Deliverable D1.5

Business Use Case: Business Use Case definition

V2.2

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D1.5 - Business Use Cases

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Executive summary

This deliverable aims at describing the business processes that are necessary for a successful implementation of new TSO/DSO interactions in the scope of CoordiNet. For this, the standardized IEC Use Case methodology is applied, which is based on the IEC 62559 template that supports the fostering of a common understanding of functionalities, actors and processes across different technical committees and different organizations.

As depicted in Figure 1, the work in Task 1.5 (described in this deliverable) is closely related to task 1.3: “Definition of products and coordination schemes” and task 1.6: “Definition of technical, environmental and economic KPIs”. All three mentioned tasks are fundamental for the demo preparation phase for the three demo countries, Greece, Spain and Sweden. More detailed work on the basis of the identified Business Use Cases (BUCs) follows in work package (WP) 2, specifically within tasks 2.1 “Coordination and knowledge sharing between demonstration campaigns on market architectures” and 2.3 “Description of network, monitoring and operation models to determine the needs of network operators for system operation”. The KPI’s that are analysed in each BUC and documented in D1.6, will play an important role for the evaluation of the demo ambitions in WP3-5 as well as for a later assessment and evaluation of the demonstration campaigns in WP6.

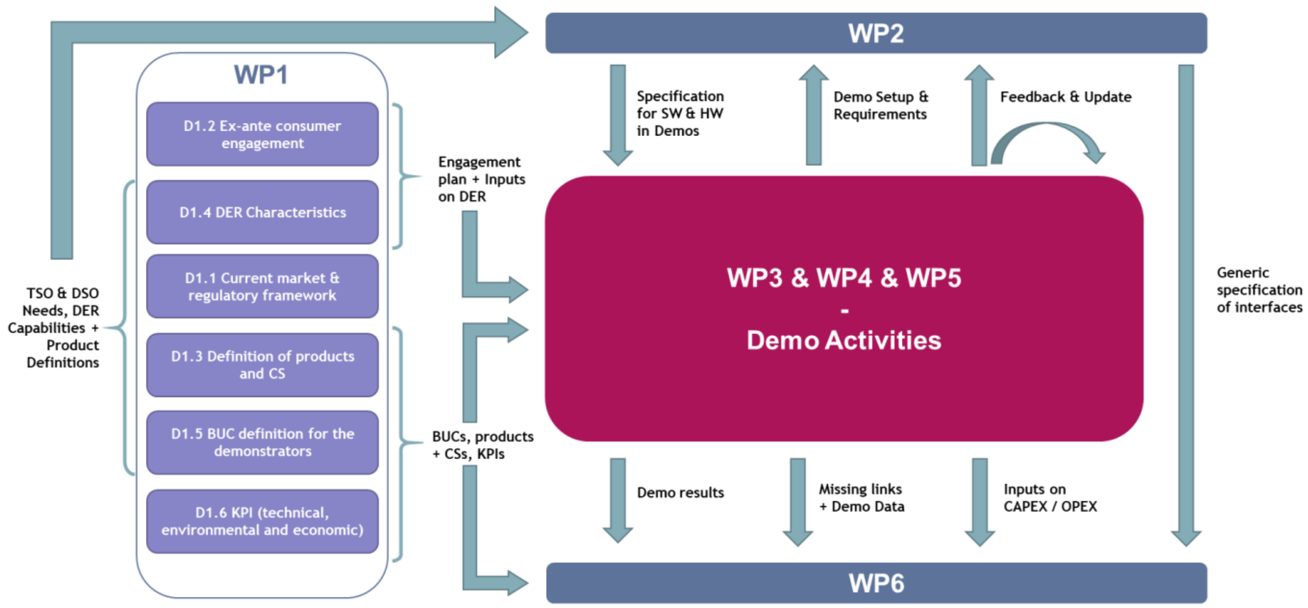

Figure 1: Main interactions and links of WP1 deliverables with the other WPs of CoordiNet project

For each demonstration campaign, four different BUCs have been identified. In the Greek demo, two main grid services are of high interest: congestion management (1) and voltage control (2). For these services, capacity and energy products (active and reactive power) are relevant. The BUCs have been separated depending on the applied coordination scheme. Since the Greek demo is planning to test a multi-level market mechanism (a) as well as a fragmented mechanism (b), the two grid services are described in four BUCs: GR-1a, GR-1b, GR-2a, and GR-2b (see blue sections in Figure 2).

The Spanish demo (marked in red in Figure 2), targets to solve congestion (1), balancing (2), voltage (3) and islanding (4) issues that can be solved through a close cooperation between the Use Case actors: the Spanish TSO, the DSOs and Flexibility Service Providers (FSPs). Thus, the Spanish demo targets to offer four types of grid services. To foster the market for these services different products can be procured. Among others, active or reactive power, short term or long term procurement, and frequency reserves have been discussed and focused in D 1.3. BUC ES-1 and ES-3 will at least be realized on the basis of a common market mechanism, while ES-2 targets to a central- and ES-4 to a local market mechanism in a first stage.

The Swedish demo focuses on congestion (1) in the distribution grid or between the transmission and distribution grid and balancing (2). In the Swedish grid, one has to differentiate between the regional DSOs, who have the connection to the TSO and the local DSOs who cover smaller parts of the systems but are connected to the regional DSO. For the grid service creation, both energy and capacity products are relevant. The development of these services is however strongly dependent on the realization of the coordination schemes, which have been identified to develop towards a multi-level market mechanism (a), distributed market mechanism (b), and a local market for the local DSO in Gotland (2). The overview of the Swedish BUCs is depicted in yellow in Figure 2.

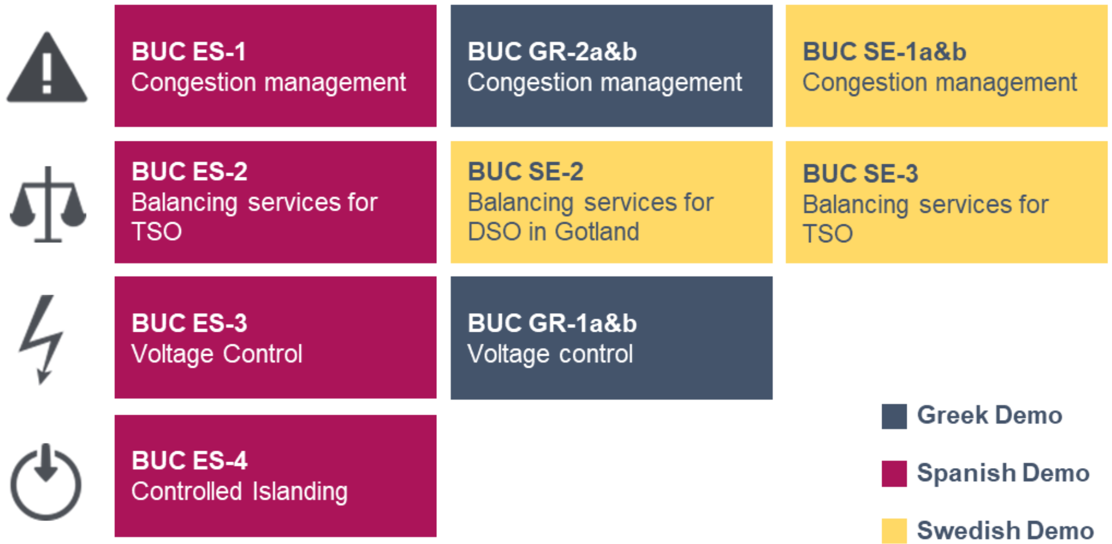

Figure 2: Overview of all presented BUCs

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Notations, abbreviations and acronyms

Table 1: Acronyms list

Acronym	Description
ACS	Institute of Automation of Complex Power Systems
ADMIE	(Greek) Independent Power Transmission Operator (=IPTO)
aFRR	Automatic Frequency Restoration Reserve
AUR	Additional Upward Reserve
BSP	Balance Service Provider
BUC	Business Use Case
Cecre	Control Centre of Renewable Energies (in Spain)
CHP	Combined Heat and Power
CIM	Common Information Model
DA	Day-Ahead
DAS	Day-Ahead Schedule
DER	Distributed Energy Resource
DG	Distributed Generation
DMS	Distributed Management System
DR	Demand Response
DSO	Distribution System Operator
DSR	Demand Side Response
EBGL	Electricity Balancing Guideline
EDIFACT	Electronic Data Interchange for Administration, Commerce and Transport
EDSO	European Distribution System Operators
EMS	Energy Management System
ESS	Energy Storage System
EV	Electric Vehicle
FCR	Frequency Containment Reserves (primary reserve)
FCR-D	(Nordic) Frequency Containment Reserve for normal operation
FCR-N	(Nordic) Frequency Containment Reserve for disturbances
FFR	Fast Frequency Reserve
FSP	Flexibility Service Providers
H-2	2 Hours Ahead Market (under discussion in Swedish system)
HEDNO	Hellenic Electricity Distribution Network Operator S.A.
HEnEx S.A	The Hellenic Energy Exchange S.A
HLUC	High Level Use Case
HV	High Voltage
ICT	Information and Communication Technology
ID	Intraday

IEC	International Electrotechnical Commission
IHE	Integrating the Healthcare Enterprise
IPTO	(Greek) Independent Power Transmission Operator (=ADMIE)
KPI	Key Performance Indicators
LV	Low Voltage
mFRR	Manual Frequency Restoration Reserves
MOL	Merit Order List
MV	Medium Voltage
PO	Operation Procedure Document (orig. Procedimiento de Operación)
PPC	Public Power Corporation
PV	Photovoltaic
REE	Red Eléctrica de España
RES	Renewable Energy Source
RR	Replacement Reserves
SGAM	Smart Grid Architecture Model
SRA	Scalability and Replicability Analysis
SUC	System Use Case
SvK	Svenska Kraftnät
TSO	Transmission System Operator
UC	Use Case
WP	Work Package

1. Introduction

A Use Case (UC) describes a system in a technology-neutral way. This document presents Use Cases that identify activities and specifications of the grid operation at the border of the transmission and the distribution system, to be tested in the demonstrations. For this, it is needed to identify participating actors that can, for instance, be systems or human actors that are playing a role within the sequence of activities of the Use Case. Use cases can be specified on different levels of granularity. In this case, a specification is made at Business Use Case (BUC) level. These BUCs should identify the high-level requirements and processes related to business goals and services.

1.1. The CoordiNet project

The CoordiNet project is a response to the call LC-SC3-ES-5-2018-2020, entitled "TSO – DSO – Consumer: Large-scale demonstrations of innovative grid services through demand response, storage and small-scale generation" of the Horizon 2020 programme. The project aims at demonstrating how Distribution System Operators (DSO) and Transmission System Operators (TSO) shall act in a coordinated manner to procure and activate grid services in the most reliable and efficient way through the implementation of three large-scale demonstrations. The CoordiNet project is centred around three key objectives:

1. To demonstrate to which extent coordination between TSO/DSO will lead to a more economic, more reliable and more environmentally friendly electricity supply to the consumers through the implementation of three demonstrations at large scale, in cooperation with market participants.

2. To define and test a set of standardized products and the related key parameters for grid services, including the reservation and activation process for the use of the assets and finally the settlement process.

3. To specify and develop a TSO-DSO-Consumers cooperation platform starting with the necessary building blocks for the demonstration sites. These components will pave the way for the interoperable development of a pan-European market that will allow all market participants to provide energy services and opens up new revenue streams for consumers providing grid services.

In total, eight demo activities will be carried out in three different countries, namely Greece, Spain, and Sweden. In each demo activity, different products will be tested, in different time frames and relying on the provision of flexibility by different types of Distributed Energy Resources (DER). Figure 3 presents an approach to identify preliminary standardized products, grid services, and coordination schemes to incorporate them into the future CoordiNet platform for the realization of the planned demo activities[1].

[1] Considering that this Deliverable D1.5 is being published at an early stage of the project, these characteristics may change. Please refer to the latest CoordiNet deliverables for updated information.

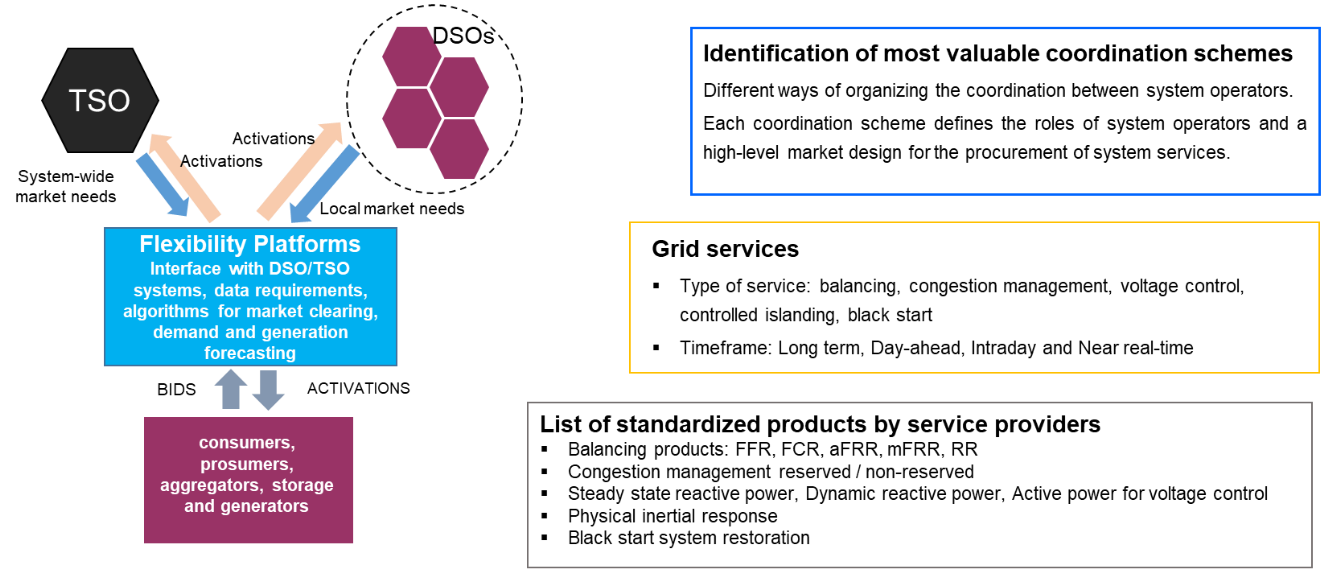


Figure 3: Overall CoordiNet approach (FFR: Fast Frequency Response, FCR: Frequency Containment Reserves, aFRR: automatic Frequency Restoration Reserves, mFRR: manual Frequency Restoration Reserves, RR: Replacement Reserves)

1.2. Scope and objective of the document

This deliverable D1.5: "Business Use Case: Business Use Case definition" includes the description of the Business Use Cases for each demonstration site according to the selected coordination schemes. The description is based on the IEC 62559 standard.

The scope of this document is to describe the BUCs definitions, actors, their functions and relations. It summarizes the activities in the task T1.5 of the CoordiNet Project and specifically aims at describing generic functional specifications of the grid services to be tested in the demonstrations in the form of BUCs. Task 1.5 forms the link between the CoordiNet coordination schemes and standardized products for grid services as identified in task 1.3 and the field demonstrations (Work Packages: WP3-WP5). Task 1.3 and task 1.5 therefore ran in parallel with close interaction between the tasks. For each demonstration, a separate Use Case is elaborated (also with respect to different coordination schemes and standardized products). The demo campaigns plan to test these identified Use Cases within the CoordiNet project.

The analysis includes:

- Description of the Use Case, in terms of coordination scheme, product for grid service, scope and objectives, involved assets and actors and the Use Case conditions
- Complete narrative of the Use Case (sequence of actions) and information exchanged
- Use case diagram showing the general architecture of the Use Case, including actors and sequence of messages exchanged between them to carry out the functionalities of the Use Case, i.e. procurement of products for grid services in a specific coordination scheme.

1.3. Structure

In Chapter 2, the Business Use Case Methodology is presented briefly. A template document has been created to collect the information on the Use Case goals of each demonstration campaign. This template is described in Section 2.4.

Chapter 3 lists the short narratives, scopes and objectives of each demonstration campaign of the demonstration sites in Greece, Spain and Sweden.

In Chapter 4 products, grid services and coordination schemes that have been identified and listed in D1.3 of this project are specifically mapped to the identified BUCs.

Chapter 5 concludes with the most important requirements for the BUCs and discusses the interconnection between the Use Cases.

2. Business Use Case Methodology

2.1. Motivation for the application of the Use Case methodology

A first step towards the realization of a project's goals is the definition of the Use Cases that will be addressed within the scope of the project. A Use Case, in fact, describes a system and its functionalities in static as well as dynamic aspects, defining the functional requirements for the business and functional layer. The static aspect concerns the actors related to the system, while the dynamic view is described through the relation between actors and the system by Use Cases.

Hence, the objective of Task 1.5 of the CoordiNet project is to describe generic functional specifications of the grid services to be tested in the demonstration sites in the form of Business Use Cases (BUCs), following the approach described in the IEC 62559 standard (Bleiker et al. 2013; VDE 2015). Such approach allows to describe Use Cases and their functionalities in a structured and organised way. This process is called Use Case Methodology and is specified by a template in the standard IEC 62559-2

The full standard template has eight sections, each of which provides information about the Use Case from different viewpoints:

1. Description of the Use Case,
2. Diagrams of the Use Case,
3. Technical details,
4. Step by step analysis of the Use Case,
5. Information exchanged,
6. Requirements,
7. Common terms and definitions,
8. Custom information.

For the definition of the BUCs in this report a shorter version of the Use Case description template, including only sections 1 and 2, is used. The Business Use Cases are, in fact, more abstract and do not include technical details.

The Business Use Cases analysis, carried out in Task 1.5 aims at providing:

D1.5 – Business Use Case definition

- A description of the high level Business Use Cases (subsections 3.X.Y.1[2]),

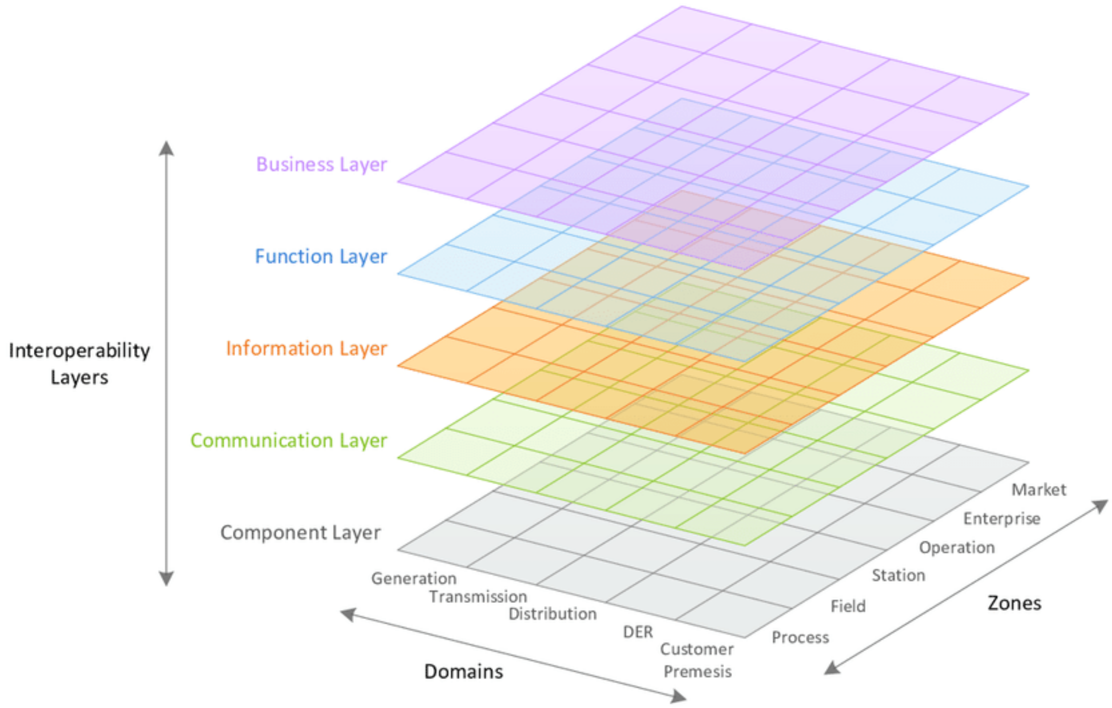
- A brief narrative of the Use Cases, describing the planned sequence of actions and , in case it is already known, which the information which is exchanged between actors (subsections 3.X.Y.2),

- The Business Use Case diagrams, showing the general architecture of the Use Cases, including actors and sequence of exchanged messages (subsections 3.X.Y.3),

- A mapping of the Business Use Cases to products, grid services and coordination schemes defined in Task 1.3 (chapter 4) (Vanschoenwinkel et al. 2019).

2.2. Description of the Use Case methodology

For better visualizing the Use Cases an architectural overview, which represents the various viewpoints described in the Use Cases, is needed. To this end the Smart Grid Architecture Model (SGAM) is used. The Model has been developed by the Smart Grid Coordination Group/Reference Architecture Working Group (SG-CG/RA) in the context of the European Commission's Standardization Mandate M/490 (CEN-Cenelec-ETSI Smart Grid Coordination Group 2012) as a holistic viewpoint of an overall architecture in the SmartGrid domain (Gottschalk et al. 2017).



[2] X depends on which demo the BUC refers to: Greece (1), Spain (2), Sweden (3)
Y varies from 1-4, since each demo presents four Business Use Cases

Figure 4: The Smart Grid Architecture Model (Gottschalk et al. 2017)

The five SGAM layers are labelled Business, Function, Information, Communication, and Component layer. The SGAM layers are defined (CEN-Cenelec-ETSI Smart Grid Coordination Group 2012; Gottschalk et al. 2017) as follows:

- The Business Layer depicts the business view regarding the information exchange within the Smart Grid. This view consists of regulatory and economic structures and policies, business models, and business portfolios as well as business capabilities. Further, it contains business processes for visualising business models and specific business projects to recognise and possibly to develop new models and projects, for instance single corporate goals like reducing the energy consumption.

- The Function Layer describes functions and services including their relations from an architectural view. These functions and services are derived from the business view and they are independent from involved actors and physical implementation in applications, systems and components, e.g. service platforms for the supplier change process.

- The Information Layer describes the used and exchanged information between actors (more precisely, systems and components). It includes the information objects and their canonical data models which represent the common semantic for functions and services to enable an interoperable exchange, e.g. CIM and EDIFACT for the data exchange of grid and customer data.

- The Communication Layer demonstrates protocols and mechanisms for an interoperable data exchange between components regarding functions or services and the corresponding information objects or data models, e.g. via TCP/IP and PLC.

- The Component Layer describes the physical distribution of all components in the Smart Grid context. This includes systems/components, applications, power system equipment, protection and tele-control devices, network infrastructure and any kind of intelligent devices, e.g. wind farms, Smart Meters, and voltage sensors.

A single layer of the SGAM is a two-dimensional plane which considers, on the one hand, the domains as the electrical energy conversion chain from generation to consumption, and on the other hand, the hierarchical zones for the management of electrical processes from market to process. It can be said, that the Smart Grid distinguishes between the electrical process and information management viewpoints in general. These domains and zones are also shown in Figure 4.

According to this concept, domains describe capacities which are physically related to the electric grid. The five domains of the SGAM are explained by (CEN-Cenelec-ETSI Smart Grid Coordination Group 2012) as follows:

- The energy conversion chain starts with the Generation of electrical energy in bulk quantities, like fossil, nuclear, and hydro power plants, off-shore wind farms, large scale solar power plants; which are typically connected to the transmission system.

- The Transmission represents the infrastructure and organisation which distributes the electricity over long distances between generation sites and cities where it is used.

- The Distribution represents the infrastructure and organisation which distributes electricity directly to customers.
- DER represent small power plants which are directly connected to the public distribution grid.
- The Customer Premises include normal consumers as well as producers in form of photovoltaic generation, electric vehicle storage, or micro turbines which are hosted by the distribution grid. The premises contain industrial, commercial and home facilities as consumers.

The zones describe the information management within the Smart Grid in a hierarchical manner. This concept considers the aggregation and functional separation in the power system management. Thereby, the data aggregation process concentrates data from the field in the station zone. The functional separation allows that different functions are assigned to specific zones. For example, reasons for a functional separation are the specific nature of functions and various user philosophies.

The zones of the SGAM are explained by (CEN-Cenelec-ETSI Smart Grid Coordination Group 2012) as follows:

- The Process includes physical, chemical and spatial transformations (e.g. electricity, solar, heat, etc.) of energy and the physical equipment that is directly involved, e.g. generators, transformers, cables.
- The Field includes the equipment to protect, control and monitor the process of the power system, e.g. controller and any kind of intelligent electronic device.
- The Station represents the aggregated level of the field zone, e.g. data concentrator, functional aggregation, and local SCADA systems.
- The Operation zone provides power system control operations in the respective domain, e.g. a distributed management system (DMS), an energy management system (EMS) in generation and transmission systems, as well as the management system for electric vehicle fleet charging.
- The Enterprise zone includes commercial and organisational processes, services and infrastructures for enterprises, e.g. asset management, logistic, customer relation management, billing and procurement.
- The Market reflects possible market operations along the energy conversion chain, e.g. energy trading.

Due to the connection between these three dimensions - layer, domains, and zones - the SGAM representation emerged allowing for the visualization of Use Cases according to the IEC 62559-2 template and some additional information, like the IHE profiles.

2.3. Using the Use Case Template according to IEC 62559 – A primer for CoordiNet

For complex systems as the aspects for TSO-DSO interaction in the scope of CoordiNet, the IEC Use Case methodology based on the IEC 62559 template supports the fostering of a common understanding of functionalities, actors and processes across different technical committees or even different organizations.

It resembles a classic requirement engineering approach and, thus, enables a common understanding between the partners of the system in the scope of the project. However, most approaches are not domain-driven, but rather method- driven as of now. With the stakeholder structure in place in the project, there is a need to align the wording for the process of requirements elicitation. This shall lead to a common structure which will support the continued use of the CoordiNet results in e.g. other H2020 projects as well as in standardization activities like the IEC SyC Smart Energy 62913 series providing best practices generic blue print Use Cases for utilities to implement.

In the following, the aspects of modelling the BUCs as well as the corresponding SGAM layer will be outlined. The BUC typically focuses on the early stages to identify a possible new business model or possible function which might be implemented. On the other hand, the so called System Use Case (SUC) exists, which is usually covering technical aspects of grid operation which are needed to the primary purpose of delivering electricity. Within the scope of BUCs, a top-down approach is usually conducted, thus, the SGAM is filled out with the business layer first.

This section details in depth what other information can be used and is modelled in the later architectural blue prints in an SGAM model. Due to the predefined structure, it also helps to ensure quality and to find relevant information for later systems engineering purposes.

In detail, the Use Case template comprised the following seven points:

- **Point 1: Overall Description of the Use Case.** This point provides an overall description of the Use Case, focusing on its objectives and scope; that is, mainly, which business case is to be resolved with this Use Case.

- **Point 2: Diagrams.** In this point experts and stakeholders create specific diagrams that facilitate the understanding of the Use Case to be defined. The IEC 62559 Use Case Template proposes typically two well-known diagrams for defining system requirements: the UML Use Case diagram and the UML Sequence diagram. Point 1 and 2 typically can also be considered as the agile User Story template in systems engineering and are detailed in later stages, when a consortium has agreed upon the Use Cases and business cases for later stages of the project to be implemented.

- **Point 3: Technical Details**. The technical details of the IEC 62559 template refer to: the list of actors /stakeholders involved in the Use Case and its business process, the events that trigger the Use Case to happen, the related standards and reports which provide context to the Use case, and key data for classifying and comparing Use Cases within the given scope of the CoordiNet project (keywords like work package, partner involved, etc.).

- **Point 4: Step by Step Analysis of the Use Case.** It details the sequence of activities required to realize the Use Case, typically being concise and consistent with the Sequence diagram but more detailed in terms of non-functional requirements.

- **Point 5: Information Exchanged.** This point summarizes the information exchanges between actors within the Use Case, typically focusing on the payloads and data objects exchanged in a process.

- **Point 6: (Non-functional) Requirements**. Describes the non-functional requirements of the steps defined in the Point 4 Step by Step Analysis of the Use Case.

- **Point 7: Common Terms and Definitions.** In this point experts can include specific terms key to understand the Use Case, thus, dealing with specific domain related vocabulary of partners involved which might not be familiar to other partners.

- **Point 8: Key Performance Indicators (KPI).** This point represents the Key Performance Indicators (KPI) that will be used to assess the solutions that realize the Use Case. One particular aspect is that in the literal sense, also metrics per se to assess the Use Case may be put here in the broader sense.

Based on the elicited Use Cases, starting with the business layer, more detailed SGAM models will be created in work package 2 (especially targeting point 5-7 above). The Project Report No. 1.6 is dedicated to thoroughly assessing point 8 (Trakas and Kleftakis 2019).

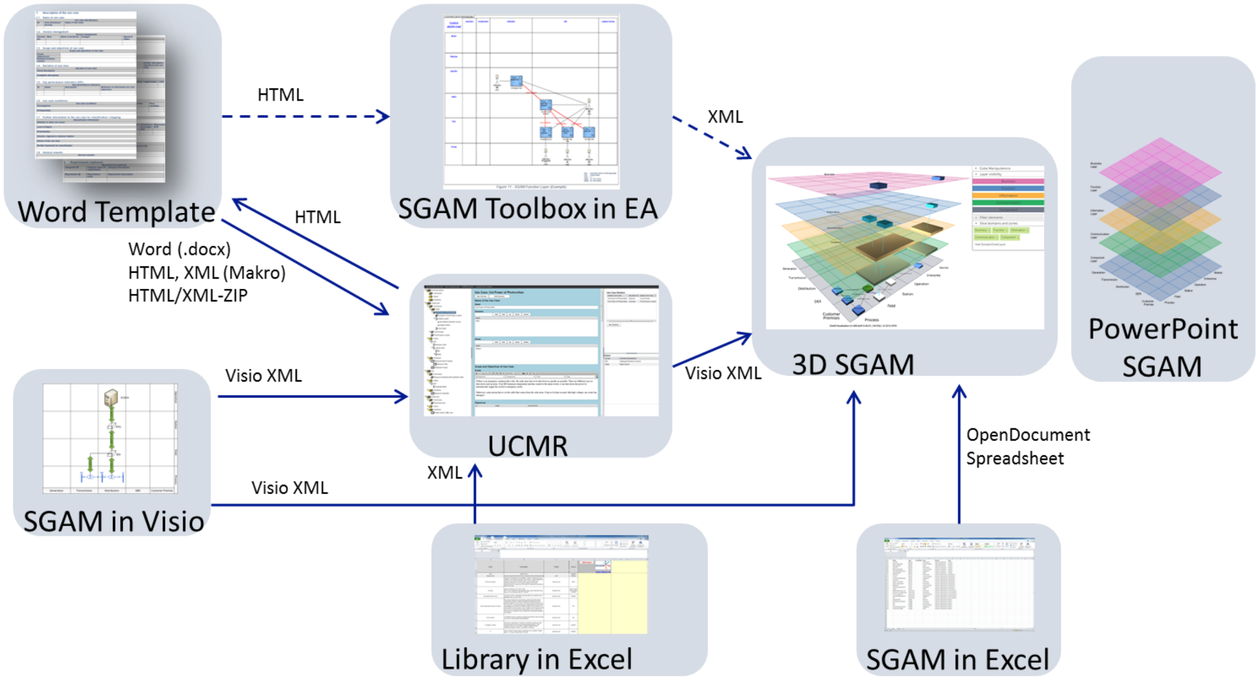


Figure 5: Tool chain for model driven development with Use Cases and SGAM

Figure 5 depicts a possible model-driven toolchain which can be used to derive SGAM models based on existing Use Cases from the IEC 62559 template. The main aim is to use preferably all documented information of the underlying project and develop a common agreement on terms, business cases, implementation at system level and to provide traceability throughout the whole process in the project. The work carried out in WP 1 will act as input and will be refined in WP 2.

The initial work done by the demos will be the starting point to incorporate the envisioned demos into the overall system architecture process, finding similarities and differences between them as well as to finally provide a SGAM to achieve a standardized big picture for CoordiNet.

2.4. Presentation of the project specific, modified Use Case template

In the following, the template is presented which has been used to communicate the BUC perspective, scope and narratives. Each template provides a section in which the authors can indicate more information about their person, organisation or e.g. standardization committee that they are representing. Thus, their role in the BUC is revealed which is important to understand the underlying perspective to the BUC creation. The system and market roles play a significant role in a later stage of the BUC, where the responsibilities and information exchange between different parties is detailed out.

Therefore, in the first part, the authors indicate which perspective is represented in the description of the narrative. The following scope and specifically the objective will depend on the business interest of the different roles and players, such as, DSOs, TSOs, Regulators, Aggregators, Large Generator Operators, etc.

Table 2: Classification of the BUC perspective

PLEASE FILL OUT ONE TEMPLATE FOR EACH IDENTIFIED USE CASE. IN CASE THAT DIFFERENT PERSPECTIVES REQUIRE SEPERATE DOCUMENTS PLEASE INDICATE YOUR VIEWPOINT FOR THIS USE CASE:
☐ DSO ☐ TSO ☐ REGULATOR ☐ Other

2.4.1. BUC Identification

In the next step, the authors are asked to determine a Use Case naming. This should be short but still cover the main method to achieve the business objectives, such as “voltage control to solve voltage violations in the distribution system due to DER in sparse grid segments”.

Table 3: Introductory section of the BUC template

Name of UC: Enter a short name that refers to the activity of the UC itself.
Name Author(s) or Committee: Person or e.g. standardization committee like Smart Grid Technical Committees or Working Group, if applicable.

2.4.2. Scope and objectives

In this following section the authors briefly describe which aspects they are interested in, what they are going to test and especially why they are interested in being active in this area.

Table 4: Objective section

Scope: Describe briefly the scope, objectives, and rationale of the UC. You can additionally use the tick boxes to specify the voltage level and markets that are subject to this Use Case.
Objective: Describe briefly the objective of the UC.

2.4.3. Narrative of the BUC

In the narrative part, the authors focus on a clear description of the main activities, and processes with a high level step by step representation of the activities of the players that are active and crucial for the realization of the BUC.

Table 5: Section for the BUC narrative

Short Description: A short narrative focusing on the question what is done in the scope of the use case. This is meant to create a brief overview.
1.

2.4.4. Further Details (Optional)

The previous section should reveal which actors are active, what kind of roles are represented and which markets are targeted. This last section, here below, adds to this and validates and gives an overview whether the narrative covers the intended markets and market players. Revealing these further details is optional for the authors.

Table 6: Details section: Selection of actors, roles, and markets

Actors&Roles, Names and Types: Please indicate which actors contribute to the Use Case in the sense of providing inputs/outputs, processing or aggregation. In case the writer of the Use Case defines an own actor, the actor shall be classified and shortly described.
☐ DSO ☐ TSO ☐ END CUSTOMERS (MV/LV) ☐ DER CUSTOMERS ☐ REGULATOR ☐ MUNICIPALITY/LOCAL AUTHORITY ☐ AGGREGATOR/FLEXIBILITY OPERATOR ☐ BALANCE RESPONSIBLE PARTY ☐ SERVICE PROVIDER ☐ Other: Specific Roles (if applicable) ☐ SYSTEM OPTIMISER ☐ DATA MANAGER ☐ SMART GRID OPERATOR ☐ NEUTRAL MARKET ENABLER ☐ CONSTRAINTS MARKET OPERATOR ☐ CUSTOMER RELATIONSHIP MANAGER ☐ OTHER 3RD PARTIES RELATIONSHIP MANAGER ☐ SYSTEM SECURITY MANAGER ☐ OTHER

2.5. Graphs

After the collection of the completed templates, one next step is to visualize the information given in the part concerning the scope. In overview diagrams each active role is represented and clustered with respect to their objectives in the particular BUC. In addition, high level information flows are represented in the overview diagram.

The information for the Sequence diagrams are taken from the narrative part of the filled templates. In the Sequence diagrams the processes are sorted with respect to their domains and their sequence in time.

3. Business Use Cases for demonstration campaigns

This chapter will provide the Business Use Case description for each demo site, according to the Use Case template presented in chapter 2.

The targeted domains are: TSO-domain, DSO-domain, a joint CoordiNet platform domain, as well as a flexibility service provider (FSP) domain, which can be divided into FSP on the transmission and distribution level. The role of the CoordiNet platform and the FSPs are very much comparable in all BUCs and demo sites, while the every-day operation and mechanisms of TSOs and DSOs differ. Therefore each of the latter two domains are described separately for each demo (see sub sections 3.1, 3.2, and 3.3).

Until recently, the distribution networks developed slowly and operated with a uni-directional power flow. Today, rapid developments can be seen in most of the distribution systems, which jeopardizes the possibility of long-term planning for new investments. This former slow-paced approach is expected to change due to the requirements of the Clean Energy Package as referred to in CoordiNet D1.1 (Lind and Ávila 2019). The change will require an active role of DSOs and the establishment of procedures to manage (frequent) congestions at DSO networks.

CoordiNet platform[3]

The CoordiNet platform is intended to form an interface that manages different interactions between the TSO, DSOs and FSPs and coordinates the different functions necessary to perform the Use Cases. The consideration of ownership of the platform and the governance structure is out of the scope of the CoordiNet project.

The focus of CoordiNet is to define the roles and functions that such a platform may have. Some of the relevant functions to be performed by the platform include: data exchange between actors related to market bids, technical limitations on networks, market clearing functions, communication of market results, submitting activation bids to service providers and grid operators. All these functions will be described in detail for each of the Business Use Cases (BUC).

FSP

FSP, the agents providing flexibility, may be connected to the distribution or to the transmission grids. The FSP can be a direct owner of flexible resources participating in the provision of the grid services or an intermediary such as independent aggregator or a retailer that represents flexible resources and coordinates their response. Therefore, flexible resources can include DERs and centralized resources connected at transmission network, although the main focus is on DER and the need to aggregate these resources as this is a novel function in the current system.

[3] Due to operational constraints and the market framework that the consortium faces today and within the scope of the project, some operations which should fall into the domain of the CoordiNet platform operator (such as market clearing), are directly allocated to either the TSO or DSO.

As defined in the CoordiNet deliverable D1.1 (Lind and Ávila 2019), DER is a concept used to encompass the multiple types of end-users connected to the distribution grid, capable of providing energy and/or services to the grid by mobilizing the flexibility they have available. The DER falls within the concept of the energy resources, in general meaning all those users that may provide services to the grid or system. Four different types of DER have been identified. Firstly, generators connected to the distribution grid or to the consumer who must be supplied, which are termed Distributed Generation (DG) (G.B. Gharehpatian and S. M. Mousavi Agah 2017). Secondly, the active demand, that is also considered a DER, named Demand Response (DR). Thirdly, storage systems, named Energy Storage Systems (ESS). In this category, batteries are also included. Finally, electric vehicles (EVs), that act as a type of ESS with some specific features. Due to their potential importance and connection availability, EV is considered separately from ESS.

It is also important to consider at which voltage level in the distribution grid the resources are connected. For example, a DG connected at the distribution high-voltage (HV)[4] level could be a wind farm of 10MW of installed capacity, while a DG connected at the low-voltage (LV) level can be a rooftop solar panel system with an installed capacity of 10kW or less. Therefore, these two DGs are clearly very different. The same can be said for DR being provided by a residential consumer or a large industrial consumer. Figure 6 summarizes the general definition of DER.

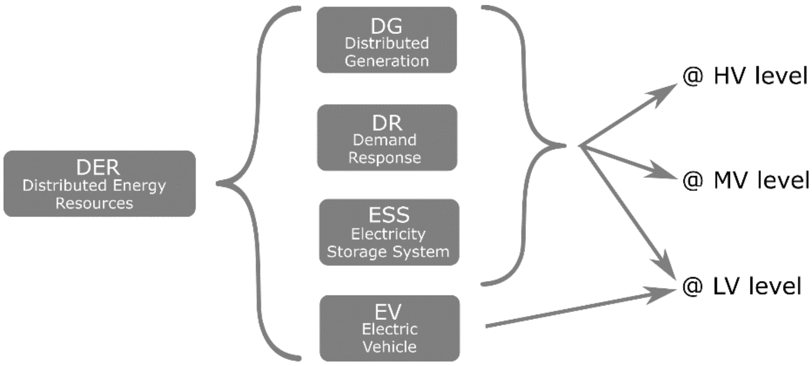


Figure 6: Classification of DER according to their nature and voltage level

More active participation of DER in e.g. the congestion management market, as well as more frequent procurement of flexibility by DSOs require a redesign of the current congestion management market and operational procedures. In addition, aggregated DER could also provide grid services such as voltage control, balancing, etc.

[4] In Europe, most DSOs also operate HV networks (Eurelectric, 2013). In general, distribution networks operate LV (<1kV), MV (typically 15, 20kV), HV (45, 66, up to 132kV), while TSOs operate Extra-High Voltage (EHV, typically 220, 275, 400kV). These boundaries, however, change from country to country. For details, please refer to (Eurelectric, 2013).

3.1. Greek demonstration BUCs

The BUCs of the Greek demo consider four differentiated domains: the TSO, the DSO, the CoordiNet platform and the FSP. The specific roles and activities of the TSO and DSO in the Greek system are described below:

Greek TSO

The Independent Power Transmission Operator (IPTO or ADMIE[5]) is responsible for the operation of the electricity transmission grid in Greece with over 11 thousand km of system covering the whole of mainland Greece and an increasing portion of the Greek Islands. IPTO undertakes the role of TSO for the Hellenic Electricity Transmission System and as such performs the duties of System operation maintenance and development so as to ensure Greece's electricity supply in a safe, efficient and reliable manner.

Due to the fact that the Greek energy market is still centralized, only the day-ahead market exists. Hence, the Greek electricity market operates as a mandatory pool in which scheduled demand and supply (production and imports) are matched exclusively on a day-ahead market with the closure time being 12:00 of the previous day. The Hellenic Energy Exchange S.A. (HEnEx S.A.), the Market Operator in Greece, is in charge of day-ahead scheduling (DAS) and settles the day-ahead energy market based on the system marginal price, which is comparable to a day-ahead price as commonly used elsewhere in the EU.

There is no separate balancing market. Instead, IPTO clears the imbalance of the DAS through a special imbalance settlement mechanism in which deviations from the DAS are charged or compensated for, based on the imbalance price. In Greece, the TSO is also responsible for the dispatch schedule, for real-time dispatch instructions, and for the settlement of all other charges or payments in the system.

In the existing market, IPTO provides ancillary services only for balancing purposes. There are three reserves related to that service:

- the primary reserve (FCR), which is utilized for frequency containment,
- the secondary reserve (aFRR and mFRR), which is provided for frequency restoration and,
- the tertiary reserve (RR), which is utilized for reserves replacement.

The transition of the Greek energy market to the target model is ongoing. It is expected that by the end of 2019 the Greek energy market would comprise four markets: forward, day-ahead (DA), intraday (ID) and the balancing market. IPTO would be responsible only for the balancing market.

Greek DSO

[5] Abbreviated form, derived from the Greek translation of the word independent transmission system operator for electrical energy, orig. ΑΔΜΗΕ

The distribution network of Greece is operated by HEDNO (Hellenic Electricity Distribution Network Operator S.A.). HEDNO was formed by the separation of the Distribution Department from the Greek national Public Power Corporation (PPC) S.A., in compliance with 2009/72/EC EU Directive related to the electricity market. It is a 100% subsidiary of PPC, however, it is independent in operation and management retaining all the independence required by the above mentioned legislative framework. HEDNO's tasks include the operation, maintenance and development of the power distribution network in Greece, as well as the assurance of a transparent and impartial access of consumers and of all network users in general.

Some of the key figures of the Greek distribution network operated by HEDNO are listed below:

- 238.242 km of Network in total
- 111.865 km of Medium Voltage Network (MV).
- 126.377 km of Low Voltage Network (LV).
- 162.614 Substations of Medium/LV.
- 989 km High Voltage Network (HV) of which the 218 km are on the Attica peninsula (covering also the capital region of Athens) and the 771 km in the non-Interconnected islands
- 232 High/MV Substations of which 20 are closed type substations within the Greek territory, 202 are located within the Interconnected System and 27 in the non-Interconnected islands.
- 7.486,139 Customers (11.536 M.V. and 7.474,603 LV).
- 43.918 GWh Customers' consumptions (11.557 in M.V. and 32.361 in LV).

This chapter lists the BUCs that will be tested in the Greek demonstration campaign.

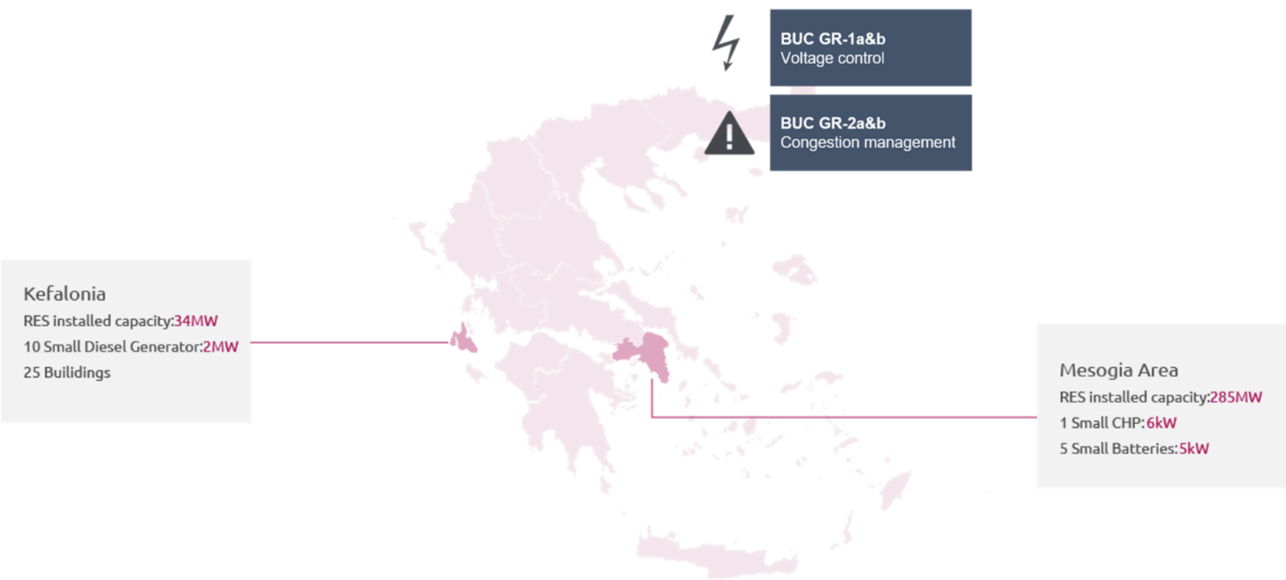


Figure 7: Map of Greek Demo Areas

All the BUCs will be tested in Kefalonia, while in Mesogeia area only BUCs GR-1a and BUCs GR-1b will be tested.

In Kefalonia and Mesogeia Area, over-voltages are mainly detected due to the increased penetration of RES, especially during the hours of low consumption. In Kefalonia, congestions are also detected due the increased penetrations of RES. Furthermore, the N-1 criterion (failure of primary substation) should be satisfied for the reliable power supply of the customers in Kefalonia. Due to the continuous increase of RES installation, voltage violations and congestions are expected to increase the next years. In order to avoid investment to upgrade the system, better use of flexibility is required.

The demos related to the BUCs that will be tested in Kefalonia will include renewable generators, large generators, aggregators, consumers and backup generators, while the demos related to the BUCs that will be tested in Mesogeia will include aggregators, consumers, renewable generators and other flexibility providers.

3.1.1. BUC GR-1a: Voltage Control – Multi-Level Market Model

3.1.1.1. Scope and objectives

This BUC describes the actions that are carried out in case of anticipated voltage violations in transmission and distribution system in order to keep the voltage level in acceptable boundaries. Flexible resources connected to the transmission and distribution system can provide flexibility to system operators to eliminate voltage violations through a market mechanism. Active and reactive power control is considered.

Three different markets will be examined depending on the time frame. These markets are

- Day Ahead (DA)
- Intraday (ID)
- Near Real Time

The voltage control shall be local as voltage is a local need for power grids. This is an important activity that is likely performed on a permanent basis to keep the grid voltage within normal ranges.

In addition, it has to be ensured that the activation of flexible resources in the distribution network by the TSO would respect distribution system constraints. A Cooperation and information exchange between the DSO and TSO are crucial for eliminating voltage violations in the most efficient way, while respecting distribution and transmission system constraints.

The objectives of this BUC are the following:

- To ensure non-discriminatory access to the market for all agents that provide grid services.

- To enable coordination and information exchange between system operators in order to improve efficiency of the system.
- To enable the TSO to use the flexibility provided by the resources connected to the distribution system for voltage control, while respecting distribution system constraints.
- To ensure a secure operation of the transmission and distribution system.
- To minimize RES curtailment due to security reasons.

3.1.1.2. Short narrative and BUC overview

The BUC describes the steps that are followed to eliminate voltage violations in the transmission and distribution system using flexibility provided by resources connected to both systems. The voltage level in transmission and distribution systems is permanently assessed and monitored by the TSO and DSO respectively, in order to decide on actions for keeping voltages of their systems within the admissible range.

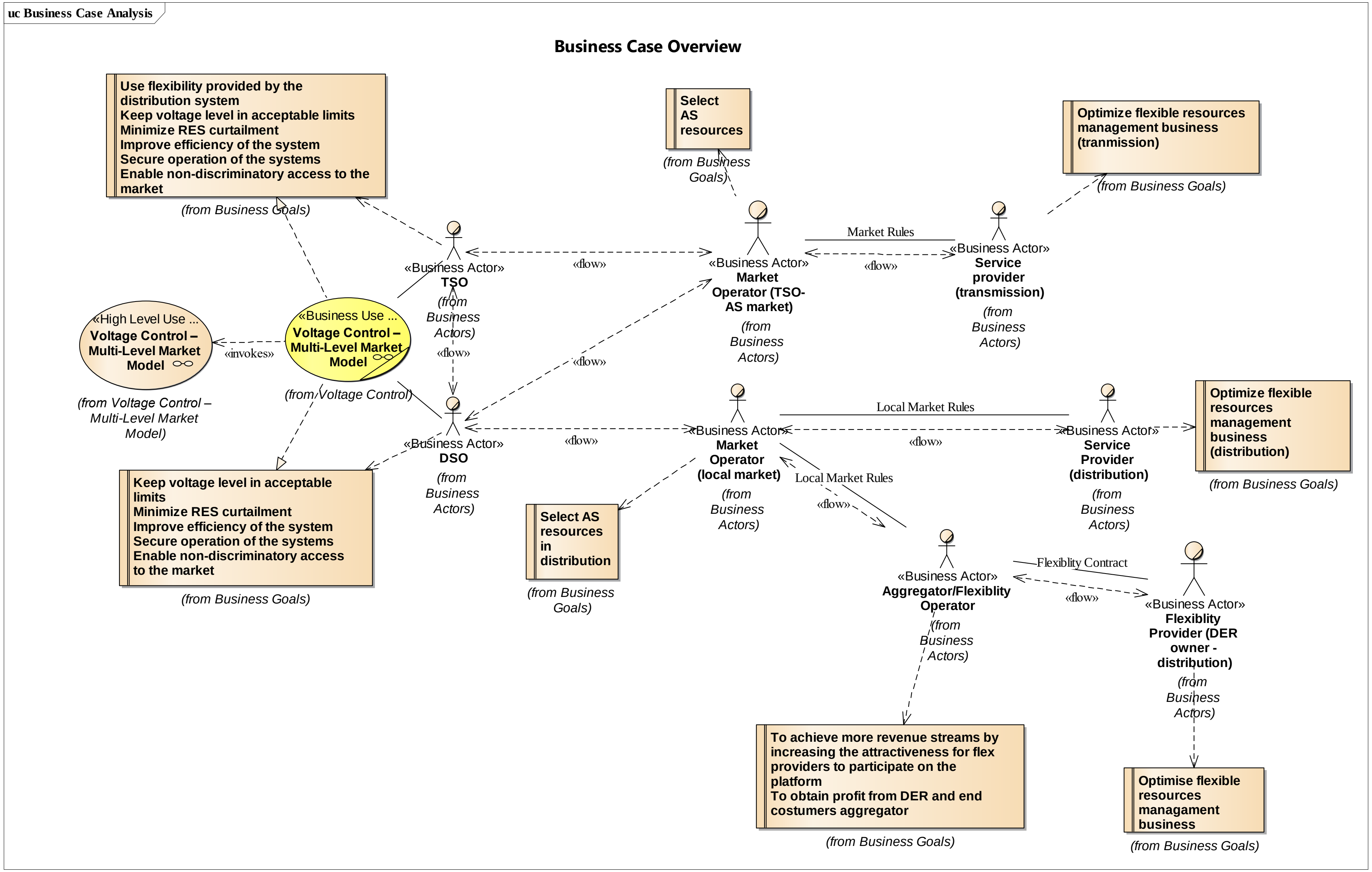


Figure 8: BUC GR-1a Overview: Voltage Control- Multi-Level Market Model

3.1.1.3. Sequence Diagram

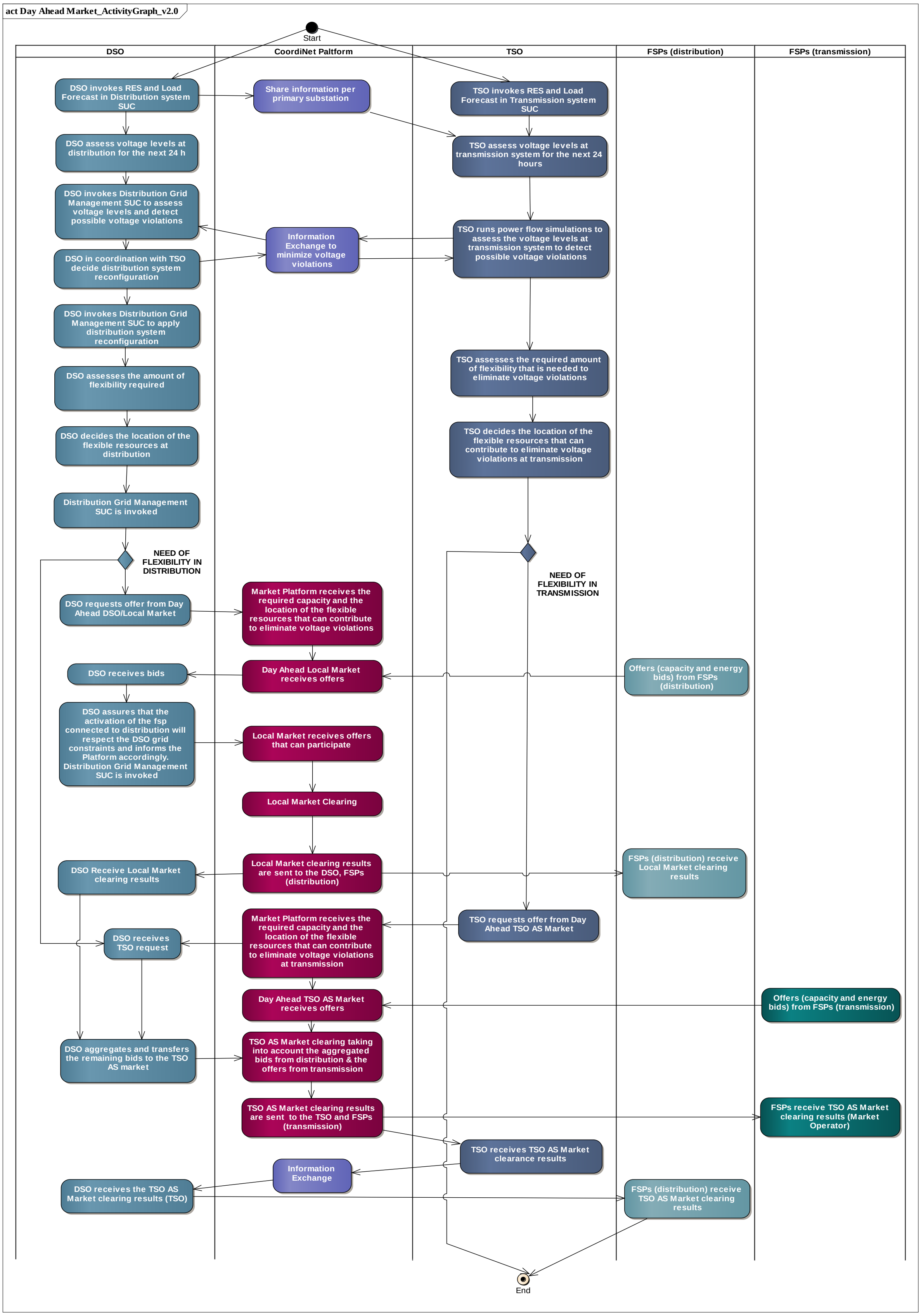


Figure 9: GR-1a Sequence Diagram – DA Process

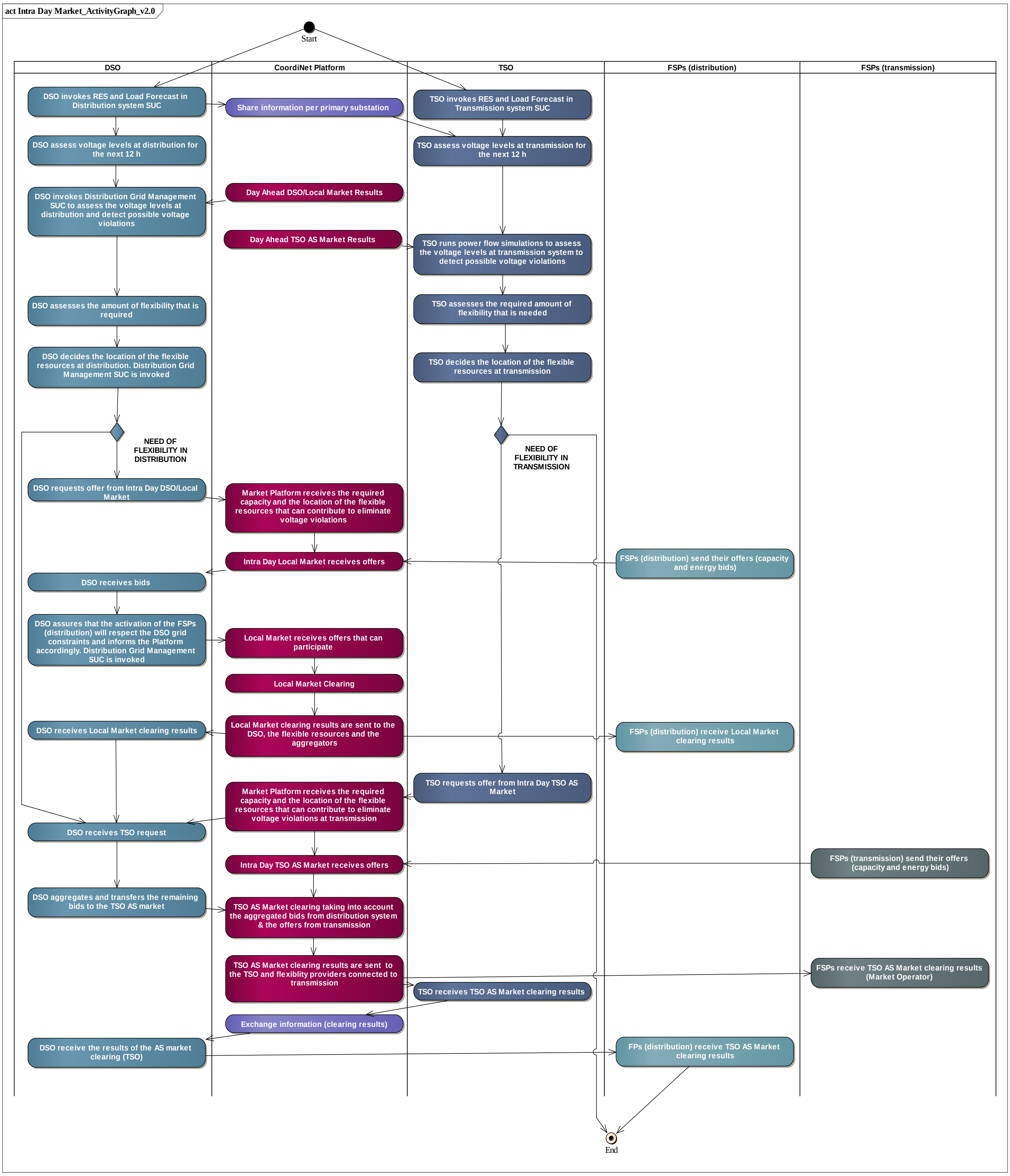


Figure 10: GR-1a Sequence Diagram – ID Process

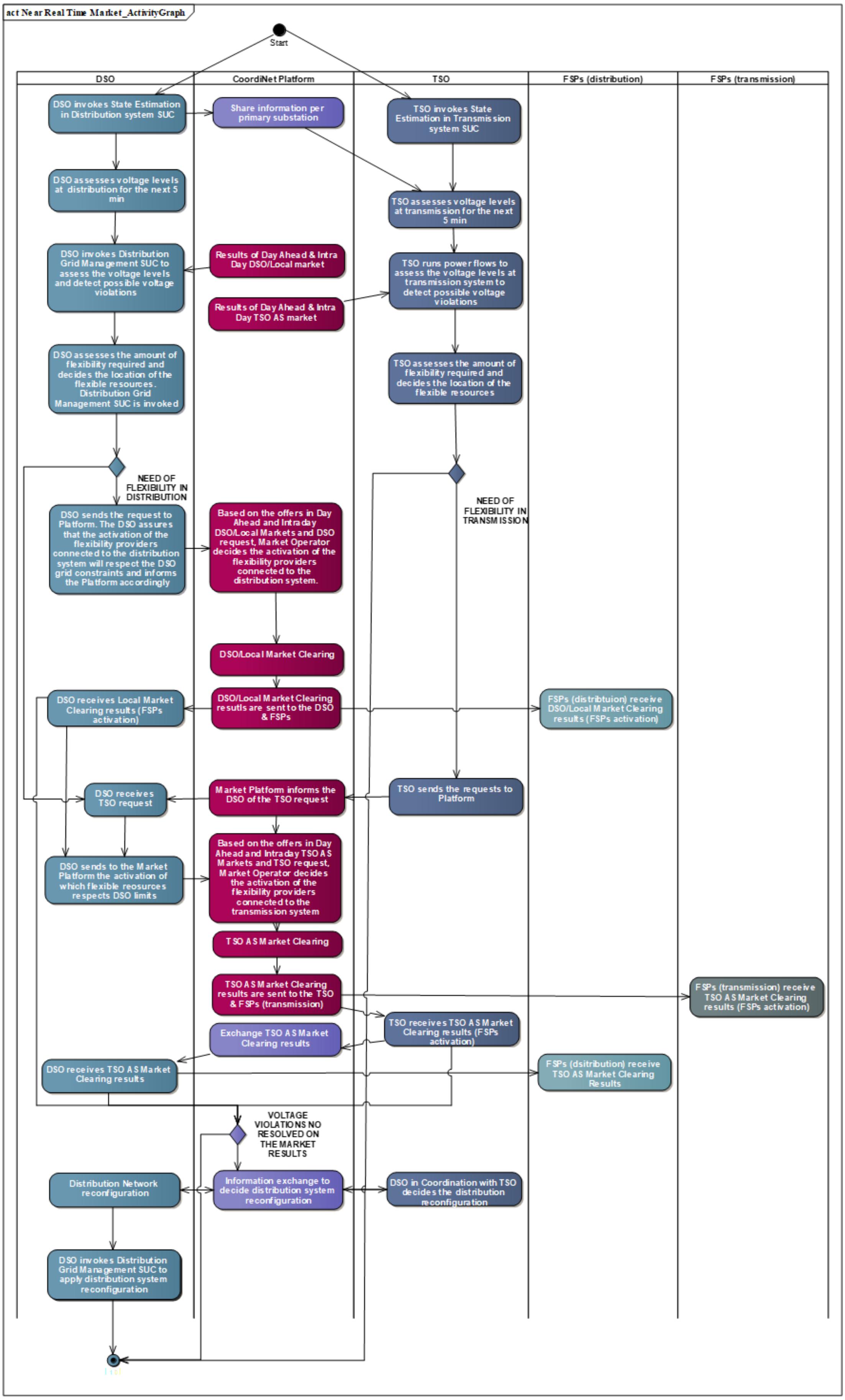


Figure 11: GR-1a Sequence Diagram - Near Real Time Process

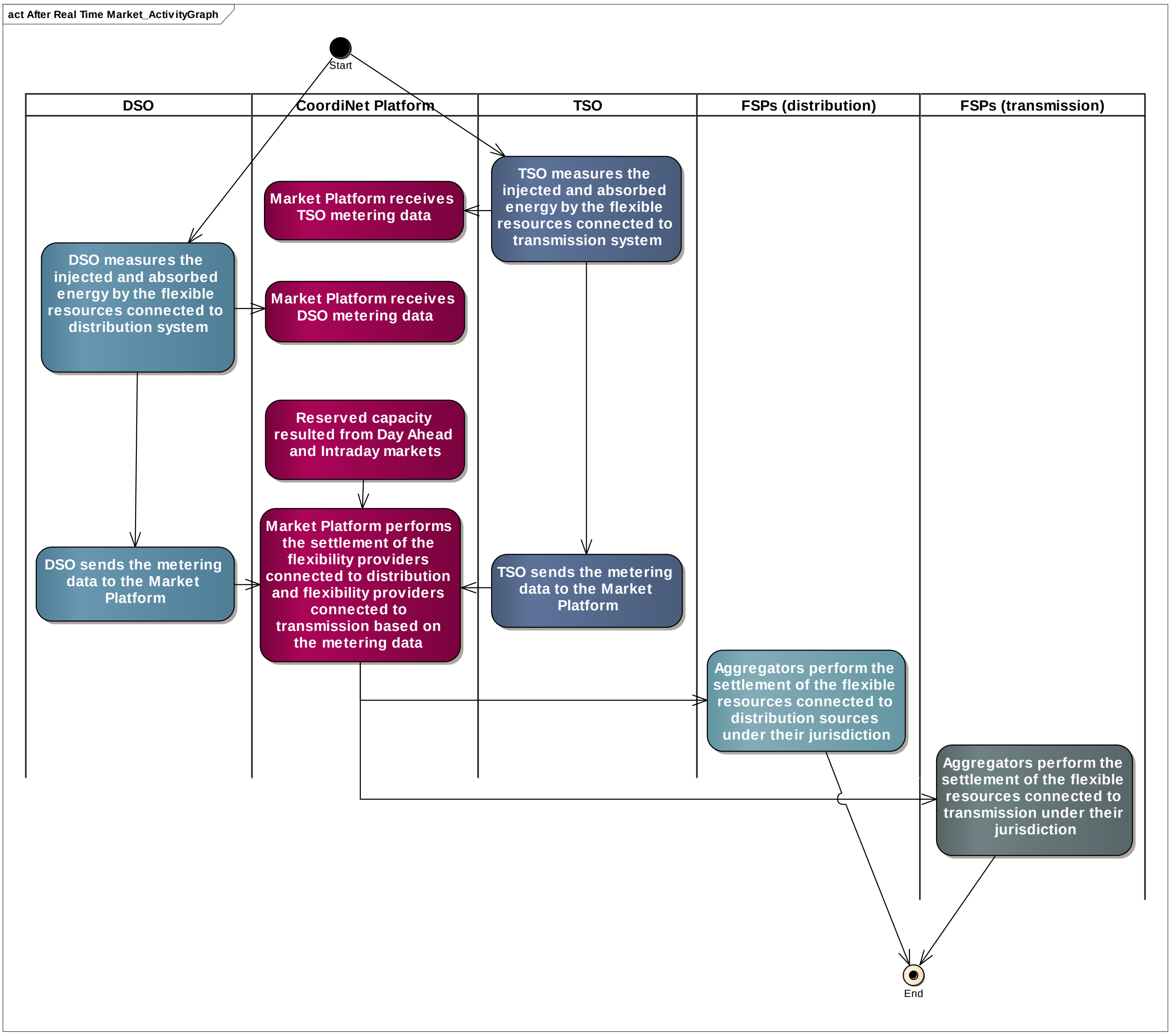


Figure 12: GR-1a Sequence Diagram - After Real Time Process

3.1.2. BUC GR-1b: Voltage Control – Fragmented Market Model

3.1.2.1. Scope and objectives

This BUC describes the actions that are carried out in case of anticipated voltage violations in transmission and distribution system in order to keep the voltage level in acceptable boundaries.

The flexible resources connected to the transmission system can provide flexibility only to the TSO and the flexible resources connected to the distribution system can provide flexibility only to the DSO. The TSO and DSO cooperate to decide on the power exchange between them. In order to do so, the TSO and DSO take into account the voltage level of the bus bars in the transmission and distribution system, respectively.

Three different markets are examined depending on the time frame. These markets are:

- DA
- ID
- Near Real Time

The voltage control shall be local as voltage is a local need for power grids. This is an important activity that is likely performed on a permanent basis to keep the grid voltage within normal ranges.

A Cooperation and information exchange between the DSO and TSO are crucial for eliminating voltage violations in the most efficient way, while respecting distribution and transmission system constraints.

The objectives of this BUC are the following:

- To ensure non-discriminatory access to the market for all agents that provide grid services.
- To enable coordination and information exchange between system operators in order to improve efficiency of the system.
- To ensure a secure operation of the transmission and distribution system.
- To minimize RES curtailment for security reasons and due to operational limits.

3.1.2.2. Short narrative and BUC overview

The BUC describes the steps that are followed to eliminate voltage violations in the transmission and distribution system when the DSO can use flexible resources connected to the distribution system and the TSO can only use flexible resources connected to the transmission system. The voltage level in transmission and distribution systems is permanently assessed and monitored by the TSO and DSO respectively, in order to decide on actions for keeping voltages of their systems within admissible range.

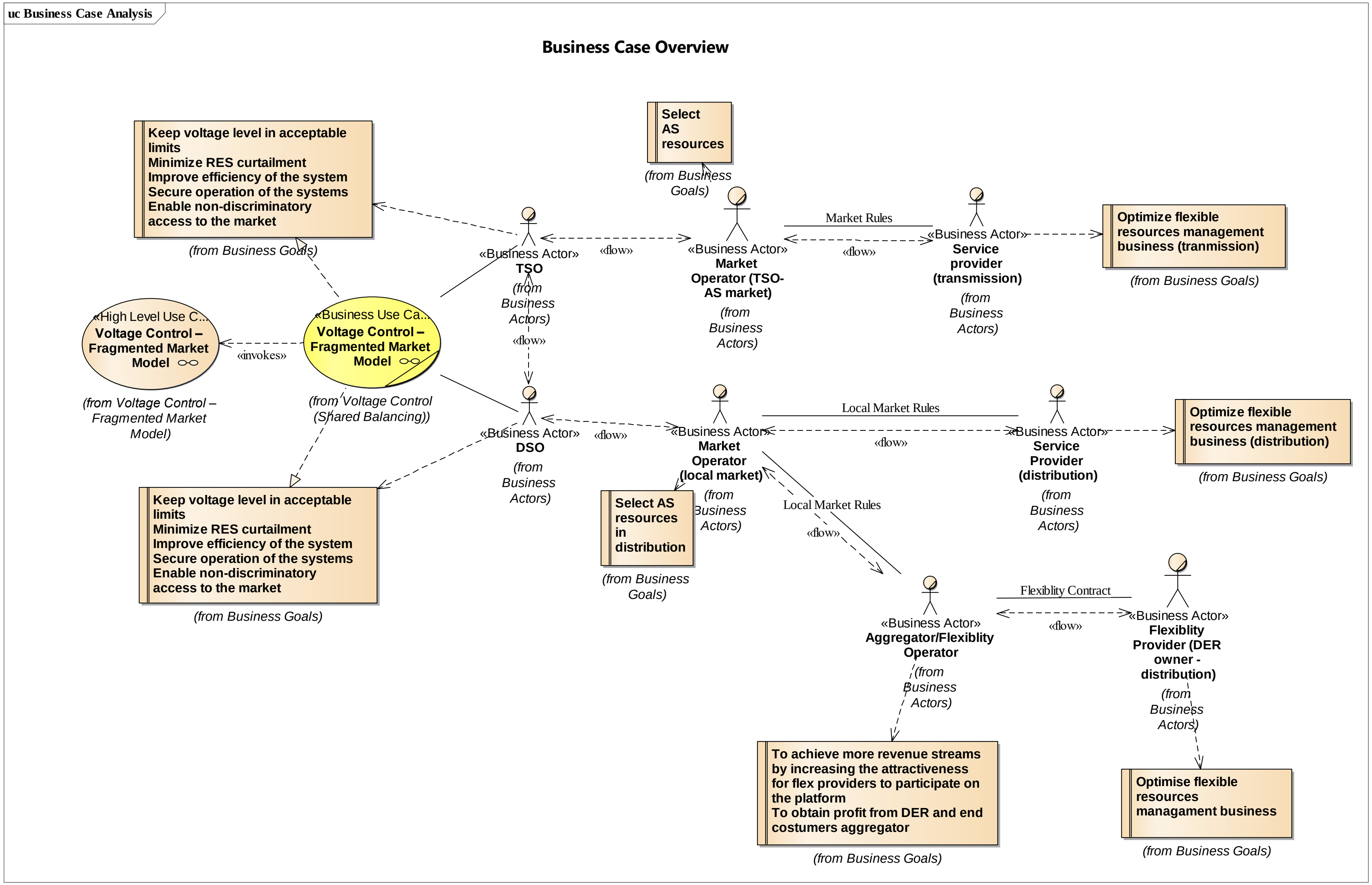


Figure 13: BUC GR-1b Overview: Voltage Control - Fragmented Market Model

3.1.2.3. Sequence Diagram

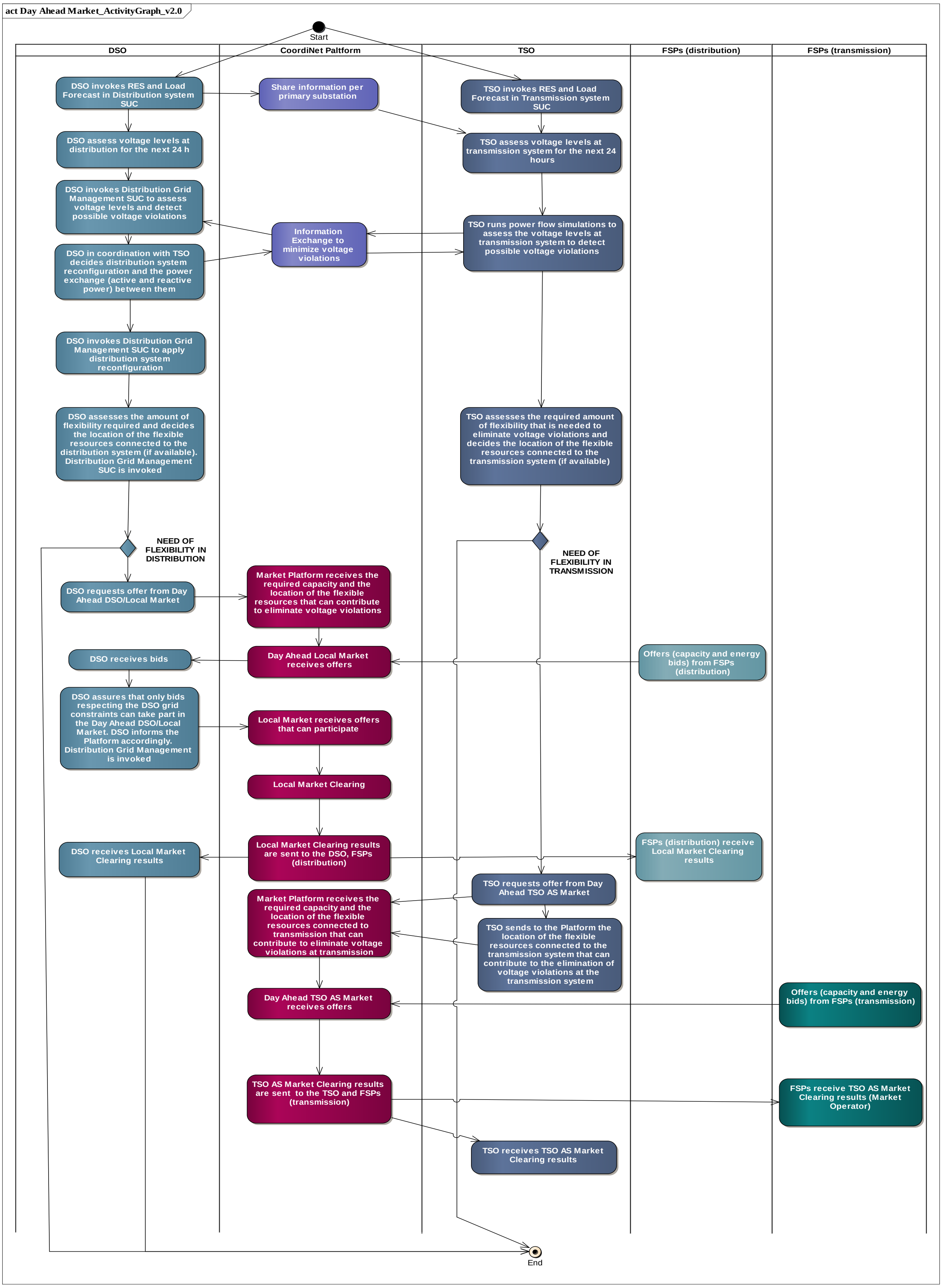


Figure 14: GR-1b Sequence Diagram - DA Process

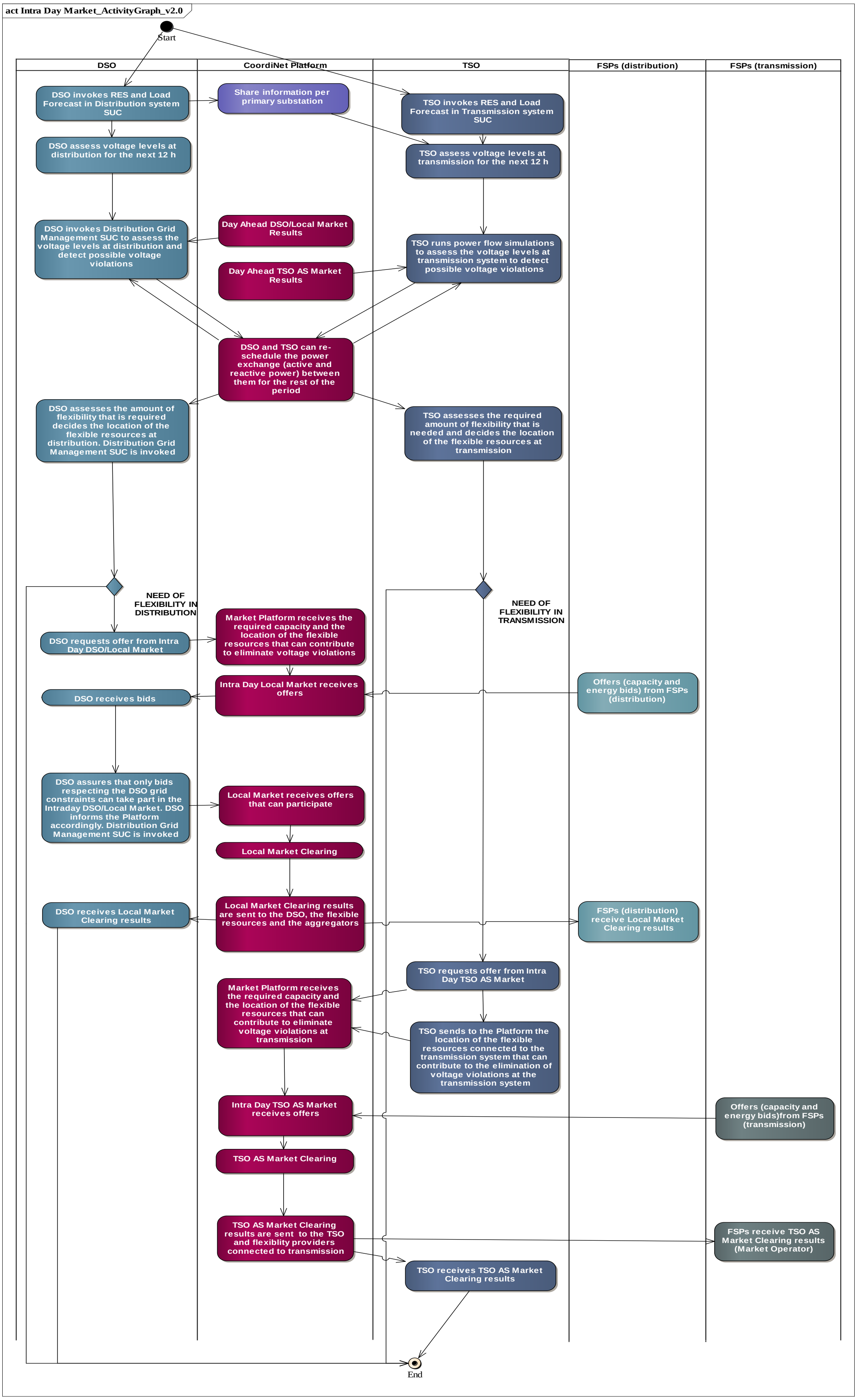


Figure 15: GR-1b Sequence Diagram – ID Process

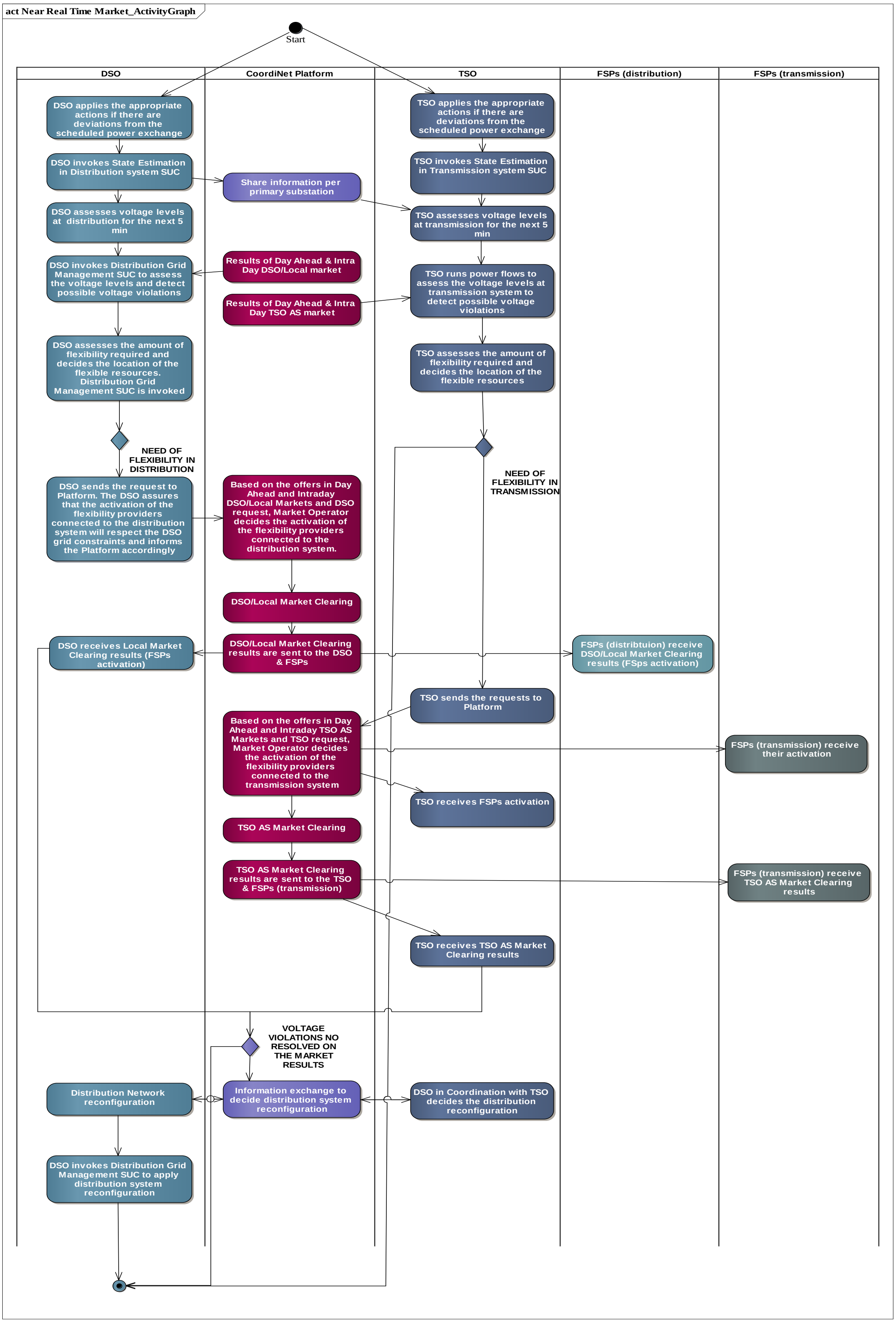


Figure 16: GR-1b Sequence Diagram - Near Real Time Process

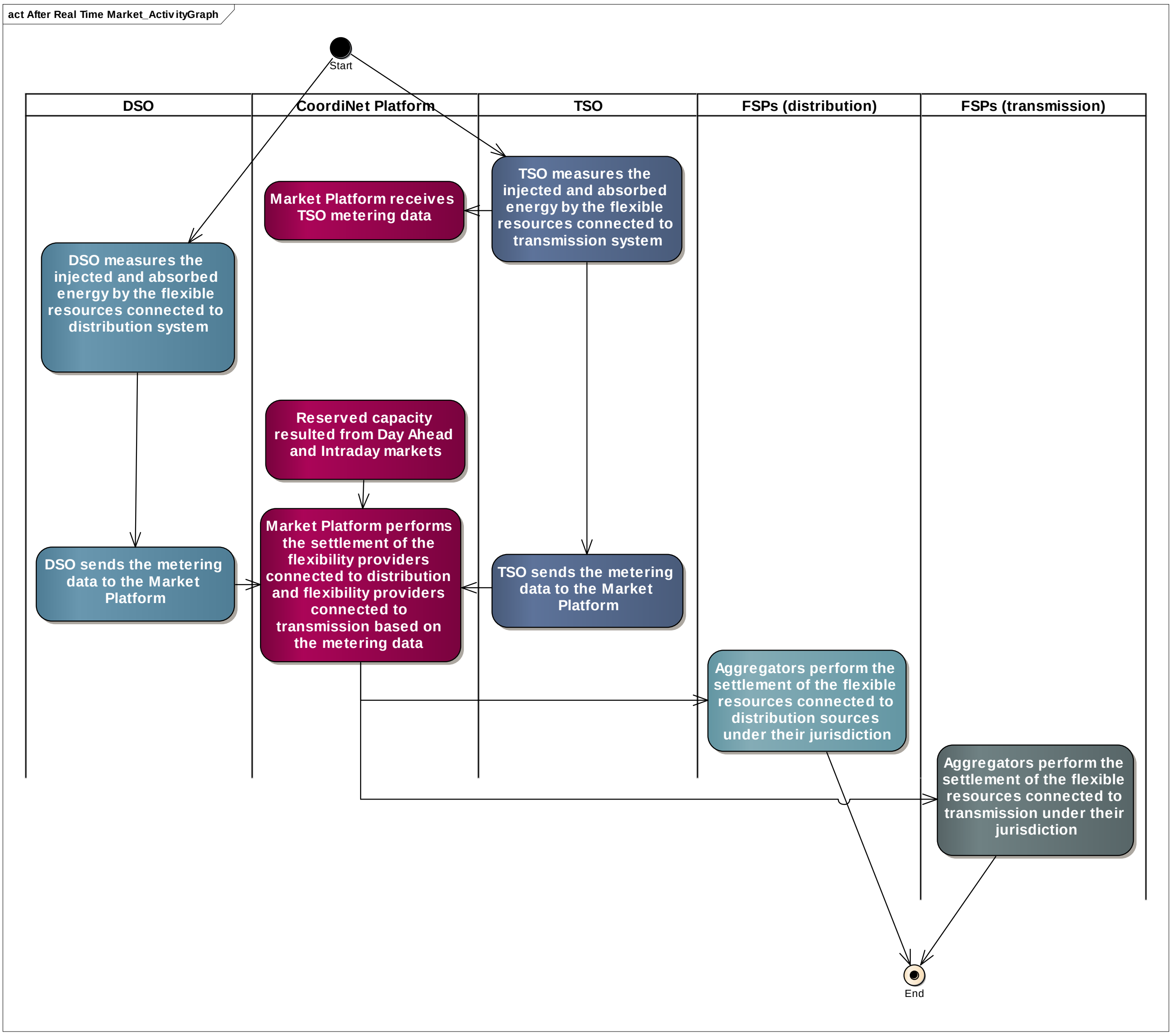


Figure 17: GR-1b Sequence Diagram - After Real Time Process

3.1.3. BUC GR-2a: Congestion Management – Multi-level Market Model

3.1.3.1. Scope and objectives

This BUC describes the actions that are carried out in case of anticipated congestions in the transmission and distribution system in order to keep power flows in the accepted thermal limits of the lines and the transformers. Flexible resources connected to the transmission and distribution system can provide flexibility to system operators to eliminate congestions through a market mechanism. Active and reactive power control is considered.

Three different markets will be examined depending on the time frame. These markets are:

- DA
- ID

- Near Real Time

In addition, it has to be ensured that the activation of flexible resources in the distribution network by the TSO would respect distribution system constraints. A cooperation and information exchange between the DSO and TSO are crucial for eliminating congestions in the most efficient way, while respecting distribution and transmission system constraints.

The objectives of this BUC are the following:

- To ensure non-discriminatory access to the market for all agents that provide grid services.
- To enable coordination and information exchange between system operators in order to improve efficiency of the system.
- To enable the TSO to use the flexibility provided by the resources connected to the distribution system for congestion management, while respecting distribution system constraints.
- To ensure a secure operation of the transmission and distribution system.
- To minimize RES curtailment due to security reasons.

3.1.3.2. Short narrative and BUC overview

The BUC describes the steps that are followed to eliminate congestions in the transmission and distribution system using flexibility provided by resources connected to both systems. The power flows in the transmission and distribution system are permanently assessed and monitored by the TSO and DSO respectively, in order to decide on actions for keeping them within the acceptable thermal limits.

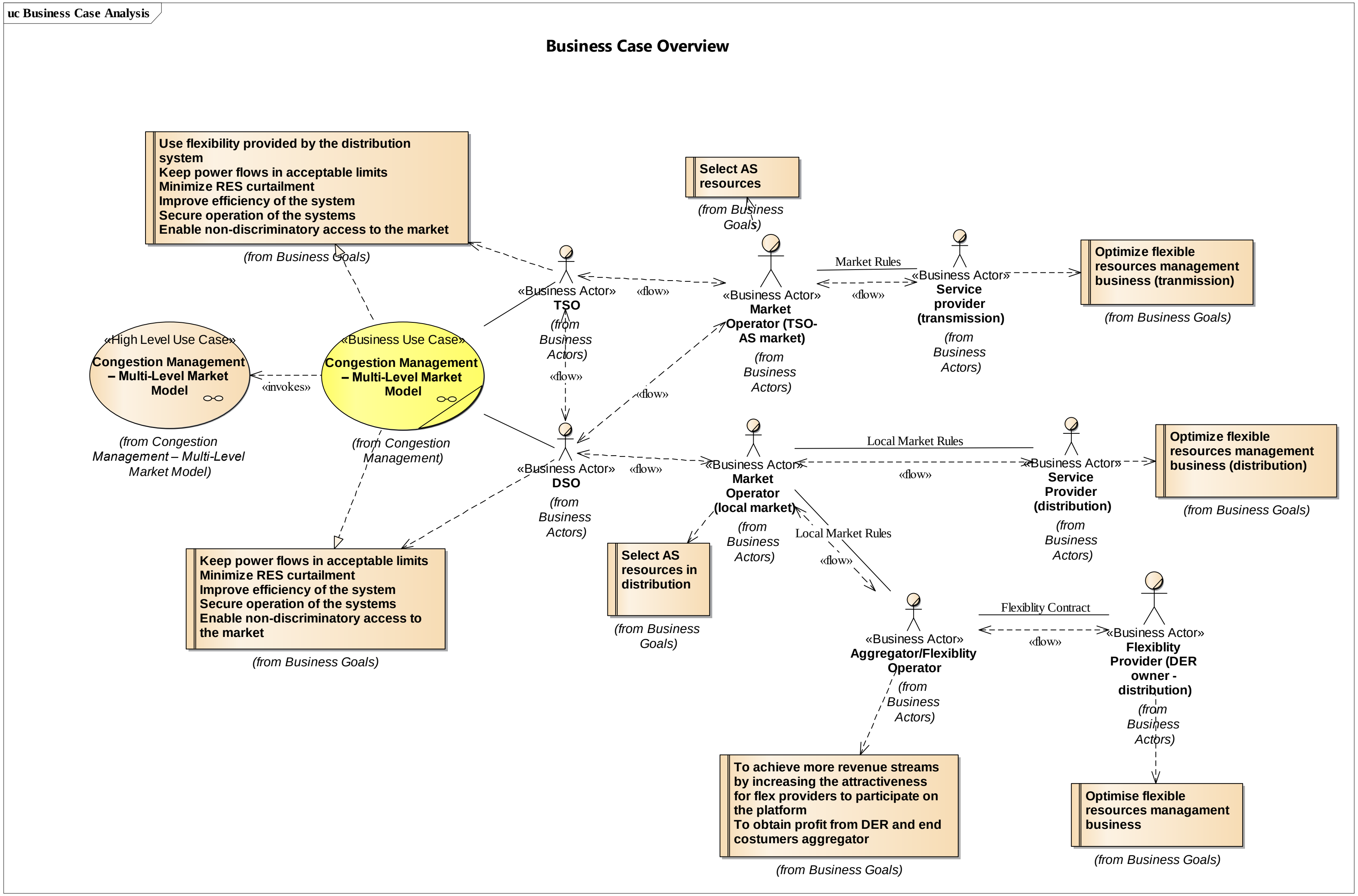


Figure 18: BUC GR-2a Overview: Congestion Management - Multi-level Market Model

3.1.3.3. Sequence Diagram

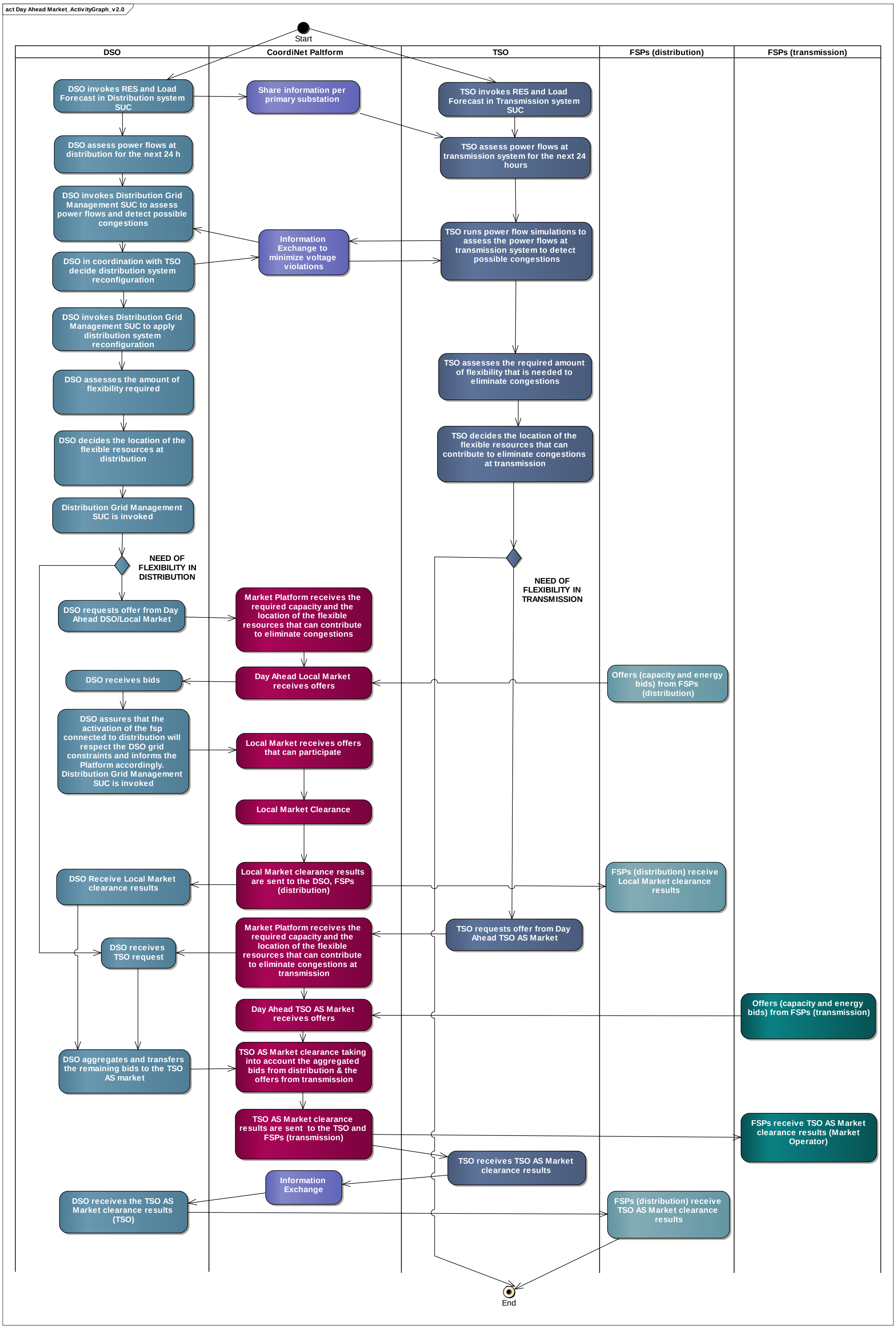


Figure 19: GR-2a Sequence Diagram - DA Process

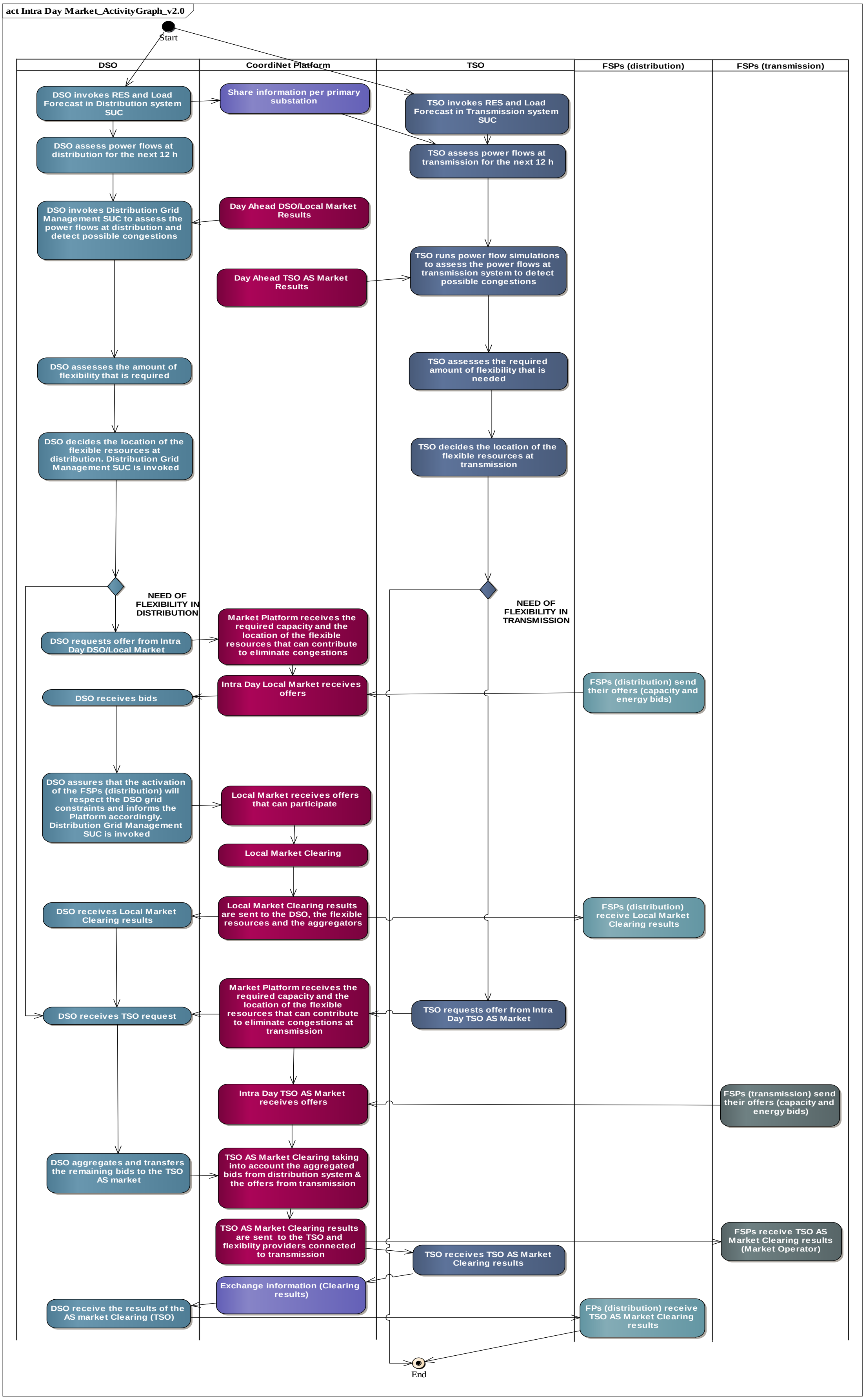


Figure 20: GR-2a Sequence Diagram - ID Process

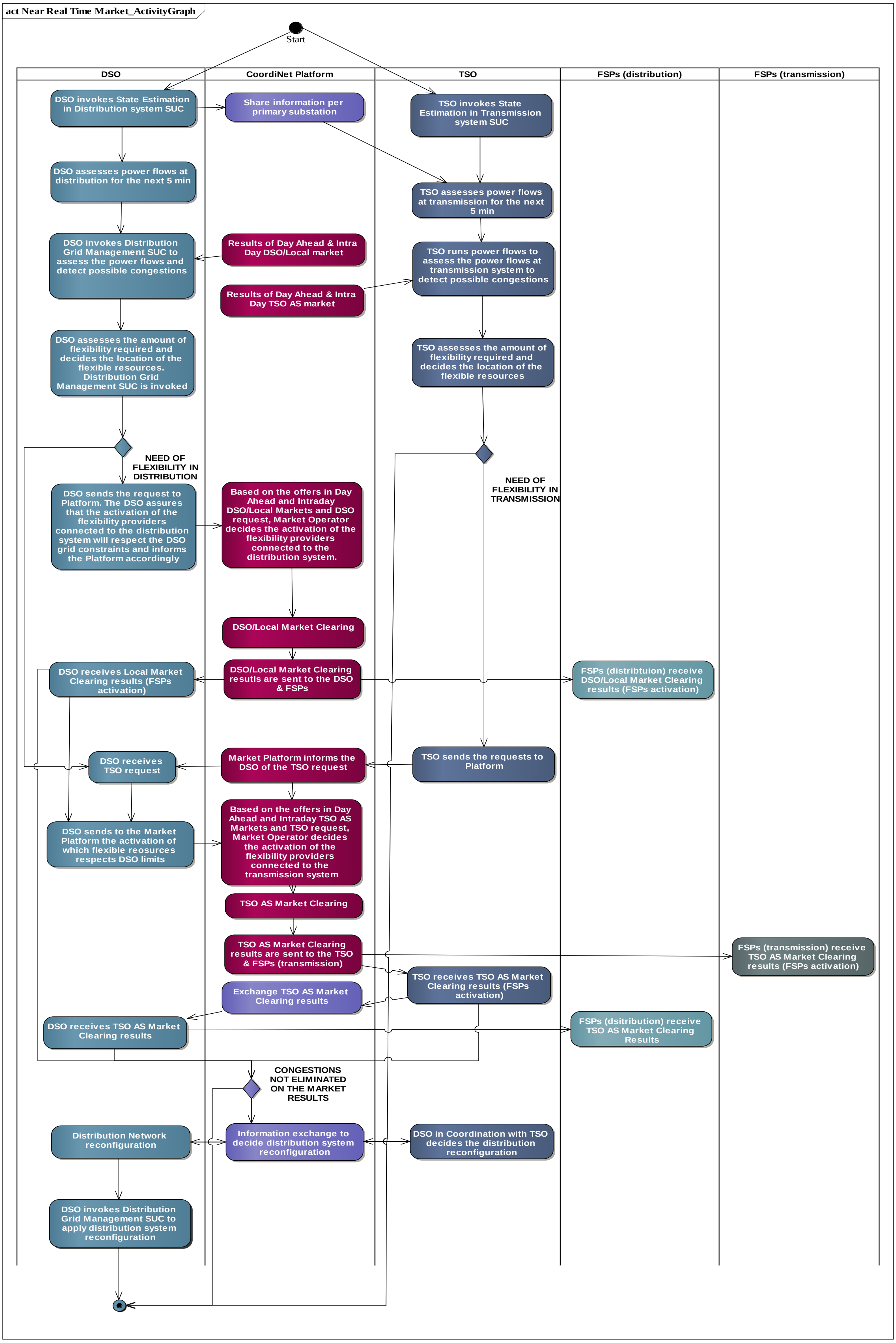


Figure 21: GR-2a Sequence Diagram - Near Real Time Process

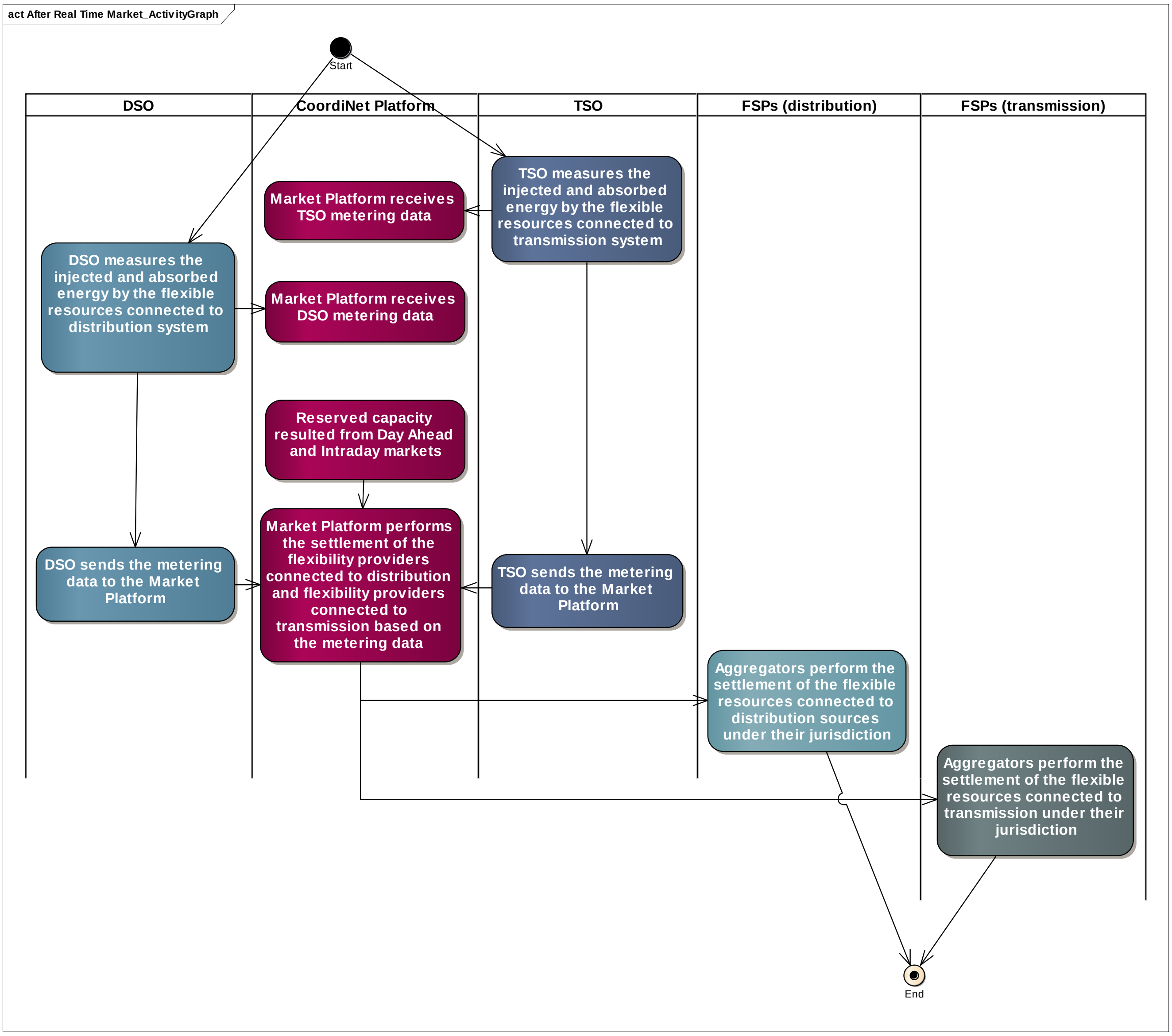


Figure 22: GR-2a Sequence Diagram - After Real Time Process

3.1.4. BUC GR-2b: Congestion Management – Fragmented Market Model

3.1.4.1. Scope and objectives

This BUC describes the actions that are carried out in case of anticipated congestions in the transmission and distribution system in order to keep power flows in the accepted thermal limits of the lines and the transformers. The flexible resources connected to the transmission system can provide flexibility only to the TSO and the flexible resources connected to the distribution system can provide flexibility only to the DSO. The TSO and DSO cooperate to decide on the power exchange between them. In order to do so, the TSO and DSO take into account the power flows of the lines in the transmission and distribution system, respectively.

Three different markets are examined depending on the time frame. These markets are:

- DA
- ID
- Near Real Time

A cooperation and information exchange between the DSO and TSO are crucial for eliminating congestions in the most efficient way, while respecting distribution and transmission system constraints.

The objectives of this BUC are the following:

- To ensure non-discriminatory access to the market for all agents that provide grid services.
- To enable coordination and information exchange between system operators in order to improve the efficiency of the system.
- To ensure a secure operation of the transmission and distribution system.
- To minimize RES curtailment due to security reasons and operational limits.

3.1.4.2. Short narrative and BUC overview

The BUC describes the steps that are followed to eliminate congestions in the transmission and distribution system when the DSO can use flexible resources connected to the distribution system and the TSO can only use flexible resources connected to the transmission system. The power flows in the transmission and distribution system is permanently assessed and monitored by the TSO and DSO respectively, in order to decide on actions for keeping them within the acceptable thermal limits.

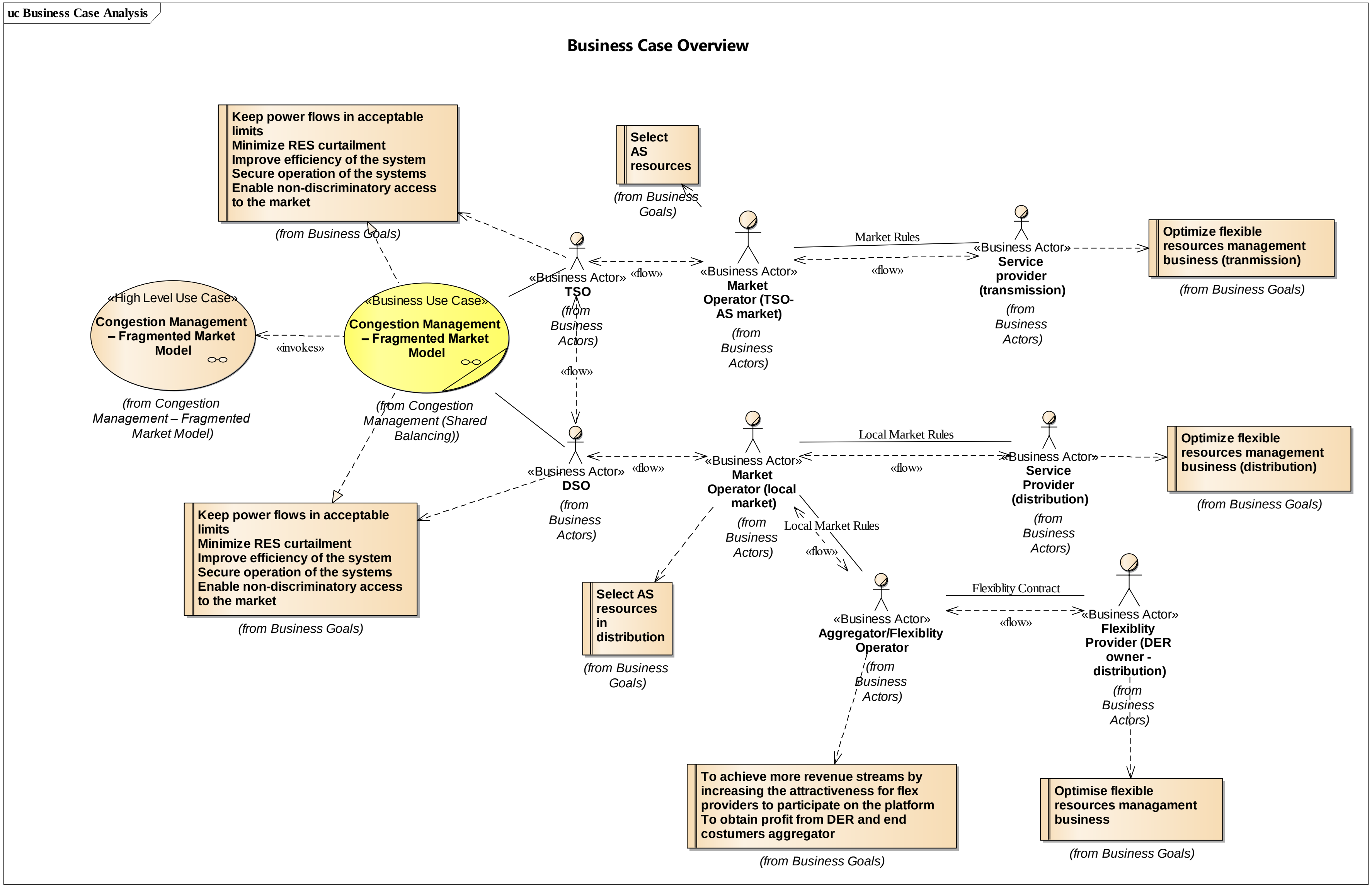


Figure 23: BUC GR-2b Overview: Congestion Management - Fragmented Market Model

3.1.4.3. Sequence Diagram

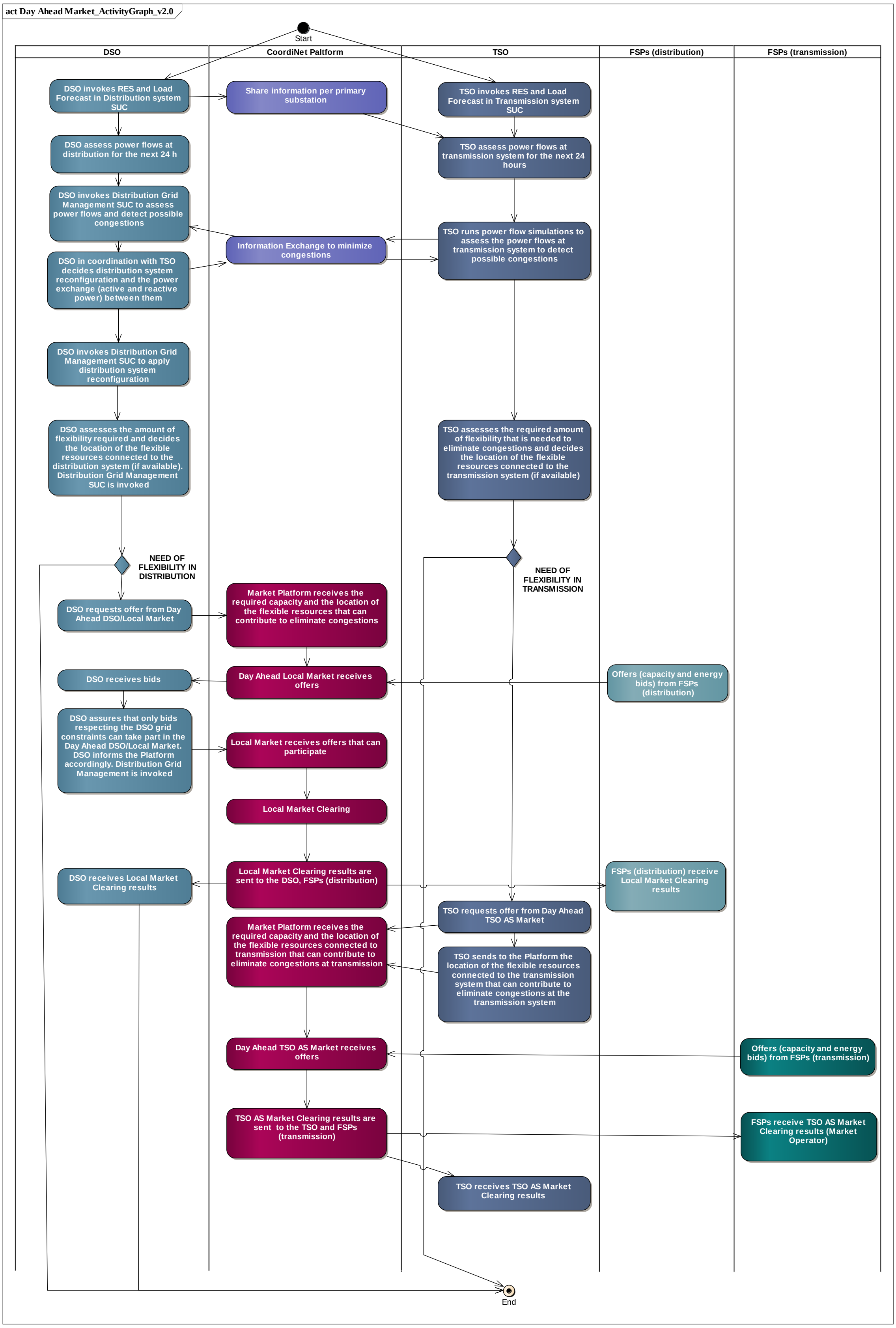


Figure 24: GR-2b Sequence Diagram - DA Process

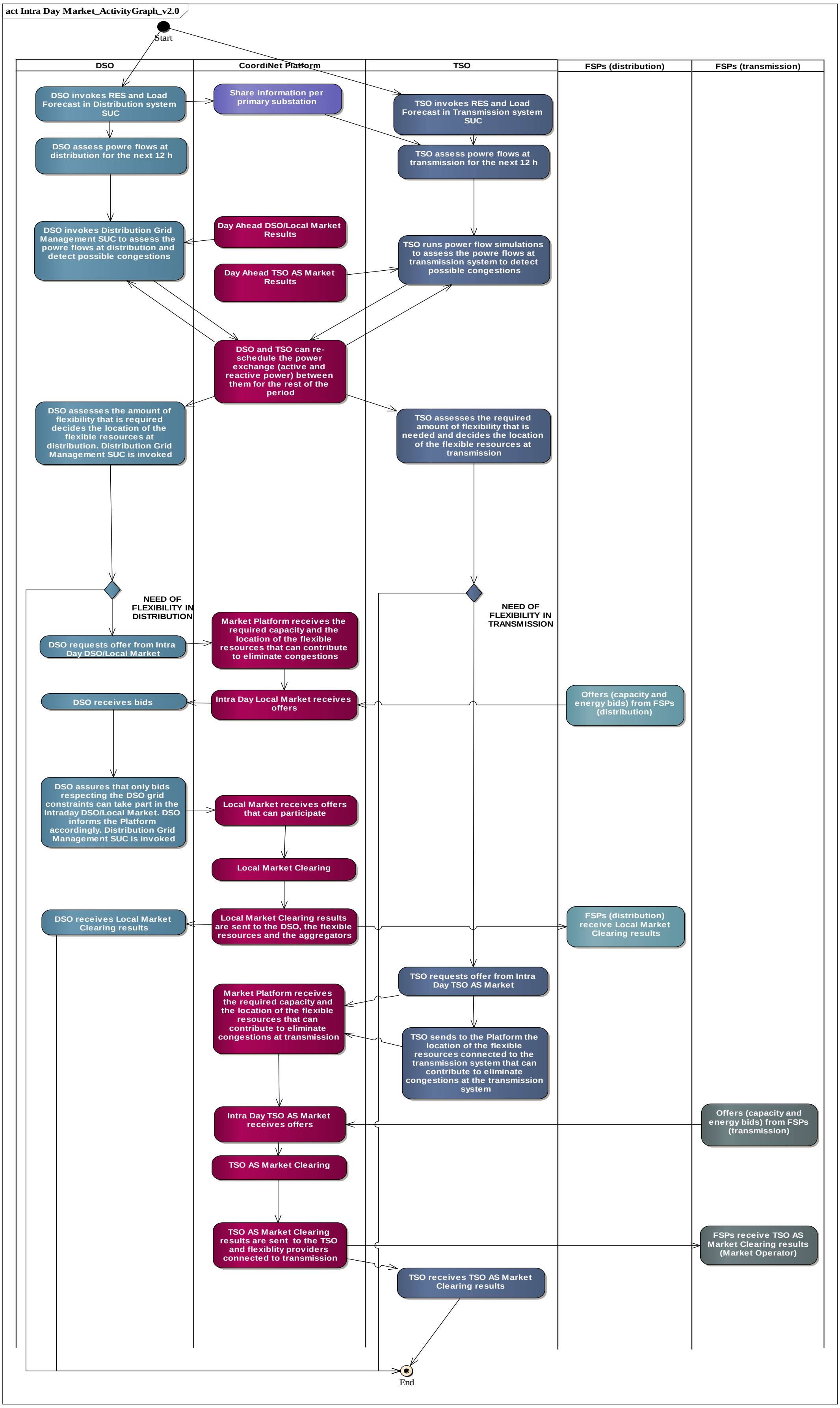


Figure 25: GR-2b Sequence Diagram - ID Process

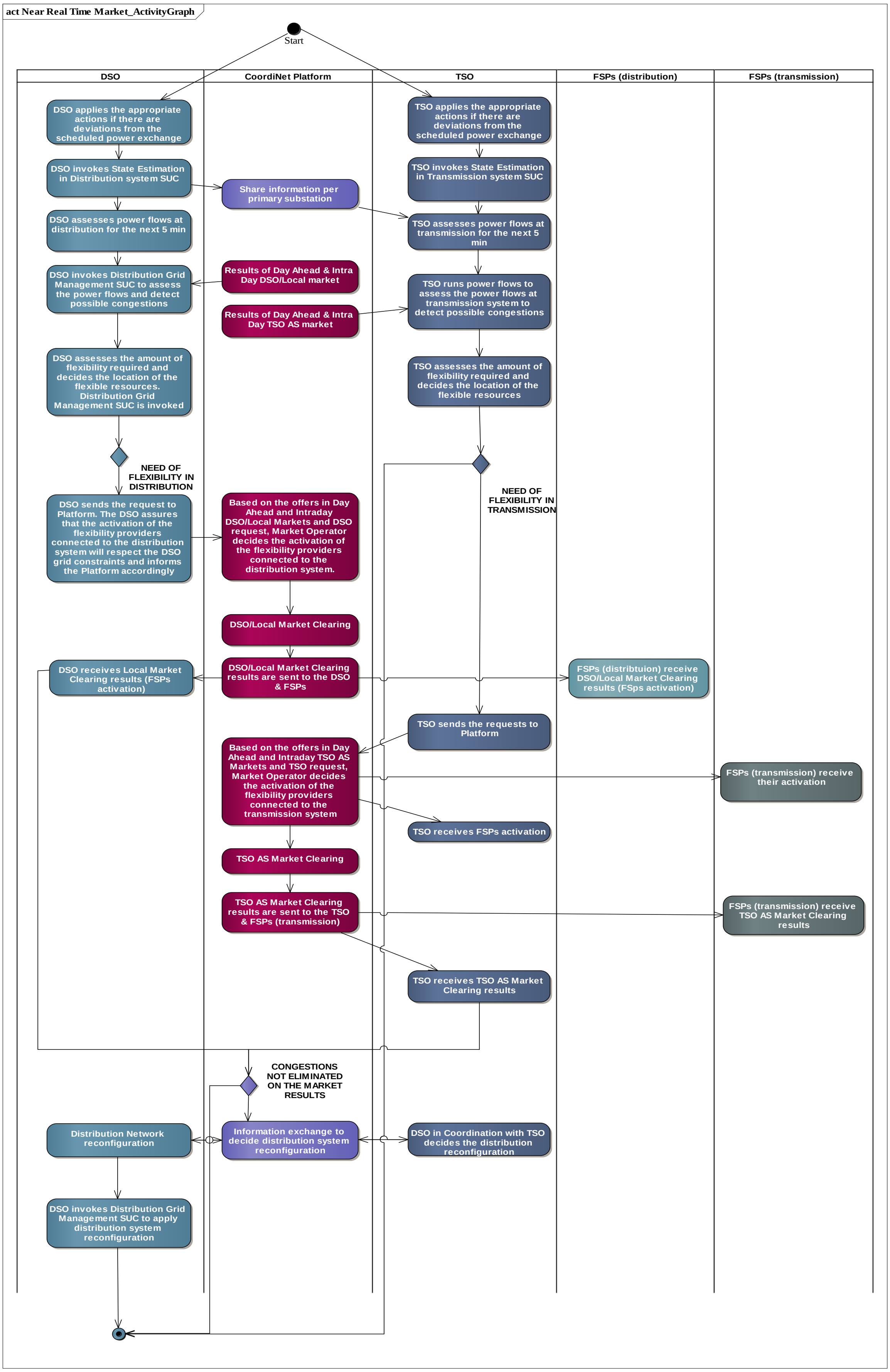


Figure 26: GR-2b Sequence Diagram - Near Real Time Process

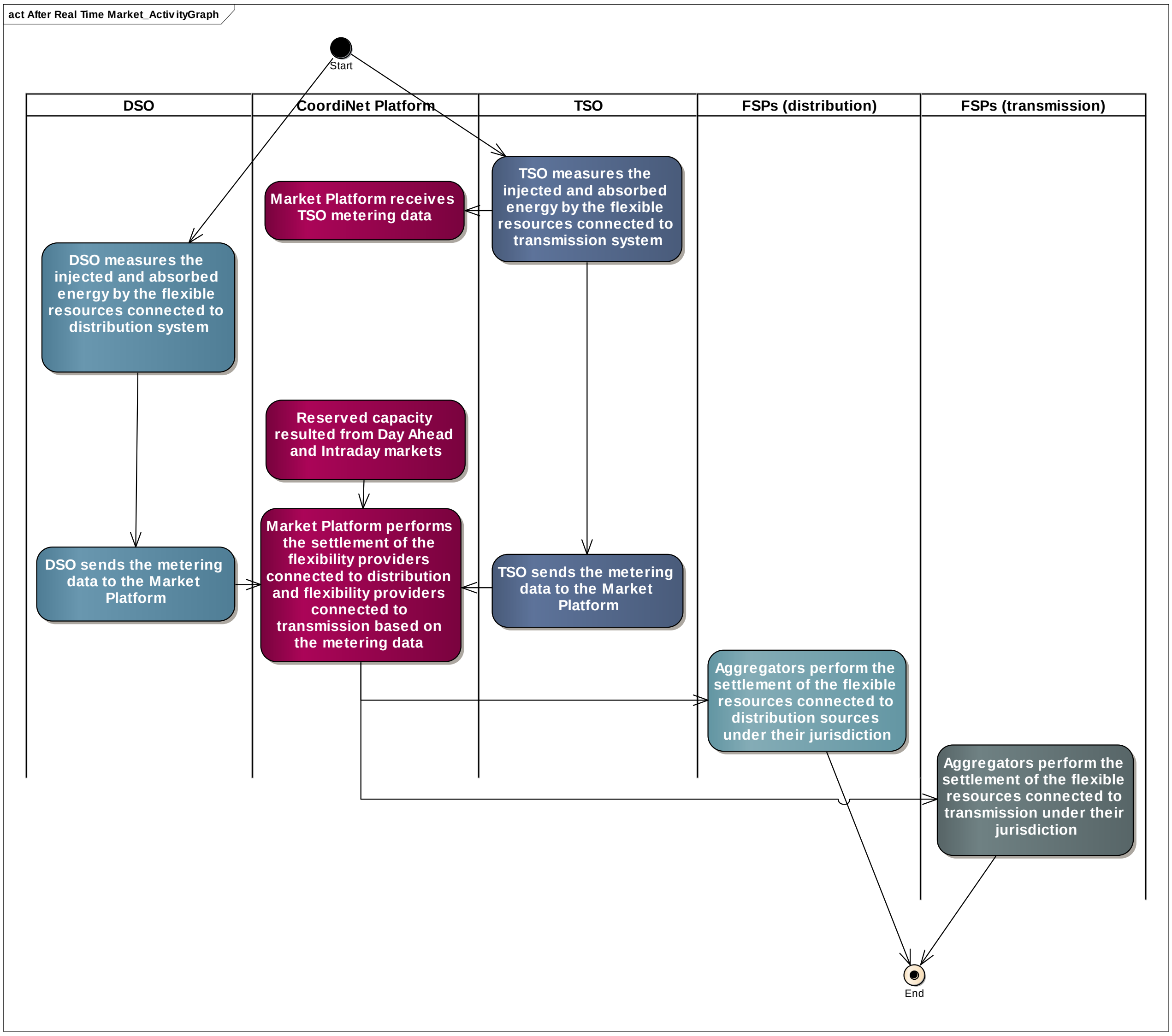


Figure 27: GR-2b Sequence Diagram - After Real Time Process

3.2. Spanish demonstration BUCs

The BUCs of the Spanish demo consider four differentiated domains: the TSO, the DSOs, the CoordiNet platform and the FSP. The specific roles and activities of the TSO and DSOs in the Spanish system are described briefly.

Spanish TSO

The Spanish TSO, Red Eléctrica de España (REE), is system and transmission network operator and owner of the transmission grid. REE operates the system in mainland Spain, as well as on the islands as well as overseas, such as in the Ceuta and Melilla cities. REE, among other activities, is in charge of solving technical restrictions of the system and keeping the system balance. In order to perform these tasks REE runs different ancillary service markets which include a congestion management market to solve the possible technical problems coming from the DA energy market. In this technical congestion management market, which is only open for generators, participants are remunerated following the pay-as-bid system (Kahn et al. 2001).

Moreover, the TSO might find it appropriate to contract additional reserves and runs therefore the Additional Upward Reserve (AUR) market if reserves are expected to be low. This market opens at 4 p.m. of the day before the day when low reserve margins are detected and closes 20 minutes later.

Subsequently the secondary (4 – 5.30 p.m.) and tertiary reserves (up until 20 min before real time) reserves are contracted. As all the prequalified generators with available tertiary reserve are obliged to provide their capacity in this last market, only energy is contracted in this market. For secondary reserves, capacity (band) and the energy is remunerated. For tertiary reserves, only the energy activated energy is remunerated.

Between ID sessions, an additional balancing market is performed (RR energy market called deviation management market with marginal pricing clearing).

Spanish DSOs

The distribution companies own and operate the distribution network in general below 110 kV. Spain has six big distribution companies with more than 100.000 clients and 327 distribution companies with less than 100.000 clients (Sede Electrónica de la CNMC 2019). The two biggest distribution companies participating in the Spanish demo are Endesa Distribución and Iberdrola Distribución Eléctrica. Endesa Distribución Eléctrica is present in 27 out of 52 Spanish provinces with 319.000 km of lines and in 2018 supplied 116.879 GWh, 44% of the total Spanish demand (Endesa Distribucíon 2019). Iberdrola Distribución is present in 25 provinces with 268.570 km of lines and supplies 93.897 GWh of loads (35% of the total demand) (i-de 2019).

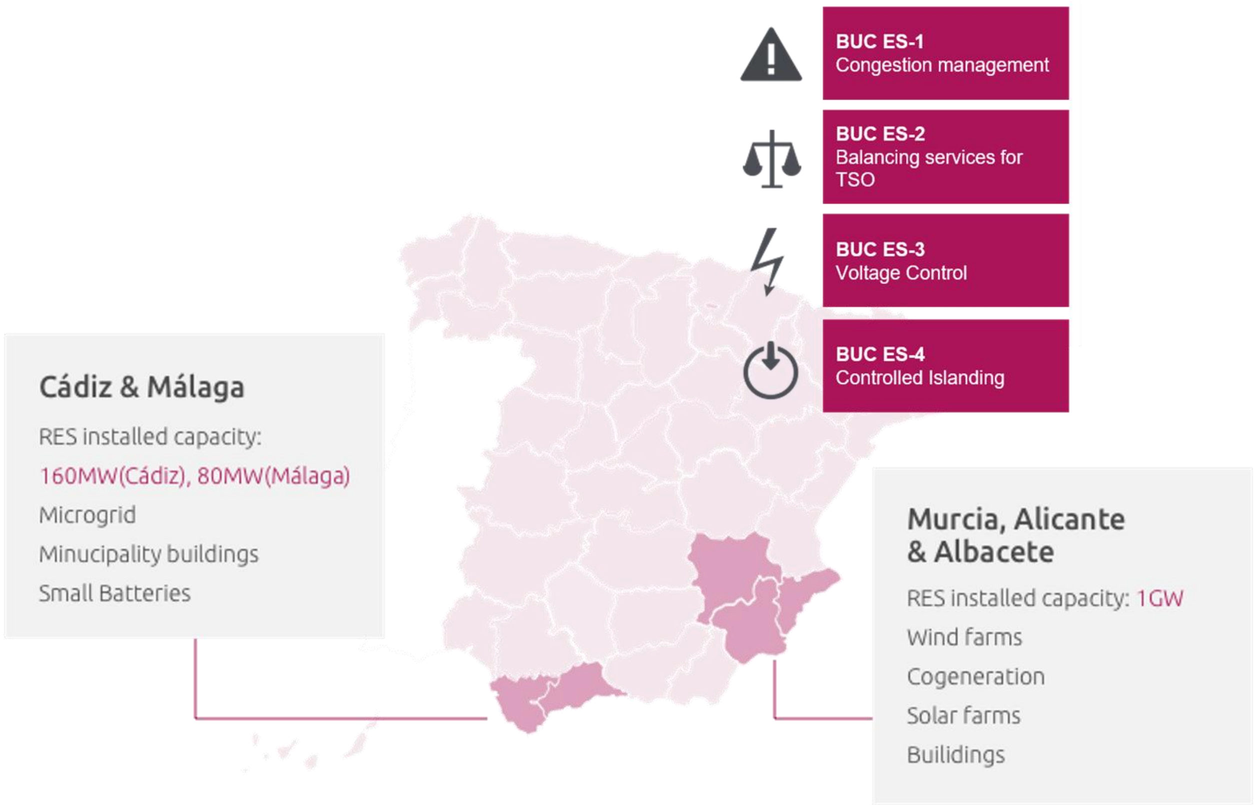


Figure 28: Map of Spanish Demo Areas

3.2.1. BUC ES-1: Congestion management- Common Market Model

3.2.1.1. Scope and objectives

The demo related to this BUC will include resources connected to both Iberdrola's and Endesa's networks. The primary actors here are the TSO and the DSOs.

Resources connected to Iberdrola's network:

- Murcia: Municipality buildings (significant demand loads).
- Alicante: Industrial load of a cement factory
- Murcia and Albacete account for more than 1GW of installed renewable (RES) capacity.

Resources connected to Endesa's network:

- Malaga: Demand side response from municipality buildings and generation resources from wind farms will provide flexibility for congestion management
- Cadiz: wind and solar photovoltaic (PV) will participate in congestion management

The main objective of this Use Case is to procure flexibility from resources connected at both TSO and DSO networks in a coordinated manner to solve temporal congestions that can occur at both networks.

Currently in Spain, the TSO manages network congestions that occur both at transmission and distribution levels. This is done through a technical constraint management market by re-dispatching generation units connected at transmission, but also at all voltage levels (including LV and MV). If needed, DSO have the possibility to request from the TSO to activate demand reduction, curtailment of generation or redispatch. The current price floor in the congestion management market is 0 €/MWh and, currently, there is no price cap applied apart from IT system limits which are set to 9999 €/MWh.

As highlighted in CoordiNet D1.1 (Lind and Ávila 2019), in Spain, DSOs can use DER, more specifically DG, to solve congestions in the same way as the TSO does. This process, however, is done through the TSO in coordination with the DSO (i.e. by using an outdated process based on an email or similar sent by the DSO to the TSO). Once congestions in the distribution grid are identified and the DSO is not able to solve the grid problem during operation, the DSO can request a dispatch towards the TSO, given that there are generation units that have an impact on the congestion. The TSO then accesses the bids and calculates the necessary redispatch to solve the detected constraints. In case a DG is redispatched, it will be remunerated according to the existing market rules (which are the same as for the units re-dispatched due to congestions in the transmission grid). For planned curtailment, producers receive no financial compensation. In addition to congestion management, DSOs may also request a change to the TSO that is in the power factor range instructions sent to generation units with an installed capacity larger than 5 MW. Nowadays, this mechanism applies only to generators and not to consumers.

Therefore, as of today, the DSO through the TSO can use DG for local congestion management and power factor control and consumers with contracted power above 5MW can participate in interruptible services.

As both the DSO and TSO send these requests, ultimately it is the TSO that receives the congestion management bids that are able to solve the constraints, assigns them and instructs the DER.

Regarding the size of DER able to provide services for congestion management to the DSO there are no limitations with respect to the voltage level to which providers are connected. Participation is currently only allowed for generation units and pumped hydro units.

As of today, in Spain, DSOs cannot sign interruptible contracts with DER. The only form of interruptible contract is between the TSO and industrial consumers. However, DSOs may use these interruptible contracts signed with the TSO to solve constraints in their networks as well.

From February 2016, all redispatch due to congestion management in the DSO or TSO network including generation from renewable sources is done via market mechanisms (Operation Procedure (PO) 3.2). In the real-time technical constraint management process, DG has to pay the downward bid price which is generally very close to 0 €/MWh so they get to keep almost 100% of the market marginal price (being the DA price of a specific hour) that they have received for selling their production in that hour. Thus, renewable generation reductions can happen because of market outcome in the congestion management or balancing market.

In any case, as a last resort, if still needed in real time, the TSO and DSO can curtail renewable generation for security reasons without a market based mechanism. However, since 2016 all congestion management situations have been solved through these market-based mechanisms.

3.2.1.2. Short narrative and BUC overview

More active participation of resources, including DER, in the congestion management market, as well as more frequent procurement of flexibility by DSOs require a rework of the current congestion management market and operational procedures so that processes that are currently performed manually can be performed in a semi-automated manner ensuring that the needed information is available to both the TSO and the affected DSOs. The purpose of this market would be to increase or decrease energy to solve grid congestions. The possibility to have a capacity product would be explored in a second stage of the demo and it is not addressed in this description.

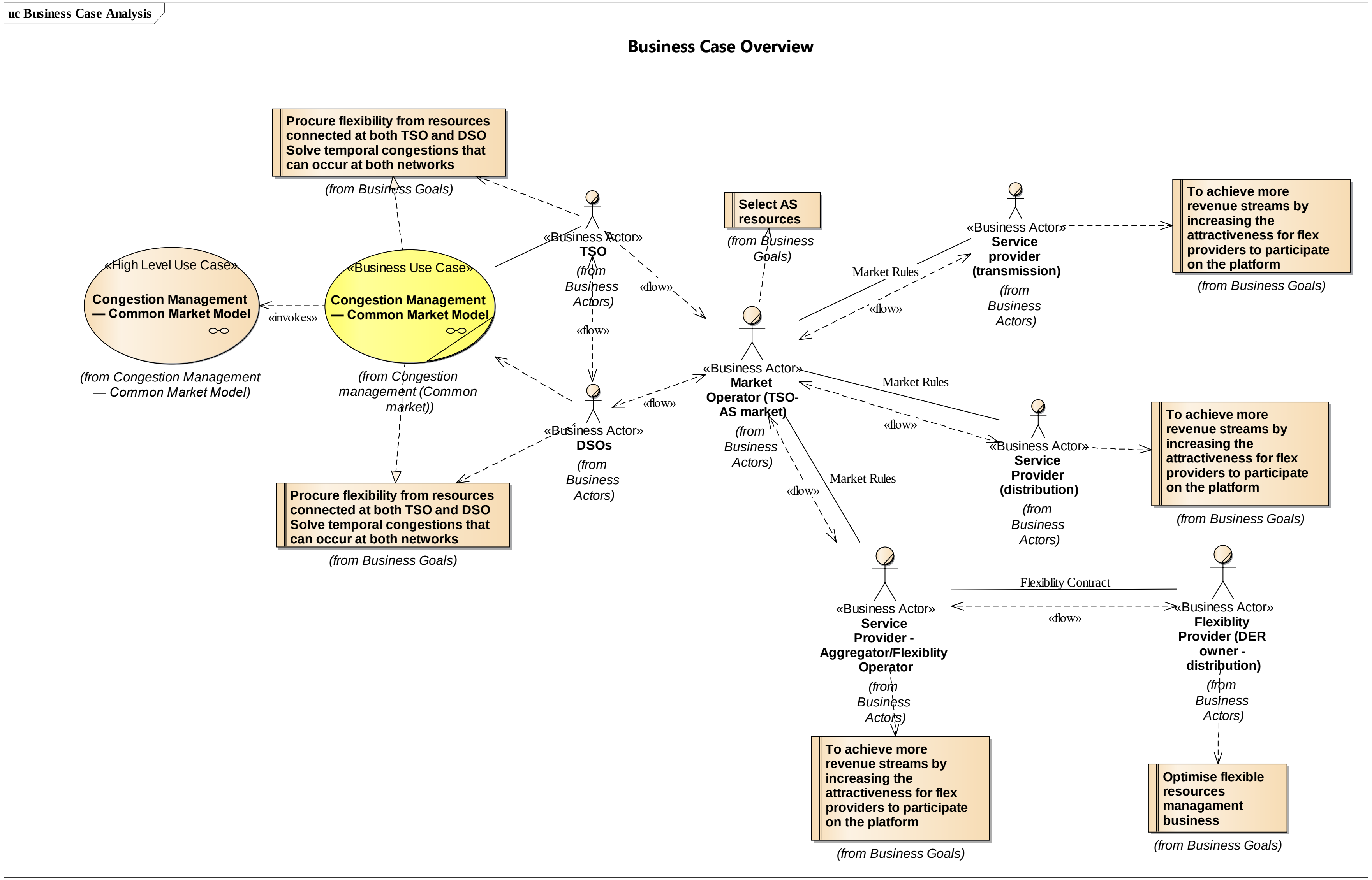


Figure 29: BUC ES-1 Overview: Congestion management- Common Market Model

3.2.1.3. Sequence Diagram

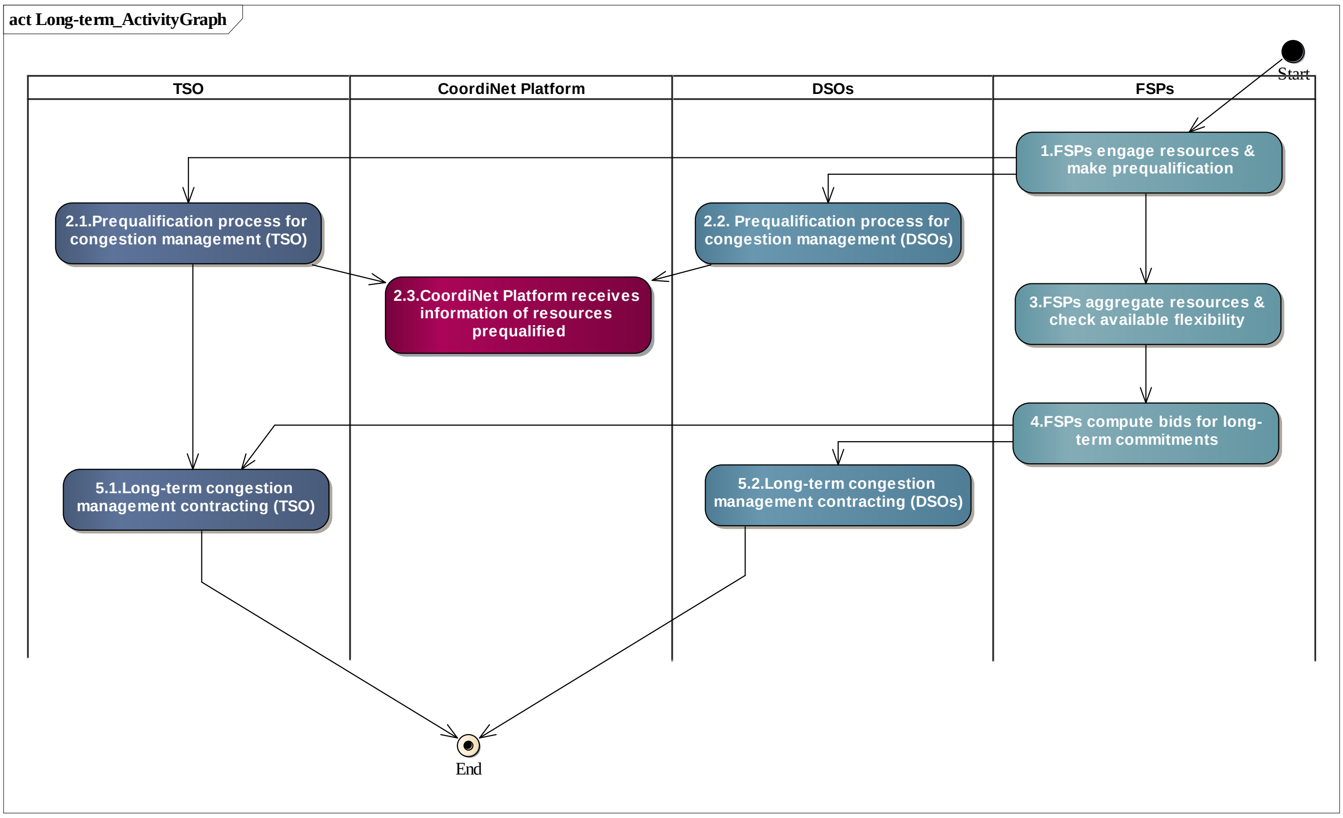


Figure 30: ES-1 Sequence Diagram - Long Term Process

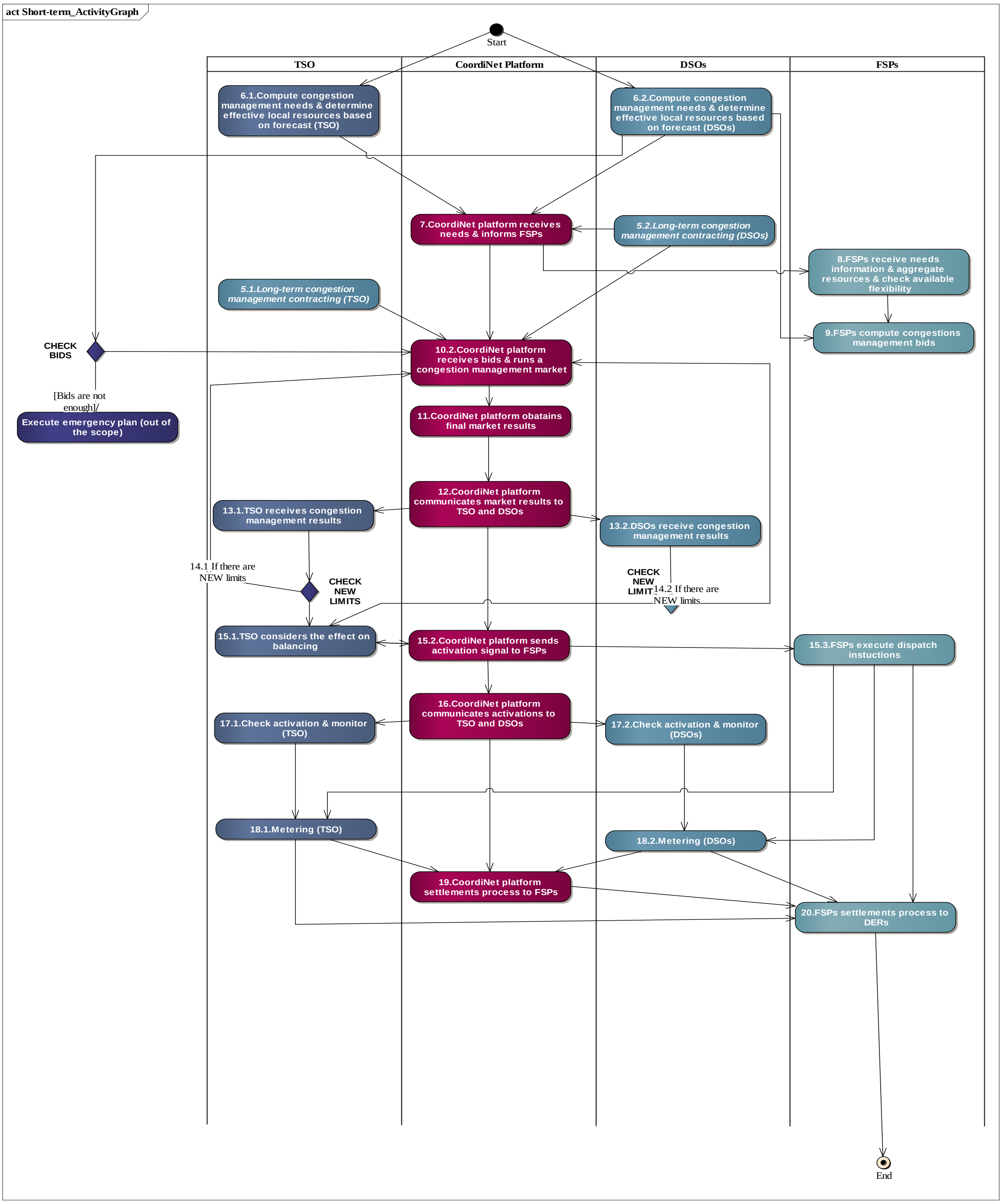


Figure 31: ES-1 Sequence Diagram - Short Term Process

3.2.2. BUC ES-2: Balancing services for TSO – Central Market Model

3.2.2.1. Scope and objectives

This BUC evaluates how to improve the coordination between the TSO and DSOs when the activation of energy resources including DER providing balancing services to the TSO increases. This might result in constraints in the DSO network. The process description would apply for both manual Frequency Restoration Reserves (mFRR) and Replacement Reserves (RR).

The resources involved in this demo will include resources connected to Iberdrola's, Endesa's and REE's networks.

Resources connected to Iberdrola's network:

- Albacete accounts for more than 340 MW of installed renewable (RES) including wind, mini-hydro and CHP capacity.

Resources connected to Endesa's network:

- Malaga: DR from municipality buildings and generation resources from wind farms.

- Cadiz: wind and solar photovoltaic (PV) plants will participate in congestion management (86 MW).

Resources connected to REE's network:

- In Murcia and Albacete, more than 800 MW of installed wind generation capacity participating is connected to the transmission network. These units can also be used in the demos to provide flexibility for distribution network uses.

- Cádiz: around 130 MW of wind power plants connected to the transmission network are participating.

The objective is to reduce balancing costs (TSO perspective), while avoiding unforeseen congestion problems at the distribution level.

3.2.2.2. Short narrative and BUC overview

Currently generation resources connected at distribution networks can provide balancing services, but demand-side resources cannot.

Similar to congestion management, the functions are divided in four relevant timescales which are described in detail below: the long-term (from years until day-ahead), the day-ahead, from one hour to real-time and post-real-time. The numbering of the functions are described according to their sequence in time and the arrows represent the flows of information among the different actors.

Two main products are relevant for balancing: the balancing capacity and the balancing energy. According to the EBGL, the balancing capacity is defined as: "a volume of reserve capacity that a balancing service provider has agreed to hold and in respect to which the balancing service provider has agreed to submit bids for a corresponding volume of balancing energy to the TSO for the duration of the contract" and the balancing energy: "means energy used by TSOs to perform balancing and provided by a balancing service provider" (European Commission, 2017).

In this Use Case, the FSP performs the function of Balance Service Provider (BSPs) which according to the EBGL means a market participant with reserve-providing units or reserve-providing groups able to provide balancing services to TSOs.

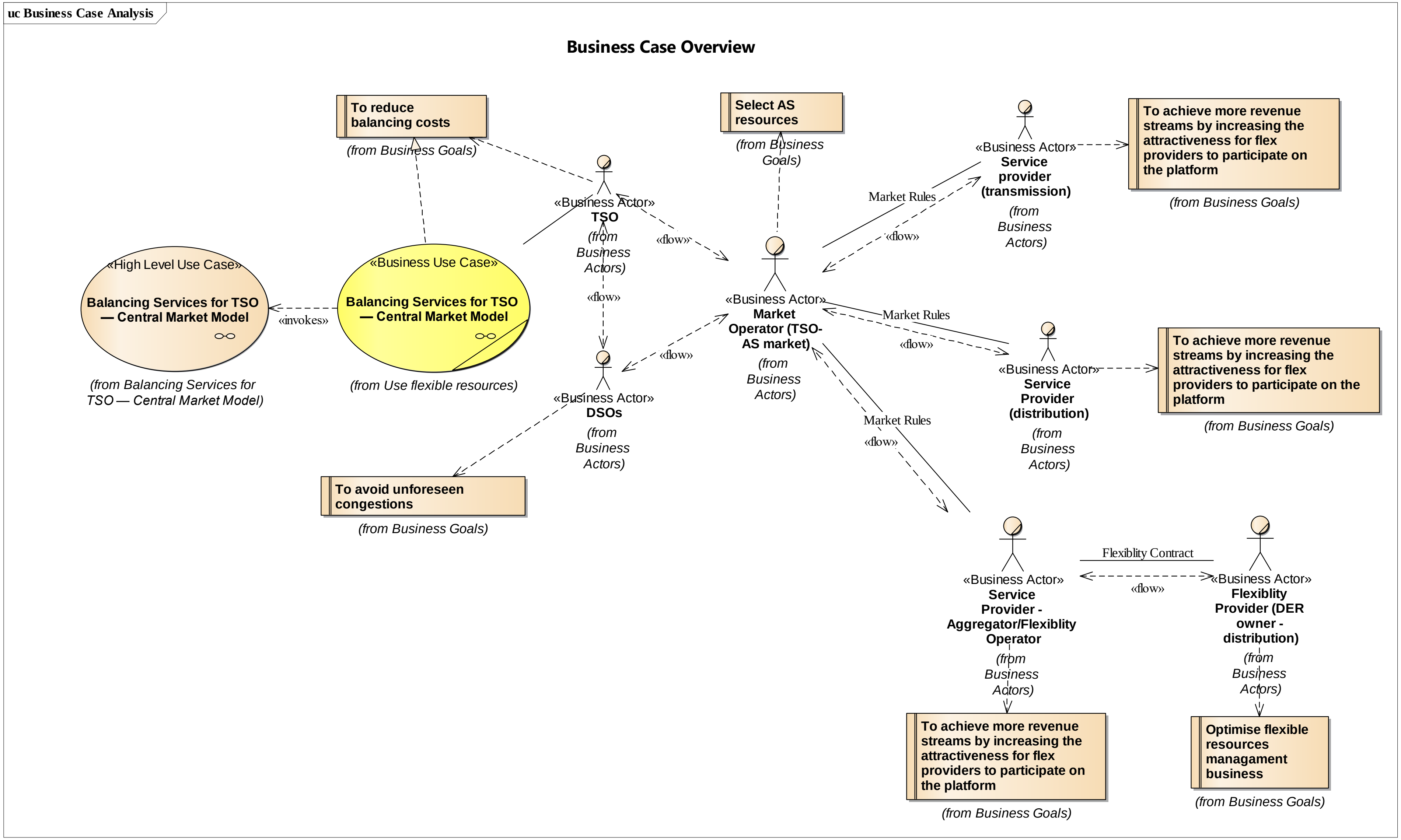


Figure 32: BUC ES-2 Overview: Balancing services for TSO - Central Market Model

3.2.2.3. Sequence Diagram

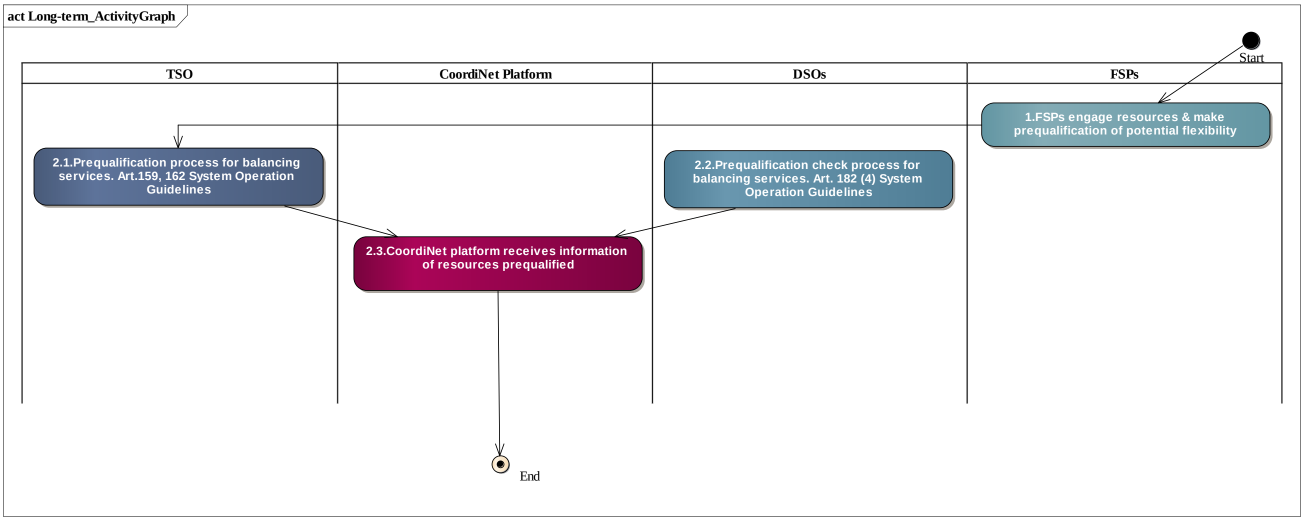


Figure 33: ES-2 Sequence Diagram - Long Term Process

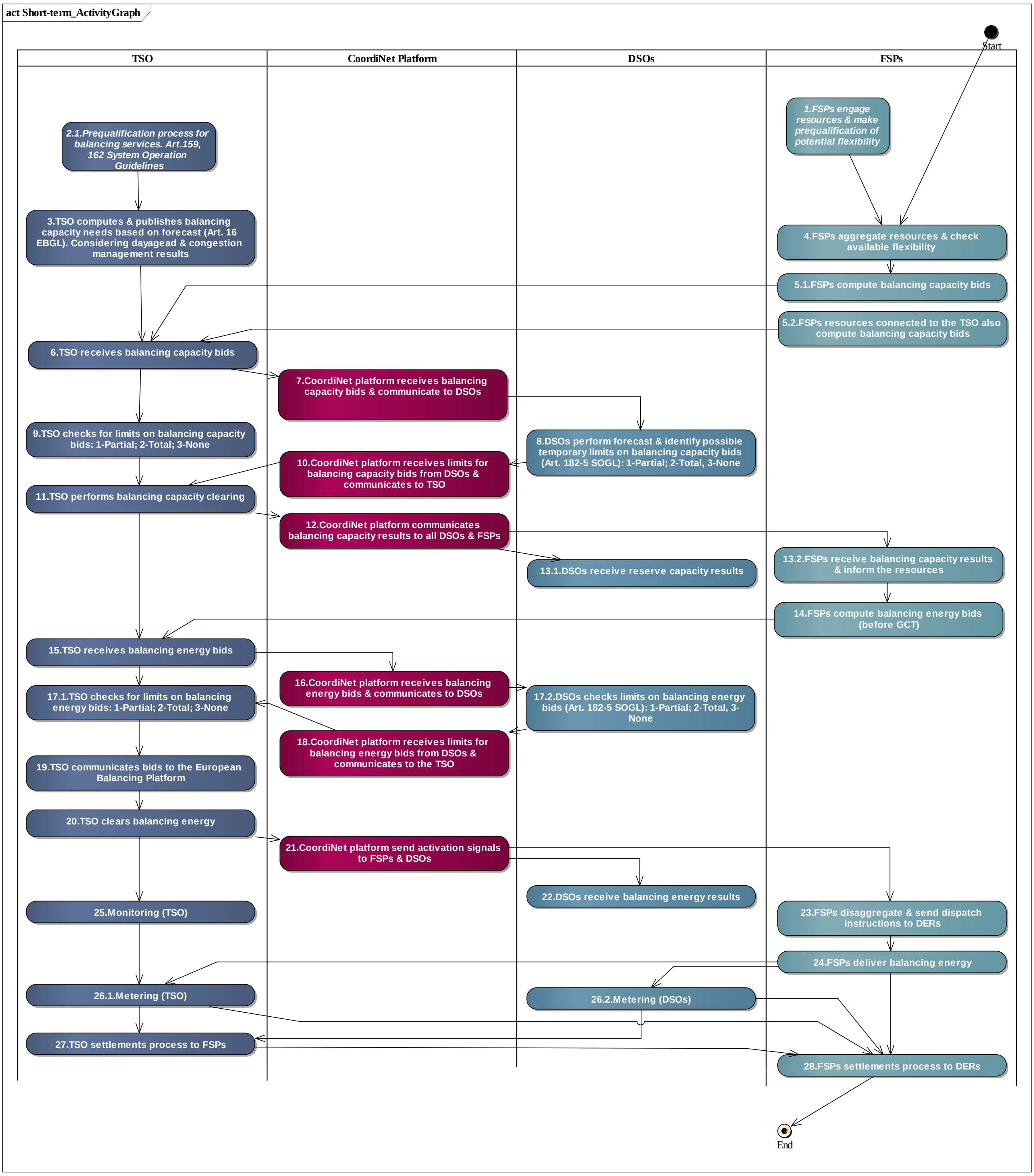


Figure 34: ES-2 Sequence Diagram - Short Term Process[6]

[6] Some market clearing steps (step 11and 20) are done outside of the CoordiNet platform (and therefore performed i.e. either by the TSO or the DSO), since the CoordiNet platform is in a young stage and thus under development.

3.2.3. BUC ES-3: Voltage control- Common Market Model

3.2.3.1. Scope and objectives

The increasing penetration of intermittent generation connected at distribution networks risks creating unwanted voltage variations. Moreover, the replacement of traditional synchronous generators by wind and solar plants -some of whose voltage control capacity may be more limited- results in voltage control scarcity in some areas of the network. However, the latest technological improvements in inverters already allow RES to support voltage control[7]. In this context, the existing voltage control mechanism based on a unique power factor setpoint by generation plants[8] can be improved by voltage setpoints at the connection point. In consequence, plants could inject -or consume- reactive power to manage voltages at their connection point with the grid. Reactive consumption is a means to reduce overvoltages in the grid, while reactive injection is the opposite and is used to increase voltages. Although overvoltages tends to be more common at off-peak hours, this depends on the grid operation and the specific plants that are producing at each time.

Currently, there is no service established for voltage control for DG. For consumers, an obligation to follow cos(fi) is established, with some exemptions. For units under the scope of the network codes defined in (European Commission 2016a, 2016b), additional requirements are applied to both DG and DER.

TSO traditionally invest in reactors to consume reactive power, however, this could be supplemented with inverters capabilities in a more cost-effective manner. Therefore, this BUC will implement a market mechanism to procure voltage control services by using new and available technologies besides traditional investments from DSOs and TSOs and beyond the current requirements.

The resources included in the demo will concern resources connected to Iberdrola's, Endesa's and REE's networks. The primary actors here are the TSO and the DSOs.

Resources connected to Iberdrola's network:

- Murcia and Albacete account for more than 340 MW of installed renewable (RES) including wind, mini-hydro and CHP capacity.
- Alicante: Industrial load of a cement factory

Resources connected to Endesa's network:

- Cadiz: wind and solar photovoltaic (PV) plants will participate in congestion management (86 MW).

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[7] For further details, see Generators Connection Grid Code (UE/2016/631 or RfG), or the Spanish TSO and DSO national implementation proposal and sent to the Spanish Regulatory Authority.
[8] See Royal Decree 413/2014 or Procedimiento de Operacion 7.4.

Resources connected to REE's network:

- In Murcia and Albacete, more than 800 MW of installed wind generation capacity participating is connected to the transmission network. These units can also be used in the demos to provide flexibility for distribution network uses.

- Cádiz: around 130 MW of wind plants power connected to the transmission network are participating.

3.2.3.2. Short narrative and BUC overview

Currently, in Spain, there is not a voltage control services market, only power factor control. Therefore, a suitable market mechanism has to be designed from scratch.

At transmission level, voltage can be controlled by the injection or consumption of reactive power. At distribution level, both active and reactive power can be used. However, in case that active power is used for solving voltage problems, the congestion management BUC would be used. At distribution level, reactive power is not as useful as at transmission level, due to its higher R/X ratio compared to transmission. Therefore, this service will be mostly provided by FSP connected at the highest voltage of the distribution network, i.e. from 132kV to 25kV, where meshed networks are commonly operated.

In a similar manner to congestion management and balancing, the functions are divided in four relevant timescales: the long-term (from years until day-ahead), the day-ahead, from one hour to real-time and post-real-time. The numbering of the functions are described according to their sequence in time and the arrows represent the flows of information among the different actors.

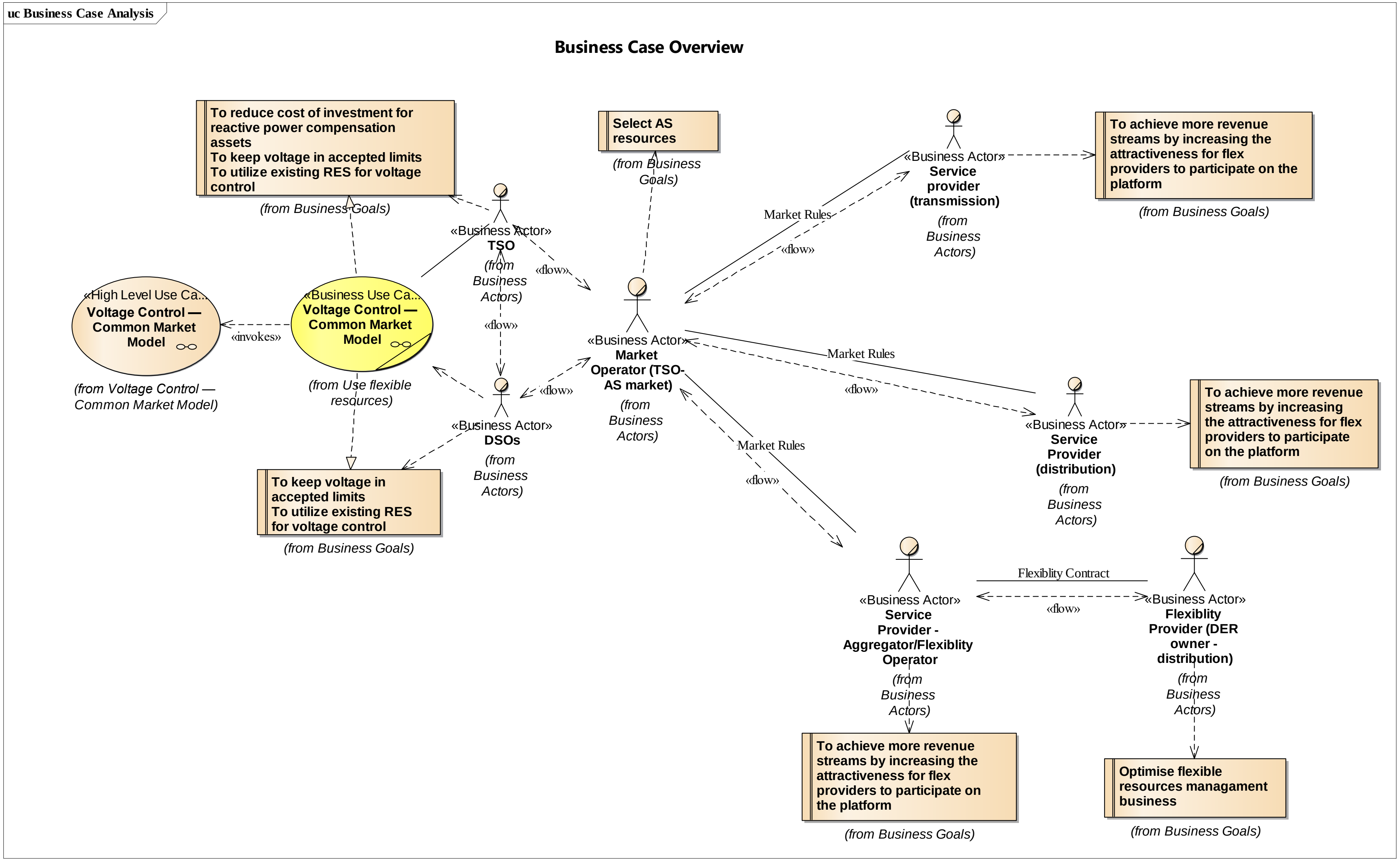

Figure 35: BUC ES-3 Overview: Voltage control- Common Market Model

3.2.3.3. Sequence Diagram

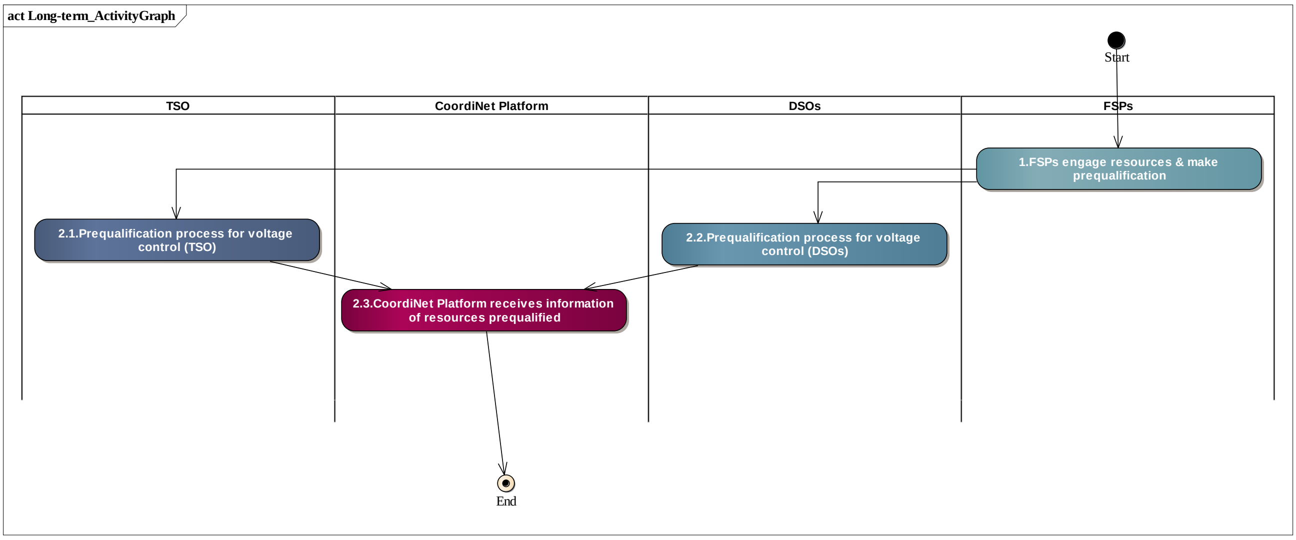

Figure 36: ES-3 Sequence Diagram – Long Term Process

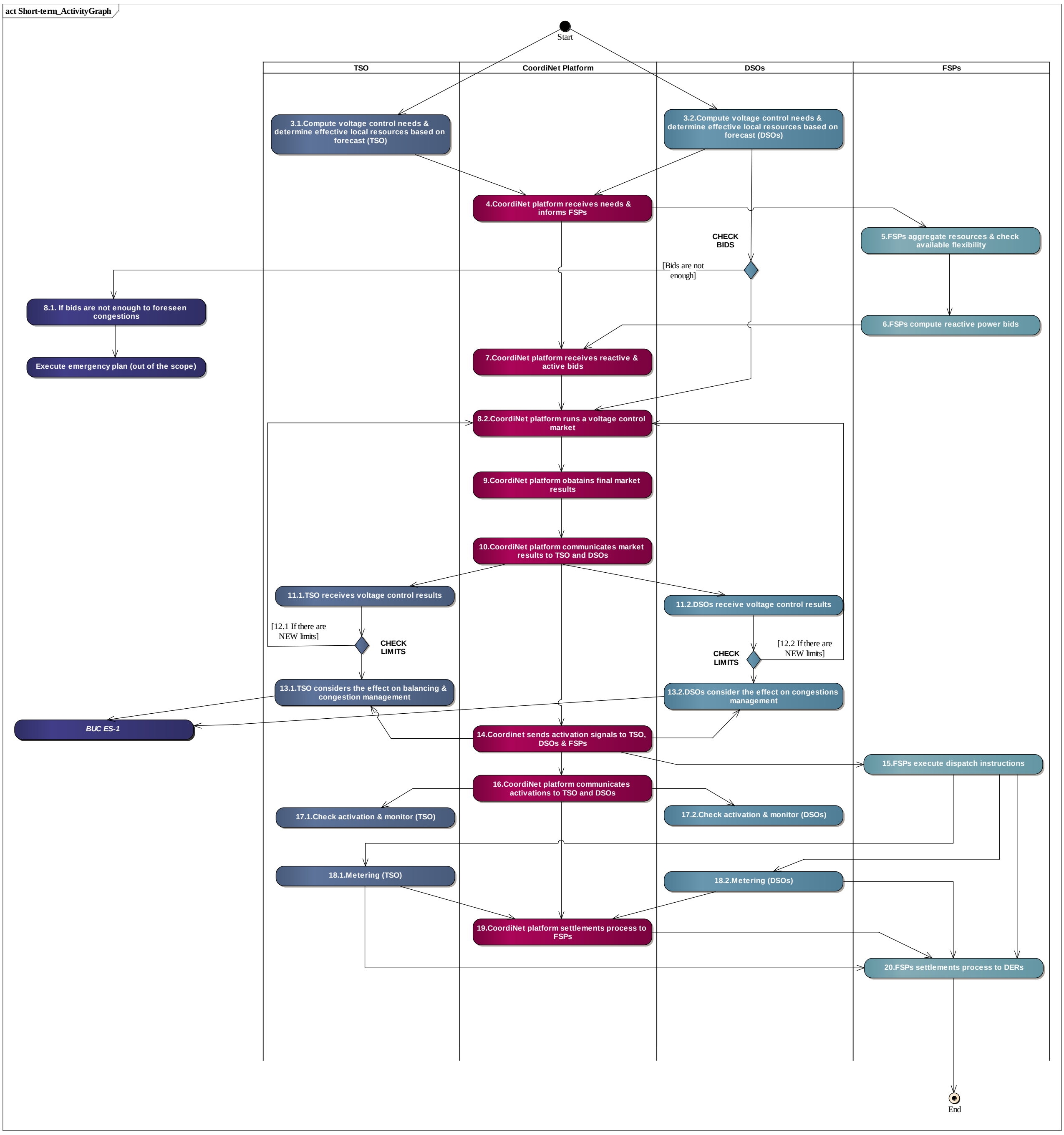

Figure 37: ES-3 Sequence Diagram - Short Term Process

3.2.4. BUC ES-4: Controlled Islanding - Local Market Model

3.2.4.1. Scope and objectives

The resources included in this demonstration activity will only be connected to Iberdrola's networks in Caravaca (Murcia), where energy storage and PV units located in medium and low voltage grids can be used. The battery capacity power is 1 250 kW for injecting and withdrawing, whereas the energy capacity is 2 772 kWh. The connected consumption is around 400kW. The primary actor is the DSO in this BUC.

The objective of this BUC is to operate part of the distribution network in an islanding mode during outages or programmed maintenance services. Without controlled islands, in case of network outages or planned maintenance, consumers may be curtailed temporarily. This is in contrast with a controlled operation which can maintain the power supply during those events.

3.2.4.2. Short narrative and BUC overview

During outages or programmed maintenance services, a part of the grid may be disconnected from the system, remaining electrically islanded. In this situation, the DSO activates DG to supply the consumers within the island during the outage or the maintenance period. The DSO has to be able to maintain under control technical parameters such as voltage and frequency in the electrical island. The DSO has to determine the size of the island which may affect the TSO. Therefore this information is communicated to the TSO.

In a similar manner to previous BUC, the functions are divided in four relevant timeframes: the long-term (from years until day-ahead), the day-ahead, from one hour to real-time and post-real-time. The numbering of the functions is described according to their sequence in time and the arrows represent the flows of information among the different actors.

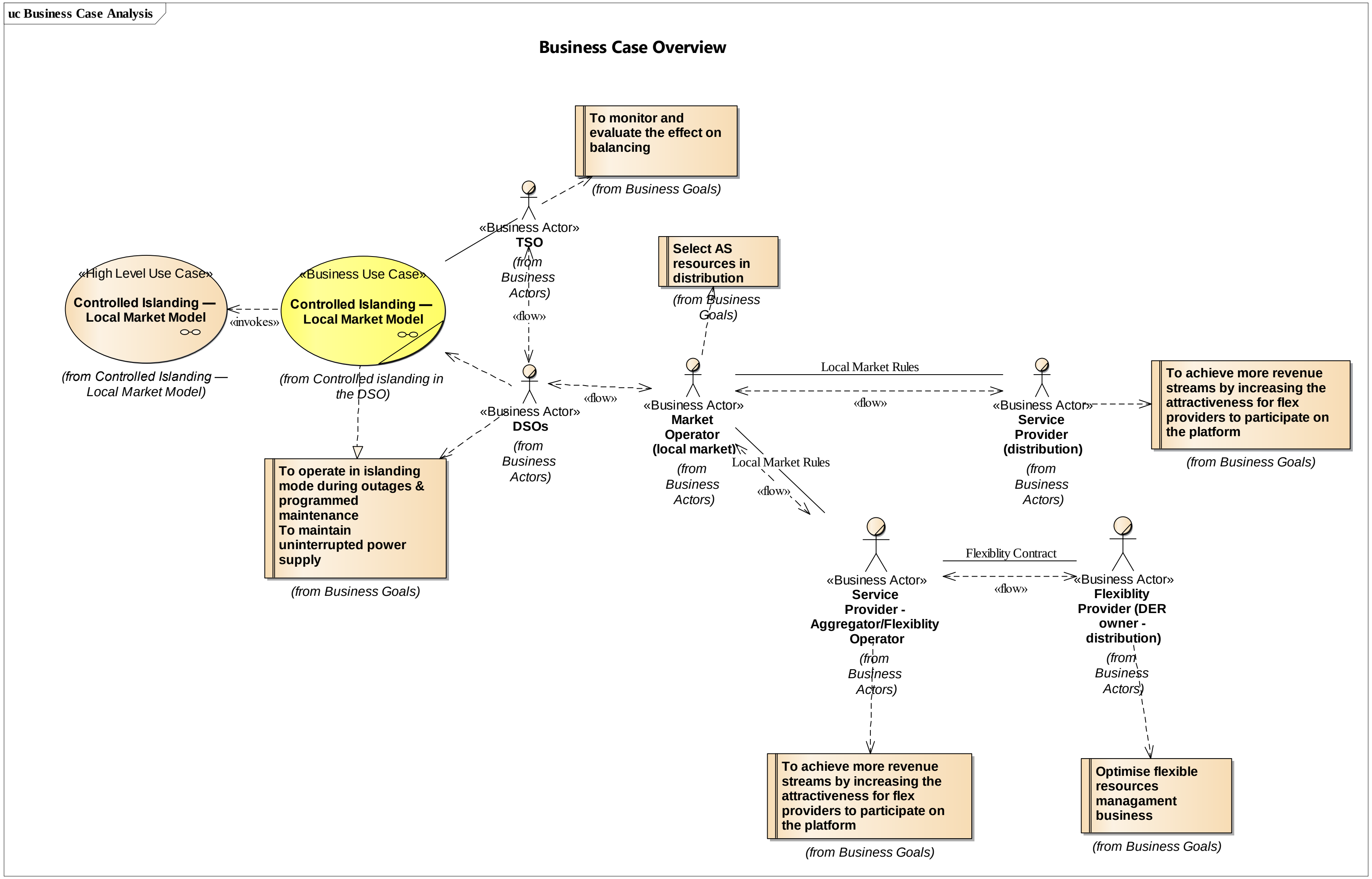

Figure 38: BUC ES-4 Overview: Controlled Islanding - Local Market Model

3.2.4.3. Sequence Diagram

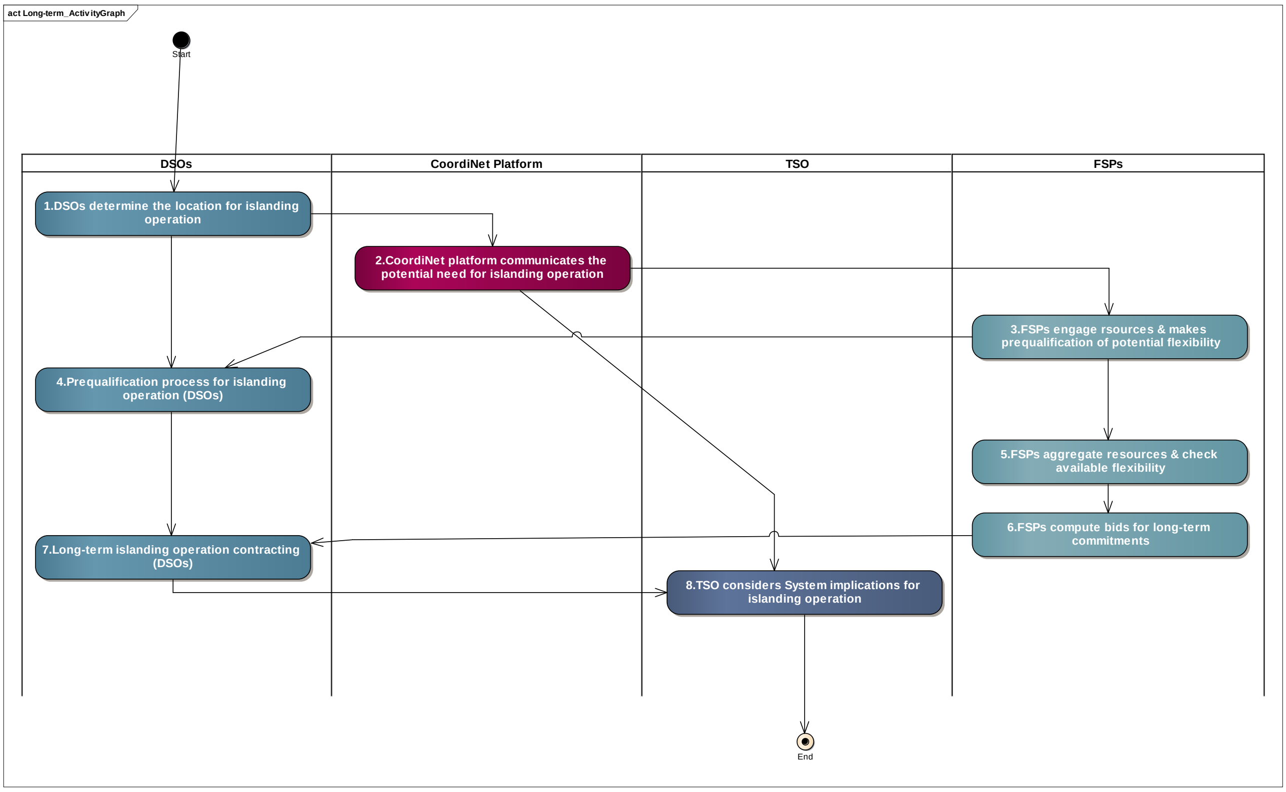

Figure 39: ES-4 Sequence Diagram - Long Term Process

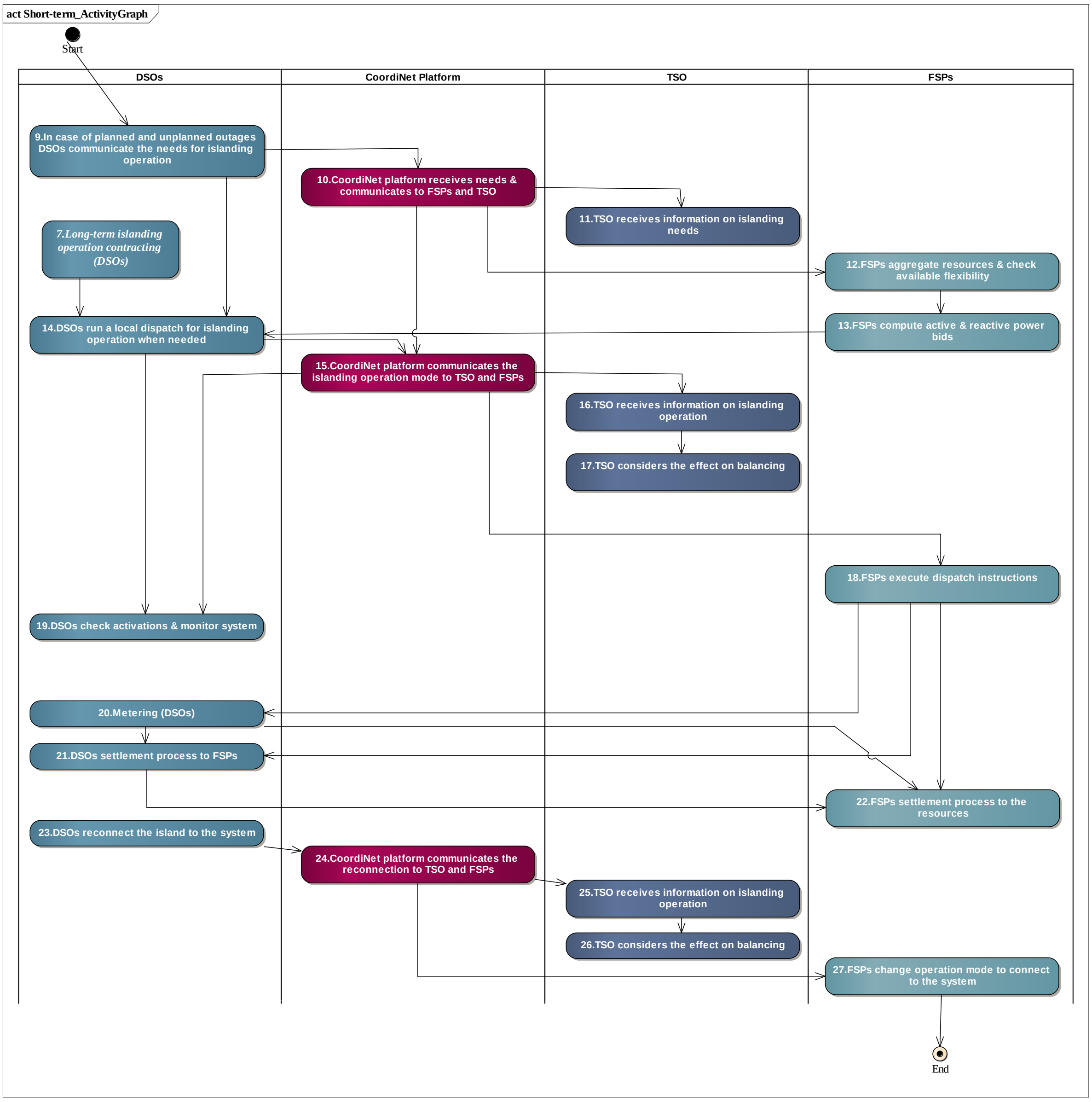

Figure 40: ES-4 Sequence Diagram - Short Term Process[9]

[9] Some dispatching steps (step 14) are done outside of the CoordiNet platform (and therefore performed i.e. either by the TSO or the DSO), since the CoordiNet platform is in a young stage and thus under development.

3.3. Swedish demonstration BUCs[10]

The BUCs of the Swedish demo consider five different domains: The local DSOs, the regional DSOs, the TSO, the flexibility provider and the CoordiNet platform. The specific roles and activities of the TSO and DSOs in the Swedish system are described briefly.

Swedish TSO

The Swedish TSO Svenska Kraftnät is the only electricity transmission system operator in Sweden. Svenska Kraftnät has two main roles: as operator of the national grid and as system responsible for the national power system.

In its grid operator role, Svenska Kraftnät is responsible for maintaining and developing the Swedish national grid for electricity. Everyone who owns a facility connected to the national grid, must pay a fee to Svenska Kraftnät, based on a particular grid tariff. The usage agreement governs how much transmission capacity the customer subscribes to. It is possible to apply for a temporary subscription in addition to the annual subscription. Subscription overrun that does not occur in the context of temporary subscription is not allowed and a high penalty fee is charged for subscription overruns.

As system responsible, Svenska Kraftnät, who is responsible for keeping balance in the grid and operates the national balancing markets in Sweden. This is done in close cooperation with the other Nordic TSOs. The mFRR market for instance is operated with a joint Nordic merit order list. Together with the Norwegian TSO, Statnett, Svenska kraftnät has the responsibility for balancing and maintaining the frequency of the entire Nordic synchronous area.

Today the markets are mFRR (Nordic energy activation market), aFRR (capacity market), FCR-N for normal operation and FCR-D for disturbances. The Nordic TSOs have developed a Nordic aFRR capacity market, with go-live pending regulatory approvals and have an ambitious plan for further developing markets, including a Nordic mFRR capacity market and aFRR energy activation market. In addition, SvK and the other Nordic TSOs plan to introduce a market for Fast Frequency Reserve (FFR).

A possible future market development linking CoordiNet gate closures with existing market gate closure times is depicted in Figure 41.

[10] The presented use cases create a big picture of objectives, active actors and their relation. The demo management targets to define information flows and functions of the sequential steps in greater detail under the scope of WP2.

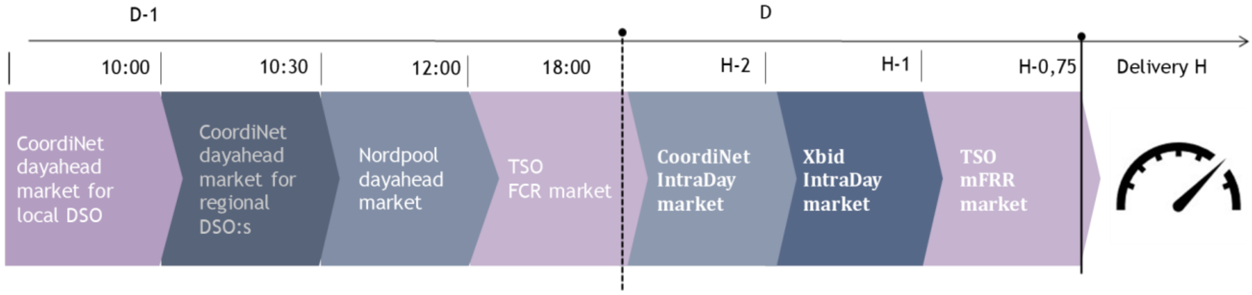

Figure 41: Draft to market closure times in Swedish system

Swedish DSOs

In Sweden there are two levels of DSOs: The low-voltage level is operated by the local DSO and the medium-voltage level by the regional DSOs. On the four different sites both levels are participating. In Skåne and in Västerbotten/Norrland, EON is the regional grid operator. In Uppland and Gotland, Vattenfall is the regional grid operator. In addition, both in Skåne and Uppland there are several local grid operators.

The local grid operators subscribe for grid capacity from the regional grid operator. Exceeding the subscription level results in a high cost for the local grid operator. In CoordiNet, local grid and regional grid operators will buy flexibility service to avoid exceeding their subscription level. Unused bids will be forwarded to the TSO mFRR market (see Figure 41).

In Gotland (see Figure 42), also system services will be bought to handle and connect new solar and wind power as well as to improve power quality and security of supply.

In Västerbotten/Norrland a peer to peer market will be established so that producers can sell their allocated capacity rights when curtailment would be necessary due to maintenance in the connecting grid.

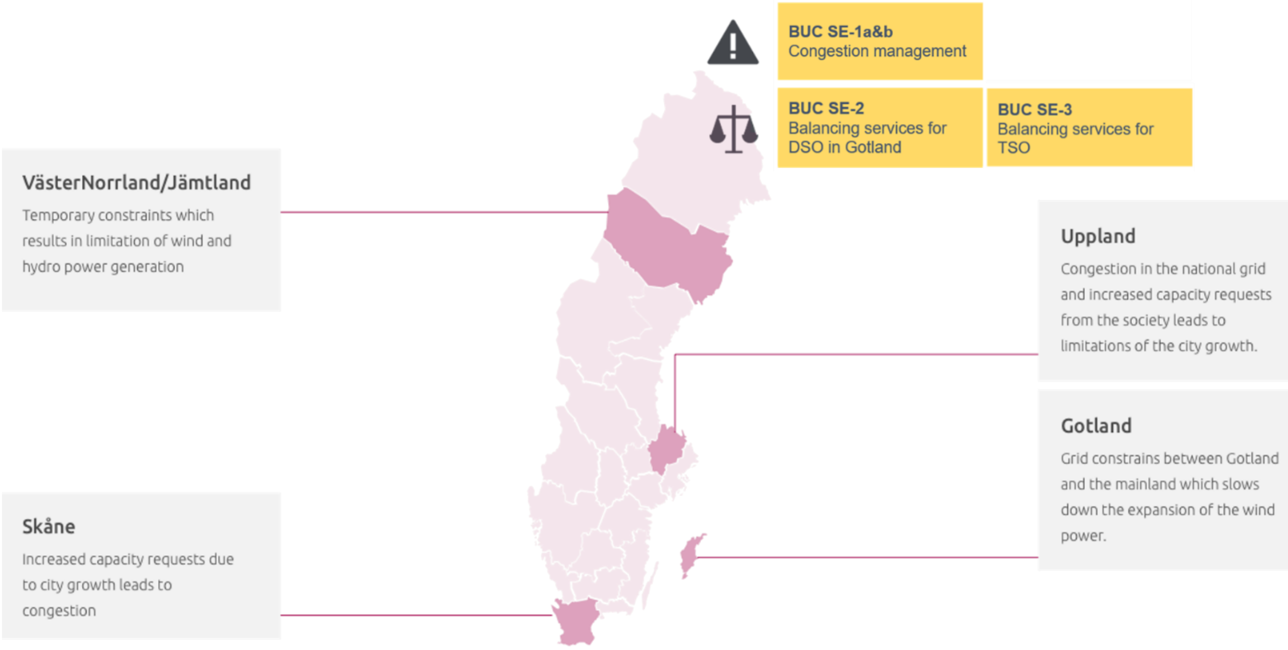

Figure 42: Map of Swedish Demo Areas

3.3.1. BUC SE-1a: Congestion management – Multi-level Market Model (in combination with BUC SE-3)

3.3.1.1. Scope and objectives

This BUC describes the actions that are carried out in case of congestions in the low voltage as well as medium voltage distribution grid in order to keep power flows within the subscription limits by the regional DSO and respectively TSO and within thermal limits of the lines and the transformers.

Flexible resources connected to the low voltage and medium voltage distribution grid can provide flexibility to the TSO or regional DSO, to eliminate congestions through a market mechanism. To this end, active power control is considered.

Short term products are traded on following markets:

- Congestion Management Day-Ahead
- Congestion Management ID

Long-term products are traded in the market:

- Firm Capacity

In addition, it has to be ensured that the activation of flexible resources in the distribution network would respect the distribution system constraints.

A cooperation and information exchange between local DSO, regional DSO and TSO are crucial for eliminating congestions in the most efficient way, for an accurate load prognosis of the power level in the medium-voltage grid and as a market driver for flexible resources as well as for a well-functioning energy market.

This BUC is designed to fit the products that derive from the geographical specifications:

In Uppland and Skåne there is an increase of power demand as cities are growing and as a result of an increasing electrification of industry and society in general. Furthermore, the closing of local CHP production increases the need for withdrawal from the transmission grid. The TSO is not able to increase the subscription level for the regional DSOs and the DSO without grid reinforcement. In the past, the regional grid has in turn denied an increase of the subscription level for the local DSOs. The necessary grid reinforcements will take up to 10 years to solve.

Also in Gotland, power demand is increasing. At the same time, RES installations are increasing and there are difficulties connecting new installations due to operational security. Gotland is an island connected to the mainland with an HVDC-link and minimizing the number of changes of flow direction on the link could increase the security of supply for the grid customers.

The objectives of this BUC are the following:

- Local and regional DSOs want to give customers opportunity to optimize their resources
- The local and regional DSOs want to meet grid needs with a market opportunity
- Flexibility providers want to meet financial goals
- The TSO wants to increase the mFRR market liquidity

3.3.1.2. Short narrative and BUC overview

The BUC describes the steps that are followed to eliminate congestions in the low-voltage and medium-voltage distribution system using flexibility provided by resources connected to both systems.

The congestion management market is open for all flexibility providers that meet pre-qualification criteria. The actors in this BUC are the grid operators and the FSPs.

Geographical areas for the market:

- Uppland
- Skåne
- Gotland

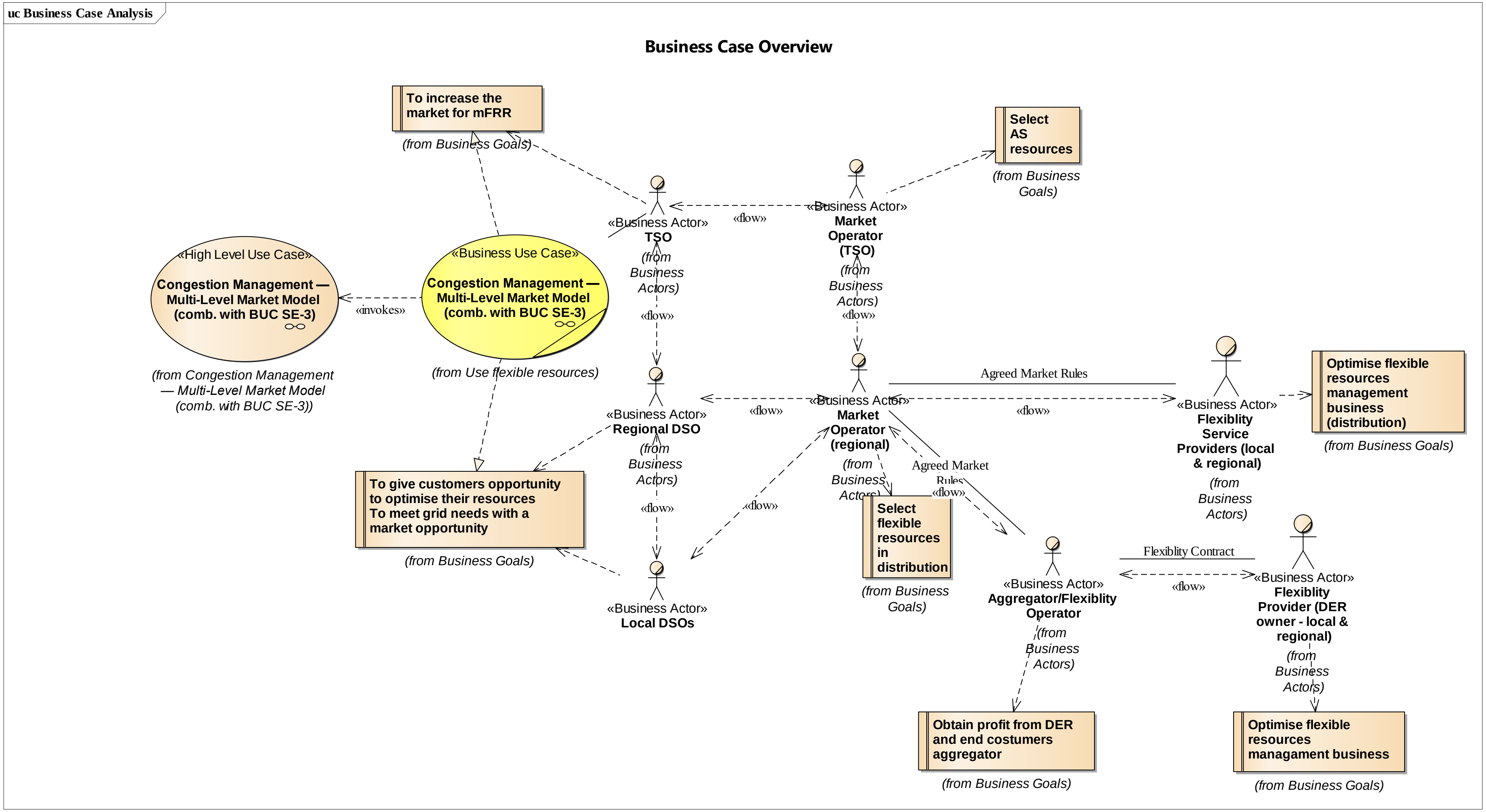

Figure 43: BUC SE-1a Overview: Congestion management - Multi-level Market Model

3.3.1.3. Sequence Diagram

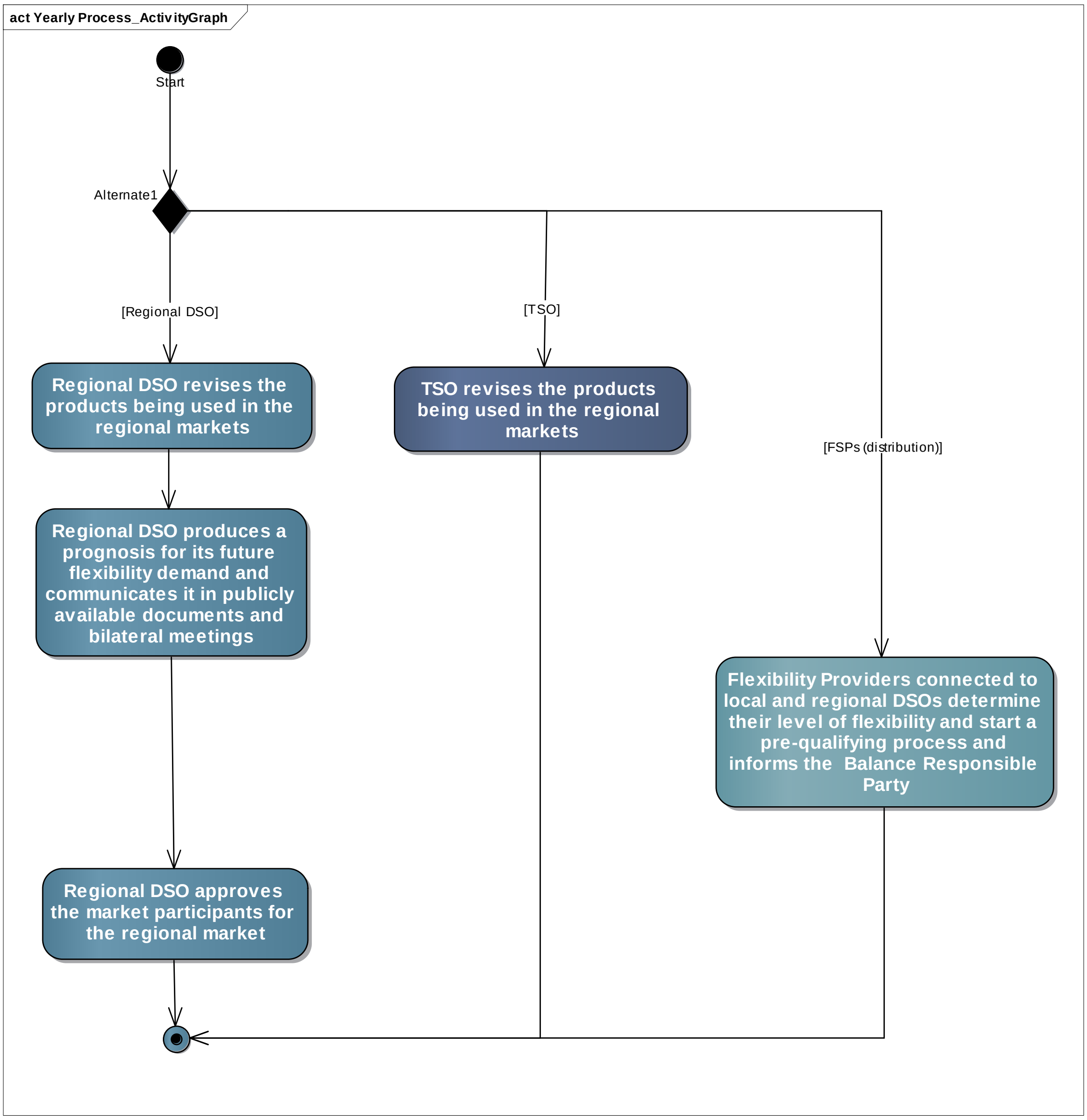

Figure 44: SE-1a Sequence Diagram - Yearly Process

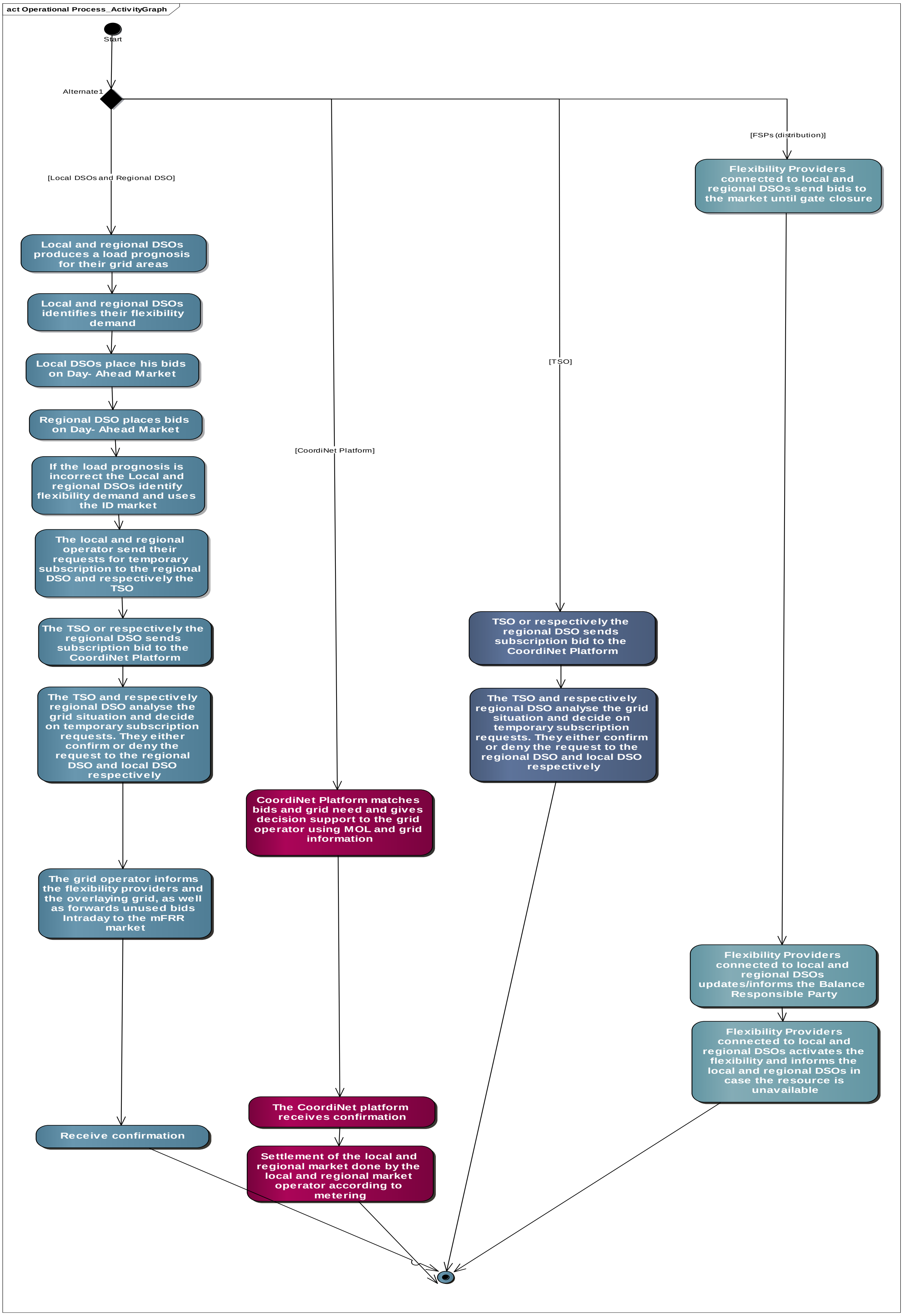

Figure 45: SE-1a Sequence Diagram - Operational Process

3.3.2. BUC SE-1b: Congestion management - Distributed Market Model

3.3.2.1. Scope and objectives

This BUC describes the actions that are carried out in case of congestions in the low voltage as well as medium voltage distribution grid using a peer to peer market.

The driver for this Use Case is that sometimes a peer to peer market can be a solution for customers when grid congestion occurs. One such clear example is congestion because of maintenance and investments in the grid.

The primary actor in this BUC is the Flexibility provider.

Geographical areas for the market:

- VästerNorrland/Jämtland
- (Gotland)

The objectives of this BUC are the following:

- Local and regional DSOs want to give customers opportunity to optimize their resources
- Local and regional DSOs meets grid needs with a market opportunity
- In addition, the flexibility provider wants to meet financial goals

3.3.2.2. Short narrative and BUC overview

The BUC[11] describes the steps that are followed to eliminate congestions in low-voltage and medium-voltage distribution system using flexiility provided by resources connected to both systems.

[11] In case that, during the project lifetime, a local interest and grid need in Gotland to use a peer-to-peer market arises, this BUC will be realized. A detailed description of this BUC is pending and will, if needed, follow in a later stage of the project (see WP2). Thus, a detailed description of the peer-to-peer market can further be developed under the scope of the CoordiNet project.

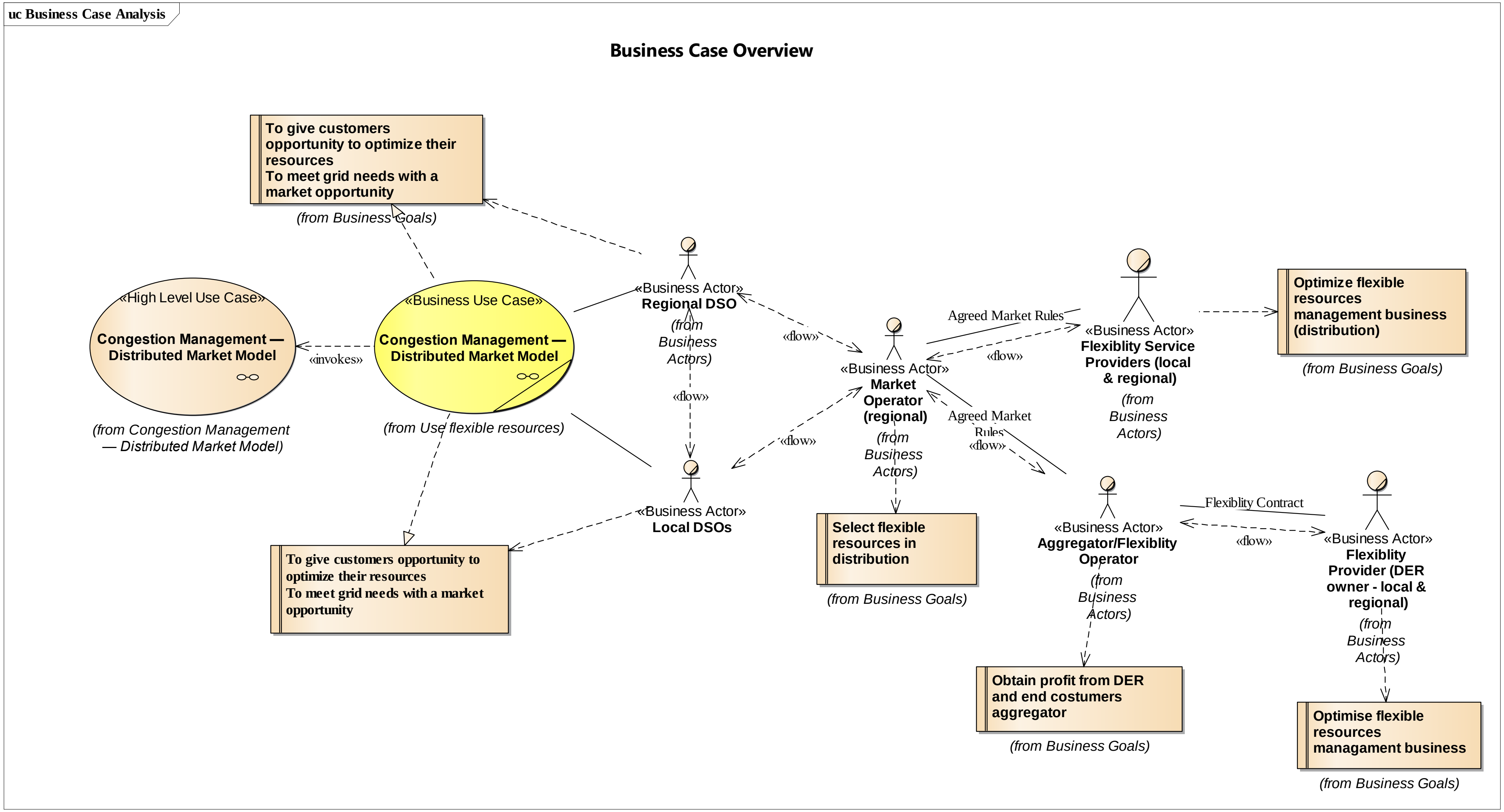

Figure 46: BUC SE-1b Overview: Congestion management - Distributed Market Model

3.3.2.3. Sequence Diagram

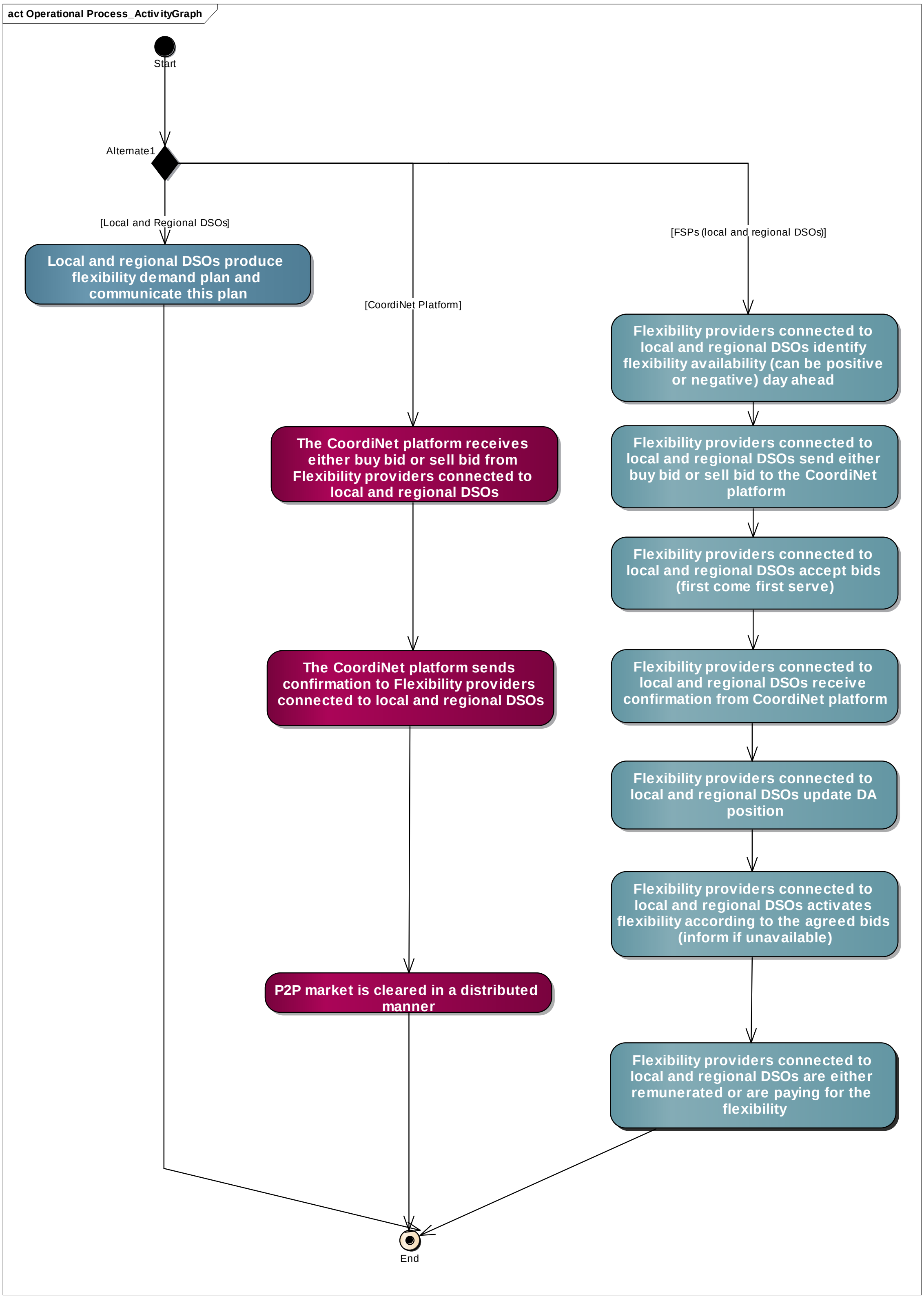

Figure 47: SE-1b Sequence Diagram - Operational Process

3.3.3. BUC SE-2: Balancing services for local DSO (in Gotland) – Local Market Model

3.3.3.1. Scope and objectives

This BUC describes the actions that are carried out when the regional and local DSOs want to use flexibility for system services for power quality and security of supply.

The regional DSO is motivated to work with the local DSO in Gotland to find a solution for the local DSOs' challenges using flexibility services on a market. Further analysis on both sides needs to be made, to understand the upcoming steps to realize this BUC. Market solutions have not been used or analysed for Gotland yet. The grid situation is very specific. The analysis should reveal which products will be utilized to solve the locally critical situation. The products under analysis are inertia, FCR and/or reactive power. Depending on the product(s), the integration on the local or peer-to-peer market will be targeted. This local DSO in Gotland is integrated and represented in BUC 1.

The objectives of this BUC are the following:

- The local DSO wants to connect new solar and wind power
- The local DSO wants to improve power quality and security of supply
- Local and regional DSO want to unlock flexibility and increase the attractiveness for flexibility providers to participate on the CoordiNet platform
- The regional DSO wants to provide solutions for the local DSO
- The TSO wants to increase the liquidity on the mFRR market
- FSPs want to optimise their resources management business

3.3.3.2. Short narrative and BUC overview[12]

After the identification of the grid needs, the local and regional DSO each use the (local and) regional market place to buy the needed services (while the products depend on the identified need). Possible products are i.e. inertia, FCR and mFRR. The CoordiNet platform will play a central role to exchange information, offer bids on products and enable to solve local grid issues. The intention is to use existing markets rules. Today these products are managed by TSO not by the regional DSOs in Sweden. The existing products and related processes might not specifically work for the grid situation of an island like Gotland. This applicability is part of the analysis that is the basis to realize the presented BUC.

[12] BUC SE-2 reveals no diagrams since a first analysis of possible products in the local distribution system of Gotland is pending. In a later stage of the project grid services, products and coordination schemes will be elaborated in greater detail, since the need for these services is already evident today.

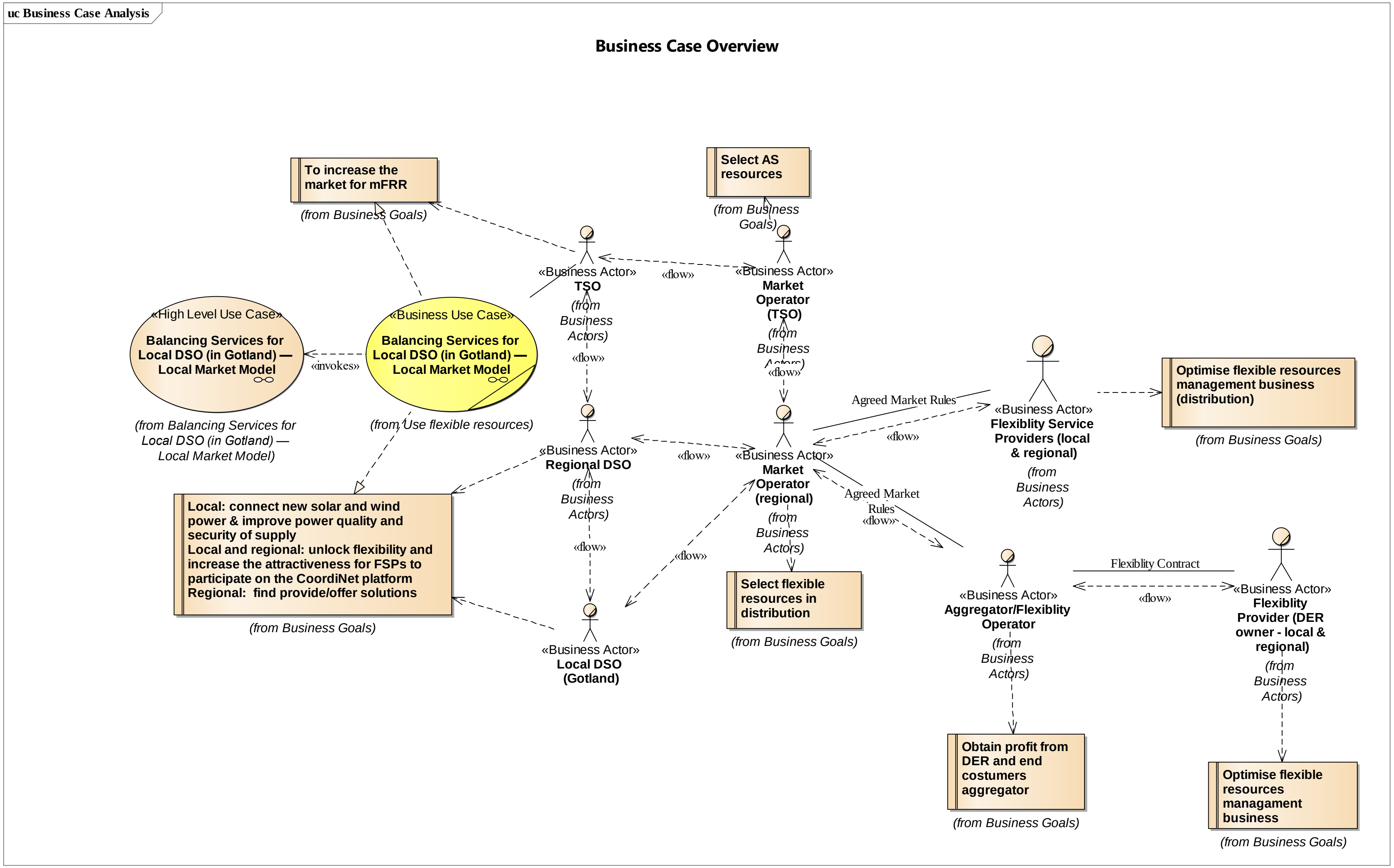

Figure 48: BUC SE-2 Overview: Balancing services for local DSO (in Gotland) - Local Market Model

3.3.4. BUC SE-3: Balancing services for TSO – Multi-level Market Model (in combination with BUC SE-1a)

3.3.4.1. Scope and objectives

This BUC describes the actions that are carried out when unused bids after the DA and ID market that meet the conditions for the balancing service mFRR (e.g. minimum bid size of 1 MW is foreseen for the CoordiNet pilot) are transferred to the TSO balancing market. The bids are activated in the same manner as other mFRR bids.

The objectives of this BUC are the following:

- The FSPs want to increase the attractiveness for flex providers to participate on the CoordiNet platform, to achieve more revenue streams
- The TSO wants to increase the liquidity of the balancing market
- Local and regional DSOs want to meet grid needs with a market opportunity

3.3.4.2. Short narrative and BUC overview

The BUC describes the steps that are followed to forward bids from the CoordiNet congestion market to the balancing market mFRR.

The TSO service market is open for all flexibility providers that meet pre-qualification criteria and have a cooperation with a BRP.

Geographical areas for the market:

- Uppland
- Skåne
- Gotland

The BUC reveals following steps:

1. Flexibility provider provide flexibility bids[13] (upward or downward regulation) to the CoordiNet platform.

2. Regional and local DSOs call bids[14], available on CoordiNet platform, for own need on

   2.1. DA and

   2.2. Two hours ahead (H-2).

3. Remaining bids meeting mFRR requirements are transferred to the TSO regulating power market at the latest at gate closure time for the TSO regulating power of this market

4. Bids are activated by the TSO

[13] Flexibility product prototype under development, one the basis of the existing mFRR product
[14] The bids are elements of BUC SE-1a

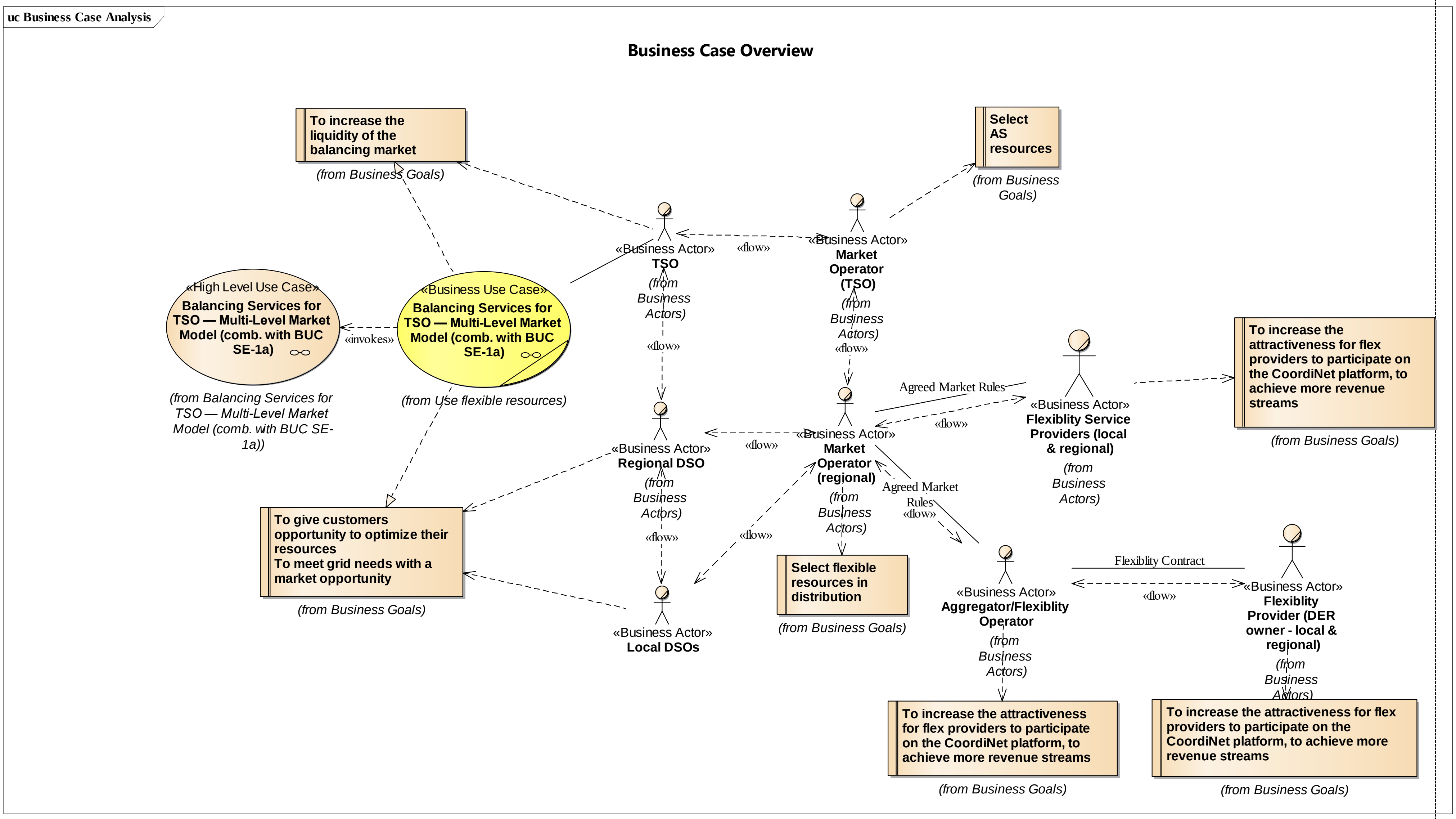

Figure 49: BUC SE-3 Overview: Balancing services for TSO - Multi-level Market Model

3.3.4.3. Sequence Diagram

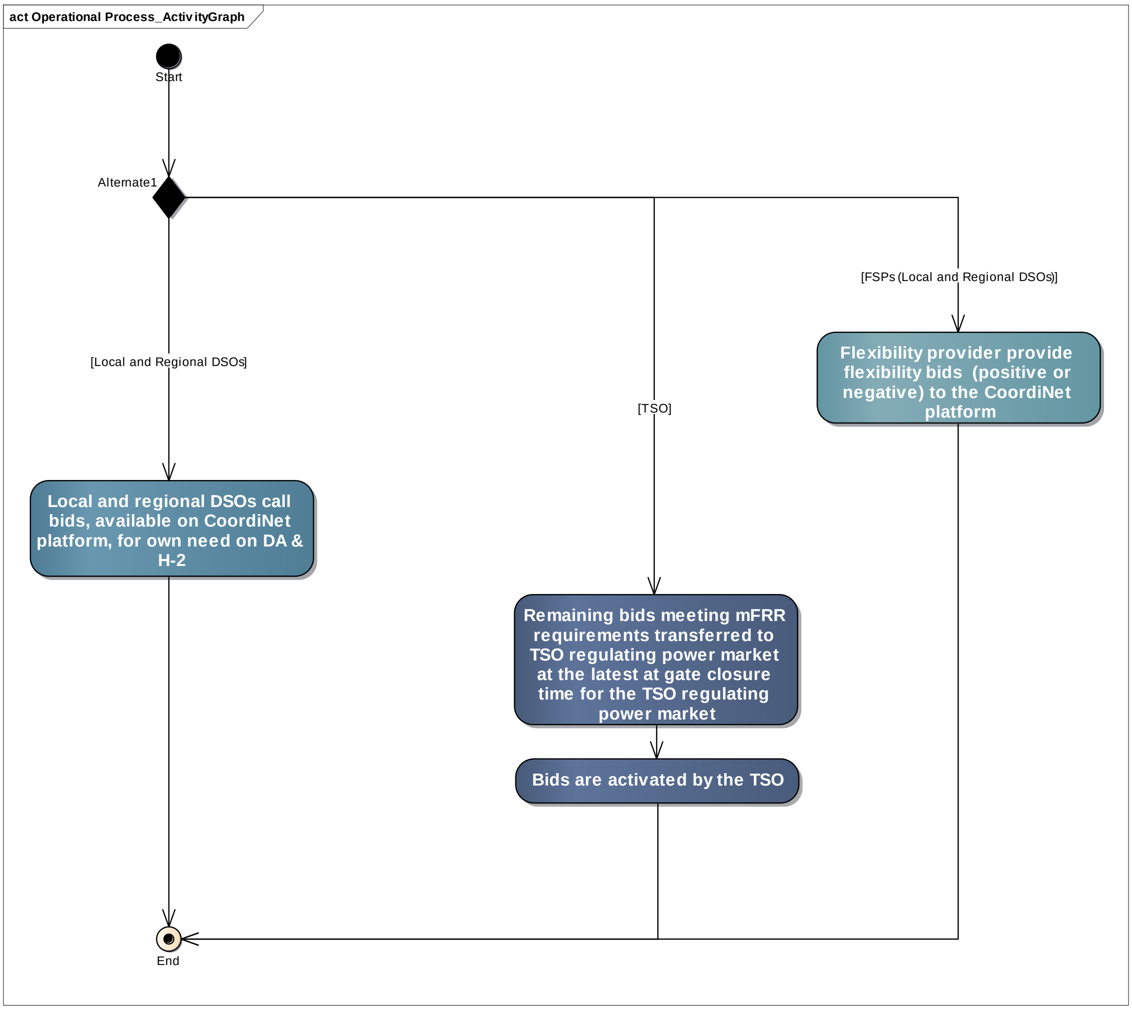

Figure 50: SE-3 Sequence Diagram - Operational Process

4. Associated grid services, products, and coordination schemes in relation to the BUCs

4.1. Grid services

Standard grid services have been analysed in (Vanschoenwinkel et al. 2019), Deliverable 1.3. As the titles of the presented BUCs indicate the following four grid services are targeted specifically in the CoordiNet project demonstration campaigns:

- **Balancing**
  Balancing services will always affect the TSO, since the measure for balancing is the system wide frequency.

- **Congestion Management**
  In contrast, congestion occurs in a limited geographical area, possibly, in the transmission or distribution network. Network congestion can occur due to limited hosting capacity and related inherent characteristics of physical assets, i.e. lines, cables or transformers. Thus congestion is a condition that describes that either one or more (thermal, voltage or stability) limits are exceeded. The congestion management service is utilized to mitigate congestion situations so that the grid is operated within the defined limits again.

- **Voltage Control**
  The grid voltage affects the transfer of active power economically, efficiently and reliably. Controlling the voltage especially in coordination with other actors, such as the TSO, is of major interest for the DSOs. Voltage control could also be dispatched to achieve a better operating state of the grid in non- congestion situations.

- **Controlled Islanding**
  Controlled islanding, is a grid service, specifically tackling the issue of TSO/DSO coordination. Having the possibility to operate the system in island mode on demand is of great value for the DSOs and the connected customers in terms of resiliency.

In addition, generally inertial response and support for black start are possible services that could be procured but are not mainly focused in this project, while the Swedish demonstration could possibly test these in WP4 (see Figure 51).

4.2. Products

Deliverable 1.3 (Vanschoenwinkel et al. 2019) focuses on identifying products for the procurement of the grid services mentioned in 4.1 (Figure 51). An elaborate analysis has been done to identify all attributes of possible products that can be of interest to enable the grid services targeted in the CoordiNet project. Thus, activation time, ramping period, mode of activation etc. have been analysed for: balancing, congestion management, voltage control, inertial response, black start and controlled islanding.

The demos, specifically with regard to the BUC framework, will deal with a subset of the products for the services. Each demo might specify the attributes in a stricter way. In addition, some of the services can be satisfied either with capacity and/or energy type products (for further information: (Vanschoenwinkel et al. 2019)).

- In the BUCs of the Greek demonstration campaign, both capacity and energy products are considered for voltage control and congestion management.

- In the BUCs of the Spanish demonstration campaign, mainly energy-based products are considered, whereas for controlled islanding, capacity would be contracted beforehand and eventually energy delivery could be rewarded in addition.

- In the BUCs of the Swedish demonstration campaign, capacity products are generally considered for congestion management. An energy product for congestion management is only considered for BUC SE-1a. For balancing, the Swedish Use Cases reveal generally energy products, while specifically BUC-SE-2 might deal with capacity products to complement to the energy product.

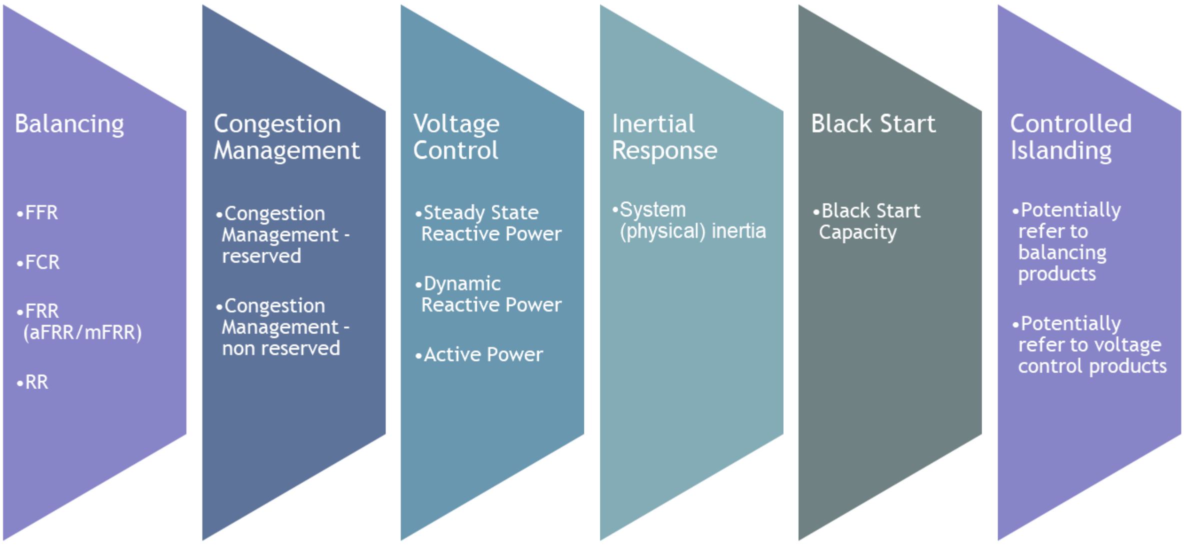

Figure 51: Products per grid service[15]

An overview of the mapping is given in Figure 52.

4.3. Coordination schemes

This chapter maps the presented BUCs to the identified coordination schemes and reveals which market models, identified in Chapter 4 of the CoordiNet deliverable no. 1.3 (Vanschoenwinkel et al. 2019), are applied in each of the Use Cases under analysis. Following coordination schemes will be applied in the different BUC which will be demonstrated within the project.

[15] Products for controlled islanding are not finalized at this stage of the project.

LOCAL MARKET MODEL

Two Use Cases apply the Local market model. The first one is the last Spanish Business Use Case which deals with controlled islanding for the DSO (BUC ES-4). Only a local need is considered and there is local acquisition of flexibility to maintain the islands during certain events such as outages or planned maintenance. In this specific case no market coordination is envisioned, although coordination would still be needed between the DSO and TSO. The third Swedish Use Case, BUC SE-2, focuses on balancing services to the DSO in Gotland. This is a special case as the DSO here has to handle some issues TSOs would typically be responsible for, i.e. balancing, inertial response. Coordination needs still need to be further discussed. Also here, the focus is on a local need and the DSO is the sole buyer.

DISTRIBUTED MARKET MODEL

The second Swedish Use Case (BUC SE-1b) focuses on a local need, i.e. congestion management in low voltage and medium voltage distribution grid by using a peer to peer market which entails local acquisition of flexibility by peers based on identified demand prognosis by the DSO. In this specific case no market coordination is needed between the TSO and DSO. The applicable market model is the Distributed market model.

CENTRAL MARKET MODEL

There is one BUC which focuses solely on a central need, i.e. the second Spanish Business Use Case (BUC ES-2) focusing on balancing services for the TSO and the TSO is the single buyer on the market. The TSO has access to DER. Grid constraints are taken into account preliminarily during pre-qualification, but also during procurement and activation. In this case the Central market model is considered.

COMMON MARKET MODEL

The first Business Use Case of the Spanish demonstrator (BUC ES-1) focuses on grid congestion management for both the TSO and DSO, while the third Spanish Use Case (BUC ES-3) focuses on voltage control for the TSO and DSO. In both cases a combination of local and central needs is considered and both SO are buying flexibility to this end. A single market is thus proposed where next to the DSO, also the TSO has direct (market) access to DER. No specific priority rules are applied. The procurement process assumes no priority of access to either SO. The coordination scheme which is applied is the Common market model.

MULTI-LEVEL MARKET MODEL

The first two Business Use Case of the Greek demonstrator focus on voltage control (BUC GR-1a) and congestion management (BUC GR-2a) respectively, for both the DSO and the TSO via a market-based mechanism. A combination of local and central needs is therefore considered in these Use Cases and both SO acquire their own flexibility on separate markets. DER can participate to the central market at to answer to the need of the TSO, but only after the needs of the DSO are covered. The TSO has thus access to DER. Sequential markets are foreseen whereby the DSO filters, aggregates and transfers flexibility offers to the central market at TSO level. The coordination scheme for these Use Cases is therefore the Multi-level market model whereby grid constraints are taken into account during pre-qualification, and procurement and activation.

The first Swedish Business Use Case (BUC SE-1a) and the fourth Swedish Use Case (BUC SE-3) should be considered together when looking at market coordination. In this case actually three different levels of SO should be distinguished: the local DSO, the regional DSO and the TSO. The Business Use Case focuses on a local need (congestion management for the local DSO and regional DSO in their respective grids) and a central need (balancing for the TSO) and how to acquire them in a coordinated manner.

A combination of local and central needs is therefore considered and multiple markets will be implemented: a regional market for congestion management for the local and regional DSO and a central market for balancing for the TSO. On the regional market priority rules are applied: the local DSO has priority over the regional DSO. Afterwards, DER can participate to the central, balancing market, but only after the needs of the DSO for congestion management are covered. From a market coordination perspective, this Use Case is similar to BUC GR-1a and BUC GR-2a. The coordination scheme for this Use Case is the Multi-level market model.

FRAGMENTED MARKET MODEL

The last two Business Use Case of the Greek demonstrator focus respectively on voltage control (BUC GR-1b) and congestion management (BUC GR-2b) for both the DSO and the TSO via a market-based mechanism. A combination of local and central needs is therefore considered in these Use Cases and both SO acquire their own flexibility on separate markets. The main difference between these Use Cases and the previous Greek Use Cases is that in this case the TSO has no access to DER; this means that distribution grid connected resources can solely provide flexibility to the local DSO market. The TSO can thus only procure flexibility services from own connected grid users, at the central market. In this case the applicable coordination scheme is the Fragmented market model.

Figure 52 summarizes the coordination schemes which will be applied in the demonstration campaigns.

5. Conclusion

This document summarizes the information collected from the demonstration campaigns, concerning:

- the individual BUC scopes which reveal the main actors, the geographical location of the demo, and the overall goal, which should match the big picture of the project ambitions,
- the individual objectives of the most relevant actors of the described BUC, and
- the individual narratives of the BUCs, explaining in a step by step approach the targeted processes.

With the collected information, diagrams have been designed and presented to visualize the actors, roles and their connections within each BUC. These so called overview diagrams also depict the individually identified objectives of the market players. In addition, the elaborated Sequence diagrams enable a clearer process flow representation in contrast to the narrative description per BUC, which is given in full length in the appendix section 7.1.

The BUC description is aligned with the identified grid services, products and coordination schemes (Task 1.3. of the CoordiNet project). The BUCs cover timeframes from long term planning up to near real time operations. An overview is depicted in Figure 52. The grid services are offered via central, centralized local, common, multi-level, fragmented and distributed market mechanisms. The project reveals cases (BUC GR-1a&b, BUC GR-2a&b, and BUC SE-1a&b), in which one grid service is tested applying different market mechanisms. The products and schemes in BUC SE-2 can vary in the course of the project, since multiple approaches will be tested for a successful implementation of new balancing solutions for the area.

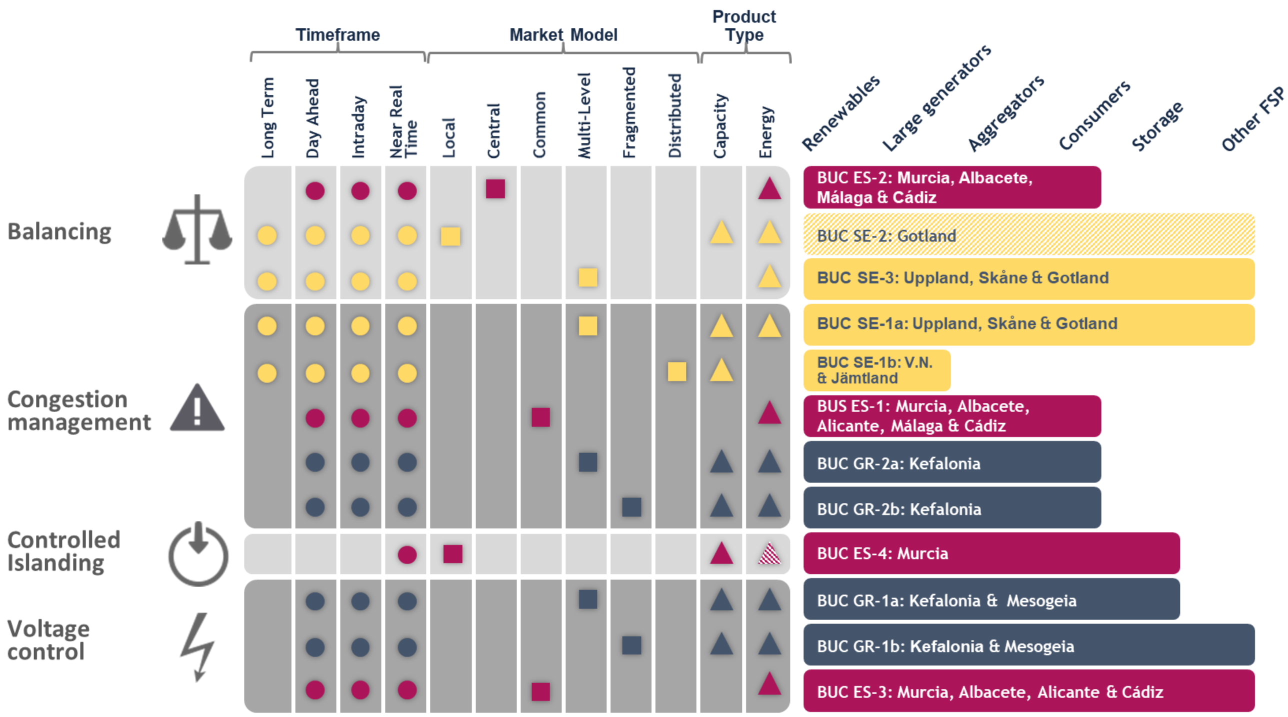

Figure 52: Coordination Schemes and Products per BUC

The presented work is a clear starting point for the WPs 3-5, as a generic orientation of the demo ambitions. It also marks the first steps for WP 2: “Markets and platform to coordinate the procurement of energy services”. The latter will focus on identifying in a vertical manner, possible communication and information aspects with reference to the earlier presented SGAM Methodology.

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7. Appendix

7.1. Detailed versions of the BUC forms

7.1.1. BUC GR-1a

PLEASE FILL OUT ONE TEMPLATE FOR EACH IDENTIFIED USE CASE. IN CASE THAT DIFFERENT PERSPECTIVES REQUIRE SEPERATE DOCUMENTS PLEASE INDICATE YOUR VIEWPOINT FOR THIS USE CASE:

☒ DSO

☒ TSO

☐ REGULATOR

☐ OTHER

Use Case Identification

Name of UC: Enter a short name that refers to the activity of the UC itself.
Voltage control in transmission system and distribution system using flexible resources connected to transmission and distribution system under the scope of a multi-level market mechanism

Name Author(s) or Committee: Person or e.g. standardization committee like Smart Grid Technical Committees or Working Group, if applicable.
ICCS/HEDNO/IPTO/ETRAID

Scope and objectives

Scope: Describe briefly the scope, objectives, and rationale of the UC. You can additionally use the tick boxes to specify the voltage level and markets that are subject to this Use Case.
This BUC describes the actions that are carried out in case of anticipated voltage violations in transmission and distribution system in order to keep voltage level in the accepted boundaries. Flexible resources connected to transmission and distribution system can provide flexibility to system operators to eliminate voltage violations through a market mechanism. DSO can use flexible resources connected to distribution system and TSO can use flexible resources connected to transmission system and flexible resources connected to distribution system whose use has been approved by DSO. Active and reactive power control is considered. Three different markets are examined depending on the time frame. These markets are • Day Ahead • Intraday • Near Real Time The voltage control shall be local as voltage is a zonal parameter for power grids. This is an important activity that is likely performed on a permanent basis to keep the grid voltage within normal ranges.

In addition, it has to be ensured that the activation of flexible resources in the distribution network by the TSO would respect distribution system constraints. A cooperation and information exchange between DSO and TSO are crucial for eliminating voltage violations with the most efficient way, while respecting distribution and transmission system constraints.

This BUC will be tested in Kefalonia and Mesogeia Area, where over-voltages are mainly detected due to the increased penetration of RES, mainly during the hours of low consumption. Due to the continuous increase of RES installation, voltage violations are expected to increase the next years. In order to avoid investment to upgrade the system, better use of flexibility is required.

In Kefalonia, renewable generators, large generators, aggregators, consumers and backup generators will be the agents that provide grid services. In Mesogeia, aggregators, consumers, renewable generators and other flexibility providers will be the agents that provide grid services.

Network under Study

☐ EHV

☒ HV

☒ MV

☒ LV

Objective: Describe briefly the objective of the UC.

The objectives of this BUC are the following:

1. To ensure non-discriminatory access to the market for all agents that provide grid services.
2. To enable coordination and information exchange between system operators in order to improve efficiency of the system.
3. To enable the TSO to use the flexibility provided by the resources connected to the distribution system for voltage control, while respecting distribution system constraints.
4. To ensure a secure operation of the transmission and distribution system.
5. To minimize RES curtailment due to security reasons and operational limits.

Narrative of the Use Case

Short Description: A <u>short</u> narrative focusing on the question what is done in the scope of the use case. This is meant to create a brief overview.

The BUC describes the steps that are followed to eliminate voltage violations in transmission and distribution system. DSO can use flexible resources connected to distribution system and TSO can use flexible resources connected to transmission system and flexible resources connected to distribution system whose use has been approved by DSO. The voltage level in transmission and distribution system is permanently assessed and monitored by TSO and DSO respectively, in order to decide actions for keeping voltages of their systems within admissible range.

The steps that are followed for each market are described below:

Day Ahead Market

1 TSO and DSO assess voltage levels at the transmission and distribution system for the next 24 hours, respectively.

1.1 DSO invokes RES and Load Forecast in Distribution system SUC (**System Use Case**). DSO shares the information per primary substation with TSO. TSO/DSO Communication Platform SUC is invoked.

1.2 Based on the forecasting, DSO invokes Distribution Grid Management SUC to assess the voltage levels at distribution system and detect possible voltage violations.

1.3 TSO invokes RES and Load Forecast in Transmission system SUC.

1.4 Based on the forecasting, TSO runs power flow simulations to assess the voltage levels at transmission system to detect possible voltage violations.

2	DSO in coordination with TSO decide reconfiguration of distribution system to eliminate/minimize anticipated voltage violations.
2.1	TSO/DSO Communication Platform SUC is invoked in order TSO and DSO to exchange information.
2.2	DSO invokes Distribution Grid Management SUC to apply distribution system reconfiguration.
3	DSO assesses the amount of flexibility that is required to eliminate voltage violations and decides the location of the flexible resources connected to the distribution system that can contribute to the elimination of voltage violations at the distribution system. Distribution Grid Management SUC is invoked.
4	In case there is a need of flexibility, DSO requests offer from Day Ahead DSO/Local Market. The required capacity and the location of the flexible resources connected to the distribution system (if available) that can contribute to the elimination of voltage violations are sent to the Platform. Market Platform SUC is invoked.
5	Flexibility providers connected to the distribution system send their offers (capacity and energy bids) that meet the requirements sent by DSO. Market Platform SUC is invoked.
6	Platform sends the bids to DSO. Market Platform SUC is invoked.
7	The DSO assures that only bids respecting the DSO grid constraints can take part in the Day Ahead DSO/Local Market. DSO informs the Platform accordingly. Distribution Grid Management SUC and Market Platform SUC are invoked.
8	Market Operator clears the Day Ahead DSO/Local Market. The results of the market are sent to the DSO and the flexibility providers connected to the distribution system. Market Platform SUC is invoked.
9	TSO assesses the required amount of flexibility that is needed to eliminate voltage violations and decides the location of the flexible resources connected to the distribution and the transmission system (if available - under which primary substations for the flexible resources connected to the distribution system) that can contribute to the elimination of voltage violations at the transmission system.
10	In case there is a need of flexibility, TSO requests offer from Day Ahead TSO AS market. In addition, TSO sends to the Platform the location of the flexible resources connected to the distribution and the transmission system that can contribute to the elimination of voltage violations at the transmission system. Market Platform SUC is invoked.
11	Platform informs the DSO of the TSO request. Market Platform SUC is invoked.
12	DSO aggregates and transfers the remaining bids that are not used for distribution system to the Day Ahead TSO AS market. TSO/DSO Communication Platform SUC is invoked
13	Flexibility providers connected to the transmission system send their offers (capacity and energy bids). Market Platform SUC is invoked.
14	Market Operator clears the Day Ahead TSO AS market taking into account the aggregated bids from distribution system and the offers from flexibility providers connected to the transmission system. The results of the market are sent to TSO and the flexibility providers connected to the transmission system. Market Platform SUC is invoked.
15	TSO sends the results of the Day Ahead TSO AS market to DSO. TSO/DSO Communication Platform SUC is invoked for the communication between TSO and DSO.
16	DSO sends the results of Day Ahead TSO AS market to the flexibility providers connected to the distribution system.
Intraday Market	
17	TSO and DSO assess voltage levels at transmission and distribution system for the next 12 hours, respectively.
17.1	DSO invokes RES and Load Forecast in Distribution system SUC. DSO shares the information per primary substation with TSO.
17.2	Based on the forecasting and the results of Day Ahead DSO/Local market, DSO invokes Distribution Grid Management SUC to assess the voltage levels at distribution system and detect possible voltage violations.
17.3	TSO invokes RES and Load Forecast in Transmission system SUC.

17.4 Based on the forecasting and the results of Day Ahead TSO AS market, TSO runs power flow simulations to assess the voltage levels at transmission system to detect possible voltage violations.

18 DSO assesses the amount of flexibility that is required to eliminate voltage violations and decides the location of the flexible resources connected to the distribution system that can contribute to the elimination of voltage violations at the distribution system. Distribution Grid Management SUC is invoked.

19 In case there is a need of flexibility, DSO requests offer from Intraday DSO/Local Market. The required capacity and the location of the flexible resources connected to the distribution system (if available) that can contribute to the elimination of voltage violations are sent to the Platform. Market Platform SUC is invoked.

20 Flexibility providers connected to the distribution system send their offers (capacity and energy bids) that meet the requirements sent by DSO. Market Platform SUC is invoked.

21 Platform sends the bids to DSO. Market Platform SUC is invoked.

22 The DSO assures that only bids respecting the DSO grid constraints can take part in the Intraday DSO/Local Market. DSO informs the Platform accordingly. Distribution Grid Management SUC and Market Platform SUC are invoked.

23 Market Operator clears the Intraday DSO/Local Market. The results of the market are sent to the DSO and the flexibility providers connected to the distribution system. Market Platform SUC is invoked.

24 TSO assesses the required amount of flexibility that is needed to eliminate voltage violations and decides the location of the flexible resources connected to the distribution and the transmission system (if available - under which primary substations for the flexible resources connected to the distribution system) that can contribute to the elimination of voltage violations at the transmission system.

25 In case there is a need of flexibility, TSO requests offer from Intraday TSO AS market. In addition, TSO sends to the Platform the location of the flexible resources connected to the distribution and the transmission system that can contribute to the elimination of voltage violations at the transmission system. Market Platform SUC is invoked.

26 Platform informs the DSO of the TSO request. Market Platform SUC is invoked.

27 DSO aggregates and transfers the remaining bids that are not used for distribution system to the Intraday TSO AS market. Market Platform SUC is invoked.

28 Flexibility providers connected to the transmission system send their offers. Market Platform SUC is invoked.

29 Market Operator clears the Intraday TSO AS market taking into account the aggregated bids from distribution system and the offers from flexibility providers connected to the transmission system. The results of the market are sent to TSO and the flexibility providers connected to the transmission system. Market Platform SUC is invoked.

30 TSO sends the results of the Intraday TSO AS market to DSO. TSO/DSO Communication Platform SUC is invoked for the communication between TSO and DSO.

31 DSO sends the results of the Intraday TSO AS market to flexibility providers connected to the distribution system.

Near Real Time Market

32 TSO and DSO assess voltage levels at transmission and distribution system for the next 5 minutes, respectively.

32.1 DSO invokes State Estimation in Distribution system SUC.

32.2 Based on the state estimation and the results of Day Ahead and Intraday markets, DSO invokes Distribution Grid Management SUC to assess the voltage levels at distribution system and detect possible voltage violations.

32.3 TSO invokes State Estimation in Transmission system SUC.

32.4 Based on the state estimation and the results of Day Ahead and Intraday market, TSO runs power flows to assess the voltage levels at transmission system to detect possible voltage violations.

33 DSO assesses the amount of flexibility that is required to eliminate voltage violations and decides the location of the flexible resources connected to the distribution system (if available) that can contribute to the elimination of voltage violations. Distribution Grid Management SUC is invoked.

34 In case there is a need of flexibility, DSO sends the request to the Platform. Market Platform SUC is invoked.

35 The DSO assures that the activation of the flexibility providers connected to the distribution system will respect the DSO grid constraints and informs the Platform accordingly. Distribution Grid Management SUC and Market Platform are invoked.

36 Based on the offers in Day Ahead and Intraday DSO/Local Markets and DSO request, Market Operator decides the activation of the flexibility providers connected to the distribution system. Platform informs DSO and the flexibility providers connected to the distribution system for their activation. Market Platform is invoked.

37 TSO assesses the required amount of flexibility that is needed to eliminate voltage violations and decides the location of the flexible resources connected to the distribution and transmission system (if available - under which primary substations for the flexible resources connected to the distribution system) that can contribute to the elimination of voltage violations.

38 In case there is a need of flexibility, TSO sends the request to the Platform. In addition, TSO sends to the Platform the location of the flexible resources connected to the distribution and the transmission system that can contribute to the elimination of voltage violations at the transmission system. Market Platform SUC is invoked.

39 Platform informs the DSO of the TSO request. Market Platform SUC is invoked.

40 DSO sends to the Platform the activation of which flexible resources connected to the distribution system respects DSO limits. Market Platform SUC is invoked.

41 Based on the offers in Day Ahead and Intraday TSO AS markets and TSO request, Market Operator decides the activation of the flexibility providers connected to the distribution and the transmission system. The results of the market are sent to TSO and the flexibility providers connected to the transmission system. Market Platform SUC is invoked.

42 TSO sends the results of the Near Real Time TSO AS market to DSO. TSO/DSO Communication Platform SUC is invoked for the communication between TSO and DSO.

43 DSO sends the results of the Near Real Time TSO AS market to flexibility providers connected to the distribution system.

44 In case the voltage violations cannot be eliminated based on the market results, DSO in coordination with TSO decide the reconfiguration of distribution system to eliminate/minimize voltage violations.

44.1 TSO/DSO Communication Platform SUC is invoked in order TSO and DSO to exchange information.

44.2 DSO invokes Distribution Grid Management SUC to apply distribution system reconfiguration.

After Real Time

45 Operators measure the injected and absorbed energy by the flexible resources connected to their systems.

45.1 TSO measures the injected and absorbed energy by the flexible resources connected to the transmission system.

45.2 DSO measures the injected and absorbed energy by the flexible resources connected to the distribution system.

46 Operators send the metering data to the Platform.

46.1 TSO sends the metering data to the Platform.

46.2 DSO sends the metering data to the Platform.

47 Platform performs the settlement of the flexible service providers based on metering data of the injected and absorbed energy and reserved capacity resulted from Day Ahead and Intraday markets.

48 Aggregators perform the settlement of the flexibility sources under their jurisdiction.

Further Details

Actors&Roles, Names and Types: Please indicate which actors contribute to the Use Case in the sense of providing inputs/outputs, processing or aggregation. In case the writer of the Use Case defines an own actor, the actor shall be classified and shortly described.
☒ DSO ☒ TSO ☒ END CUSTOMERS (MV/LV) ☒ DER CUSTOMERS ☐ REGULATOR ☐ MUNICIPALITY/LOCAL AUTHORITY ☒ AGGREGATOR/FLEXIBILITY OPERATOR ☐ BALANCE RESPONSIBLE PARTY ☒ SERVICE PROVIDER ☐ Other: **Specific Roles (if applicable)** ☒ SYSTEM OPTIMISER ☒ DATA MANAGER ☐ SMART GRID OPERATOR ☒ NEUTRAL MARKET ENABLER ☒ CONSTRAINTS MARKET OPERATOR ☐ CUSTOMER RELATIONSHIP MANAGER ☐ OTHER 3RD PARTIES RELATIONSHIP MANAGER ☒ SYSTEM SECURITY MANAGER ☒ OTHER:

7.1.2. BUC GR-1b

PLEASE FILL OUT ONE TEMPLATE FOR EACH IDENTIFIED USE CASE. IN CASE THAT DIFFERENT PERSPECTIVES REQUIRE SEPERATE DOCUMENTS PLEASE INDICATE YOUR VIEWPOINT FOR THIS USE CASE:

☒ DSO

☒ TSO

☐ REGULATOR

☐ OTHER

Use Case Identification

Name of UC: Enter a short name that refers to the activity of the UC itself.
Voltage control in transmission system and distribution system using flexible resources connected to transmission and distribution system under the scope of a fragmented market mechanism

Name Author(s) or Committee: Person or e.g. standardization committee like Smart Grid Technical Committees or Working Group, if applicable.
ICCS/HEDNO/IPTO/ETRAID

Scope and objectives

<table>
<tr><td>Scope: Describe briefly the scope, objectives, and rationale of the UC. You can additionally use the tick boxes to specify the voltage level and markets that are subject to this Use Case.</td></tr>
<tr><td>This BUC describes the actions that are carried out in case of anticipated voltage violations in transmission and distribution system in order to keep voltage level in the accepted boundaries. The flexible resources connected to the transmission system can provide flexibility only to TSO and the flexible resources connected to the distribution system can provide flexibility only to DSO. TSO and DSO cooperate to decide the power exchange between them. In order to decide the power exchange between, TSO and DSO take into account the voltage level of the buses in transmission and distribution system, respectively.

Three different markets are examined depending on the time frame. These markets are
• Day Ahead
• Intraday
• Near Real Time
The voltage control shall be local as voltage is a zonal parameter for power grids. This is an important activity that is likely performed on a permanent basis to keep the grid voltage within normal ranges.
A cooperation and information exchange between DSO and TSO are crucial for eliminating voltage violations with the most efficient way, while respecting distribution and transmission system constraints.
This BUC will be tested in Kefalonia and Mesogeia Area, where over-voltages are mainly detected due to the increased penetration of RES, mainly during the hours of low consumption. Due to the continuous increase of RES installation, voltage violations are expected to increase the next years. In order to avoid investment to upgrade the system, better use of flexibility is required.
In Kefalonia, renewable generators, large generators, aggregators, consumers and backup generators will be the agents that provide grid services. In Mesogeia, aggregators, consumers, renewable generators and other flexibility providers will be the agents that provide grid services.
In Mesogeia and Near Real Time market, a centralized and a peer-to-peer approach will be implemented for the optimal activation of flexible resources. The implementation of peer-to-peer approach aims at enabling the participation of a significantly high number of flexible resources (consumers that participate in the demand response mechanism) by achieving higher scalability, reducing computational effort and enhancing resiliency since the activation of flexible resources will not be relied on a central platform.
Network under Study
☐ EHV
☒ HV
☒ MV
☒ LV
Market under Study
☒ Day Ahead Energy Market
☐ Day Ahead Balancing Market
☒ Intraday Energy Market
☐ Intraday Balancing Market
☒ FLEXIBILITY MARKET
☒ DISTRIBUTION CONSTRAINTS MARKET
☒ CAPACITY MARKET</td></tr>
</table>

☐ OTHER
Objective: Describe briefly the objective of the UC.
The objectives of this BUC are the following: 1. To ensure non-discriminatory access to the market for all agents that provide grid services. 2. To enable coordination and information exchange between system operators in order to improve efficiency of the system. 3. To ensure a secure operation of the transmission and distribution system. 4. To minimize RES curtailment due to security reasons and operational limits.

Narrative of the Use Case

Short Description: A short narrative focusing on the question what is done in the scope of the use case. This is meant to create a brief overview.
The BUC describes the steps that are followed to eliminate voltage violations in transmission and distribution system when DSO can use flexible resources connected to distribution system and TSO can use flexible resources connected to transmission system. The voltage level in transmission and distribution system is permanently assessed and monitored by TSO and DSO respectively, in order to decide actions for keeping voltages of their systems within admissible range. The steps that are followed for each market are described below: **Day Ahead Market** 2. TSO and DSO assess voltage levels at transmission and distribution system for the next 24 hours, respectively. 3. DSO invokes RES and Load Forecast in Distribution system SUC (System Use Case). DSO shares the information per primary substation with TSO. TSO/DSO Communication Platform SUC is invoked. 4. Based on the forecasting, DSO invokes Distribution Grid Management SUC to assess the voltage levels at distribution system and detect possible voltage violations. 5. TSO invokes RES and Load Forecast in Transmission system SUC. 6. Based on the forecasting, TSO runs power flow simulations to assess the voltage levels at transmission system to detect possible voltage violations. 7. DSO in coordination with TSO decide the reconfiguration of distribution system and the power exchange (active and reactive power) between them in order to eliminate/minimize anticipated voltage violations. Setpoint or a range of power exchange is decided by TSO and DSO. 8. TSO/DSO Communication Platform SUC is invoked in order TSO and DSO to exchange information. 9. DSO invokes Distribution Grid Management SUC to apply distribution system reconfiguration. 10. DSO assesses the amount of flexibility that is required to eliminate voltage violations and decides the location of the flexible resources connected to the distribution system (if available) that can contribute to the elimination of voltage violations at the distribution system. Distribution Grid Management SUC is invoked. 11. In case there is a need of flexibility, DSO requests offer from Day Ahead DSO/Local Market. The required capacity and the location of the flexible resources connected to the distribution system that can contribute to the elimination of voltage violations are sent to the Platform. Market Platform SUC is invoked. 12. Flexibility providers connected to the distribution system send their offers (capacity and energy bids) that meet the requirements sent by DSO. Market Platform SUC is invoked. 13. Platform sends the bids to DSO. Market Platform SUC is invoked.

14. DSO assures that only bids respecting the DSO grid constraints can take part in the Day Ahead DSO/Local Market. DSO informs the Platform accordingly. Distribution Grid Management SUC and Market Platform SUC are invoked.
15. Market Operator clears the Day Ahead DSO/Local Market. The results of the market are sent to DSO and flexibility providers connected to the distribution system. Market Platform SUC is invoked.
16. TSO assesses the required amount of flexibility that is needed to eliminate voltage violations at transmission system and decides the location of the flexible resources connected to the transmission system (if available) that can contribute to the elimination of voltage violations at the transmission system.
17. In case there is a need of flexibility, TSO requests offer from Day Ahead TSO AS market. In addition, TSO sends to the Platform the location of the flexible resources connected to the transmission system that can contribute to the elimination of voltage violations at the transmission system. Market Platform SUC is invoked.
18. Flexibility providers connected to the transmission system send their offers (capacity and energy bids). Market Platform SUC is invoked.
19. Market Operator clears the Day Ahead TSO AS market. The results of the market are sent to TSO, the flexibility providers connected to the transmission system. Market Platform SUC is invoked.

Intraday Market

1. TSO and DSO assess voltage levels at transmission and distribution system for the next 12 hours, respectively.

1.1. DSO invokes RES and Load Forecast in Distribution system SUC. DSO shares the information per primary substation with TSO.

1.2. Based on the forecasting and the results of the Day Ahead DSO/Local market, DSO invokes Distribution Grid Management SUC to assess the voltage levels at distribution system and detect possible voltage violations.

1.3. TSO invokes RES and Load Forecast in Transmission system SUC.

1.4. Based on the forecasting and the results of the Day Ahead TSO AS market, TSO runs power flow simulations to assess the voltage levels at transmission system to detect possible voltage violations.

2. DSO and TSO can re-schedule the power exchange (active and reactive power) between them for the rest of the period.
3. DSO assesses the amount of flexibility that is required to eliminate voltage violations and decides the location of the flexible resources connected to the distribution system (if available) that can contribute to the elimination of voltage violations at the distribution system. Distribution Grid Management SUC is invoked.
4. In case there is a need of flexibility, DSO requests offer from Intraday DSO/Local Market. The required capacity and the location of the flexible resources connected to the distribution system that can contribute to the elimination of voltage violations are sent to the Platform. Market Platform SUC is invoked.
5. Flexibility providers connected to the distribution system send their offers (capacity and energy bids) that meet the requirements sent by DSO. Market Platform SUC is invoked.
6. Platform sends the bids to DSO. Market Platform SUC is invoked.
7. The DSO assures that only bids respecting the DSO grid constraints can take part in the Intraday DSO/Local Market. DSO informs the Platform accordingly. Distribution Grid Management SUC and Market Platform SUC are invoked.
8. Market Operator clears the Intraday DSO/Local Market. The results of the market are sent to the DSO and flexibility providers connected to the distribution system. Market Platform SUC is invoked.
9. TSO assesses the required amount of flexibility that is needed to eliminate voltage violations and decides the location of the flexible resources connected to the transmission system (if available) that can contribute to the elimination of voltage violations at the transmission system.

10. In case there is a need of flexibility, TSO requests offer from Intraday TSO AS market. In addition, TSO sends to the Platform the location of the flexible resources connected to the transmission system that can contribute to the elimination of voltage violations at the transmission system. Market Platform SUC is invoked.
11. Flexibility providers connected to the transmission system send their offers. Market Platform SUC is invoked.
12. Market Operator clears the Intraday TSO AS market. The results of the market are sent to TSO and the flexibility providers connected to the transmission system. Market Platform SUC is invoked.

Near Real Time Market

1 DSO and TSO apply the appropriate actions if there are deviations from the scheduled power exchange

2 TSO and DSO assess voltage levels at transmission and distribution system for the next 5 minutes, respectively.

2.1 DSO invokes State Estimation in Distribution system SUC.

2.2 Based on the state estimation and the results of Day Ahead and Intraday markets, DSO invokes Distribution Grid Management SUC to assess the voltage levels at distribution system and detect possible voltage violations.

2.3 TSO invokes State Estimation in Transmission system SUC.

2.4 Based on the state estimation and the results of Day Ahead and Intraday market, TSO runs power flows to assess the voltage levels at transmission system to detect possible voltage violations.

3 DSO assesses the amount of flexibility that is required to eliminate voltage violations and decides the location of the flexible resources connected to the distribution system (if available) that can contribute to the elimination of voltage violations. Distribution Grid Management SUC is invoked.

4 In case there is a need of flexibility, DSO sends the request to the Platform. In addition, the location of the flexible resources connected to the distribution system that can contribute to the elimination of voltage violations are sent to the Platform. Market Platform SUC is invoked.

5 The DSO assures that the activation of the flexibility providers connected to the distribution system will respect the DSO grid constraints and informs the Platform accordingly. Distribution Grid Management SUC and Market Platform are invoked.

(As an alternative of step 29, a peer-to-peer approach will be examined for the activation of flexible resources)

a. The Platform sends a signal to the flexible resources identified by the DSO and informs them about the DSO requirement.
b. Activation of the flexible resources is calculated via a peer-to-peer approach. The activation of each flexible resource is decided based on the energy bids made in Day Ahead and Intraday DSO/Local Market and the goal is to minimize the total cost.
c. The flexible resources inform the Platform about their activation based on the peer-to-peer approach results
d. The Platform informs the DSO about the activation of the flexible resources and the peer-to-peer approach results.

6 Based on the offers in Day Ahead and Intraday DSO/Local Markets and DSO request, Market Operator decides the activation of the flexibility providers connected to the distribution system. Platform informs DSO and the flexibility providers connected to the distribution system for their activation. Market Platform is invoked.

7 TSO assesses the required amount of flexibility that is needed to eliminate voltage violations at transmission system and decides the location of the flexible resources (if available) connected to the transmission system that can contribute to the elimination of voltage violations.

8 In case there is a need of flexibility, TSO sends the request to the Platform. In addition, TSO sends to the Platform the location of the flexible resources connected to the transmission system that can contribute to the elimination of voltage violations at the transmission system. Market Platform SUC is invoked.

9	Based on the offers in Day Ahead and Intraday TSO AS markets and TSO request, Market Operator decides the activation of the flexibility providers connected to the transmission system. Platform informs TSO and the flexibility providers connected to the transmission system for their activation. Market Platform is invoked.
10	In case the voltage violations cannot be eliminated based on the market results, DSO in coordination with TSO decide the reconfiguration of distribution system and re-schedule the power exchange (active and reactive power) between them in order to eliminate/minimize voltage violations.
10.1	TSO/DSO Communication Platform SUC is invoked in order TSO and DSO to exchange information.
10.2	DSO invokes Distribution Grid Management SUC to apply distribution system reconfiguration.
After Real Time	
1	Operators measure the injected and absorbed energy by the flexible resources connected to their systems.
1.1	TSO measures the injected and absorbed energy by the flexible resources connected to the transmission system.
1.2	DSO measures the injected and absorbed energy by the flexible resources connected to the distribution system.
2	Operators send the metering data to the Platform.
2.1	TSO sends the metering data to the Platform.
2.2	DSO sends the metering data to the Platform.
3	Platform performs the settlement of the flexible service providers based on metering data of the injected and absorbed energy and reserved capacity resulted from Day Ahead and Intraday markets.
4	Aggregators perform the settlement of the flexibility sources under their jurisdiction.

Further Details

Actors&Roles, Names and Types: Please indicate which actors contribute to the Use Case in the sense of providing inputs/outputs, processing or aggregation. In case the writer of the Use Case defines an own actor, the actor shall be classified and shortly described.
☒ DSO ☒ TSO ☒ END CUSTOMERS (MV/LV) ☒ DER CUSTOMERS ☐ REGULATOR ☐ MUNICIPALITY/LOCAL AUTHORITY ☒ AGGREGATOR/FLEXIBILITY OPERATOR ☐ BALANCE RESPONSIBLE PARTY ☒ SERVICE PROVIDER ☐ Other: Specific Roles (if applicable) ☒ SYSTEM OPTIMISER ☒ DATA MANAGER ☐ SMART GRID OPERATOR ☒ NEUTRAL MARKET ENABLER ☒ CONSTRAINTS MARKET OPERATOR ☐ CUSTOMER RELATIONSHIP MANAGER ☐ OTHER 3RD PARTIES RELATIONSHIP MANAGER

☒ SYSTEM SECURITY MANAGER
☒ OTHER:

7.1.3. BUC GR-2a

PLEASE FILL OUT ONE TEMPLATE FOR EACH IDENTIFIED USE CASE. IN CASE THAT DIFFERENT PERSPECTIVES REQUIRE SEPERATE DOCUMENTS PLEASE INDICATE YOUR VIEWPOINT FOR THIS USE CASE:

☒ DSO

☒ TSO

☐ REGULATOR

☐ Other

Use Case Identification

Name of UC: Enter a short name that refers to the activity of the UC itself.
Congestion management in transmission system and distribution system using flexible resources connected to transmission and distribution system under the scope of a multi-level market mechanism.

Name Author(s) or Committee: Person or e.g. standardization committee like Smart Grid Technical Committees or Working Group, if applicable.
ICCS/HEDNO/IPTO/ETRAID

Scope and objectives

Scope: Describe briefly the scope, objectives, and rationale of the UC. You can additionally use the tick boxes to specify the voltage level and markets that are subject to this Use Case.
This BUC describes the actions that are carried out in case of anticipated congestions in transmission and distribution system in order to keep power flows in the accepted thermal limits of the lines and the transformers. Flexible resources connected to transmission and distribution system can provide flexibility to system operators to eliminate congestions though a market mechanism. DSO can use flexible resources connected to distribution system and TSO can use flexible resources connected to transmission system and flexible resources connected to distribution system whose use has been approved by DSO. Active and reactive power control is considered. Three different markets will be examined depending on the time frame. These markets are • Day Ahead • Intraday • Near Real Time In addition, it has to be ensured that the activation of flexible resources in the distribution network by the TSO would respect distribution system constraints. A cooperation and information exchange between DSO and TSO are crucial for eliminating congestions with the most efficient way, while respecting distribution and transmission system constraints.

This BUC will be tested in Kefalonia, where congestions are detected due to the increased penetration of RES. Due to the continuous increase of RES installation, congestions are expected to increase the next years. In order to avoid investment to upgrade the system, better use of flexibility is required. In addition, the N-1 criterion (failure of a primary transformer) should be satisfied for the reliable power supply of the customers.
In Kefalonia, renewable generators, large generators, aggregators, consumers and backup generators will be the agents that provide grid services.

Network under Study

☐ EHV

☒ HV

☒ MV

☒ LV

Objective: Describe briefly the objective of the UC.

The objectives of this BUC are the following:

1. To ensure non-discriminatory access to the market for all agents that provide grid services.
2. To enable coordination and information exchange between system operators in order to improve efficiency of the system.
3. To enable the TSO to use the flexibility provided by the resources connected to the distribution system for congestion management, while respecting distribution system constraints.
4. To ensure a secure operation of the transmission and distribution system.

To minimize RES curtailment due to security reasons and operational limits.

Narrative of the Use Case

Short Description: A short narrative focusing on the question what is done in the scope of the use case. This is meant to create a brief overview.

The BUC describes the steps that are followed to eliminate congestions in transmission and distribution system. DSO can use flexible resources connected to distribution system and TSO can use flexible resources connected to transmission system and flexible resources connected to distribution system whose use has been approved by DSO. The power flows in transmission and distribution system is permanently assessed and monitored by TSO and DSO respectively, in order to decide actions for keeping voltages of their systems within admissible range.
The steps that are followed for each market are described below:
Day Ahead Market

1 TSO and DSO assess power flows at transmission and distribution system for the next 24 hours, respectively.

1.1 DSO invokes RES and Load Forecast in Distribution system SUC (**System Use Case**). DSO shares the information per primary substation with TSO.

1.2 Based on the forecasting, DSO invokes Distribution Grid Management SUC to assess the power flows at distribution system and detect possible congestions.

1.3 TSO invokes RES and Load Forecast in Transmission system SUC.

1.4 Based on the forecasting, TSO runs power flow simulations to assess the power flows at transmission system to detect possible congestions.

2 DSO in coordination with TSO decide reconfiguration of distribution system to eliminate/minimize anticipated congestions.

2.1 TSO/DSO Communication Platform SUC is invoked in order TSO and DSO to exchange information.

2.2 DSO invokes Distribution Grid Management SUC to apply distribution system reconfiguration.

3	DSO assesses the amount of flexibility that is required to eliminate congestions and decides the location of the flexible resources connected to the distribution system (if available) that can contribute to the elimination of congestions at the distribution system. Distribution Grid Management SUC is invoked.
4	In case there is a need of flexibility, DSO requests offer from Day Ahead DSO/Local Market. The required capacity and the location of the flexible resources connected to the distribution system that can contribute to the elimination of congestions are sent to the Platform. Market Platform SUC is invoked.
5	Flexibility providers connected to the distribution system send their offers (capacity and energy bids) that meet the requirements sent by DSO. Market Platform SUC is invoked.
6	Platform sends the bids to DSO. Market Platform SUC is invoked.
7	The DSO assures that only bids respecting the DSO grid constraints can take part in the Day Ahead DSO/Local Market. DSO informs the Platform accordingly. Distribution Grid Management SUC and Market Platform SUC are invoked.
8	Market Operator clears the Day Ahead DSO/Local Market. The results of the market are sent to the DSO and the flexibility providers connected to the distribution system. Market Platform SUC is invoked.
9	TSO assesses the required amount of flexibility that is needed to eliminate congestions and decides the location of the flexible resources connected to the distribution and the transmission system (if available - under which primary substations for the flexible resources connected to the distribution system) that can contribute to the elimination of congestions at the transmission system.
10	In case there is a need of flexibility, TSO requests offer from the Day Ahead TSO AS market. In addition, TSO sends to the Platform the location of the flexible resources connected to the distribution and the transmission system that can contribute to the elimination of congestions at the transmission system. Market Platform SUC is invoked.
11	Platform informs the DSO of the TSO request. Market Platform SUC is invoked.
12	DSO aggregates and transfers the remaining bids that are not used for distribution system to the TSO AS market. TSO/DSO Communication Platform SUC is invoked
13	Flexibility providers connected to the transmission system send their offers (capacity and energy bids). Market Platform SUC is invoked.
14	Market Operator clears the Day Ahead TSO AS market taking into account the aggregated bids from distribution system and the offers from flexibility providers connected to the transmission system. The results of the market are sent to TSO and the flexibility providers connected to the transmission system. Market Platform SUC is invoked.
15	TSO sends the results of the Day Ahead TSO AS market to DSO. TSO/DSO Communication Platform SUC is invoked for the communication between TSO and DSO.
16	DSO sends the results of the Day Ahead TSO AS market to the flexibility providers connected to the distribution system.
Intraday Market	
17	TSO and DSO assess power flows at transmission and distribution system for the next 12 hours, respectively.
17.1	DSO invokes RES and Load Forecast in Distribution system SUC. DSO shares the information per primary substation with TSO.
17.2	Based on the forecasting and the results of DSO/Local market, DSO invokes Distribution Grid Management SUC to assess the power flows at distribution system and detect possible congestions.
17.3	TSO invokes RES and Load Forecast in Transmission system SUC.
17.4	Based on the forecasting and the results of Day Ahead TSO AS market, TSO runs power flow simulations to assess the power flows at transmission system to detect possible congestions.
18	DSO assesses the amount of flexibility that is required to eliminate congestions and decides the location of the flexible resources connected to the distribution system (if available) that can contribute to the elimination of congestions at the distribution system. Distribution Grid Management SUC is invoked.

19	In case there is a need of flexibility, DSO requests offer from Intraday DSO/Local Market. The required capacity and the location of the flexible resources connected to the distribution system that can contribute to the elimination of congestions are sent to the Platform. Market Platform SUC is invoked.
20	Flexibility providers connected to the distribution system send their offers (capacity and energy bids) that meet the requirements sent by DSO. Market Platform SUC is invoked.
21	Platform sends the bids to DSO. Market Platform SUC is invoked.
22	The DSO assures that only bids respecting the DSO grid constraints can take part in the Intraday DSO/Local Market. DSO informs the Platform accordingly. Distribution Grid Management SUC and Market Platform SUC are invoked.
23	Market Operator clears the Intraday DSO/Local Market. The results of the market are sent to the DSO and the flexibility providers connected to the distribution system. Market Platform SUC is invoked.
24	TSO assesses the required amount of flexibility that is needed to eliminate congestions and decides the location of the flexible resources connected to the distribution and the transmission system (if available - under which primary substations for the flexible resources connected to the distribution system) that can contribute to the elimination of congestions at the transmission system.
25	In case there is a need of flexibility, TSO requests offer from Intraday TSO AS market. In addition, TSO sends to the Platform the location of the flexible resources connected to the distribution and the transmission system that can contribute to the elimination of congestions at the transmission system. Market Platform SUC is invoked.
26	Platform informs the DSO of the TSO request. Market Platform SUC is invoked.
27	DSO aggregates and transfers the remaining bids that are not used for distribution system to the Intraday TSO AS market. Market Platform SUC is invoked.
28	Flexibility providers connected to the transmission system send their offers. Market Platform SUC is invoked.
29	Market Operator clears the Intraday TSO AS market taking into account the aggregated bids from distribution system and the offers from flexibility providers connected to the transmission system. The results of the market are sent to TSO and the flexibility providers connected to the transmission system. Market Platform SUC is invoked.
30	TSO sends the results of the Intraday TSO AS market to DSO. TSO/DSO Communication Platform SUC is invoked for the communication between TSO and DSO.
31	DSO sends the results of the Intraday TSO AS market to flexibility providers connected to the distribution system.
Near Real Time Market	
32	TSO and DSO assess power flows at transmission and distribution system for the next 5 minutes, respectively.
32.1	DSO invokes State Estimation in Distribution system SUC.
32.2	Based on the state estimation and the results of Day Ahead and Intraday markets, DSO invokes Distribution Grid Management SUC to assess power flows at distribution system and detect possible congestions.
32.3	TSO invokes State Estimation in Transmission system SUC.
32.4	Based on the state estimation and the results of Day Ahead and Intraday market, TSO runs power flows to assess power flows at transmission system to detect possible congestions.
33	DSO assesses the amount of flexibility that is required to eliminate congestions and decides the location of the flexible resources connected to the distribution system (if available) that can contribute to the elimination of congestions. Distribution Grid Management SUC is invoked.
34	In case there is a need of flexibility, DSO sends the request to the Platform. Market Platform SUC is invoked.
35	The DSO assures that the activation of the flexibility providers connected to the distribution system will respect the DSO grid constraints and informs the Platform accordingly. Distribution Grid Management SUC and Market Platform are invoked.

36	Based on the offers in Day Ahead and Intraday DSO/Local Markets and DSO request, Market Operator decides the activation of the flexibility providers connected to the distribution system. Platform informs DSO and the flexibility providers connected to the distribution system for their activation. Market Platform is invoked.
37	TSO assesses the required amount of flexibility that is needed to eliminate congestions and decides the location of the flexible resources connected to the distribution and the transmission system (if available - under which primary substations for the flexible resources connected to the distribution system) that can contribute to the elimination of congestions.
38	In case there is a need of flexibility, TSO sends the request to the Platform. In addition, TSO sends to the Platform the location of the flexible resources connected to the distribution and the transmission system that can contribute to the elimination of congestions at the transmission system. Market Platform SUC is invoked.
39	Platform informs the DSO of the TSO request. Market Platform SUC is invoked.
40	DSO sends to the Platform the activation of which flexible resources connected to the distribution system respects DSO limits. Market Platform SUC is invoked.
41	Based on the offers in Day Ahead and Intraday TSO AS markets and TSO request, Market Operator decides the activation of the flexibility providers connected to the distribution and the transmission system. The results of the market are sent to TSO and the flexibility providers connected to the transmission system. Market Platform SUC is invoked.
42	TSO sends the results of the Near Real Time TSO AS market to DSO. TSO/DSO Communication Platform SUC is invoked for the communication between TSO and DSO.
43	DSO sends the results of the Near Real Time TSO AS market to flexibility providers connected to the distribution system.
44	In case the congestions cannot be eliminated based on the market results, DSO in coordination with TSO decide the reconfiguration of distribution system to eliminate/minimize congestions.
44.1	TSO/DSO Communication Platform SUC is invoked in order TSO and DSO to exchange information.
44.2	DSO invokes Distribution Grid Management SUC to apply distribution system reconfiguration.
After Real Time	
45	Operators measure the injected and absorbed energy by the flexible resources connected to their systems.
45.1	TSO measures the injected and absorbed energy by the flexible resources connected to the transmission system.
45.2	DSO measures the injected and absorbed energy by the flexible resources connected to the distribution system.
46	Operators send the metering data to the Platform.
46.1	TSO sends the metering data to the Platform.
46.2	DSO sends the metering data to the Platform.
47	Platform performs the settlement of the flexible service providers based on metering data of the injected and absorbed energy and reserved capacity resulted from Day Ahead and Intraday markets.
48	Aggregators perform the settlement of the flexibility sources under their jurisdiction.

Further Details

Actors&Roles, Names and Types: Please indicate which actors contribute to the Use Case in the sense of providing inputs/outputs, processing or aggregation. In case the writer of the Use Case defines an own actor, the actor shall be classified and shortly described.
☒ DSO ☒ TSO

☒ End Customers (MV/LV) ☒ DER Customers ☐ Regulator ☐ Municipality/Local Authority ☒ Aggregator/Flexibility Operator ☐ Balance Responsible Party ☒ Service Provider ☐ Other: Specific Roles (if applicable) ☒ System Optimiser ☒ Data Manager ☐ Smart Grid Operator ☒ Neutral Market Enabler ☒ Constraints Market Operator ☐ Customer Relationship Manager ☐ Other 3rd Parties Relationship Manager ☒ System Security Manager ☐ Other:

7.1.4. BUC GR-2b

PLEASE FILL OUT ONE TEMPLATE FOR EACH IDENTIFIED USE CASE. IN CASE THAT DIFFERENT PERSPECTIVES REQUIRE SEPERATE DOCUMENTS PLEASE INDICATE YOUR VIEWPOINT FOR THIS USE CASE:

☒ DSO

☒ TSO

☐ REGULATOR

☐ OTHER

Use Case Identification

Name of UC: Enter a short name that refers to the activity of the UC itself.
Congestion management in transmission system and distribution system using flexible resources connected to transmission and distribution system under the scope of a fragmented market mechanism.

Name Author(s) or Committee: Person or e.g. standardization committee like Smart Grid Technical Committees or Working Group, if applicable.
ICCS/HEDNO/IPTO/ETRAID

Scope and objectives

Scope: Describe briefly the scope, objectives, and rationale of the UC. You can additionally use the tick boxes to specify the voltage level and markets that are subject to this Use Case.
This BUC describes the actions that are carried out in case of anticipated congestions in transmission and distribution system in order to keep power flows in the accepted thermal limits of the lines and the transformers. The flexible resources connected to the transmission system can provide flexibility only to TSO and the flexible resources connected to the distribution system can provide flexibility only to DSO. TSO and DSO cooperate to decide the power exchange between them. In order to decide the power exchange between, TSO and DSO take into account the power flows of the lines in transmission and distribution system, respectively. Three different markets are examined depending on the time frame. These markets are • Day Ahead • Intraday • Near Real Time A cooperation and information exchange between DSO and TSO are crucial for eliminating congestions with the most efficient way, while respecting distribution and transmission system constraints. This BUC will be tested in Kefalonia, where congestions are detected due to the increased penetration of RES. Due to the continuous increase of RES installation, congestions are expected to increase the next years. In order to avoid investment to upgrade the system, better use of flexibility is required. In addition, the N-1 criterion (failure of a primary transformer) should be satisfied for the reliable power supply of the customers. In Kefalonia, renewable generators, large generators, aggregators, consumers and backup generators will be the agents that provide grid services. **Network under Study** ☐ EHV ☒ HV ☒ MV ☒ LV
Objective: Describe briefly the objective of the UC.
The objectives of this BUC are the following: 1. To ensure non-discriminatory access to the market for all agents that provide grid services. 2. To enable coordination and information exchange between system operators in order to improve efficiency of the system. 3. To ensure a secure operation of the transmission and distribution system. To minimize RES curtailment due to security reasons and operational limits.

Narrative of the Use Case

Short Description: A <u>short</u> narrative focusing on the question what is done in the scope of the use case. This is meant to create a brief overview.
The BUC describes the steps that are followed to eliminate congestions in transmission and distribution system when DSO can use flexible resources connected to distribution system and TSO can use flexible resources connected to transmission system. The power flows in transmission and distribution system is permanently assessed and monitored by TSO and DSO respectively, in order to decide actions for keeping them within the acceptable thermal limits. The steps that are followed for each market are described below: **Day Ahead Market**

1	TSO and DSO assess power flows at transmission and distribution system for the next 24 hours, respectively.
1.1	DSO invokes RES and Load Forecast in Distribution system System Use Case (SUC). DSO shares the information per primary substation with TSO. TSO/DSO Communication Platform SUC is invoked.
1.2	Based on the forecasting, DSO invokes Distribution Grid Management SUC to assess the power flows at distribution system and detect possible congestions.
1.3	TSO invokes RES and Load Forecast in Transmission system SUC.
1.4	Based on the forecasting, TSO runs power flow simulations to assess the power flows at transmission system to detect possible congestions.
2	DSO in coordination with TSO decide the reconfiguration of distribution system and the power exchange (active and reactive power) between them in order to eliminate/minimize anticipated congestions. Setpoint or a range of power exchange is decided by TSO and DSO.
2.1	TSO/DSO Communication Platform SUC is invoked in order TSO and DSO to exchange information.
2.2	DSO invokes Distribution Grid Management SUC to apply distribution system reconfiguration.
3	DSO assesses the amount of flexibility that is required to eliminate congestions and decides the location of the flexible resources connected to the distribution system (if available) that can contribute to the elimination of congestions at the distribution system. Distribution Grid Management SUC is invoked.
4	In case there is a need of flexibility, DSO requests offer from Day Ahead DSO/Local Market. The required capacity and the location of the flexible resources connected to the distribution system that can contribute to the elimination of congestions are sent to the Platform. Market Platform SUC is invoked.
5	Flexibility providers connected to the distribution system send their offers (capacity and energy bids) that meet the requirements sent by DSO. Market Platform SUC is invoked.
6	Platform sends the bids to DSO. Market Platform SUC is invoked.
7	DSO assures that only bids respecting the DSO grid constraints can take part in the Day Ahead DSO/Local Market. DSO informs the Platform accordingly. Distribution Grid Management SUC and Market Platform SUC are invoked.
8	Market Operator clears the Day Ahead DSO/Local Market. The results of the market are sent to DSO and flexibility providers connected to the distribution system. Market Platform SUC is invoked.
9	TSO assesses the required amount of flexibility that is needed to eliminate congestions at transmission system and decides the location of the flexible resources connected to the transmission system (if available) that can contribute to the elimination of congestions at the transmission system.
10	In case there is a need of flexibility, TSO requests offer from Day Ahead TSO AS market. In addition, TSO sends to the Platform the location of the flexible resources connected to the transmission system that can contribute to the elimination of congestions at the transmission system. Market Platform SUC is invoked.
11	Flexibility providers connected to the transmission system send their offers (capacity and energy bids). Market Platform SUC is invoked.
12	Market Operator clears the Day Ahead TSO AS market. The results of the market are sent to TSO, the flexibility providers connected to the transmission system. Market Platform SUC is invoked.
Intraday Market	
13	TSO and DSO assess power flows at transmission and distribution system for the next 12 hours, respectively.
13.1	DSO invokes RES and Load Forecast in Distribution system SUC. DSO shares the information per primary substation with TSO.
13.2	Based on the forecasting and the results of the Day Ahead DSO/Local market, DSO invokes Distribution Grid Management SUC to assess the power flows at distribution system and detect possible congestions.
13.3	TSO invokes RES and Load Forecast in Transmission system SUC.

13.4 Based on the forecasting and the results of the Day Ahead TSO AS market, TSO runs power flow simulations to assess the power flows at transmission system to detect possible congestions.

14 DSO and TSO can re-schedule the power exchange (active and reactive power) between them for the rest of the period.

15 DSO assesses the amount of flexibility that is required to eliminate congestions and decides the location of the flexible resources connected to the distribution system (if available) that can contribute to the elimination of congestions at the distribution system. Distribution Grid Management SUC is invoked.

16 In case there is a need of flexibility, DSO requests offer from Intraday DSO/Local Market. The required capacity and the location of the flexible resources connected to the distribution system that can contribute to the elimination of congestions are sent to the Platform. Market Platform SUC is invoked.

17 Flexibility providers connected to the distribution system send their offers (capacity and energy bids) that meet the requirements sent by DSO. Market Platform SUC is invoked.

18 Platform sends the bids to DSO. Market Platform SUC is invoked.

19 The DSO assures that only bids respecting the DSO grid constraints can take part in the Intraday DSO/Local Market. DSO informs the Platform accordingly. Distribution Grid Management SUC and Market Platform SUC are invoked.

20 Market Operator clears the Intraday DSO/Local Market. The results of the market are sent to the DSO and flexibility providers connected to the distribution system. Market Platform SUC is invoked.

21 TSO assesses the required amount of flexibility that is needed to eliminate congestions and decides the location of the flexible resources connected to the transmission system (if available) that can contribute to the elimination of congestions at the transmission system.

22 In case there is a need of flexibility, TSO requests offer from Intraday TSO AS market. In addition, TSO sends to the Platform the location of the flexible resources connected to the transmission system that can contribute to the elimination of congestions at the transmission system. Market Platform SUC is invoked.

23 Flexibility providers connected to the transmission system send their offers. Market Platform SUC is invoked.

24 Market Operator clears the Intraday TSO AS market. The results of the market are sent to TSO and the flexibility providers connected to the transmission system. Market Platform SUC is invoked.

Near Real Time Market

25 DSO and TSO apply the appropriate actions if there are deviations from the scheduled power exchange

26 TSO and DSO assess power flows at transmission and distribution system for the next 5 minutes, respectively.

26.1 DSO invokes State Estimation in Distribution system SUC.

26.2 Based on the state estimation and the results of Day Ahead and Intraday markets, DSO invokes Distribution Grid Management SUC to assess the power flows at distribution system and detect possible congestions.

26.3 TSO invokes State Estimation in Transmission system SUC.

26.4 Based on the state estimation and the results of Day Ahead and Intraday market, TSO runs power flows to assess the power flows at transmission system to detect possible congestions.

27 DSO assesses the amount of flexibility that is required to eliminate congestions and decides the location of the flexible resources connected to the distribution system (if available) that can contribute to the elimination of congestions. Distribution Grid Management SUC is invoked.

28 In case there is a need of flexibility, DSO sends the request to the Platform. In addition, the location of the flexible resources connected to the distribution system that can contribute to the elimination of congestions are sent to the Platform. Market Platform SUC is invoked.

29 The DSO assures that the activation of the flexibility providers connected to the distribution system will respect the DSO grid constraints and informs the Platform accordingly. Distribution Grid Management SUC and Market Platform are invoked.

30	Based on the offers in Day Ahead and Intraday DSO/Local Markets and DSO request, Market Operator decides the activation of the flexibility providers connected to the distribution system. Platform informs DSO and the flexibility providers connected to the distribution system for their activation. Market Platform is invoked.
31	TSO assesses the required amount of flexibility that is needed to eliminate congestions at transmission system and decides the location of the flexible resources connected to the transmission system (if available) that can contribute to the elimination of congestions.
32	In case there is a need of flexibility, TSO sends the request to the Platform. In addition, TSO sends to the Platform the location of the flexible resources connected to the transmission system that can contribute to the elimination of congestions at the transmission system. Market Platform SUC is invoked.
33	Based on the offers in Day Ahead and Intraday TSO AS markets and TSO request, Market Operator decides the activation of the flexibility providers connected to the transmission system. Platform informs TSO and the flexibility providers connected to the transmission system for their activation. Market Platform is invoked.
34	In case the congestions cannot be eliminated based on the market results, DSO in coordination with TSO decide the reconfiguration of distribution system and re-schedule the power exchange (active and reactive power) between them in order to eliminate/minimize congestions.
34.1	TSO/DSO Communication Platform SUC is invoked in order TSO and DSO to exchange information.
34.2	DSO invokes Distribution Grid Management SUC to apply distribution system reconfiguration.
After Real Time	
35	Operators measure the injected and absorbed energy by the flexible resources connected to their systems.
35.1	TSO measures the injected and absorbed energy by the flexible resources connected to the transmission system.
35.2	DSO measures the injected and absorbed energy by the flexible resources connected to the distribution system.
36	Operators send the metering data to the Platform.
36.1	TSO sends the metering data to the Platform.
36.2	DSO sends the metering data to the Platform.
37	Platform performs the settlement of the flexible service providers based on metering data of the injected and absorbed energy and reserved capacity resulted from Day Ahead and Intraday markets.
38	Aggregators perform the settlement of the flexibility sources under their jurisdiction.

7.1.5. BUC ES-1

PLEASE FILL OUT ONE TEMPLATE FOR EACH IDENTIFIED USE CASE. IN CASE THAT DIFFERENT PERSPECTIVES REQUIRE SEPERATE DOCUMENTS PLEASE INDICATE YOUR VIEWPOINT FOR THIS USE CASE:

Use Case Identification

Name of UC: Enter a short name that refers to the activity of the UC itself.
Grid congestion management provided to the TSO and DSO under the scope of a common market mechanism

Name Author(s) or Committee: Person or e.g. standardization committee like Smart Grid Technical Committees or Working Group, if applicable.
Comillas/Iberdrola/Endesa/Tecnalia/REE

Scope and objectives

Scope: Describe briefly the scope, objectives, and rationale of the UC. You can additionally use the tick boxes to specify the voltage level and markets that are subject to this Use Case.
In the Spanish demo, grid congestions services can be provided to both the TSO and DSOs. This service can therefore solve the congestion problems that can occur either due to contingencies, programmed maintenance or more frequent or structural congestions due to limited transfer capacity at TSO and DSOs networks. These structural congestions are currently common at TSO networks, but in the future with flexible operation of DSO networks these structural congestions can be also expected at lower voltage levels. In order to solve congestions, for the focus of this BUC, changes in active power are required. Voltage control by changes in reactive power are addressed in a separate BUC. The resources included in the demo will include resources connected to Iberdrola's, Endesa's and REE's networks. Resources connected to Iberdrola's network: 1. Murcia: Municipality buildings (significant demand loads). 2. Alicante: Industrial load of a cement factory. 3. Murcia and Albacete account for more than 1 GW of installed renewable (RES) capacity. Resources connected to Endesa's network: 4. Malaga: Demand Response (DR) from municipalities buildings and generation resources from wind farms will provide flexibility for congestion management 5. Cadiz: wind and solar photovoltaic (PV) will participate in congestion management (86 MW) Resources connected to REE's network: 6. In Murcia and Albacete more than 800 MW of installed wind generation capacity participating is connected to the transmission network. These units can also be used in the demos to provide flexibility for distribution network uses. 7. Cádiz: around 130 MW of wind plants connected to the transmission network are participating.
Objective: Describe briefly the objective of the UC.
The main objective of this BUC is to procure flexibility from resources connected at both TSO and DSO networks in a coordinated manner to solve transitory congestions that can occur at both networks. Currently in Spain, the TSO manages network congestions that occur both at transmission and distribution levels through a technical constraint management market by re-dispatching generation units connected at transmission, but also at all voltage levels (including LV and MV). If needed, DSO have the possibility to request from the TSO to call the use of the the interruptibility service (i.e. demand reduction activation from large industrial consumers which have been pre-contracted) or as for redispaching and curtailment of generation. The current price floor in the congestion management market is 0 €/MWh and, currently, there is no price cap applied apart from IT system limits which is set to 9999 €/MWh. As highlighted in CoordiNet D1.1 (Lind and Ávila 2019), in Spain, DSOs can use DER, more specifically DG, to solve congestions in the same way as the TSO does. This process, however, is done through the TSO in coordination with the DSO (i.e. after an outdated process based on an email or similar sent by the DSO to the TSO). Once congestions in the distribution grid are identified and DSO are not able to solve the problem operating the network, then, if there are generation units that have an impact on the congestion, the needs for change the dispatch are sent from the DSO to the TSO who accesses the bids and calculates the necessary redispatch to solve the detected constraints[16]. In case a DG is redispatched, it will be

[16] Process described in the Procedimiento de Operación (Operation Procedure) 3.2.

remunerated according to the existing market rules (which are the same as the units re-dispatched due to congestions in the transmission grid). For planned curtailment, producers receive no financial compensation. In addition to congestion management, DSOs may also request a change to the TSO in the power factor range instructions sent to generation units with an installed capacity larger than 5 MW. Nowadays, this mechanism applies only for generators and not for consumers.
Therefore, as of today, the DSO through the TSO can use DG for local congestion management and power factor control and consumers with contracted power above 5MW can participate in interruptible services. As the DSO and TSO send these requests, ultimately is the TSO that receives the congestion management bids that are able to solve the constraints, assigns them and instructs the DER.
Regarding the size of DER able to provide services for congestion management to the DSO there are no limitations with respect to the voltage level to which providers are connected. Participation is currently only allowed for generation units and pumped hydro units.
As of today, in Spain, DSOs cannot sign interruptible contracts with DER. The only form of interruptible contract is between the TSO and industrial consumers. However, DSOs may use these interruptible contracts signed with the TSO to solve constraints in their networks as well.
From February 2016, all redispatch due to congestion management in the DSO or TSO network including generation from renewable sources is done via market mechanisms (PO 3.2). In the real-time technical constraint management process, DG has to pay the downward bid price which is generally very close to 0 €/MWh so they get to keep almost 100% of the market marginal price (being the Day Ahead price of a specific hour) that they have received for selling their production in that hour. Thus, renewable generation reductions can happen because of market outcome in the congestion management or balancing market.
In any case, as a last resort, if still needed in real time, the TSO and DSO can curtail renewable generation for security reasons without a market based mechanism. However, since 2016 all congestion management situations have been solved through these market-based mechanisms.

Network under Study

☐ EHV

☒ HV

☒ MV

☒ LV

Narrative of the Use Case

Short Description: A <u>short</u> narrative focusing on the question what is done in the scope of the use case. This is meant to create a brief overview.

More active participation of resources including DER in the congestion management market, as well as more frequent procurement of flexibility by DSOs require a boost of the current congestion management market and operational procedures so that processes that are currently performed manually can be performed in a semi-automated manner and ensuring that the needed information is available to both the TSO and the affected DSOs. The product traded would be to increase or decrease energy to solve grid congestions, the possibility to have a capacity product would be explored in a second stage of the demo and it is not addressed in the following description.
The functions are divided in four relevant timescales, which are described in detail below: the long-term (from years until day-ahead ahead), the day-ahead, balancing timeframe (from one hour to real-time) and after real-time. The numbering of the functions is described according to the sequential action and the arrows represent the information flows among the different actors.

Long-term

A prerequisite for the Use Case is the product definition, which is addressed in CoordiNet in D1.3. Once the products are defined, the next step starts with the customers´ engagement and evaluate their flexibility (Step 1). Once the flexibility is known, a prequalification process will be carried out between the FSP and the TSO, DSO or both (step 2.1 and 2.2) and inform the CoordiNet platform (step 2.3). As resources can provide congestion management services to both TSO and DSO the prequalification has to be coordinated among the TSO and DSO.

Long-term procurement of congestion management services may be necessary to include flexible resources' in the planning process in a level playing field with traditional network investments or "wires solutions". Currently in Spain, the TSO contracts long-term flexibility only through interruptible contracts with large industrial consumers which is intended to be used for security reasons. Although the long-term procurement of flexibility for congestion management purposes from the TSO and DSO may be necessary, it requires a thorough evaluation which will not be addressed for the Spanish demo. Again, as both grid operators may procure flexibility through long-term contracts, a coordination is essential to guarantee that conditions from both grid operators are compatible. The possibility to include this long-term procurement is defined with steps 3 to 5 in the diagram.

Day-ahead

At the day ahead timeframe, after the day-ahead energy market takes place, the congestion management market takes place to account for possible network congestions. The process will start with computing the foreseen requirements from the TSO and DSOs and determining the effective local resources that can potentially solve the network constraints based on the power flows forecasts (steps 6.1 and 6.2). These effective local resources will be determined from those that have been prequalified and accounting for the impact on the identified congestion and which have offered bids. The TSO and DSO will inform the platform which are the resources that have influence on the congestions (step 7).

In the meantime, the FSP have to aggregate DERs and determine the available flexibility (step 8) and compute congestion management bids for the relevant location (step 9.1). Meanwhile, resources connected at transmission network also compute their bids for the market (step 9.2).

The CoordiNet platform will receive the needs and the effective local resources identified from the TSO and DSOs, as well as the bids from FSP (step 10.2). If bids are not enough to foreseen congestions, then emergency plan has to be activated (step 10.1) which is out of the scope of this document and even of CoordiNet Spanish demo. A detailed procedure and the definition of the clearing algorithm have to be defined to handle situations where potential conflicts emerge. For example, the same resources may be used to solve congestions that affect two networks in the opposite direction. Therefore, the overall system approach has to be considered (step 10.2). Once all the relevant constraints and available resources have been considered, the CoordiNet platform obtains the results (step 11) and communicates them to the TSO and DSO (step 12). Both grid operators will receive the results (step 13.1 and 13.2) and check their feasibility (step 14.1 and 14.2). If there were any additional constraints, then the market could be run again (back to step 10.2), depending on the situation.

From 1 hour before to real time

From about one hour before real time, the TSO manages the balancing of the system and it can be the case that a resource used for balancing is not available anymore for congestion management or, by activating resources for congestion management; it can affect the balancing of the system. Therefore, the TSO has to establish a procedure to account these effects (step 15.1). The final results are also sent to the concerned FSPs (15.2). Coordinet platform will also inform the flexibility activations to the TSO, who will also inform the (European) balancing platform to correct the corresponding short and long balancing positions as consequence of their activation, so that the BRPs whose position has been affected are not penalized for this reason. The FSP has to perform the activation of resources manually or automatically (step 15.3). The platform communicates the activation to the TSO and DSOs (step 16) who have to check the activation and monitor the system (step 17.1 and 17.2) to verify the fulfilment of the service (congestion management).

After real-time

Once the services are delivered, the electricity generated or consumed has to be metered. In Spain, who performs the metering activity depends on the consumption, generation and the grid level of their connection point. For consumers, metering activity is only performed by DSO regardless the grid level (transmission or distribution) where they are connected to. However, metering for generators with capacity below 450kW is performed by DSO, while all the rest is done by TSO regardless the grid level (transmission or distribution) where they are connected to (step 18). The CoordiNet platform will then

use the metering data to perform the settlement process of congestion management services with FSPs (Step 19) and then the FSP will perform the individual settlement with the resources which may include other services of even the energy sold in the day-ahead market or other contractual agreements (step 20).

Further Details

Actors&Roles, Names and Types: Please indicate which actors contribute to the Use Case in the sense of providing inputs/outputs, processing or aggregation. In case the writer of the Use Case defines an own actor, the actor shall be classified and shortly described.
The primary actors are the TSO and the DSOs. ☒ DSO ☒ TSO ☒ End Customers (MV/LV) ☒ DER Customers ☐ Regulator ☒ Municipality/Local Authority ☒ Aggregator/Flexibility Operator ☒ Balance Responsible Party ☒ Service Provider ☒ Other: CoordiNet Platform

7.1.6. BUC ES-2

PLEASE FILL OUT ONE TEMPLATE FOR EACH IDENTIFIED USE CASE. IN CASE THAT DIFFERENT PERSPECTIVES REQUIRE SEPERATE DOCUMENTS PLEASE INDICATE YOUR VIEWPOINT FOR THIS USE CASE:

Use Case Identification

Name of UC: Enter a short name that refers to the activity of the UC itself.
Procure and manage balancing services (FRR and RR) to reduce balancing cost <u>under the scope of a central market mechanism</u>

Name Author(s) or Committee: Person or e.g. standardization committee like Smart Grid Technical Committees or Working Group, if applicable.
Comillas/Iberdrola/Endesa/Tecnalia/REE

Scope and objectives

Scope: Describe briefly the scope, objectives, and rationale of the UC. You can additionally use the tick boxes to specify the voltage level and markets that are subject to this Use Case.
Network under Study ☐ EHV ☒ HV ☒ MV ☒ LV

This BUC evaluates how to improve the coordination between the TSO and DSOs when the activation of energy resources including DER providing balancing services to the TSO increases. This might result in constraints in the DSO network. The process description would apply for both manual Frequency Restauration Reserves (mFRR) and Replacement Reserves (RR).
The resources involved in the demo will include resources connected to Iberdrola's, Endesa's and REE's networks.
Resources connected to Iberdrola's network:

1. Albacete accounts for more than 340 MW of installed renewable (RES) including wind, mini-hydro and CHP (combined heat and power) capacity.

Resources connected to Endesa's network:

2. Malaga: DR from municipalities' buildings and generation resources from wind farms.
3. Cadiz: wind and solar photovoltaic (PV) plants will participate in congestion management (86 MW).

Resources connected to REE's network:

4. In Murcia and Albacete, more than 800 MW of installed wind generation capacity participating is connected to the transmission network. These units can also be used in the demos to provide flexibility for distribution network uses.
5. Cádiz: around 130 MW of wind plants connected to the transmission network are participating.

Objective: Describe briefly the objective of the UC.

- TSO: Reducing balancing cost (TSO perspective)
- DSO: Avoiding unforeseen congestion problems at the distribution level

Narrative of the Use Case

Short Description: A short narrative focusing on the question what is done in the scope of the use case. This is meant to create a brief overview.

Currently generation resources connected at distribution networks can provide balancing services, but not demand-side resources.
In a similar manner to congestion management, the functions are divided in four relevant timescales which are described in detail below: the long-term (from years until day-ahead), the day-ahead, from one hour to real-time and post-real-time. The numbering of the functions are described according to the sequential action and the arrows represent the flows of information among the different actors.
Two main products are relevant for balancing: the balancing capacity and the balancing energy. According to the EBGL, the balancing capacity is defined as: "a volume of reserve capacity that a balancing service provider has agreed to hold and in respect to which the balancing service provider has agreed to submit bids for a corresponding volume of balancing energy to the TSO for the duration of the contract" and the balancing energy: "means energy used by TSOs to perform balancing and provided by a balancing service provider" (European Commission 2017). The flow diagram specifies the functions necessary to deliver both services.
In this Use Case, the FSP performs the function of Balance Service Provider (BSPs) which according to the EBGL means a market participant with reserve-providing units or reserve-providing groups able to provide balancing services to TSOs.

Long-term

The balancing products are being defined in the European Balancing Platforms (see CoordiNet D1.1 - (Lind and Ávila 2019)), specifically they have been harmonized in the TERRE and MARI platform for both RR and mFRR, respectively. In a similar manner as congestion management, the first steps will be to engage resources and understand their flexibility (step 1). Once the flexibility is known, the TSO performs a prequalification process to the FSP that are interested in providing balancing (step 2). As resources are connected to the DSO, the TSO performs the prequalification with information exchange with the DSO (Art. 182 of SOGL) and inform the CoordiNet platform.

Day-ahead

In Spain, the balancing process starts after the day-ahead and congestion management market. The TSO computes the balancing capacity needed based on the energy market results and its own forecasts (Step 3). The FSP estimate the available flexibility (step 4) and compute the balancing capacity bids (step 5.1) in a similar manner that resources that are connected to the TSO (step 5.2). The TSO receives the capacity balancing bids[17] (step 6) and communicates them to the CoordiNet platform which send them to the relevant DSOs (Step 7). The DSOs forecast and identify transitory limits in their networks (step 8). These limits can restrict completely the bids from FSP in the balancing markets or only partially. In a similar manner, the TSO may identify limits on certain bids (step 9). The limits from DSOs are communicated to the platform (step 10) and then to the TSO runs the balancing capacity market and obtains results (step 11). These results are then communicated to the platform which sends them to the DSO and the FSP (step 12). The DSO considers this information in its system (step 13.1) and the FSP informs the affected resources (step 13.2).

From 1 hour before to real time

Based on the balancing capacity and additional available information the FSP submit balancing energy bids to the TSO before the gate-closure time of the balancing energy markets (step 14). Resources that have not provided balancing capacity can, in any case, also provide balancing energy (voluntary bids).

The TSO receives the balancing energy bids until the gate-closure time of each balancing service (step 15). Then, the TSO communicates these bids to the platform, which are sent to the DSO (step 16). Both the TSO and DSOs check again if new limits on their networks are foreseen which may restrict the delivery of balancing energy (step 17.1 and 17.2). Any additional limit is communicated to the platform, which informs the TSO (step 18). Considering this information, the TSO communicates the available energy balancing bids to the European Balancing Platforms and its balancing needs (step 19). The Balancing platforms (MARI, TERRE, PICASSO) perform the energy balancing market clearing considering also all relevant information and bids available from neighbouring systems (step 20) and submits the results to the platform (step 21). The CoordiNet platform then submits the results to DSO (step 22) and the FSP, which has to allocate the response to the controlled resources (step 23) and deliver balancing energy (step 24). Meanwhile, the TSO has to monitor the system and guarantee adequate energy balancing of the system (step 25).

After real-time

The TSO and DSO read the delivered and consumed energy for balancing (step 26). Then the TSO performs the balancing settlement with the FSP based on the energy delivered as well as on the corresponding penalties for non-delivery (step 27). The FSP will then perform its own settlement with the final provision of services (step 28).

Further Details

Actors&Roles, Names and Types: Please indicate which actors contribute to the Use Case in the sense of providing inputs/outputs, processing or aggregation. In case the writer of the Use Case defines an own actor, the actor shall be classified and shortly described.
The system balancing is a function performed exclusively by the TSO. Therefore, the primary actor in this BUC is the TSO. ☒ DSO

[17] A separation can be made for FRR and RR capacity products and different markets can be established but they would follow similar procedure.

☒ TSO ☒ End Customers (MV/LV) ☒ DER Customers ☐ Regulator ☐ Municipality/Local Authority ☒ Aggregator/Flexibility Operator ☒ Balance Responsible Party ☒ Service Provider ☒ Other: CoordiNet Platform

7.1.7. BUC ES-3

PLEASE FILL OUT ONE TEMPLATE FOR EACH IDENTIFIED USE CASE. IN CASE THAT DIFFERENT PERSPECTIVES REQUIRE SEPERATE DOCUMENTS PLEASE INDICATE YOUR VIEWPOINT FOR THIS USE CASE:

Use Case Identification

Name of UC: Enter a short name that refers to the activity of the UC itself.
Voltage control provided to the TSO and DSO under the scope of a common market mechanism

Name Author(s) or Committee: Person or e.g. standardization committee like Smart Grid Technical Committees or Working Group, if applicable.
Comillas/Iberdrola/Endesa/Tecnalia/REE

Scope and objectives

Scope: Describe briefly the scope, objectives, and rationale of the UC. You can additionally use the tick boxes to specify the voltage level and markets that are subject to this Use Case.
The resources included in the demo will include resources connected to Iberdrola's, Endesa's and REE's networks. Resources connected to Iberdrola's network: 1. Murcia and Albacete account for more than 340 MW of installed renewable (RES) including wind, mini-hydro and CHP (combined heat and power) capacity. 2. Alicante: Industrial load of a cement factory Resources connected to REE's network: 3. In Murcia and Albacete, more than 800 MW of installed wind generation capacity participating is connected to the transmission network. These units can also be used in the demos to provide flexibility for distribution network uses. Resources connected to Endesa's network: 4. Cadiz: wind and solar photovoltaic (PV) plants will participate in congestion management (86 MW). 5. Cádiz: around 130 MW of wind plants connected to the transmission network are participating.

Network under Study ☐ EHV ☒ HV ☒ MV ☒ LV
Objective: Describe briefly the objective of the UC.
The increasing penetration of intermittent generation connected at distribution networks might create unwanted voltage variations. Moreover, the replacement of traditional synchronous generators by wind and solar plants –some of whose voltage control capacity may be more limited- results in voltage control scarcity in some areas of the network. However, the latest technological improvements in inverters allow RES to already support voltage control. In this context, the existing voltage control mechanism based on a unique power factor setpoint by generation plant can be improved by voltage setpoints at the connection point. In consequence, plants could inject -or consume- reactive power to manage voltages at their connection point with the grid. Reactive consumption is a means to reduce overvoltages in the grid, while reactive injection is the opposite and used to increase voltages. Although overvoltages tend to be more common at offpeak hours, this depends on the grid operation and the specific plants that are producing at each time. Currently, there is no service established for voltage control for DG and, for consumers, an obligation to follow cos(fi) is established, with some exemptions. For units under the scope of the (European Commission 2016a, 2016b), additional requirements are applied to both DG and DER. TSO traditionally invest in reactors to consume reactive power, however, this could be supplemented with inverters capabilities in a more cost-effective manner.

Narrative of the Use Case

Short Description: A short narrative focusing on the question what is done in the scope of the use case. This is meant to create a brief overview.
Currently, in Spain, there is not a voltage control services market, only power factor control. Therefore, a suitable market mechanism has to be design from scratch. At transmission level, voltage can be controlled by the injection or consumption of reactive power. At distribution level, but, both active and reactive power have to be used. However, in case that active power is used for solving voltage problems, the congestion management BUC would be used. At distribution level, reactive power is not as useful as at transmission level, due to its higher R/X ratio compared to transmission. Therefore, this service will be mostly provided by FSP connected at the highest voltage of the distribution network, i.e. from 132kV to 25kV, where meshed networks are commonly operated. In a similar manner to congestion management and balancing, the functions are divided in four relevant timescales which are described in detail below: the long-term (from years until day-ahead), the day-ahead, from one hour to real-time and post-real-time. The numbering of the functions are described according to the sequential actions and the arrows represent the flows of information among the different actors. **Long-term** A prerequisite for the Use Case is the product definition, which is addressed in CoordiNet in D1.3. Once the products are defined, the next step starts with the engagement of customers and the evaluation of their potential reactive power provision (Step 1). After the potential is known, a prequalification process will be carried out by the FSP towards the TSO, the DSO or both (step 2.1 and 2.2) and inform the CoordiNet platform (step 2.3). As resources can provide reactive power for voltage control to both TSO and DSO, the prequalification has to be coordinated among the TSO and DSO. For voltage control, long-term procurement may not be relevant for the Spanish case, as resources can provide both reactive and active power together. Therefore, it is not expect gaming from FSP or other market power failures at the moment that may require long-term procurement of reactive power.

Day-ahead The process will start with computing the foreseen requirements from the TSO and DSOs and determining the effective local resources that can potentially solve the voltage power problems, based on the power flows forecasts (steps 3.1 and 3.2). These effective local resources will be determined from those that have been prequalified and accounting for the impact on the identified location. It may be the case that voltage problems are not frequent and, thus, the TSO and DSO can inform the platform when and where voltage problems emerge (step 4). It is important to note that needs can be both of consumption or generation of reactive power. In the meantime, the FSP have to aggregate DERs and determine the available flexibility (step 5) and compute reactive power bids for the relevant location (step 6.1). Meanwhile, resources connected at transmission network also compute their bids for the market (step 6.2). The CoordiNet platform will receive the needs and the effective local resources identified from the TSO and DSO, as well as the bids from FSP (step 7). If bids are not enough to resolve the foreseen voltage needs, an emergency plan may need to be activated (step 8.1), which is out of the scope of this document and even of the CoordiNet Spanish demo. A detailed procedure and the definition of the clearing algorithm have to be defined to handle situations where potential conflicts emerge. For example, the same resources may be used to solve voltage problems that affect two networks in the opposite direction. Therefore, the overall system approach has to be considered (step 8.2). Once all the relevant constraints and available resources have been considered, the CoordiNet platform obtains the results (step 9) and communicates them to the TSO and DSO (step 10). Both grid operators will receive the results (step 11.1 and 11.2) and check their feasibility (step 12.1 and 12.2) if there were any additional voltage control problems, then the market has to be run again (back to step 8.2). **From 1 hour before to real time** From about one hour before real time, when changes in reactive power are needed for voltage control, there may be consequences on congestion management or even on system balancing. Therefore, the DSO and TSO has to establish a procedure to account these effects (step 13) and then inform this to the CoordiNet platform before sending the activation signals to FSP (step 14). The FSP has to perform the activation of resources manually or automatically (step 15). The platform communicates the activation to the TSO and DSOs (step 16), who have to check the activation and monitor the system (step 17.1 and 17.2). **After real-time** Once the services are delivered, consumption and generation of reactive power is metered. As mentioned before, in Spain, who performs the metering activity depends on the consumption, generation and the grid level of their connection point . For consumers, metering activity is only performed by the DSO, regardless the grid level (transmission or distribution) where they are connected to. However, metering for generators with capacity below 450kW is performed by DSO, while all the rest is done by TSO regardless the grid level (transmission or distribution) where they are connected to (step 18). The CoordiNet platform will then use the metering data to perform the settlement process for reactive power delivered with FSPs (Step 19) and then the FSP perform the individual settlement with the resources which may include other services or even the energy sold in energy market or other contractual agreements (step 20).

Further Details

Actors&Roles, Names and Types: Please indicate which actors contribute to the Use Case in the sense of providing inputs/outputs, processing or aggregation. In case the writer of the Use Case defines an own actor, the actor shall be classified and shortly described.
The primary actors are the TSO and the DSOs. ☒ DSO ☒ TSO ☒ End Customers (MV/LV)

☒ DER Customers ☐ Regulator ☒ Municipality/Local Authority ☒ Aggregator/Flexibility Operator ☒ Balance Responsible Party ☒ Service Provider ☒ Other: CoordiNet Platform

7.1.8. BUC ES-4

PLEASE FILL OUT ONE TEMPLATE FOR EACH IDENTIFIED USE CASE. IN CASE THAT DIFFERENT PERSPECTIVES REQUIRE SEPERATE DOCUMENTS PLEASE INDICATE YOUR VIEWPOINT FOR THIS USE CASE:

Use Case Identification

Name of UC: Enter a short name that refers to the activity of the UC itself.
Controlled Islanding provided to the DSO under the scope of a local market mechanism

Name Author(s) or Committee: Person or e.g. standardization committee like Smart Grid Technical Committees or Working Group, if applicable.
Comillas/Iberdrola/Endesa/Tecnalia/REE

Scope and objectives

Scope: Describe briefly the scope, objectives, and rationale of the UC. You can additionally use the tick boxes to specify the voltage level and markets that are subject to this Use Case.
The resources included in this demonstration activity will only be connected to Iberdrola's networks in Caravaca (Murcia), where energy storage and PV units located in medium and low voltage grids can be used. The battery capacity power is 1 250 kW for injecting and withdrawing, whereas the energy capacity is 2 772 kWh. The connected consumption is around 400kW. **Network under Study** ☐ EHV ☐ HV ☒ MV ☐ LV
Objective: Describe briefly the objective of the UC.
The objective of this BUC is to operate part of the distribution network in an islanding mode during outages or programmed maintenance services. Without controlled islands, in case of network outages or planned maintenance, consumers may face a temporal curtailment during those events in contrast with a controlled operation which can maintain the power supply during those events.

Narrative of the Use Case

Short Description: A short narrative focusing on the question what is done in the scope of the use case. This is meant to create a brief overview.
During outages or programmed maintenance services, a part of the grid may be disconnected from the system, remaining electrically islanded. In this situation, the DSO activates DG to supply the consumers

within the island during the outage or the maintenance period. The DSO has to be able to maintain under control technical parameters such as voltage and frequency in the electrical island. The DSO has to determine the size of the island which may affect and need to be communicated with the TSO.

In a similar manner to previous BUC, the functions are divided in four relevant timescales which are described in detail below: the long-term (from years until day-ahead), the day-ahead, from one hour to real-time and post-real-time. The numbering of the functions is described according to the sequential action and the arrows represent the flows of information among the different actors.

Long-term

A prerequisite for the Use Case is the product definition, which is addressed in CoordiNet in D1.3. Once the products are defined, the next step starts with the evaluation of the DSO of the islanding needs (step 1). Once the needs and location are identified, they are communicated to the platform (step 2), so that it makes this information available for FSP in order to engage customers and evaluate their flexibility (Step 3). Once the flexibility is known, a prequalification process will be carried out between the FSP and DSO (step 4). For this service, it is essential to guarantee a long-term commitment, so a long-term contract is necessary between the DSO and the FSP (steps 5 to 7). On the other hand, the TSO has to be aware of the possible islanding operation, to take it into account for the system balancing and security (step 8).

Day-ahead

In case of planned outages, the DSO communicates to FSP the needs for islanding operation for the following day (step 9). It may be the case that the usage of this service is not frequent, the DSO will inform the platform when it is required (step 10). The platform will inform the TSO (step 11) and the FSP when islanding operation is needed, then the FSP aggregate DERs and determine the available flexibility (step 12) and the available flexibility (step 13).

From 1 hour before to real time

The DSO performs the islanding operation when needed and dispatch resources according to the price-quantity bids for both active and reactive power in order to maintain frequency and voltage in security limits in the electrical island (step 14). The DSO communicates to the CoordiNet platform the islanding operation, which informs the TSO and FSP (step 15). The TSO receives the information of islanding operation (step 16) and considers the net effect on the system's balancing (step 17). In the meantime, the FSP execute the instructions from the DSO (step 18).

After real-time

After the islanding operation, the DSOs meters the energy delivered and all the energy withdrawn from consumers during the islanding operation mode (step 20) and performs the settlement (step 21) or alternatively the CoordiNet platform can also do it. Finally, the FSP perform the individual settlement with the resources which may include other services (step 22).

After the event takes place

The electrical island has to be reconnected with the rest of the system (step 23). This action has to be communicated to the CoordiNet platform which informs the TSO and the FSP (step 24). The TSO receives the information of islanding operation (step 25) and considers the net effect on the system's balancing (step 26). In the meantime, the FSP execute the instructions to reconnect from the DSO (step 27).

Further Details

Actors&Roles, Names and Types: Please indicate which actors contribute to the Use Case in the sense of providing inputs/outputs, processing or aggregation. In case the writer of the Use Case defines an own actor, the actor shall be classified and shortly described.
The primary actor is the DSO. ☒ DSO ☒ TSO

☐ End Customers (MV/LV) ☒ DER Customers ☐ Regulator ☒ Municipality/Local Authority ☒ Aggregator/Flexibility Operator ☐ Balance Responsible Party ☒ Service Provider ☒ Other: CoordiNet Platform

7.1.9. BUC SE-1a

PLEASE FILL OUT ONE TEMPLATE FOR EACH IDENTIFIED USE CASE. IN CASE THAT DIFFERENT PERSPECTIVES REQUIRE SEPERATE DOCUMENTS PLEASE INDICATE YOUR VIEWPOINT FOR THIS USE CASE:

☒ DSO

☒ TSO

☐ REGULATOR

☐ OTHER

Use Case Identification

Name of UC: Enter a short name that refers to the activity of the UC itself.
Congestion management in low voltage and medium voltage distribution grid under the scope of a multi-level market mechanism (with reference to BUC SE-3)
Name Author(s) or Committee: Person or e.g. standardization committee like Smart Grid Technical Committees or Working Group, if applicable.
Vattenfall Eldistribution, E:ON Energidistribution and Svenska Kraftnät

Scope and objectives

Scope: Describe briefly the scope, objectives, and rationale of the UC. You can additionally use the tick boxes to specify the voltage level and markets that are subject to this Use Case.
This BUC describes the actions that are carried out in case of congestions in low voltage as well as medium voltage distribution grid in order to keep power flows in the accepted subscription limits towards overlying grid operator or in thermal limits of the lines and the transformers. Flexible resources connected to low voltage and medium voltage distribution grid can provide flexibility to system operators to eliminate congestions though a market mechanism. Active power control is considered. Short term products are traded on following markets • Capacity Day-Ahead • Capacity Intraday Long-term products are traded in the market • Firm capacity

In addition, it has to be ensured that the activation of flexible resources in the distribution network would respect distribution system constraints. A cooperation and information exchange between DSO and TSO are crucial for eliminating congestions in the most efficient way, for a good load prognosis of the power level in the medium-voltage grid and as a market driver for flexible resources as well for a functioning energy market. This BUC is designed to fit the products that derive from the geographical specifications: In Uppland and Skåne an increase of power demand can be seen, since cities are growing and electrification is a driver for the industry and society to become fossil-free and local production in CHP is closing down. The TSO has denied raise of subscription level for the regional DSO and the regional grid has denied raise of subscription level for the local DSO. The TSO has bottle-necks in the grid that will take up to 10 years to solve this. In Gotland, there is an increase of power demand expected when cities are growing and electrification is a driver for the industry and society to become fossil-free. At the same time, due to the continuous increase of RES installation in Gotland, there is congestions from production. Gotland is an island connected to the mainland with an HVDC-link and minimizing the amount of reverse of the link could increases the power supply of the customers. **Network under Study** ☐ EHV ☒ HV ☐ MV ☐ LV
Objective: Describe briefly the objective of the UC.
The objectives of this BUC are the following: 1. DSO wants to give customers opportunity to optimize their resources 2. DSO meets grid needs with a market opportunity 3. Flexibility provider wants to meet financial goals 4. TSO wants to increase the market for mFRR

Narrative of the Use Case

Short Description: A short narrative focusing on the question what is done in the scope of the use case. This is meant to create a brief overview.
The BUC describes the steps that are followed to eliminate congestions in low-voltage and medium-voltage distribution system using flexibility provided by resources connected to both systems. The market is open for all flexibility providers that meet pre-qualification criteria, limit is number of meters. The actor in this BUC are the Grid operators and the Flexibility provider. Geographical areas for the market: • Uppland • Skåne • Gotland The steps that are followed for each market are described below: **Yearly process** 1. The TSO and DSO revise the products being used in the regional markets 2. Yearly the DSOs produces a prognosis for their future flexibility demand and communicates it to the market 3. The flexibility provider determines their level of flexibility and starts a pre-qualifying process and informs the Balance Responsible Party

4. The DSO approve the market participants for the regional market

Operational process

5. The flexibility providers put bids to the market until gate closure
6. The DSO produces a load prognosis for the grid
7. The DSO identifies flexibility demand
    a. Places bids on Day- Ahead
    b. If the load prognosis is incorrect the DSO identifies flex demand and uses Intraday
8. First the local and then the regional DSOs send a request for temporary subscription to the TSO
9. The TSO or respectively the regional DSO sends subscription bid to the CoordiNet Platform
10. The grid operator decides and confirms bids.
11. The CoordiNet platform matches bids and grid need and gives decision support to the grid operator using MOL and grid information.
12. The grid operator informs the flexibility providers and the overlaying grid, as well as forwards unused bids Intraday to the mFRR market
13. The flexibility provider updates/informs the Balance Responsible Party
14. The flexibility provider activates the flexibility and informs the grid operator if the resource is unavailable
15. Receive confirmation
16. Settlement after metering

The coordination is according to this local market logic where you see the gate closure times for the potential different relevant markets for a flexible resource.

Further Details

Actors&Roles, Names and Types: Please indicate which actors contribute to the Use Case in the sense of providing inputs/outputs, processing or aggregation. In case the writer of the Use Case defines an own actor, the actor shall be classified and shortly described.
☒ DSO ☒ TSO ☐ End Customers (MV/LV) ☐ DER Customers ☐ Regulator ☐ Municipality/Local Authority ☒ Aggregator/Flexibility Operator ☐ Balance Responsible Party ☐ Service Provider

7.1.10. BUC SE-1b

PLEASE FILL OUT ONE TEMPLATE FOR EACH IDENTIFIED USE CASE. IN CASE THAT DIFFERENT PERSPECTIVES REQUIRE SEPERATE DOCUMENTS PLEASE INDICATE YOUR VIEWPOINT FOR THIS USE CASE:

☒ DSO

☒ TSO

☐ REGULATOR

☐ OTHER

Use Case Identification

Name of UC: Enter a short name that refers to the activity of the UC itself.
Congestion management in low voltage and medium voltage distribution grid under the scope of a distributed market mechanism

Name Author(s) or Committee: Person or e.g. standardization committee like Smart Grid Technical Committees or Working Group, if applicable.
Vattenfall Eldistribution, E:ON Energidistribution and Svenska Kraftnät

Scope and objectives

Scope: Describe briefly the scope, objectives, and rationale of the UC. You can additionally use the tick boxes to specify the voltage level and markets that are subject to this Use Case.
This BUC describes the actions that are carried out in case of congestions in low voltage as well as medium voltage distribution grid using a peer to peer market. The driver for this user case is that sometimes a peer to peer market can be solution for customers when grid congestion occurs. One such clear example is congestion because of maintenance and investments in the grid. The market is open for all flexibility providers that meet pre-qualification criteria, limit is number of meters. The primary actor in this BUC is the Flexibility provider. Geographical areas for the market: • VästerNorrland/Jämtland • (Gotland) **Network under Study** ☐ EHV ☐ HV ☒ MV ☒ LV
Objective: Describe briefly the objective of the UC.
The objectives of this BUC are the following: 1. DSO wants to give customers opportunity to optimize their resources 2. DSO meets grid needs with a market opportunity 3. Flexibility provider wants to meet financial goals

Narrative of the Use Case

Short Description: A short narrative focusing on the question what is done in the scope of the use case. This is meant to create a brief overview.

D1.5 – Business Use Case definition

The BUC describes the steps that are followed to eliminate congestions in low-voltage and medium-voltage distribution system using flexibility provided by resources connected to both systems. The market is open for all flexibility providers that meet pre-qualification criteria, limit is number of meters. The steps that are followed for each market are described below: 1. Grid operator produces flexibility demand plan and communicate this plan 2. Flexibility providers identify flexibility availability (can be positive or negative) day ahead 3. Flexibility providers send either buy bid or sell bid to the CoordiNet platform 4. Flexibility providers accept bids (first come first serve) 5. Flexibility providers receive confirmation from CoordiNet platform 6. Flexibility providers update DA position 7. Flexibility providers activates flexibility according to the agreed bids (inform if unavailable) 8. P2P market is cleared. Flexibility providers are either remunerated or are paying for the flexibility.

Further Details

Actors&Roles, Names and Types: Please indicate which actors contribute to the Use Case in the sense of providing inputs/outputs, processing or aggregation. In case the writer of the Use Case defines an own actor, the actor shall be classified and shortly described.
☒ DSO ☒ TSO ☐ End Customers (MV/LV) ☐ DER Customers ☐ Regulator ☐ Municipality/Local Authority ☒ Aggregator/Flexibility Operator ☐ Balance Responsible Party ☐ Service Provider

7.1.11. BUC SE-2

PLEASE FILL OUT ONE TEMPLATE FOR EACH IDENTIFIED USE CASE. IN CASE THAT DIFFERENT PERSPECTIVES REQUIRE SEPERATE DOCUMENTS PLEASE INDICATE YOUR VIEWPOINT FOR THIS USE CASE:

☒ DSO

☒ TSO

☐ REGULATOR

☐ OTHER

Use Case Identification

Name of UC: Enter a short name that refers to the activity of the UC itself.
Flexibility providers offer balancing services to the local DSO in Gotland under the scope of a local market mechanism

Name Author(s) or Committee: Person or e.g. standardization committee like Smart Grid Technical Committees or Working Group, if applicable.
Vattenfall Eldistribution, E:ON Energidistribution and Svenska Kraftnät

Scope and objectives

Scope: Describe briefly the scope, objectives, and rationale of the UC. You can additionally use the tick boxes to specify the voltage level and markets that are subject to this Use Case.
This BUC describes the actions that are carried out DSO want to use flexibility for system services for power quality and delivery of supply The regional DSO is motivated to work with the local DSO in Gotland to find a solution for the local DSOs challenges using flexibility services on a market. Further analysis on both sides needs to be made, to understand the upcoming steps to realize this BUC. Market solutions have not been used or analysed for Gotland yet. The grid situation is very specific. The analysis should reveal which products will be utilized to solve the locally critical situation. The products under analysis are inertia, FCR and/or reactive power. Depending on the product, the integration on the local or peer-to-peer market will be targeted. This local DSO in Gotland is integrated and represented in BUC 1. The project expects to draw lessons learned. **Network under Study** ☐ EHV ☐ HV ☒ MV ☒ LV
Objective: Describe briefly the objective of the UC.
The objectives of this BUC are the following: 1. Local DSO wants to connect new solar and wind power 2. Local DSO wants to improve power quality and delivery of supply 3. Local and regional DSO wants to unlock flexibility and increase the attractiveness for flex providers to participate on the CoordiNet platform 4. Regional DSO wants to find solutions for local DSO

Narrative of the Use Case

Short Description: A short narrative focusing on the question what is done in the scope of the use case. This is meant to create a brief overview.
After the identication of the grid needs, the local and regional DSO each use the (local and) regional market place to buy the needed services (while the products depend on the identified need). Possible products are i.e. inertia, FCR and mFRR. The CoordiNet platform will play a central role to exchange information, offer bids on products and enable to solve local grid issues. The intention is to use existing market rules. Today these products are managed by TSO not by the regional DSOs in Sweden. The existing products and according processed might not specifically work for the grid situation of an island like Gotland. This applicability is part of the analysis that is the basis to realize the presented BUC.

Further Details

Actors&Roles, Names and Types: Please indicate which actors contribute to the Use Case in the sense of providing inputs/outputs, processing or aggregation. In case the writer of the Use Case defines an own actor, the actor shall be classified and shortly described.
☒ DSO ☒ TSO ☐ End Customers (MV/LV) ☐ DER Customers ☐ Regulator ☐ Municipality/Local Authority ☒ Aggregator/Flexibility Operator ☐ Balance Responsible Party ☐ Service Provider ☐ Other:

7.1.12. BUC SE-3

PLEASE FILL OUT ONE TEMPLATE FOR EACH IDENTIFIED USE CASE. IN CASE THAT DIFFERENT PERSPECTIVES REQUIRE SEPERATE DOCUMENTS PLEASE INDICATE YOUR VIEWPOINT FOR THIS USE CASE:

☒ DSO

☒ TSO

☐ REGULATOR

☐ OTHER

Use Case Identification

Name of UC: Enter a short name that refers to the activity of the UC itself.
Flexibility providers offer balancing services to the TSO <u>under the scope of a multi-level market mechanism</u> (with reference to BUC SE-1a)

Name Author(s) or Committee: Person or e.g. standardization committee like Smart Grid Technical Committees or Working Group, if applicable.
Vattenfall Eldistribution, E:ON Energidistribution and Svenska Kraftnät

Scope and objectives

Scope: Describe briefly the scope, objectives, and rationale of the UC. You can additionally use the tick boxes to specify the voltage level and markets that are subject to this Use Case.

D1.5 – Business Use Case definition

This BUC describes the actions that are carried out when unused bids that meet the conditions for the balancing service mFRR (pilot 1 MW) are transferred to the TSO regulating power market. The bids are activated in the same manner as other mFRR bids. **Network under Study** ☐ EHV ☐ HV ☒ MV ☒ LV

Objective: Describe briefly the objective of the UC.
The objectives of this BUC are the following: 1. Increase the attractiveness for flex providers to participate on the CoordiNet platform by opening the possibility to also be called in the balancing market 2. Increase available balancing bids for the TSO

Narrative of the Use Case

Short Description: A short narrative focusing on the question what is done in the scope of the use case. This is meant to create a brief overview.
The BUC describes the steps that are followed to forward bids from the CoordiNet congestion market to the balancing market mFRR. The market is open for all flexibility providers that meet pre-qualification criteria and has a cooperation with the BRP. Geographical areas for the market: • Uppland • Skåne • Gotland The BUC has the following steps: 5. Flexibility provider provide bids to the CoordiNet platform. 6. DSO call bids for own needs D-1 and H-2. 7. Remaining bids meeting mFRR requirements transferred to TSO regulating power market at the latest at gate closure time for the regulating power market 8. Bids are activated by the TSO

Further Details

Actors&Roles, Names and Types: Please indicate which actors contribute to the Use Case in the sense of providing inputs/outputs, processing or aggregation. In case the writer of the Use Case defines an own actor, the actor shall be classified and shortly described.
☒ DSO ☒ TSO ☐ End Customers (MV/LV) ☐ DER Customers ☐ Regulator ☐ Municipality/Local Authority ☒ Aggregator/Flexibility Operator ☐ Balance Responsible Party

☐ Service Provider ☐ Other: