2-Schedule	

		(planned energy trading) and potential flexibilities	grid connection node incl. contracted frequency reserve, flexibility potential and opportunity costs			Operator (DS_O)		
2.1.1.2		Create planned grid asset utilization	FCP needs planned grid asset utilization data for improved forecast	send	Distribution System Operator (DS_O)	Forecast Provider (FCP)	Info3-Grid asset utilization	
2.1.1.3		Forecast small generation and load	Small generation: with fixed feed-in tariff	send	Forecast Provider (FCP)	Distribution System Operator (DS_O)	Info4-Forecast	

- 2.1.2. DS_O predicts schedule adjustments for own congestions and sends Merit Order List (MOL) to TS_O

Business section: Selection/Bidding/Day ahead process/DS_O predicts schedule adjustments for own congestions and sends Merit Order List (MOL) to TS_O



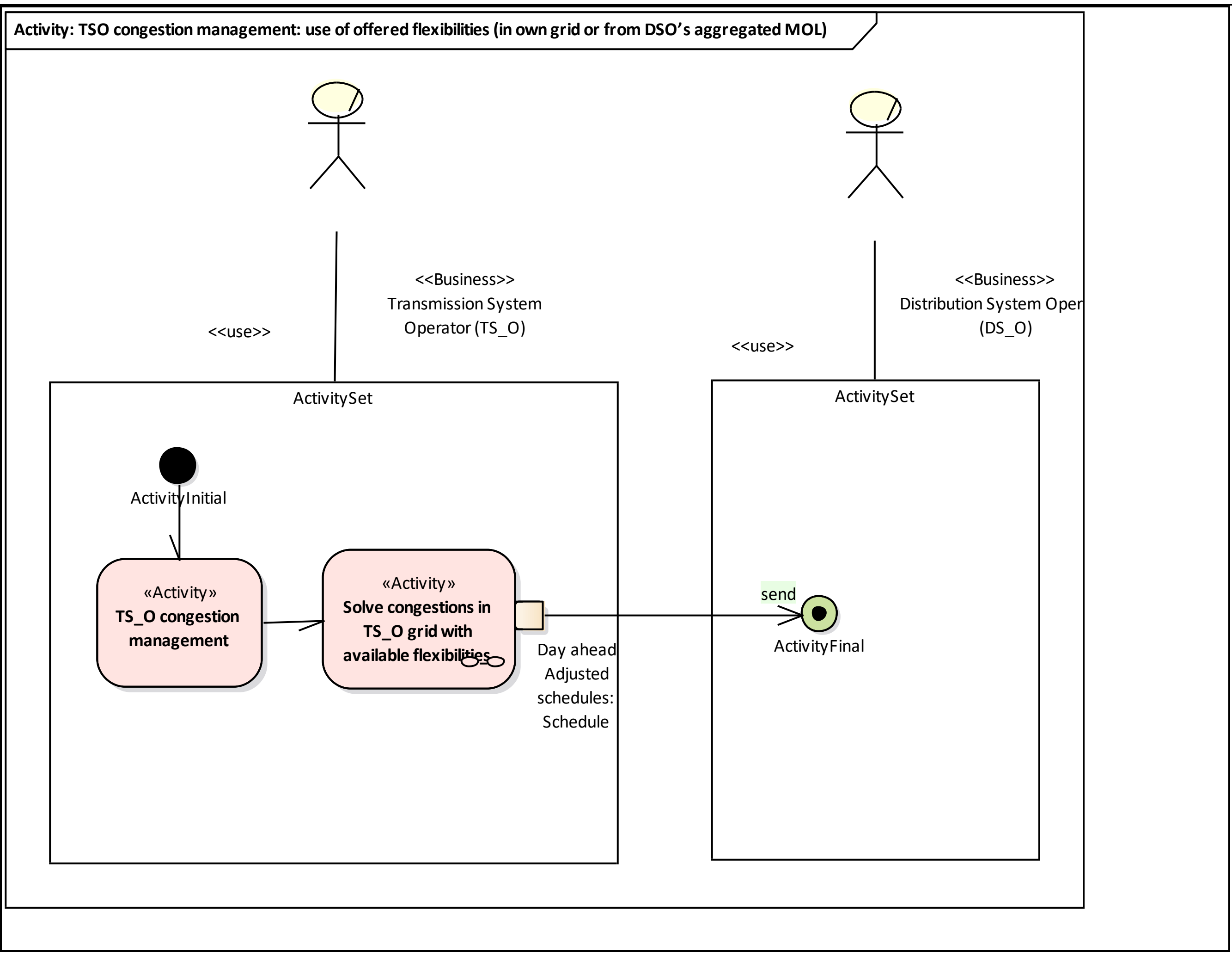
Activity step by step analysis

Scenario								
Scenario name	Selection/Bidding							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
2.1.2.1		Predict congestions in DS_O grid	from load flow, generation (day-ahead schedule and forecast), state estimation and asset utilization		Distribution System Operator (DS_O)			
2.1.2.2		Solve congestions in DS_O grid with	Adjusting schedules and if necessary limiting remaining		Distribution System Operator (DS_O)			

		available flexibilities	flexibilities of generators					
2.1.2.3		Aggregate schedules and remaining flexibilities per DS_O-TS_O grid node	Including physical and cost sensitivity (enhanced merit order list: (e.g. an activation of 50 MW can have a physical impact of only 30 MW at TSO-DSO-interface, although incurring costs for 50 MW))		Distribution System Operator (DS_O)	Transmission System Operator (TS_O)	Info2-Schedule	

- 2.1.3. TS_O congestion management: use of offered flexibilities (in own grid or from DS_O's aggregated MOL)

Business section: Selection/Bidding/Day ahead process/TS_O congestion management: use of offered flexibilities (in own grid or from DS_O's aggregated MOL)



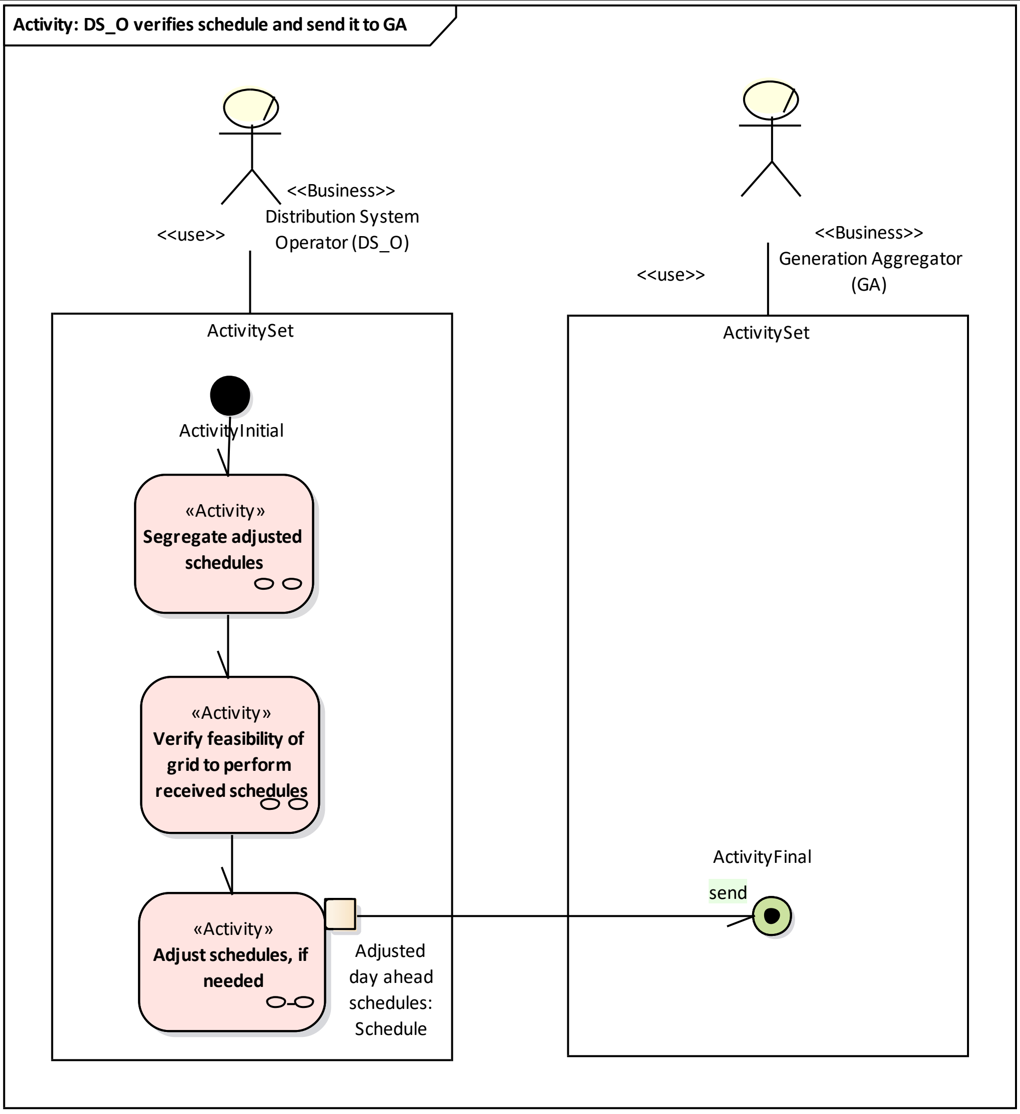
Activity step by step analysis

Scenario								
Scenario name	Selection/Bidding							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
2.1.3.1		TS_O congestion management	European coordination process, predicting congestions in own grid		Transmission System Operator (TS_O)			
2.1.3.2		Solve congestions in	Adjusting schedules and if	send	Transmission System	Distribution System	Info2-Schedule	

		TS_O grid with available flexibilities	necessary limiting remaining flexibilities of generators		Operator (TS_O)	Operator (DS_O)		

- 2.1.4. DS_O verifies schedule and sends it to GA

Business section: Selection/Bidding/Day ahead process/DS_O verifies schedule and sends it to GA



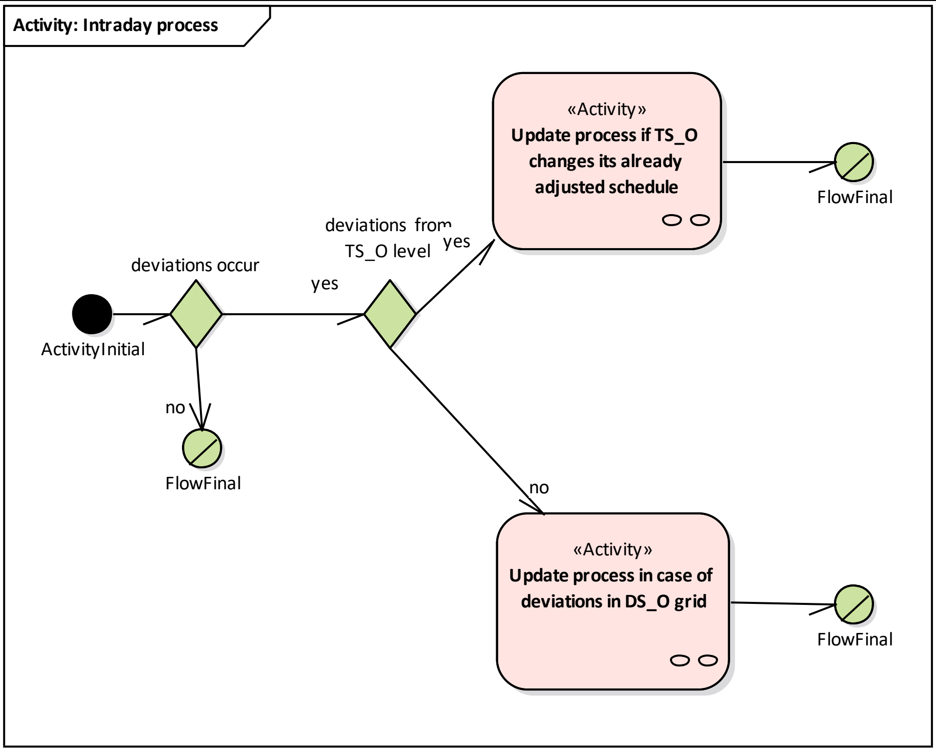
Activity step by step analysis

Scenario	
Scenario name	Selection/Bidding

Step No	*Event*	*Name of process/activity*	*Description of process/activity*	*Service*	*Information producer (actor)*	*Information receiver (actor)*	*Information exchanged (IDs)*	*Requirement, R-IDs*
2.1.4.1		Segregate adjusted schedules	For each plant in DS_O grid		Distribution System Operator (DS_O)			
2.1.4.2		Verify feasibility of grid to perform received schedules	DS_O executes simulation, if received adjustments cause congestions (repetition of 2.1.2.1)		Distribution System Operator (DS_O)			
2.1.4.3		Adjust schedules, if needed	Repetition of 2.1.2.2	send	Distribution System Operator (DS_O)	Generation Aggregator (GA)	Info2-Schedule	

- 2.2. Intraday process

Business section: Selection/Bidding/Intraday process

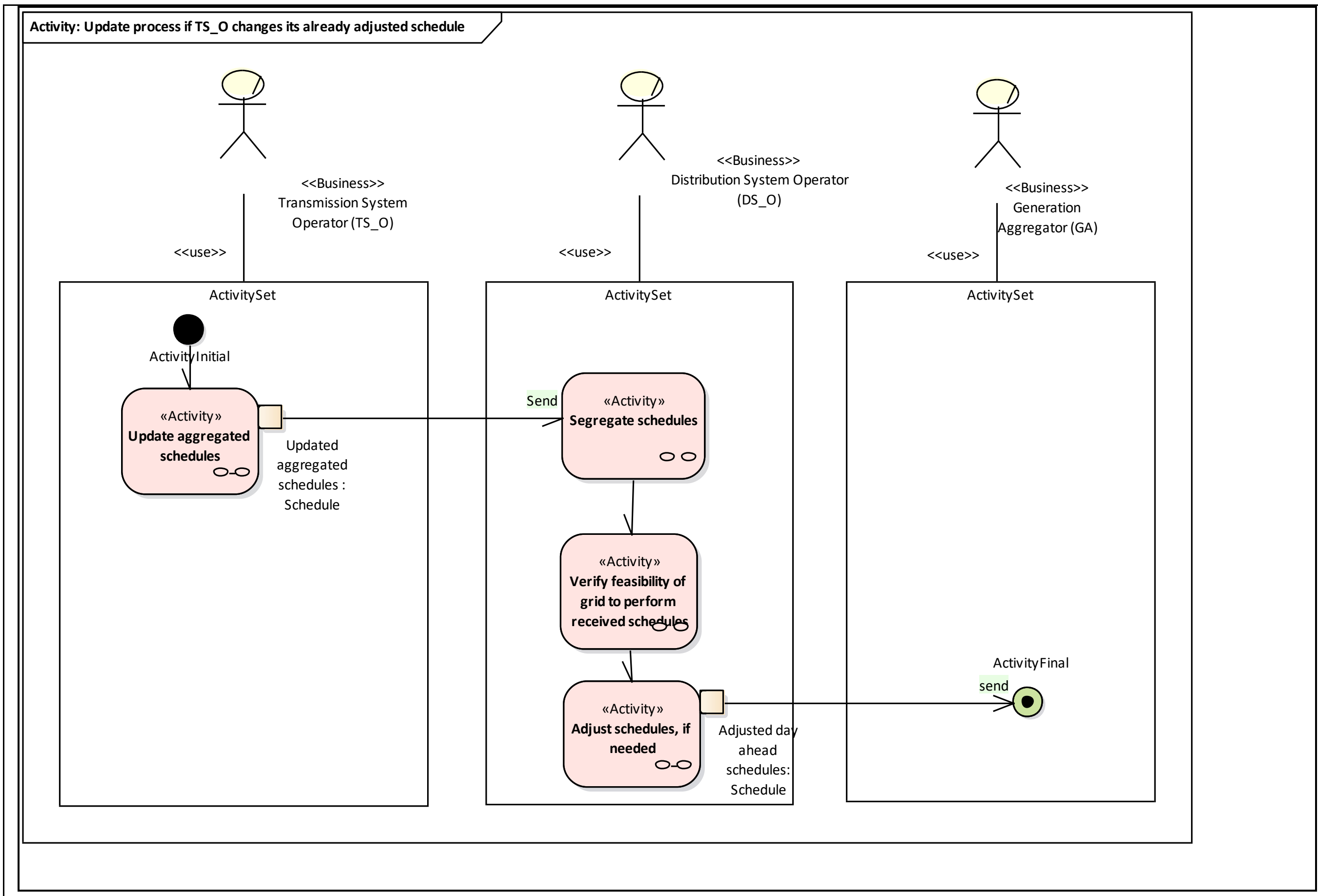


Activity step by step analysis

Scenario								
Scenario name	Selection/Bidding							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
2.2.1		Update process if TS_O changes its already adjusted schedule						
2.2.2		Update process in case of deviations in DS_O grid	Deviations: forecasts, GA's schedules, state estimation					

- 2.2.1. Update process if TS_O changes its already adjusted schedule

Business section: Selection/Bidding/Intraday process/Update process if TS_O changes its already adjusted schedule



Activity step by step analysis

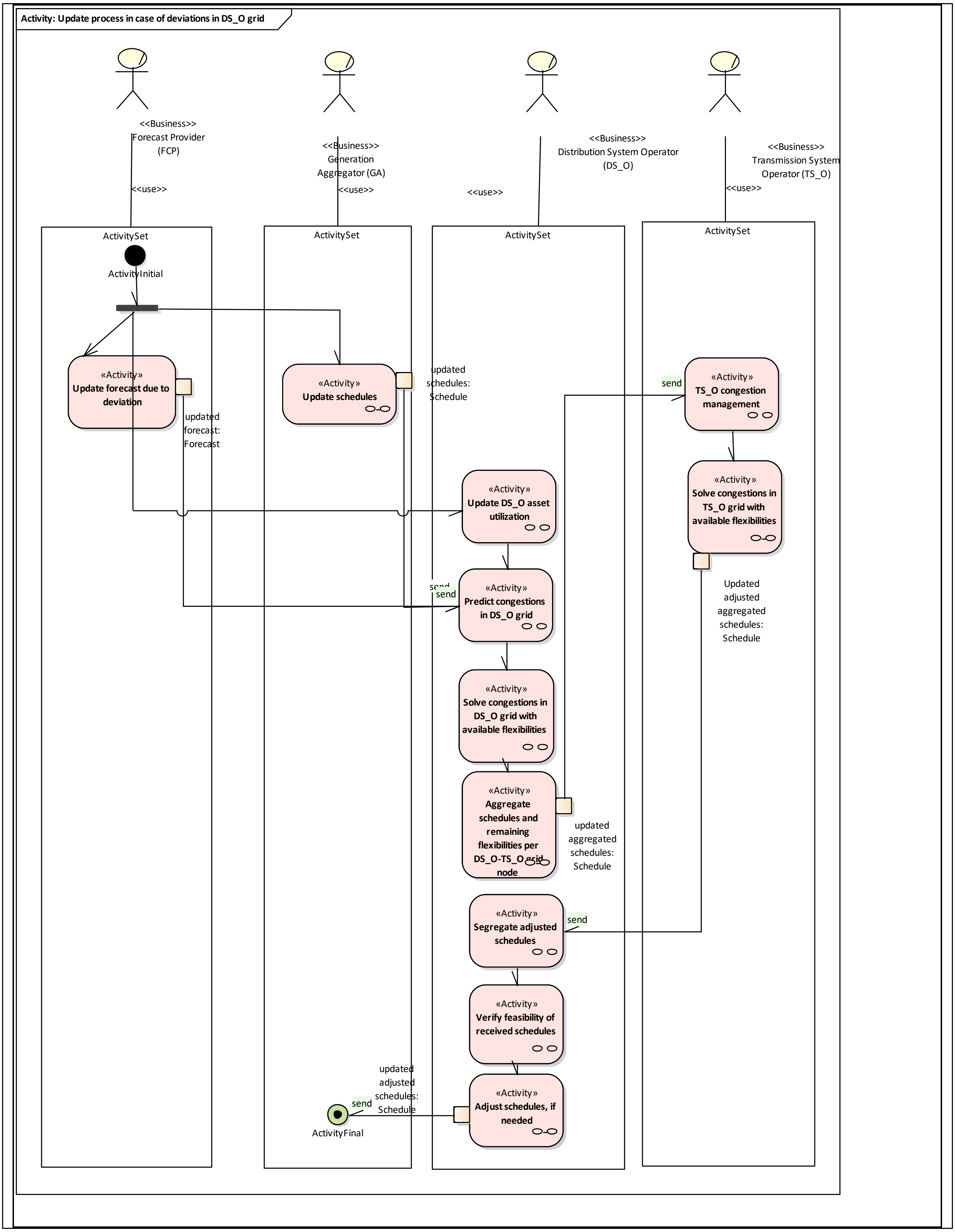
Scenario								
Scenario name	Selection/Bidding							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
2.2.1.1		Update aggregated schedules	If deviations in need of DS_O's flexibilities occur	Send	Transmission System Operator (TS_O)	Distribution System Operator (DS_O)	Info2-Schedule	
2.2.1.2		Segregate schedules	For each plant in DS_O grid		Distribution System Operator (DS_O)			
2.2.1.3		Verify feasibility of grid to	Simulation if received		Distribution System			

		perform received schedules	adjustments cause congestions (repetition of 2.1.2.1)		Operator (DS_O)			
2.2.1.4		Adjust schedules, if needed	Repetition of 2.1.2.2	send	Distribution System Operator (DS_O)	Generation Aggregator (GA)	Info2-Schedule	

- 2.2.2. Update process in case of deviations in DS_O grid

Business section: Selection/Bidding/Intraday process/Update process in case of deviations in DS_O grid

Deviations: forecasts, GA's schedules, state estimation

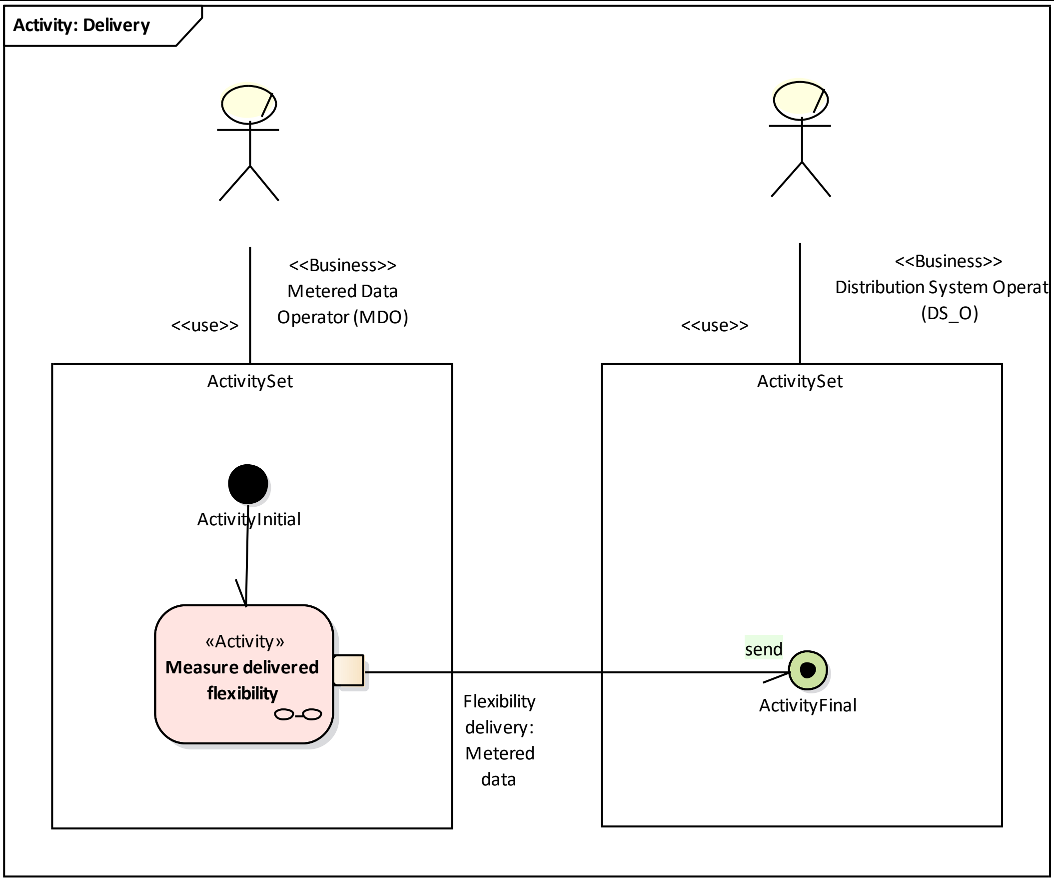

Activity: Update process in case of deviations in DS_O grid
<<Business>> Forecast Provider (FCP)
<<Business>> Generation Aggregator (GA)
<<Business>> Distribution System Operator (DS_O)
<<Business>> Transmission System Operator (TS_O)
<<use>>
<<use>>
<<use>>
<<use>>
ActivitySet
ActivitySet
ActivitySet
ActivitySet
ActivityInitial
«Activity» Update forecast due to deviation
updated forecast: Forecast
«Activity» Update schedules
updated schedules: Schedule
«Activity» TS_O congestion management
send
«Activity» Solve congestions in TS_O grid with available flexibilities
Updated adjusted aggregated schedules: Schedule
«Activity» Update DS_O asset utilization
send
«Activity» Predict congestions in DS_O grid
«Activity» Solve congestions in DS_O grid with available flexibilities
«Activity» Aggregate schedules and remaining flexibilities per DS_O-TS_O grid node
updated aggregated schedules: Schedule
«Activity» Segregate adjusted schedules
send
«Activity» Verify feasibility of received schedules
updated adjusted schedules: Schedule
send
«Activity» Adjust schedules, if needed
ActivityFinal

Activity step by step analysis

Scenario								
Scenario name	Selection/Bidding							
Step No	**Event**	**Name of process/activity**	**Description of process/activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information exchanged (IDs)**	**Requirement, R-IDs**
2.2.2.1		Update forecast due to deviation		send	Forecast Provider (FCP)	Distribution System Operator (DS_O)	Info4-Forecast	
2.2.2.2		Update schedules		send	Generation Aggregator (GA)	Distribution System Operator (DS_O)	Info2-Schedule	
2.2.2.3		Update DS_O asset utilization			Distribution System Operator (DS_O)			
2.2.2.4		Predict congestions in DS_O grid	Repetition of 2.1.2.1		Distribution System Operator (DS_O)			
2.2.2.5		Solve congestions in DS_O grid with available flexibilities	Repetition of 2.1.2.2.		Distribution System Operator (DS_O)			
2.2.2.6		Aggregate schedules and remaining flexibilities per DS_O-TS_O grid node	Send, if threshold exceeded	send	Distribution System Operator (DS_O)	Transmission System Operator (TS_O)	Info2-Schedule	
2.2.2.7		TS_O congestion management	Repetition of 2.1.3.1., but		Transmission System			

			without European coordination process		Operator (TS_O)			
2.2.2.8		Solve congestions in TS_O grid with available flexibilities	Repetition of 2.1.3.2.	send	Transmission System Operator (TS_O)	Distribution System Operator (DS_O)	Info2-Schedule	
2.2.2.9		Segregate adjusted schedules	DS_O. Repetition of 2.1.4.1.		Distribution System Operator (DS_O)			
2.2.2.10		Verify feasibility of received schedules	Repetition of 2.1.4.2.		Distribution System Operator (DS_O)			
2.2.2.11		Adjust schedules, if needed	Repetition of 2.1.4.3.	send	Distribution System Operator (DS_O)	Generation Aggregator (GA)	Info2-Schedule	

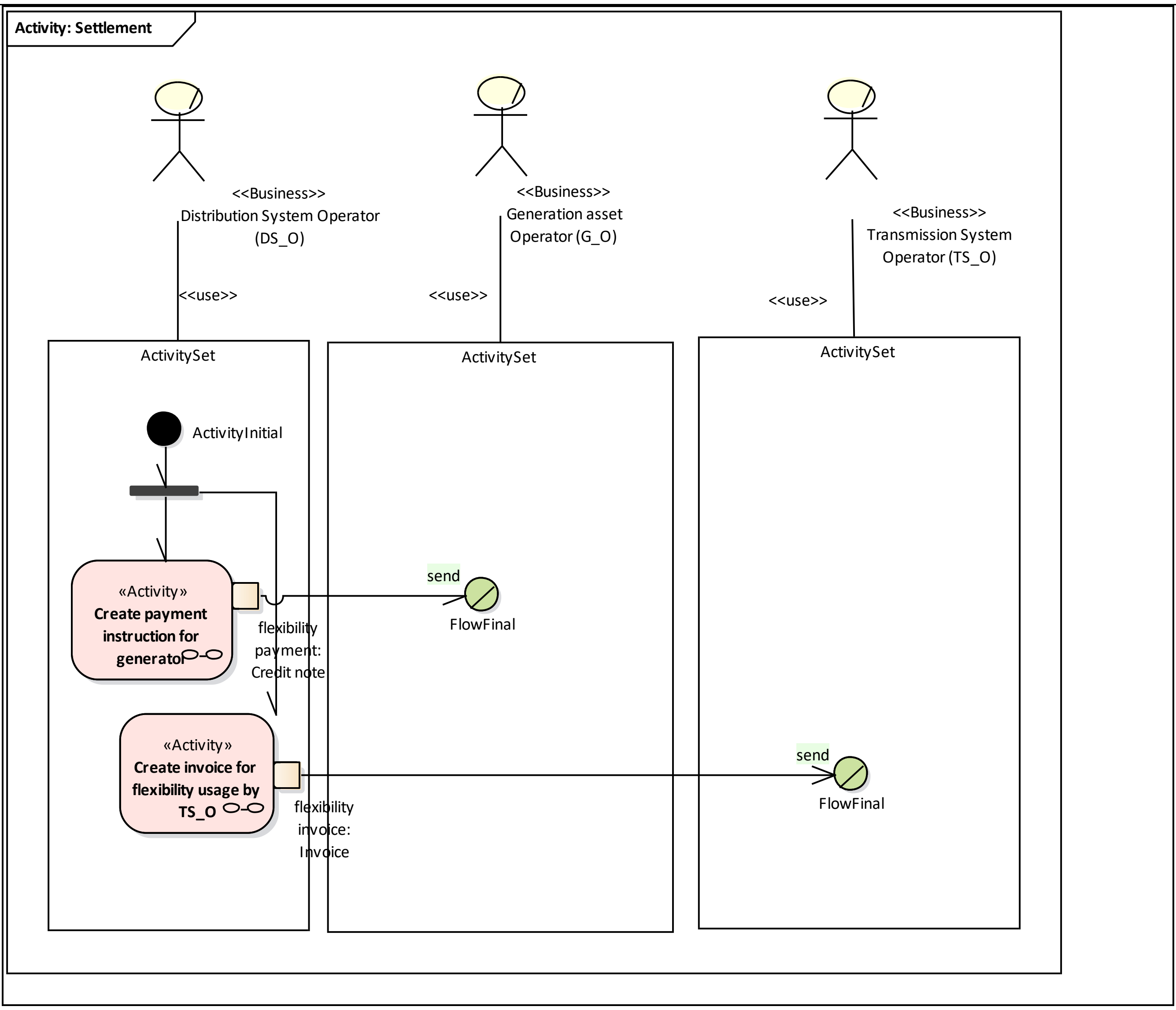
4.2.3 DELIVERY



Scenario step by step analysis

Scenario								
Scenario name	Delivery							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
3.1		Measure delivered flexibility		send	Metered Data Operator (MDO)	Distribution System Operator (DS_O)	Info5-Metered data	

4.2.4 SETTLEMENT



Scenario step by step analysis

Scenario								
Scenario name	Settlement							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
4.1		Create payment instruction for generator	According to regulation (different procedures for calculation of payment might apply, see Bundesnetzagentur:	send	Distribution System Operator (DS_O)	Generation asset Operator (G_O)	Info6-Credit note	

			"Leitfaden zum EEG-Einspeisemanagement")					
4.2		Create invoice for flexibility usage by TS_O	Including analysis which flexibilities the TS_O activated	send	Distribution System Operator (DS_O)	Transmission System Operator (TS_O)	Info7-Invoice	

5. INFORMATION EXCHANGED

Information exchanged			
Information exchanged, ID	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
Info1	Framework Agreement	Agreement from GA to send schedules per grid connection point day ahead after closure of related markets, but before 2:30pm. Updates of schedules will be sent by GA if a threshold of a certain amount is exceeded. Selection of cost compensation methodology is according to regulation.	
Info2	Schedule	Energy traded, FCR traded, aFRR traded, mFRR traded, potential for Redispatch, restriction in generation/load (all per 15 minutes), P/Q capabilitiy	
Info3	Grid asset utilization	Information about available assets and historical and actual usage of assets (utilization rate).	
Info4	Forecast	Generation of small RES with fixed feed-in tariff and load.	
Info5	Metered data	Contains metering data for billing process	
Info6	Credit note	Address of credit note receiver, generation asset number at grid connection point, time frame of flexibility activation, reimbursed specific flexibility costs in €/MWh, flexibility delivery in MWh, reimbursed total flexibility costs in €	
Info7	Invoice	Address of invoice receiver, time frame of flexibility activation, activated generation assets, specific flexibility costs in €/MWh per asset, total flexibility costs per asset in €, total flexibility costs in €, underlying regulation scheme	

TABLE 9 BUC DE-AP

Manage reactive power flexibility to support voltage control and congestion management in the German demo

Based on IEC 62559-2 edition 1
Generated from UML Use Case Repository with Modsarus® (EDF R&D Tool)

1. DESCRIPTION OF THE USE CASE

1.1 NAME OF USE CASE

Use case identification		
ID	***Area(s)/Domain(s)/Zone(s)***	***Name of use case***
DE-RP	Germany	Manage reactive power flexibility to support voltage control and congestion management in the German demo

1.2 VERSION MANAGEMENT

Version management				
Version No.	***Date***	***Name of author(s)***	***Changes***	***Approval status***
1	2018-04-27	MS, JB	First draft	
2	2018-05-14	MS, JB	Completion of description	
3	2018-05-16	FD	Integrated the BUC split + minor corrections	
4	2018-05-23	FD	Integration of updates	
5	2018-06-04	MS	Proposed version from demo	
6	2018-06-11	Cyril Effantin	Consolidation in a common UC repository	
7	2018-06-21	JB	Editorial improvements	
8	2018-06-26	FD	Textual modifications	
9	2018-07-26	Cyril Effantin	Minor UML fixes.	
10	2018-10-18	Cyril Effantin	Changes in role model and UML related parts.	

1.3 SCOPE AND OBJECTIVES OF USE CASE

Scope and objectives of use case	
Scope	This use case will explain how reactive power flexibilities from the distribution grid can be used to support reactive power management in the transmission grid, while respecting the distribution grid constraints on the one hand and using reactive power management in the distribution grid on the other hand. The timing of this use case in EU-SysFlex lasts from day ahead to real-time. Reactive power flexibilities are activated with operating signals to units.
Objective(s)	Offering further reactive power flexibility options for voltage control and congestion management to TSOs by activating flexibilities in the distribution grid
Related business case(s)	Voltage Control Congestion Management

1.4 NARRATIVE OF USE CASE

Narrative of use case
Short description
The BUC addresses the need of enhancing reactive power management coordination between TSOs and DSOs in order to optimize the flexibility use regarding constraints in distribution and transmission grid and therefore

reduce the overall system costs.

Reactive power management supports voltage control management and congestion management. The reason why to adjust reactive power flows will not be discussed in this BUC.

To solve congestions it is necessary to optimize the grid. Therefore, reactive power is needed as well as active power which is why there is a strong link between this reactive power management BUC and the active power management BUC.

Activation of reactive power will be carried out within real time via an operation signal directly to the unit, but the first approximation about available reactive power flexibilities will be sent day ahead to the TSO. This day ahead information indicates if there are major issues the DSO or TSO needs to react to with enhanced grid optimization. Therefore, this BUC describes the optimization of the distribution grid and aggregation of residual flexibilities for the TSO in order to optimize flexibility activation and thus system costs. The DSO will guarantee that no congestion in its distribution grid remains and no additional congestions in its distribution grid occurs when the TSO activates flexibilities for reactive/active power management or frequency reserve.

The day ahead process will be continued in an intraday timeline to react on faults or deviations in forecast.

The main innovations of the BUC are:

- DSO improves knowledge of TSO about interdependencies between TSO/DSO grid interconnection points when using flexibilities in the distribution grid
- DSO receives day ahead schedules of generators (RES and conventional) connected to its grid
- DSO informs TSO about aggregated available reactive power flexibilities in distribution grid
  o approximation day-ahead to detect violations
  o prediction with less deviation intraday to react to operational needs
- DSO considers in own congestion management possible activation of frequency products directly contracted by TSO
- DSO ensures that no constraints are violated in distribution grid if TSO activates flexibilities in distribution grid
- DSO activates units if TSO wants to activate flexibilities in the distribution grid

Complete description

1. Problem statement:

In 2030, an increasing share of RES is expected. Therefore, needed flexibilities have to be provided by RES. For the need of congestion management, please refer to the problem statement in the active power management BUC. Requirements of reactive power management will also increase, caused by high share of volatile feed-in and intended reliable energy supply.

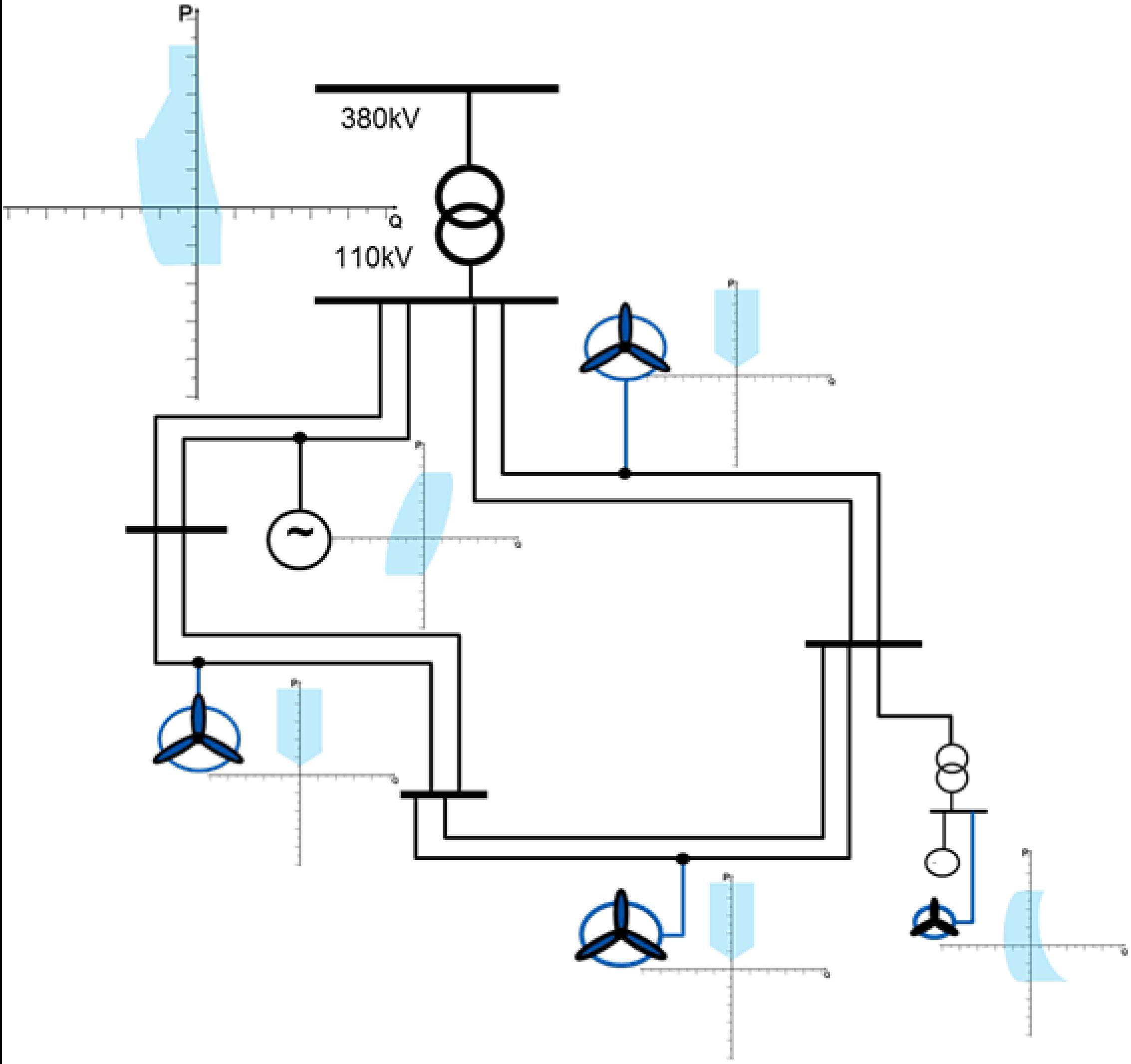
The following BUC will use all possible generator flexibilities in the distribution grid in order to receive the appropriate amount of reactive power in the transmission and distribution grid in the most cost-efficient way.

2. Goal of the use case

This use case enables TSOs to react on reactive power needs for congestion and voltage control management with a known flexibility at the DSO-TSO interface. Hence, TSOs can include the potential of units in the distribution grid to its own power flow analysis.

The aggregation of reactive power flexibility at the TSO-DSO-interface depends on physical constraints in the distribution grid. In addition the aggregation of reactive power flexibility does not solely depend on flexibility offered by connected units, it also depends on the transmission ability of the grid considering active power flows.

An example of the aggregation of different flexibilities in the active and reactive operating range towards the P/Q flexibility potential is shown in the following picture.



The strong link between active and reactive power management leads to a similar process for both BUCs. The differences are in the deviation of reactive power flow forecast compared to active power flow forecasts. To ensure the schedule of active power, reactive power flows can be adapted. In addition, the goal of this BUC is an efficient reactive power management and the support towards the TSO offering flexibilities from the distribution grid. The activation of reactive power provision is carried out in real time (compared to schedule-based active power activation)

3. Current underlying German electricity market design- Grid codes determine ranges of reactive power provision dependent on active power.

- Network operators must pay for any further reactive power provision. In case of additional need there is a bilateral negotiation between network operator and operator of the connected unit for contracting and paying

details. Therefore, there is no marketplace existing yet.
- Reactive power is activated in real time by the connected network operator.

4. Necessary modifications of the German market design for the BUC.For fulfilling the objectives of the BUC, no regulatory modifications are necessary. However, certain agreements between different actors are necessary, which are stated in section “1.6 use case conditions”.

5. Possible developments, making adaptions of market design necessary
Market for reactive power flexibility beyond grid code range, including billing process

<u>Detailed Steps:</u>
· Prequalification phase :
Generation Aggregator (GA) and Distribution Network Operator (DSO) sign an agreement that the GA sends schedules of planned generation, contracted frequency reserve, flexibility potential and flexibility costs day ahead.

· Selecting/Bidding phase:
In the following description “schedules” are mentioned for active power as precise value. For reactive power, an approximated value is used in planning processes due to unstable external influences of reactive power flows (e.g. weather). The approximation becomes more precise while continuing the day ahead process in intraday. Close to real time the value is as exact as needed to set an operating point. The activation of reactive power via a direct signal to the unit to set the unit’s operating point is carried out in real time.
In day ahead, the different GA submit their generation schedules, containing data about planned generation, contracted frequency reserve capacity as well as residual flexibility/ReDispatch potential and its flexibility price. For small units without a schedule (small RES, household loads, etc.), forecasts will be used to predict their generation/consumption. Reactive power flexibility potential is derived by the active power schedule and the settled P/Q-range in the grid connection contract (based on grid codes).
The DSO aggregates the different flexibilities day ahead after gate closure of the day-ahead markets. Afterwards, the DSO performs a load flow analysis based on individual schedules of generation units and industrial loads and the forecasted aggregated schedules of small generation and loads. If congestions or voltage range deviations* are forecasted, the DSO selects available flexibilities (based on a price and sensitivity decision) to solve these limit violations in its own grid. In a next step, the DSO submits the remaining flexibility potential to the TSO at each TSO-DSO interconnection point. The DSO guarantees that the remaining flexibility is not violating any distribution grid constraints. Therefore, an optimization of conditions in the distribution grid is necessary. This optimization includes active and reactive power flows to find an overall optimum.
DSO and TSO determine which flexibilities shall be activated based on their physical location and price, e.g. if resources from the distribution grid are selected, the TSO sends an adjusted aggregated schedule to the DSO (aggregated at the level of the TSO-DSO interface) for active power, which influences the flexibility potential of reactive power. In case of the use of reactive power flexibility the coordination process to set the operating

point for the interface starts close to real time, so that the DSO can segregate the operating point for each unit. The DSO sends the activation signals to the generation units providing the flexibility in real time.
* In Section 4.2 ("Steps – Scenarios"), "congestions" refer to violations of both voltage and current limits. However, reactive power flexibility is mostly used to prevent violations of voltage limits.

· Delivery phase:
The delivery of flexibility is proven by metered data sent from the Metered Data Operator (MDO) to the DSO.

· Settlement phase
Settlement, i.e. sending invoices and paying for the flexibility activation, is not needed in this BUC as the use of reactive power flexibility is offered via a grid connection contract (range as stated in grid codes) .

Summary of use case

- **Prequalification**
  Description:
    - Send framework agreement with schedule delivery requirements
      Description: Schedules: planned generation, flexibility potential and opportunity costs
    - Send signed framework agreement
      Description:
- **Selection/Bidding**
  Description: Day ahead and intraday
    - **Day ahead process**
      Description:
        - **DS_O receives day ahead schedules from GA and FCP**
          Description:
            - Create day ahead operation schedule (planned energy trading) and potential flexibilities
              Description: Schedules: planned generation per grid connection node incl. contracted frequency reserve, flexibility potential and opportunity costs
            - Create planned grid asset utilization
              Description: FCP needs planned grid asset utilization data for improved forecast
            - Forecast small generation and load
              Description: Small generation: with fixed feed-in tariff (no need to send schedules, TS_O is GA and markets the energy)
        - **DS_O predicts schedule adjustments for own congestions and sends Merit Order List (MOL) to TS_O**
          Description:
            - Predict congestions in DS_O grid
              Description: calculating approximate reactive power flow

- Solve congestions in DS_O grid with available flexibilities
  Description: if necessary adjusting reactive power flow and limiting remaining flexibilities of generators

- Aggregate schedules and remaining flexibilities per DS_O-TS_O grid node
  Description: Only reactive power potentials, no active power.

- **TS_O congestion management: use of offered flexibilities (in own grid or from DS_O's aggregated MOL)**
  Description:

  - TS_O congestion forecast
    Description: European coordination process, predicting congestions in own grid

  - Solve congestions in TS_O grid with available flexibilities
    Description:

- **DS_O verifies schedule**
  Description:

  - Segregate adjusted schedules
    Description: For each plant. Only reactive power-potentials.

  - Verify feasibility of grid to perform received schedules
    Description: In combination with adjusted active power schedules simulation if received reactive power adjustments cause congestions (repetition of 2.1.2.1)

- **Intraday process**
  Description:

  - **Update process if TS_O changes its already adjusted schedule**
    Description:

    - Update aggregated schedules
      Description: If need of DS_O's flexibilities occur

    - Segregate aggregated schedules
      Description: For each plant in DS_O grid. Only Q-potentials, no active power.

    - Verify feasibility of grid to perform received schedules
      Description: In combination with adjusted active power schedules simulation if received reactive power adjustments cause congestions (repetition of 2.1.2.1)

  - **Update process in case of deviations in DS_O grid**
    Description:

    - Update forecast due to deviation
      Description:

    - Update schedules
      Description:

- Update asset utilization
  Description: Due to faults (e.g. line tripping)

- Predict congestions in DS_O grid
  Description: Repetition of 2.1.2.1

- Solve congestions in DS_O grid with available flexibilities
  Description: Repetition of 2.1.2.2

- Aggregate schedules and remaining flexibilities per DS_O-TS_O grid node
  Description: Repetition of 2.1.2.3.

- Predict congestion in TS_O grid
  Description: Where necessary coordination with other TS_Os

- Solve congestions in TS_O grid with available flexibilities
  Description: if necessary limiting remaining flexibilities at DS_O-TS_O-connection-point; Repetition of 2.1.3.2.

- Segregate adjusted schedules
  Description: Repetition of 2.1.4.1.

- Verify feasibility of grid to perform received schedules
  Description: Repetition of 2.1.4.2.

- **Close to Real Time process**
  Description:

  - **TS_O indicates use of reactive power flexibility**
    Description:

    - Create aggregated need of reactive power flexibility
      Description:

    - Segregate aggregated need of flexibility
      Description: set operating point for each unit in DS_O grid

    - Verify feasibility of flexibility
      Description: considering constraints in maximum adjustment per timeframe, e.g. 3 Mvar per 2 minutes

    - Create operating point
      Description:

  - **TS_O doesn't indicate use of reactive power flexibility**
    Description:

    - Create need of reactive power flexibility
      Description: DS_O optimizes reactive power flows, considering losses in grid, voltage control and constraints in maximum adjustment per timeframe, e.g. 3 Mvar per 2 minutes

- Create operating point
  Description:

- **Delivery**
  Description: (close to real time)
  - Measure delivered flexibility
    Description:
- **Settlement**
  Description: not needed for demonstration

1.5 KEY PERFORMANCE INDICATORS (KPI)

1.6 USE CASE CONDITIONS

	Use case conditions
	Assumptions
1	Regulatory framework stays the same: Reactive power delivery per grid code mandate without compensation within certain range (grid connection contract) - no billing process needed in BUC. Assumption, that in BUC/demonstrator no reactive power potential beyond grid connection contract is necessary.
	Prerequisites
1	Wrong schedules: It has to be discussed with the TSO, if penalties for wrong schedules are used in the ReDispatch process.
2	TSO/DSO coordination mechanism: TSO agrees with DSO to activate flexibilities for reactive power management and voltage control (i.e. frequency reserve methodology is not changed) using the Merit Order List at the TSO-DSO-interface in order to avoid pushing each other in congestions
3	Communication process: is fixed with defined information paths.
4	Schedules per grid connection point: Generation Aggregators (GA) with units in the distribution grid agree with DSO to send schedules, flexibility potential and opportunity costs day-ahead. In return, the DSO sends the curtailment signals to the GA day-ahead so that the GA has time to optimize the balance group.
5	Relevance thresholds for sending updated data: has to be agreed with TSO
6	Flexibility aggregation: The DSO aggregates the available flexibility, considering the sensitivity of the flexibility at the TSO-DSO-interface and submits the Merit Order List of the flexibilities to the TSO (therefore no commercial activity, only data routing/aggregation/evaluation).
7	Assets used: For reactive power management, the demonstrator focuses on flexibilities of RES, CHP and conventional generators at 110 kV level. Potential assets: The demonstrator is technically designed for all kind of generators and loads at every voltage level.
8	Grid data calculation (e.g. state estimation): It will be updated continuously for load flow calculation and sensitivity analysis

1.7 FURTHER INFORMATION TO THE USE CASE FOR CLASSIFICATION/MAPPING

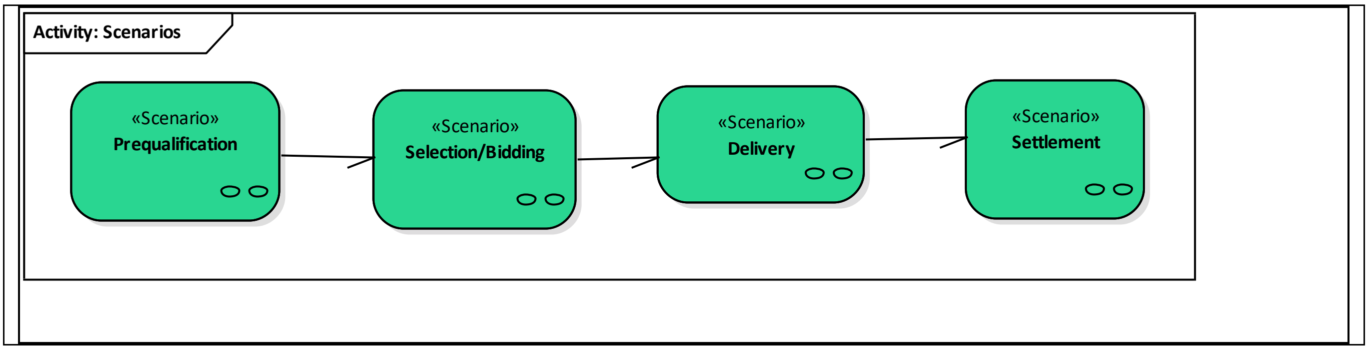
Classification information
Relation to other use cases
Level of depth
BUC for German Demo WP6
Prioritisation
Generic, regional or national relation
solving regional problems, European deployment
Nature of the use case
BUC
Further keywords for classification

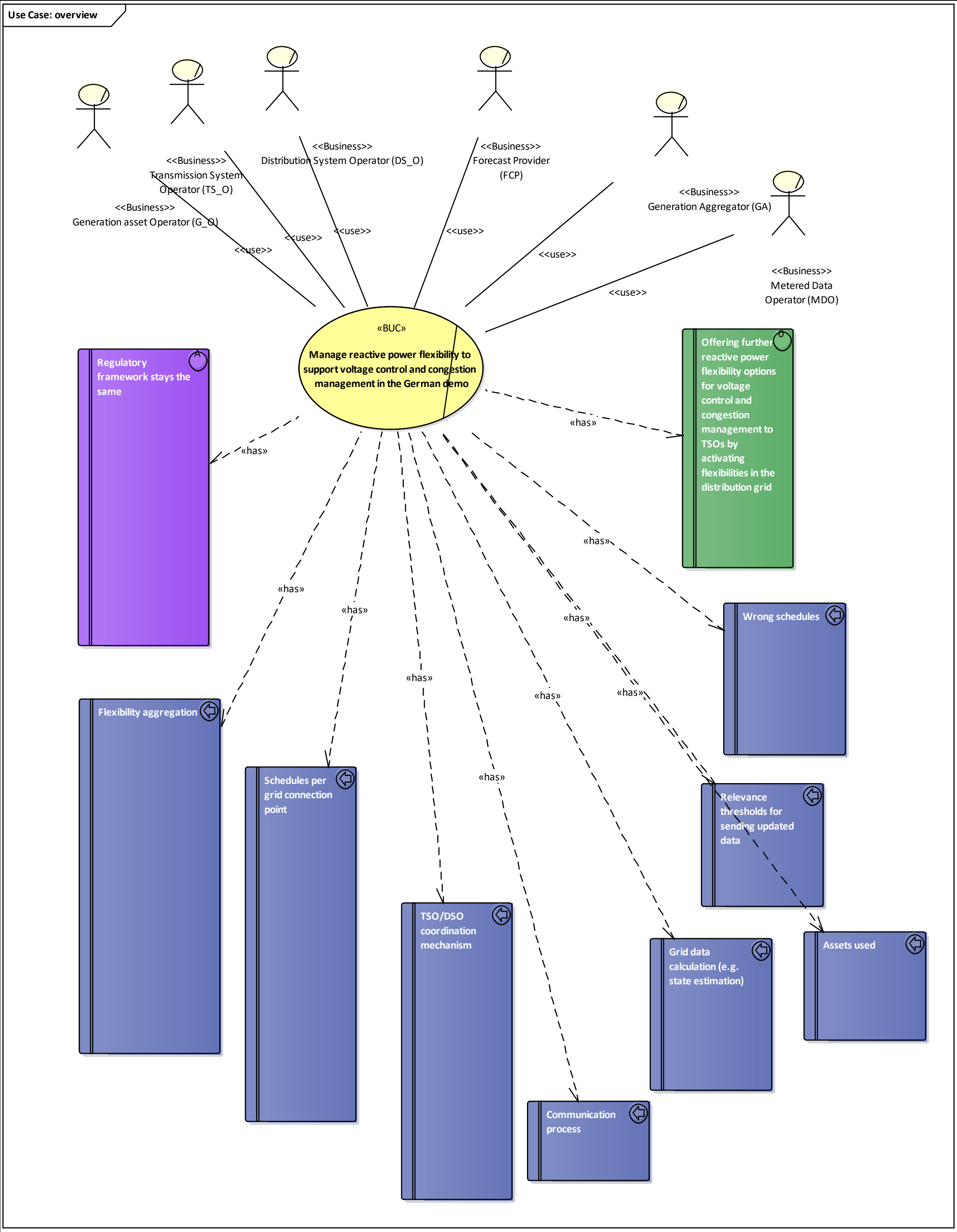
1.8 GENERAL REMARKS

General remarks
GeneralRemarks1: This use case supports the TSO with flexibilities from distribution grid. The DSO aggregates predicted available flexibilities per grid node as support. Consequently, cooperation between TSO and DSO is necessary.

2. DIAGRAMS OF USE CASE

Diagram(s) of use case


Activity: Scenarios
«Scenario»
Prequalification
«Scenario»
Selection/Bidding
«Scenario»
Delivery
«Scenario»
Settlement



3. TECHNICAL DETAILS

3.1 ACTORS

Actors

Grouping (e.g. domains, zones)		***Group description***	
Actor name	***Actor type***	***Actor description***	***Further information specific to this use case***
Generation asset Operator (G_O)	Business	Operate one or several generation asset(s)	Processes reactive power operating signals
Distribution System Operator (DS_O)	Business	Elaborate network development plan (including defining system needs for distribution) Ensure a transparent and non-discriminatory access to the distribution network for each user Operate the distribution grid over a specific region in a secure, reliable and efficient way Optimize system operation distribution grid from planning to real-time, using available levers (grid expansion, flexibility activation,...) Assess network status of the distribution grid and broadcast selected information of the network status to eligible actors (e.g. aggregators, other system operators) Support the Transmission System Operator in carrying out its responsibilities (including load shedding) and coordinate measures if necessary	Technical aggregation of residual flexibility potential towards TSO
Metered Data Operator (MDO)	Business	Provide metered data to authorized users in a transparent and non-discriminatory manner	
Generation Aggregator (GA)	Business	Aggregate and maximize value of generation portfolio resources Provide flexibility by generation assets to the system operators	Role is taken over by TSO for small RES and CHP generation with fixed feed-in tariff.
Forecast Provider (FCP)	Business	Provide forecasts of RES, small generation and consumption load based	Forecasts small RES (which don’t need a schedule due to fixed tariff), small generation and consumption load based

		on different data (e.g. weather data and historical load flow) to other roles	on different data (e.g. weather data and historical load flow)
Transmission System Operator (TS_O)	Business	Elaborate network development plan (including defining system needs for transmission) Ensure a transparent and non-discriminatory access to the transmission network for each user Operate the transmission grid over a specific region in a secure, reliable and efficient way Secure and manage in real time the physical generation-consumption balance on a geographical perimeter, including ensuring the frequency control service Optimize transmission system operation from planning to real-time, using available levers (grid expansion, flexibility activation,...) Assess network status of the transmission grid and broadcast selected information of the network status to eligible actors (e.g. aggregators, other system operators) Provide data to the interconnection capacity market operator for the management of cross border transactions In critical situations, implement dedicated actions and deliver alerts during stress events If necessary, implement emergency measures (e.g. system defence plan) including load shedding	Uses interface to DSO to select flexibilities at DSO grid for own reactive power management

3.2 REFERENCES

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

1	Law	Generation and Load Data Provision Methodology	active	Data exchange procedures	European Commission	
2	Law	EnWG, EEG, ARegV	active	Flexibility usage, coordination TSO/DSO, compensation for active power flexibility towards Genetor Operator, cost recognition for active power flexibility (TSO and DSO)	German legislation	
3	Guideline	UCTE Operation Handbook	active	ReDispatch Process, Coordination European grid operators, applicable standards for grid operation	ENTSO-E	
4	Guideline	System Operation Guideline	in development	Data exchange procedures	European Commission	
5	Standard	ISO 27019	active	Information security management for energy grids	International Organization for Standardization	
6	Guideline	Leitfaden zum Einspeisemanagement 2.1	active	Methodology for calculation of flexibility cost compensation towards G_O	German Regulation Agency (Bundesnetzagentur)	
7	Guideline	Technische Anschlussbedingungen Hochspannungsnetz	active	Reactive power provision requirements for connected assets	MITNETZ STROM	

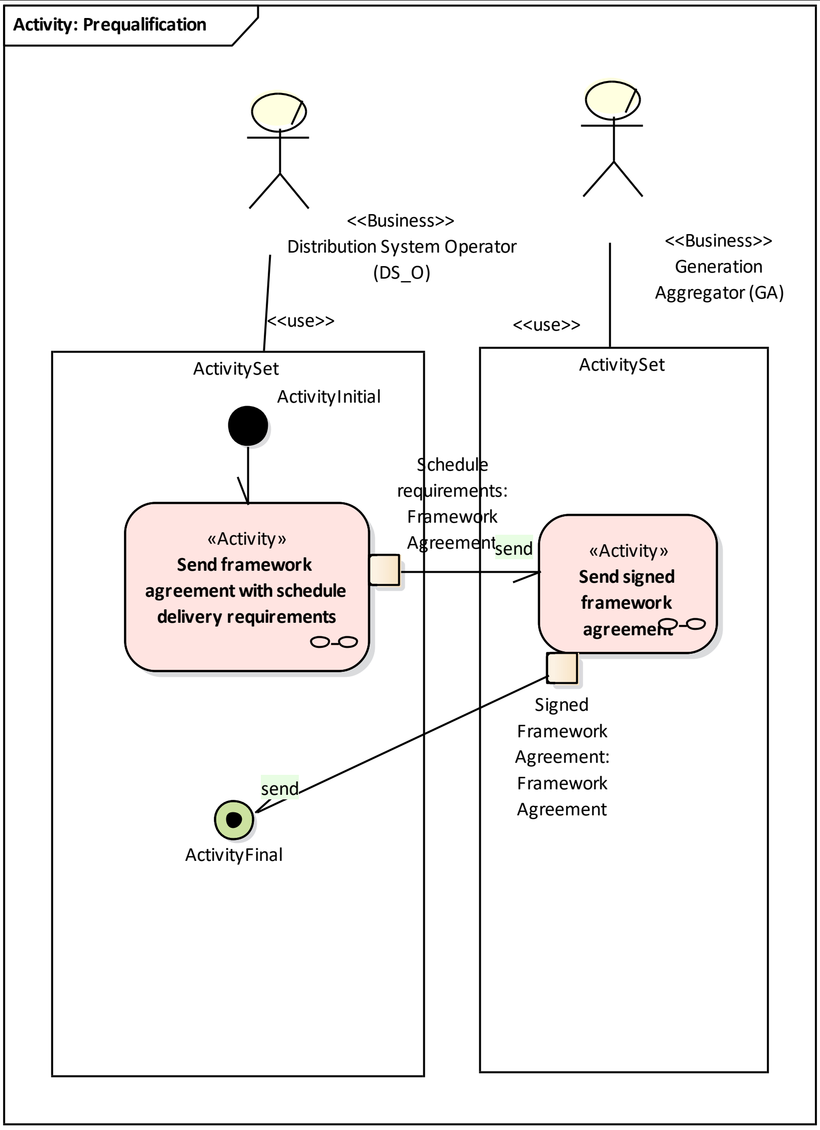
4. STEP BY STEP ANALYSIS OF USE CASE

4.1 OVERVIEW OF SCENARIOS

Scenario conditions						
No.	***Scenario name***	***Scenario description***	***Primary actor***	***Triggering event***	***Pre-condition***	***Post-condition***
1	Prequalification					
2	Selection/Bidding	Day ahead and intraday				
3	Delivery	(close to real time)				
4	Settlement	not needed for demonstration				

4.2 STEPS - SCENARIOS

4.2.1 PREQUALIFICATION



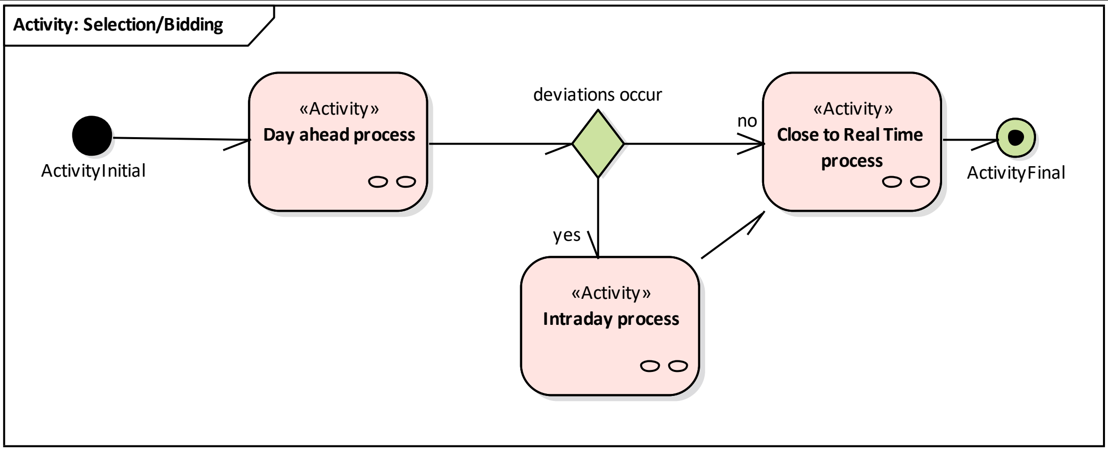
Scenario step by step analysis

Scenario								
Scenario name	Prequalification							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
1.1		Send framework agreement with	Schedules: planned generation,	send	Distribution System	Generation Aggregator (GA)	Info1-Framework Agreement	

		schedule delivery requirements	flexibility potential and opportunity costs		Operator (DS_O)			
1.2		Send signed framework agreement		send	Generation Aggregator (GA)	Distribution System Operator (DS_O)	Info1-Framework Agreement	

4.2.2 SELECTION/BIDDING

Day ahead and intraday

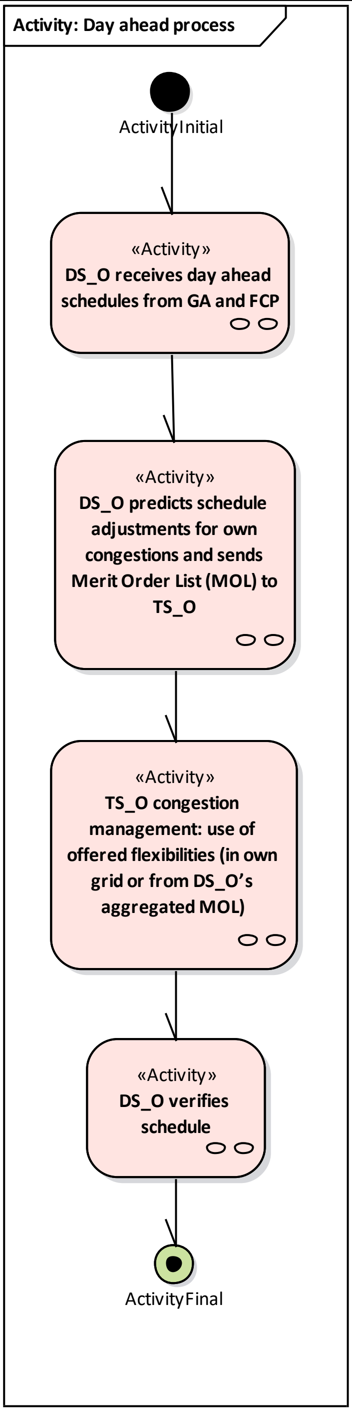


Scenario step by step analysis

Scenario								
Scenario name	Selection/Bidding							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
2.1		Day ahead process						
2.2		Intraday process						
2.3		Close to Real Time process						

- 2.1. Day ahead process

Business section: Selection/Bidding/Day ahead process



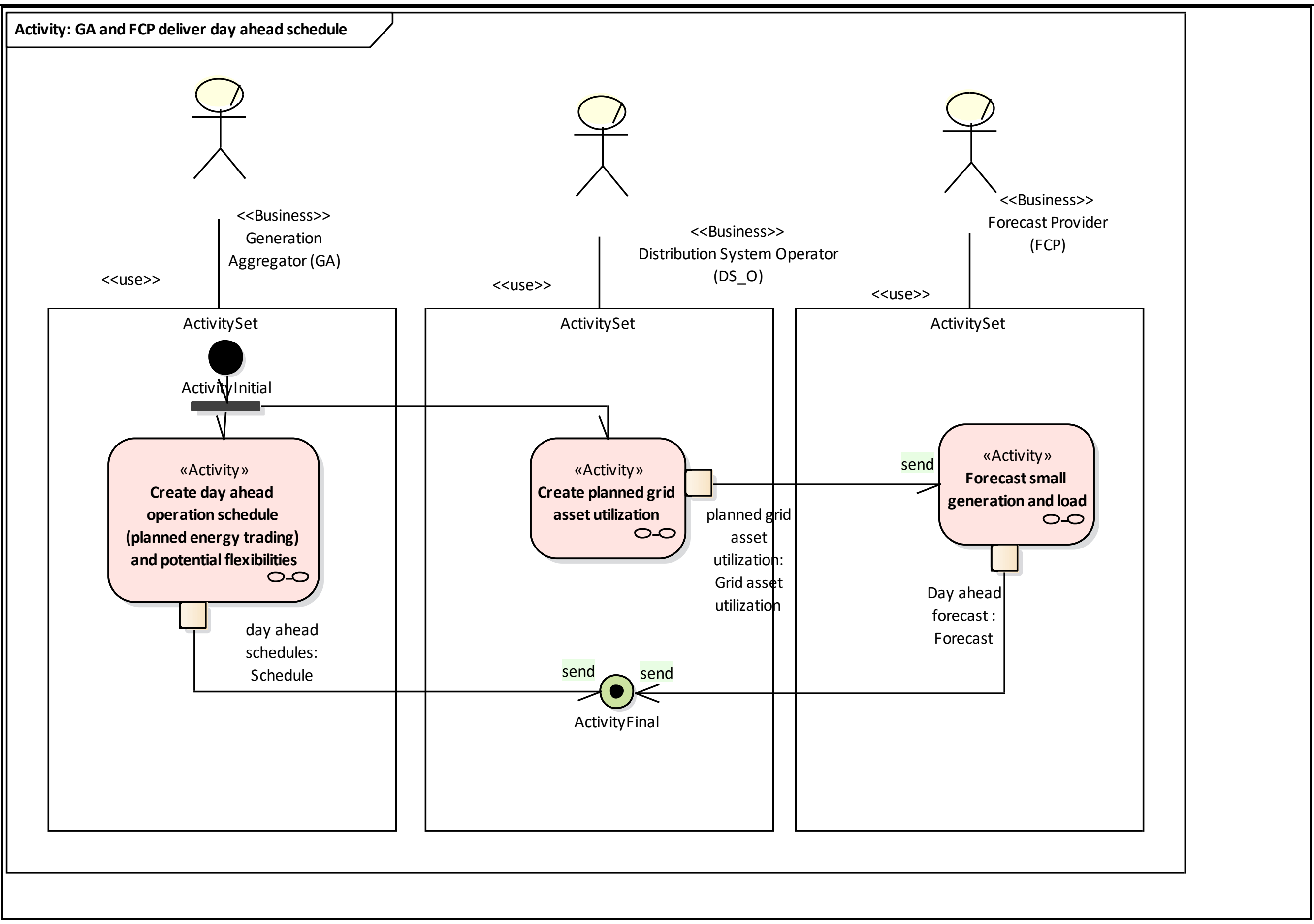
Activity step by step analysis

Scenario	
Scenario name	Selection/Bidding

Step No	*Event*	*Name of process/activity*	*Description of process/activity*	*Service*	*Information producer (actor)*	*Information receiver (actor)*	*Information exchanged (IDs)*	*Requirement, R-IDs*
2.1.1		DS_O receives day ahead schedules from GA and FCP						
2.1.2		DS_O predicts schedule adjustments for own congestions and sends Merit Order List (MOL) to TS_O						
2.1.3		TS_O congestion management: use of offered flexibilities (in own grid or from DS_O's aggregated MOL)						
2.1.4		DS_O verifies schedule						

- 2.1.1. DS_O receives day ahead schedules from GA and FCP

Business section: Selection/Bidding/Day ahead process/DS_O receives day ahead schedules from GA and FCP



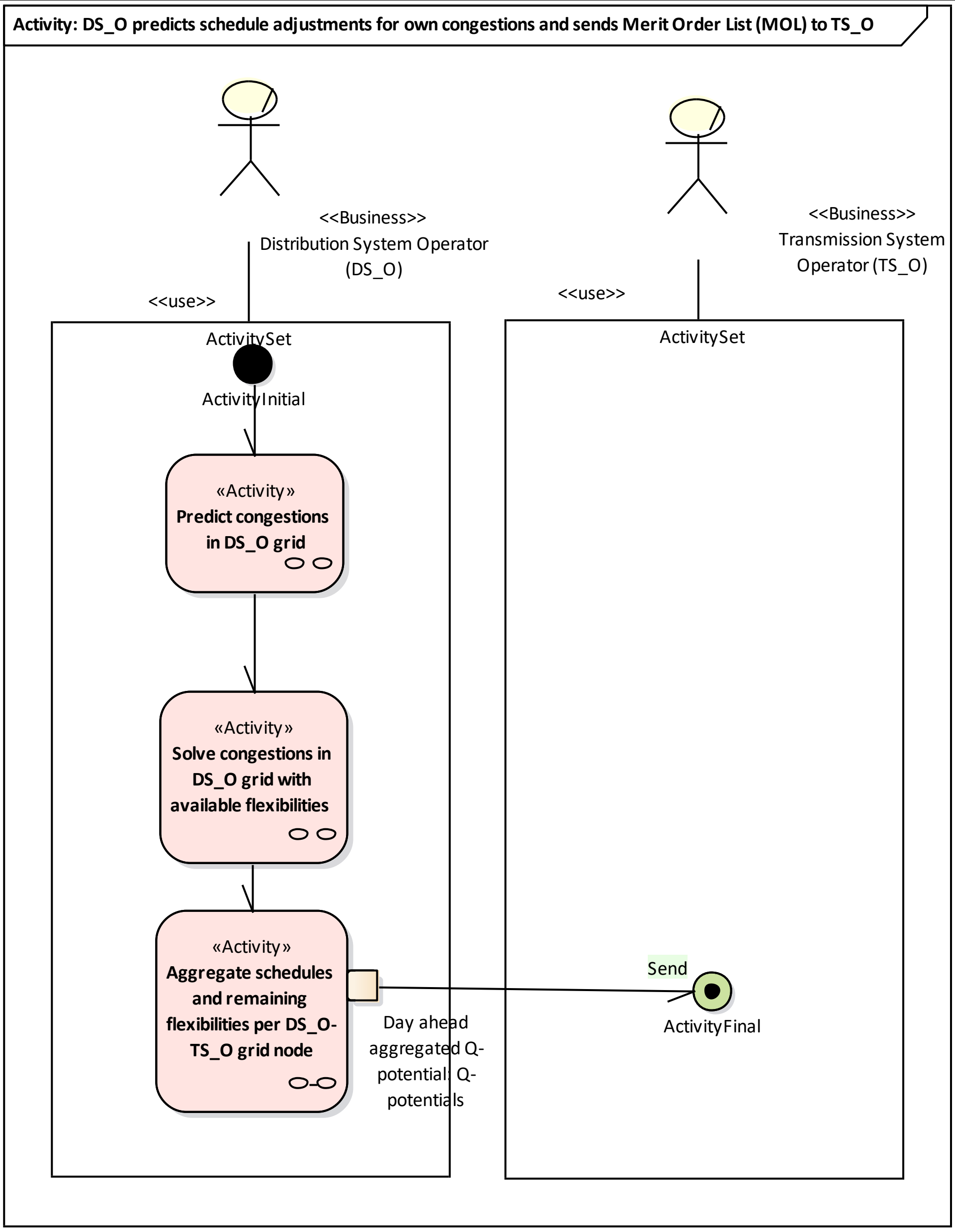
Activity step by step analysis

Scenario								
Scenario name	Selection/Bidding							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
2.1.1.1		Create day ahead operation schedule (planned energy trading) and potential flexibilities	Schedules: planned generation per grid connection node incl. contracted frequency reserve, flexibility potential and opportunity costs	send	Generation Aggregator (GA)	Distribution System Operator (DS_O)	Info2-Schedule	

2.1.1.2		Create planned grid asset utilization	FCP needs planned grid asset utilization data for improved forecast	send	Distribution System Operator (DS_O)	Forecast Provider (FCP)	Info3-Grid asset utilization	
2.1.1.3		Forecast small generation and load	Small generation: with fixed feed-in tariff (no need to send schedules, TS_O is GA and markets the energy)	send	Forecast Provider (FCP)	Distribution System Operator (DS_O)	Info4-Forecast	

- 2.1.2. DS_O predicts schedule adjustments for own congestions and sends Merit Order List (MOL) to TS_O

Business section: Selection/Bidding/Day ahead process/DS_O predicts schedule adjustments for own congestions and sends Merit Order List (MOL) to TS_O



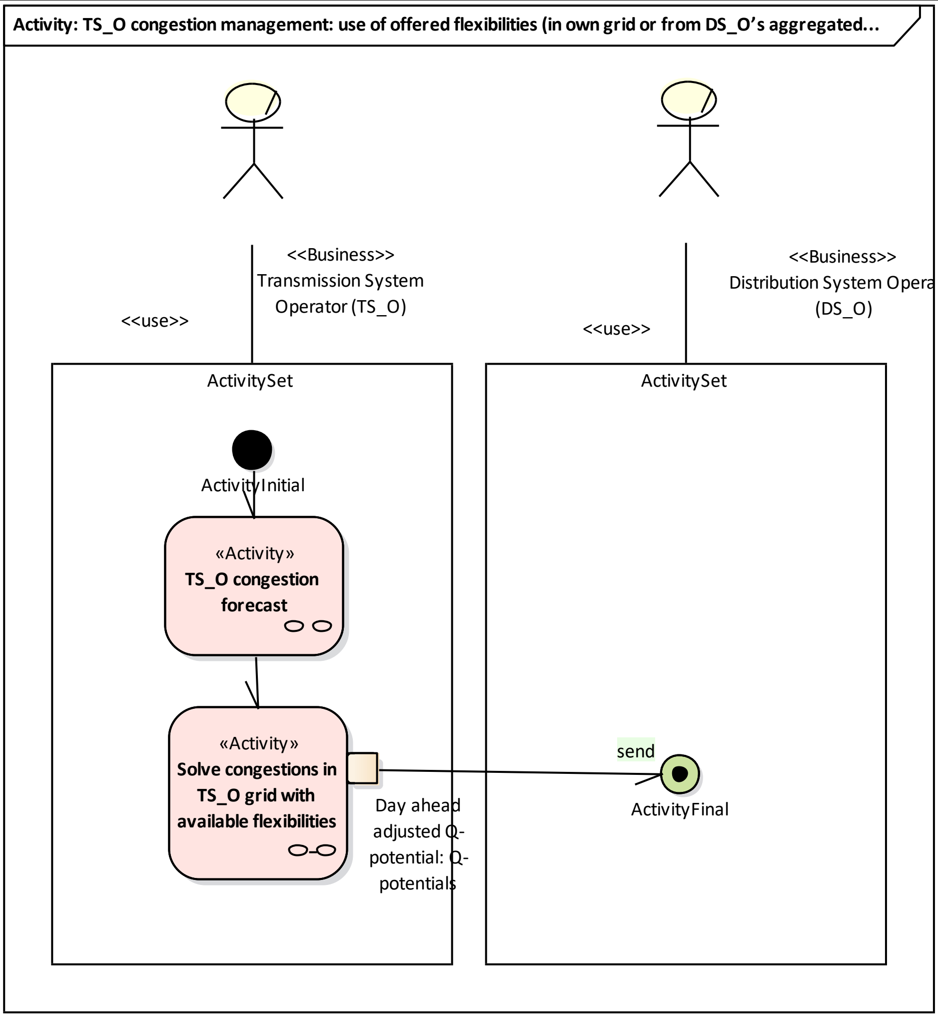
Activity step by step analysis

Scenario								
Scenario name	Selection/Bidding							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
2.1.2.1		Predict congestions in DS_O grid	calculating approximate		<u>Distribution System</u>			

			reactive power flow		Operator (DS_O)			
2.1.2.2		Solve congestions in DS_O grid with available flexibilities	if necessary adjusting reactive power flow and limiting remaining flexibilities of generators		Distribution System Operator (DS_O)			
2.1.2.3		Aggregate schedules and remaining flexibilities per DS_O-TS_O grid node	Only reactive power potentials, no active power.	Send	Distribution System Operator (DS_O)	Transmission System Operator (TS_O)	Info5-Q-potentials	

- 2.1.3. TS_O congestion management: use of offered flexibilities (in own grid or from DS_O's aggregated MOL)

Business section: Selection/Bidding/Day ahead process/TS_O congestion management: use of offered flexibilities (in own grid or from DS_O's aggregated MOL)



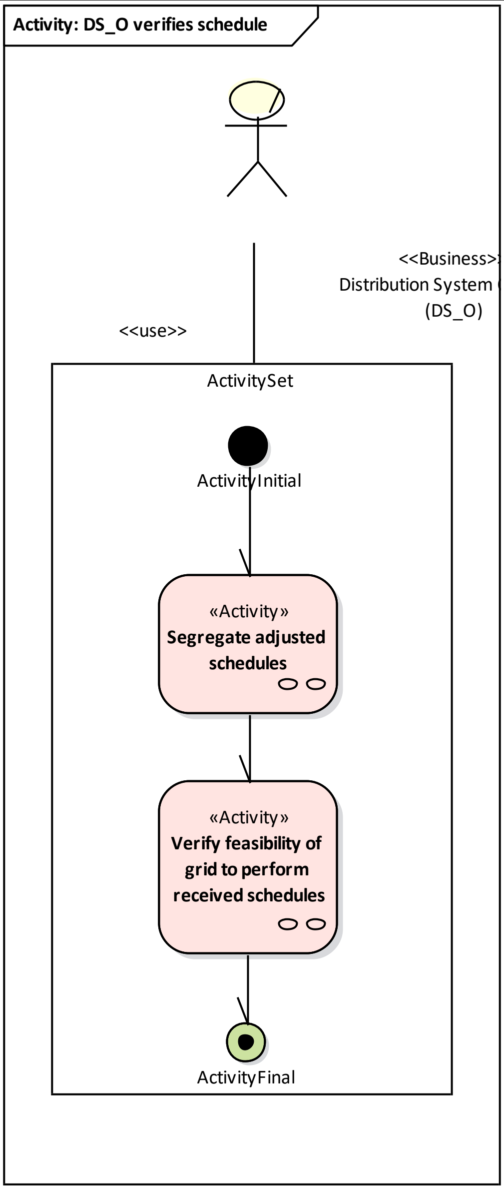
Activity step by step analysis

Scenario								
Scenario name	Selection/Bidding							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
2.1.3.1		TS_O congestion forecast	European coordination process, predicting congestions in own grid		Transmission System Operator (TS_O)			

2.1.3.2		Solve congestions in TS_O grid with available flexibilities		send	Transmission System Operator (TS_O)	Distribution System Operator (DS_O)	Info5-Q-potentials	

- 2.1.4. DS_O verifies schedule

Business section: Selection/Bidding/Day ahead process/DS_O verifies schedule



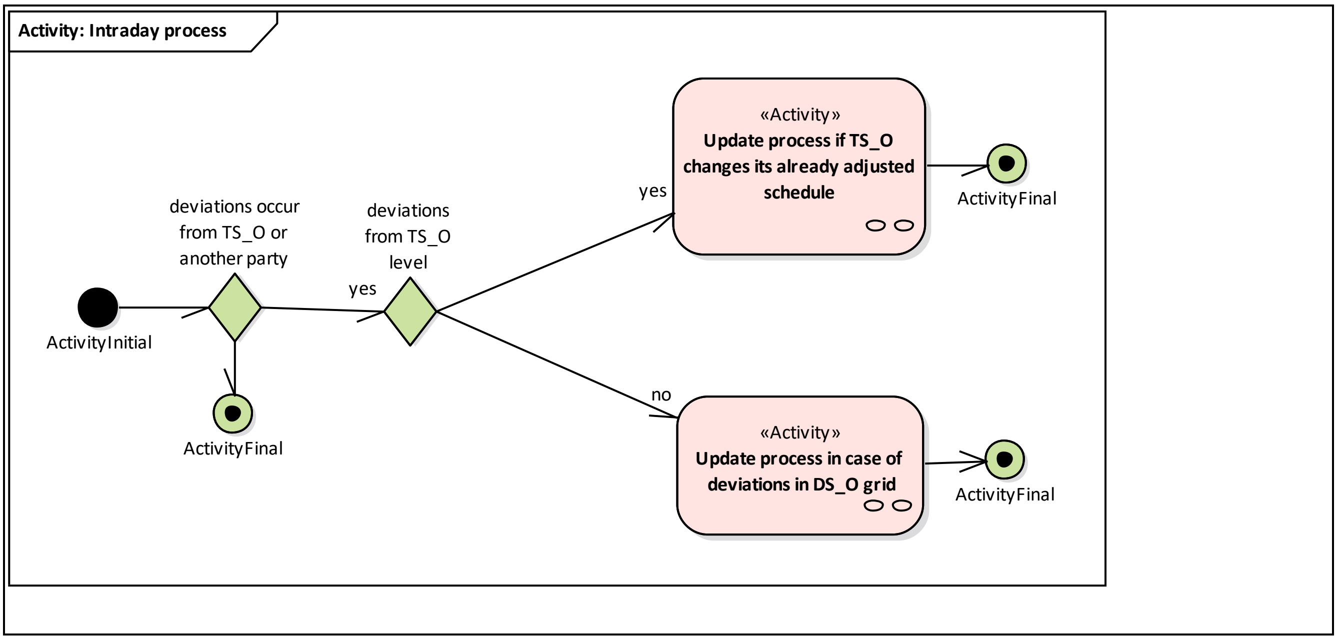
Activity step by step analysis

Scenario

Scenario name	Selection/Bidding							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
2.1.4.1		Segregate adjusted schedules	For each plant. Only reactive power-potentials.		Distribution System Operator (DS_O)			
2.1.4.2		Verify feasibility of grid to perform received schedules	In combination with adjusted active power schedules simulation if received reactive power adjustments cause congestions (repetition of 2.1.2.1)		Distribution System Operator (DS_O)			

- 2.2. Intraday process

Business section: Selection/Bidding/Intraday process

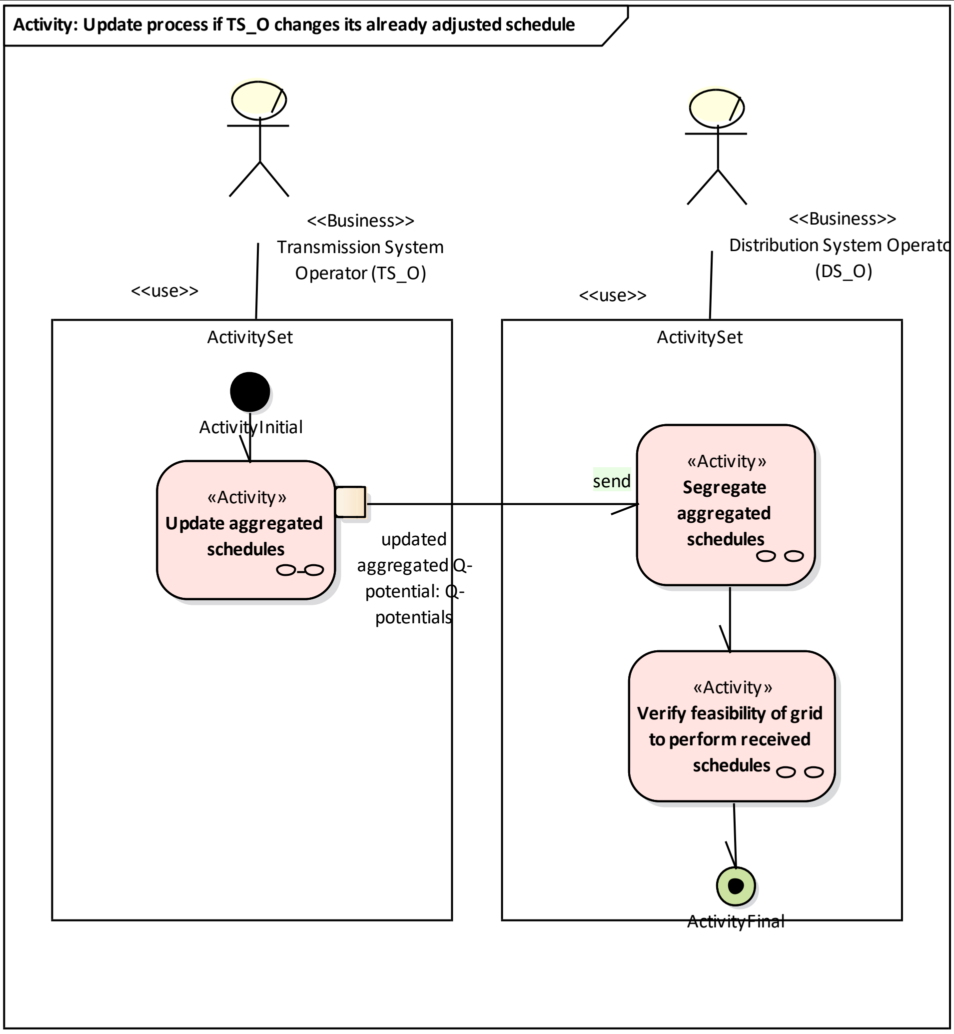


Activity step by step analysis

Scenario								
Scenario name	Selection/Bidding							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
2.2.1		Update process if TS_O changes its already adjusted schedule						
2.2.2		Update process in case of deviations in DS_O grid						

- 2.2.1. Update process if TS_O changes its already adjusted schedule

Business section: Selection/Bidding/Intraday process/Update process if TS_O changes its already adjusted schedule



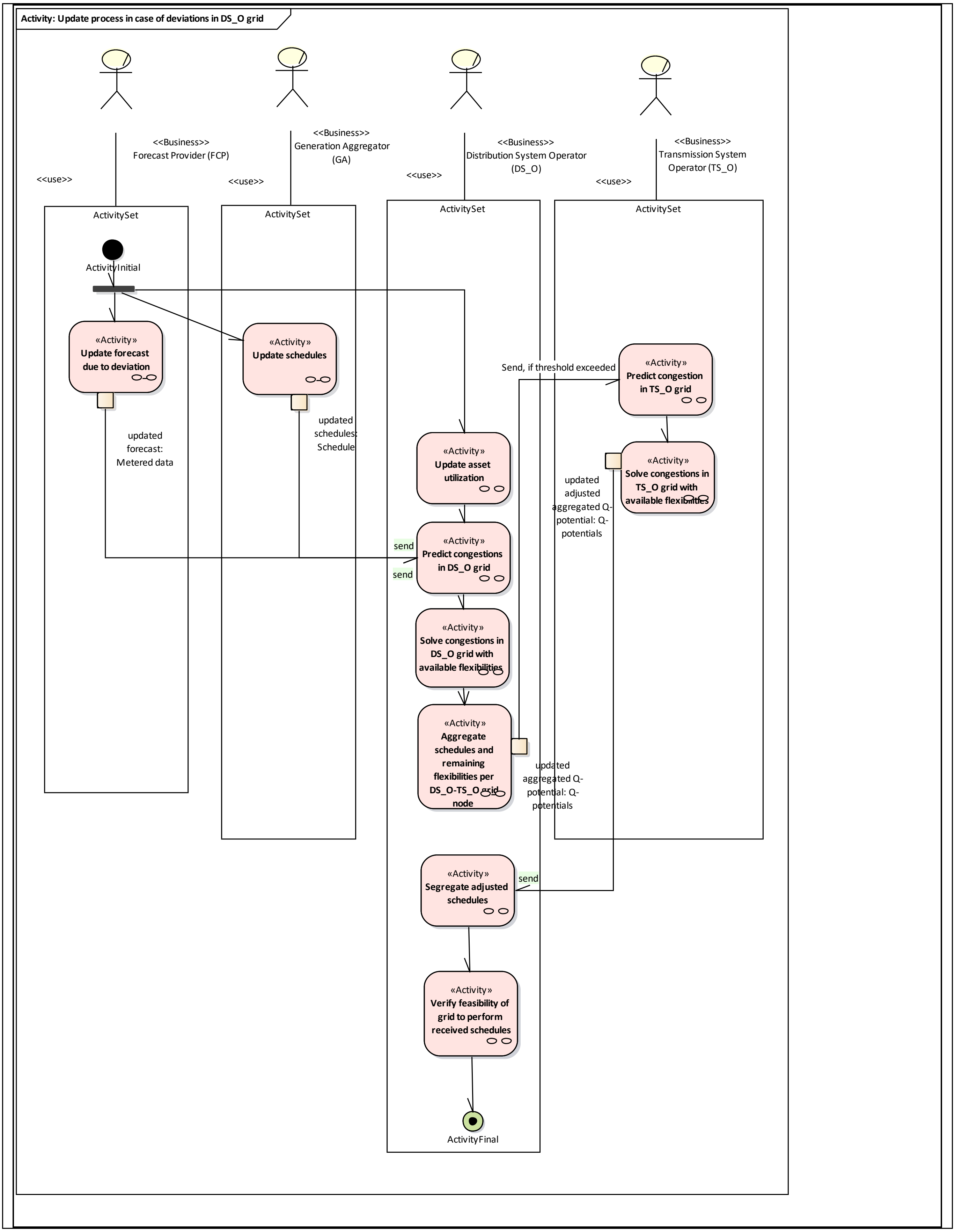
Activity step by step analysis

Scenario								
Scenario name	Selection/Bidding							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
2.2.1.1		Update aggregated schedules	If need of DS_O's flexibilities occur	send	Transmission System Operator (TS_O)	Distribution System Operator (DS_O)	Info5-Q-potentials	
2.2.1.2		Segregate aggregated schedules	For each plant in DS_O grid. Only Q-		Distribution System			

			potentials, no active power.		Operator (DS_O)			
2.2.1.3		Verify feasibility of grid to perform received schedules	In combination with adjusted active power schedules simulation if received reactive power adjustments cause congestions (repetition of 2.1.2.1)		Distribution System Operator (DS_O)			

- 2.2.2. Update process in case of deviations in DS_O grid

Business section: Selection/Bidding/Intraday process/Update process in case of deviations in DS_O grid


Activity: Update process in case of deviations in DS_O grid
<<Business>> Forecast Provider (FCP)
<<Business>> Generation Aggregator (GA)
<<Business>> Distribution System Operator (DS_O)
<<Business>> Transmission System Operator (TS_O)
<<use>>
<<use>>
<<use>>
<<use>>
ActivitySet
ActivitySet
ActivitySet
ActivitySet
ActivityInitial
«Activity» Update forecast due to deviation
«Activity» Update schedules
updated forecast: Metered data
updated schedules: Schedule
«Activity» Update asset utilization
send
send
«Activity» Predict congestions in DS_O grid
«Activity» Solve congestions in DS_O grid with available flexibilities
«Activity» Aggregate schedules and remaining flexibilities per DS_O-TS_O grid node
updated aggregated Q-potential: Q-potentials
Send, if threshold exceeded
«Activity» Predict congestion in TS_O grid
«Activity» Solve congestions in TS_O grid with available flexibilities
updated adjusted aggregated Q-potential: Q-potentials
«Activity» Segregate adjusted schedules
send
«Activity» Verify feasibility of grid to perform received schedules
ActivityFinal

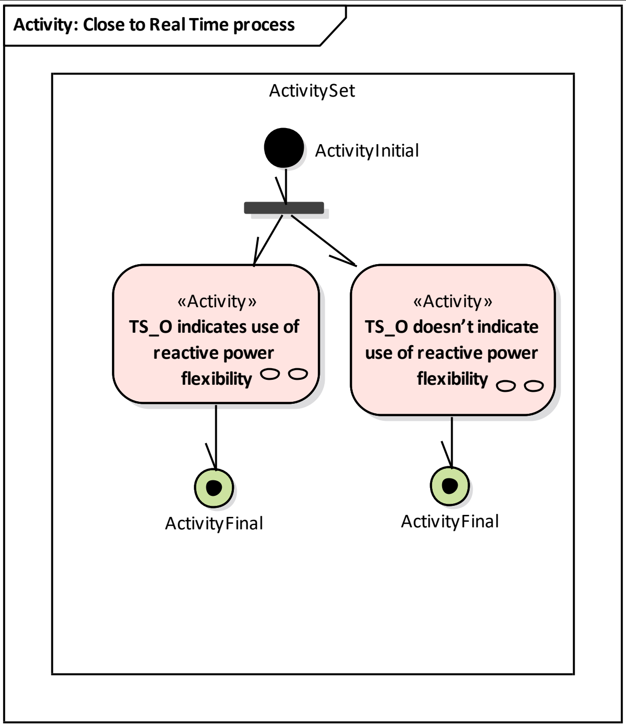
Activity step by step analysis

Scenario								
Scenario name	Selection/Bidding							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
2.2.2.1		Update forecast due to deviation		send	Forecast Provider (FCP)	Distribution System Operator (DS_O)	Info6-Metered data	
2.2.2.2		Update schedules		send	Generation Aggregator (GA)	Distribution System Operator (DS_O)	Info2-Schedule	
2.2.2.3		Update asset utilization	Due to faults (e.g. line tripping)		Distribution System Operator (DS_O)			
2.2.2.4		Predict congestions in DS_O grid	Repetition of 2.1.2.1		Distribution System Operator (DS_O)			
2.2.2.5		Solve congestions in DS_O grid with available flexibilities	Repetition of 2.1.2.2		Distribution System Operator (DS_O)			
2.2.2.6		Aggregate schedules and remaining flexibilities per DS_O-TS_O grid node	Repetition of 2.1.2.3.	Send, if threshold exceeded	Distribution System Operator (DS_O)	Transmission System Operator (TS_O)	Info5-Q-potentials	

2.2.2.7		Predict congestion in TS_O grid	Where necessary coordination with other TS_Os		Transmission System Operator (TS_O)			
2.2.2.8		Solve congestions in TS_O grid with available flexibilities	if necessary limiting remaining flexibilities at DS_O-TS_O-connection-point; Repetition of 2.1.3.2.	send	Transmission System Operator (TS_O)	Distribution System Operator (DS_O)	Info5-Q-potentials	
2.2.2.9		Segregate adjusted schedules	Repetition of 2.1.4.1.		Distribution System Operator (DS_O)			
2.2.2.10		Verify feasibility of grid to perform received schedules	Repetition of 2.1.4.2.		Distribution System Operator (DS_O)			

- 2.3. Close to Real Time process

Business section: Selection/Bidding/Close to Real Time process

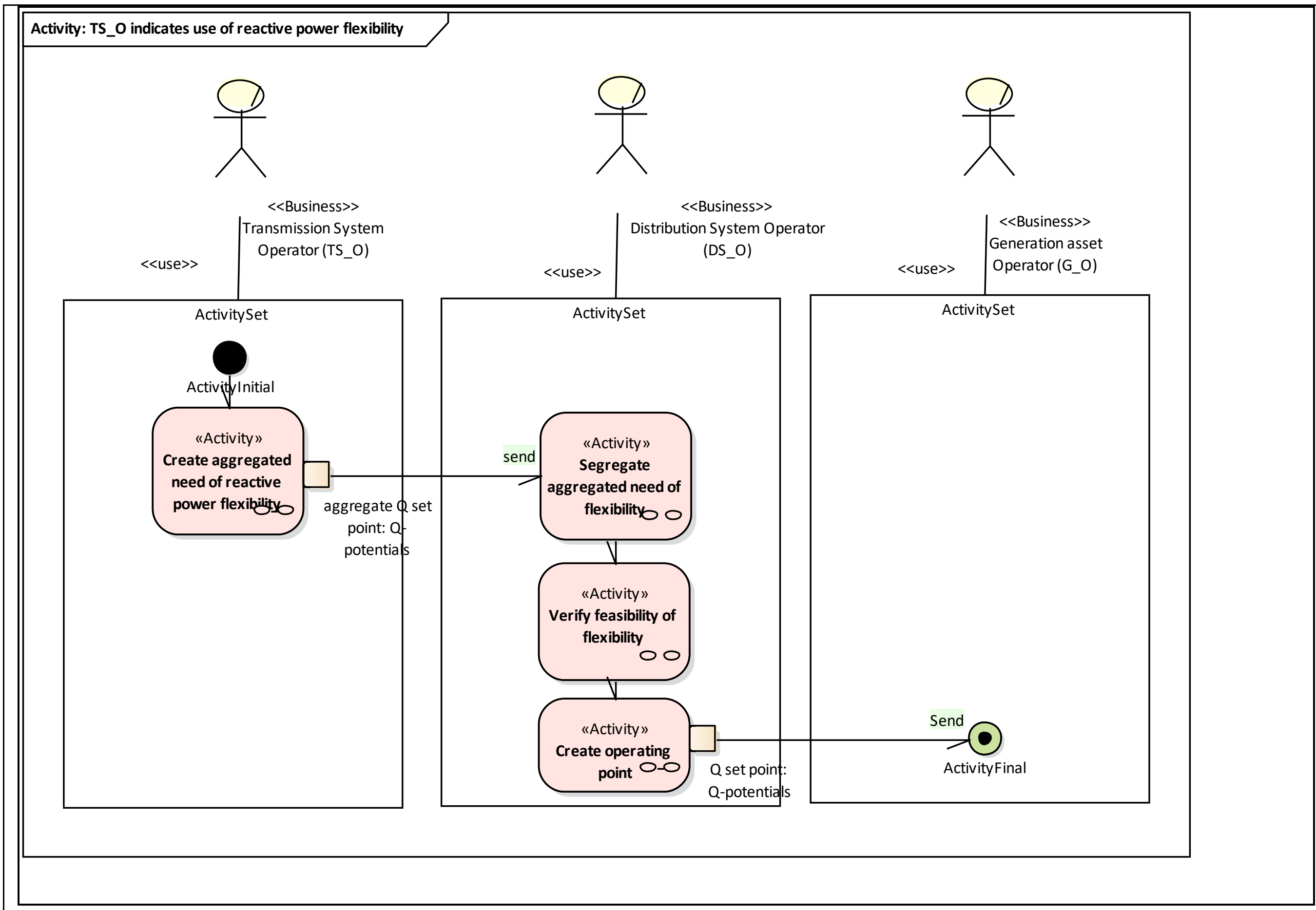


Activity step by step analysis

Scenario								
Scenario name	Selection/Bidding							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
2.3.1		TS_O indicates use of reactive power flexibility			Transmission System Operator (TS_O)			
2.3.2		TS_O doesn't indicate use of reactive power flexibility			Transmission System Operator (TS_O)			

- 2.3.1. TS_O indicates use of reactive power flexibility

Business section: Selection/Bidding/Close to Real Time process/TS_O indicates use of reactive power flexibility



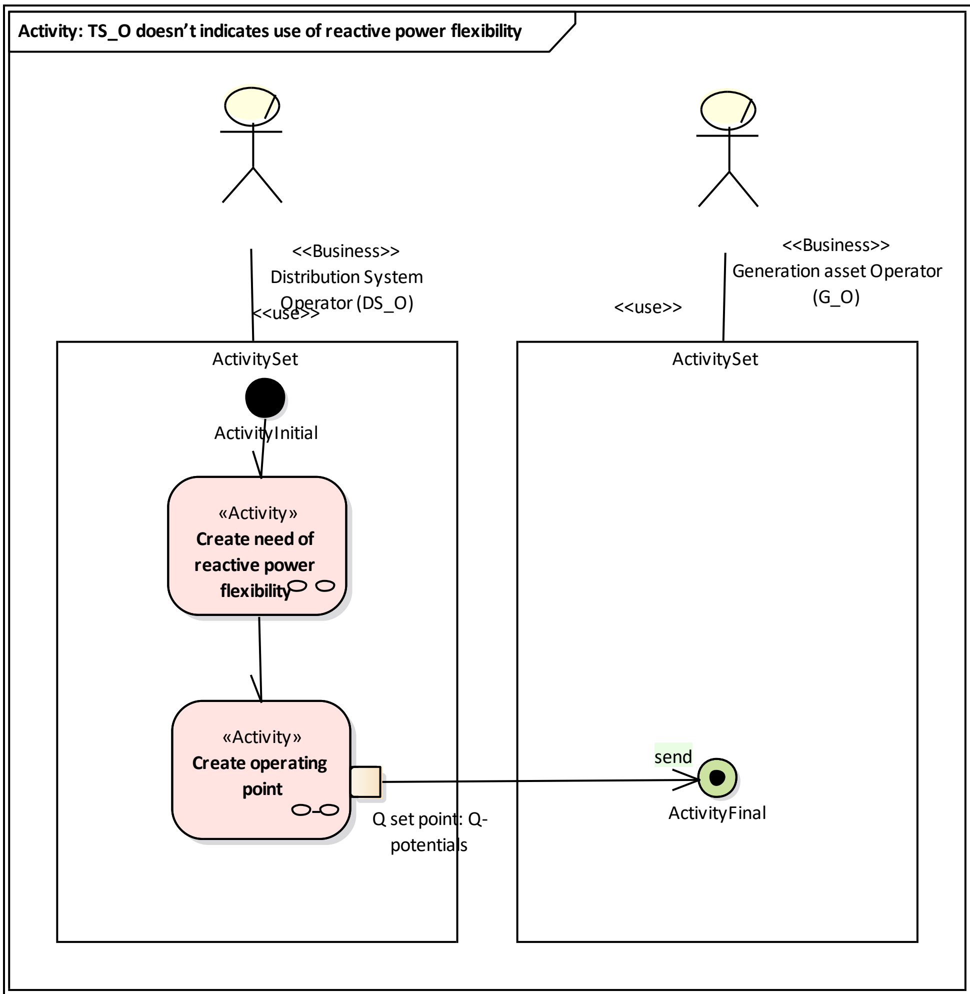
Activity step by step analysis

Scenario								
Scenario name	Selection/Bidding							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
2.3.1.1		Create aggregated need of reactive power flexibility		send	Transmission System Operator (TS_O)	Distribution System Operator (DS_O)	Info5-Q-potentials	
2.3.1.2		Segregate aggregated need of flexibility	set operating point for each unit in DS_O grid		Distribution System Operator (DS_O)			
2.3.1.3		Verify feasibility of flexibility	considering constraints in		Distribution System			

			maximum adjustment per timeframe, e.g. 3 Mvar per 2 minutes		Operator (DS_O)			
2.3.1.4		Create operating point		Send	Distribution System Operator (DS_O)	Generation asset Operator (G_O)	Info5-Q-potentials	

- ## 2.3.2. TS_O doesn't indicate use of reactive power flexibility

Business section: Selection/Bidding/Close to Real Time process/TS_O doesn't indicate use of reactive power flexibility

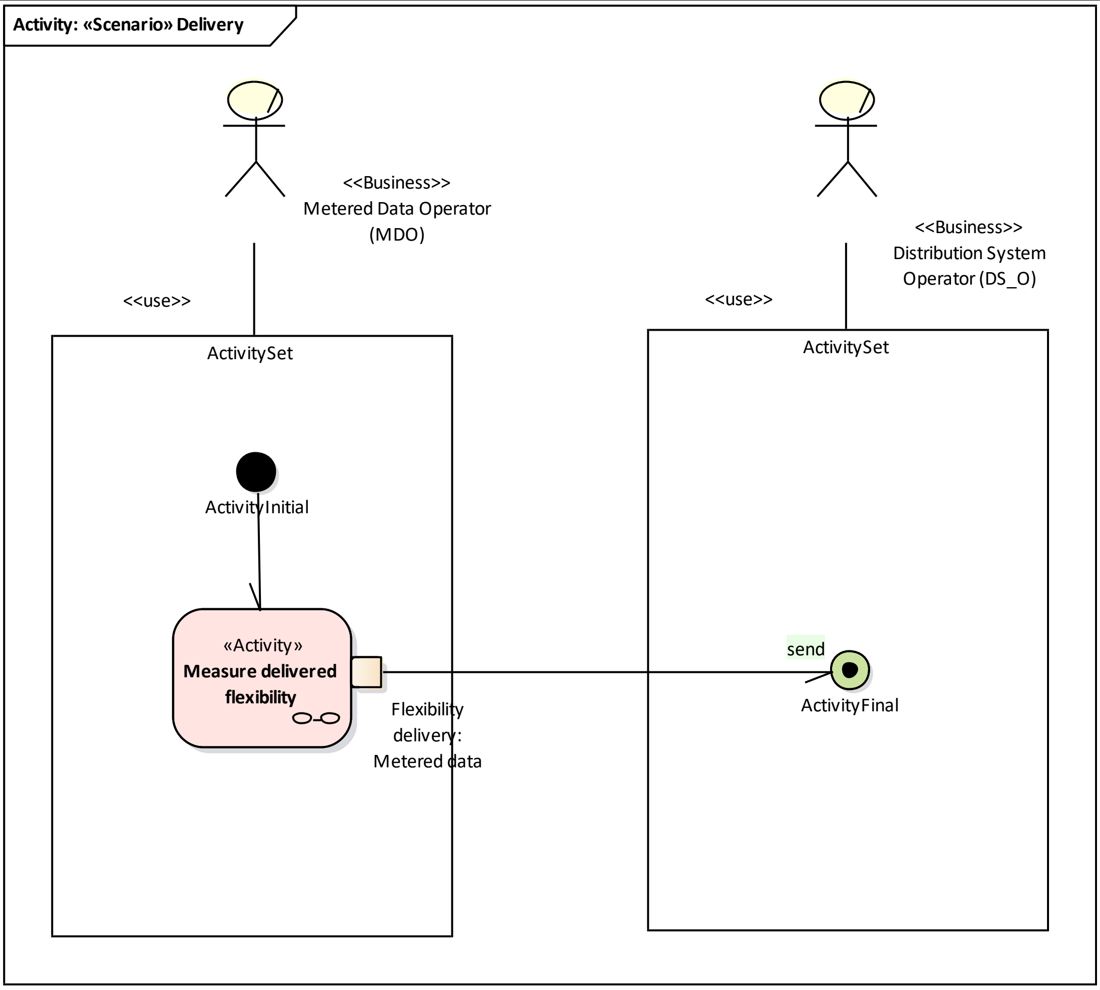


Activity step by step analysis

Scenario								
Scenario name	Selection/Bidding							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
2.3.2.1		Create need of reactive power flexibility	DS_O optimizes reactive power flows, considering losses in grid, voltage control and constraints in maximum adjustment per timeframe, e.g. 3 Mvar per 2 minutes		Distribution System Operator (DS_O)			
2.3.2.2		Create operating point		send	Distribution System Operator (DS_O)	Generation asset Operator (G_O)	Info5-Q-potentials	

4.2.3 DELIVERY

(close to real time)



Scenario step by step analysis

Scenario								
Scenario name	Delivery							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
3.1		Measure delivered flexibility		send	Metered Data Operator (MDO)	Distribution System Operator (DS_O)	Info6-Metered data	

5. INFORMATION EXCHANGED

Information exchanged			
Information exchanged, ID	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***

Info1	Framework Agreement	Agreement from GA to send schedules per grid connection point day ahead after closure of related markets, but before 2:30pm. Updates of schedules will be sent by GA if a threshold of a certain amount is exceeded. Selection of cost compensation methodology is according to regulation.	
Info2	Schedule	Energy traded, FCR traded, aFRR traded, mFRR traded, potential for Redispatch, restriction in generation/load (all per 15 minutes), P/Q capabilitiy	
Info3	Grid asset utilization	Information about available assets and historical and actual usage of assets (utilization rate).	
Info4	Forecast	Generation of small RES with fixed feed-in tariff and load.	
Info5	Q-potentials	reactive power flow (considering deviation) and potential range of reactive power flexibility	
Info6	Metered data	Contains metering data for billing process	

TABLE 10 BUC DE-RP

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

Based on IEC 62559-2 edition 1
Generated from UML Use Case Repository with Modsarus® (EDF R&D Tool)

1. DESCRIPTION OF THE USE CASE

1.1 NAME OF USE CASE

Use case identification		
ID	***Area(s)/Domain(s)/Zone(s)***	***Name of use case***
IT-AP	Italy	Manage active power flexibility to support mFRR/RR and congestion management in the Italian demo

1.2 VERSION MANAGEMENT

Version management				
Version No.	***Date***	***Name of author(s)***	***Changes***	***Approval status***
1	2018-05-30	Daniele Clerici	Proposed version from demo	
2	2018-06-11	Cyril Effantin	Consolidation in a common UC repository	
3	2018-07-30	Cyril Effantin	Minor UML fixes on Daniele version from 02-07-2018	
4	2018-09-18	Daniele Clerici	Update from Daniele Clerici	

5	2018-10-10	Daniele Clerici	Update based on role model evolution	

1.3 SCOPE AND OBJECTIVES OF USE CASE

Scope and objectives of use case	
Scope	Provide active power flexibilities from distribution grid for mFRR/RR and congestion resolution services to the Transmission Network in real-time operations. The market operator (at distribution level, MO_D) manages a local flexibility market, collects and aggregates flexibility offers from customers and aggregators and provide them to the centralized market operator (at transmission level, MO_T). The distribution system operator (DS_O) can exploit flexibilities to solve congestions in distribution grid; it cannot use its own assets (ex: Battery Storage) for participating to the centralized transmission ancillary services (mFRR/RR market), but only for distribution system management and for solving imbalances (counter-activations in case of activation of flexibilities for local congestion managements) .
Objective(s)	Manage a local flexibility market and provide aggregated flexibilities at Primary Substation interface, guaranteeing secure operations of the distribution grid. Increase the participation of distributed energy resources in the transmission network mFRR/RR market
Related business case(s)	Frequency Control Congestion Management

1.4 NARRATIVE OF USE CASE

Narrative of use case
Short description
Following the increase of RES connected to the electric networks, novel operating schemes should be explored in order to address the specific needs of both distribution and transmission grids, allowing reliable and secure operations also in presence of a consistent amount of not programmable RES based generators, also connected to distribution networks. These needs drive to an enhanced cooperation between distribution system operator and transmission system operator, which could manage their own grids and connected resources in a secure and efficient way and, at the same time, supporting the grid activities of each other. This cooperation can be realized in different ways, one of them being the local management of distributed energy resources (DER) at distribution level: the distribution system operator can improve the distribution network management and, at the same time, can act as a market facilitator promoting the participation of DER (generators, loads, storages) in services provision to the transmission network. The market operator at distribution level (MO_D) manages a local market in order to activate flexible resources for congestion management. The market is organized in real-time (i.e. each 15 minutes) and

distribution resources submit flexibility bids with the same frequency. The distribution system operator may select the optimal activations for the foreseen distribution congestions management. The market operator (MO_D) also guarantees that all the requested activations in total have no consequences on system balancing. The remaining flexibilities are aggregated and submitted to the real-time ancillary services market (i.e. mFRR, RR and transmission network congestion management) managed by the market operator (MO_T) at transmission level.

Complete description

In this section, the previous short description is expanded; for each phase, the relevant steps, involved actors and their interactions are detailed:

Prequalification:

In a long-term time frame, the MO_D collects participation requests from customers and verifies if the resources meet the necessary requirements for local market registration.
The MO_D is also responsible for periodical verification and consequent renewal/drop of the registration of resource to the local flexibility market.

Bidding/Selection:

In real-time framework, the MO_D organizes a local flexibility market for active power flexibility provision; 15 minutes time slots are considered.
The local market is open for bidding for a full time slot; once closed, all the bids collected by the MO_D are considered in the optimization/resource selection phase, which lasts for another full time slot. In total, the bidding/selection phase lasts 30 minutes (two time slots).
Once the market is closed, the DS_O communicates to the MO_D the updated network configuration and the most recent resources production/consumption forecast related to the time instants for which the market is about to be cleared. These information include the updated flexibility status of DS_O energy assets.
The result of the market clearing is a set of optimal activations of the available flexibilities. Since local congestion management process (at distribution level) drives to active/reactive power imbalances, the MO_D clears the market also considering suitable countermeasures to solve them by using, if possible, DS_O own assets exclusively, in order to allow most of the customers to participate to the services provision to the MO_T.
Taking into account these preliminary selected activations, the MO_D groups all the remaining flexibilities in a parametric curve (quantity vs. price) and submits a bid for the real-time centralized mFRR/RR market, managed by the MO_T. Once the centralized mFRR/RR market is cleared, the MO_T sends back to the MO_D the requested power flexibility to be activated.
The MO_D disaggregates the power profile received from the MO_T, allocating the total flexibility between resources (including DS_O assets) and creating the corresponding activation signals, in preparation for the delivery phase.

Delivery:

This phase starts at the beginning of the time slot next to Bidding/Selection phase, when the DS_O sends the activation signals to the contracted resources; in this phase the resources must follow the set-points calculated in the Bidding/Selection phase.

The activation signal is sent, simultaneously, also to the MDO for the synchronization of the measurement process. The MDO is responsible for measurements collection and certification; the measurements are taken at the resources connection nodes and at primary substation interface.

On a daily basis, the MDO aggregates all the measurements and stores them for the settlement phase.

Settlement:

In the long-term time frame (ex: monthly), the MO_D requests the measurements report to the MDO, then it prepares the invoice for service provision to be sent to the MO_T.

After receiving and checking the invoice, the MO_T sends the payment to the MO_D, who disaggregates it and sends the corresponding remuneration to each resource.

Summary of use case

- **Prequalification**
  Description: In a long-term time frame, the MO_D collects participation requests from customers and verifies if the resources meet the necessary requirements for local market registration.
  The MO_D is also responsible for periodical verification and consequent renewal/drop of the registration of resources to the local flexibility market.
  - Prepare participation request
    Description: The generator(s) who wants to participate to the local flexibilities market, prepares a formal request and submits it to the local market operator;
  - Prepare participation request
    Description: The aggregator(s) who wants to participate to the local flexibilities market, prepares a formal request and submits it to the local market operator;
  - Check participation request
    Description: The local market operator collects the requests for the participation to the local flexibility market and checks them for consistency; in this step, the market operator checks that the resources are suitable for the specific service they want to provide, based on reports produced by an independent certification body (see Assumptions)
  - Reject request
    Description: The market operator prepares an official rejection document for the resources who don't meet the necessary requirements for participating to the local flexibilities market; the document contains all the necessary information for the resources, to solve the issues and submit a new, potentially successful, request.

- Reject request
  Description: The market operator prepares an official rejection document for the resources who don't meet the necessary requirements for participating to the local flexibilities market; the document contains all the necessary information for the resources, to solve the issues and submit a new, potentially successful, request.

- Check rejection
  Description: The generator(s) receives the rejection document from the market operator; in this document are specified the actions to be done to reach the requirements for participating to the local market, so the generator(s) can take the necessary actions and submits a new request;

- Check rejection
  Description: The aggregator(s) receives the rejection document from the market operator; in this document are specified the actions to be done to reach the requirements for participating to the local market, so the aggregator(s) can take the necessary actions and submits a new request;

- Accept request
  Description: The market operator officially registers the resources who meet the requirements for flexibilities provision; then it prepares an official acceptation document and releases it to registered resources; the market operator is responsible to periodically checking the resources and renew or revoke registration;

- Accept request
  Description: The market operator officially registers the resources who meet the requirements for flexibilities provision; then it prepares an official acceptation document and releases it to registered resources; the market operator is responsible to periodically checking the resources and renew or revoke registration;

- Receive confirmation
  Description: The generator(s) receives the acceptance confirmation and the registration details, so it can participate to the local market;

- Receive confirmation
  Description: The aggregator(s) receives the acceptance confirmation and the registration details, so it can participate to the local market;

- **Selection/Bidding**
  Description: In real-time framework, the MO_D organizes a local flexibility market for active power flexibility provision; 15 minutes time slots are considered.
  The local market is open for bidding for a full time slot; once closed, all the bids collected by the MO_D are considered in the optimization/resource selection phase, which lasts for another full time slot. In total, the bidding/selection phase lasts 30 minutes (two time slots).
  Once the market is closed, the DS_O communicates to the MO_D the updated network configuration and the most recent resources production/consumption forecast related to the time instants for which the market is about to be cleared. This information includes the updated flexibility status of DS_O energy assets.
  The result of the market clearing is a set of optimal activations of the available flexibilities. Since the local congestion management process (at distribution level) drives to active/reactive power imbalances, the MO_D clears the market also considering suitable countermeasures to solve them by using, if possible, DS_O own assets exclusively, in order to allow most of the customers to participate to the services provision to the transmission network.

Taking into account these preliminary selected activations, the MO_D groups all the remaining flexibilities in a parametric curve (quantity vs. price) and submits a bid for the real-time centralized mFRR/RR market, managed by the MO_T. Once the centralized mFRR/RR market is cleared, the MO_T sends back to the MO_D the requested power flexibility to be activated. The MO_D disaggregates the power profile received from the MO_T, allocating the total flexibility between resources (including DS_O assets) and creating the corresponding activation signals, in preparation for the delivery phase.

- Open the local flexibilities market
  Description: The local market operator (MO_D) opens the local flexibility market 30 minutes (two 15 minutes time slots) before the time slot during which the service will be provided, allowing the local customers to submit their bids;

- Create bid for local market
  Description: The DER operator(s) analyzes the foreseen plant generation profile for the next 15 minutes slot and evaluates the active power flexibility it can provide to the market; then prepares an offer and sends it to the local market operator (MO_D)

- Create bid for local market
  Description: The aggregator(s) analyzes the foreseen generation profile of its customers portfolio for the next 15 minutes slot and evaluates the active power flexibility it can provide to the market; then prepares an offer and sends it to the local market operator (MO_D)

- Collect bids
  Description: The market operator keeps the market open for a whole 15 minutes time slot, collecting all the bids received within this time span;

- Close the local flexibilities market
  Description: After 15 minutes (one time slot) after the market opening, and 15 minutes before the service provision, the MO_D closes the market; no more bids can be accepted for the selected time slot. Then, it collects from the DS_O the updated network information.

- Provide updated network information
  Description: Once the market is closed, the DS_O communicates to the MO_D:
  1-the updated network configuration;
  2-the most recent resources production/consumption forecast;
  3-the flexibility status of its own energy assets;
  All these information are related to the delivery time slot.

- Perform optimization and aggregate bids
  Description: The MO_D receives the updated network status from the DS_O, then it runs necessary calculations and Optimal Power Flows to:
  1-Verify that the activation of the flexibilities don't create issues to the Distribution Network; if necessary, it can limit or delete the flexibilities which may be dangerous for system security;
  2-Select the bids to be exploited for congestion management in the Distribution Network;
  3-Calculate (if necessary) the set-points for DS_O energy assets for re-balancing purposes (in case the activation of flexibilities for local congestion management drive to imbalances at Primary Substation interface)
  At the end of the process it aggregates the remaining flexibilities in a single bid, based on a parametric curve (energy vs cost)and offers it on the centralized AS market;

- Manage centralized AS market
  Description: The MO_T manages the centralized AS market, including the aggregated bid provided by the MO_D;

- Select power profile
  Description: The MO_T, based on the parametric curve received from the MO_D, selects the active power profile (at PS) which fits its needs and transmits it back to MO_D;

- Prepare activation signals
  Description: The MO_D receives the active power profile from the MO_T and disaggregates it, preparing the activation signals for the delivery.

- **Delivery**
  Description: This phase starts at the beginning of the time slot next to Bidding/Selection phase, when the MO_D sends the activation signals to the contracted resources.
  The activation signal is sent, simultaneously, also to the MDO for the synchronization of the measurement process. The MDO is responsible for measurements collection and certification; the measurements are taken at the resources connection nodes and at primary substation interface.
  On a daily basis, the MDO aggregates all the measurements and stores them for the settlement phase.

  - Send activation signals
    Description: The MO_D, at the beginning of the 15 minutes slot, sends, simultaneously, the activation signals to the resources involved, to the DS_O for its assets, and to the MDO for the synchronization of the measurement process.

  - Send activation signals
    Description: The MO_D, at the beginning of the 15 minutes slot, sends, simultaneously, the activation signals to the resources involved, to the DS_O for its assets, and to the MDO for the synchronization of the measurement process.

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  - Send activation signals
    Description: The MO_D, at the beginning of the 15 minutes slot, sends, simultaneously, the activation signals to the resources involved, to the DS_O for its assets, and to the MDO for the synchronization of the measurement process.

  - Provide flexibility
    Description: The generator(s) receives the activation signal and manages its own plant accordingly for the whole duration of the time slot;

  - Provide flexibility
    Description: The aggregator(s) receives the activation signal and manages its portfolio of customers accordingly for the whole duration of the time slot;

  - Manage owned energy assets
    Description: The DS_O receives the activation signal and manages its own energy assets accordingly for the whole duration of the time slot;

- Do measurements
  Description: The MDO receives from the MO_D the activation signal and takes measures from the meters installed at the connection points of the selected resources; it checks also for deviations of the actual profiles from the scheduled ones

- Post-process measurements
  Description: The MDO stores the measurements and prepares them for the settlement phase;

- **Settlement**
  Description: In the long-term time frame (ex: monthly), the MO_D requests the measurements report to the MDO, then it prepares the invoice for service provision to be sent to the MO_T. After receiving and checking the invoice, the MO_T send the payment to the MO_D, who disaggregates it and sends the corresponding remuneration to each resource.

  - Request measurements
    Description: On a monthly basis, the MO_D requests the measurements taken during the previous month to the MDO;

  - Aggregate measurements
    Description: The MDO aggregates the metered data (related to the resources who participated to ancillary services provision to the transmission network), as well as the measurements of the power exchange at the primary substation interface; then it prepares a measurements report and sends it to the local market operator MO_D.

  - Prepare invoice
    Description: The local market operator (MO_D) calculates the remuneration for the service based on the bid offered in the centralized market, as well as the penalties due to the deviations from the contracted set-points (if occurred). Then it prepares an invoice and submits it to the MO_T for service payment

  - Check the invoice
    Description: The MO_T receives the invoice for the service from the MO_D and checks it;

  - Prepare the payment
    Description: The MO_T prepares the payment and sends it to the MO_D;

  - Receive payment for service
    Description: The MO_D receives the payment from the MO_T; based on the bids offered from the resources and the actual flexibility provision certified by the measurements, the MO_D calculates the remuneration for each resource who participated in the local flexibility market. Then, it prepares the payment and send it to the resources.

  - Receive payment for service
    Description: The MO_D receives the payment from the MO_T; based on the bids offered from the resources and the actual flexibility provision certified by the measurements, the MO_D calculates the remuneration for each resource who participated in the local flexibility market. Then, it prepares the payment and send it to the resources.

  - Receive remuneration
    Description: The generator(s) are remunerated for the flexibility provided;

- Receive remuneration
  Description: The aggregator(s) are remunerated for the flexibility provided;

1.5 KEY PERFORMANCE INDICATORS (KPI)

1.6 USE CASE CONDITIONS

	Use case conditions
	Assumptions
1	Assumption: In this Business Use Case it is assumed that both the generator asset operator (G_O) role and aggregator role act as Commercial Market Players; the first represents a CMP with one generator portfolio, while the second represents a CMP with multiple resources portfolio. The processes which describe the management of the portfolio by the aggregator(s) are not described in this Business Use Case.
2	Assumption: At present (2018) the Italian Regulatory framework considers a DSO/TSO coordination scheme based on a centralized Ancillary Services market model. In this context the Distribution System Operator acts only as a System Operator: it cannot participate to the centralized AS Market and it doesn't have any control on power flexibilities delivery. Only from a system security perspective, during the pre-qualification phase of flexibility offers, it can certify if a specific flexibility exploitation can be harmful for the distribution system operation. The private customers (loads, generators under 10 MVA), which can provide at least 1 MW (currently only within pilot projects) of power flexibility, can be connected directly with the TSO network management system, participating to the AS market. For this Business Use Case a coordination scheme based on local AS market model is considered. In this coordination scheme the Distribution System Operator organizes and manages a local flexibility market at distribution network level; practically, it acts both as a System Operator and a Market Operator. It has also the responsibility of the aggregation of distributed resources for the provision of AS in the centralized market managed by the Transmission System Operator. The Distribution System Operator can exploit distributed flexibilities for congestion management at distribution network level, it is responsible for solving consequent imbalances and it can limit the flexibility offers if their activation results in constraints violations.
3	Assumption: This Business Use Case describes in details the business process behind the support of mFRR service in the centralized AS market. The process description is applicable also for the support of RR service, since the mFRR and RR differ mainly in the activation time.
4	Assumption: In this Business Use Case the DS_O, MO_D and MDO roles correspond to different actors even if, in some countries (Italy included), they may all belong to a single stakeholder (most likely the Distribution System Operator): this approach allows to describe the whole business process in a more general way, facilitating its replicability in other regulatory/technical frameworks.
5	Assumption: In this Business Use Case it is assumed that the MO_T role (as in the actual Italian scenario) belongs to a single stakeholder, the Transmission System Operator.

Prerequisites	
1	PreCondition: In order to access the local flexibility market, the distributed resources must comply with the technical requirements for AS provision. The pre-qualification process can be done in two phases: -The DER owner requests a technical pre-qualification to a Certified Body (third-party) who verifies and validates the DER technical capability for providing ancillary services. The technical certification must be presented to the MO_D and it is mandatory for the resource registration in the local market; this phase is described more in details in the "Prequalification" scenario. -The system pre-qualification is done by the MO_D, after each market closure, within the activity "Perform optimization and aggregate bids" during the "Selection/Bidding"scenario.
2	PreCondition: In the Italian Demo, the Distribution System Operator has its own assets for distribution system management, including a Battery Energy Storage System connected directly to the distribution network. In the context of this Use Case (and the Project) the BESS will be used only for “non-commercial” services, such as the rebalancing of the resources after flexibilities exploiting for local congestion management. This guarantees: -that the activations requested by the Distribution System Operator would not cause system imbalance, -the highest participation of local resources to the ancillary services provision to the transmission network.

1.7 FURTHER INFORMATION TO THE USE CASE FOR CLASSIFICATION/MAPPING

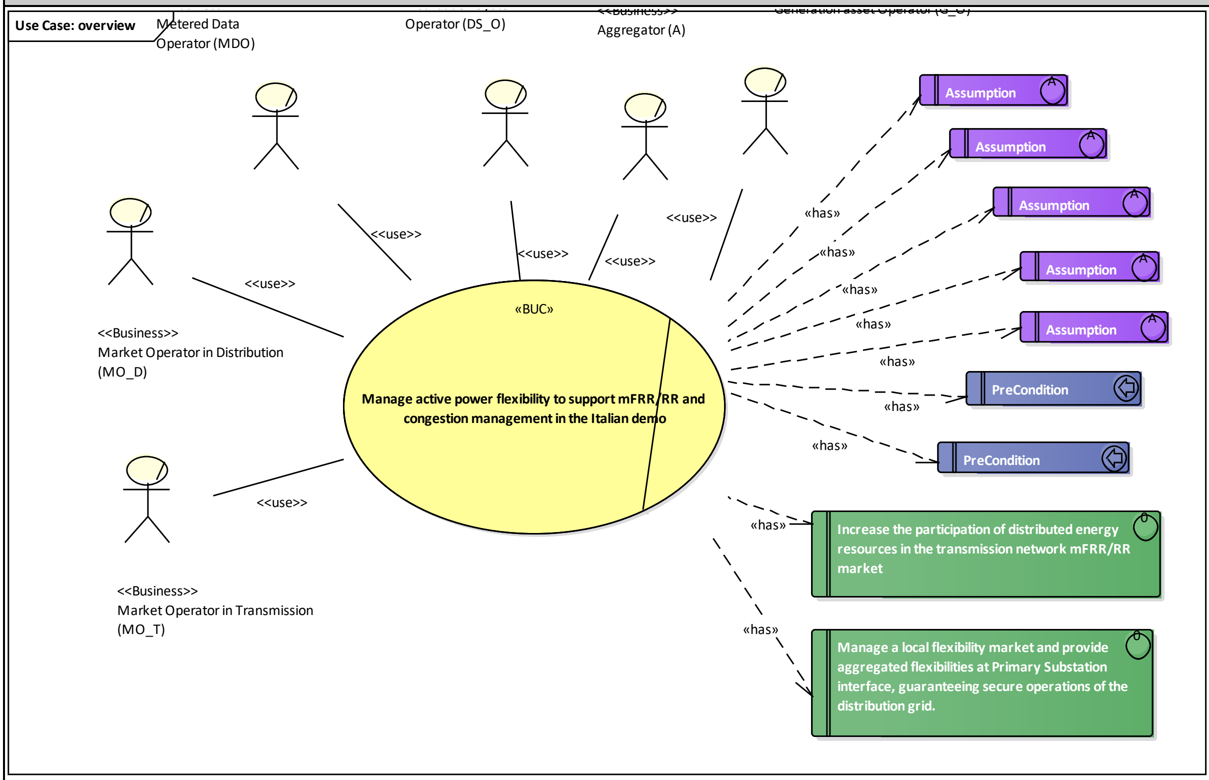
Classification information
Relation to other use cases
Level of depth
BUC for the Italian Demo. Black-box (the roles are considered from a black-box perspective and their organisational entities are not detailed in the steps of the Use Case)
Prioritisation
Generic, regional or national relation
Italian Demo
Nature of the use case
BUC
Further keywords for classification

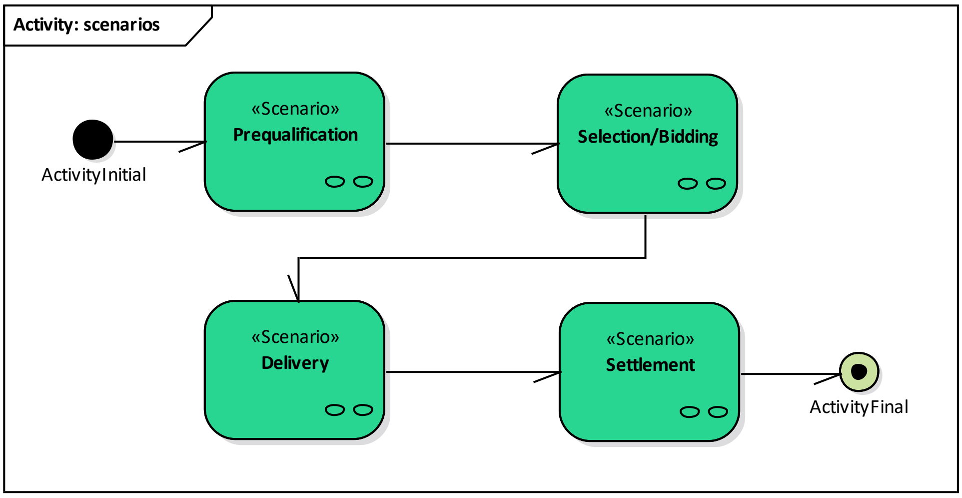
1.8 GENERAL REMARKS

General remarks
GeneralRemarks1:

2. DIAGRAMS OF USE CASE

Diagram(s) of use case





3. TECHNICAL DETAILS

3.1 ACTORS

Actors			
Grouping (e.g. domains, zones)	***Group description***		
Actor name	***Actor type***	***Actor description***	***Further information***

			specific to this use case
Market Operator in Transmission (MO_T)	Business	Organize auctions (continuous auction, discrete auctions, call for tenders) between buyers and sellers of electricity-related products in the markets, and more generally publish the corresponding prices, for assets connected to transmission grid Manage/operate the platform for trading (where bids and offers are collected) Clear the market and communicate results	
Metered Data Operator (MDO)	Business	Provide metered data to authorized users in a transparent and non-discriminatory manner	
Generation asset Operator (G_O)	Business	Operate one or several generation asset(s)	
Aggregator (A)	Business	Aggregate and maximise value of portfolio(s) of resources	
Distribution System Operator (DS_O)	Business	Elaborate network development plan (including defining system needs for distribution) Ensure a transparent and non-discriminatory access to the distribution network for each user Operate the distribution grid over a specific region in a secure, reliable and efficient way Optimize system operation distribution grid from planning to real-time, using available levers (grid expansion, flexibility activation,...) Assess network status of the distribution grid and broadcast selected information of the network status to eligible actors (e.g. aggregators, other system operators) Support the Transmission System Operator in carrying out its responsibilities (including load shedding) and coordinate measures if necessary	
Market Operator in Distribution (MO_D)	Business	Organize auctions (continuous auction, discrete auctions, call for tenders) between buyers and sellers of electricity-related products in the markets, and more generally publish the corresponding prices, for assets connected to distribution grid Manage/operate the platform for trading (where bids and offers are collected) Clear the market and communicate results	

3.2 REFERENCES

4. STEP BY STEP ANALYSIS OF USE CASE

4.1 OVERVIEW OF SCENARIOS

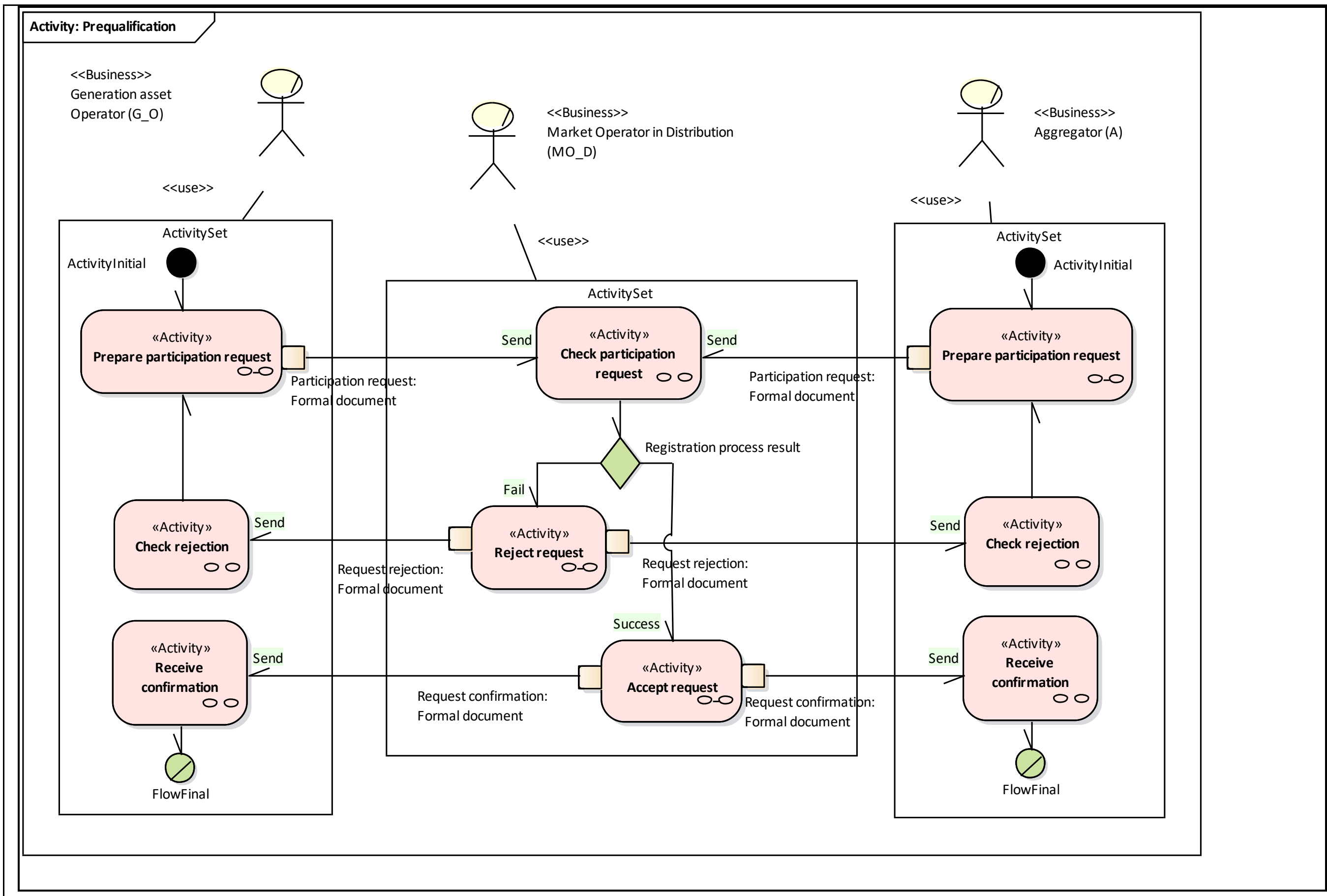
Scenario conditions						
No.	***Scenario name***	***Scenario description***	***Primary actor***	***Triggering event***	***Pre-condition***	***Post-condition***
1	Prequalification	In a long-term time frame, the MO_D collects participation requests from customers and verifies if the resources meet the necessary requirements for local market registration. The MO_D is also responsible for periodical verification and consequent renewal/drop of the registration of resources to the local flexibility market.				
2	Selection/Bidding	In real-time framework, the MO_D organizes a local flexibility market for active power flexibility provision; 15 minutes time slots are considered. The local market is open for bidding for a full time slot; once closed, all the bids collected by the MO_D are considered in the optimization/resource selection phase, which lasts for another full time slot. In total, the bidding/selection phase lasts 30 minutes (two time slots). Once the market is closed, the DS_O communicates to the MO_D the updated network configuration and the most recent resources production/consumption forecast related to the time instants for which the market is about to be cleared. This information includes the updated flexibility status of DS_O energy assets. The result of the market clearing is a set of optimal activations of the available flexibilities. Since the local congestion management process (at distribution level) drives to active/reactive power imbalances, the MO_D clears the market also considering suitable countermeasures to solve them by using, if possible, DS_O own assets exclusively, in order to allow most of the customers to participate to the services provision to the transmission network. Taking into account these preliminary				

		selected activations, the MO_D groups all the remaining flexibilities in a parametric curve (quantity vs. price) and submits a bid for the real-time centralized mFRR/RR market, managed by the MO_T. Once the centralized mFRR/RR market is cleared, the MO_T sends back to the MO_D the requested power flexibility to be activated. The MO_D disaggregates the power profile received from the MO_T, allocating the total flexibility between resources (including DS_O assets) and creating the corresponding activation signals, in preparation for the delivery phase.				
3	Delivery	This phase starts at the beginning of the time slot next to Bidding/Selection phase, when the MO_D sends the activation signals to the contracted resources. The activation signal is sent, simultaneously, also to the MDO for the synchronization of the measurement process. The MDO is responsible for measurements collection and certification; the measurements are taken at the resources connection nodes and at primary substation interface. On a daily basis, the MDO aggregates all the measurements and stores them for the settlement phase.				
4	Settlement	In the long-term time frame (ex: monthly), the MO_D requests the measurements report to the MDO, then it prepares the invoice for service provision to be sent to the MO_T. After receiving and checking the invoice, the MO_T send the payment to the MO_D, who disaggregates it and sends the corresponding remuneration to each resource.				

4.2 STEPS - SCENARIOS

4.2.1 PREQUALIFICATION

In a long-term time frame, the MO_D collects participation requests from customers and verifies if the resources meet the necessary requirements for local market registration.
The MO_D is also responsible for periodical verification and consequent renewal/drop of the registration of resources to the local flexibility market.



Scenario step by step analysis

Scenario								
Scenario name	Prequalification							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
1.1		Prepare participation request	The generator(s) who wants to participate to the local flexibilities market, prepares a formal request and submits it to the local market operator;	Send	Generation asset Operator (G_O)	Market Operator in Distribution (MO_D)	Info1- Formal document	
1.2		Prepare participation request	The aggregator(s) who wants to participate to the local flexibilities market, prepares a	Send	Aggregator (A)	Market Operator in Distribution (MO_D)	Info1- Formal document	

			formal request and submits it to the local market operator;					
1.3		Check participation request	The local market operator collects the requests for the participation to the local flexibility market and checks them for consistency; in this step, the market operator checks that the resources are suitable for the specific service they want to provide, based on reports produced by an independent certification body (see Assumptions)		Market Operator in Distribution (MO_D)			
1.4		Reject request	The market operator prepares an official rejection document for the resources who don't meet the necessary requirements for participating to the local flexibilities market; the document contains all the necessary information for the resources, to solve the issues and submit a new, potentially successful, request.	Send	Market Operator in Distribution (MO_D)	Aggregator (A)	Info1-Formal document	

1.5		Reject request	The market operator prepares an official rejection document for the resources who don't meet the necessary requirements for participating to the local flexibilities market; the document contains all the necessary information for the resources, to solve the issues and submit a new, potentially successful, request.	Send	Market Operator in Distribution (MO_D)	Generation asset Operator (G_O)	Info1-Formal document	
1.6		Check rejection	The generator(s) receives the rejection document from the market operator; in this document are specified the actions to be done to reach the requirements for participating to the local market, so the generator(s) can take the necessary actions and submits a new request;		Generation asset Operator (G_O)			
1.7		Check rejection	The aggregator(s) receives the rejection document from the market operator; in this document are specified the actions to be done to reach the requirements for		Aggregator (A)			

			participating to the local market, so the aggregator(s) can take the necessary actions and submits a new request;					
1.8		Accept request	The market operator officially registers the resources who meet the requirements for flexibilities provision; then it prepares an official acceptation document and releases it to registered resources; the market operator is responsible to periodically checking the resources and renew or revoke registration;	Send	Market Operator in Distribution (MO_D)	Aggregator (A)	Info1-Formal document	
1.9		Accept request	The market operator officially registers the resources who meet the requirements for flexibilities provision; then it prepares an official acceptation document and releases it to registered resources; the market operator is responsible to periodically checking the resources and renew or revoke registration;	Send	Market Operator in Distribution (MO_D)	Generation asset Operator (G_O)	Info1-Formal document	

1.10		Receive confirmation	The generator(s) receives the acceptance confirmation and the registration details, so it can participate to the local market;		Generation asset Operator (G_O)			
1.11		Receive confirmation	The aggregator(s) receives the acceptance confirmation and the registration details, so it can participate to the local market;		Aggregator (A)			

4.2.2 SELECTION/BIDDING

In real-time framework, the MO_D organizes a local flexibility market for active power flexibility provision; 15 minutes time slots are considered.

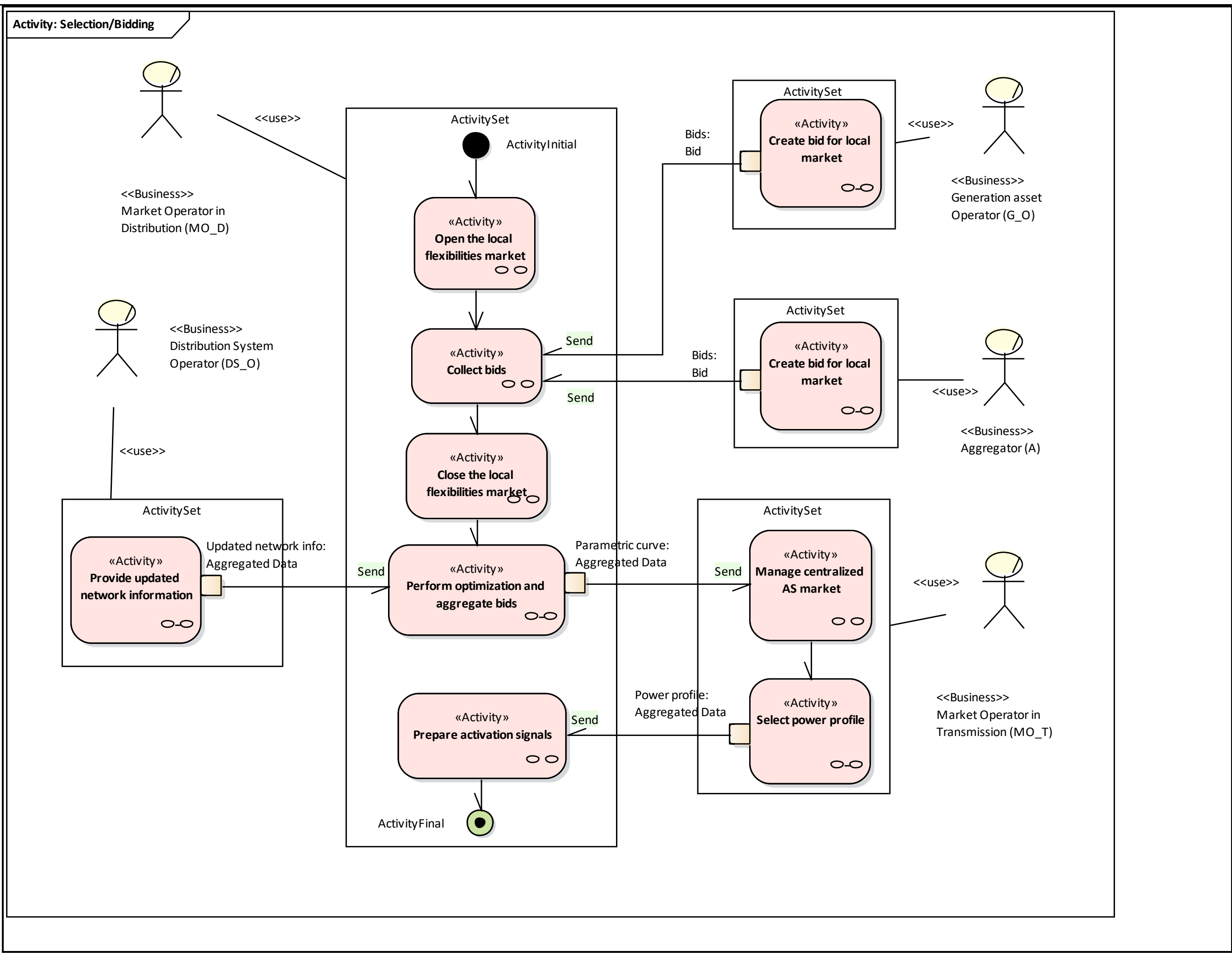
The local market is open for bidding for a full time slot; once closed, all the bids collected by the MO_D are considered in the optimization/resource selection phase, which lasts for another full time slot. In total, the bidding/selection phase lasts 30 minutes (two time slots).

Once the market is closed, the DS_O communicates to the MO_D the updated network configuration and the most recent resources production/consumption forecast related to the time instants for which the market is about to be cleared. This information includes the updated flexibility status of DS_O energy assets.

The result of the market clearing is a set of optimal activations of the available flexibilities. Since the local congestion management process (at distribution level) drives to active/reactive power imbalances, the MO_D clears the market also considering suitable countermeasures to solve them by using, if possible, DS_O own assets exclusively, in order to allow most of the customers to participate to the services provision to the transmission network.

Taking into account these preliminary selected activations, the MO_D groups all the remaining flexibilities in a parametric curve (quantity vs. price) and submits a bid for the real-time centralized mFRR/RR market, managed by the MO_T. Once the centralized mFRR/RR market is cleared, the MO_T sends back to the MO_D the requested power flexibility to be activated.

The MO_D disaggregates the power profile received from the MO_T, allocating the total flexibility between resources (including DS_O assets) and creating the corresponding activation signals, in preparation for the delivery phase.



Scenario step by step analysis

Scenario								
Scenario name	Selection/Bidding							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
2.1		Open the local flexibilities market	The local market operator (MO_D) opens the local flexibility market 30 minutes (two 15 minutes time slots) before the time slot during which the service		Market Operator in Distribution (MO_D)			

			will be provided, allowing the local customers to submit their bids;					
2.2		Create bid for local market	The DER operator(s) analyzes the foreseen plant generation profile for the next 15 minutes slot and evaluates the active power flexibility it can provide to the market; then prepares an offer and sends it to the local market operator (MO_D)	Send	Generation asset Operator (G_O)	Market Operator in Distribution (MO_D)	Info2-Bid	
2.3		Create bid for local market	The aggregator(s) analyzes the foreseen generation profile of its customers portfolio for the next 15 minutes slot and evaluates the active power flexibility it can provide to the market; then prepares an offer and sends it to the local market operator (MO_D)	Send	Aggregator (A)	Market Operator in Distribution (MO_D)	Info2-Bid	
2.4		Collect bids	The market operator keeps the market open for a whole 15 minutes time slot, collecting all the bids received within this time span;		Market Operator in Distribution (MO_D)			
2.5		Close the local flexibilities market	After 15 minutes (one time slot) after the market opening, and 15 minutes before the service provision, the MO_D closes the		Market Operator in Distribution (MO_D)			

			market; no more bids can be accepted for the selected time slot. Then, it collects from the DS_O the updated network information.					
2.6		Provide updated network information	Once the market is closed, the DS_O communicates to the MO_D: 1-the updated network configuration; 2-the most recent resources production/consumption forecast; 3-the flexibility status of its own energy assets; All these information are related to the delivery time slot.	Send	Distribution System Operator (DS_O)	Market Operator in Distribution (MO_D)	Info3-Aggregated Data	
2.7		Perform optimization and aggregate bids	The MO_D receives the updated network status from the DS_O, then it runs necessary calculations and Optimal Power Flows to: 1-Verify that the activation of the flexibilities don't create issues to the Distribution Network; if necessary, it can limit or delete the flexibilities which may be dangerous for system security; 2-Select the bids to be exploited for congestion	Send	Market Operator in Distribution (MO_D)	Market Operator in Transmission (MO_T)	Info3-Aggregated Data	

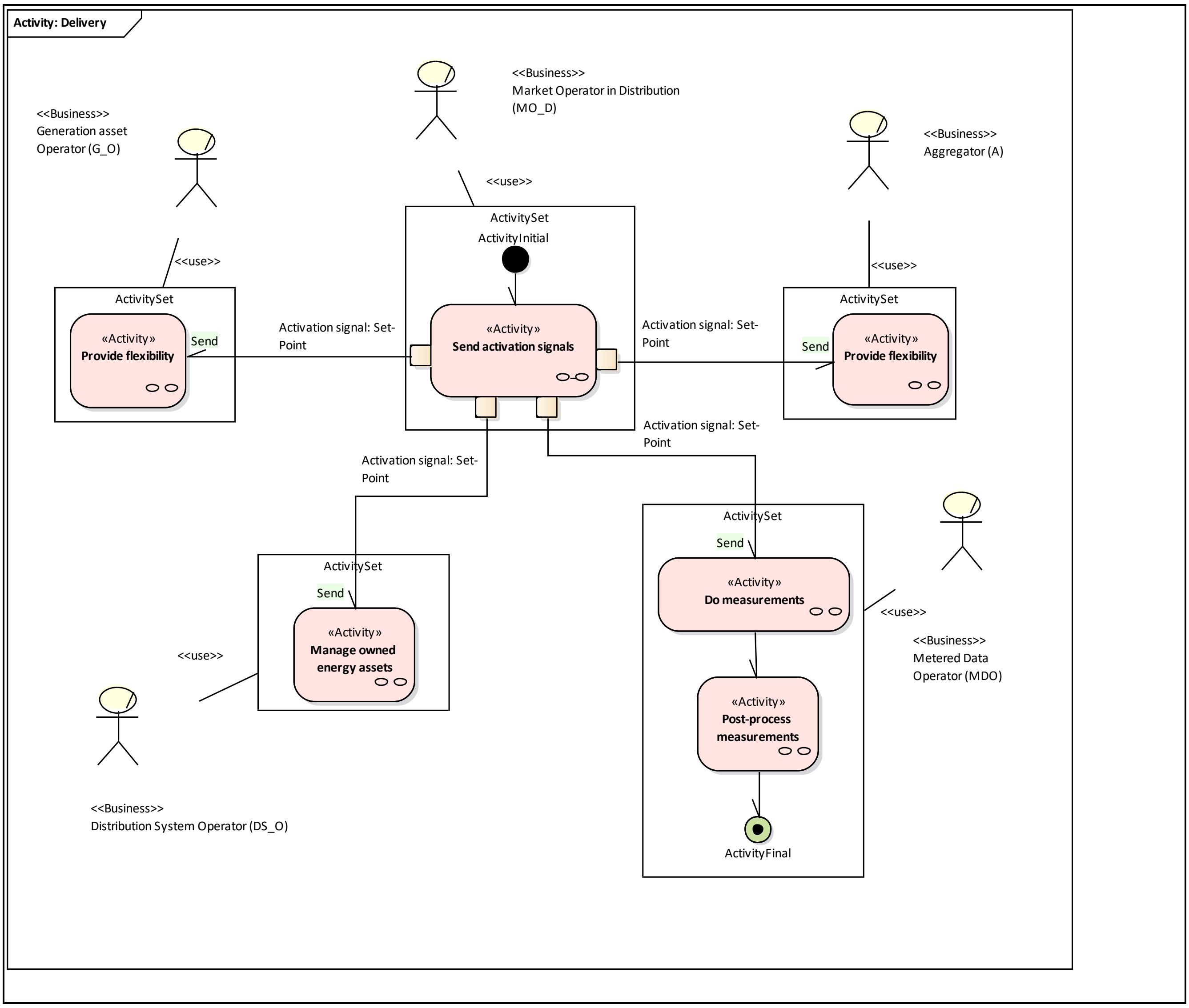
			management in the Distribution Network; 3-Calculate (if necessary) the set-points for DS_O energy assets for re-balancing purposes (in case the activation of flexibilities for local congestion management drive to imbalances at Primary Substation interface) At the end of the process it aggregates the remaining flexibilities in a single bid, based on a parametric curve (energy vs cost)and offers it on the centralized AS market;					
2.8		Manage centralized AS market	The MO_T manages the centralized AS market, including the aggregated bid provided by the MO_D;		Market Operator in Transmission (MO_T)			
2.9		Select power profile	The MO_T, based on the parametric curve received from the MO_D, selects the active power profile (at PS) which fits its needs and transmits it back to MO_D;	Send	Market Operator in Transmission (MO_T)	Market Operator in Distribution (MO_D)	Info3-Aggregated Data	
2.10		Prepare activation signals	The MO_D receives the active power profile from the MO_T and disaggregates it, preparing the activation signals for the delivery.		Market Operator in Distribution (MO_D)		Info4-Set-Point	

4.2.3 DELIVERY

This phase starts at the beginning of the time slot next to Bidding/Selection phase, when the MO_D sends the activation signals to the contracted resources.

The activation signal is sent, simultaneously, also to the MDO for the synchronization of the measurement process. The MDO is responsible for measurements collection and certification; the measurements are taken at the resources connection nodes and at primary substation interface.

On a daily basis, the MDO aggregates all the measurements and stores them for the settlement phase.



Scenario step by step analysis

Scenario	
Scenario name	Delivery

Step No	*Event*	*Name of process/activity*	*Description of process/activity*	*Service*	*Information producer (actor)*	*Information receiver (actor)*	*Information exchanged (IDs)*	*Requirement, R-IDs*
3.1		Send activation signals	The MO_D, at the beginning of the 15 minutes slot, sends, simultaneously, the activation signals to the resources involved, to the DS_O for its assets, and to the MDO for the synchronization of the measurement process.	Send	Market Operator in Distribution (MO_D)	Distribution System Operator (DS_O)	Info4-Set-Point	
3.2		Send activation signals	The MO_D, at the beginning of the 15 minutes slot, sends, simultaneously, the activation signals to the resources involved, to the DS_O for its assets, and to the MDO for the synchronization of the measurement process.	Send	Market Operator in Distribution (MO_D)	Generation asset Operator (G_O)	Info4-Set-Point	
3.3		Send activation signals	The MO_D, at the beginning of the 15 minutes slot, sends, simultaneously, the activation signals to the resources involved, to the DS_O for its assets, and to the MDO for the synchronization of the measurement process.	Send	Market Operator in Distribution (MO_D)	Aggregator (A)	Info4-Set-Point	

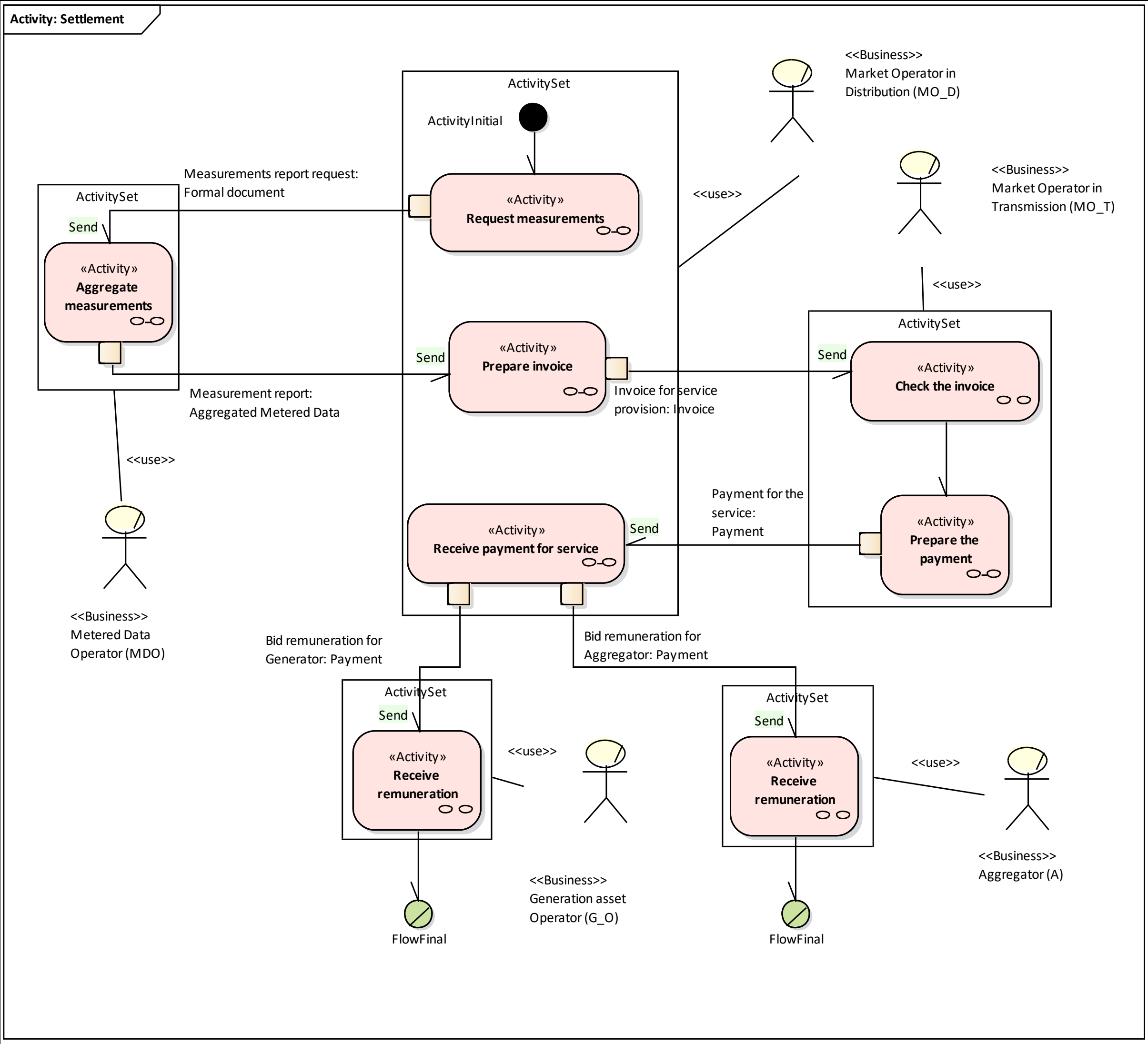
3.4		Send activation signals	The MO_D, at the beginning of the 15 minutes slot, sends, simultaneously, the activation signals to the resources involved, to the DS_O for its assets, and to the MDO for the synchronization of the measurement process.	Send	Market Operator in Distribution (MO_D)	Metered Data Operator (MDO)	Info4-Set-Point	
3.5		Provide flexibility	The generator(s) receives the activation signal and manages its own plant accordingly for the whole duration of the time slot;		Generation asset Operator (G_O)			
3.6		Provide flexibility	The aggregator(s) receives the activation signal and manages its portfolio of customers accordingly for the whole duration of the time slot;		Aggregator (A)			
3.7		Manage owned energy assets	The DS_O receives the activation signal and manages its own energy assets accordingly for the whole duration of the time slot;		Distribution System Operator (DS_O)			
3.8		Do measurements	The MDO receives from the MO_D the activation signal and takes measures from the meters installed		Metered Data Operator (MDO)			

			at the connection points of the selected resources; it checks also for deviations of the actual profiles from the scheduled ones						
3.9		Post-process measurements	The MDO stores the measurements and prepares them for the settlement phase;		Metered Data Operator (MDO)				

4.2.4 SETTLEMENT

In the long-term time frame (ex: monthly), the MO_D requests the measurements report to the MDO, then it prepares the invoice for service provision to be sent to the MO_T.

After receiving and checking the invoice, the MO_T send the payment to the MO_D, who disaggregates it and sends the corresponding remuneration to each resource.



Scenario step by step analysis

Scenario								
Scenario name	Settlement							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
4.1		Request measurements	On a monthly basis, the MO_D requests the measurements taken during the previous month to the MDO;	Send	Market Operator in Distribution (MO_D)	Metered Data Operator (MDO)	Info1-Formal document	

4.2		Aggregate measurements	The MDO aggregates the metered data (related to the resources who participated to ancillary services provision to the transmission network), as well as the measurements of the power exchange at the primary substation interface; then it prepares a measurements report and sends it to the local market operator MO_D.	Send	Metered Data Operator (MDO)	Market Operator in Distribution (MO_D)	Info5-Aggregated Metered Data	
4.3		Prepare invoice	The local market operator (MO_D) calculates the remuneration for the service based on the bid offered in the centralized market, as well as the penalties due to the deviations from the contracted set-points (if occurred). Then it prepares an invoice and submits it to the MO_T for service payment	Send	Market Operator in Distribution (MO_D)	Market Operator in Transmission (MO_T)	Info6-Invoice	
4.4		Check the invoice	The MO_T receives the invoice for the service from the MO_D and checks it;		Market Operator in Transmission (MO_T)			

4.5		Prepare the payment	The MO_T prepares the payment and sends it to the MO_D;	Send	Market Operator in Transmission (MO_T)	Market Operator in Distribution (MO_D)	Info7-Payment	
4.6		Receive payment for service	The MO_D receives the payment from the MO_T; based on the bids offered from the resources and the actual flexibility provision certified by the measurements, the MO_D calculates the remuneration for each resource who participated in the local flexibility market. Then, it prepares the payment and send it to the resources.	Send	Market Operator in Distribution (MO_D)	Aggregator (A)	Info7-Payment	
4.7		Receive payment for service	The MO_D receives the payment from the MO_T; based on the bids offered from the resources and the actual flexibility provision certified by the measurements, the MO_D calculates the remuneration for each resource who participated in the local flexibility market. Then, it prepares the	Send	Market Operator in Distribution (MO_D)	Generation asset Operator (G_O)	Info7-Payment	

			payment and send it to the resources.						
4.8		Receive remuneration	The generator(s) are remunerated for the flexibility provided;		Generation asset Operator (G_O)				
4.9		Receive remuneration	The aggregator(s) are remunerated for the flexibility provided;		Aggregator (A)				

5. INFORMATION EXCHANGED

Information exchanged			
Information exchanged, ID	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
Info1	Formal document	It may include: • Object; • Description; • Name of recipient; • Date; • Signature; • Data; • Technical report; • Schedules; • ...	
Info2	Bid	It must include the following information: • Product name; • Capacity/Energy (MW/MVAr); • Activation price (Euro); • Date;	
Info3	Aggregated Data	It may include: • Power/voltage profiles; • Parametric curves; • Merit-order lists; • Arrays; • ...	
Info4	Set-Point	It may include: • Asset/device ID code;	

		• Numeric values; • Control signals; • Duration; • ...	
Info5	Aggregated Metered Data	For a period of month,it may include (15 min resolution): • Unit-specific daily average power • Unit-specific daily maximum power • Agreed set-point; • Capability area limit; • Deviations; • ...	
Info6	Invoice	The invoice must contain: • Object of the invoice; • Justification; • Name of recipient; • Amount; • Due date; • Bank account;	
Info7	Payment	The payment must contain: • Object of the payment; • Justification; • Name of recipient; • Amount; • Date;	

TABLE 11 BUC IT-AP

Manage reactive power flexibility to support voltage control and congestion management in the Italian demo

Based on IEC 62559-2 edition 1
Generated from UML Use Case Repository with Modsarus® (EDF R&D Tool)

1. DESCRIPTION OF THE USE CASE

1.1 NAME OF USE CASE

Use case identification		
ID	***Area(s)/Domain(s)/Zone(s)***	***Name of use case***
IT-RP	Italy	Manage reactive power flexibility to support voltage control and congestion management in the Italian demo

1.2 VERSION MANAGEMENT

Version management				
Version No.	***Date***	***Name of author(s)***	***Changes***	***Approval status***
1	2018-05-30	Daniele Clerici	Proposed version from demo	
2	2018-06-11	Cyril Effantin	Consolidation in a common UC repository	
3	2018-07-30	Cyril Effantin	Minor UML fixes on Daniele version from 02-07-2018	
4	2018-09-18	Daniele Clerici	Update from Daniele Clerici	
5	2018-10-10	Daniele Clerici	Update based on role model evolution	

1.3 SCOPE AND OBJECTIVES OF USE CASE

Scope and objectives of use case	
Scope	Manage the reactive power exchange at Primary Substation interface for voltage control and congestion management in real-time operations of the transmission network. The fulfilment of these services is performed by the Distribution System Operator through suitable optimization processes, exploiting reactive power flexibilities connected to the distribution network. These flexibilities come from distributed resources connected to the distribution network and from Distribution System Operator own assets (i.e. Battery Energy Storage Systems, STATCOM, other..). These mixed flexibilities portfolio may, potentially, drive to a broader capability area in order to constantly guarantee the provision of the agreed reactive power exchange between the distribution and transmission networks.
Objective(s)	Manage and optimise the distribution network in real-time, allowing the Distribution System Operator to procure the contracted reactive capability from flexible distribution resources. Provide a broader reactive power capability area at Primary Substation interface, through the exploitation of a portfolio of flexible resources Manage the flexibilities portfolio, exploiting the reactive power flexibilities from private resources connected to the distribution grid
Related business case(s)	Voltage Control Congestion Management

1.4 NARRATIVE OF USE CASE

Narrative of use case

Short description
Following the increase of RES connected to the electric networks, novel operating schemes should be explored in order to address the specific needs of both distribution and transmission grids, allowing reliable and secure operations also in presence of a consistent amount of RES. These needs drive to an enhanced cooperation between Distribution System Operator (DS_O) and Transmission System Operator (TS_O), which could manage their own grids and connected resources in a profitable and secure way and, at the same time, supporting the grid activities of each other. In the following, the activities behind this cooperation are explained, referring specifically to the reactive power exchange, managed by the DS_O, for voltage control and congestion management purposes in transmission network. The DS_O stipulates long-term agreements with distributed resources for reactive power flexibility. In intra-day operation (every 6 hours), it aggregates the distributed resources flexibility in a single capability curve and provide it to the TS_O who gives a feedback (scheduled profile) on the basis of its necessity for voltage regulation and congestion management. During the operation, the TS_O periodically sends set-points (based on the agreed profile) for reactive power exchange at Primary Substation to the DS_O, who optimizes its grid by calculating suitable set-points for the resources participating in this service provision. The DS_O supports private resources participation, in addition to its own assets, in order to expand the flexibility sources portfolio for increasing the capability area at the Primary Substation interface.
Complete description
In this section, the previous short description is expanded; for each phase, the relevant steps, involved actors and their interactions are detailed: **Prequalification:** On a long-term basis, the DS_O stipulates agreements with distributed resources for reactive power capability exploitation. These resources, grouped together with DS_O own assets, form a "flexibility portfolio" which allows the DS_O to guarantee a suitable reactive power capability at Primary Substation interface in several operating conditions, addressing it to voltage control and congestion management. **Selection/Bidding:** The selection scenario considers two different main activities, based on different time-frames: the selection process done in the intra-day (every 6 hours) and the selection process done in real-time, just before the delivery of the service (the time slot ahead). In intra-day, on a 6 hours slot basis, the DS_O checks the resources who will participate to the service provision in the next intra-day time slot (next 6 hours), calculates the aggregated reactive power capability at Primary

Substation interface and submits it to the TS_O. The TS_O selects the power profile (within the capability provided by the DS_O) which is suitable for its needs and transmits it to the DS_O, who performs a network optimization to determine the optimal allocation of capacity between the available resources.
In real-time (at the beginning of each time slot), after receiving the set-point for reactive power exchange for the next time slot from the TS_O, the DS_O performs a new optimization process in order to:
1-take into account the actual distribution network state;
2-take into account modifications of the scheduled profile from the TS_O (within the capability provided by DS_O), due to the actual conditions of the transmission network;
3-actualize the capability allocation done before the beginning of the present 6 hours time slot.
Finally, the DS_O calculates the optimal set-points and sends them to the resources, in preparation for the delivery phase.

Delivery:

This phase starts at the beginning of the time slot next to Selection phase, when the TS_O sends the activation signal to the DS_O, which transfers it to the involved resources; in this phase, the resources must follow the set-points calculated in the Selection phase.
The activation signal is sent, simultaneously, also to the MDO for the synchronization of the measurement process. The MDO is responsible for measurements collection and certification; the measurements are taken at the resources connection nodes and at the primary substation interface.
On a daily basis, the MDO aggregates all the measurements and stores them for the settlement phase.

Settlement:

In the long-term time frame (ex: monthly), the DS_O requests the measurements report to the MDO; then, based on the certified measurements, it calculates and sends the corresponding remuneration to each resource.

Summary of use case

- **Prequalification**
  Description: On a long-term basis, the DS_O stipulates agreements with distributed resources for reactive power capability exploitation. These resources, grouped together with DS_O own assets, form a "flexibility portfolio" which allows the DS_O to guarantee a suitable reactive power capability at Primary Substation interface in several operating conditions, addressing it to voltage control and congestion management.
  - Prepare participation request
    Description: The generator(s) who wants to make its reactive power capability available for voltage control and congestion management, prepares a formal request and submits it to the DS_O;

- Prepare participation request
  Description: The aggregator(s) who wishes to make its total reactive power capability available for voltage control and congestion management, prepares a formal request and submits it to the DS_O. This request specifies the details of the resources (from the aggregator's portfolio) who will be exploited for the flexibility provision.

- Check participation request
  Description: The DS_O collects the requests for the participation to the voltage control and congestion management and checks them for consistency; in this step, the DS_O checks that the resources are suitable for the specific flexibility they want to provide, based on reports produced by an independent certification body (see Assumptions)

- Reject request
  Description: The DS_O prepares an official rejection document for the resources who don't meet the necessary requirements for the participation to the voltage control and congestion management; the document contains all the necessary information for the resources, to solve the issues and submit a new, potentially successful, request.

- Reject request
  Description: The DS_O prepares an official rejection document for the resources who don't meet the necessary requirements for the participation to the voltage control and congestion management; the document contains all the necessary information for the resources, to solve the issues and submit a new, potentially successful, request.

- Check rejection
  Description: The generator(s) receives the rejection document from the DS_O; in this document are specified the actions to be done for reach the requirements for participating to the voltage control and congestion management, so the generator(s) can take the necessary actions and submit a new request;

- Check rejection
  Description: The aggregator(s) receives the rejection document from the DS_O; in this document are specified the actions to be done for reach the requirements for participating to the voltage control and congestion management, so the aggregator(s) can take the necessary actions and submit a new request;

- Accept request
  Description: The DS_O officially registers the resources who meet the requirements for participating to the voltage control and congestion management; then it prepares an official acceptation document and release it to registered resources; the DS_O is responsible to periodically checking the resources and renew or revoke registration;

- Accept request
  Description: The DS_O officially registers the resources who meet the requirements for participating to the voltage control and congestion management; then it prepares an official acceptation document and release it to registered resources; the DS_O is responsible to periodically checking the resources and renew or revoke registration;

- Receive confirmation
  Description: The generator(s) receives the acceptance confirmation and the registration details; as a result, its reactive power capability will be added, by the DS_O, to the equivalent capability at Primary Substation for voltage control and congestion management purposes.

- Receive confirmation
  Description: The aggregator(s) receives the acceptance confirmation and the registration details; as a result, the reactive power capabilities of the resources included in its portfolio will be added, by the DS_O, to the equivalent capability at Primary Substation for voltage control and congestion management purposes.

- **Selection/Bidding**
  Description: The selection scenario considers two different main activities, based on different time-frames: the selection process done in the intra-day (every 6 hours) and the selection process done in real-time, just before the delivery of the service (the time slot ahead).
  In intra-day, on a 6 hours slot basis, the DS_O checks the resources who will participate to the service provision in the next intra-day time slot (next 6 hours), calculates the aggregated reactive power capability at Primary Substation interface and submits it to the TS_O. The TS_O selects the power profile (within the capability provided by the DS_O) which is suitable for its needs and transmits it to the DS_O, who performs a network optimization to determine the optimal allocation of capacity between the available resources.
  In real-time (at the beginning of each time slot), after receiving the set-point for reactive power exchange for the next time slot from the TS_O, the DS_O performs a new optimization process in order to:
  1-take into account the actual distribution network state;
  2-take into account modifications of the scheduled profile from the TS_O (within the capability provided by DS_O), due to the actual conditions of the transmission network;
  3-actualize the capability allocation done before the beginning of the present 6 hours time slot.
  Finally, the DS_O calculates the optimal set-points and sends them to the resources, in preparation for the delivery phase.

  - **Selection - Intra-day**
    Description: The DS_O requests to the distributed resources, participating in the service provision, their reactive power capability curve for the next intra-day time slot (next 6 hours); at the same time it checks the flexibility availability of its own assets. Finally it aggregates all the available flexibilities in a single capability curve at the Primary Substation, and communicates it to the TS_O. The TS_O checks the aggregated capability, select the power profile which is suitable for its needs and communicates it to the DS_O.
    The DS_O performs a network optimization to determine the optimal allocation of capacity between the available resources.

    - Collect capability data
      Description: The DS_O collects the capability curves from all the certified resources who want to participate to the reactive power exchange for the next intra-day time slot.

    - Calculate capability curve
      Description: The aggregator(s) provide the capability curves (of the resources included in its portfolio and participating to the service provision) for the next intra-day time slot and submits it to the DS_O;

    - Calculate capability curve
      Description: The generator(s), based on the production forecast, calculates the actual capability curve for the next intra-day time slot and submits it to the DS_O;

    - Calculate total capability
      Description: The DS_O aggregates all the capability curves in a single equivalent one at Primary Substation interface, and communicates it to the TS_O

- Calculate flexibility area
  Description: The TS_O performs its own calculation and determines the reactive power profile which can fit its needs for the next intra-day time slot; then, it communicates it to the DS_O;

- Perform network optimization
  Description: The DS_O analyzes the scheduled profile received from the TS_O and performs the necessary calculations to determine the optimal allocation of capacity between the participating resources;

- **Selection - Real-Time**
  Description: In real-time (at the beginning of each time slot), the TS_O sends a set-point for reactive power exchange for the next time slot; time slots have a 15 minutes duration.
  The DS_O performs a new optimization process in order to:
  1-take into account the actual distribution network state;
  2-take into account modifications of the scheduled profile from the TS_O (within the capability provided by DS_O), due to the actual conditions of the transmission network;
  3-actualize the capability allocation done before the beginning of the present 6 hours time slot.

  The optimization process allows the DS_O to find suitable set-points for the distributed resources, taking into account their actual operating conditions (ex: capability reduction due to participation in congestion management or other services) and their actual network state; in this phase the DS_O can adjust the share of capability between the available resources in order to fulfil the agreed reactive power exchange. Finally, the DS_O sends the calculated set-points to the resources in preparation for delivery phase.

  - Send set-point
    Description: The TS_O sends the set-point for reactive power exchange at Primary Substation interface to the DS_O; this happens 15 minutes (one time slot) in advance in respect to the beginning of service provision time slot. The set-point may deviate from the scheduled profile (based on the actual operating conditions of the transmission network) but must be within the capability band provide by the DS_O;

  - Perform network optimization
    Description: The DS_O receives the set-point from the TS_O and runs another optimization process for taking in to account the actual state of distribution network and actualize the allocation of the requested reactive power between the resources; then it calculates suitable set-points and sends them to the resources;

  - Perform network optimization
    Description: The DS_O receives the set-point from the TS_O and runs another optimization process for taking in to account the actual state of distribution network and actualize the allocation of the requested reactive power between the resources; then it calculates suitable set-points and sends them to the resources;

  - Receive set-point
    Description: The aggregator(s) receives the set-points in preparation of the delivery phase;

  - Receive set-point
    Description: The generator(s) receives the set-points in preparation of the delivery phase;

- **Delivery**
  Description: This phase starts at the beginning of the time slot next to Selection phase, when the TS_O sends the activation signal to the DS_O, which transfers it to the involved resources; in this phase the resources must follow the set-points calculated in the Selection phase.
  The activation signal is sent, simultaneously, also to the MDO for the synchronization of the measurement process. The MDO is responsible for measurements collection and certification; the measurements are taken at the resources connection nodes and at the primary substation interface.
  On a daily basis, the MDO aggregates all the measurements and stores them for the settlement phase.

  - Send activation signal
    Description: The TS_O, at the beginning of the 15 minutes slot, sends the activation signal for the previously released set-points; the activation signal is also sent, simultaneously, to the MDO for the synchronization of the measurement process at Primary Substation interface;

  - Transfer activation signal
    Description: The DS_O receives the activation signal from the TS_O and transmits it to resources and to the MDO, for the synchronization of the measurement process;

  - Transfer activation signal
    Description: The DS_O receives the activation signal from the TS_O and transmits it to resources and to the MDO, for the synchronization of the measurement process;

  - Transfer activation signal
    Description: The DS_O receives the activation signal from the TS_O and transmits it to resources and to the MDO, for the synchronization of the measurement process;

  - Follow set-points
    Description: The generator(s) receives the activation signal and manages its own plant accordingly for the whole duration of the time slot;

  - Follow set-points
    Description: The aggregator(s) receives the activation signal and manages its portfolio of customers accordingly for the whole duration of the time slot;

  - Do measurements
    Description: The MDO receives from the DS_O the activation signal and takes measures from the meters installed at the connection points of the selected resources; it checks also for deviations of the actual profiles from the scheduled set-points

  - Post-process measurements
    Description: The MDO stores the measurements and prepares them for the settlement phase;
- **Settlement**
  Description: In the long-term time frame (ex: monthly), the DS_O requests the measurements report to the MDO; then, based on the certified measurements, it calculates and sends the corresponding remuneration to each resource.

  - Request measurements
    Description: On a monthly basis, the DS_O requests the measurements taken during the previous month to the MDO;

  - Aggregate measurements
    Description: The MDO aggregates the metered data related to the resources who participated

to voltage control and congestion management services, as well as the measurements of the power exchange at the primary substation interface; then it prepares a measurements report and sends it to the DS_O.

- Check measures and calculate grid fees
  Description: Based on the actual capacity provided by each resource (certified by the measurements), the DS_O calculates a reduction to be applied to grid fees (as well as penalties, if necessary) for the participating resources.

1.5 KEY PERFORMANCE INDICATORS (KPI)

1.6 USE CASE CONDITIONS

Use case conditions	
Assumptions	
1	Assumption: In this Business Use Case the DS_O and MDO roles correspond to different actors even if, in some countries (Italy included), they may both belong to a single stakeholder (most likely the Distribution System Operator): this approach allows to describe the whole business process in a more general way, facilitating its replicability in other regulatory/technical frameworks.
2	Assumption: In this Business Use Case it is assumed that the generator asset operator (G_O) role has a single resource portfolio (owned generator), while the Aggregator role has multiple resources portfolio. The processes which describe the management of the portfolio by the Aggregator(s) are not described in this Business Use Case.
3	Assumption: At present (2018) the Italian Regulatory framework considers a DSO/TSO coordination scheme based on a centralized Ancillary Services market model for frequency-based services. The provision of voltage support within a market approach is still in a pilot phase and involves large generators only. For this Business Use Case a coordination scheme based on shared balancing responsibility model is considered. In this coordination scheme the Distribution System Operator and Transmission System Operator, intra-day (with fixed time slots of 6 hours), agreed on reactive power exchange profile at Primary Substation interface, addressing it to voltage control and congestion management. The Distribution System Operator has the responsibility to follow the agreed exchange profile, using all the available flexibility resources connected to the distribution grid.
4	Assumption: In this Business Use Case it is assumed that the TS_O role (as in the actual Italian scenario) belongs to a single stakeholder, the Transmission System Operator.
5	Assumption: Since in this Business Use Case no market is considered, there is no remuneration for the resources which make available their capability to the DS_O. Anyway, since the exploitation of these resources may reduce distribution network costs, it is assumed that the DS_O applies a reduction in grid fees for the participating resources, as well as penalties if the agreed capability is not provided.
Prerequisites	

1	PreCondition: In order to participate to the voltage control support process, the distributed resources must comply with the technical and system requirements. The pre-qualification process can be done in two phases: -The DER owner requests a technical pre-qualification to a Certified Body (third-party) who verifies and validates the DER technical capability for providing ancillary services. The technical certification must be presented to the DS_O and it is mandatory for the resource registration; this phase is described in the "Prequalification" scenario. -The system pre-qualification is done by the DS_O during the "Selection/Bidding"scenario, both in the intra-day and in the real-time timeframes.

1.7 FURTHER INFORMATION TO THE USE CASE FOR CLASSIFICATION/MAPPING

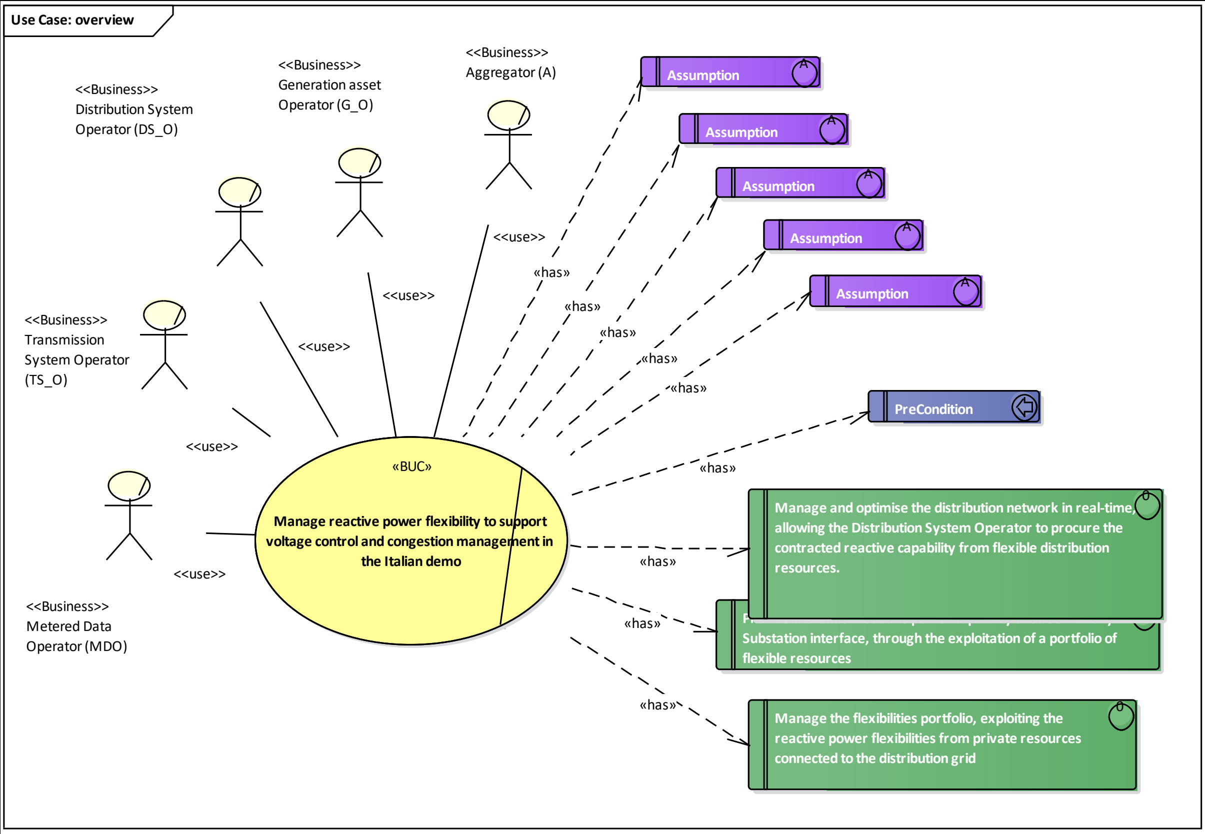
Classification information
Relation to other use cases
Level of depth
BUC for the Italian Demo. Black-box (the roles are considered from a black-box perspective and their organisational entities are not detailed in the steps of the Use Case)
Prioritisation
Generic, regional or national relation
Italian Demo
Nature of the use case
BUC
Further keywords for classification

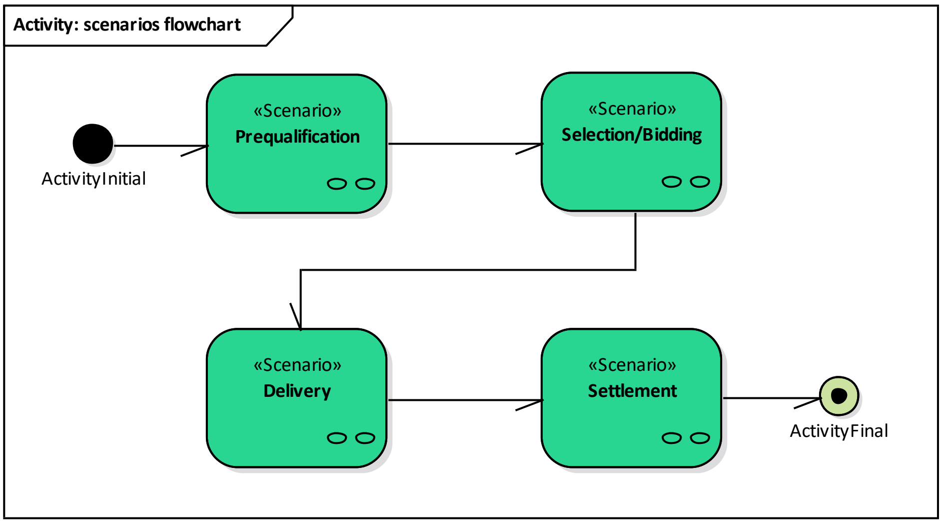
1.8 GENERAL REMARKS

General remarks

2. DIAGRAMS OF USE CASE

Diagram(s) of use case





3. TECHNICAL DETAILS

3.1 ACTORS

Actors	
Grouping (e.g. domains, zones)	***Group description***

Actor name	*Actor type*	*Actor description*	*Further information specific to this use case*
Transmission System Operator (TS_O)	Business	Elaborate network development plan (including defining system needs for transmission) Ensure a transparent and non-discriminatory access to the transmission network for each user Operate the transmission grid over a specific region in a secure, reliable and efficient way Secure and manage in real time the physical generation-consumption balance on a geographical perimeter, including ensuring the frequency control service Optimize transmission system operation from planning to real-time, using available levers (grid expansion, flexibility activation,...) Assess network status of the transmission grid and broadcast selected information of the network status to eligible actors (e.g. aggregators, other system operators) Provide data to the interconnection capacity market operator for the management of cross border transactions In critical situations, implement dedicated actions and deliver alerts during stress events If necessary, implement emergency measures (e.g. system defence plan) including load shedding	
Distribution System Operator (DS_O)	Business	Elaborate network development plan (including defining system needs for distribution) Ensure a transparent and non-discriminatory access to the distribution network for each user Operate the distribution grid over a specific region in a secure, reliable and efficient way Optimize system operation distribution grid from planning to real-time, using available levers (grid expansion, flexibility activation,...) Assess network status of the distribution grid and broadcast selected information of the network status to eligible actors (e.g. aggregators, other system operators) Support the Transmission System Operator in carrying out its responsibilities (including load shedding) and coordinate measures if necessary	

Generation asset Operator (G_O)	Business	Operate one or several generation asset(s)	
Aggregator (A)	Business	Aggregate and maximise value of portfolio(s) of resources	
Metered Data Operator (MDO)	Business	Provide metered data to authorized users in a transparent and non-discriminatory manner	

3.2 REFERENCES

4. STEP BY STEP ANALYSIS OF USE CASE

4.1 OVERVIEW OF SCENARIOS

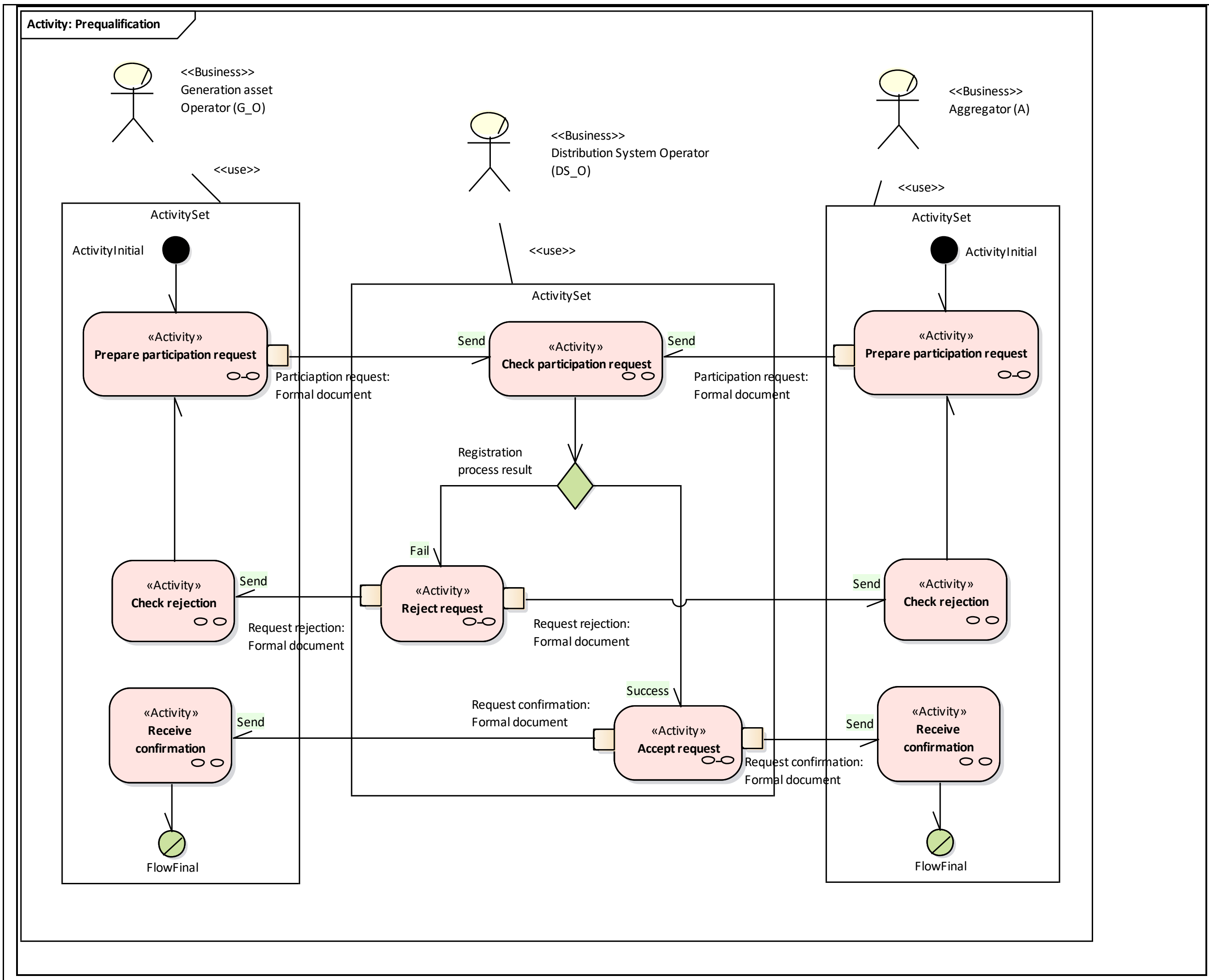
Scenario conditions							
No.	***Scenario name***	***Scenario description***	***Primary actor***	***Triggering event***	***Pre-condition***	***Post-condition***
1	Prequalification	On a long-term basis, the DS_O stipulates agreements with distributed resources for reactive power capability exploitation. These resources, grouped together with DS_O own assets, form a "flexibility portfolio" which allows the DS_O to guarantee a suitable reactive power capability at Primary Substation interface in several operating conditions, addressing it to voltage control and congestion management.				
2	Selection/Bidding	The selection scenario considers two different main activities, based on different time-frames: the selection process done in the intra-day (every 6 hours) and the selection process done in real-time, just before the delivery of the service (the time slot ahead). In intra-day, on a 6 hours slot basis, the DS_O checks the resources who will participate to the service provision in the next intra-day time slot (next 6 hours), calculates the aggregated reactive power capability at Primary Substation interface and submits it to the TS_O. The TS_O selects the power profile (within the capability provided by the DS_O) which is suitable for its needs and transmits it to the DS_O, who performs a network optimization to determine the optimal allocation of capacity between the available resources. In real-time (at the beginning of each time slot), after receiving the set-point for				

		reactive power exchange for the next time slot from the TS_O, the DS_O performs a new optimization process in order to: 1-take into account the actual distribution network state; 2-take into account modifications of the scheduled profile from the TS_O (within the capability provided by DS_O), due to the actual conditions of the transmission network; 3-actualize the capability allocation done before the beginning of the present 6 hours time slot. Finally, the DS_O calculates the optimal set-points and sends them to the resources, in preparation for the delivery phase.				
3	Delivery	This phase starts at the beginning of the time slot next to Selection phase, when the TS_O sends the activation signal to the DS_O, which transfers it to the involved resources; in this phase the resources must follow the set-points calculated in the Selection phase. The activation signal is sent, simultaneously, also to the MDO for the synchronization of the measurement process. The MDO is responsible for measurements collection and certification; the measurements are taken at the resources connection nodes and at the primary substation interface. On a daily basis, the MDO aggregates all the measurements and stores them for the settlement phase.				
4	Settlement	In the long-term time frame (ex: monthly), the DS_O requests the measurements report to the MDO; then, based on the certified measurements, it calculates and sends the corresponding remuneration to each resource.				

4.2 STEPS - SCENARIOS

4.2.1 PREQUALIFICATION

On a long-term basis, the DS_O stipulates agreements with distributed resources for reactive power capability exploitation. These resources, grouped together with DS_O own assets, form a "flexibility portfolio" which allows the DS_O to guarantee a suitable reactive power capability at Primary Substation interface in several operating conditions, addressing it to voltage control and congestion management.



Scenario step by step analysis

Scenario								
Scenario name	Prequalification							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
1.1		Prepare participation request	The generator(s) who wants to make its reactive power capability available for voltage control and congestion management,	Send	Generation asset Operator (G_O)	Distribution System Operator (DS_O)	Info1-Formal document	

			prepares a formal request and submits it to the DS_O;					
1.2		Prepare participation request	The aggregator(s) who wishes to make its total reactive power capability available for voltage control and congestion management, prepares a formal request and submits it to the DS_O. This request specifies the details of the resources (from the aggregator's portfolio) who will be exploited for the flexibility provision.	Send	Aggregator (A)	Distribution System Operator (DS_O)	Info1-Formal document	
1.3		Check participation request	The DS_O collects the requests for the participation to the voltage control and congestion management and checks them for consistency; in this step, the DS_O checks that the resources are suitable for the specific flexibility they want to provide, based on reports produced by an independent certification body (see Assumptions)		Distribution System Operator (DS_O)			

1.4		Reject request	The DS_O prepares an official rejection document for the resources who don't meet the necessary requirements for the participation to the voltage control and congestion management; the document contains all the necessary information for the resources, to solve the issues and submit a new, potentially successful, request.	Send	Distribution System Operator (DS_O)	Aggregator (A)	Info1- Formal document	
1.5		Reject request	The DS_O prepares an official rejection document for the resources who don't meet the necessary requirements for the participation to the voltage control and congestion management; the document contains all the necessary information for the resources, to solve the issues and submit a new, potentially successful, request.	Send	Distribution System Operator (DS_O)	Generation asset Operator (G_O)	Info1- Formal document	
1.6		Check rejection	The generator(s) receives the rejection document from the DS_O; in this document are		Generation asset Operator (G_O)			

			specified the actions to be done for reach the requirements for participating to the voltage control and congestion management, so the generator(s) can take the necessary actions and submit a new request;					
1.7		Check rejection	The aggregator(s) receives the rejection document from the DS_O; in this document are specified the actions to be done for reach the requirements for participating to the voltage control and congestion management, so the aggregator(s) can take the necessary actions and submit a new request;		Aggregator (A)			
1.8		Accept request	The DS_O officially registers the resources who meet the requirements for participating to the voltage control and congestion management; then it prepares an official acceptation document and release it to registered resources;	Send	Distribution System Operator (DS_O)	Aggregator (A)	Info1- Formal document	

			the DS_O is responsible to periodically checking the resources and renew or revoke registration;					
1.9		Accept request	The DS_O officially registers the resources who meet the requirements for participating to the voltage control and congestion management; then it prepares an official acceptation document and release it to registered resources; the DS_O is responsible to periodically checking the resources and renew or revoke registration;	Send	Distribution System Operator (DS_O)	Generation asset Operator (G_O)	Info1- Formal document	
1.10		Receive confirmation	The generator(s) receives the acceptance confirmation and the registration details; as a result, its reactive power capability will be added, by the DS_O, to the equivalent capability at Primary Substation for voltage control and congestion management purposes.		Generation asset Operator (G_O)			

1.11		Receive confirmation	The aggregator(s) receives the acceptance confirmation and the registration details; as a result, the reactive power capabilities of the resources included in its portfolio will be added, by the DS_O, to the equivalent capability at Primary Substation for voltage control and congestion management purposes.		Aggregator (A)			

4.2.2 SELECTION/BIDDING

The selection scenario considers two different main activities, based on different time-frames: the selection process done in the intra-day (every 6 hours) and the selection process done in real-time, just before the delivery of the service (the time slot ahead).

In intra-day, on a 6 hours slot basis, the DS_O checks the resources who will participate to the service provision in the next intra-day time slot (next 6 hours), calculates the aggregated reactive power capability at Primary Substation interface and submits it to the TS_O. The TS_O selects the power profile (within the capability provided by the DS_O) which is suitable for its needs and transmits it to the DS_O, who performs a network optimization to determine the optimal allocation of capacity between the available resources.

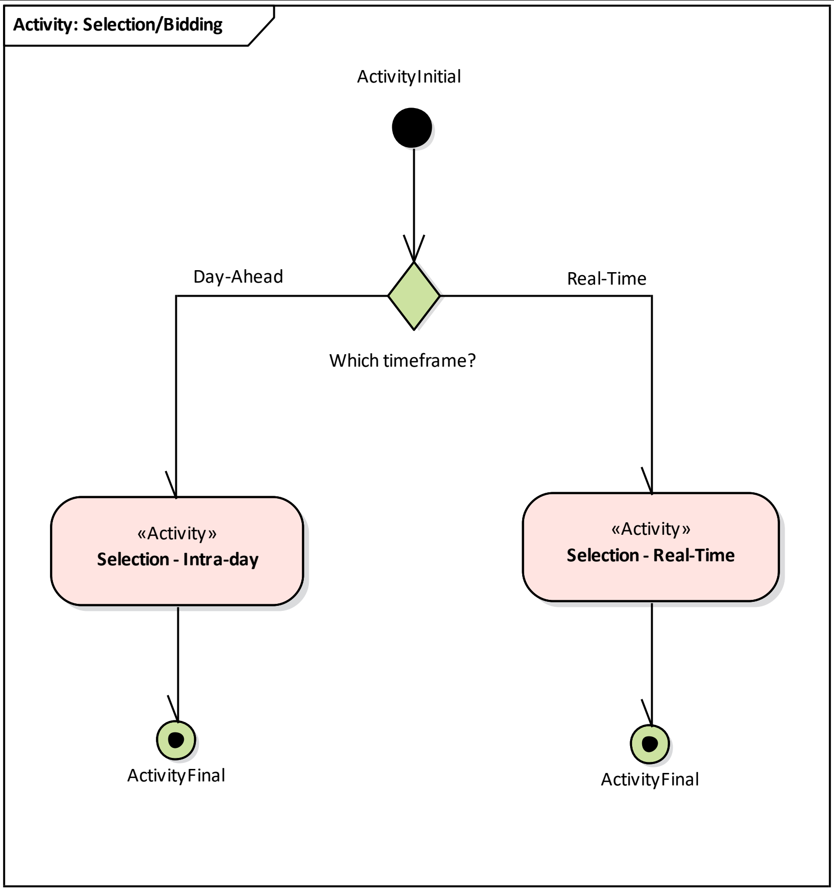
In real-time (at the beginning of each time slot), after receiving the set-point for reactive power exchange for the next time slot from the TS_O, the DS_O performs a new optimization process in order to:

1-take into account the actual distribution network state;

2-take into account modifications of the scheduled profile from the TS_O (within the capability provided by DS_O), due to the actual conditions of the transmission network;

3-actualize the capability allocation done before the beginning of the present 6 hours time slot.

Finally, the DS_O calculates the optimal set-points and sends them to the resources, in preparation for the delivery phase.



Scenario step by step analysis

Scenario								
Scenario name	Selection/Bidding							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
2.1		Selection - Intra-day	The DS_O requests to the distributed resources, participating in the service provision, their reactive power capability curve for the next intra-day time slot (next 6 hours); at the same time it					

			checks the flexibility availability of its own assets. Finally it aggregates all the available flexibilities in a single capability curve at the Primary Substation, and communicates it to the TS_O. The TS_O checks the aggregated capability, select the power profile which is suitable for its needs and communicates it to the DS_O. The DS_O performs a network optimization to determine the optimal allocation of capacity between the available resources.					
2.2		Selection - Real-Time	In real-time (at the beginning of each time slot), the TS_O sends a set-point for reactive power exchange for the next time slot; time slots have a 15 minutes duration. The DS_O performs a new optimization process in order to: 1-take into account the actual distribution network state; 2-take into account modifications of the scheduled profile from					

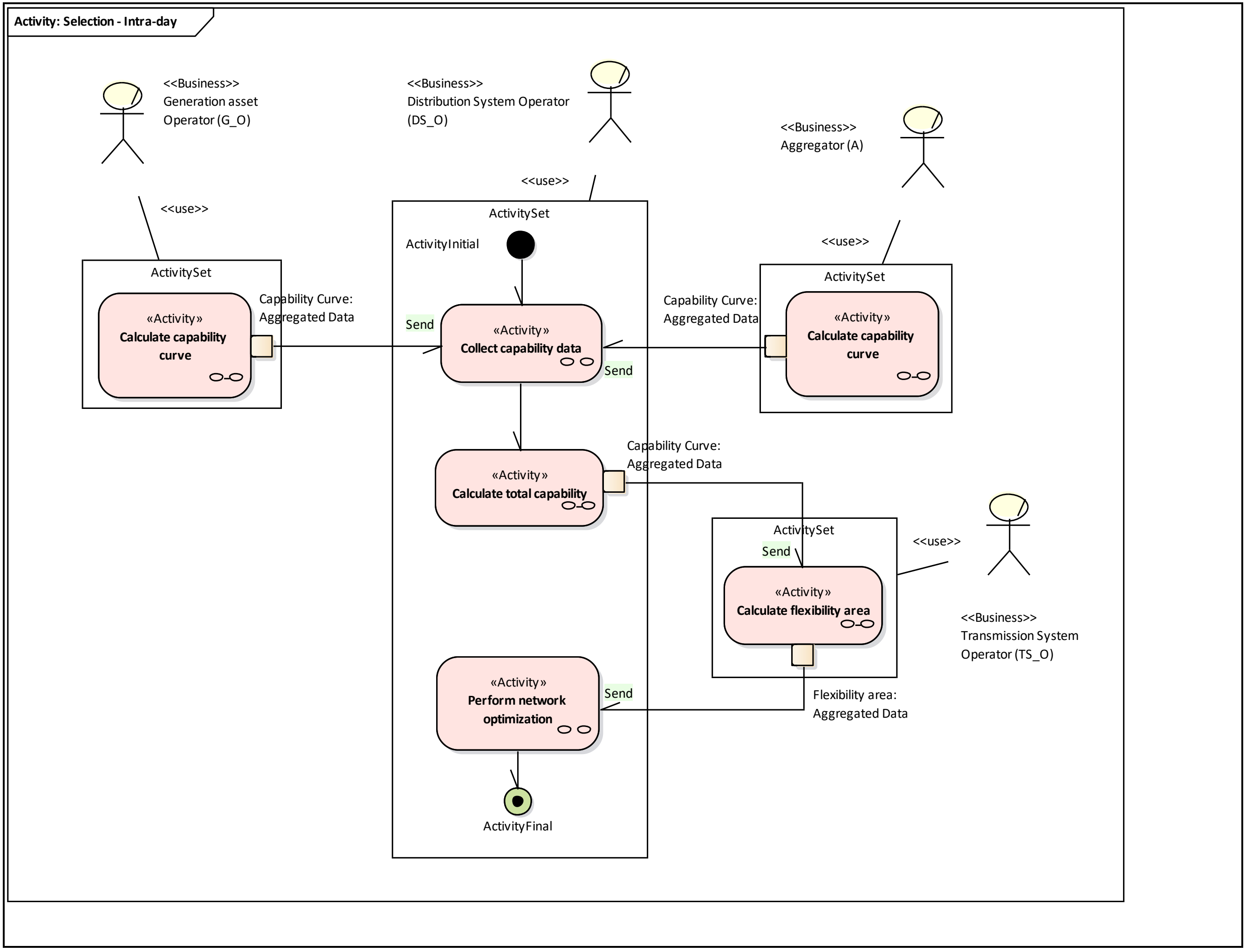
			the TS_O (within the capability provided by DS_O), due to the actual conditions of the transmission network; 3-actualize the capability allocation done before the beginning of the present 6 hours time slot. The optimization process allows the DS_O to find suitable set-points for the distributed resources, taking into account their actual operating conditions (ex: capability reduction due to participation in congestion management or other services) and their actual network state; in this phase the DS_O can adjust the share of capability between the available resources in order to fulfil the agreed reactive power exchange. Finally, the DS_O sends the calculated set-points to the resources in preparation for delivery phase.					

- ## 2.1. Selection - Intra-day

Business section: Selection/Bidding/Selection - Intra-day

The DS_O requests to the distributed resources, participating in the service provision, their reactive power capability curve for the next intra-day time slot (next 6 hours); at the same time it checks the flexibility availability of its own assets. Finally it aggregates all the available flexibilities in a single capability curve at the Primary Substation, and communicates it to the TS_O. The TS_O checks the aggregated capability, select the power profile which is suitable for its needs and communicates it to the DS_O.

The DS_O performs a network optimization to determine the optimal allocation of capacity between the available resources.



Activity step by step analysis

Scenario	
Scenario name	Selection/Bidding

Step No	Event	Name of process/activity	Description of process/activity	Service	Information producer (actor)	Information receiver (actor)	Information exchanged (IDs)	Requirement, R-IDs
2.1.1		Collect capability data	The DS_O collects the capability curves from all the certified resources who want to participate to the reactive power exchange for the next intra-day time slot.		Distribution System Operator (DS_O)			
2.1.2		Calculate capability curve	The aggregator(s) provide the capability curves (of the resources included in its portfolio and participating to the service provision) for the next intra-day time slot and submits it to the DS_O;	Send	Aggregator (A)	Distribution System Operator (DS_O)	Info2-Aggregated Data	
2.1.3		Calculate capability curve	The generator(s), based on the production forecast, calculates the actual capability curve for the next intra-day time slot and submits it to the DS_O;	Send	Generation asset Operator (G_O)	Distribution System Operator (DS_O)	Info2-Aggregated Data	
2.1.4		Calculate total capability	The DS_O aggregates all the capability curves in a single equivalent one at Primary	Send	Distribution System Operator (DS_O)	Transmission System Operator (TS_O)	Info2-Aggregated Data	

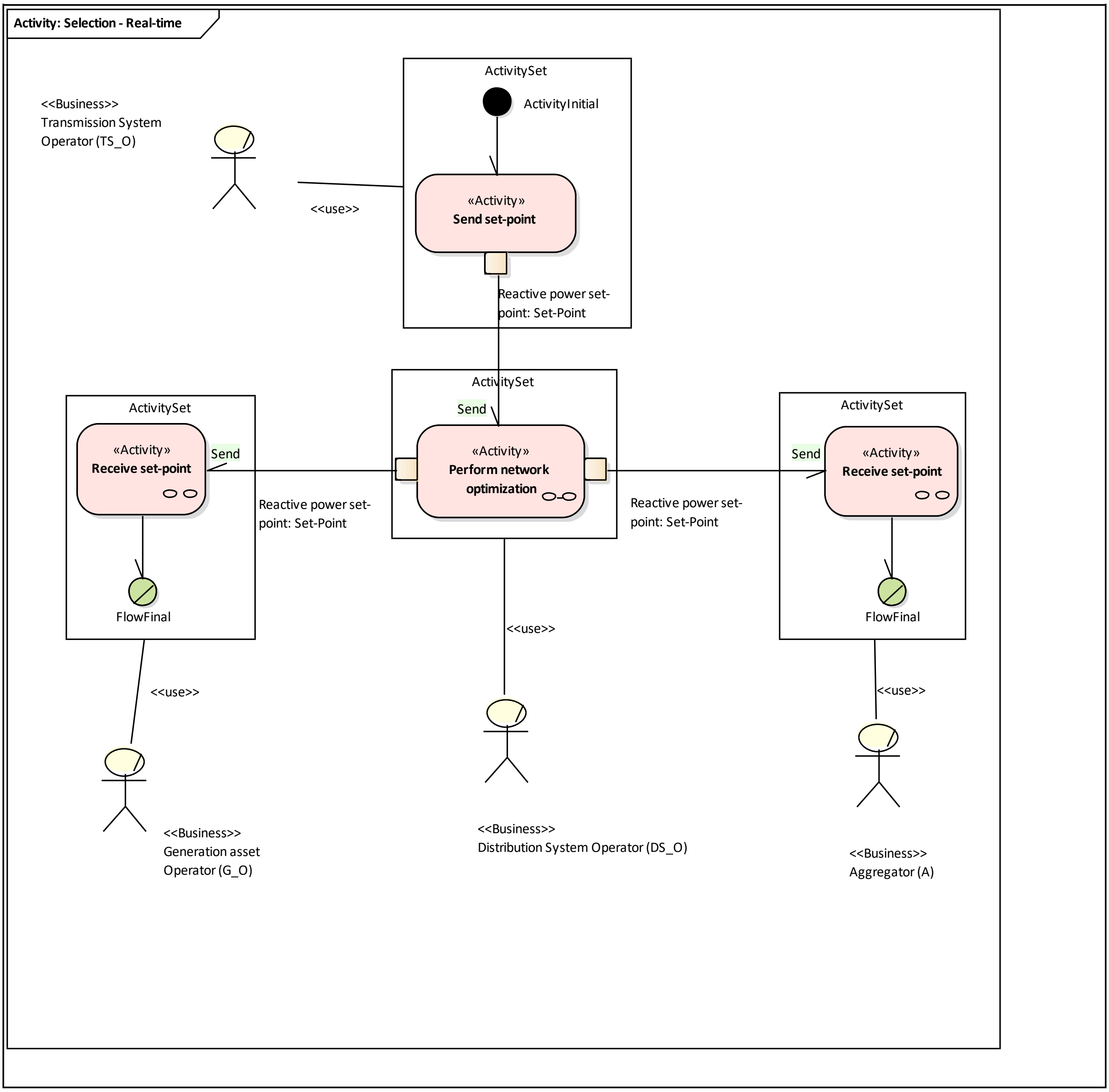
			Substation interface, and communicates it to the TS_O					
2.1.5		Calculate flexibility area	The TS_O performs its own calculation and determines the reactive power profile which can fit its needs for the next intra-day time slot; then, it communicates it to the DS_O;	Send	Transmission System Operator (TS_O)	Distribution System Operator (DS_O)	Info2-Aggregated Data	
2.1.6		Perform network optimization	The DS_O analyzes the scheduled profile received from the TS_O and performs the necessary calculations to determine the optimal allocation of capacity between the participating resources;		Distribution System Operator (DS_O)			

- ## 2.2. Selection - Real-Time

Business section: Selection/Bidding/Selection - Real-Time

In real-time (at the beginning of each time slot), the TS_O sends a set-point for reactive power exchange for the next time slot; time slots have a 15 minutes duration.
The DS_O performs a new optimization process in order to:
1-take into account the actual distribution network state;
2-take into account modifications of the scheduled profile from the TS_O (within the capability provided by DS_O), due to the actual conditions of the transmission network;
3-actualize the capability allocation done before the beginning of the present 6 hours time slot.

The optimization process allows the DS_O to find suitable set-points for the distributed resources, taking into account their actual operating conditions (ex: capability reduction due to participation in congestion management or other services) and their actual network state; in this phase the DS_O can adjust the share of capability between the available resources in order to fulfil the agreed reactive power exchange. Finally, the DS_O sends the calculated set-points to the resources in preparation for delivery phase.



Activity step by step analysis

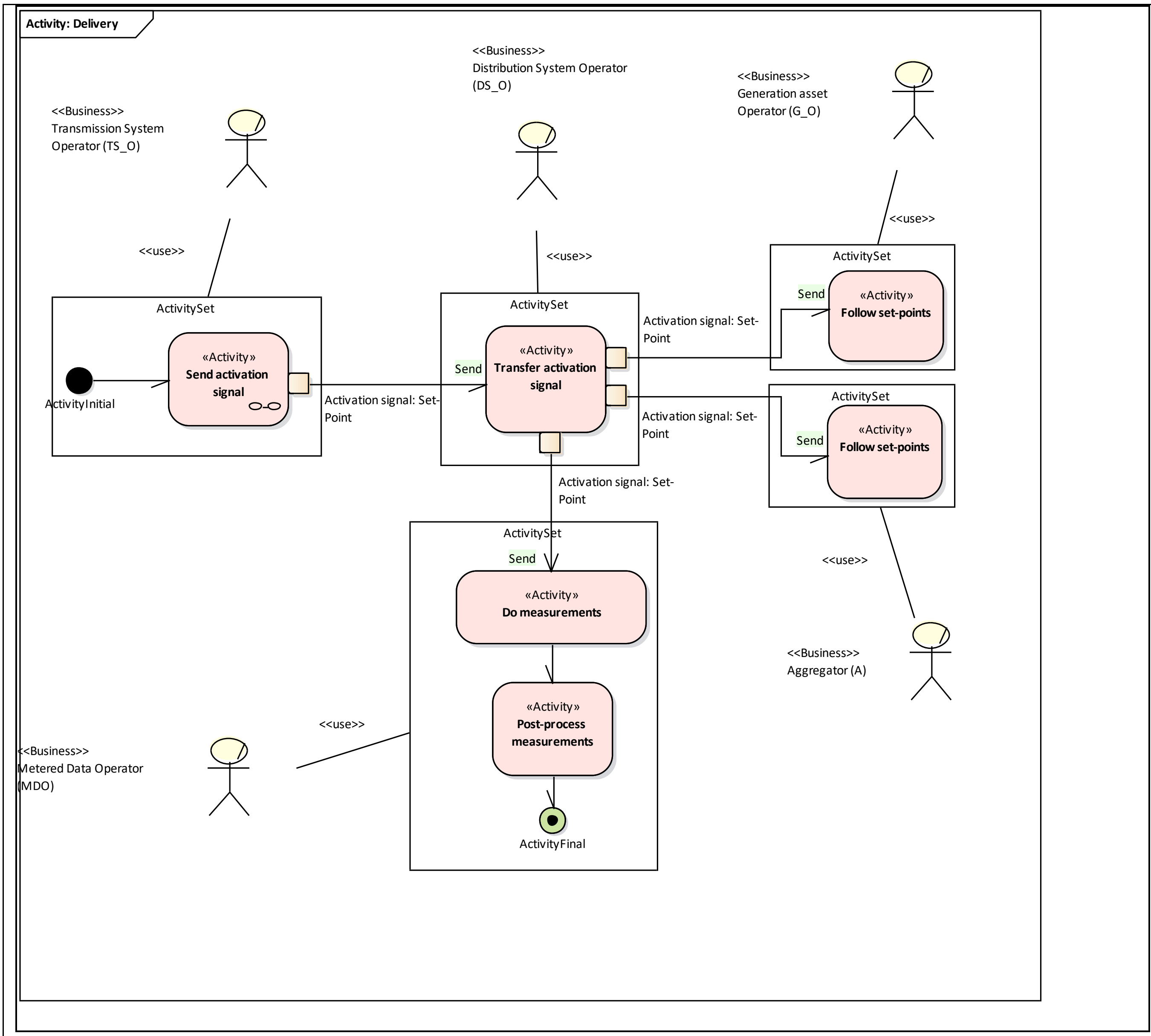
Scenario	
Scenario name	Selection/Bidding

Step No	*Event*	*Name of process/activity*	*Description of process/activity*	*Service*	*Information producer (actor)*	*Information receiver (actor)*	*Information exchanged (IDs)*	*Requirement, R-IDs*
2.2.1		Send set-point	The TS_O sends the set-point for reactive power exchange at Primary Substation interface to the DS_O; this happens 15 minutes (one time slot) in advance in respect to the beginning of service provision time slot. The set-point may deviate from the scheduled profile (based on the actual operating conditions of the transmission network) but must be within the capability band provide by the DS_O;	Send	Transmission System Operator (TS_O)	Distribution System Operator (DS_O)	Info3-Set-Point	
2.2.2		Perform network optimization	The DS_O receives the set-point from the TS_O and runs another optimization process for taking in to account the actual state of distribution network and actualize the allocation of the requested reactive power between the resources; then it calculates suitable set-points and sends	Send	Distribution System Operator (DS_O)	Aggregator (A)	Info3-Set-Point	

			them to the resources;					
2.2.3		Perform network optimization	The DS_O receives the set-point from the TS_O and runs another optimization process for taking in to account the actual state of distribution network and actualize the allocation of the requested reactive power between the resources; then it calculates suitable set-points and sends them to the resources;	Send	Distribution System Operator (DS_O)	Generation asset Operator (G_O)	Info3-Set-Point	
2.2.4		Receive set-point	The aggregator(s) receives the set-points in preparation of the delivery phase;		Aggregator (A)			
2.2.5		Receive set-point	The generator(s) receives the set-points in preparation of the delivery phase;		Generation asset Operator (G_O)			

1.6.1. DELIVERY

This phase starts at the beginning of the time slot next to Selection phase, when the TS_O sends the activation signal to the DS_O, which transfers it to the involved resources; in this phase the resources must follow the set-points calculated in the Selection phase.
The activation signal is sent, simultaneously, also to the MDO for the synchronization of the measurement process. The MDO is responsible for measurements collection and certification; the measurements are taken at the resources connection nodes and at the primary substation interface.
On a daily basis, the MDO aggregates all the measurements and stores them for the settlement phase.



Scenario step by step analysis

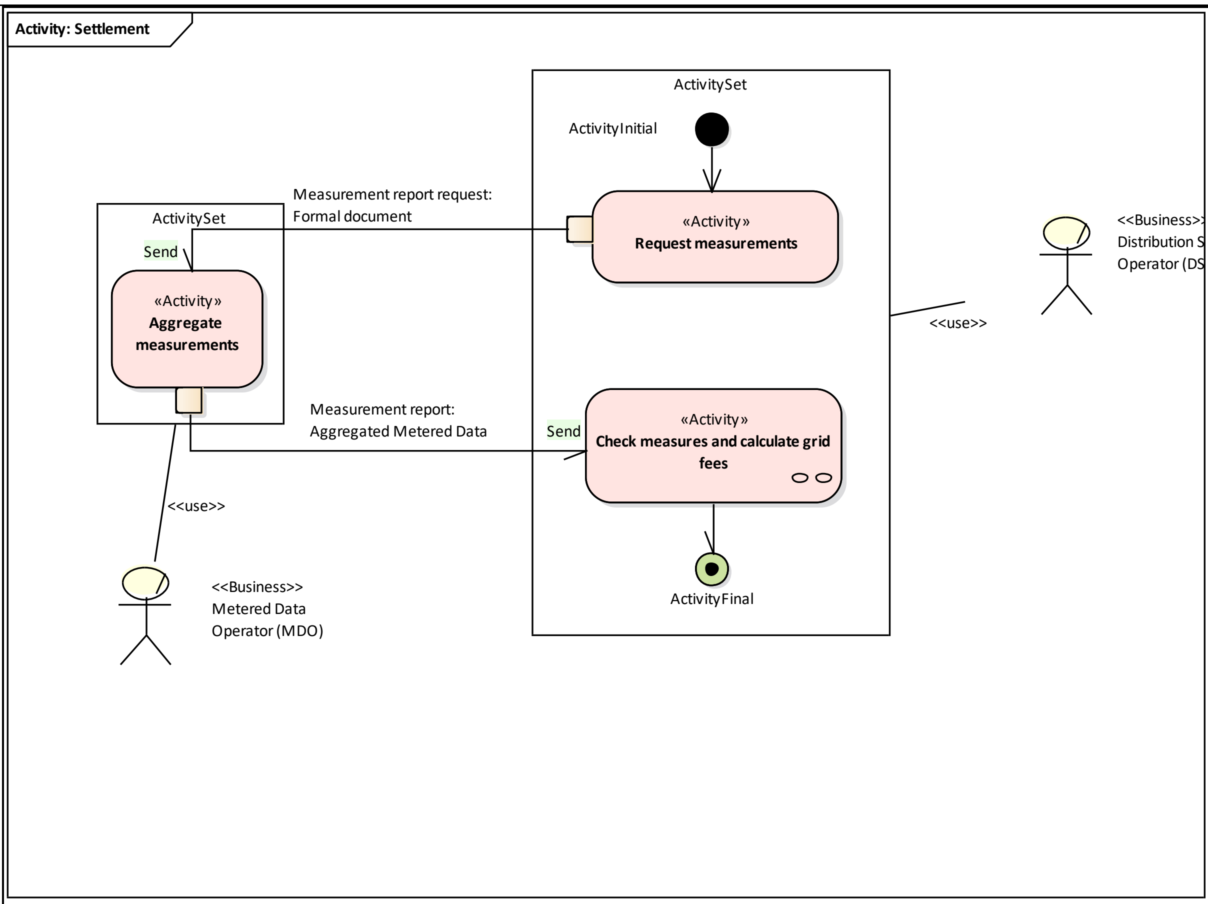
Scenario								
Scenario name	Delivery							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
3.1		Send activation signal	The TS_O, at the beginning of the 15 minutes slot, sends the activation signal	Send	Transmission System Operator (TS_O)	Distribution System Operator (DS_O)	Info3-Set-Point	

			for the previously released set-points; the activation signal is also sent, simultaneously, to the MDO for the synchronization of the measurement process at Primary Substation interface;					
3.2		Transfer activation signal	The DS_O receives the activation signal from the TS_O and transmits it to resources and to the MDO, for the synchronization of the measurement process;	Send	Distribution System Operator (DS_O)	Metered Data Operator (MDO)	Info3-Set-Point	
3.3		Transfer activation signal	The DS_O receives the activation signal from the TS_O and transmits it to resources and to the MDO, for the synchronization of the measurement process;	Send	Distribution System Operator (DS_O)	Aggregator (A)	Info3-Set-Point	
3.4		Transfer activation signal	The DS_O receives the activation signal from the TS_O and transmits it to resources and to the MDO, for the synchronization of the measurement process;	Send	Distribution System Operator (DS_O)	Generation asset Operator (G_O)	Info3-Set-Point	
3.5		Follow set-points	The generator(s) receives the		Generation asset			

			activation signal and manages its own plant accordingly for the whole duration of the time slot;		Operator (G_O)			
3.6		Follow set-points	The aggregator(s) receives the activation signal and manages its portfolio of customers accordingly for the whole duration of the time slot;		Aggregator (A)			
3.7		Do measurements	The MDO receives from the DS_O the activation signal and takes measures from the meters installed at the connection points of the selected resources; it checks also for deviations of the actual profiles from the scheduled set-points		Metered Data Operator (MDO)			
3.8		Post-process measurements	The MDO stores the measurements and prepares them for the settlement phase;		Metered Data Operator (MDO)			

4.2.3 SETTLEMENT

In the long-term time frame (ex: monthly), the DS_O requests the measurements report to the MDO; then, based on the certified measurements, it calculates and sends the corresponding remuneration to each resource.



Scenario step by step analysis

Scenario								
Scenario name	Settlement							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
4.1		Request measurements	On a monthly basis, the DS_O requests the measurements taken during the previous month to the MDO;	Send	Distribution System Operator (DS_O)	Metered Data Operator (MDO)	Info1-Formal document	
4.2		Aggregate measurements	The MDO aggregates the metered data related to the resources who	Send	Metered Data Operator (MDO)	Distribution System Operator (DS_O)	Info4-Aggregated Metered Data	

			participated to voltage control and congestion management services, as well as the measurements of the power exchange at the primary substation interface; then it prepares a measurements report and sends it to the DS_O.					
4.3		Check measures and calculate grid fees	Based on the actual capacity provided by each resource (certified by the measurements), the DS_O calculates a reduction to be applied to grid fees (as well as penalties, if necessary) for the participating resources.		Distribution System Operator (DS_O)			

5. INFORMATION EXCHANGED

Information exchanged			
Information exchanged, ID	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
Info1	Formal document	It may include: • Object; • Description; • Name of recipient; • Date; • Signature; • Data; • Technical report; • Schedules;	

		• ...	
Info2	Aggregated Data	It may include: • Power/voltage profiles; • Parametric curves; • Merit-order lists; • Arrays; • ...	
Info3	Set-Point	It may include: • Asset/device ID code; • Numeric values; • Control signals; • Duration; • ...	
Info4	Aggregated Metered Data	For a period of month,it may include (15 min resolution): • Unit-specific daily average power • Unit-specific daily maximum power • Agreed set-point; • Capability area limit; • Deviations; • ...	

TABLE 12 BUC IT-RP

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

Based on IEC 62559-2 edition 1
Generated from UML Use Case Repository with Modsarus® (EDF R&D Tool)

1. DESCRIPTION OF THE USE CASE

1.1 NAME OF USE CASE

Use case identification		
ID	***Area(s)/Domain(s)/Zone(s)***	***Name of use case***
PT-FxH-AP	Portugal	Manage active power flexibility to support mFRR/RR and congestion management in the FlexHub Portuguese demo

1.2 VERSION MANAGEMENT

Version management				
Version No.	***Date***	***Name of author(s)***	***Changes***	***Approval status***
1	2018-05-28	Jose Villar	Proposed version from demo	
2	2018-06-14	Cyril Effantin	Consolidation in a common UC repository from Flexhub update received on the 14/06/2018	
3	2018-07-26	Cyril Effantin	Fixing formatting issues, UML prequalification phase	
4	2018-10-15	Jose Villar	Update based on use case validation.	
5	2018-12-05	Cyril Effantin	Update based on role model modification.	

1.3 SCOPE AND OBJECTIVES OF USE CASE

Scope and objectives of use case	
Scope	While operating reserves are generally used to correct system imbalances, replacement reserves (or similar mechanisms) are used to restore the required level of operating reserves to be prepared for further system imbalances, to solve large imbalances forecasted by the TSO (represented by the role TS_O in the UML part of this BUC, while the DSO will be represented by the role DS_O) for the next time periods, or even to solve congestions. Reserves are usually procured by TSOs, in charge of the system security. These reserves can only be provided by conventional generators in some countries, or by conventional generators and large consumers in others, but usually not by resources connected to the distribution networks. However, under scenarios with large penetration of renewable generation, it is important to use as many sources of flexibility as possible to help keeping the system balanced at any time. This business use case proposes an extension of the current Portuguese replacement reserve market (tertiary reserve market) to make it more flexible, allowing generation and loads to provide this service, making it closer to real time, and allowing resources connected at the distribution network as aggregated replacement reserve (active power) providers, but guaranteeing that no distribution network constraints are violated.
Objective(s)	Inclusion of new types of active power providers:

	• Inclusion, as aggregated reserve providers, of new providers that could aggregate load and generation resources connected at the distribution networks. TSO-DSO coordination: • TSO-DSO coordination mechanism to allow the participation of distributed network resources, but guaranteeing that, for those bids involving resources connected to distribution networks, its activation does not violate any distribution network constraint. Close to real-time TSO active power market: • Extension of the current replacement (tertiary) reserve market to make it more flexible, allowing generation and loads to provide the service, and making it closer to real time.
Related business case(s)	Congestion Management Frequency Control

1.4 NARRATIVE OF USE CASE

Narrative of use case
Short description
This BUC aims to set the main rules to extend the current Portuguese tertiary reserve (replacement reserve) market to include load and generation connected both at the transmission and distribution grids to provide replacement reserve (active power) service. For each market session, the market agents can update their bids offering fast energy delivering for the 15 minutes time-intervals of a delivery horizon of 7 hours. This delivery horizon is to account for possible specificities of resources, which combined with non-curtailable bids, allow to limit excessive resource activation switching. The delivery horizon should also allow a better reserves planning for the TSO. The bids must specify the additional energy that the market agents can provide at each time interval from their current energy schedule for this same time period, and how this energy is shared among the resources managed by the market agent, so that both TSO and DSO can perform their respective security network checking. Market agents can aggregate different types of resources, both connected to the transmission network and to the distribution network, into a same aggregated bid. Those bids involving distribution network resources are marked when they are received by the TSO market platform, so that they can be latter on checked by the DSO before being accepted to provide the service. When the TSO needs active power for the next delivery horizon, it selects from the bids pool the cheapest bids

until its needs are met. In case a marked bid is selected, the FlexHub associated with the corresponding distribution network is called before clearing it for activation. A a traffic light information is issued for the bid that indicates if the resources offered can be activated totally (green light), partially (yellow light) or cannot be activated (red light) due to violations of distribution network constraints where they are connected. The bid can therefore be cleared totally, partially or discarded. This selection and TL qualification process is repeted for each bid until all TSO needs are met.

Complete description

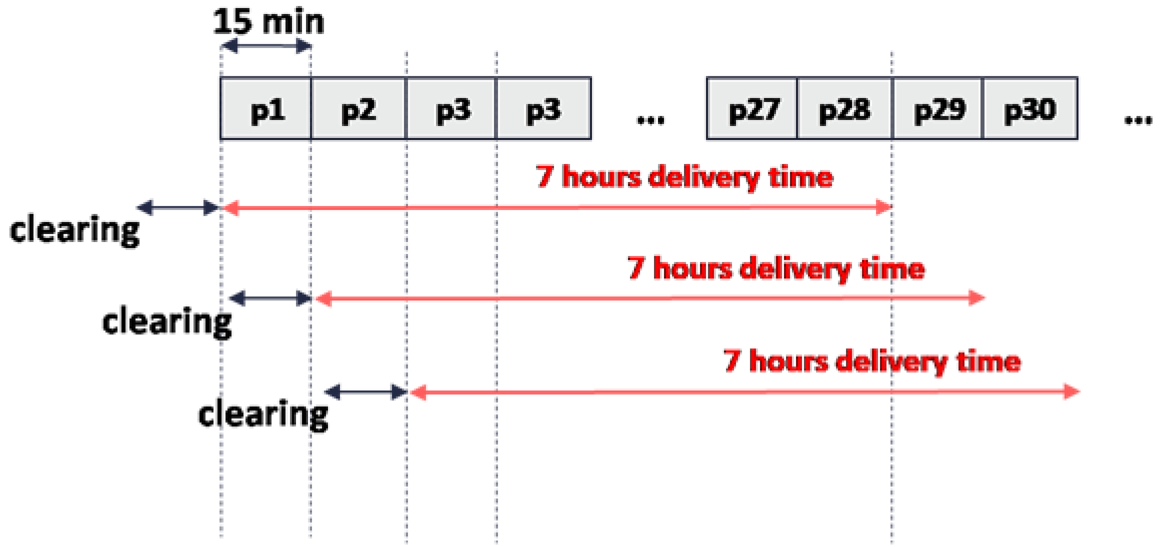
For coherence with how the demonstration has been designed, the description of this BUC has been done with stakeholders instead of roles. However, for more generality, the UML part of this BUC is described in term of roles, even if introducing the role of Market Operator (MO) implies more complex interactions between the TSO and the MO that have been omitted for simplicity.

This BUC proposes a global market for providing active power to the TSO, as an extension of the existing tertiary reserve (replacement reserve) market of several countries, such as Portugal or Spain. It is being designed so that load and generation connected both at the transmission and distribution networks are allowed to provide the service in an aggregated way. However, disaggregated information is needed to allow the TSO and the DSO to verify that no grid constraints are violated.

Although this BUC focuses on the coordination mechanism (traffic light qualification) that allows to provide the service from resources connected at the distribution grid without violating distribution grids constraints, the whole active power market has been redesigned and described for completeness.
The following resources of the distribution network could be considered:

- Industrial consumers loads
- Distributed generators
- Storage

This BUC considers a rolling window of 28 time-intervals of 15 minutes (coherent with the XBID market project as an initial schedule to compute the reserve from) to conform a delivery horizon time of 7 hours. This delivery horizon, combined with non-curtailable bids allows to avoid excessive switching of resources and provides a sensible programming period for the TSO. Gate closure should be close to the delivery horizon to provide a close to real-time active power service to the TSO.



For each new market session, each 15 minutes, the TSO publishes the profile of the expected needs of active power for the next delivery horizon. Market agents can then update their bids for each market session, which could remain latent until cleared or replaced by new bids by the market agents themselves. The bids sent must be stored in a TSO market platform similar to the existing one for the current tertiary reserve (also called regulation reserve) market. Bids including resources connected at distribution grids are marked when sent for future checking before being accepted.

For the clearing process, the TSO should order the bids by their prices, so that it can select the cheapest bids to meet its active power needs. For those bids that are marked, before being cleared, the TSO requests the DSO to compute and send the bid traffic light (TL) qualification. To do so, the FlexHub traffic light qualification tool is run by the DSO to determine if the activation of the resources of the marked bid (therefore connected at the corresponding distribution grid) may cause grid constraint problems if activated. The TL qualification can be a green light, in which case the TSO can accept the bid resources totally for its activation, a yellow light meaning that the bid can only be accepted partially to avoid distribution grid constraints violations, and a red light meaning that the bid must be discarded (due to distribution grid constraints violations) and replaced by the next cheapest bid. The above clearing process implies that each distribution network willing to operate in this replacement reserve market should include the corresponding FlexHub tools for the TL qualification, and the proper TSO-DSO real-time coordination mechanisms.
The following information is needed to compute the TL qualification:

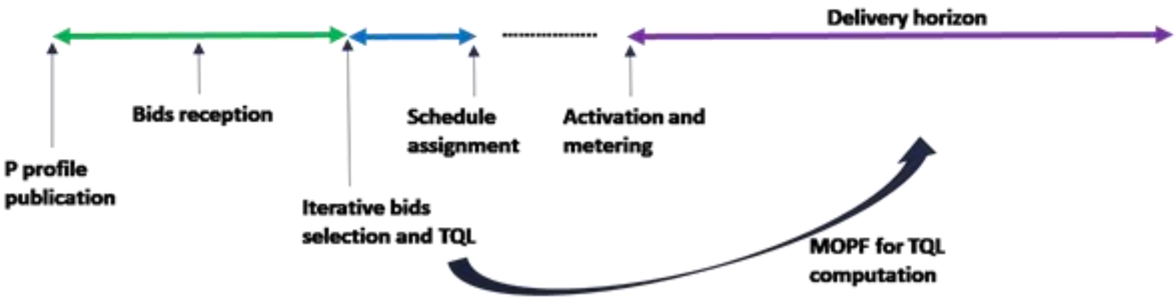
- Load and RES forecasts of the nodes of the distribution grid for all the time intervals of the delivery horizon.
- Information about network topology ("normal" topology)
- Information about topology changes for the next hours (e.g., planned maintenance actions)
- Technical network constraints (e.g. 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

After accepting a bid, the TSO informs the market agents and the DSO of the new schedules, so that the former can proceed to the resources activation, and the DSO can supervise the distribution grid security adequately.

For each market session, the market price of each time interval is set to the price of the most expensive cleared bid for this time interval (marginal pricing, or pay as clear).

This time sequence for a unique market session is summarized in the following figure:



During the operation, an external entity (metered data operator) measures and stores the active power provided by the resources located at the distribution network (managed by the market agents) for future settlement. Resources connected at the transmission network are currently being measured by the TSO, although also an independent entity could be in charge of this task.

The settlement process has several relevant aspects to consider:
-The TSO requests measurements from the metering entity (for assets in the distribution network) and uses its own measurements in the transmission grid to compute the settlement for each market agent, as the market prices of each time-interval of each market session multiplied by the market agent cleared reserves for these time intervals, minus the penalties for non-providing the requested reserves.
-It is the responsibility of the aggregators to solve its contractual rights and obligations with the owners of the resources providing the service (biding and settlement, including imbalances).
-The active power service cost should be shared by the final users and by those not complying with their active power commitments through penalties.
-Penalties can allow or not internal aggregator compensation and a correct design is important for system efficiency. For example, too high penalties, 1) allowing compensation at the aggregator level, may cause inefficient system resources activation to avoid penalties, and 2) applied directly at the resources level, may disincentive market participation due to the penalty risks, reducing resources availability. In addition, although cost reflective penalties improve global efficiency, they can decrease the system security, while large penalties may disincentivize market participation.

Summary of use case

- **Prequalification**
  Description: The TSO with the help of the DSO registers and tests the technical characteristics of the assets of the entities that want to participate in the market (capability of providing the service, communications, etc), and verifies the financial guarantees according to the pre-establish market rules. It also coordinates with the DSO by communicating the assets of its grid involved in the pre-qualification process, to facilitate the TLQ process that will take place in real time.

  - Request pre-qualification for market participation
    Description:

  - Verify request and provide signed agreement
    Description:

  - Verify request and provide signed agreement
    Description:

  - Register assets participating for future TLQ process
    Description:
- **Selection/Bidding**
  Description: For each new market session, each 15 minutes, the TSO publishes the profile of the expected needs of active power for the next delivery horizon. Market agents can then update their bids for each market session, which could remain latent until cleared or replaced by new bids by the market agents themselves. The bids sent must be stored in a TSO market platform similar to the existing one for the current tertiary reserve (also called regulation reserve) market. Bids including resources connected at distribution grids are marked when sent for future checking before being accepted.

  For the clearing process, the TSO should order the bids by their prices, so that it can select the cheapest bids to meet its active power needs. For those bids that are marked, before being cleared, the TSO requests the DSO to compute and send the bid traffic light (TL) qualification. To do so, the FlexHub traffic light qualification tool is run by the DSO to determine if the activation of the resources of the marked bid (therefore connected at the corresponding distribution grid) may cause grid constraint problems if activated. The TL qualification can be a green light, in which case the TSO can accept the bid resources totally for its activation, a yellow light meaning that the bid can only be accepted partially to avoid distribution grid constraints violations, and a red light meaning that the bid must be discarded (due to distribution grid constraints violations) and replaced by the next cheapest bid. The above clearing process implies that each distribution network willing to operate in this replacement reserve market should include the corresponding FlexHub tools for the TL qualification, and the proper TSO-DSO real-time coordination mechanisms.
  The following information is needed to compute the TL qualification:
  - 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

After accepting a bid, the TSO informs the market agents and the DSO of the new schedules, so that the former can proceed to the resources activation, and the DSO can supervise the distribution grid security adequately.

For each market session, the market price of each time interval is set to the price of the most expensive cleared bid for this time interval (marginal pricing, or pay as clear).

- Compute and transfer P profile need
  Description:
- Publish P profile need
  Description:
- Compute and send bids
  Description:
- Select bids for the service
  Description:
- Compute TL qualification
  Description:
- Clear the amount of active power needed, subject to TL limitations
  Description:
- Assign P schedule
  Description:

- **Delivery**
  Description: During the operation, an external entity (metered data operator) measures and stores the active power provided by the resources located at the distribution network (managed by the market agents) for future settlement. Resources connected at the transmission network are currently being measured by the TSO, although also an independent entity could be in charge of this task.
  - Request resource activation
    Description:
  - Activate resource for P provision
    Description:
  - Activate resource for P provision
    Description:
  - Measure P provided
    Description:
  - Measure P provided
    Description:

- Store data for future usage
  Description:

- Store data for future usage
  Description:

- **Settlement**
  Description: The settlement process has several relevant aspects to consider:

  -The TSO requests measurements from the metering entity (for assets in the distribution network) and uses its own measurements in the transmission grid to compute the settlement for each market agent, as the market prices of each time-interval of each market session multiplied by the market agent cleared reserves for these time intervals, minus the penalties for non-providing the requested reserves.

  -It is the responsibility of the aggregators to solve its contractual rights and obligations with the owners of the resources providing the service (biding and settlement, including imbalances).

  -The active power service cost should be shared by the final users and by those not complying with their active power commitments through penalties.

  -Penalties can allow or not internal aggregator compensation, and a correct design is important for system efficiency. For example, too high penalties, 1) allowing compensation at the aggregator level, may cause inefficient system resources activation to avoid penalties, and 2) applied directly at the resources level, may disincentive market participation due to the penalty risks, reducing resources availability. In addition, although cost reflective penalties improve global efficiency, they can decrease the system security, while large penalties may disincentivize market participation.

  - Send metered data for settlement
    Description:

  - Compute settlement and send data used and invoice
    Description:

  - Compute settlement according to contracts with flexibility providers and invoice
    Description:

  - Verify settlement
    Description:

  - Verify settlement
    Description:

1.5 KEY PERFORMANCE INDICATORS (KPI)

1.6 USE CASE CONDITIONS

	Use case conditions
	Assumptions
1	Assumptions: With respect to regulatory aspects:

- Currently, conventional generators and pumped-storage units have to present mandatory tertiary reserve bids with the amount of tertiary reserve available. This reserve is the maximum active power that can be provided up or down for the corresponding deliver horizon.
- The service is provided by balancing zones (although this may change soon with the expected European markets harmonization as is the XBID intraday market), and only by conventional generators and pumped-storage units (and by other TSO connected to the system).

Therefore, an appropriate regulation should be put in place with the following assumptions:

- The possibility of new aggregator agents to provide the service, combining load and generation resources connected both at the transmission and distribution networks.
- Adaptation of the time-intervals and delivery horizons of the current tertiary reserve market to those proposed in this BUC.
- Possible avoidance of balancing zones to simplify market rules.
- An energy market already in place with same time-intervals, as will result from the XBID market project, will help to coordinate energy and reserve markets, since the energy schedules resulting from this energy markets (with any additional constraints checking if needed) could be the starting position from which to compute the available replacement reserve of each resource.

Other assumptions are:

- Full knowledge of the distribution grid topology available for the DSO to be able to qualify the bids involving resources located at the distribution network.
- Real-time measurements and forecasts for all nodes with 15 minutes resolution, for TL qualification computation and service provision verification. The DSO or a third party could be in charge of metering and data storing for those resources connected to the distribution grid.
- Fast communication mechanisms in place for TSO-DSO communication.
- A prequalification phase (prequalification, certification and registration process) should be put in place to allow the resources to participate in this market. Since it is not considered an essential part of this BUC this phase will be omitted.

Prerequisites	
1	Preconditions: • This BUC focuses on the TL qualification, although it was decided, to design and describe in a simplified way the whole restoration reserve market to put the TL in context and in value. • With respect to the demonstration, it is important to note that active power (or energy) has always economic impacts, and therefore it is not easily expected the possibility of real active power (or energy) modulation for this BUC with real units. • Therefore, simulations may be needed to test some of the main aspects of the proposed BUC, and in particular those related to the traffic light qualification of the aggregator bids.

1.7 FURTHER INFORMATION TO THE USE CASE FOR CLASSIFICATION/MAPPING

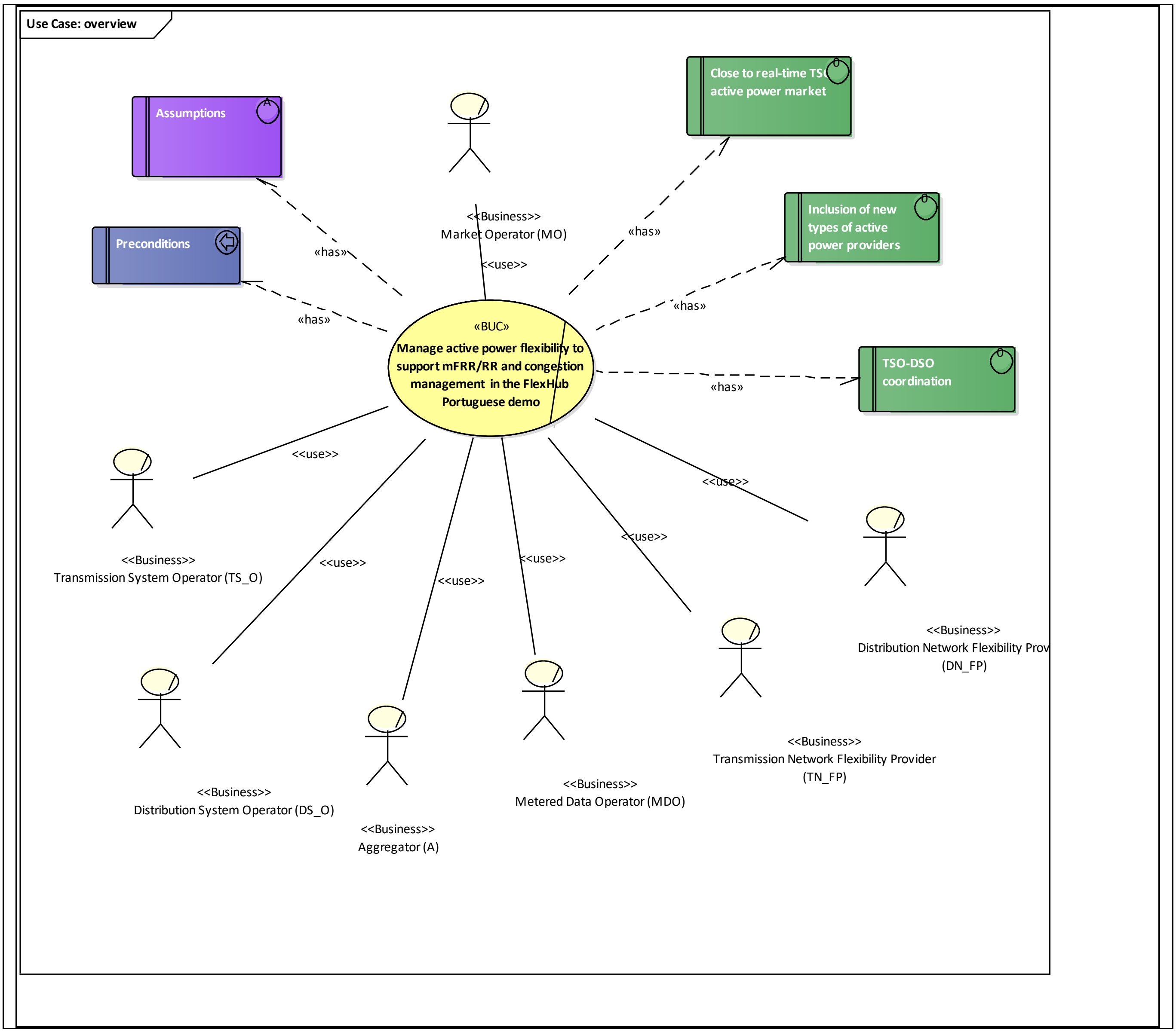
Classification information
Relation to other use cases
Level of depth

BUC for Portugal FlexHub Demo
Prioritisation
Generic, regional or national relation
National
Nature of the use case
BUC
Further keywords for classification

1.8 GENERAL REMARKS

2. DIAGRAMS OF USE CASE

Diagram(s) of use case


Use Case: overview
Assumptions
Preconditions
Close to real-time TSO active power market
Inclusion of new types of active power providers
TSO-DSO coordination
«has»
«has»
«has»
«has»
«has»
<<Business>>
Market Operator (MO)
<<use>>
«BUC»
Manage active power flexibility to support mFRR/RR and congestion management in the FlexHub Portuguese demo
<<use>>
<<Business>>
Transmission System Operator (TS_O)
<<use>>
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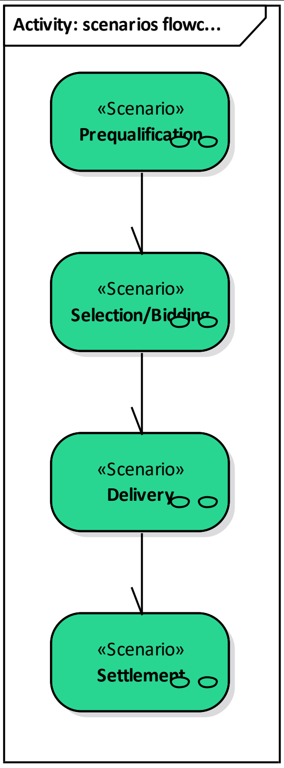
<<use>>
<<Business>>
Distribution Network Flexibility Prov
(DN_FP)
<<Business>>
Transmission Network Flexibility Provider
(TN_FP)
<<Business>>
Distribution System Operator (DS_O)
<<Business>>
Metered Data Operator (MDO)
<<Business>>
Aggregator (A)



3. TECHNICAL DETAILS

3.1 ACTORS

Actors			
Grouping (e.g. domains, zones)		***Group description***	
Actor name	***Actor type***	***Actor description***	***Further information specific to this use case***
Transmission System Operator (TS_O)	Business	Elaborate network development plan (including defining system needs for transmission) Ensure a transparent and non-discriminatory access to the transmission network for each user Operate the transmission grid over a specific region in a secure, reliable and efficient way Secure and manage in real time the physical generation-consumption balance on a geographical perimeter, including ensuring the frequency control service Optimize transmission system operation from planning to real-time, using available levers (grid expansion, flexibility activation,...)	

		Assess network status of the transmission grid and broadcast selected information of the network status to eligible actors (e.g. aggregators, other system operators) Provide data to the interconnection capacity market operator for the management of cross border transactions In critical situations, implement dedicated actions and deliver alerts during stress events If necessary, implement emergency measures (e.g. system defence plan) including load shedding	
Distribution System Operator (DS_O)	Business	Elaborate network development plan (including defining system needs for distribution) Ensure a transparent and non-discriminatory access to the distribution network for each user Operate the distribution grid over a specific region in a secure, reliable and efficient way Optimize system operation distribution grid from planning to real-time, using available levers (grid expansion, flexibility activation,...) Assess network status of the distribution grid and broadcast selected information of the network status to eligible actors (e.g. aggregators, other system operators) Support the Transmission System Operator in carrying out its responsibilities (including load shedding) and coordinate measures if necessary	
Metered Data Operator (MDO)	Business	Provide metered data to authorized users in a transparent and non-discriminatory manner	
Transmission Network Flexibility Provider (TN_FP)	Business	Provide flexibility by assets connected to the transmission network	
Distribution Network Flexibility Provider (DN_FP)	Business	Provide flexibility by assets connected to the distribution network	
Aggregator (A)	Business	Aggregate and maximise value of portfolio(s) of resources	
Market Operator (MO)	Business	Organize auctions (continuous auction, discrete auctions, call for tenders) between buyers and sellers of electricity-related products in the markets, and more generally publish the corresponding prices, for assets connected to transmission or distribution grid	

		Manage/operate the platform for trading (where bids and offers are collected) Clear the market and communicate results	

3.2 REFERENCES

4. STEP BY STEP ANALYSIS OF USE CASE

4.1 OVERVIEW OF SCENARIOS

Scenario conditions						
No.	***Scenario name***	***Scenario description***	***Primary actor***	***Triggering event***	***Pre-condition***	***Post-condition***
1	Prequalification	The TSO with the help of the DSO registers and tests the technical characteristics of the assets of the entities that want to participate in the market (capability of providing the service, communications, etc), and verifies the financial guarantees according to the pre-establish market rules. It also coordinates with the DSO by communicating the assets of its grid involved in the pre-qualification process, to facilitate the TLQ process that will take place in real time.				
2	Selection/Bidding	For each new market session, each 15 minutes, the TSO publishes the profile of the expected needs of active power for the next delivery horizon. Market agents can then update their bids for each market session, which could remain latent until cleared or replaced by new bids by the market agents themselves. The bids sent must be stored in a TSO market platform similar to the existing one for the current tertiary reserve (also called regulation reserve) market. Bids including resources connected at distribution grids are marked when sent for future checking before being accepted. For the clearing process, the TSO should order the bids by their prices, so that it can select the cheapest bids to meet its active power needs. For those bids that are marked, before being cleared, the TSO requests the DSO to compute and send the bid traffic light (TL) qualification. To do so, the FlexHub traffic light qualification tool is run by the DSO to determine if the				

		activation of the resources of the marked bid (therefore connected at the corresponding distribution grid) may cause grid constraint problems if activated. The TL qualification can be a green light, in which case the TSO can accept the bid resources totally for its activation, a yellow light meaning that the bid can only be accepted partially to avoid distribution grid constraints violations, and a red light meaning that the bid must be discarded (due to distribution grid constraints violations) and replaced by the next cheapest bid. The above clearing process implies that each distribution network willing to operate in this replacement reserve market should include the corresponding FlexHub tools for the TL qualification, and the proper TSO-DSO real-time coordination mechanisms. The following information is needed to compute the TL qualification: • 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 After accepting a bid, the TSO informs the market agents and the DSO of the new schedules, so that the former can proceed to the resources activation, and the DSO can supervise the distribution grid security adequately. For each market session, the market price of				

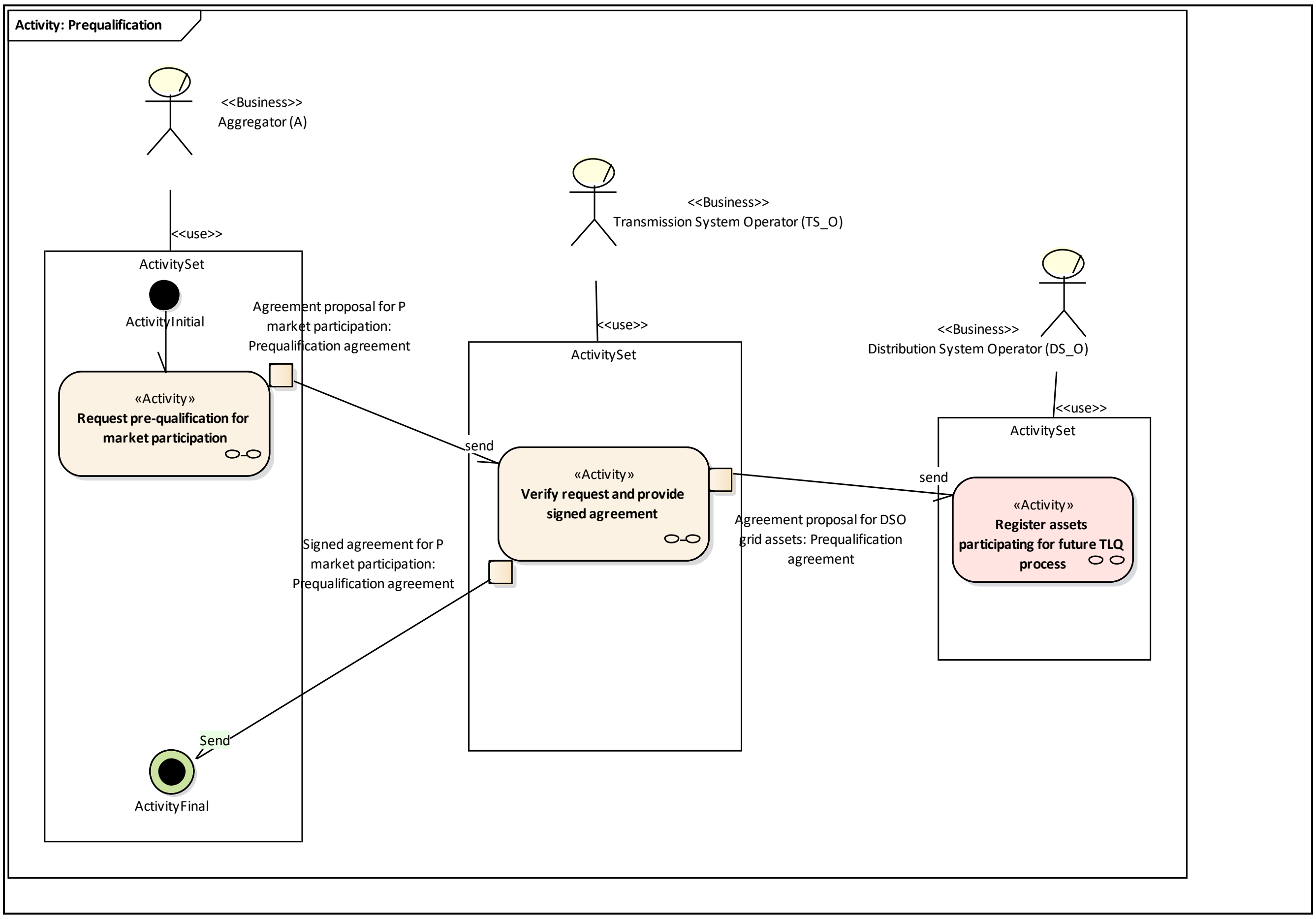
		each time interval is set to the price of the most expensive cleared bid for this time interval (marginal pricing, or pay as clear).				
3	Delivery	During the operation, an external entity (metered data operator) measures and stores the active power provided by the resources located at the distribution network (managed by the market agents) for future settlement. Resources connected at the transmission network are currently being measured by the TSO, although also an independent entity could be in charge of this task.				
4	Settlement	The settlement process has several relevant aspects to consider: -The TSO requests measurements from the metering entity (for assets in the distribution network) and uses its own measurements in the transmission grid to compute the settlement for each market agent, as the market prices of each time-interval of each market session multiplied by the market agent cleared reserves for these time intervals, minus the penalties for non-providing the requested reserves. -It is the responsibility of the aggregators to solve its contractual rights and obligations with the owners of the resources providing the service (biding and settlement, including imbalances). -The active power service cost should be shared by the final users and by those not complying with their active power commitments through penalties. -Penalties can allow or not internal aggregator compensation, and a correct design is important for system efficiency. For example, too high penalties, 1) allowing compensation at the aggregator level, may cause inefficient system resources activation to avoid penalties, and 2) applied directly at the resources level, may disincentive market participation due to the penalty risks, reducing resources				

		availability. In addition, although cost reflective penalties improve global efficiency, they can decrease the system security, while large penalties may disincentivize market participation.				

4.2 STEPS - SCENARIOS

4.2.1 PREQUALIFICATION

The TSO with the help of the DSO registers and tests the technical characteristics of the assets of the entities that want to participate in the market (capability of providing the service, communications, etc), and verifies the financial guarantees according to the pre-establish market rules. It also coordinates with the DSO by communicating the assets of its grid involved in the pre-qualification process, to facilitate the TLQ process that will take place in real time.



Scenario step by step analysis

Scenario								
Scenario name	Prequalification							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***

1.1		Request pre-qualification for market participation		send	Aggregator (A)	Transmission System Operator (TS O)	Info1-Prequalification agreement	
1.2		Verify request and provide signed agreement		send	Transmission System Operator (TS O)	Distribution System Operator (DS O)	Info1-Prequalification agreement	
1.3		Verify request and provide signed agreement		Send	Transmission System Operator (TS O)	Aggregator (A)	Info1-Prequalification agreement	
1.4		Register assets participating for future TLQ process			Distribution System Operator (DS O)			

4.2.2 SELECTION/BIDDING

For each new market session, each 15 minutes, the TSO publishes the profile of the expected needs of active power for the next delivery horizon. Market agents can then update their bids for each market session, which could remain latent until cleared or replaced by new bids by the market agents themselves. The bids sent must be stored in a TSO market platform similar to the existing one for the current tertiary reserve (also called regulation reserve) market. Bids including resources connected at distribution grids are marked when sent for future checking before being accepted.

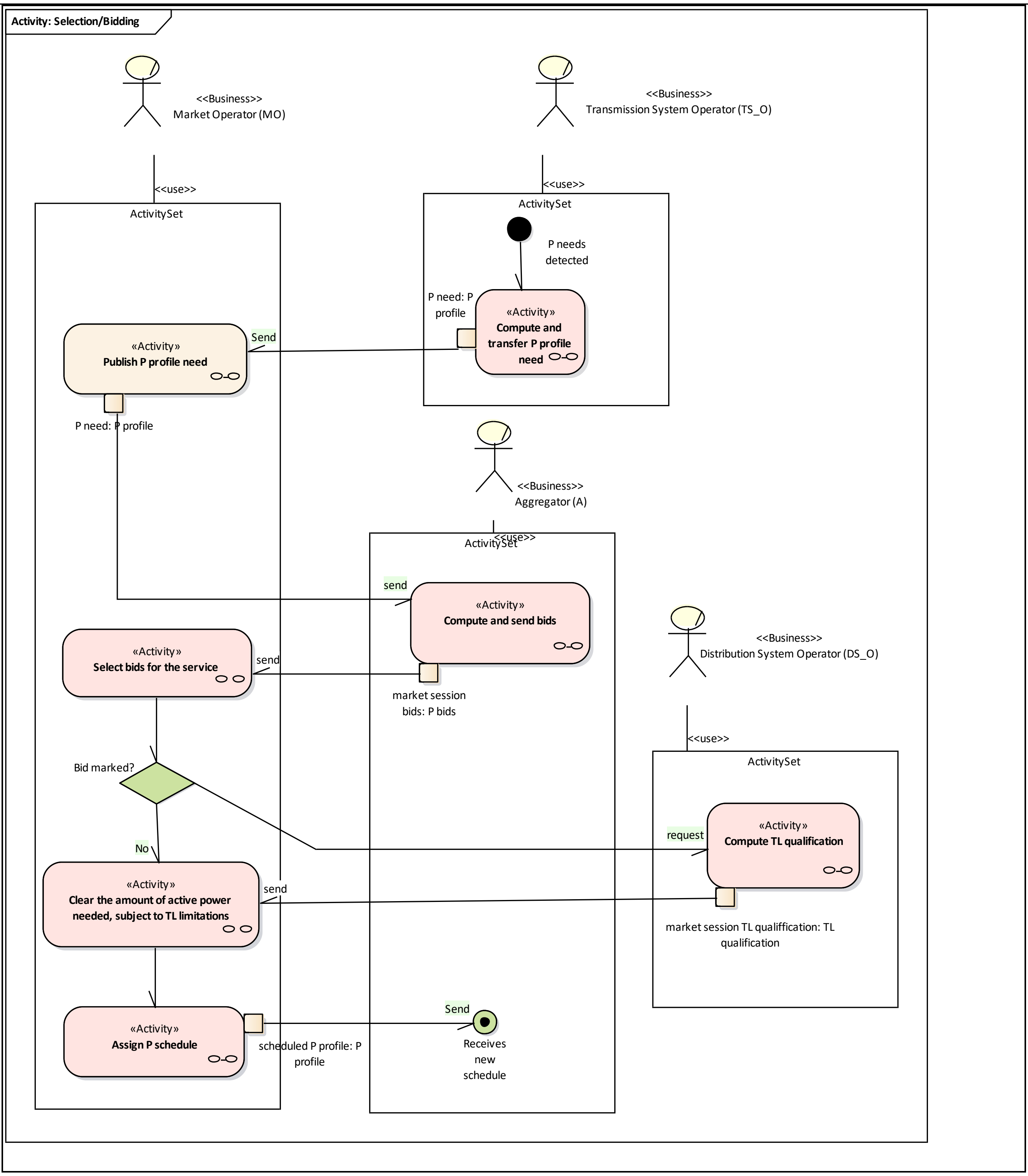
For the clearing process, the TSO should order the bids by their prices, so that it can select the cheapest bids to meet its active power needs. For those bids that are marked, before being cleared, the TSO requests the DSO to compute and send the bid traffic light (TL) qualification. To do so, the FlexHub traffic light qualification tool is run by the DSO to determine if the activation of the resources of the marked bid (therefore connected at the corresponding distribution grid) may cause grid constraint problems if activated. The TL qualification can be a green light, in which case the TSO can accept the bid resources totally for its activation, a yellow light meaning that the bid can only be accepted partially to avoid distribution grid constraints violations, and a red light meaning that the bid must be discarded (due to distribution grid constraints violations) and replaced by the next cheapest bid. The above clearing process implies that each distribution network willing to operate in this replacement reserve market should include the corresponding FlexHub tools for the TL qualification, and the proper TSO-DSO real-time coordination mechanisms.
The following information is needed to compute the TL qualification:

- 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

After accepting a bid, the TSO informs the market agents and the DSO of the new schedules, so that the former can proceed to the resources activation, and the DSO can supervise the distribution grid security adequately.

For each market session, the market price of each time interval is set to the price of the most expensive cleared bid for this time interval (marginal pricing, or pay as clear).



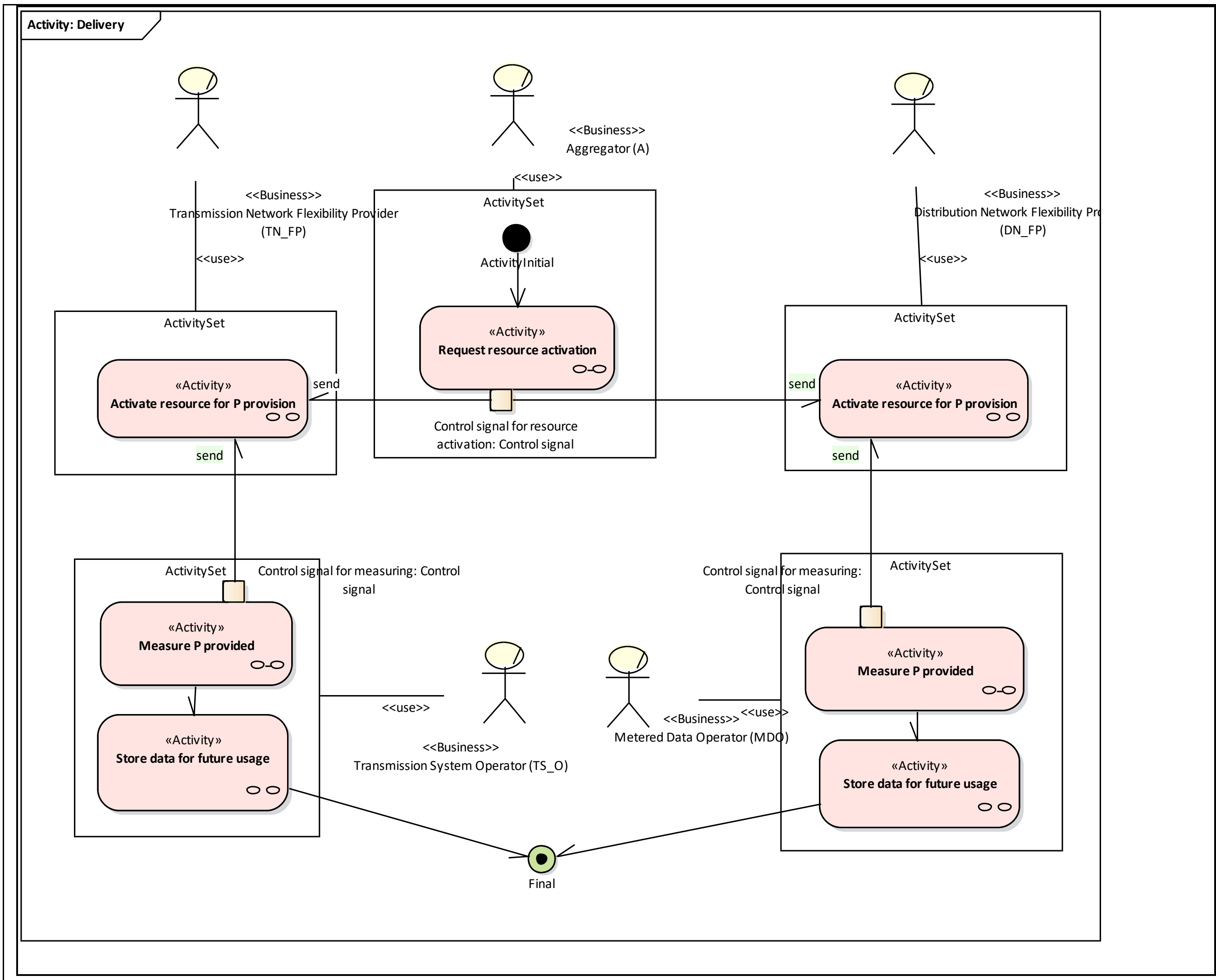
Scenario step by step analysis

Scenario	
Scenario name	Selection/Bidding

Step No	*Event*	*Name of process/activity*	*Description of process/activity*	*Service*	*Information producer (actor)*	*Information receiver (actor)*	*Information exchanged (IDs)*	*Requirement, R-IDs*
2.1		Compute and transfer P profile need		Send	Transmission System Operator (TS_O)	Market Operator (MO)	Info2-P profile	
2.2		Publish P profile need		send	Market Operator (MO)	Aggregator (A)	Info2-P profile	
2.3		Compute and send bids		send	Aggregator (A)	Market Operator (MO)	Info3-P bids	
2.4		Select bids for the service			Market Operator (MO)			
2.5		Compute TL qualification		send	Distribution System Operator (DS_O)	Market Operator (MO)	Info4-TL qualification	
2.6		Clear the amount of active power needed, subject to TL limitations			Market Operator (MO)			
2.7		Assign P schedule		Send	Market Operator (MO)	Aggregator (A)	Info2-P profile	

4.2.3 DELIVERY

During the operation, an external entity (metered data operator) measures and stores the active power provided by the resources located at the distribution network (managed by the market agents) for future settlement. Resources connected at the transmission network are currently being measured by the TSO, although also an independent entity could be in charge of this task.



Scenario step by step analysis

Scenario								
Scenario name	Delivery							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
3.1		Request resource activation		send	Aggregator (A)	Distribution Network Flexibility Provider (DN_FP), Transmission Network	Info5-Control signal	

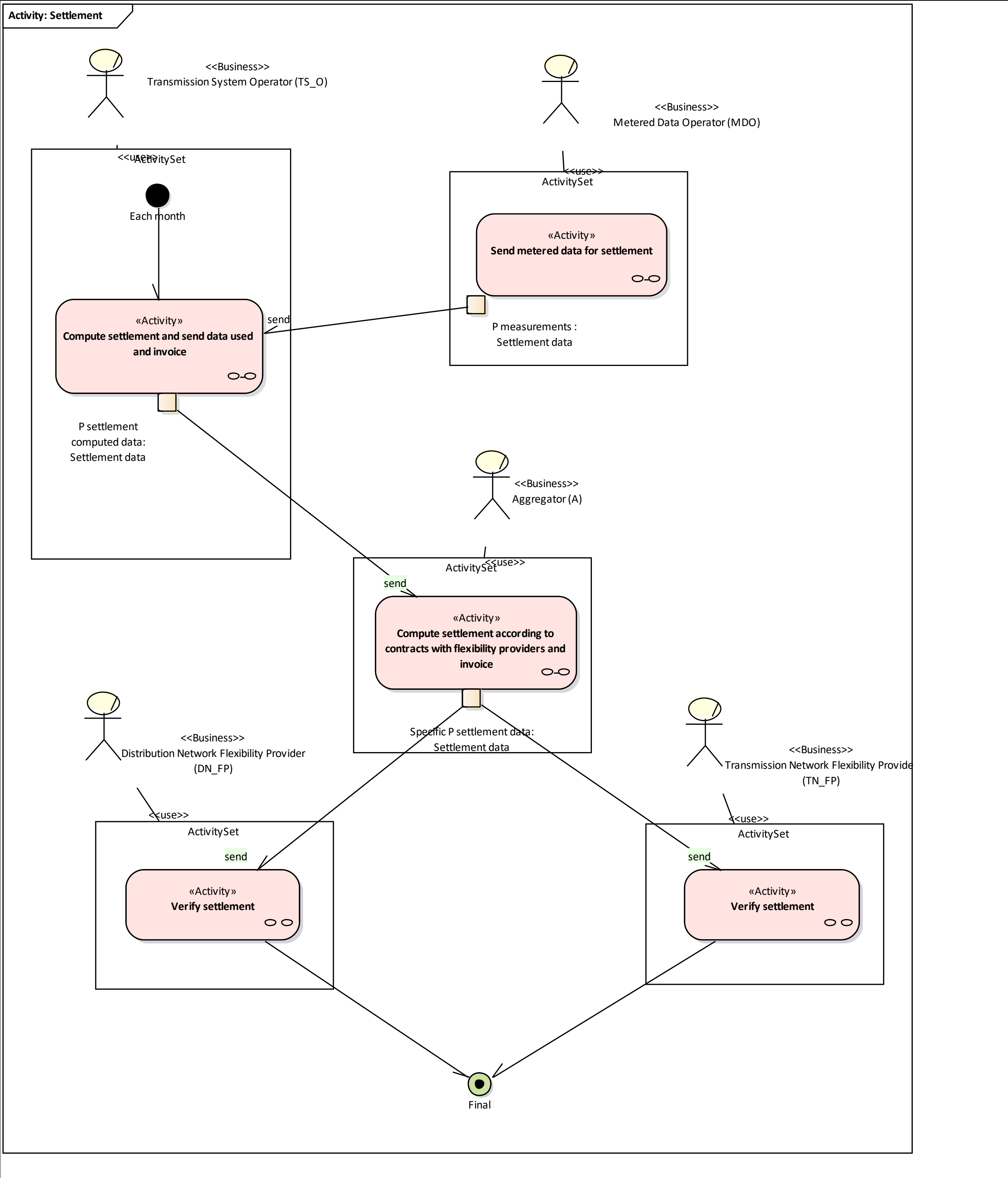
							Flexibility Provider (TN_FP)		
3.2		Activate resource for P provision				Distribution Network Flexibility Provider (DN_FP)			
3.3		Activate resource for P provision				Transmission Network Flexibility Provider (TN_FP)			
3.4		Measure P provided			send	Transmission System Operator (TS_O)	Transmission Network Flexibility Provider (TN_FP)	Info5-Control signal	
3.5		Measure P provided			send	Metered Data Operator (MDO)	Distribution Network Flexibility Provider (DN_FP)	Info5-Control signal	
3.6		Store data for future usage				Transmission System Operator (TS_O)			
3.7		Store data for future usage				Metered Data Operator (MDO)			

4.2.4 SETTLEMENT

The settlement process has several relevant aspects to consider:

-The TSO requests measurements from the metering entity (for assets in the distribution network) and uses its own measurements in the transmission grid to compute the settlement for each market agent, as the market prices of each time-interval of each market session multiplied by the market agent cleared reserves for these time intervals, minus the penalties for non-providing the requested reserves.

-It is the responsibility of the aggregators to solve its contractual rights and obligations with the owners of the resources providing the service (biding and settlement, including imbalances). -The active power service cost should be shared by the final users and by those not complying with their active power commitments through penalties. -Penalties can allow or not internal aggregator compensation, and a correct design is important for system efficiency. For example, too high penalties, 1) allowing compensation at the aggregator level, may cause inefficient system resources activation to avoid penalties, and 2) applied directly at the resources level, may disincentive market participation due to the penalty risks, reducing resources availability. In addition, although cost reflective penalties improve global efficiency, they can decrease the system security, while large penalties may disincentivize market participation.



Scenario step by step analysis

Scenario	
Scenario name	Settlement

Step No	*Event*	*Name of process/activity*	*Description of process/activity*	*Service*	*Information producer (actor)*	*Information receiver (actor)*	*Information exchanged (IDs)*	*Requirement, R-IDs*
4.1		Send metered data for settlement		send	Metered Data Operator (MDO)	Transmission System Operator (TS_O)	Info6-Settlement data	
4.2		Compute settlement and send data used and invoice		send	Transmission System Operator (TS_O)	Aggregator (A)	Info6-Settlement data	
4.3		Compute settlement according to contracts with flexibility providers and invoice		send	Aggregator (A)	Distribution Network Flexibility Provider (DN_FP), Transmission Network Flexibility Provider (TN_FP)	Info6-Settlement data	
4.4		Verify settlement			Transmission Network Flexibility Provider (TN_FP)			
4.5		Verify settlement			Distribution Network Flexibility Provider (DN_FP)			

5. INFORMATION EXCHANGED

Information exchanged			
Information exchanged, ID	*Name of information*	*Description of information exchanged*	*Requirement, R-IDs*
Info1	Prequalification agreement	Contract between a market operator entity and a market agent to allow and regulate the market participation of the agent.	

Info2	P profile	Profile of active power needed for the 28 time-intervals of 15 min of the delivering horizon of 7 hours.	
Info3	P bids	Profile of active power offered for the 28 time-intervals of 15 min the delivering horizon of 7 hours. The bid should include -the aggregator identification, corresponding to an aggregator previously qualified to participate in the market -the aggregated resources identification, corresponding to a previously registered aggregator resources. -The delivering horizon for which the bid is sent, or none if the bid is to remain valid until overwritten or cleared. -if the bid is curtailable, or non-curtailable when it can only be cleared totally or otherwise rejected. -the amount of active power offered per time interval, in MW (if constant active power assumed) -the price of the active energy per time interval, in €/MWh -the active power offered disaggregated by individual resources for grid constraints checking	
Info4	TL qualification	The TL qualification of the bid, computed by the FlexHub, indicates with a green light that the TSO can clear the bid resources totally for its next activation, with a yellow light meaning that the bid can only be cleared partially to avoid distribution grid constraints violations (the amount that can be cleared for each time period of the delivering horizon being also part of the TL qualification) , and a red light meaning that the bid must be discarded (due distribution grid constraints violations) and possibly replaced by the next cheapest bid.	
Info5	Control signal	Control signal for starting an activity such as activating a resource or metering	
Info6	Settlement data	Detailed information about the settled service, with the information and links needed to settle or to understand and verify a settlement, and the invoice if any.	

TABLE 13 BUC PT-FXH-AP

Manage reactive power flexibility to support voltage control and congestion management in the FlexHub Portuguese demo

Based on IEC 62559-2 edition 1
Generated from UML Use Case Repository with Modsarus® (EDF R&D Tool)

1. DESCRIPTION OF THE USE CASE

1.1 NAME OF USE CASE

Use case identification		
ID	***Area(s)/Domain(s)/Zone(s)***	***Name of use case***
PT-FxH-RP	Portugal	Manage reactive power flexibility to support voltage control and congestion management in the FlexHub Portuguese demo

1.2 VERSION MANAGEMENT

Version management				
Version No.	***Date***	***Name of author(s)***	***Changes***	***Approval status***
1	2018-05-28	Jose Villar	Proposed version from demo	
2	2018-06-14	Cyril Effantin	Consolidation in a common UC repository from last Flexub update on the 14/06/2018	
3	2018-10-15	Jose Villar	Update based on use case validation.	
4	2018-12-05	Cyril Effantin	Update based on role model modification.	

1.3 SCOPE AND OBJECTIVES OF USE CASE

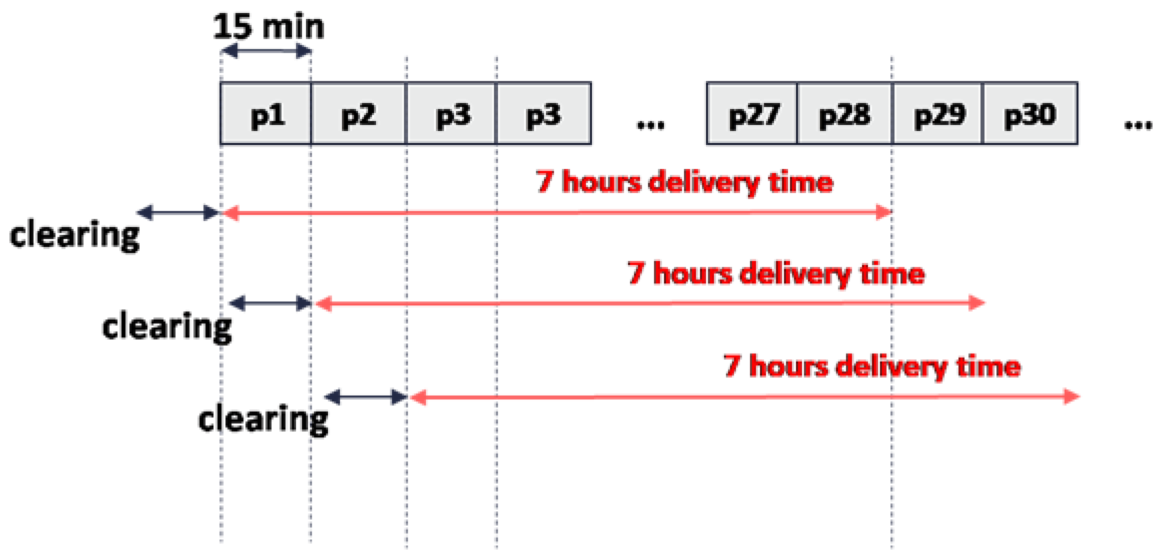
Scope and objectives of use case	
Scope	In traditional power systems, voltage support has typically been provided by conventional generators, already paid back or still recovering costs mainly through energy markets, and to a lesser extent, through ancillary services markets. However, under a very large RES integration scenario, conventional generation units will dramatically decrease in number due to strict environmental regulations and a lower economic viability (lower prices and lower capacity factors), and new sources of system services must be investigated. This business use case is for providing reactive power to the TSO (represented by the role TS_O in the UML part of this BUC) at the TSO-DSO connection point (the DSO will be represented by the role DS_O in the UML part of this BUC) for voltage control, by using the resources connected to the distribution network managed with a distribution network local market. This local market could also be part of a larger regional market (out of the scope of this BUC) where the TSO could select reactive power from different local sources, such as other distribution networks or any other type of local reactive power resource.
Objective(s)	Proper timing design:

	• Use proper time periods, delivering time, and simple and complex (if feasible) bids to allow for a sufficient and flexible reactive power control but avoiding excessive switching and degradation of assets. Create local reactive power market: • Establish a local market mechanism to incentivize private agents' participation to complement DSO resources, so that the DSO can use its own resources and the commercial ones to comply with TSO Q requirements. Provide reactive power from the distribution grid: • Use DSO and private resources connected to the distribution network to provide reactive power in response to TSO requirements, guaranteeing that no distribution network constraints are violated.
Related business case(s)	Congestion Management Voltage Control

1.4 NARRATIVE OF USE CASE

Narrative of use case
Short description
This BUC aims to set the main rules of a local market for providing reactive power to the TSO at the TSO-DSO connection point, by using the resources connected at the distribution network. For the next delivery horizon, the TSO publishes its reactive power needs as a profile (for the set of consecutive time intervals of the next delivery horizon) of the reactive power needed at the TSO-DSO connection point or in the same connection zone (where other resources or distribution networks could also be connected). The market agents can 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. Each PQ map provides 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 allows the TSO to select the least costly resources (if other are also available at the connection zone) to meet its reactive power requirements, and decide the final profile of reactive power to be procured at the TSO-DSO connection point.

The DSO clears the market to meet 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, which guarantees that no distribution network constraints are violated.
Complete description
For coherence with how the demonstration has been designed, the description of this BUC has been done with stakeholders instead of roles. However, for more generality, the UML part of this BUC is described in term of roles, even if introducing the role of Market Operator (MO) implies more complex interactions between the DSO and the MO that have been omitted for simplicity. This BUC describes a local market for providing reactive power to the TSO at the TSO-DSO connection point. The objective is to use the resources connected to the distribution network (including the DSO resources) that could be able to provide reactive power regulation. These resources could be: 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 DSO resources (already paid by other remuneration mechanisms) are used first, before using the additional resources offered by the market agents. This BUC includes the following steps: -Every 15 minutes, the TSO sends the reactive power profile needs to the DSO for the next delivery horizon of 7 hours (28 time-periods of 15min). The time sequence of this market is depicted in the following figure:

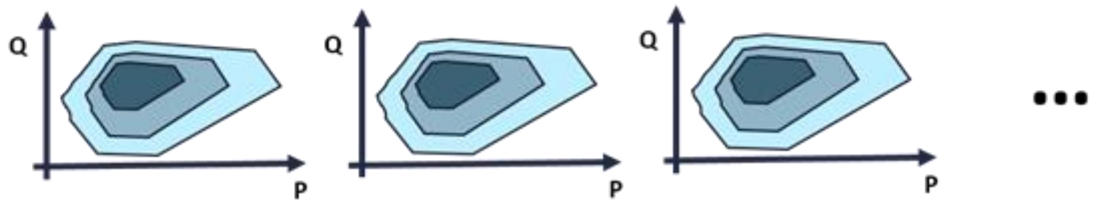


-The DSO communicates this profile to the market agents that can adapt their bids to the newly published profile, or keep them as before, remaining in this case latent until cleared or explicitly modified by the market agent themselves.
-With the available bids previously sent by the market agents (aggregators, aggregating one or more service providers), the DSO uses the FlexHub to compute, for each time interval of the delivery horizon, the PQ map that allows the TSO to know the amount of the aggregated reactive power available and the cost (depending on the amount of reactive power to be used), guaranteeing that the available reactive power can be supplied without the violation of the distribution network constraints. The PQ maps are then the aggregated resources available at the TSO-DSO connection point and the corresponding cost, so the TSO can select the total aggregated Q profile needed.
-The DSO matches the resources to this TSO Q profile, guaranteeing that no constraints of the grid it operates are violated.

The PQ maps are computed as follows:

-The DSO provides to the FlexHub the load and RES forecasts for the delivery horizon considered and for all nodes of the distribution network.
-Although at the primary substations measurements are often collected and made available each 15 minutes, measurements at the secondary substations are usually no available with the same frequency. In case measurements were missing, some kind of load allocation process could be needed to estimate missing active and reactive power measurements over the network nodes for each period of the delivery horizon. However this is out of the scope of this BUC.
-Multi-period optimal power flow (MOPF) executions are used to compute the cost level curves of the PQ maps for each time period of the delivery horizon, so as to provide a sufficiently accurate representation of the available ranges of PQ resources and the corresponding costs. Larger cost resolutions require a larger amount of MOPF executions, so a trade-off must be reached according to the maximum execution time. The resources must be represented as market bids in the market FlexHub platform, offering reactive power increments from

the current resource schedule (from previous market clearings whose delivery horizons overlap with the current one) with the associated cost. The format of the market bids should allow for non-curtailable bids (not allowing partial activation), so that bids for particular assets (such as capacitor banks) can be activated for part or for the whole delivery period, avoiding excessive switching and degradation of particular assets, if it proves to be computationally feasible. Note that multi-temporal PQ-maps only provide accurate information when there are no complex bids with transversal temporal constraint, since in this case, selecting an amount of Q for a particular time period can modify the available Q for the rest of time periods. Note also that, since P is assumed to remain fixed, PQ maps are Q maps for this particular BUC.



With the PQ maps, the TSO has a better information to decide, from its available reactive power resources (that could also be managed in a more global regional market including other closer distribution networks and local resources), the least costly alternative (or the set of least costly solutions) to meet its needs.

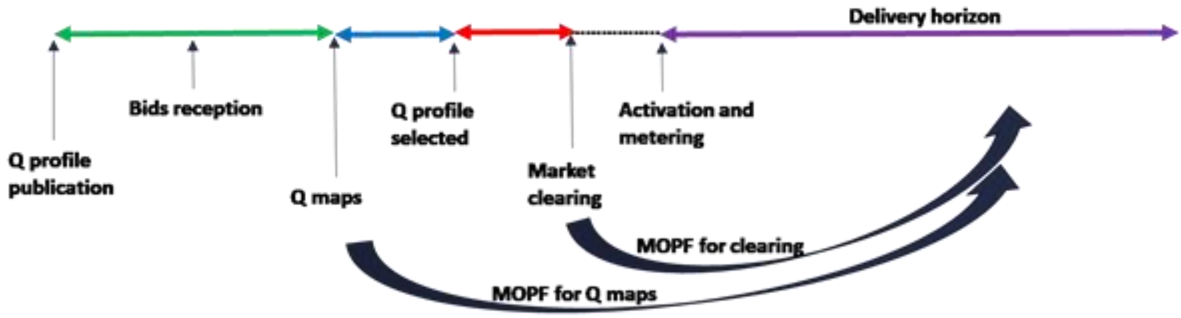
If DSO aggregated resources are selected, then the DSO uses the FlexHub multi-period power flow (MOPF) to clear the market and select the optimal resources for the service provision that do not compromise its distribution network security (no voltage or overload constraint violations of the distribution network). The resource assignment is communicated to the market agents that are responsible of activating them. To compute the MOPF the same information as for the PQ-maps is needed:
-Load and RES forecasts for the whole delivery horizon and for all nodes.
-Information about the network topology ("normal" topology)
-Information about topology changes during the next delivery horizon (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).
-reactive power bids

With this information the FlexHub uses the MOPF with the available bids (resources offered with the corresponding price, sent to the FlexHub market platform), to match the bids to the required TSO Q profile. The market price is set to the price of the most expensive cleared bid (also known as pay as clear or marginal pricing).

After clearing the local market, the DSO:
-Informs the market agents of the new schedules (that may replace previous ones for the overlapping periods),

which become responsible of their resources activation.
-Informs the TSO of the Q profile finally provided.

This time sequence for a unique market session is summarized in the following figure:



During the operation, an external entity (metered data operator) measures and stores the reactive power provided by the market agents and DSO resources for future settlement. The TSO also measures the total reactive power provided at the TSO-DSO connection point.

The settlement process is as follows.

-The DSO computes the market cost of the service by multiplying the total reactive power provided at the TSO-DSO connection point per time interval by the time interval market price.
-Since some bids may have been matched to solve DSO grid constraints, the DSO also estimates the cost of using these resources by clearing the market with a null TSO Q profile. This way a cost sharing mechanisms can be set up between TSO and DSO for the resources usage.
-Deviations of the real reactive power provided from the scheduled one implies penalties that should also be considered in the total service cost.

The DSO settles the provision of the service (as for other similar commodities, the settlement period could be established in one month). For each market agent (aggregator) it computes:
-the market cost of the service as the scheduled reactive power for each time interval of each delivery horizon of the settlement period by the corresponding market price.
-The penalty corresponding to the deviation between the scheduled and the real provided reactive power. Penalties should be such that 1) There are no incentives to reactive power imbalances, and 2) they are related to the cost of the imbalance or the cost of solving it if any other mechanism is available.
-It is the responsibility of the aggregators to solve its contractual rights and obligations with the owners of the resources providing the service (biding and settlement, including imbalances).

The reactive power service can be considered as another system service, and its cost could be shared by the final users and by those not complying with their reactive power commitments (through the corresponding penalties), although it is out of the scope of this BUC to address the global reactive power remuneration mechanism.

For already existing DSO assets, other regulated remuneration mechanism are already in place, and providing this service should not imply any additional remuneration. New investments could follow the same mechanisms, although the market should incentivize market agents participation for providing this service, avoiding additional DSO investments. DSO market participation should be avoided since DSO acts also as market operator.

Summary of use case

- **Prequalification**
  Description: 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.
  - Request pre-qualification for market participation
    Description: Request for agreement to participate in the market, by providing the technical data, tests, and economical guarantees needed according to the market rules.
  - Verify request and provide signed agreement
    Description:
- **Selection/Bidding**
  Description: Every 15 minutes, the TSO sends the reactive power profile needs to the DSO for the next delivery horizon of 7 hours (28 time-periods of 15 minutes).

  The DSO communicates this profile to the market agents that can adapt their bids to the newly published profile, or keep them as before, remaining in this case latent until cleared or explicitly modified by the market agent themselves.

  With the available bids previously sent by the market agents, the DSO uses the FlexHub to compute, for each time interval of the delivery horizon, the PQ map that informs the TSO of the amount of aggregated reactive power available and its cost (depending on the amount of reactive power to be used), guaranteeing that the available reactive power can be supplied without the violation of the distribution network constraints. PQ maps are computed for each time period of the delivery horizon. A trade-off between the cost resolution and the computation time must be reached, since larger cost resolutions require larger computation times.

  The resources are represented as market bids in the market FlexHub platform, offering reactive power increments from the current resource schedule (from previous market clearings whose delivery horizons overlap with the current one) with the associated cost. The format of the market bids should allow for non-curtailable bids, so that bids for particular assets (such as capacitor banks) can be activated for part or for the whole delivery period, avoiding excessive switching and degradation of particular assets, if it proves to be computationally feasible. However, note that in case there are complex bids with inter-temporal constraints, PQ maps provide only approximate information, since selecting some amount of Q power for a particular time interval can modify the remaining reactive power and costs for the rest of time periods.

With the PQ maps, the TSO can check from its available reactive power resources (that could also be managed in a more global regional market including other closer distribution networks and local resources) the least costly solution (or the set of least costly solutions) to meet its needs.

A final Q profile to be provided from the distribution network resources is finally issued by the TSO and communicated to the DSO. The DSO uses the FlexHub multi-period power flow (MOPF) to clear the market and select the optimal resources for the service provision that do not compromise its distribution network security (no voltage or overload constraint violations of the distribution network). The bids matching is then published for the agents, responsible of activating the corresponding resources. To compute the MOPF (as for the PQ maps) the following data are needed:

-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 in the FlexHub market platform. The market price is then set to the price of the most expensive cleared bid (also known as pay as clear or marginal pricing).

If it is computationally feasible, the algorithm will be designed to be able to deal with bids with complex conditions such as the non-curtailable condition.

- Compute and publish Q profile
  Description:
- Share Q profile with aggregators
  Description:
- Compute and send bids
  Description:
- Compute and send PQ maps
  Description:
- Select Q aggregated resources
  Description:
- Clear market and assign schedules
  Description:

- **Delivery**
  Description: After clearing the local market, the resulting schedules have to be used by the DSO and by the market agents to activate the corresponding cleared resources.

  An external entity (metered data operator) measures and stores the reactive power provided by the market agents and DSO resources for future settlement. The TSO also measures the total reactive power provided at the TSO-DSO connection point.

  - Activate the resources to provide the reactive power scheduled
    Description:

- Activate the resources to provide the reactive power scheduled
  Description:

- Activate the resource for Q provision
  Description:

- Measure final Q provided
  Description:

- Store data for future usage
  Description:

- Measure final Q provided
  Description:

- Store data for future usage
  Description:

- **Settlement**
  Description: The settlement process is as follows.

  -The DSO computes the market cost of the service by multiplying the total reactive power provided at the TSO-DSO connection point per time interval by the time interval market price.
  -Since some bids may have been matched to solve DSO grid constraints, the DSO also estimates the cost of using these resources by clearing the market with a null TSO Q profile. This way a cost sharing mechanisms can be set up between TSO and DSO for the resources usage.
  -Deviations of the real reactive power provided from the scheduled one implies penalties that should also be considered in the total service cost.

  The DSO settles the provision of the service (as for other similar commodities, the settlement period could be established in one month). For each market agent (aggregator) it computes:
  -the market cost of the service as the scheduled reactive power for each time interval of each delivery horizon of the settlement period by the corresponding market price.
  -The penalty corresponding to the deviation between the scheduled and the real provided reactive power. Penalties should be such that 1) There are no incentives to reactive power imbalances, and 2) they are related to the cost of the imbalance or the cost of solving it if any other mechanism is available.
  -It is the responsibility of the aggregators to solve its contractual rights and obligations with the owners of the resources providing the service (biding and settlement, including imbalances).

  The reactive power service can be considered as another system service, and its cost could be shared by the final users and by those not complying with their reactive power commitments (through the corresponding penalties), although it is out of the scope of this BUC to address the global reactive power remuneration mechanism.

  For already existing DSO assets, other regulated remuneration mechanism are already in place, and providing this service should not imply any additional remuneration. New investments could follow the same mechanisms, although the market should incentivize market agents participation for providing this service, avoiding additional DSO investments. DSO market participation should be avoided since DSO acts also as market operator.

  - Compute TSO-DSO settlement, and send data used and invoice
    Description:

- Send metered data for settlement
  Description:
- Compute local market settlement (cleared bids and penalties) and send data and invoice
  Description:
- Compute settlement according to contractual agreements and send data and invoice
  Description:

1.5 KEY PERFORMANCE INDICATORS (KPI)

1.6 USE CASE CONDITIONS

	Use case conditions
	Assumptions
1	Assumptions: With respect to regulatory aspects at the TSO-DSO connection point: • Current regulation incentivizes 0 reactive exchanges. This means that the reactive power generated must be inside a range around cero, and if this range is exceeded,, penalties must be paid. • Therefore network usage tariffs establish a positive price for both inductive and capacitive reactive. • Additional penalizations for large inductive reactive are applied • To keep the reactive null at the TSO-DSO interface, the DSO uses its own resources (condenser batteries, OLTC). • However, TSO and DSO agree sometimes different Q values. Since current regulation does not consider this situation, a posterior negotiation is needed to avoid penalties. Therefore, an appropriate regulation should be put in place with the following assumptions: • The possibility of establishing local distribution network markets • Allowing commercial exchanges among the TSO and the DSO to incentivize new services provided by the resources available at the distribution network • Allow the DSO to manage these local markets, since clearing is better performed by considering simultaneously the network constraints. DSO roles should, therefore, be clearly regulated to avoid market distortions. This BUC proposes to use DSO resources first (already paid or being paid by the final customers) with null additional cost for providing this service, and using the market agent bids for the remaining reactive power needed. Future DSO investments could managed by a third party market agents, or replaced by private market agents investments. Other assumptions are: • Full knowledge of the distribution grid topology is available • Real-time measurements are available for data collecting, network state estimation, and service provision verification. The DSO or a third party could be in charge of metering and data storing. • Active and reactive power measurements and forecasts (for each delivery horizon) with 15 minutes resolution time are needed at all nodes. • Market agents are responsible of their matched resources activation.

- A prequalification phase (pre-qualification, certification and registration process) should be put in place to allow the resources to participate in this market, verifying their technical capabilities. Since it is not considered an essential part of this BUC, this phase will be omitted.

Prerequisites	
1	Preconditions: The demo will focus on 1. The FlexHub tools, namely the PQ maps computation, the market platform and the MOPF for market clearing. 2. The activation of selected resources to provide reactive power. These resources are those connected at Frades primary substation with the following configuration: -Vila da Ponte without capacitor banks. -Caniçada with two steps of 3.43 MVar each. -Wind park Barroso II - 12,3 MW | Barroso III - 22 MW -Wind park Barroso II - 6 WG | Barroso III - 11 WG -Possible Run-of-river hydro power plant or mini hydro, connected to the HV DSO grid.

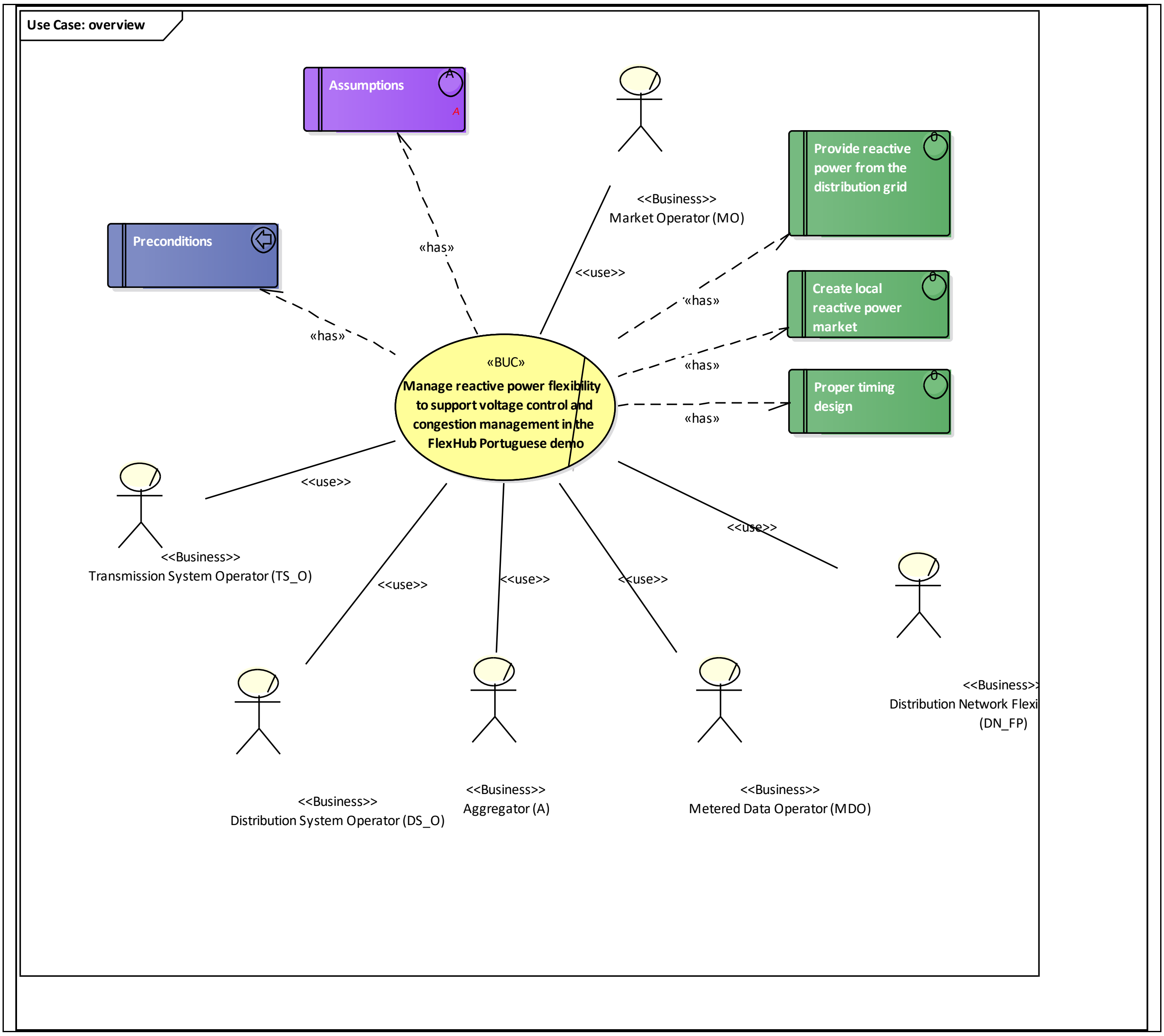
1.7 FURTHER INFORMATION TO THE USE CASE FOR CLASSIFICATION/MAPPING

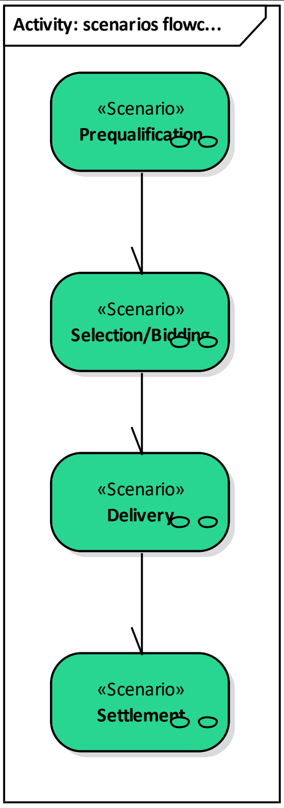
Classification information
Relation to other use cases
Level of depth
BUC for Portugal FlexHub Demo
Prioritisation
Generic, regional or national relation
National
Nature of the use case
BUC
Further keywords for classification

1.8 GENERAL REMARKS

2. DIAGRAMS OF USE CASE

Diagram(s) of use case


Use Case: overview
Assumptions
Preconditions
«has»
«has»
<<Business>>
Market Operator (MO)
<<use>>
Provide reactive power from the distribution grid
Create local reactive power market
Proper timing design
«has»
«has»
«has»
«BUC»
Manage reactive power flexibility to support voltage control and congestion management in the FlexHub Portuguese demo
<<use>>
<<Business>>
Transmission System Operator (TS_O)
<<use>>
<<use>>
<<use>>
<<use>>
<<Business>>
Distribution Network Flexi
(DN_FP)
<<Business>>
Distribution System Operator (DS_O)
<<Business>>
Aggregator (A)
<<Business>>
Metered Data Operator (MDO)



3. TECHNICAL DETAILS

3.1 ACTORS

Actors			
Grouping (e.g. domains, zones)		*Group description*	
Actor name	*Actor type*	*Actor description*	*Further information specific to this use case*
Transmission System Operator (TS_O)	Business	Elaborate network development plan (including defining system needs for transmission) Ensure a transparent and non-discriminatory access to the transmission network for each user Operate the transmission grid over a specific region in a secure, reliable and efficient way Secure and manage in real time the physical generation-consumption balance on a geographical perimeter, including ensuring the frequency control service Optimize transmission system operation from planning to real-time, using available levers (grid expansion, flexibility	

		activation,...) Assess network status of the transmission grid and broadcast selected information of the network status to eligible actors (e.g. aggregators, other system operators) Provide data to the interconnection capacity market operator for the management of cross border transactions In critical situations, implement dedicated actions and deliver alerts during stress events If necessary, implement emergency measures (e.g. system defence plan) including load shedding	
Distribution Network Flexibility Provider (DN_FP)	Business	Provide flexibility by assets connected to the distribution network	
Distribution System Operator (DS_O)	Business	Elaborate network development plan (including defining system needs for distribution) Ensure a transparent and non-discriminatory access to the distribution network for each user Operate the distribution grid over a specific region in a secure, reliable and efficient way Optimize system operation distribution grid from planning to real-time, using available levers (grid expansion, flexibility activation,...) Assess network status of the distribution grid and broadcast selected information of the network status to eligible actors (e.g. aggregators, other system operators) Support the Transmission System Operator in carrying out its responsibilities (including load shedding) and coordinate measures if necessary	
Metered Data Operator (MDO)	Business	Provide metered data to authorized users in a transparent and non-discriminatory manner	
Aggregator (A)	Business	Aggregate and maximise value of portfolio(s) of resources	
Market Operator (MO)	Business	Organize auctions (continuous auction, discrete auctions, call for tenders) between buyers and sellers of electricity-related products in the markets, and more generally publish the corresponding prices, for assets connected to transmission or distribution grid Manage/operate the platform for trading (where bids and	

		offers are collected) Clear the market and communicate results	

3.2 REFERENCES

4. STEP BY STEP ANALYSIS OF USE CASE

4.1 OVERVIEW OF SCENARIOS

Scenario conditions						
No.	***Scenario name***	***Scenario description***	***Primary actor***	***Triggering event***	***Pre-condition***	***Post-condition***
1	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.				
2	Selection/Bidding	Every 15 minutes, the TSO sends the reactive power profile needs to the DSO for the next delivery horizon of 7 hours (28 time-periods of 15 minutes). The DSO communicates this profile to the market agents that can adapt their bids to the newly published profile, or keep them as before, remaining in this case latent until cleared or explicitly modified by the market agent themselves. With the available bids previously sent by the market agents, the DSO uses the FlexHub to compute, for each time interval of the delivery horizon, the PQ map that informs the TSO of the amount of aggregated reactive power available and its cost (depending on the amount of reactive power to be used),				

		guaranteeing that the available reactive power can be supplied without the violation of the distribution network constraints. PQ maps are computed for each time period of the delivery horizon. A trade-off between the cost resolution and the computation time must be reached, since larger cost resolutions require larger computation times. The resources are represented as market bids in the market FlexHub platform, offering reactive power increments from the current resource schedule (from previous market clearings whose delivery horizons overlap with the current one) with the associated cost. The format of the market bids should allow for non-curtailable bids, so that bids for particular assets (such as capacitor banks) can be activated for part or for the whole delivery period, avoiding excessive switching and degradation of particular assets, if it proves to be computationally feasible. However, note that in case there are complex bids with inter-temporal constraints, PQ maps provide only approximate information, since selecting some amount of Q power for a particular time interval can modify the remaining reactive power and costs for the rest of time periods. With the PQ maps, the TSO can check from its available reactive power resources (that				

		could also be managed in a more global regional market including other closer distribution networks and local resources) the least costly solution (or the set of least costly solutions) to meet its needs. A final Q profile to be provided from the distribution network resources is finally issued by the TSO and communicated to the DSO. The DSO uses the FlexHub multi-period power flow (MOPF) to clear the market and select the optimal resources for the service provision that do not compromise its distribution network security (no voltage or overload constraint violations of the distribution network). The bids matching is then published for the agents, responsible of activating the corresponding resources. To compute the MOPF (as for the PQ maps) the following data are needed: -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 in the FlexHub market platform. The market price is then set to the price of the most expensive cleared bid (also known as pay as clear or marginal pricing). If it is computationally feasible, the algorithm will be designed to be able to deal with bids with complex conditions such as the non-curtailable condition.				
3	Delivery	After clearing the local market, the resulting schedules have to be used by the DSO and by the market agents to activate the corresponding cleared resources. An external entity (metered data operator) measures and stores the reactive power provided by the market agents and DSO resources for future settlement. The TSO also measures the total reactive power provided at the TSO-DSO connection point.				
4	Settlement	The settlement process is as follows. -The DSO computes the market cost of the service by multiplying the total reactive power provided at the TSO-DSO connection point per time interval by the time interval market price. -Since some bids may have been matched to solve DSO grid constraints, the DSO also estimates the cost of using these resources by clearing the market with a null TSO Q			TSO-DSO connection point measurements: The TSO will have to measure the reactive power actually delivered at the TSO-DSO connection point to be able to perform the settlement with the DSO. The DSO will also probably have to measure the reactive power actually delivered at the TSO-	

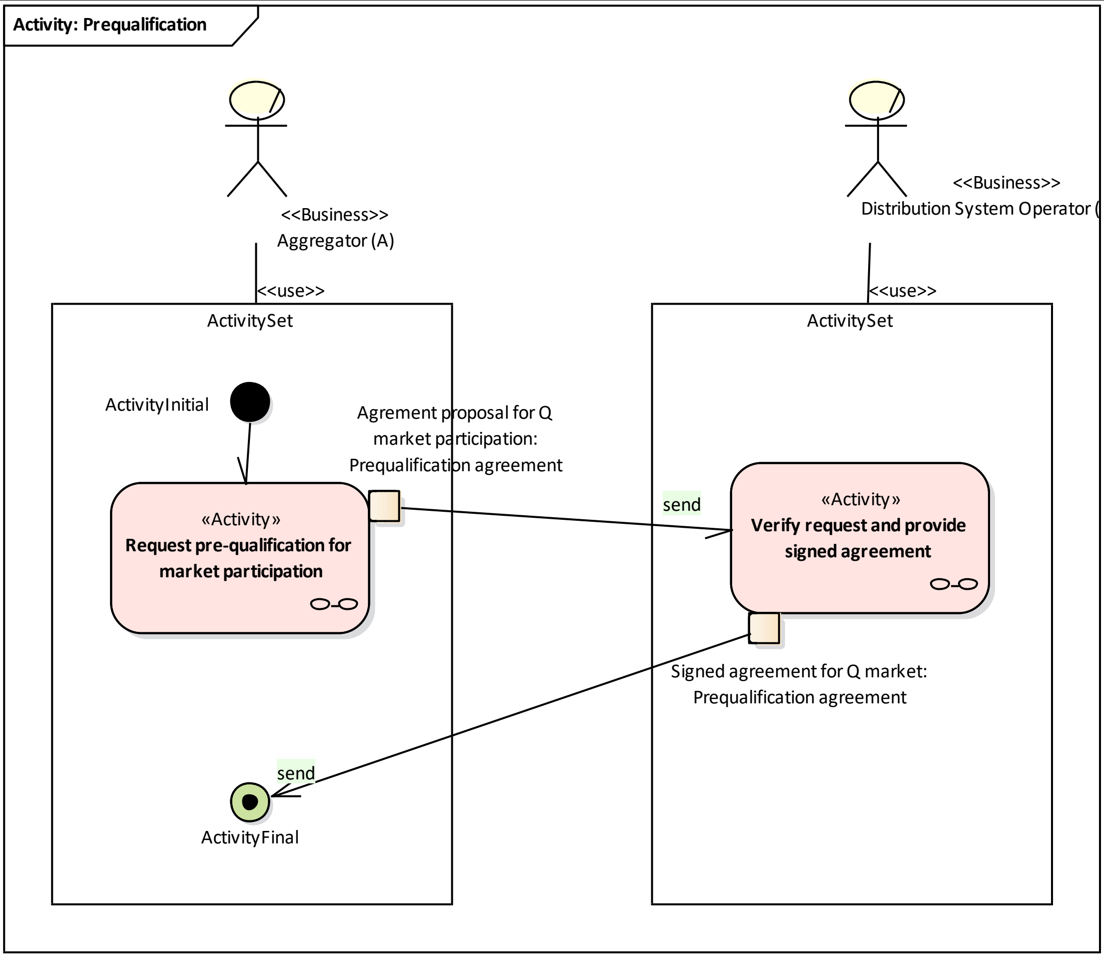
		profile. This way a cost sharing mechanisms can be set up between TSO and DSO for the resources usage. -Deviations of the real reactive power provided from the scheduled one implies penalties that should also be considered in the total service cost. The DSO settles the provision of the service (as for other similar commodities, the settlement period could be established in one month). For each market agent (aggregator) it computes: -the market cost of the service as the scheduled reactive power for each time interval of each delivery horizon of the settlement period by the corresponding market price. -The penalty corresponding to the deviation between the scheduled and the real provided reactive power. Penalties should be such that 1) There are no incentives to reactive power imbalances, and 2) they are related to the cost of the imbalance or the cost of solving it if any other mechanism is available. -It is the responsibility of the aggregators to solve its contractual rights and obligations with the owners of the resources providing the service (biding and settlement, including imbalances). The reactive power service can be considered as another system service, and its cost could be shared by the final users and by those not			DSO to verify the settlement proposed by the TSO. DSO measurements: The DSO could also measure the active power provided by the aggregated resources to compare with the data provided by the Metering data operator.	

		complying with their reactive power commitments (through the corresponding penalties), although it is out of the scope of this BUC to address the global reactive power remuneration mechanism. For already existing DSO assets, other regulated remuneration mechanism are already in place, and providing this service should not imply any additional remuneration. New investments could follow the same mechanisms, although the market should incentivize market agents participation for providing this service, avoiding additional DSO investments. DSO market participation should be avoided since DSO acts also as market operator.				

4.2 STEPS - SCENARIOS

4.2.1 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.



Scenario step by step analysis

Scenario									
Scenario name		Prequalification							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
1.1		Request pre-qualification for market participation	Request for agreement to participate in the market, by providing the technical data, tests, and economical guarantees	send	Aggregator (A)	Distribution System Operator (DS_O)	Info1-Prequalification agreement	

			needed according to the market rules.					
1.2		Verify request and provide signed agreement		send	Distribution System Operator (DS_O)	Aggregator (A)	Info1- Prequalification agreement	

4.2.2 SELECTION/BIDDING

Every 15 minutes, the TSO sends the reactive power profile needs to the DSO for the next delivery horizon of 7 hours (28 time-periods of 15 minutes).

The DSO communicates this profile to the market agents that can adapt their bids to the newly published profile, or keep them as before, remaining in this case latent until cleared or explicitly modified by the market agent themselves.

With the available bids previously sent by the market agents, the DSO uses the FlexHub to compute, for each time interval of the delivery horizon, the PQ map that informs the TSO of the amount of aggregated reactive power available and its cost (depending on the amount of reactive power to be used), guaranteeing that the available reactive power can be supplied without the violation of the distribution network constraints. PQ maps are computed for each time period of the delivery horizon. A trade-off between the cost resolution and the computation time must be reached, since larger cost resolutions require larger computation times.

The resources are represented as market bids in the market FlexHub platform, offering reactive power increments from the current resource schedule (from previous market clearings whose delivery horizons overlap with the current one) with the associated cost. The format of the market bids should allow for non-curtailable bids, so that bids for particular assets (such as capacitor banks) can be activated for part or for the whole delivery period, avoiding excessive switching and degradation of particular assets, if it proves to be computationally feasible. However, note that in case there are complex bids with inter-temporal constraints, PQ maps provide only approximate information, since selecting some amount of Q power for a particular time interval can modify the remaining reactive power and costs for the rest of time periods.

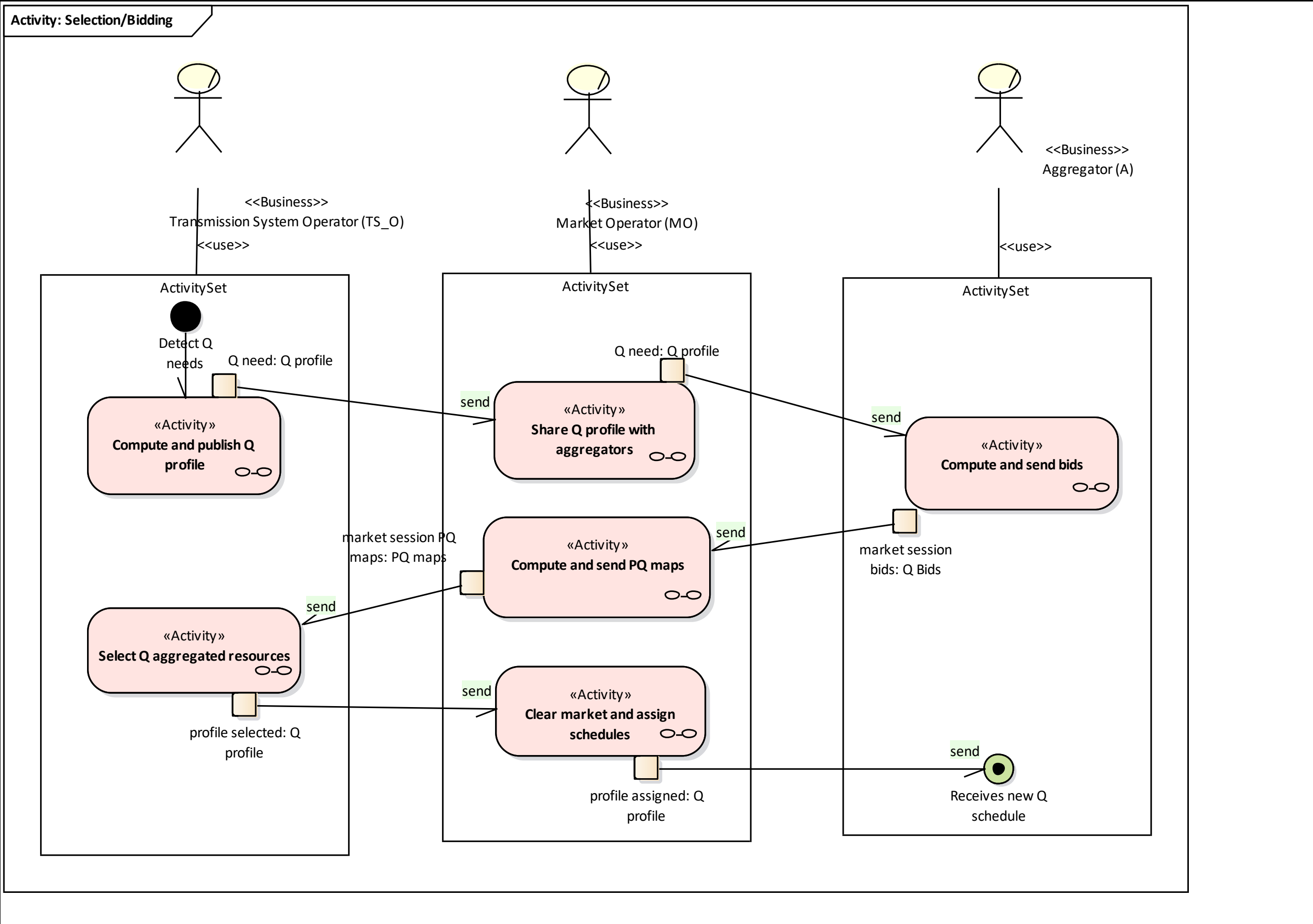
With the PQ maps, the TSO can check from its available reactive power resources (that could also be managed in a more global regional market including other closer distribution networks and local resources) the least costly solution (or the set of least costly solutions) to meet its needs.

A final Q profile to be provided from the distribution network resources is finally issued by the TSO and communicated to the DSO. The DSO uses the FlexHub multi-period power flow (MOPF) to clear the market and select the optimal resources for the service provision that do not compromise its distribution network security (no voltage or overload constraint violations of the distribution network). The bids matching is then published for the agents, responsible of activating the corresponding resources. To compute the MOPF (as for the PQ maps) the following data are needed:

-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 in the FlexHub market platform. The market price is then set to the price of the most expensive cleared bid (also known as pay as clear or marginal pricing).

If it is computationally feasible, the algorithm will be designed to be able to deal with bids with complex conditions such as the non-curtailable condition.



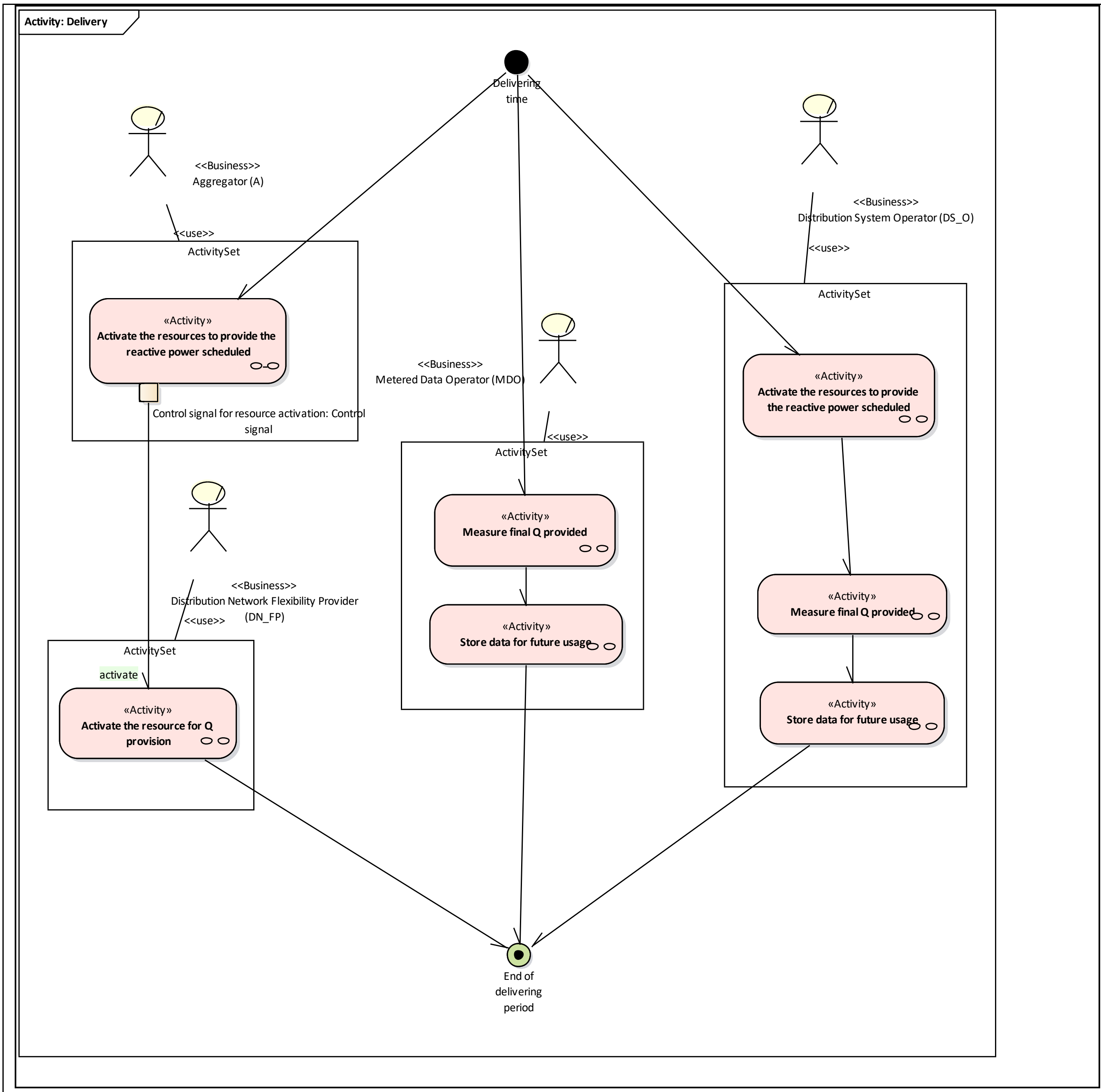
Scenario step by step analysis

Scenario								
Scenario name	Selection/Bidding							
Step No	*Event*	*Name of process/activity*	*Description of process/activity*	*Service*	*Information producer (actor)*	*Information receiver (actor)*	*Information exchanged (IDs)*	*Requirement, R-IDs*
2.1		Compute and publish Q profile		send	Transmission System Operator (TS O)	Market Operator (MO)	Info2-Q profile	
2.2		Share Q profile with aggregators		send	Market Operator (MO)	Aggregator (A)	Info2-Q profile	
2.3		Compute and send bids		send	Aggregator (A)	Market Operator (MO)	Info3-Q Bids	
2.4		Compute and send PQ maps		send	Market Operator (MO)	Transmission System Operator (TS O)	Info4-PQ maps	
2.5		Select Q aggregated resources		send	Transmission System Operator (TS O)	Market Operator (MO)	Info2-Q profile	
2.6		Clear market and assign schedules		send	Market Operator (MO)	Aggregator (A)	Info2-Q profile	

4.2.3 DELIVERY

After clearing the local market, the resulting schedules have to be used by the DSO and by the market agents to activate the corresponding cleared resources.

An external entity (metered data operator) measures and stores the reactive power provided by the market agents and DSO resources for future settlement. The TSO also measures the total reactive power provided at the TSO-DSO connection point.



Scenario step by step analysis

Scenario								
Scenario name	Delivery							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
3.1		Activate the resources to			Distribution System			

		provide the reactive power scheduled			Operator (DS_O)			
3.2		Activate the resources to provide the reactive power scheduled		activate	Aggregator (A)	Distribution Network Flexibility Provider (DN_FP)	Info5-Control signal	
3.3		Activate the resource for Q provision			Distribution Network Flexibility Provider (DN_FP)			
3.4		Measure final Q provided			Metered Data Operator (MDO)			
3.5		Store data for future usage			Metered Data Operator (MDO)			
3.6		Measure final Q provided			Distribution System Operator (DS_O)			
3.7		Store data for future usage			Distribution System Operator (DS_O)			

4.2.4 SETTLEMENT

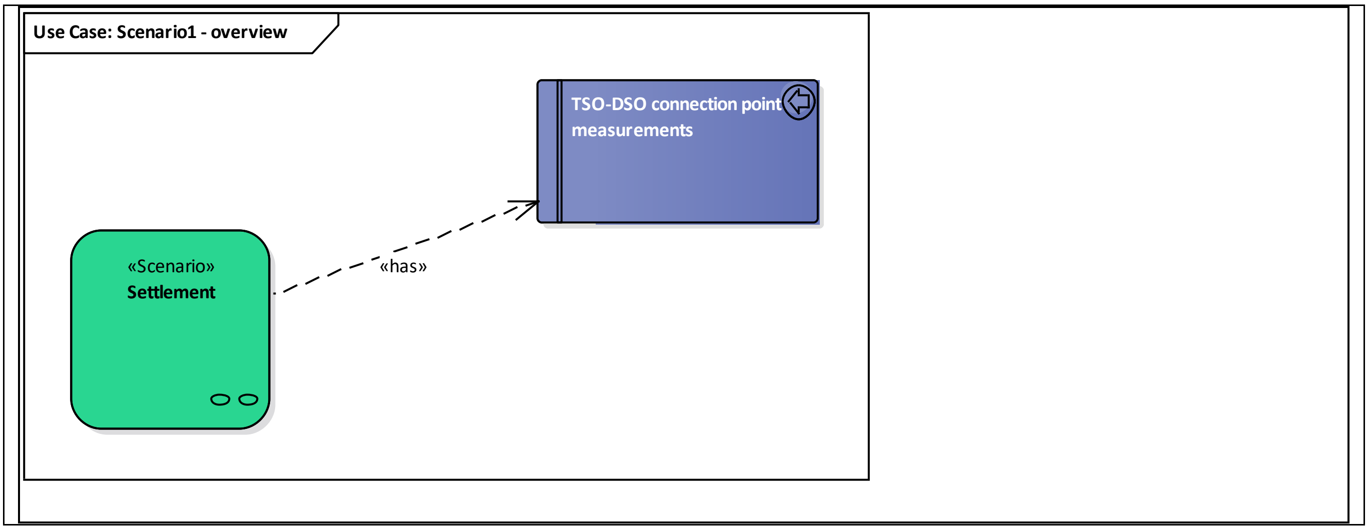
The settlement process is as follows.

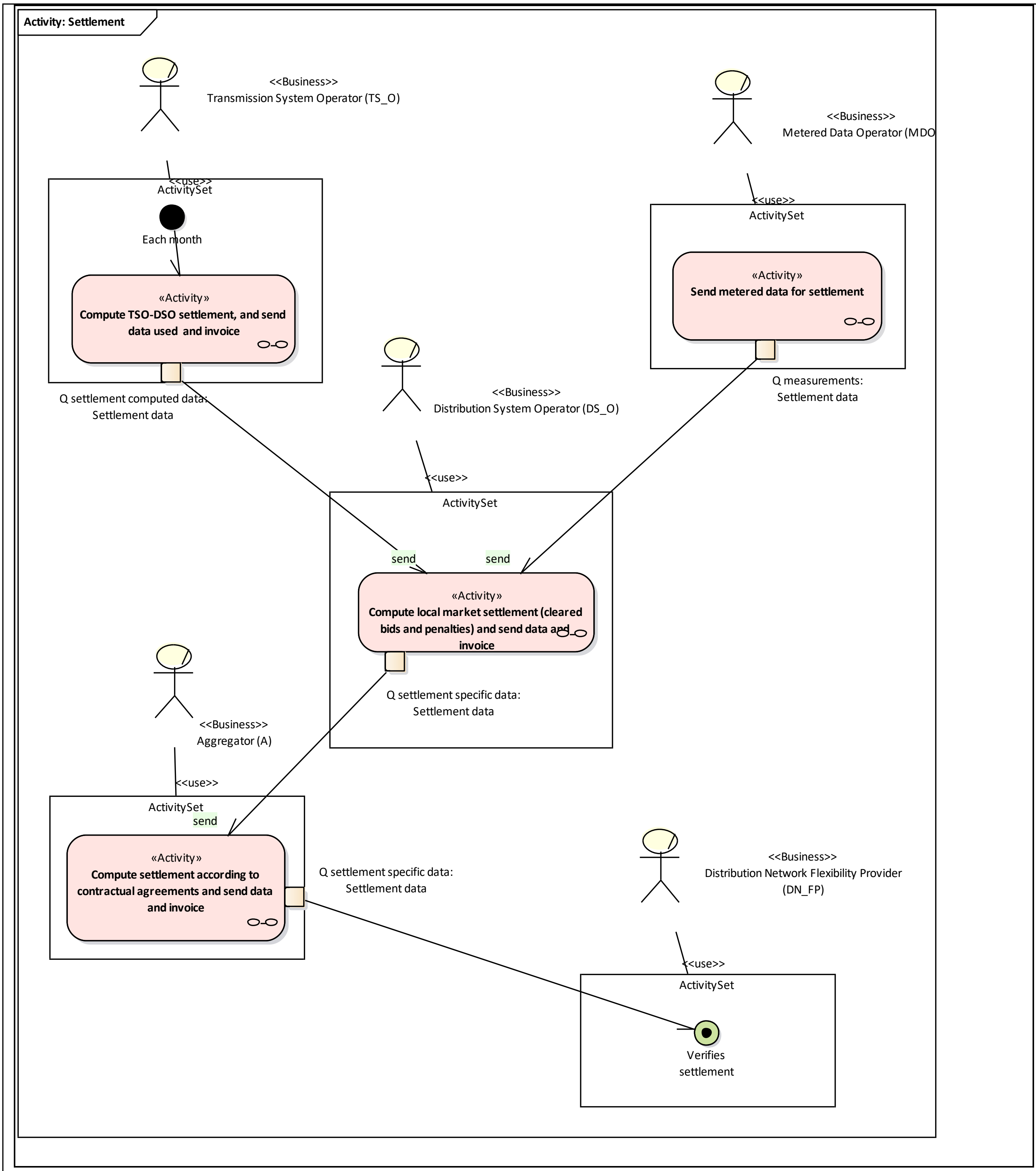
-The DSO computes the market cost of the service by multiplying the total reactive power provided at the TSO-DSO connection point per time interval by the time interval market price.
-Since some bids may have been matched to solve DSO grid constraints, the DSO also estimates the cost of using these resources by clearing the market with a null TSO Q profile. This way a cost sharing mechanisms can be set up between TSO and DSO for the resources usage.
-Deviations of the real reactive power provided from the scheduled one implies penalties that should also be considered in the total service cost.

The DSO settles the provision of the service (as for other similar commodities, the settlement period could be established in one month). For each market agent (aggregator) it computes:
-the market cost of the service as the scheduled reactive power for each time interval of each delivery horizon of the settlement period by the corresponding market price.
-The penalty corresponding to the deviation between the scheduled and the real provided reactive power. Penalties should be such that 1) There are no incentives to reactive power imbalances, and 2) they are related to the cost of the imbalance or the cost of solving it if any other mechanism is available.
-It is the responsibility of the aggregators to solve its contractual rights and obligations with the owners of the resources providing the service (biding and settlement, including imbalances).

The reactive power service can be considered as another system service, and its cost could be shared by the final users and by those not complying with their reactive power commitments (through the corresponding penalties), although it is out of the scope of this BUC to address the global reactive power remuneration mechanism.

For already existing DSO assets, other regulated remuneration mechanism are already in place, and providing this service should not imply any additional remuneration. New investments could follow the same mechanisms, although the market should incentivize market agents participation for providing this service, avoiding additional DSO investments. DSO market participation should be avoided since DSO acts also as market operator.


Use Case: Scenario1 - overview
TSO-DSO connection point measurements
«Scenario»
Settlement
«has»



Scenario step by step analysis

Scenario	
Scenario name	Settlement

Step No	*Event*	*Name of process/activity*	*Description of process/activity*	*Service*	*Information producer (actor)*	*Information receiver (actor)*	*Information exchanged (IDs)*	*Requirement, R-IDs*
4.1		Compute TSO-DSO settlement, and send data used and invoice		send	Transmission System Operator (TS_O)	Distribution System Operator (DS_O)	Info6-Settlement data	
4.2		Send metered data for settlement		send	Metered Data Operator (MDO)	Distribution System Operator (DS_O)	Info6-Settlement data	
4.3		Compute local market settlement (cleared bids and penalties) and send data and invoice		send	Distribution System Operator (DS_O)	Aggregator (A)	Info6-Settlement data	
4.4		Compute settlement according to contractual agreements and send data and invoice			Aggregator (A)	Distribution Network Flexibility Provider (DN_FP)	Info6-Settlement data	

5. INFORMATION EXCHANGED

Information exchanged			
Information exchanged, ID	*Name of information*	*Description of information exchanged*	*Requirement, R-IDs*
Info1	Prequalification agreement	Contract between a market operator entity and a market agent to allow and regulate the market participation of the agent.	
Info2	Q profile	Profile of reactive power needed for the 28 time intervals of 15 min of the delivering horizon of 7 hours.	
Info3	Q Bids	Profile of reactive power offered for the 28 time intervals of 15 min the delivering horizon of 7 hours. The bid should include -the aggregator identification, corresponding to an aggregator previously qualified to participate in the	

		market -the resource identification, corresponding to a previously registered aggregator resource. -The delivering horizon for which the bid is sent, or none if the bid is to remain valid until overwritten or cleared. -if the bid is curtailable, or non-curtailable when it can only be cleared totally or otherwise rejected. -the amount of reactive power offered per time interval, in MVAR (if constant reactive power assumed) -the price of the reactive energy per time interval, in €/MVARh	
Info4	PQ maps	PQ map for each of the 28 time intervals of 15 min of the delivering horizon of 7 hours. PQ maps have active and reactive powers in x and y axis, and the price (computed from the price of the bids) in the z axis, and are built by computing constant price curves with a predefined resolution.	
Info5	Control signal	Control signal for starting an activity such as activating a resource or metering	
Info6	Settlement data	Detailed information about the settled service, with the information and links needed to settle or to understand and verify a settlement, and the invoice if any.	

TABLE 14 BUC PT-FXH-RP

Provide active distribution grid dynamic model for transmission operator in the FlexHub Portuguese demo

Based on IEC 62559-2 edition 1
Generated from UML Use Case Repository with Modsarus® (EDF R&D Tool)

1. DESCRIPTION OF THE USE CASE

1.1 NAME OF USE CASE

Use case identification		
ID	***Area(s)/Domain(s)/Zone(s)***	***Name of use case***
PT-FxH-DM	Portugal	Provide active distribution grid dynamic model for transmission operator in the FlexHub Portuguese demo

1.2 VERSION MANAGEMENT

Version management				
Version No.	***Date***	***Name of author(s)***	***Changes***	***Approval status***

1	2018-05-28	Jose Villar	Proposed version from demo	
2	2018-06-14	Cyril Effantin	Consolidation in a common UC repository from Flexhub update received on the 14/06/2018	
3	2018-10-15	Jose Villar	Update based on use case validation.	
4	2018-12-05	Cyril Effantin	Update based on role model modification.	

1.3 SCOPE AND OBJECTIVES OF USE CASE

Scope and objectives of use case	
Scope	This BUC sets the rules for providing active distribution grids' dynamic response models to be delivered to TSOs (the TSO will be represented by the role TS_O in the UML part of this BUC) for dynamic stability studies for planning purposes. Nowadays, TSOs regularly, on some years basis (could be for example between 2 and 5), perform studies in order to evaluate in advance the expected performance of its power system regarding the overall stability following major disturbances. These studies allows to identify the need for new investments, tuning of controllers and assessing the stability margins of the power system. Currently, we are facing a paradigm change in power generation. Instead of having bulk power plants connected to the transmission grid, with the increasing level of renewables we are observing that power generation is becoming dispersed and often connected on distribution grids. In addition, the smart grid concepts are being exploited, and in a near future, it is expected that system support actions could be provided by the demand-side. Simultaneously, the ENTSO-e has published guidelines in the form of connection codes for the interconnection of new generation units, which may be also located on the distribution grid. The distribution grid dynamic model that is here described is intended to be a basic tool to help the DSO (the DSO will be represented by the role DS_O in the UML part of this BUC) on defining the set of parameters that describe the available technologies, as well as its combined response to frequency and voltage. This model framework will be then delivered to the TSO, which will substitute the actual load model by this new DSO dynamic model. On the framework of the EU-SysFlex project, the DSO dynamic model is a service that DSOs could provide to TSOs, and is included in the Flexibility Hub (FlexHub) platform, with the benefits of the existing interaction layers.
Objective(s)	Voltage and frequency dynamics:

	• The dynamic model should represent the dynamic behaviour in terms of voltage and frequency variations Derive a simplified dynamic model of the distribution network: • The objective is to derive simplified distribution grid dynamic model to be delivered to the TSO
Related business case(s)	Information Service

1.4 NARRATIVE OF USE CASE

Narrative of use case
Short description
This BUC describes a service consisting of the provision of equivalent data in the form of a simplified dynamic model, to represent a given active distribution grid to be used by TSO of the transmission grid where the distribution grid is connected, to perform network dynamic studies. This service comprises the model development, its delivery and its periodical update, according to the TSO requests. The simplified model is based on an approximate electrical equivalent, whose structure derivation is based on replicating the aggregated response of the distribution system to voltage and frequency related disturbances occurring at the transmission level. Then the model parameters can be estimated by using meta-heuristic optimization methods for the parameters estimation, by comparing the equivalent structure's response to the fully detailed system.
Complete description
This BUC describes a service consisting of the provision of equivalent data in the form of a simplified dynamic model, to represent a given active distribution grid to be used by TSO of the transmission grid where the distribution grid is connected, to perform network dynamic studies. TSOs currently perform studies to evaluate in advance the expected performance of its power system regarding the overall stability following major disturbances, to evaluate the power system resilience under different operational scenarios. In these studies, distribution networks are usually represented by load models connected below the TSO-DSO transformers. From the TSOs perspective, the RES connected at transmission grids are represented by generic or manufacturer models. Nonetheless, the approach followed to model distribution grid does not currently comprise RES representation. However, the increase of distributed generation makes advisable to improve the distribution network models for a better representation of their dynamic behavior. In addition, new services are being introduced and new flexibility means are being integrated into the distribution grids (frequency

responsive loads, Electric Vehicles (EV), storage, etc), transforming them in the so-called active distribution grids.

For the sake of completeness, it is therefore important to provide TSOs at least with an approximate dynamic model allowing to take into consideration the response of the components connected to distribution grids when performing power system dynamic studies. Simultaneously, it is impossible to fully simulate all the existing distribution grids in TSO studies since this could require an enormous computational burden. Being aware of that limitation, the service that is described here is the provision of a simplified active network dynamic model that must comprise main frequency and voltage-dependent dynamics in an aggregated and simplified manner.

The active distribution network dynamic model must encompass the network topology characteristic (meshed, radial or meshed/radial), represented by a limited number of nodes with equivalent impedance, as well as the transformer, and represent the combined dynamic response of the different technologies that may exist. Regarding the frequency and voltage responsive technologies, the simplified model should encompass:

- Electric vehicles (with service support functions)
- Loads (frequency responsive or voltage responsive)
- Constant power loads (non-responsive)
- Wind farms (with grid support functionalities)
- Mini-hydro power plants;
- Combined heat and power plants;
- PV plants;
- Storage (electro-chemical)
- Etc

Besides having different technologies, it is important that DSOs have access to the characteristics of these technologies and of the services that they are able to provide in order to build a representative model. So, it is crucial that these characteristics are provided by the actors that operate each asset (Asset operator in the UML description), such as:

- RES farm operators
- Big load consumers

To interact with the DSO, it has been assumed that these resources are represented by a generic Aggregator, that could be the own asset operator or represent a larger set of aggregated resources.

Finally, knowing the network characteristics, the dynamic response characteristics and the existing flexibilities, the DSO should build up the active distribution network dynamic model to be provided to the TSO. Depending on the existing information and data, this model can be derived on two manners:

- If data and parameters are existing, the DSO can perform some calculations and feed these parameters to the model using a lumped representation of the technologies.
- If data and parameters are non-existing, the DSO should derive the equivalent model based on historic data related with dynamic response of the grid following frequency and voltage disturbances, using a

parameter determination tool to derive the most convenient set of parameters that describe the dynamic response of its distribution grid in a combined manner.

Regarding network representation, it is intended to limit the meshed active distribution network representation up to five buses with equivalent impedance. Regarding radial network, it is expected to represent it by a single equivalent impedance as well as the transformer reactance.

For both aforementioned approaches, it is expected that TSOs require the data with a given time in advance so that DSOs are able to compute and deliver the active distribution grid dynamic model. As aforementioned, TSOs' studies may be performed from a yearly to five years' time frame so, it is expected that the DSO is able to improve the active distribution network dynamic model by determining new parameters as well as by collecting innovative information that may be of importance (connection of new technologies, retrofits, etc).

Regarding remuneration, this service does not exist currently. However, it could be a regulated service, in the future. DSOs should have, at least, manpower costs for constructing the models and probably these costs should be eligible for operational costs. Nonetheless, the remuneration schemes are out of the scope of this model description.

Summary of use case

- **Delivery**
  Description: Every one to five years the TSO requires from the DSO the dynamic model of the distribution grid that the DSO is managing, to build the transmission grid dynamic model. This is done in advance so that the DSO is able to compute and deliver the active distribution grid dynamic model considering the dynamic features of the grid it manages, and including updated information of the main relevant assets connected to its grid.

  It is also expected that the DSO will be able to improve the active distribution network dynamic model by determining new parameters as well as by collecting innovative information that may be of importance (connection of new technologies, retrofits, etc), being part of this delivering scenario.

  The DSO builds and provides the requested active distribution network dynamic model. Depending on the existing information and data, the model can be derived in two manners:

  - If data and parameters are existing, the DSO can perform some calculations and feed these parameters in the model using a lumped representation of the technologies.

  - If data and parameters are non-existing, the DSO should derive the equivalent model based on historic data related with dynamic response of the grid following frequency and voltage disturbances, using a parameter determination tool to derive the most convenient set of parameters that describe the dynamic response of its distribution grid on a combined manner.

Regarding network representation, it is intended to limit the meshed active distribution network representation up to five buses with equivalent impedance. Regarding radial network, it is expected to represent it by a single equivalent impedance as well as the transformer reactance.

Regarding remuneration, this service does not exist currently. However, it could be a regulated service, in the future. DSOs should have, at least, manpower costs for constructing the models and probably these costs should be eligible as operational costs. Nonetheless, the remuneration schemes are out of the scope of this model description.

- Request the dynamic model at the TSO/DSO connection point
  Description:
- Request assets dynamic data
  Description:
- Request assets dynamic data
  Description:
- Prepare data and send
  Description:
- Prepare data and send
  Description:
- Compute dynamic equivalent model
  Description:
- Send dynamic model description
  Description:
- Perform dynamic analyses
  Description:

1.5 KEY PERFORMANCE INDICATORS (KPI)

1.6 USE CASE CONDITIONS

Use case conditions	
Assumptions	
1	Assumptions: Key assumptions: • The active distribution network dynamic model is intended for TSO use by substituting the DSO/TSO representative component (usually load); • The active distribution network dynamic model is a simplified distribution grid representation that intends to be the most accurate regarding the DSO-connected response to grid disturbances; • The disturbances to be considered for the sake of the models' study are frequency and voltage disturbance;

- The active distribution network dynamic model should not be considered as a DSO network representation, namely for short-circuit studies. The technologies connected to the DSO grid are mainly converter interfaced thus not significantly contributing to the short circuit current.

Prerequisites	
1	Preconditions: This BUC intends to set the rules for developing active distribution grids´ dynamic response models to be delivered to TSO for dynamic stability studies for planning purposes. Validation and demonstration are still to be defined. Two possible alternatives are: comparison of the proposed model with the original detailed distribution network model, under different disturbances simulation scenarios (at the TSO DSO connection point); or comparison of the simplified model results with real measurements at the TSO DSO connection under disturbances scenarios.

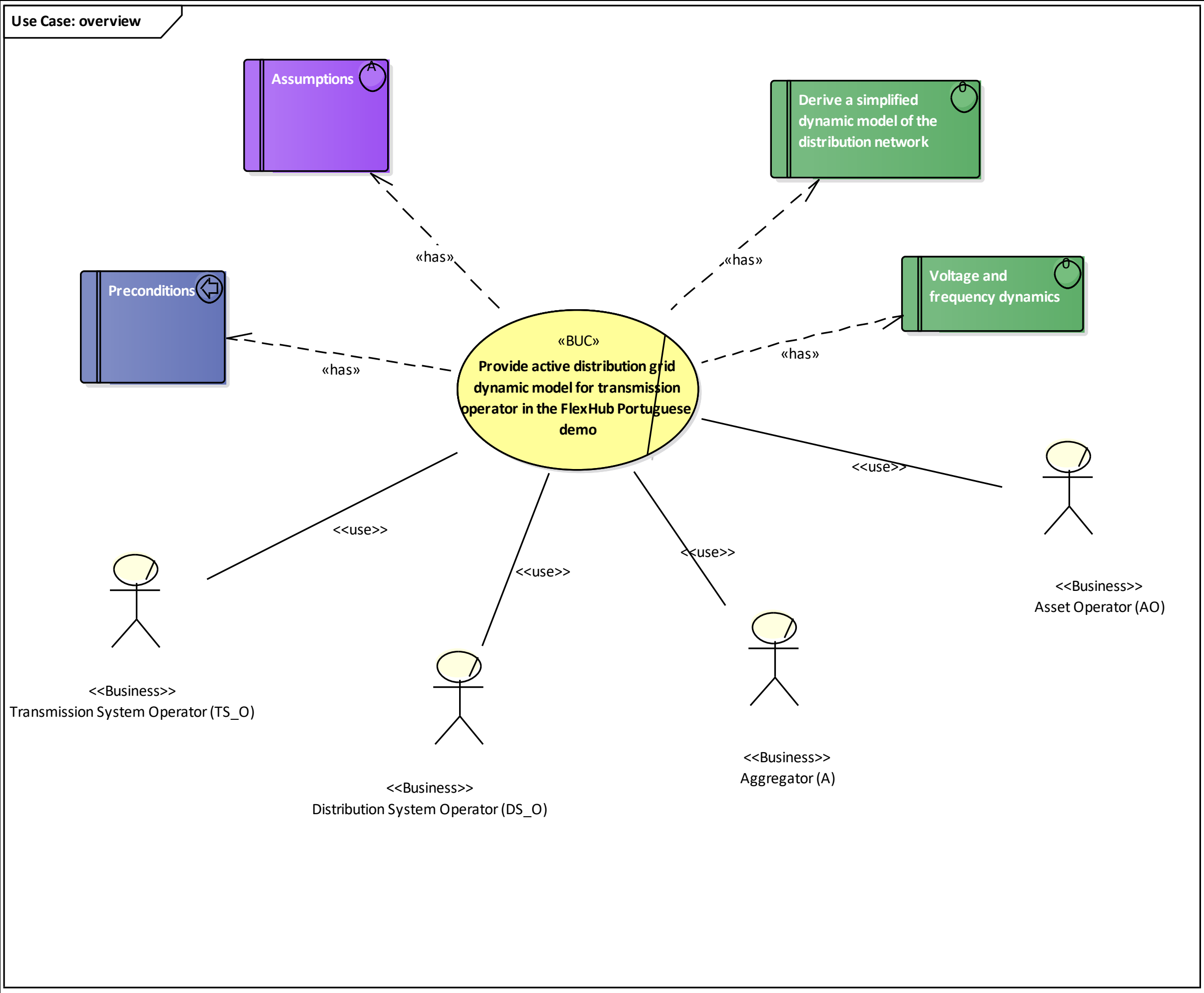
1.7 FURTHER INFORMATION TO THE USE CASE FOR CLASSIFICATION/MAPPING

Classification information
Relation to other use cases
Level of depth
BUC for Portugal FlexHub Demo
Prioritisation
Generic, regional or national relation
National
Nature of the use case
BUC
Further keywords for classification

1.8 GENERAL REMARKS

2. DIAGRAMS OF USE CASE

Diagram(s) of use case



3. TECHNICAL DETAILS

3.1 ACTORS

Actors			
Grouping (e.g. domains, zones)		*Group description*	
Actor name	*Actor type*	*Actor description*	*Further information specific to this use case*
Transmission System Operator (TS_O)	Business	Elaborate network development plan (including defining system needs for transmission) Ensure a transparent and non-discriminatory access to the transmission network for each user Operate the transmission grid over a specific region in a secure, reliable and efficient way Secure and manage in real time the physical generation-consumption balance on a geographical perimeter,	

		including ensuring the frequency control service Optimize transmission system operation from planning to real-time, using available levers (grid expansion, flexibility activation,...) Assess network status of the transmission grid and broadcast selected information of the network status to eligible actors (e.g. aggregators, other system operators) Provide data to the interconnection capacity market operator for the management of cross border transactions In critical situations, implement dedicated actions and deliver alerts during stress events If necessary, implement emergency measures (e.g. system defence plan) including load shedding	
Distribution System Operator (DS_O)	Business	Elaborate network development plan (including defining system needs for distribution) Ensure a transparent and non-discriminatory access to the distribution network for each user Operate the distribution grid over a specific region in a secure, reliable and efficient way Optimize system operation distribution grid from planning to real-time, using available levers (grid expansion, flexibility activation,...) Assess network status of the distribution grid and broadcast selected information of the network status to eligible actors (e.g. aggregators, other system operators) Support the Transmission System Operator in carrying out its responsibilities (including load shedding) and coordinate measures if necessary	
Asset Operator (AO)	Business	Operate a set of assets connected to distribution grid which may cover consumption, storage or generation assets.	
Aggregator (A)	Business	Aggregate and maximise value of portfolio(s) of resources	

3.2 REFERENCES

4. STEP BY STEP ANALYSIS OF USE CASE

4.1 OVERVIEW OF SCENARIOS

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

1	Delivery	Every one to five years the TSO requires from the DSO the dynamic model of the distribution grid that the DSO is managing, to build the transmission grid dynamic model. This is done in advance so that the DSO is able to compute and deliver the active distribution grid dynamic model considering the dynamic features of the grid it manages, and including updated information of the main relevant assets connected to its grid. It is also expected that the DSO will be able to improve the active distribution network dynamic model by determining new parameters as well as by collecting innovative information that may be of importance (connection of new technologies, retrofits, etc), being part of this delivering scenario. The DSO builds and provides the requested active distribution network dynamic model. Depending on the existing information and data, the model can be derived in two manners: • If data and parameters are existing, the DSO can perform some calculations and feed these parameters in the model using a lumped representation of the technologies. • If data and parameters are non-existing, the DSO should derive the equivalent model based on historic data related with dynamic response of the grid following frequency and voltage disturbances, using a parameter determination tool to derive the most convenient set of parameters that describe the dynamic response of its distribution grid on a combined manner. Regarding network representation, it is intended to limit the meshed active distribution network representation up to five buses with equivalent impedance. Regarding radial network, it is expected to represent it by a single equivalent impedance as well as the transformer reactance. Regarding remuneration, this service does not exist				

		currently. However, it could be a regulated service, in the future. DSOs should have, at least, manpower costs for constructing the models and probably these costs should be eligible as operational costs. Nonetheless, the remuneration schemes are out of the scope of this model description.				

4.2 STEPS - SCENARIOS

4.2.1 DELIVERY

Every one to five years the TSO requires from the DSO the dynamic model of the distribution grid that the DSO is managing, to build the transmission grid dynamic model. This is done in advance so that the DSO is able to compute and deliver the active distribution grid dynamic model considering the dynamic features of the grid it manages, and including updated information of the main relevant assets connected to its grid.

It is also expected that the DSO will be able to improve the active distribution network dynamic model by determining new parameters as well as by collecting innovative information that may be of importance (connection of new technologies, retrofits, etc), being part of this delivering scenario.

The DSO builds and provides the requested active distribution network dynamic model. Depending on the existing information and data, the model can be derived in two manners:

- If data and parameters are existing, the DSO can perform some calculations and feed these parameters in the model using a lumped representation of the technologies.
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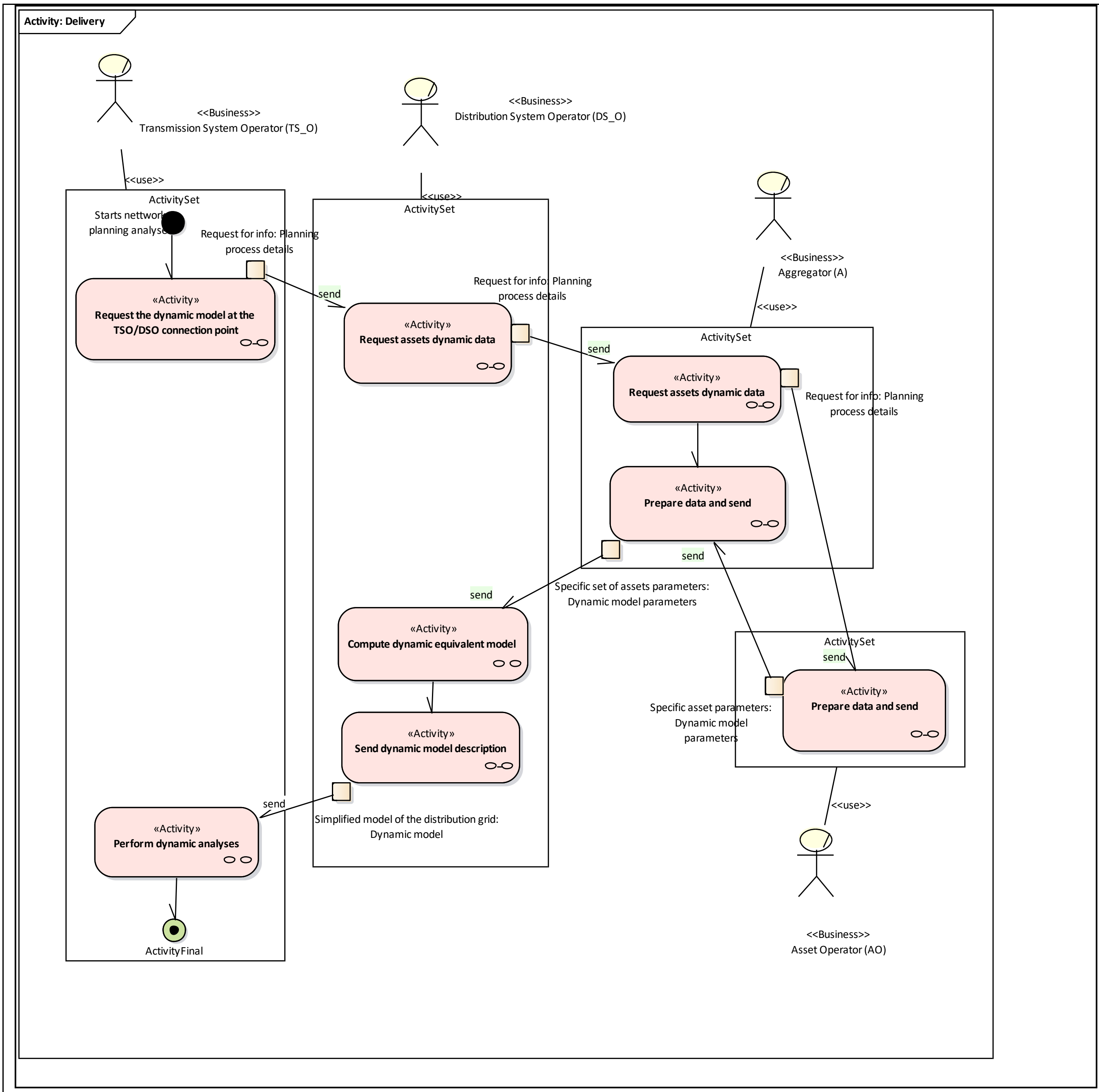


Scenario step by step analysis

<table>
<tr><th colspan="9">Scenario</th></tr>
<tr><td>Scenario name</td><td colspan="8">Delivery</td></tr>
<tr><td>Step No</td><td>Event</td><td>Name of process/activity</td><td>Description of process/activity</td><td>Service</td><td>Information producer (actor)</td><td>Information receiver (actor)</td><td>Information exchanged (IDs)</td><td>Requirement, R-IDs</td></tr>
<tr><td>1.1</td><td></td><td>Request the dynamic model at</td><td></td><td>send</td><td>Transmission System</td><td>Distribution System</td><td>Info1-Planning</td><td></td></tr>
</table>

		the TSO/DSO connection point			Operator (TS O)	Operator (DS O)	process details	
1.2		Request assets dynamic data		send	Distribution System Operator (DS O)	Aggregator (A)	Info1-Planning process details	
1.3		Request assets dynamic data		send	Aggregator (A)	Asset Operator (AO)	Info1-Planning process details	
1.4		Prepare data and send		send	Aggregator (A)	Distribution System Operator (DS O)	Info2-Dynamic model parameters	
1.5		Prepare data and send		send	Asset Operator (AO)	Aggregator (A)	Info2-Dynamic model parameters	
1.6		Compute dynamic equivalent model			Distribution System Operator (DS O)			
1.7		Send dynamic model description		send	Distribution System Operator (DS O)	Transmission System Operator (TS O)	Info3-Dynamic model	
1.8		Perform dynamic analyses			Transmission System Operator (TS O)			

5. INFORMATION EXCHANGED

Information exchanged			
Information exchanged, ID	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
Info1	Planning process details	Information on the planning process to be started, including the time period to consider.	

Info2	Dynamic model parameters	Basic dynamic parameters, or operation data for its estimation	
Info3	Dynamic model	Meshed active distribution networks will have up to five buses with equivalent impedance. Radial networks are expected to be represented by a single equivalent impedance as well as the transformer reactance. The active distribution network dynamic model must encompass the network topology characteristic (meshed, radial or meshed/radial), represented by a limited number of nodes with equivalent impedance, as well as the transformer, and represent the combined dynamic response of the different technologies that may exist. Regarding the frequency and voltage responsive technologies, the simplified model should encompass: : • Electric Vehicles (with service support functions) • Loads (Frequency responsive or voltage responsive) • Constant power loads (non-responsive) • Wind farms (with grid support functionalities) • Mini-hydro power plants; • Combined heat and power plants; • PV plants; • Storage (electrochemical) • Etc	

TABLE 15 BUC PT-FXH-DM

Manage VPP active power flexibility to support aFRR in VPP Portuguese Demo

Based on IEC 62559-2 edition 1
Generated from UML Use Case Repository with Modsarus® (EDF R&D Tool)

1. DESCRIPTION OF THE USE CASE

1.1 NAME OF USE CASE

Use case identification		
ID	***Area(s)/Domain(s)/Zone(s)***	***Name of use case***
PT-VPP-AP1	Portugal	Manage VPP active power flexibility to support aFRR in VPP Portuguese Demo

1.2 VERSION MANAGEMENT

Version management

Version No.	Date	Name of author(s)	Changes	Approval status
1	2018-05-28	Nuno Lopes Filipe	Proposed version from demo	
2	2018-06-11	Cyril Effantin	Consolidation in a common UC repository	
3	2018-07-26	Cyril Effantin	UML fixes based on the Nuno Lopes Filipe 22-06-2016 version.	
4	2018-09-07	Nuno Lopes Filipe	Update from Nuno Lopes Filipe	
5	2018-10-23	Cyril Effantin	Changes on role model and impacted UML parts	

1.3 SCOPE AND OBJECTIVES OF USE CASE

Scope and objectives of use case	
Scope	In the context of the Portuguese Demo WP7 a Virtual Power Plant (VPP) will be 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).
Objective(s)	Real-time management of the storage and generation portfolio: based on mathematical models including short term balancing operations. Market bidding suite for the different markets: (day ahead, intraday, system services) respecting long term strategies for storage management; Enhanced computational management system: integrating forecasting modules for prices, energy supply and demands; Remunerate the Wind Power Plants: that in the future will lose the feed-in-tariffs; Aggregation of mixed resources: for the efficient management of a portfolio, the hydro could compensate the deviations for the wind power plants;
Related business case(s)	Frequency Control

1.4 NARRATIVE OF USE CASE

Narrative of use case
Short description
• **Description of the needs**:

Since it is foreseen that, in a near future, wind farms (and other DER) will no longer have feed-in tariffs and a high penetration of renewable energy is expected, it is crucial that utilities start studying ways to manage their assets in such markets.

- **Description of the service:**

In the aFRR market the TSO is responsible for setting up the market, identifying the needs for ancillary services and contracting the services, to guaranty the security of the national electrical system.

The flexibility provided by combined large-scale generation, large-scale storage and RES power plants via the optimized operation of a variable speed pumped storage power plant, will allow the Generation Aggregator to make optimized bids to the market and manage the portfolio more efficiently, all of this through a VPP.

The VPP tools, will provide decision support for the bidding at the different markets (day ahead, intraday, ancillary services) and for optimized dispatching of the units within VPP.

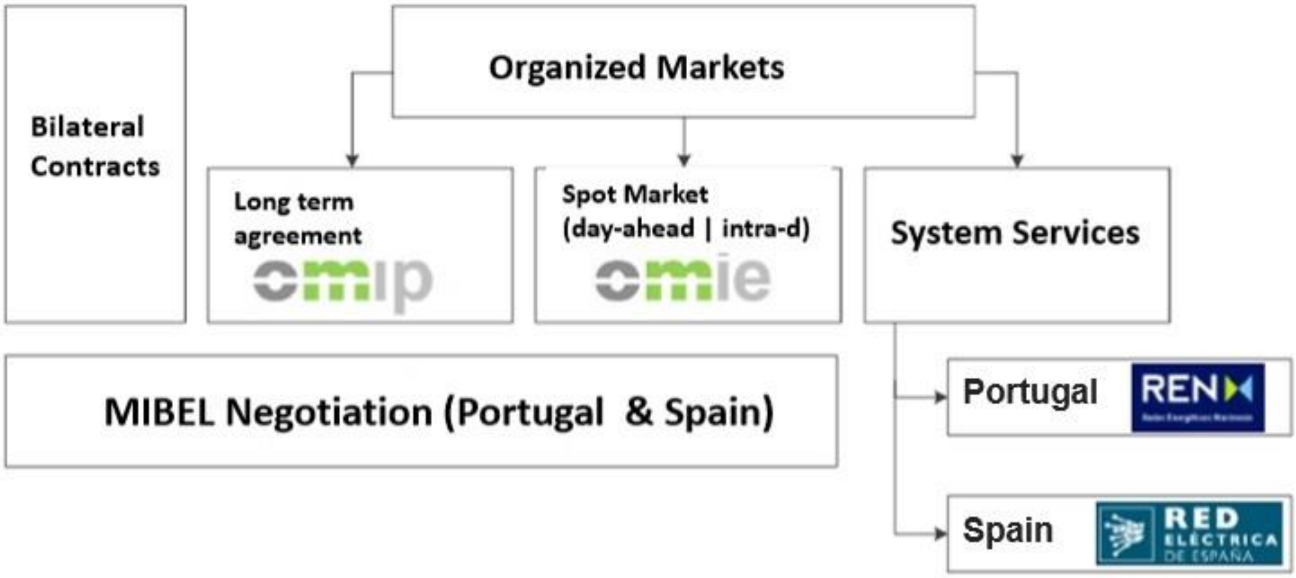
The flexibilities coming from generation units (conventional and RES) are offered through a mandatory mechanism and are remunerated based on opportunity costs in case they are selected.
Remark: TSO is an archetype player who carries out several Business Roles for this service (MO, TS_O).

Complete description

Market Description:

· Portugal and Spain share a common day ahead and bilateral contract electricity market since 2007 (MIBEL, see Figure);
· There is a chronology for the Iberian energy market, with a day ahead market and 6 intraday markets;
· The day ahead represents around 90% of the energy volume (including bilateral trading), intraday is about 10%;
· The operation planning involves a day ahead market that accepts buying and selling bids to the next day for 24 hour trading periods. Then, the two TSO's validate the schedules together with bilateral contracts checking interconnection limits in the first place. Market splitting is used to deal with congestion in interconnection lines, eventually leading to different prices in Portugal and Spain. Congestions internal to each country are solved using incremental/decremental bids submitted by generators. After obtaining a first feasible schedule a market is run to assign up and down aFRR leading to the final schedule by 15.00. At 20.00 each day starts the first session of the intra-day market completely covering the next day. As mentioned before there are currently 6 sessions of the intra-day market at 20.00 of the previous day, at 0.00, at 4.00, at 8.00, at 12.00 and at 16.00 of the operation day;
· The Portuguese energy market has the concept of balancing areas which are define as a set of physical units, that could be generation or storage, belonging to the same Market Agent (MA) and are connected in a certain grid area. For a certain balancing area, the deviations to the energy program are aggregated;
· The imbalances are calculated regarding the program the balancing area should provide and the real output

for the balancing area. The penalties are calculated dividing the system cost for everyone that has an imbalance (despite if it is against or in favor to the system). This payment goes to those power plants that maintained the system in an equilibrium (deal with the other's imbalances);



· Due to the limited interconnection capacity, several technical activities as procurement and the provision of Ancillary Services are not yet entirely harmonized and fully integrated and continue to be provided within the control area of each country and are under the responsibility of each TSO (REN for Portugal);
· The safe management of the electric system, both from an economic and security point of view, requires a central controller to perform the power and frequency control in order to maintain the imbalaces at the interconnection with Spain within reasonable limits, considering the programmed schedules, and to collaborate in the maintenance of the joint European frequency;
· Some of the ancillary services are mandatory and not remunerated such as Primary reserve and Q regulation, but the aFRR and mFRR/RR are remunerated;
· The aFRR is traded in an organized market (once a day at 19:45 local time) for the day ahead;
· The service traded is defined as capacity and energy-based and sometimes is possible to have upwards and downwards reserves in the same period (Hour). The service must be provided according to the bids the agent place in the reserve markets;

Description of the service

The VPP tools will provide decision support for the bidding at the different markets (day ahead, intraday, ancillary services) and for optimized dispatching of the units within VPP.
Every decision support module of VPPs heavily depends on accurate forecasts of e.g. energy market prices, supply and demand. That's why the foundation of the tool is a development of specific forecasting modules for wind and solar energy supply as well as water energy inflows, the tradable amount of energy, the expected prices for different market layers of interest (day-ahead, intra-day, balancing market).

A price forecasting module will be set up to generate forecasts for the following variables:
(a) electrical energy in the day-ahead and intraday sessions;
(b) capacity price for frequency containment reserve;
(c) price for upward and downward balancing reserves. In addition to point forecast values, a probabilistic forecast will be produced.
The forecast uncertainty is either measured in a probabilistic manner or by analysis
(i.) the residual error distribution or
(ii.) the density of multiple forecasted scenarios.

Besides forecasts for the price segments (a), (b) and (c), a forecast module for the expected energy supply of RES to augment the estimation of the available energy supply of the VPP, for helping to identify the expected energy consumption. Energy supply as well as demand forecasts are not provided in the form of point forecasts, but confidence intervals are given to support a robust optimization (i.e. optimization under uncertainty).

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. Managing efficiently a generation and storage energy portfolio will allow a future scenario with a high renewables penetration while maintaining 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 four phases:
Prequalification phase:
In this phase the Generator Aggregator, represented by the VPP, must sent the registration request to the TSO for aFRR provision, and fulfill its requirements in the form of tests.

Selection/Bidding phase:
The generators will send their availability to the VPP that, with the help of its forecasting tools, will send optimal aFRR offers to the TSO.
The TSO will publish the list of contracted resources for each hour of the day ahead.

Delivery:
The TSO send the aFRR request to the Generator Aggregator, that through the VPP will manage the request within its protfolio, fulfilling the request.

Settlement:
The TSO initiates the settlement process sending the payment/invoice to the Generator Aggregator that will make the payments/invoices to the generation units. There will be a payment for the regulation band and for

the mobilized energy.

The deviations will cause the payment of penalties.

Each of these phases will be described, in more detail, in the next section.

Summary of use case

- **Prequalification**
  Description: The market players / generation aggregators need to 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: communications velocity, real energy generated, gradient variation of the energy produced and response to random generation requests. The request must be done 5 working days ahead.

  The Generator Aggregator gets access to the flexibility of resources through contracts with asset owners, and has control over the resources.

  Between 18h and 18:45 (day d-1) all the market players put the offers, for each physical unit, for the secondary regulation band, for each hour of the day d.
  All bids should respect:
  · The ratio between the upward and downward Secondary Regulation Band established by the TSO (currently 2:1) with the tolerance of 5%;
  · The minimum secondary regulatory band established by the TSO to offer in the block with lower price (minimum size of the bid Block);
  · The technical limits of the Physical Unit (Pmáx and Pmin);
  The TSO shall establish and communicate to all Market Agents, before 13h of each day, the necessary reserve of secondary regulation in the system for each programming period of the following day, establishing, in addition to the ratio required between the up and down regulating bands to be offered, the minimum secondary regulation band to be offered per offer, in the lowest price bid block.

  The VPP forecasting modules will determine the availability for the renewable generation resources. At the same time, it will have online information from the generation and storage units about their availability and real production.

  - Register for aFRR providers
    Description: The market players / generation aggregators need to register for aFRR providers and fulfil the requirements specified by the Power System Operator.

  - Perform the tests
    Description: The TS_O performs tests on the units were the technical and operational capability will be evaluated: communications velocity, real energy generated, gradient variation of the energy produced and response to random generation requests.

  - Manage the request within the portfolio (VPP)
    Description: The VPP receives the TS_O requests, runs its algorithm and performs the optimal dispatch of the generation units.

  - Adjust the operation setpoint
    Description: The generation units included in the VPP portfolio adjust the output according to the VPP orders.

- Give response to the tests (VPP)
  Description: The VPP sends the tests response to the TS_O.

- **Selection/Bidding**
  Description: The VPP tools, with the forecasting complex modules, will provide decision support for the bidding at the aFRR market.
  The VPP 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 following steps are envisioned for an optimized bidding support of a market:
  · Provide numeric predictions of renewable energy supply (i.e. wind, solar) and water inflow based on weather forecasts;
  · Forecast possible capacities and merit order from previous auction to compute the tradable amount of electrical energy;
  · Forecasts prices (offer distribution) for this auction;
  · Use long term strategies and long-term price forecasts to evaluate the offering of storing/releasing energy in/of the reservoirs;
  · Propose optimized offers for the auction.

  Offer should have the following information:
  · Offer number, k;
  · Offer for the up-reserve regulation k, MW;
  · Offer for the down reserve regulation k, MW;
  · Unitary price for the aFRR band k, €/MW;

  At 19h the TSO publishes the list of resources contracted for each hour for the day-ahead. The selection is based on the following criteria:
  · The set of offers that minimize the contracted aFRR band cost. The contracted offers will be valued at the unit closing price of this market (marginal price);
  · aFRR offers that cause grid restrictions, when redispatch, will be excluded from the contracting process;
  · The sum of the contracted bands should be around ± 10% of the required aFRR band value established by the TSO, for each hour.

  - Send the needs for aFRR regulation band
    Description: The TS_O shall establish and communicate to all Market Agents, before 13h of each day, the necessary aFRR in the system for each programming period of the following day.

  - Send resources availability
    Description: Generation units send online information about their availability.

  - Activate the forecasting tools
    Description: The VPP tools, with the forecasting complex modules, will provide decision support for the bidding at the aFRR market.

  - Create optimal bids
    Description: The VPP 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).

  - Wait for market closure
    Description: Between 18h and 18:45 (day d-1) all the market players put the offers, for each physical unit, for the aFRR regulation band, for each hour of the day d.

- Close aFRR Market
  Description: At 19h the TS_O publishes the list of resources contracted for each hour for the day-ahead.

- Integrate the info in the optimal dispatch tool
  Description: The GA will receive, from the TS_O, the information about the contracted regulation band and the price assigned.

- **Delivery**
  Description: The aFRR is requested by the TSO to the Generation Aggregator that owns the VPP.
  The VPP receives the request and activates through the Automatic Generation Control the service provision with the real-time management of the storage and generation portfolio. After the submission and acceptance of energy and reserve offers in the electricity market, a control layer will ensure that the VPP complies with its market commitments in each time instance. The models will handle short term balancing operations, like the change of frequency (i.e. energy consumption/generation of pump turbines or the reduction of energy produced in wind farms).
  The system will consider situations where a generation plant is unavailable and find compensation (e.g. increase production) or decide to buy the missing electricity on the market or take it from an energy storage. The control system will manage imbalances within its generation/storage portfolio.

  - Send request for aFRR regulation
    Description: The aFRR is requested by the TS_O to the Generation Aggregator that owns the VPP.

  - Manage the request (VPP)
    Description: The VPP receives the request and activates through the Automatic Generation Control the service provision with the real-time management of the storage and generation portfolio.

  - Manage the request (VPP)
    Description: The VPP receives the request and activates through the Automatic Generation Control the service provision with the real-time management of the storage and generation portfolio.

  - Adjust the operation setpoint
    Description: The generation units included in the VPP portfolio adjusts the output according to the VPP orders.

  - Evaluate the response
    Description: The TS_O verifies the correct response from the contracted generation.

- **Settlement**
  Description: The market of secondary reserve is "Pay as clear".
  The payment includes the regulation band fee and the energy fee based on market clearing.
  The regulatory band contracted to each production unit will be valued at the unit price of the last contracted offer for the corresponding programming time;
  The energy for the aFRR will be remunerated at the price of the last RR offer, in the respective programmed period, that was mobilized to complement the secondary regulation. The remuneration will be made at the value of the RR mobilized, in the same regulation direction, up or down reserve.

The deviations in the service provision will make the producer incur in monetary costs calculated by physical unit and for the different hours of the daily program (h).

- Calculate the payment for delivery of the contracted regulation band and energy mobilized
  Description: The TS_O checks if the capacity and energy that was promised/mobilized has been delivered. The regulatory band contracted will be valued at the price of the last contracted offer for the corresponding programmed hour. The energy will be remunerated at the price of the last RR regulation offer, in the respective programmed period, that was mobilized to complement the aFRR regulation.

- Prepare the payment
  Description: If the capacity is provided and the service fulfilled the TS_O makes the payment to the GA, that will make the payment to the generation/storage owners.

- Prepare the invoice
  Description: If the capacity is not provided then the GA as to pay penalties. The TS_O sends the invoice for the payment

- Process the payment to the generator
  Description: The GA determines the generator compensation by the service provision and makes the payment.

- Process the invoice
  Description: The GA sends the invoice for the generator if the service assigned was not provided.

1.5 KEY PERFORMANCE INDICATORS (KPI)

1.6 USE CASE CONDITIONS

	Use case conditions
	Assumptions
1	rules relevant for the market assumed (future market): • There are no feed-in tariffs; • Market players can do aggregated offers; • There are no balancing areas, and market players can balance their own production accordingly to what they offered.
2	barriers for implementing the BUC (based on current context): • In Portugal, there is no specific regulatory framework regarding aggregation, and currently, there are no active aggregators in operation; • Most of the actual RES connected to the grid have feed-in tariffs, but many of those contracts will end in a near future. The new PV and Wind projects won't have feed-in tariffs; • The price presented in aFRR band offers may be limited to a value proposed by the TSO and approved by the Portuguese NRA; • The main market access requirement in terms of capacity is 0.1 MW.
	Prerequisites

1	Prerequisites: • In Portugal the aFRR is automatically activated by the TSO through an AGC automatism that acts directly in the power plant. For the demonstration, the VPP needs to bypass that mechanism and be able to control directly the hydro power plant; • In regard to the real-time management of the storage and generation portfolio, after the submission and acceptance of energy and reserve offers in the electricity market, a control layer is needed to ensure that the VPP complies with its market commitments in each time instance; • The automatic generation regulators should be Proportional Integral, with time constants of 30s, and the time cycle of the controller should be between 1 and 5 seconds; • In order for the VPP to provide the aFRR service, it must participate on the day ahead and intraday energy markets, being itself a party responsible for the imbalances (BRP) or part of a larger group with balancing responsibilities.

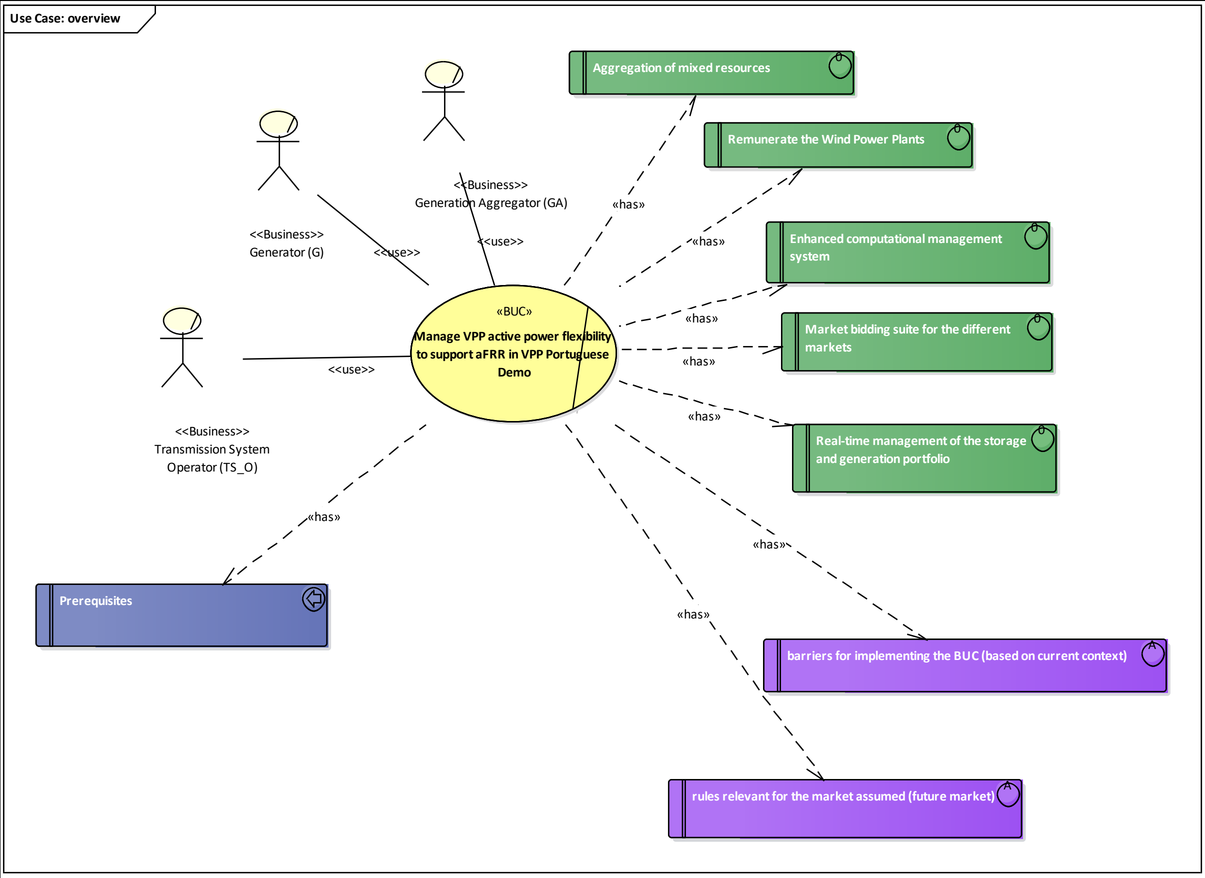
1.7 FURTHER INFORMATION TO THE USE CASE FOR CLASSIFICATION/MAPPING

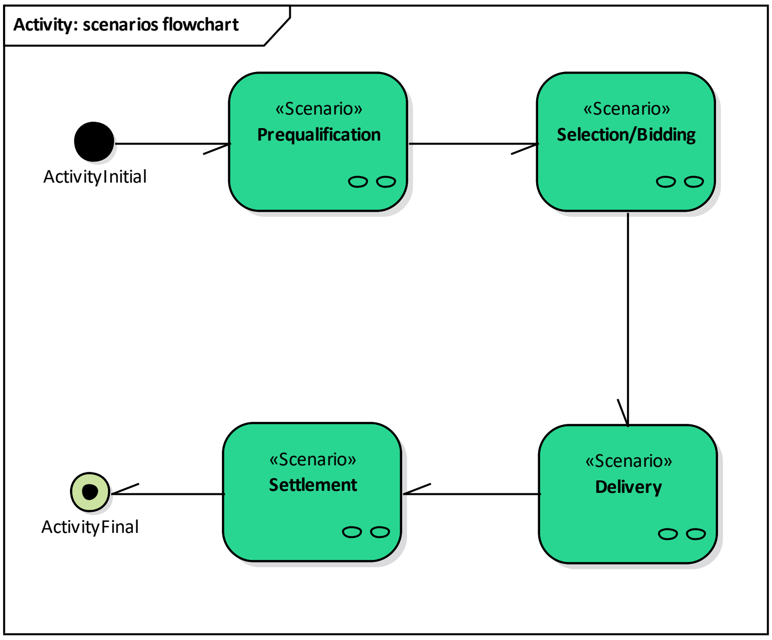
Classification information
Relation to other use cases
Level of depth
BUC for Portugal VPP Demo
Prioritisation
Generic, regional or national relation
National
Nature of the use case
BUC
Further keywords for classification

1.8 GENERAL REMARKS

2. DIAGRAMS OF USE CASE

Diagram(s) of use case





3. TECHNICAL DETAILS

3.1 ACTORS

Actors

Grouping (e.g. domains, zones)		***Group description***	
Actor name	***Actor type***	***Actor description***	***Further information specific to this use case***
Generator (G)	Business	Invest in, maintain and operate the asset(s) Select the contractual framework with relevant stakeholders related to the energy contract and the provision of flexibility/other system services	
Generation Aggregator (GA)	Business	Aggregate and maximize value of generation portfolio resources Provide flexibility by generation assets to the system operators	
Transmission System Operator (TS_O)	Business	Elaborate network development plan (including defining system needs for transmission) Ensure a transparent and non-discriminatory access to the transmission network for each user Operate the transmission grid over a specific region in a secure, reliable and efficient way Secure and manage in real time the physical generation-consumption balance on a geographical perimeter, including ensuring the frequency control service Optimize transmission system operation from planning to real-time, using available levers (grid expansion, flexibility activation,...) Assess network status of the transmission grid and broadcast selected information of the network status to eligible actors (e.g. aggregators, other system operators) Provide data to the interconnection capacity market operator for the management of cross border transactions In critical situations, implement dedicated actions and deliver alerts during stress events If necessary, implement emergency measures (e.g. system defence plan) including load shedding	

3.2 REFERENCES

4. STEP BY STEP ANALYSIS OF USE CASE

4.1 OVERVIEW OF SCENARIOS

Scenario conditions

No.	Scenario name	Scenario description	Primary actor	Triggering event	Pre-condition	Post-condition
1	Prequalification	The market players / generation aggregators need to 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: communications velocity, real energy generated, gradient variation of the energy produced and response to random generation requests. The request must be done 5 working days ahead. The Generator Aggregator gets access to the flexibility of resources through contracts with asset owners, and has control over the resources. Between 18h and 18:45 (day d-1) all the market players put the offers, for each physical unit, for the secondary regulation band, for each hour of the day d. All bids should respect: · The ratio between the upward and downward Secondary Regulation Band established by the TSO (currently 2:1) with the tolerance of 5%; · The minimum secondary regulatory band established by the TSO to offer in the block with lower price (minimum size of the bid Block); · The technical limits of the Physical Unit (Pmáx and Pmin); The TSO shall establish and communicate to all Market Agents, before 13h of each day, the necessary reserve of secondary regulation in the system for each programming period of the following day, establishing, in addition to the ratio required between the up and down regulating bands to be offered, the minimum secondary regulation band to be offered per offer, in the lowest price bid block. The VPP forecasting modules will				

		determine the availability for the renewable generation resources. At the same time, it will have online information from the generation and storage units about their availability and real production.				
2	Selection/Bidding	The VPP tools, with the forecasting complex modules, will provide decision support for the bidding at the aFRR market. The VPP 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 following steps are envisioned for an optimized bidding support of a market: · Provide numeric predictions of renewable energy supply (i.e. wind, solar) and water inflow based on weather forecasts; · Forecast possible capacities and merit order from previous auction to compute the tradable amount of electrical energy; · Forecasts prices (offer distribution) for this auction; · Use long term strategies and long-term price forecasts to evaluate the offering of storing/releasing energy in/of the reservoirs; · Propose optimized offers for the auction. Offer should have the following information: · Offer number, k; · Offer for the up-reserve regulation k, MW; · Offer for the down reserve regulation k, MW; · Unitary price for the aFRR band k, €/MW; At 19h the TSO publishes the list of resources contracted for each hour for the day-ahead. The selection is based on the following criteria: · The set of offers that minimize the contracted aFRR band cost. The contracted offers will be valued at the unit closing price of this market (marginal price);				

		· aFRR offers that cause grid restrictions, when redispatch, will be excluded from the contracting process; · The sum of the contracted bands should be around ± 10% of the required aFRR band value established by the TSO, for each hour.				
3	Delivery	The aFRR is requested by the TSO to the Generation Aggregator that owns the VPP. The VPP receives the request and activates through the Automatic Generation Control the service provision with the real-time management of the storage and generation portfolio. After the submission and acceptance of energy and reserve offers in the electricity market, a control layer will ensure that the VPP complies with its market commitments in each time instance. The models will handle short term balancing operations, like the change of frequency (i.e. energy consumption/generation of pump turbines or the reduction of energy produced in wind farms). The system will consider situations where a generation plant is unavailable and find compensation (e.g. increase production) or decide to buy the missing electricity on the market or take it from an energy storage. The control system will manage imbalances within its generation/storage portfolio.				
4	Settlement	The market of secondary reserve is "Pay as clear". The payment includes the regulation band fee and the energy fee based on market clearing. The regulatory band contracted to each production unit will be valued at the unit price of the last contracted offer for the corresponding programming time; The energy for the aFRR will be remunerated at the price of the last RR offer, in the respective programmed period, that was mobilized to complement the secondary regulation. The remuneration will be made at the value of the RR mobilized, in the same regulation direction, up or down reserve.				

		The deviations in the service provision will make the producer incur in monetary costs calculated by physical unit and for the different hours of the daily program (h).				

4.2 STEPS - SCENARIOS

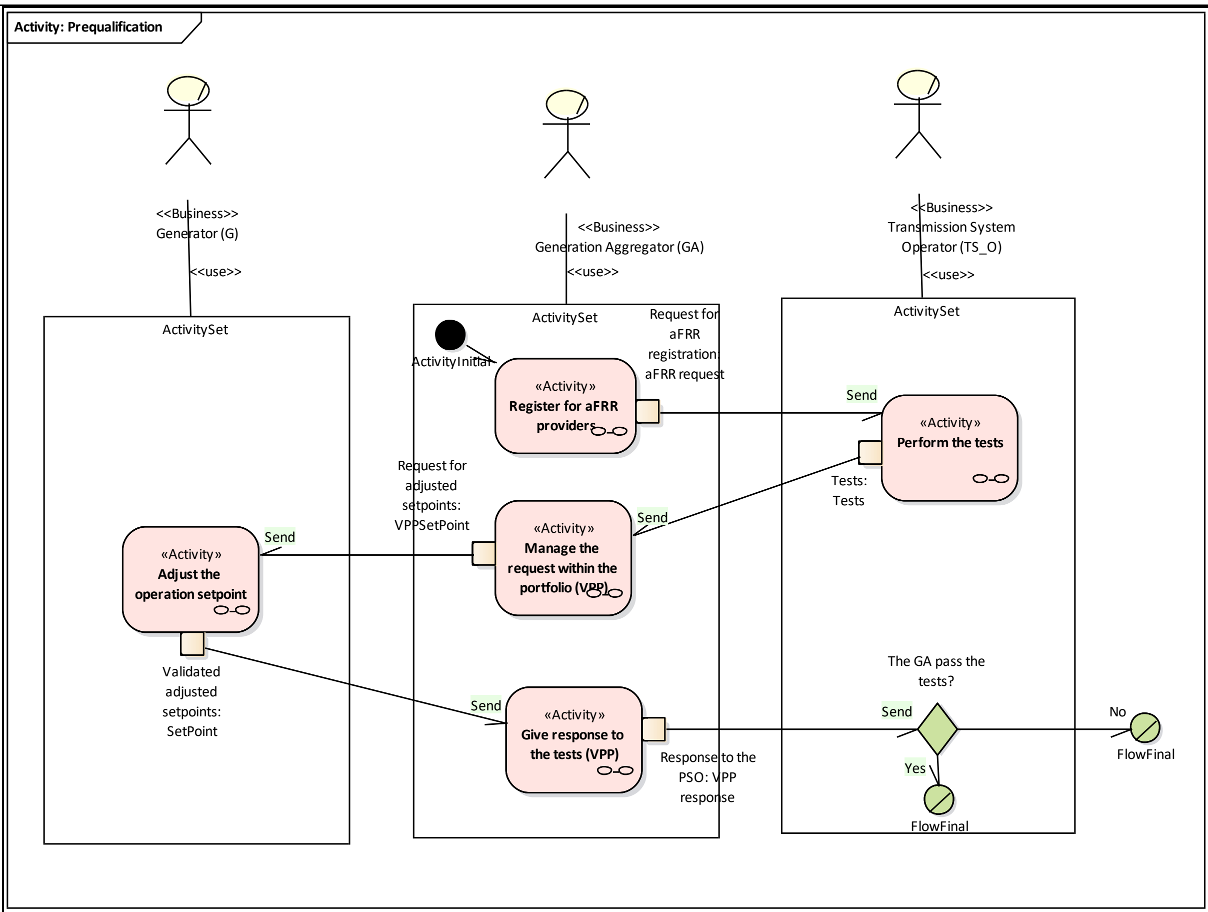
4.2.1 PREQUALIFICATION

The market players / generation aggregators need to 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: communications velocity, real energy generated, gradient variation of the energy produced and response to random generation requests. The request must be done 5 working days ahead.

The Generator Aggregator gets access to the flexibility of resources through contracts with asset owners, and has control over the resources.

Between 18h and 18:45 (day d-1) all the market players put the offers, for each physical unit, for the secondary regulation band, for each hour of the day d.
All bids should respect:
· The ratio between the upward and downward Secondary Regulation Band established by the TSO (currently 2:1) with the tolerance of 5%;
· The minimum secondary regulatory band established by the TSO to offer in the block with lower price (minimum size of the bid Block);
· The technical limits of the Physical Unit (Pmáx and Pmin);
The TSO shall establish and communicate to all Market Agents, before 13h of each day, the necessary reserve of secondary regulation in the system for each programming period of the following day, establishing, in addition to the ratio required between the up and down regulating bands to be offered, the minimum secondary regulation band to be offered per offer, in the lowest price bid block.

The VPP forecasting modules will determine the availability for the renewable generation resources. At the same time, it will have online information from the generation and storage units about their availability and real production.



Scenario step by step analysis

Scenario								
Scenario name	Prequalification							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
1.1		Register for aFRR providers	The market players / generation aggregators need to register for aFRR providers and fulfil the requirements specified by the Power System Operator.	Send	Generation Aggregator (GA)	Transmission System Operator (TS_O)	Info1-aFRR request	

1.2		Perform the tests	The TS_O performs tests on the units were the technical and operational capability will be evaluated: communications velocity, real energy generated, gradient variation of the energy produced and response to random generation requests.	Send	Transmission System Operator (TS_O)	Generation Aggregator (GA)	Info2-Tests	
1.3		Manage the request within the portfolio (VPP)	The VPP receives the TS_O requests, runs its algorithm and performs the optimal dispatch of the generation units.	Send	Generation Aggregator (GA)	Generator (G)	Info3-VPPSetPoint	
1.4		Adjust the operation setpoint	The generation units included in the VPP portfolio adjust the output according to the VPP orders.	Send	Generator (G)	Generation Aggregator (GA)	Info4-SetPoint	
1.5		Give response to the tests (VPP)	The VPP sends the tests response to the TS_O.	Send	Generation Aggregator (GA)	Transmission System Operator (TS_O)	Info5-VPP response	

4.2.2 SELECTION/BIDDING

The VPP tools, with the forecasting complex modules, will provide decision support for the bidding at the aFRR market.

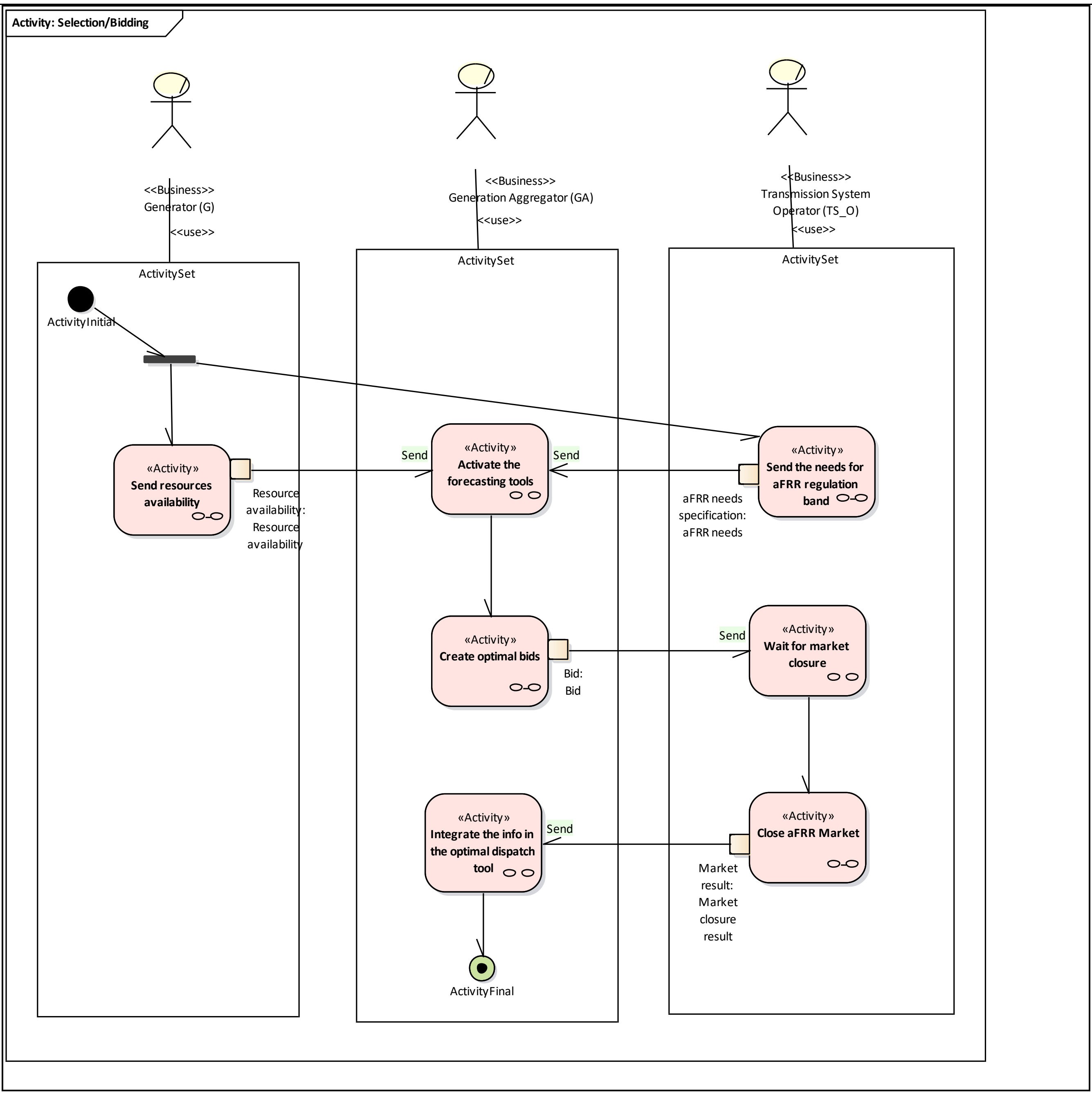
The VPP will do optimal offers and bidding strategies for the combined operation of RES and large-scale storage power plants participating in the electricity market (both energy and ancillary services).

The following steps are envisioned for an optimized bidding support of a market:

· Provide numeric predictions of renewable energy supply (i.e. wind, solar) and water inflow based on weather forecasts;

· Forecast possible capacities and merit order from previous auction to compute the tradable amount

of electrical energy; · Forecasts prices (offer distribution) for this auction; · Use long term strategies and long-term price forecasts to evaluate the offering of storing/releasing energy in/of the reservoirs; · Propose optimized offers for the auction. Offer should have the following information: · Offer number, k; · Offer for the up-reserve regulation k, MW; · Offer for the down reserve regulation k, MW; · Unitary price for the aFRR band k, €/MW; At 19h the TSO publishes the list of resources contracted for each hour for the day-ahead. The selection is based on the following criteria: · The set of offers that minimize the contracted aFRR band cost. The contracted offers will be valued at the unit closing price of this market (marginal price); · aFRR offers that cause grid restrictions, when redispatch, will be excluded from the contracting process; · The sum of the contracted bands should be around ± 10% of the required aFRR band value established by the TSO, for each hour.



Scenario step by step analysis

Scenario								
Scenario name	Selection/Bidding							
Step No	**Event**	**Name of process/activity**	**Description of process/activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information exchanged (IDs)**	**Requirement, R-IDs**

2.1		Send the needs for aFRR regulation band	The TS_O shall establish and communicate to all Market Agents, before 13h of each day, the necessary aFRR in the system for each programming period of the following day.	Send	Transmission System Operator (TS_O)	Generation Aggregator (GA)	Info6-aFRR needs	
2.2		Send resources availability	Generation units send online information about their availability.	Send	Generator (G)	Generation Aggregator (GA), Generation Aggregator (GA)	Info7-Resource availability	
2.3		Activate the forecasting tools	The VPP tools, with the forecasting complex modules, will provide decision support for the bidding at the aFRR market.		Generation Aggregator (GA)			
2.4		Create optimal bids	The VPP 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).	Send	Generation Aggregator (GA)	Transmission System Operator (TS_O), Transmission System Operator (TS_O)	Info8-Bid	
2.5		Wait for market closure	Between 18h and 18:45 (day d-1) all the market players		Transmission System			

			put the offers, for each physical unit, for the aFRR regulation band, for each hour of the day d.		Operator (TS_O)			
2.6		Close aFRR Market	At 19h the TS_O publishes the list of resources contracted for each hour for the day-ahead.	Send	Transmission System Operator (TS_O)	Generation Aggregator (GA)	Info9-Market closure result	
2.7		Integrate the info in the optimal dispatch tool	The GA will receive, from the TS_O, the information about the contracted regulation band and the price assigned.		Generation Aggregator (GA)			

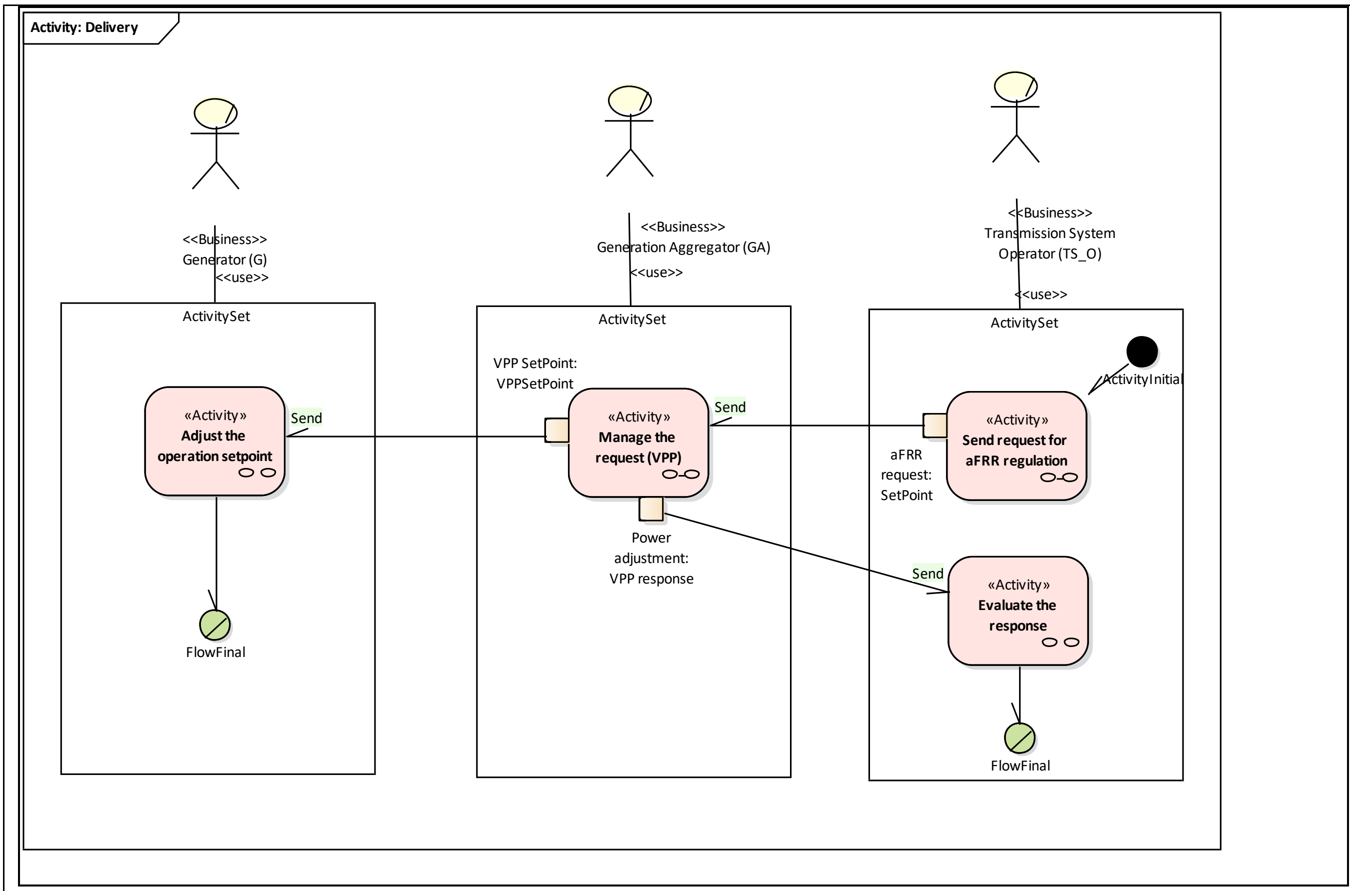
4.2.3 DELIVERY

The aFRR is requested by the TSO to the Generation Aggregator that owns the VPP.

The VPP receives the request and activates through the Automatic Generation Control the service provision with the real-time management of the storage and generation portfolio. After the submission and acceptance of energy and reserve offers in the electricity market, a control layer will ensure that the VPP complies with its market commitments in each time instance.

The models will handle short term balancing operations, like the change of frequency (i.e. energy consumption/generation of pump turbines or the reduction of energy produced in wind farms).

The system will consider situations where a generation plant is unavailable and find compensation (e.g. increase production) or decide to buy the missing electricity on the market or take it from an energy storage. The control system will manage imbalances within its generation/storage portfolio.



Scenario step by step analysis

Scenario								
Scenario name	Delivery							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
3.1		Send request for aFRR regulation	The aFRR is requested by the TS_O to the Generation Aggregator that owns the VPP.	Send	Transmission System Operator (TS_O)	Generation Aggregator (GA)	Info4-SetPoint	
3.2		Manage the request (VPP)	The VPP receives the request and activates through the Automatic Generation Control	Send	Generation Aggregator (GA)	Transmission System Operator (TS_O)	Info5-VPP response	

			the service provision with the real-time management of the storage and generation portfolio.					
3.3		Manage the request (VPP)	The VPP receives the request and activates through the Automatic Generation Control the service provision with the real-time management of the storage and generation portfolio.	Send	Generation Aggregator (GA)	Generator (G)	Info3-VPPSetPoint	
3.4		Adjust the operation setpoint	The generation units included in the VPP portfolio adjusts the output according to the VPP orders.		Generator (G)			
3.5		Evaluate the response	The TS_O verifies the correct response from the contracted generation.		Transmission System Operator (TS_O)			

4.2.4 SETTLEMENT

The market of secondary reserve is "Pay as clear".

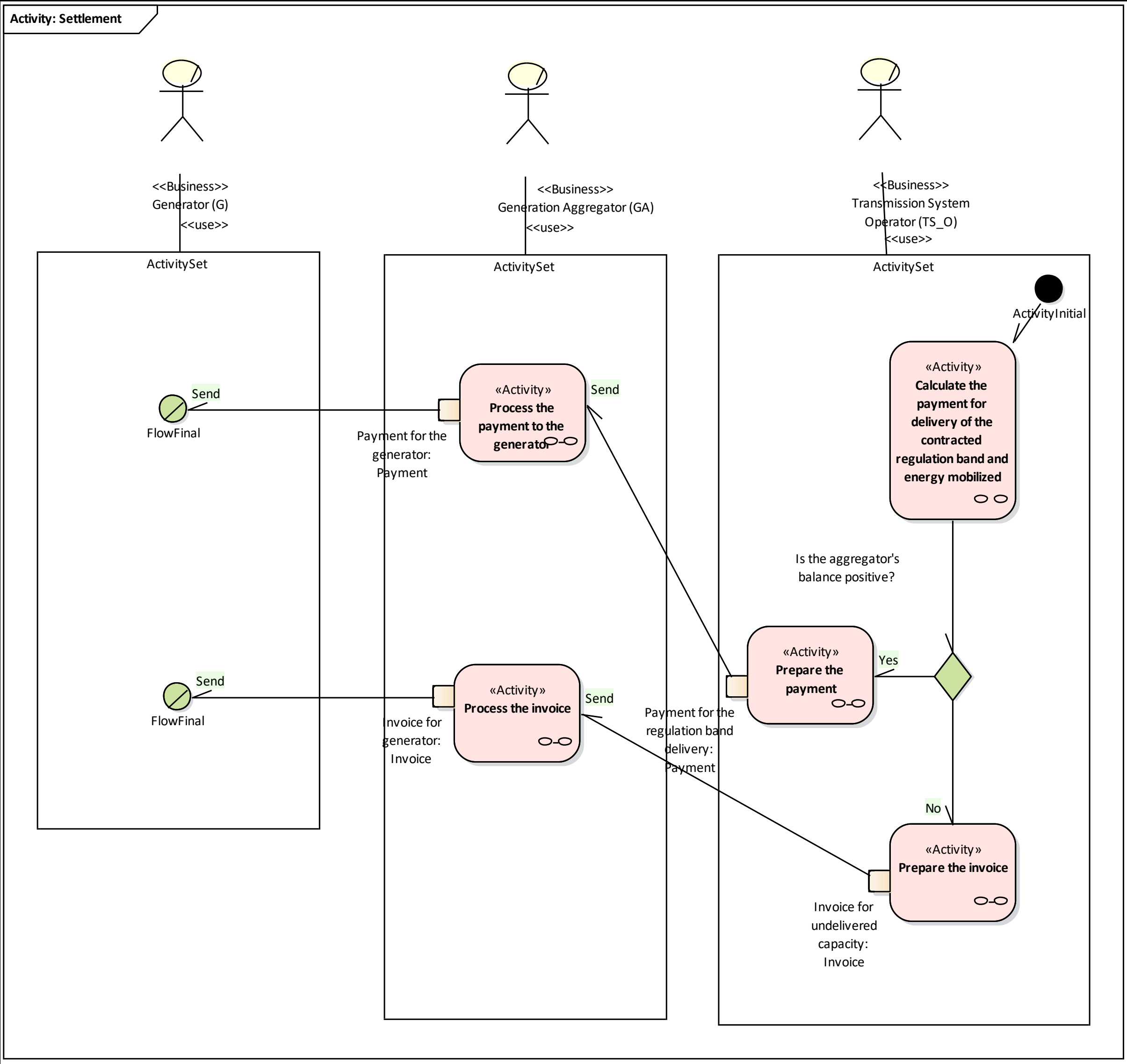
The payment includes the regulation band fee and the energy fee based on market clearing.

The regulatory band contracted to each production unit will be valued at the unit price of the last contracted offer for the corresponding programming time;

The energy for the aFRR will be remunerated at the price of the last RR offer, in the respective programmed period, that was mobilized to complement the secondary regulation. The remuneration will be made at the value of the RR mobilized, in the same regulation direction, up or down reserve.

BUSINESS USE CASES FOR INNOVATIVE SYSTEM SERVICES
DELIVERABLE: D3.3

The deviations in the service provision will make the producer incur in monetary costs calculated by physical unit and for the different hours of the daily program (h).



Scenario step by step analysis

Scenario								
Scenario name	Settlement							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
4.1		Calculate the payment for delivery of the	The TS_O checks if the capacity and energy that was		<u>Transmission System</u>			

		contracted regulation band and energy mobilized	promised/mobilized has been delivered. The regulatory band contracted will be valued at the price of the last contracted offer for the corresponding programmed hour. The energy will be remunerated at the price of the last RR regulation offer, in the respective programmed period, that was mobilized to complement the aFRR regulation.		Operator (TS_O)			
4.2		Prepare the payment	If the capacity is provided and the service fulfilled the TS_O makes the payment to the GA, that will make the payment to the generation/storage owners.	Send	Transmission System Operator (TS_O)	Generation Aggregator (GA)	Info10-Payment	
4.3		Prepare the invoice	If the capacity is not provided then the GA as to pay penalties. The TS_O sends the invoice for the payment	Send	Transmission System Operator (TS_O)	Generation Aggregator (GA)	Info11-Invoice	
4.4		Process the payment to the generator	The GA determines the generator compensation by the service provision and makes the payment.	Send	Generation Aggregator (GA)	Generator (G)	Info10-Payment	

4.5		Process the invoice	The GA sends the invoice for the generator if the service assigned was not provided.	Send	Generation Aggregator (GA)	Generator (G)	Info11-Invoice	

5. INFORMATION EXCHANGED

Information exchanged			
Information exchanged, ID	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
Info1	aFRR request	The generation aggregator needs to register for aFRR provider and fulfil the TSO requirements.	
Info2	Tests	The requirements will be in a form of tests performed by the TSO on the units were the technical and operational capability will be evaluated: communications velocity, real energy generated, gradient variation of the energy produced and response to random generation requests.	
Info3	VPPSetPoint	VPP setpoint that will manage the generation portfolio in an optimal way.	
Info4	SetPoint	Up or down set point, that represents a energy need.	
Info5	VPP response	The VPP will manage, within its portfolio, the availability of the units to fulfil the request. After that, it will send the confirmation of the power effectively mobilized to the TSO.	
Info6	aFRR needs	The TSO shall establish and communicate to all Market Agents, before 13h of each day, the necessary reserve of secondary regulation in the system.	
Info7	Resource availability	The VPP should have online information about the resource availability, so it can manage the request within its portfolio	
Info8	Bid	Offer should have the following information: • Offer number, k; • Offer for the up-reserve regulation k, MW; • Offer for the down reserve regulation k, MW; • Unitary price for the aFRR regulation band k, €/MW or unitary price for energy k, €/MWh;	
Info9	Market closure result	At 19h the TSO publishes the list of resources contracted for each hour for the day-ahead. The selection is based on the following criteria: · The set of offers that minimize the contracted secondary band cost. The contracted offers will be valued at the unit closing price of this market; · Secondary regulation offers that cause grid restrictions, when redispatch, will be excluded from the contracting process; · The sum of the contracted bands should be around ± 10%	

		of the required secondary regulation band value established by the TSO, for each hour.	
Info10	Payment	The payment must contain : • Object and justification of the payment • name of recipient • amount • date	
Info11	Invoice	The invoice must contain : • object of the invoice • justification • name of recipient • amount • due date • bank account	

TABLE 16 BUC PT-VPP-AP1

Manage VPP active power flexibility to support mFRR/RR in VPP Portuguese Demo

Based on IEC 62559-2 edition 1
Generated from UML Use Case Repository with Modsarus® (EDF R&D Tool)

1. DESCRIPTION OF THE USE CASE

1.1 NAME OF USE CASE

Use case identification		
ID	***Area(s)/Domain(s)/Zone(s)***	***Name of use case***
PT-VPP-AP2	Portugal	Manage VPP active power flexibility to support mFRR/RR in VPP Portuguese Demo

1.2 VERSION MANAGEMENT

Version management				
Version No.	***Date***	***Name of author(s)***	***Changes***	***Approval status***
1	2018-05-28	Nuno Lopes Filipe	Proposed version from demo	
2	2018-06-11	Cyril Effantin	Consolidation in a common UC repository	
3	2018-07-26	Cyril Effantin	UML fixes based on the Nuno Lopes Filipe 22-06-2016 version.	

4	2018-09-07	Nuno Lopes Filipe	Update from Nuno Lopes Filipe	
5	2018-10-23	Cyril Effantin	Changes on role model and impacted UML parts	

1.3 SCOPE AND OBJECTIVES OF USE CASE

Scope and objectives of use case	
Scope	In the context of the Portuguese Demo WP7 a Virtual Power Plant (VPP) will be 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 regulation reserve services (mFRR/RR - manual frequency restoration reserve / regulation reserve).
Objective(s)	Enhanced computational management system: integrating forecasting modules for prices, energy supply and demands; Real-time management of the storage and generation portfolio: based on mathematical models including short term balancing operations. Market bidding suite for the different markets: (day ahead, intraday, system services) respecting long term strategies for storage management; Remunerate the Wind Power Plants: that in the future will lose the feed-in-tariffs; Aggregation of mixed resources: for the efficient management of a portfolio, the hydro could compensate the deviations for the wind power plants;
Related business case(s)	Frequency Control

1.4 NARRATIVE OF USE CASE

Narrative of use case
Short description
· **Description of the needs**: Since it is foreseen that, in a near future, wind farms (and other DER) will no longer have feed-in tariffs and a high penetration of renewable energy is expected, it is crucial that utilities start studying ways to manage their assets in such markets. · **Description of the service:** In the mFRR/RR market, the TSO is responsible for setting up the market, identifying the needs for ancillary services and contracting the services, to guaranty the security of the national electrical system. The flexibility provided by combined large-scale generation, large-scale storage and RES power plants via the optimized operation of a variable speed pumped storage power plant, will allow the Generation Aggregator to

make optimized bids to the market and manage the portfolio more efficiently, all of this through a VPP.

The VPP tools, will provide decision support for the bidding at the different markets (day ahead, intraday, ancillary services) and for optimized dispatching of the units within VPP.

The flexibilities coming from generation units (conventional and RES) are offered through a mandatory mechanism and are remunerated based on opportunity costs in case they are selected.

Remark: TSO is an archetype player who carry out several Business Roles for this service (MO, TS_O).

Complete description

Market Description:

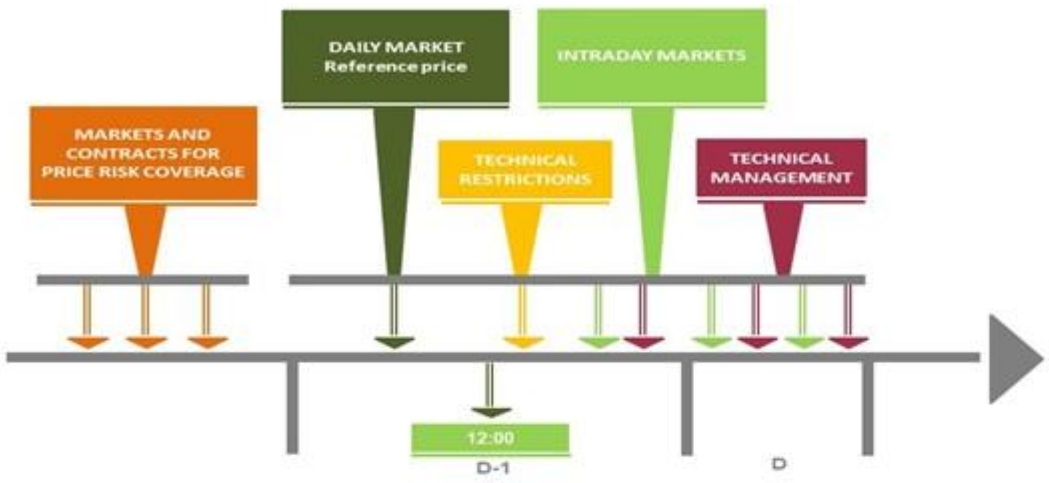
Electricity prices in Europe are set daily (every day of the year) at 12 noon, for the twenty-four hours of the following day, in what we refer to as the Day Ahead Market. The price and volume of energy over a specific hour are determined by the point at which the supply and demand curves meet, according to the marginal pricing model adopted by the EU, based on the algorithm approved for all European markets (EUPHEMIA) and now of application, besides Spain and Portugal, in Austria, Belgium, Czech Republic, Denmark, Estonia, France, Finland, Germany, Hungary, Italy, Latvia, Lithuania, Luxemburg, the Netherlands, Poland, Romania, Slovakia, Slovenia, Sweden, Norway, and the United Kingdom.

Portugal and Spain share a common day ahead and bilateral contract electricity market since 2007 (MIBEL). Buying and selling players may trade on our market regardless of whether they are in Spain or in Portugal. Their purchase and sale bids are accepted according to their economic merit order, until the interconnection between Spain and Portugal is fully occupied. If at a certain time of the day the capacity of the interconnection is such that it permits the flow of the electricity traded by the agents, the price of electricity for that hour will be the same for Spain and Portugal.

If, on the other hand, the interconnection is fully occupied at that time, the price-setting algorithm (EUPHEMIA) is run separately so that there is a price difference between the two countries. In 2014, the price of electricity was the same in Spain and Portugal for 90% of the time, which confirms that the integration of the Iberian market is working properly.

The mechanism described for setting the price of electricity on the daily market in Spain and Portugal is referred to as market splitting, being the same mechanism as the one used across Europe.

Once the daily market has ended, and until 12:45 p.m. the following day, six adjustment markets are held (called intraday markets), which allow those buyers and sellers who so wish to submit bids for the purchase and sale of electricity in order to adjust their generation and consumption schedules to their best forecasts for their real-time needs.



It is expected that during 2018 these intradays markets will be mainly replaced by the XBID, an European continuous trading platform, that will be implemented in most of the countries.
The Portuguese energy market has the concept of balancing areas which are defined as a set of physical units, that could be generation or storage, belonging to the same Market Agent (MA) and are connected in a certain grid area. For a balancing area, the deviations to the energy program are aggregated. The imbalances are calculated regarding the program that the balancing area should provide and the real output. The penalties are calculated dividing the system cost for everyone that has an imbalance (despite if it is against or in favour to the system). This payment goes to those power plants that maintained the system in an equilibrium (deal with the other's imbalances).
Due to the limited interconnection capacity, several technical activities as procurement and the provision of Ancillary Services are not yet entirely harmonized or fully integrated and continue to be provided within the control area of each country and is under the responsibility of each TSO (REN for Portugal). Some of the ancillary services are mandatory and not remunerated such as primary reserve and Q regulation, but the aFRR and mFRR/RR are remunerated.
The current EBGL from the EU establishes different types of reserves for these "service", namely the RR and the mFRR. Nevertheless, in Portugal and in Spain for now there is only the concept of Tertiary Reserve, to allow the TSO to balance the systems after the response of the Secondary Reserve.
The service traded is defined as energy-based and must be provided according to the bids the agent places in the reserve markets.

Description of the service:
The VPP tools will provide decision support for the bidding at the different markets (day ahead, intraday, ancillary services) and for optimized dispatching of the units within VPP.
Every decision support module of VPPs heavily depends on accurate forecasts of e.g. energy market prices, supply and demand. That's why the foundation of the tool is a development of specific forecasting modules for wind and solar energy supply as well as water energy inflows, the tradable amount of energy, the expected

prices for different market layers of interest (day-ahead, intra-day, balancing market).
A price forecasting module will be set up to generate forecasts for the following variables:
(a) electrical energy in the day-ahead and intraday sessions;
(b) capacity price for frequency containment reserve;
(c) price for upward and downward balancing reserves. In addition to point forecast values, a probabilistic forecast will be produced.
The forecast uncertainty is either measured in a probabilistic manner or by analysing
(i.) the residual error distribution or
(ii.) the density of multiple forecasted scenarios.
Besides forecasts for the price segments **(a)**, **(b)** and **(c)**, a forecast module for the expected energy supply of RES to augment the estimation of the available energy supply of the VPP, for helping to identify the expected energy consumption. Energy supply as well as demand forecasts are not provided in the form of point forecasts, but confidence intervals are given to support a robust optimization (i.e. optimization under uncertainty).
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. Managing efficiently 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:
Selection/Bidding phase:
The generators will send their availability to the VPP that, with the help of its forecasting tools, will send optimal mFRR/RR offers to the TSO.
The VPP should update its offers based on the market participation.

Delivery:
The TSO sends the RR request to the Generator Aggregator that, through the VPP, will manage the request within its generation portfolio, fulfilling the request. The offers are considered contracted at the moment of activation.

Settlement:
The TSO initiates the settlement process by sending the payment/invoice to the Generator Aggregator that will process the payments/invoices to the generation units. There will be a payment for the mobilized energy.
The deviations will cause the penalties payment.
Each of these phases will be described, in more detail, in the next section.

Summary of use case

- **Selection/Bidding**
  Description: The VPP tools, with the complex forecasting modules, will provide decision support for the bidding at the tertiary regulation market.
  The VPP 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 following steps are envisioned for an optimized bidding support of a market:
  · Provide numeric predictions of renewable energy supply (i.e. wind, solar) and water inflow based on weather forecasts;
  · Forecast possible capacities and merit order from previous auction to compute the tradable amount of electrical energy;
  · Forecasts prices (offer distribution) for this auction;
  · Use long term strategies and long-term price forecasts to evaluate the offering of storing/releasing energy in/of the reservoirs;
  · Propose optimized offers for the auction.

  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 RR. The offer price for the activation of the downwards regulatory reserve has the character of a repurchase price of the equivalent energy not produced.
  These offers must present the value of the reserve in MW and the respective price in € / MWh. The offered reserve blocks could not be divided.

  The general criteria for the RR contracting is the following:
  · TSO will mobilize the provision of this service with minimum cost criteria, considering the existing offers at the time of activation;
  · Only offers with a price greater than or equal to zero shall be considered;
  · An offer will not be mobilized if it causes a technical restriction;
  · When a certain resource is mobilized in a particular direction of regulation, and within the same time period, there is the need to mobilize energy regulation in the opposite direction, the latter will be mobilized in the first place, followed by the previously mobilized and only then it will be turn for the offers in the opposite direction. The payment obligations shall be solely for the energy effectively provided.

  - Define the needs for mFRR/RR
    Description: The TS_O defines the needs for upward/downwards regulations, for each hour of the day, taking into account the demand forecast. There is also an additional reserve that corresponds to the maximum power that can be lost due to any single equipment outage increased by 2% of the demand forecasted for that period.

  - Send resources availability
    Description: Generation units send online information about their availability and real production.

  - Activate the forecasting tools
    Description: The VPP tools, with the forecasting complex modules, will provide decision support for the bidding at the mFRR/RR market.

  - Create optimal bids
    Description: The VPP 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).

- Update the offers based on availability and market participation
  Description: The market players that make the RR offers for the generation/pumping units, shall update their offers within the same day of operation whenever any of the following situations, that modify the availability of regulation reserve, occur:
  - The production program of the unit changes due to the intraday market sessions;
  - Unexpected unavailability of the generation/pumping unit;

  In the case of hydro units, when there is lack or excess of water in the reservoirs or other adverse hydrological conditions.

- Wait for market closure
  Description: 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 TS_O the information regarding the mFRR/RR.

- Integrate the info in the system
  Description: Based on the offers the TS_O creates the merit order for the resources activation

- **Delivery**
  Description: The offers available for RR are considered contracted at the moment of activation. To this end, 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 activations are made in Power (MW) and not in Energy, always respecting the technical limits of the units, namely the upward and downward gradients of the generation/pumping units that compose it.
  After clearing the aFRR market, the TSO activates the RR market, typically from 18.00 to 21.00.
  The VPP receives the request and activates automatically the service provision with the real-time management of the storage and generation portfolio. After the submission and acceptance of energy and reserve offers in the electricity market, a control layer will ensure that the VPP complies with its market commitments in each time instant.
  The models will handle short term balancing operations, like the change of frequency (i.e. energy consumption/generation of pump turbines or the reduction of energy produced in wind farms).
  The system will consider situations where a generation plant is unavailable and find compensation (e.g. increase production) or decide to buy the missing electricity on the market or take it from an energy storage. The control system will manage imbalances within its generation portfolio.

  - Send request for mFRR/RR
    Description: The offers available for mFRR/RR are considered contracted at the moment of mobilization. To this end, TS_O uses the available offers offered by the market players/generation aggregators and mobilizes those that follow the criteria defined in the bidding phase.

  - Manage the request (VPP)
    Description: The VPP receives the request and activates automatically the service provision with the real-time management of the storage and generation portfolio.

  - Manage the request (VPP)
    Description: The VPP receives the request and activates automatically the service provision with the real-time management of the storage and generation portfolio.

- Adjust the operation setpoint
  Description: The generation units included in the VPP portfolio adjusts the output according to the VPP orders.

- Evaluate the response
  Description: The TS_O verifies the correct response from the contracted generation.

- **Settlement**
  Description: The RR market is "Pay as clear".
  In the RR service, only those market players/generation aggregators whose units were mobilized are remunerated, and the remuneration is attributed only for the energy actually used during the time of activation, as opposed to the reserve of secondary regulation which is also remunerated by the power availability.
  The RR energy is remunerated at the marginal price of the last mobilized offer, whether fully or partially activated, in each direction of regulation (up and down).
  The downwards regulation reserve price has the character of a repurchase price of equivalent not produced energy, that is, the remuneration of the TSO will be attributed to the agent that provides the downwards regulation.
  The non-compliance, by the market players/generation aggregators, with the regulation reserve provision is identified in terms of power not supplied or delivered with a deficit in comparison to the value required by the TSO and the corresponding energy accounted for each programming hour. The non-compliance is calculated by the difference between the energy emitted by the physical unit and the integral of the power required and registered in the TSO computer system, for each 15-minute period. All non-compliances should be reported by the TSO to the regulator, ie ERSE.
  This energy will be valued at the weighted average price of the deviation energy, either by excess of energy supplied (positive price) or by defect of energy supplied (negative price). In practice, the positive price indicates the TSO payment to the market player that provided more power than required, always at a weighted average price lower than the market, and the negative price includes the market player payment to the TSO for the energy that it should have supplied and which has not provided, typically at a value higher than the market price.

- Calculate the GA balance in the service delivery
  Description: The TS_O checks if the energy that was offered/mobilized has been delivered.

- Prepare the payment
  Description: If the energy is provided and the service fulfilled the TS_O makes the payment to the GA, that will make the payment to the generation/storage owners. The mFRR/RR energy is remunerated at the marginal price of the last mobilized offer, whether fully or partially activated, in each direction of regulation (up and down).

- Prepare the invoice
  Description: The non-compliance, by the market players/generation aggregators, with the regulation reserve provision is identified in terms of power not supplied or delivered with a deficit in comparison to the value required by the TS_O and the corresponding energy accounted for each programming hour. If the capacity is not provided then the GA as to pay penalties. The TS_O sends the invoice for the payment.

- Process the payment to the generator
  Description: The GA determines the generator compensation by the service provision and makes the payment.

- Process the invoice
  Description: The GA sends the invoice for the generator if the service assigned was not provided.

1.5 KEY PERFORMANCE INDICATORS (KPI)

1.6 USE CASE CONDITIONS

Use case conditions	
Assumptions	
1	barriers for implementing the BUC (based on current context): • In Portugal, there is no specific regulatory framework regarding aggregation, and currently, there are no active aggregators in operation; • Most of the actual RES connected to the grid have feed-in tariffs, but many of those contracts will end in a near future. The new PV and Wind projects won't have feed-in tariffs; • The main market access requirement in terms of minimum capacity is 0.1 MW;
2	rules relevant for the market assumed (future market): • There are no feed-in tariffs; • Market players can do aggregated offers; • There are no balancing areas, and market players can balance their own production accordingly to what they offered;
Prerequisites	
1	prerequisites: • Regarding the real-time management of the storage and generation portfolio, after the submission and acceptance of energy and reserve offers in the electricity market, a control layer is needed to ensure that the VPP complies with its market commitments in each time instant; • There is no need to register for mFRR/RR provision, if an asset participates on the energy market and has available regulation reserve, qualifies automatically. That is the reason there is no prequalification phase for this service provision; • In order for the VPP to provide the mFRR/RR service, it must participate on the day ahead and intraday energy markets, being itself a party responsible for the imbalances (BRP) or part of a larger group with balancing responsibilities.

1.7 FURTHER INFORMATION TO THE USE CASE FOR CLASSIFICATION/MAPPING

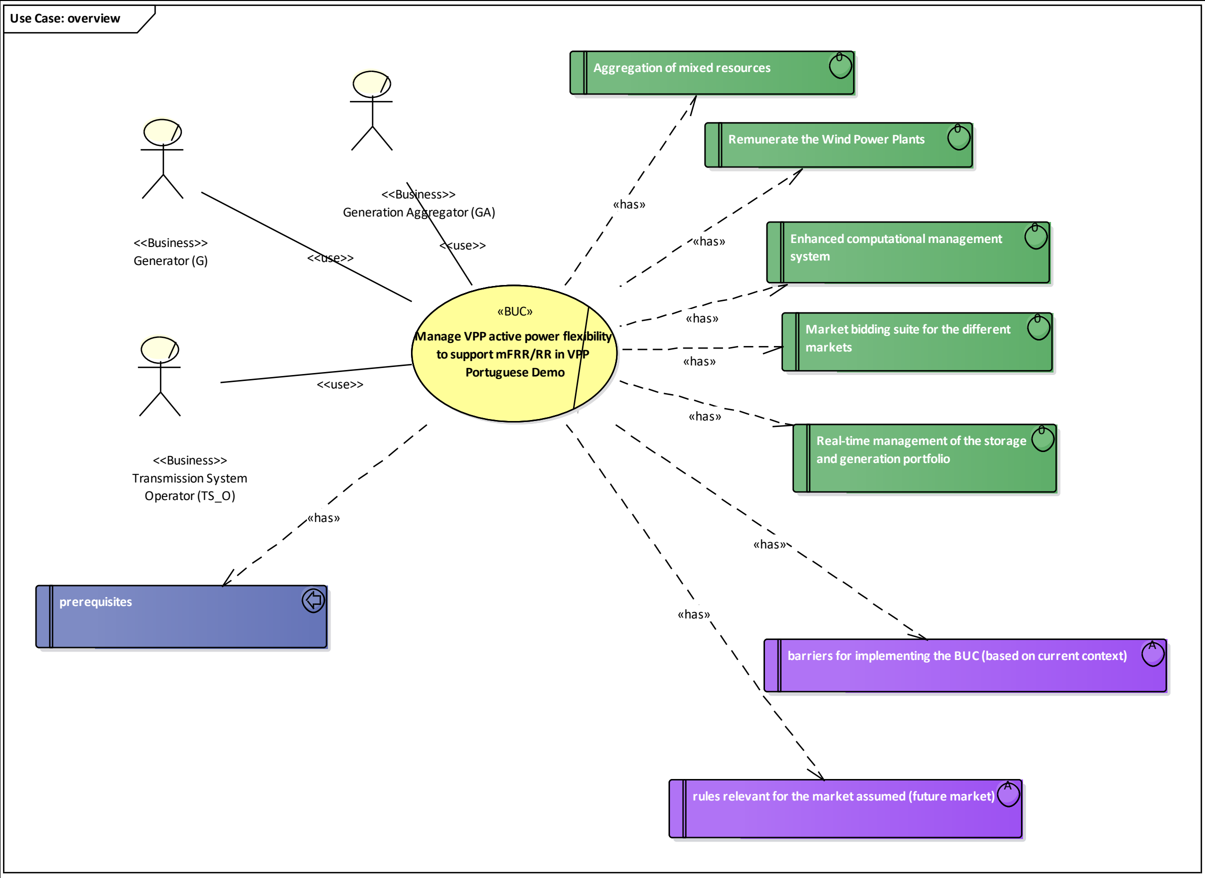
Classification information
Relation to other use cases
Level of depth
BUC for Portugal VPP Demo
Prioritisation

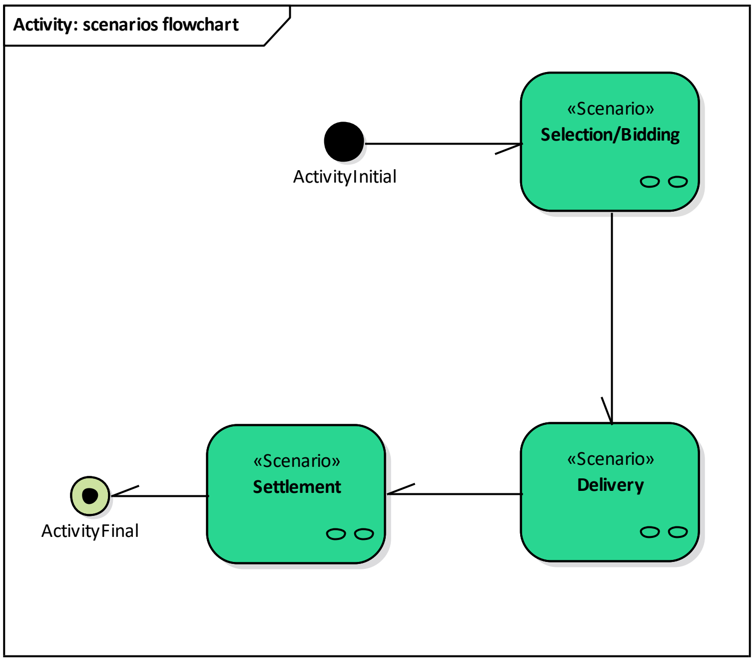
Generic, regional or national relation
National
Nature of the use case
BUC
Further keywords for classification

1.8 GENERAL REMARKS

2. DIAGRAMS OF USE CASE

Diagram(s) of use case





3. TECHNICAL DETAILS

3.1 ACTORS

Actors

Grouping (e.g. domains, zones)		*Group description*	
Actor name	*Actor type*	*Actor description*	*Further information specific to this use case*
Generator (G)	Business	Invest in, maintain and operate the asset(s) Select the contractual framework with relevant stakeholders related to the energy contract and the provision of flexibility/other system services	
Generation Aggregator (GA)	Business	Aggregate and maximize value of generation portfolio resources Provide flexibility by generation assets to the system operators	
Transmission System Operator (TS_O)	Business	Elaborate network development plan (including defining system needs for transmission) Ensure a transparent and non-discriminatory access to the transmission network for each user Operate the transmission grid over a specific region in a secure, reliable and efficient way Secure and manage in real time the physical generation-consumption balance on a geographical perimeter, including ensuring the frequency control service Optimize transmission system operation from planning to real-time, using available levers (grid expansion, flexibility activation,...) Assess network status of the transmission grid and broadcast selected information of the network status to eligible actors (e.g. aggregators, other system operators) Provide data to the interconnection capacity market operator for the management of cross border transactions In critical situations, implement dedicated actions and deliver alerts during stress events If necessary, implement emergency measures (e.g. system defence plan) including load shedding	

3.2 REFERENCES

4. STEP BY STEP ANALYSIS OF USE CASE

4.1 OVERVIEW OF SCENARIOS

Scenario conditions

No.	Scenario name	Scenario description	Primary actor	Triggering event	Pre-condition	Post-condition
1	Selection/Bidding	The VPP tools, with the complex forecasting modules, will provide decision support for the bidding at the tertiary regulation market. The VPP 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 following steps are envisioned for an optimized bidding support of a market: · Provide numeric predictions of renewable energy supply (i.e. wind, solar) and water inflow based on weather forecasts; · Forecast possible capacities and merit order from previous auction to compute the tradable amount of electrical energy; · Forecasts prices (offer distribution) for this auction; · Use long term strategies and long-term price forecasts to evaluate the offering of storing/releasing energy in/of the reservoirs; · Propose optimized offers for the auction. 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 RR. The offer price for the activation of the downwards regulatory reserve has the character of a repurchase price of the equivalent energy not produced. These offers must present the value of the reserve in MW and the respective price in € / MWh. The offered reserve blocks could not be divided. The general criteria for the RR contracting is the following: · TSO will mobilize the provision of this service with minimum cost criteria, considering the existing offers at the time of activation; · Only offers with a price greater than or				

		equal to zero shall be considered; · An offer will not be mobilized if it causes a technical restriction; · When a certain resource is mobilized in a particular direction of regulation, and within the same time period, there is the need to mobilize energy regulation in the opposite direction, the latter will be mobilized in the first place, followed by the previously mobilized and only then it will be turn for the offers in the opposite direction. The payment obligations shall be solely for the energy effectively provided.				
2	Delivery	The offers available for RR are considered contracted at the moment of activation. To this end, 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 activations are made in Power (MW) and not in Energy, always respecting the technical limits of the units, namely the upward and downward gradients of the generation/pumping units that compose it. After clearing the aFRR market, the TSO activates the RR market, typically from 18.00 to 21.00. The VPP receives the request and activates automatically the service provision with the real-time management of the storage and generation portfolio. After the submission and acceptance of energy and reserve offers in the electricity market, a control layer will ensure that the VPP complies with its market commitments in each time instant. The models will handle short term balancing operations, like the change of frequency (i.e. energy consumption/generation of pump turbines or the reduction of energy produced in wind farms). The system will consider situations where a generation plant is unavailable and find compensation (e.g. increase production) or decide to buy the missing electricity on the market or take it from an energy storage. The control system will manage imbalances within its generation portfolio.				

3	Settlement	The RR market is "Pay as clear". In the RR service, only those market players/generation aggregators whose units were mobilized are remunerated, and the remuneration is attributed only for the energy actually used during the time of activation, as opposed to the reserve of secondary regulation which is also remunerated by the power availability. The RR energy is remunerated at the marginal price of the last mobilized offer, whether fully or partially activated, in each direction of regulation (up and down). The downwards regulation reserve price has the character of a repurchase price of equivalent not produced energy, that is, the remuneration of the TSO will be attributed to the agent that provides the downwards regulation. The non-compliance, by the market players/generation aggregators, with the regulation reserve provision is identified in terms of power not supplied or delivered with a deficit in comparison to the value required by the TSO and the corresponding energy accounted for each programming hour. The non-compliance is calculated by the difference between the energy emitted by the physical unit and the integral of the power required and registered in the TSO computer system, for each 15-minute period. All non-compliances should be reported by the TSO to the regulator, ie ERSE. This energy will be valued at the weighted average price of the deviation energy, either by excess of energy supplied (positive price) or by defect of energy supplied (negative price). In practice, the positive price indicates the TSO payment to the market player that provided more power than required, always at a weighted average price lower than the market, and the negative price includes the market player payment to the TSO for the energy that it should have supplied and which has not provided, typically at a value higher than the market price.				

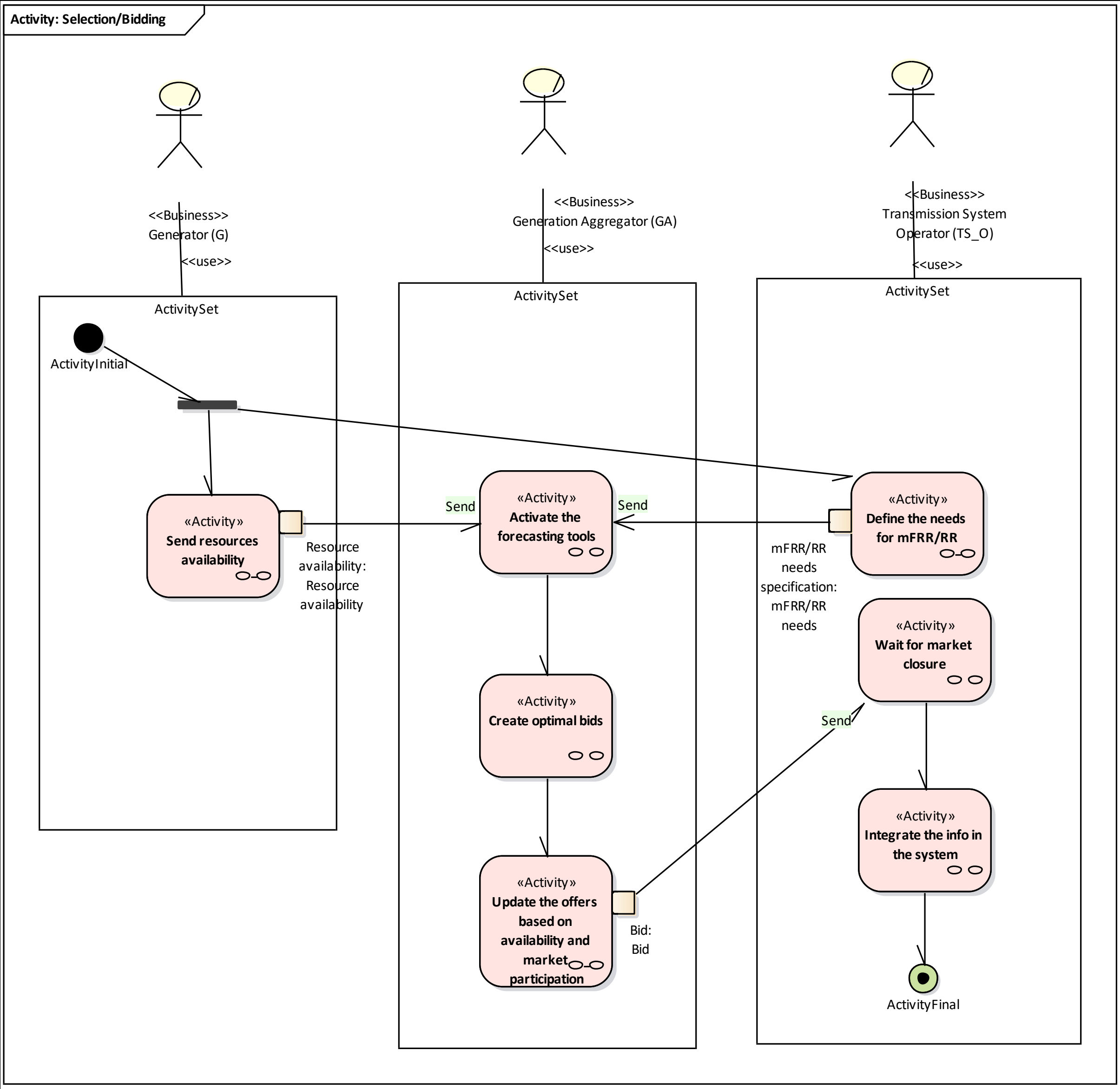
4.2 STEPS - SCENARIOS

4.2.1 SELECTION/BIDDING

The VPP tools, with the complex forecasting modules, will provide decision support for the bidding at the tertiary regulation market.
The VPP 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 following steps are envisioned for an optimized bidding support of a market:
· Provide numeric predictions of renewable energy supply (i.e. wind, solar) and water inflow based on weather forecasts;
· Forecast possible capacities and merit order from previous auction to compute the tradable amount of electrical energy;
· Forecasts prices (offer distribution) for this auction;
· Use long term strategies and long-term price forecasts to evaluate the offering of storing/releasing energy in/of the reservoirs;
· Propose optimized offers for the auction.

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 RR.
The offer price for the activation of the downwards regulatory reserve has the character of a repurchase price of the equivalent energy not produced.
These offers must present the value of the reserve in MW and the respective price in € / MWh. The offered reserve blocks could not be divided.

The general criteria for the RR contracting is the following:
· TSO will mobilize the provision of this service with minimum cost criteria, considering the existing offers at the time of activation;
· Only offers with a price greater than or equal to zero shall be considered;
· An offer will not be mobilized if it causes a technical restriction;
· When a certain resource is mobilized in a particular direction of regulation, and within the same time period, there is the need to mobilize energy regulation in the opposite direction, the latter will be mobilized in the first place, followed by the previously mobilized and only then it will be turn for the offers in the opposite direction. The payment obligations shall be solely for the energy effectively provided.



Scenario step by step analysis

Scenario								
Scenario name	Selection/Bidding							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
1.1		Define the needs for mFRR/RR	The TS_O defines the needs for upward/downwards	Send	Transmission System	Generation Aggregator (GA)	Info1-mFRR/RR needs	

			regulations, for each hour of the day, taking into account the demand forecast. There is also an additional reserve that corresponds to the maximum power that can be lost due to any single equipment outage increased by 2% of the demand forecasted for that period.		Operator (TS_O)			
1.2		Send resources availability	Generation units send online information about their availability and real production.	Send	Generator (G)	Generation Aggregator (GA)	Info2-Resource availability	
1.3		Activate the forecasting tools	The VPP tools, with the forecasting complex modules, will provide decision support for the bidding at the mFRR/RR market.		Generation Aggregator (GA)			
1.4		Create optimal bids	The VPP 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).	Sends	Generation Aggregator (GA)	Transmission System Operator (TS_O)		
1.5		Update the offers based on availability and market participation	The market players that make the RR offers for the generation/pumping units, shall update their offers within the same day of operation whenever any of the following situations, that modify the availability	Send	Generation Aggregator (GA)	Transmission System Operator (TS_O)	Info3-Bid	

			of regulation reserve, occur: • The production program of the unit changes due to the intraday market sessions; • Unexpected unavailability of the generation/pumping unit; In the case of hydro units, when there is lack or excess of water in the reservoirs or other adverse hydrological conditions.					
1.6		Wait for market closure	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 TS_O the information regarding the mFRR/RR.		Transmission System Operator (TS_O)			
1.7		Integrate the info in the system	Based on the offers the TS_O creates the merit order for the resources activation		Transmission System Operator (TS_O)			

4.2.2 DELIVERY

The offers available for RR are considered contracted at the moment of activation. To this end, TSO uses the available offers offered by the market players/generation aggregators and mobilizes those that follow the criteria defined in the bidding phase.

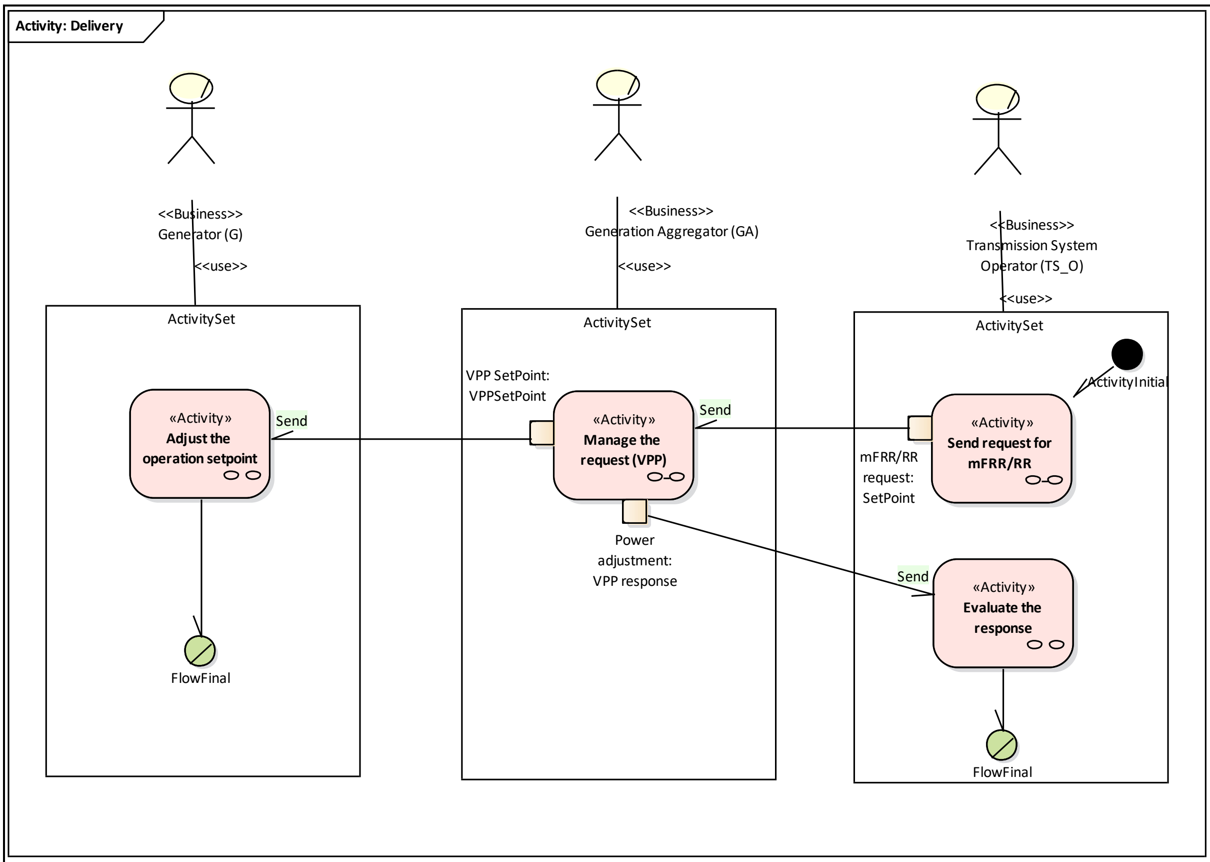
The activations are made in Power (MW) and not in Energy, always respecting the technical limits of the units, namely the upward and downward gradients of the generation/pumping units that compose it.

After clearing the aFRR market, the TSO activates the RR market, typically from 18.00 to 21.00.

The VPP receives the request and activates automatically the service provision with the real-time management of the storage and generation portfolio. After the submission and acceptance of energy and reserve offers in the electricity market, a control layer will ensure that the VPP complies with its market commitments in each time instant.

The models will handle short term balancing operations, like the change of frequency (i.e. energy consumption/generation of pump turbines or the reduction of energy produced in wind farms).

The system will consider situations where a generation plant is unavailable and find compensation (e.g. increase production) or decide to buy the missing electricity on the market or take it from an energy storage. The control system will manage imbalances within its generation portfolio.



Scenario step by step analysis

Scenario									
Scenario name	Delivery								
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
2.1		Send request for mFRR/RR	The offers available for mFRR/RR are considered contracted at the	Send	Transmission System Operator (TS_O)	Generation Aggregator (GA)	Info4-SetPoint	

			moment of mobilization. To this end, TS_O uses the available offers offered by the market players/generation aggregators and mobilizes those that follow the criteria defined in the bidding phase.					
2.2		Manage the request (VPP)	The VPP receives the request and activates automatically the service provision with the real-time management of the storage and generation portfolio.	Send	Generation Aggregator (GA)	Transmission System Operator (TS_O)	Info5-VPP response	
2.3		Manage the request (VPP)	The VPP receives the request and activates automatically the service provision with the real-time management of the storage and generation portfolio.	Send	Generation Aggregator (GA)	Generator (G)	Info6-VPPSetPoint	
2.4		Adjust the operation setpoint	The generation units included in the VPP portfolio adjusts the output according to the VPP orders.		Generator (G)			
2.5		Evaluate the response	The TS_O verifies the correct response from the contracted generation.		Transmission System Operator (TS_O)			

4.2.3 SETTLEMENT

The RR market is “Pay as clear”.

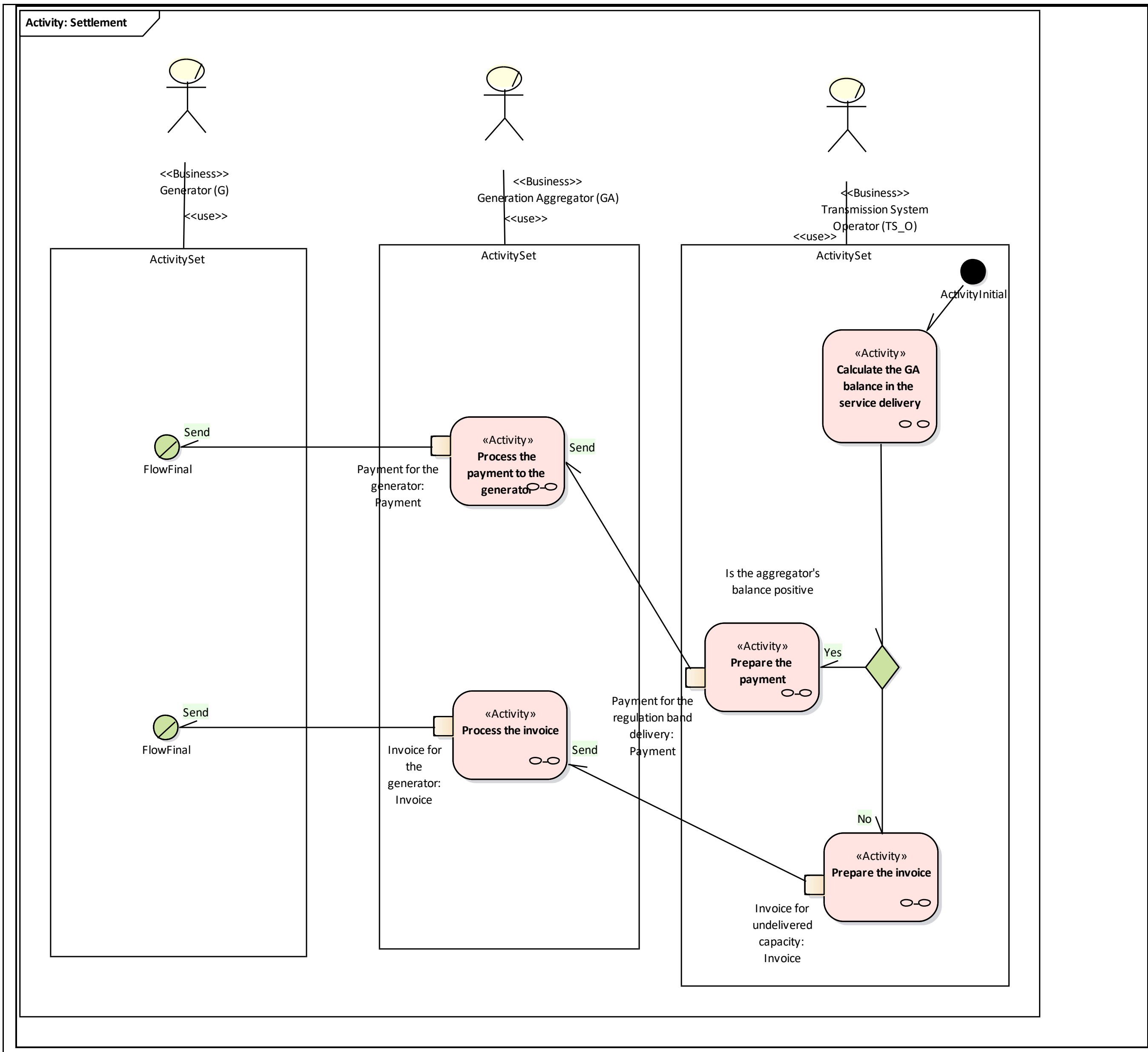
In the RR service, only those market players/generation aggregators whose units were mobilized are remunerated, and the remuneration is attributed only for the energy actually used during the time of activation, as opposed to the reserve of secondary regulation which is also remunerated by the power availability.

The RR energy is remunerated at the marginal price of the last mobilized offer, whether fully or partially activated, in each direction of regulation (up and down).

The downwards regulation reserve price has the character of a repurchase price of equivalent not produced energy, that is, the remuneration of the TSO will be attributed to the agent that provides the downwards regulation.

The non-compliance, by the market players/generation aggregators, with the regulation reserve provision is identified in terms of power not supplied or delivered with a deficit in comparison to the value required by the TSO and the corresponding energy accounted for each programming hour. The non-compliance is calculated by the difference between the energy emitted by the physical unit and the integral of the power required and registered in the TSO computer system, for each 15-minute period. All non-compliances should be reported by the TSO to the regulator, ie ERSE.

This energy will be valued at the weighted average price of the deviation energy, either by excess of energy supplied (positive price) or by defect of energy supplied (negative price). In practice, the positive price indicates the TSO payment to the market player that provided more power than required, always at a weighted average price lower than the market, and the negative price includes the market player payment to the TSO for the energy that it should have supplied and which has not provided, typically at a value higher than the market price.



Scenario step by step analysis

Scenario								
Scenario name	Settlement							
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
3.1		Calculate the GA balance in the service delivery	The TS_O checks if the energy that was		Transmission System Operator (TS_O)			

			offered/mobilized has been delivered.					
3.2		Prepare the payment	If the energy is provided and the service fulfilled the TS_O makes the payment to the GA, that will make the payment to the generation/storage owners. The mFRR/RR energy is remunerated at the marginal price of the last mobilized offer, whether fully or partially activated, in each direction of regulation (up and down).	Send	Transmission System Operator (TS_O)	Generation Aggregator (GA)	Info7-Payment	
3.3		Prepare the invoice	The non-compliance, by the market players/generation aggregators, with the regulation reserve provision is identified in terms of power not supplied or delivered with a deficit in comparison to the value required by the TS_O and the corresponding energy accounted for each programming hour. If the capacity is not provided then the GA as to pay penalties.	Send	Transmission System Operator (TS_O)	Generation Aggregator (GA)	Info8-Invoice	

			The TS_O sends the invoice for the payment.					
3.4		Process the payment to the generator	The GA determines the generator compensation by the service provision and makes the payment.	Send	Generation Aggregator (GA)	Generator (G)	Info7-Payment	
3.5		Process the invoice	The GA sends the invoice for the generator if the service assigned was not provided.	Send	Generation Aggregator (GA)	Generator (G)	Info8-Invoice	

5. INFORMATION EXCHANGED

Information exchanged			
Information exchanged, ID	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
Info1	mFRR/RR needs	Should be define in terms of upward/downwards regulations, for each hour of the day, taking into account the demand forecast.	
Info2	Resource availability	The VPP should have online information about the resource availability, so it can manage the request within its portfolio	
Info3	Bid	Offer should have the following information: • Offer number, k; • Offer for the up-reserve regulation k, MW; • Offer for the down reserve regulation k, MW; • Unitary price for the aFRR regulation band k, €/MW or unitary price for energy k, €/MWh;	
Info4	SetPoint	Up or down set point, that represents a energy need.	
Info5	VPP response	The VPP will manage, within its portfolio, the availability of the units to fulfil the request. After that, it will send the confirmation of the power effectively mobilized to the TSO.	
Info6	VPPSetPoint	VPP setpoint that will manage the generation portfolio in an optimal way.	
Info7	Payment	The payment must contain : • Object and justification of the payment • name of recipient • amount	

		• date	
Info8	Invoice	The invoice must contain : • object of the invoice • justification • name of recipient • amount • due date • bank account	

TABLE 17 BUC PT-VPP-AP2