H2020 – LC-SC3-ES-5-2018-2020
Innovation Action

INTERRFACE

TSO-DSO-Consumer INTERFACE aRchitecture to provide innovative Grid Services for an efficient power system

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 824330

D3.1 Definition of new/changing requirements for services

Report Identifier:	D3.1		
Work-package, Task:	WP3, T3.1	**Status – Version:**	1.0
Distribution Security:	PU	**Deliverable Type:**	R
Editor:	RSE		
Contributors:	RSE, EMP, ENTSO, UPRC		
Reviewers:	UPB, LOY		
Quality Reviewer:	ED		
Keywords:	Market, services, products, business use cases, functional use cases		
Project website: www.interrface.eu			

Table of Contents

List of Tables

List of Figures

Abbreviations

aFRR	Automatic Frequency Restoration Reserve
BESS	Battery Energy Storage System
BSP	Balancing Service Providers
BUC	Business Use Case
CHP-DH	Combined Heat and Power – District Heating
CM	Congestion Management
DER	Distributed Energy Source
DSO	Distribution System Operator
ERPS	Enhanced Reactive Power Service
EV	Electric Vehicles
FCR	Frequency Containment Reserves
FFR	Fast Frequency Reserves
FRT	Fault-Ride-Through Capability
IEGSA	Integrated pan-European Grid Services Architecture
LV	Low Voltage
mFRR	Manual Frequency Restoration Reserve
ORPS	Obligatory Reactive Power Service
P2P	Peer-to-peer
PV	Photo-Voltaic Plant
RR	Replacement Reserve
SO	System Operator
TSO	Transmission System Operator

Executive Summary

This report, collecting the outcome of task 3.1, aims at defining in a formal way the interactions between the different players involved in the provision of ancillary services from entities connected to transmission and distribution grids. This work is propaedeutic to elaborating the specifications for the implementation of the same services into the IEGSA platform.

After some debate, it was decided to restrict the list of services to be implemented into the IEGSA to the following ones:

- *aFRR*
- *mFRR*
- *Short term CM*
- *Operational CM (including the action through voltage regulation in distribution).*

Therefore, after a synthetic introduction of characteristics and terminology of all ancillary services, the focus is narrowed to the above ones. For each of them, the interactions between the different player are described for a small number of market frameworks of interest provided by T3.2 and described in detail in the deliverable D3.2.

As the INTERRFACE project is going to apply the IEGSA to seven demos (WPs 5, 6 and 7), the creation of the above mentioned interactions description was achieved after polling all the demos for understanding:

- *which ancillary services they are going to implement*
- *what kind of implementation they have in mind.*

This process was complicated by the fact that the stage of evolution of the demos during the first project year was not (at least in a few cases) sufficiently advanced. That made it necessary to supplement the "bottom-up" analysis of the demos Business Use Cases with a second phase of "top down" analysis, starting from the services specifications and trying to define an "envelope" of the needs of the different demos while preserving some generality in the implementation of the different services.

As already mentioned, the present deliverable has to be seen as part of a group of three defining, respectively:

- *services, actors and interactions (D3.1)*
- *real time markets framework (D3.2)*
- *data requirements and exchanges between actors (D3.3).*

1 Introduction

1.1 Background

Decarbonization is a priority for the European system now and in the next years. This process passes through the necessity to convert the electric generation park into one more environmentally friendly, by continuing on the present pathway to increase the installed capacity of Renewable Energy Sources (RSE). These generators are mostly based on wind and solar primary sources, characterized by an intermittent and not completely predictable generation pattern. All this has strong implications on real time system services, which become a more and more important component of the electricity markets chain.

In this framework, the need for system reserves is increasing and will even more increase in the next years.

Another important phenomenon taking place in the present years is the fact that distribution grids are gradually becoming active: a wide number of subjects (generically called Distributed Energy Sources) are being connected to distribution, thus bringing to a transformation in its role from pure passive network bringing the power produced by big generators to where it is consumed, to an active grid where power is often produced and can either be consumed locally or remount to transmission. .In this way, distribution entities could also be enabled to provide services to the system, thus increasing the amount of reserve and the level of security of the electric networks.

Hence, the idea of the INTERRFACE project to create a "standard" package (the IEGSA platform) that should be used for connecting all the system subjects that are involved to provide ancillary services: from the end-users (often connected to distribution grids) to the Distribution System Operators (DSOs), to the Transmission System Operator (TSO).

Such platform should not only defined which data are exchanged, but also implement the interactions necessary in order to implement the most important system services. Defining which services to implement and define for each of them in detail the interactions between the different subjects is the final goal of the present deliverable.

The present deliverable is part of a group of three defining, respectively:

- services, actors and interactions (D3.1)
- real time markets framework (D3.2)
- data requirements and exchanges between actors (D3.3).

1.2 Scope and objectives of the document

As clarified above, aim of the present deliverable is to define in a formal way the interactions between the different players involved in the provision of ancillary services from entities connected to transmission and distribution grids. This work is propaedeutic to elaborating the specifications for the implementation of the same services into the IEGSA platform.

As the INTERRFACE project is going to apply the IEGSA to seven demos (WPs 5, 6 and 7), the creation of the above mentioned interactions description was achieved after polling all the demos for understanding:

- which ancillary services they are going to implement
- what kind of implementation they have in mind.

This process was complicated by the fact that the stage of evolution of the demos during the first project year was not (at least in a few cases) sufficiently advanced. That made it necessary to supplement the "bottom-up" analysis of the demos Business Use Cases with a second phase of "top down" analysis, starting from the services specifications and trying to define an "envelope" of the needs of the different demos while preserving some generality in the implementation of the different services.

1.3 Document structure

In consideration of the above needs and operative pathway, the present deliverable is structured in the following way:

- Chapter 2 provides the methodology adopted to define the interactions between the different entities which are part of the ancillary services provision for the services which were selected to be described in detail. As a matter of fact, it describes the work done in the T3.1 of the INTERRFACE project
- Chapter 3 first tries to set out a standard nomenclature for ancillary services. In this way, each of the most important system services is defined in a dedicated card where the perimeter of the service, who provides it and where this service is tested (in case) by the INTERRFACE demos.
- Chapter 4 summarizes the main achievements of previous EU Projects which have dealt with ancillary services.
- Chapter 5 adopts a bottom-up approach and analyses Business Use Cases of each of the seven INTERRFACE Demos in order to define requisites in terms of services and highlight the different ways to conceive these services by the different demos (comparison tables are provided at the end of the chapter).
- Chapter 6 reverses the approach and while taking into account the needs analyzed in chapter 5, adopts a top-down approach aiming at defining standard services implementations. It starts from the services specifications but then tries to define an "envelope" preserving generality in the implementation of the different services.
- Chapter 7 provides some conclusions.

2 Methodology

Task 3.1 of the INTERRFACE project aims at analysing which ancillary services should be implemented in detail by the IEGSA platform and define for each of them the interactions between the different player involved in the provision of ancillary services from entities connected to transmission and distribution grids. This work is propaedeutic to elaborating the specifications for the implementation of the same services into the IEGSA platform.

After some debate, it was decided to restrict the list of services to be implemented into the IEGSA to the following ones:

- aFRR
- mFRR
- Short term CM
- Operational CM (including the action through voltage regulation in distribution).

Therefore, after a synthetic introduction of characteristics and terminology of all ancillary services, the focus is narrowed to the above ones. For each of them, the interactions between the different player are described for a small number of market frameworks of interest provided by T3.2 and described in detail in the deliverable D3.2.

As the INTERRFACE project is going to apply the IEGSA to seven demos (WPs 5, 6 and 7), the creation of the above mentioned interactions description was achieved after polling all the demos for understanding:

- which ancillary services they are going to implement
- what kind of implementation they have in mind.

This process doesn't include to analyse market framework (T3.2) and data flows/interactions with the database (T3.3) but a tight synergy has to be maintained in order to foster a coherent overall process outcome.

The deliverable D3.1 is finalized within January 2020, but in consideration of the fact that the seven demos will intensely work for the whole year 2020 and better design their set up, an update is foreseen by the end of 2020 in case this can help to include more details and a better analysis.

Figure 1 includes full detail on the way adopted to operate in T3.1:

- A top-down analysis was first carried out in order to analyse which services to implement, which are the actors and roles for them, which the interactions and which the procuring mechanisms; this was done also taking into account the results of previous EU Projects.
- The bottom up analysis of end-users point of view (analysed in WP2 and reported in the relevant deliverables) was also duly taken into account.
- Then a two steps mechanism was implemented, featuring first a bottom-up requirements analysis for each of the seven project demos and then a top-down phase which brought to define (chapter 6) the interactions between the subjects involved in the services provision).
- The final phase will consist in analysing the further work done by the demos during 2020 and could bring to an update of the present deliverable by end 2020.

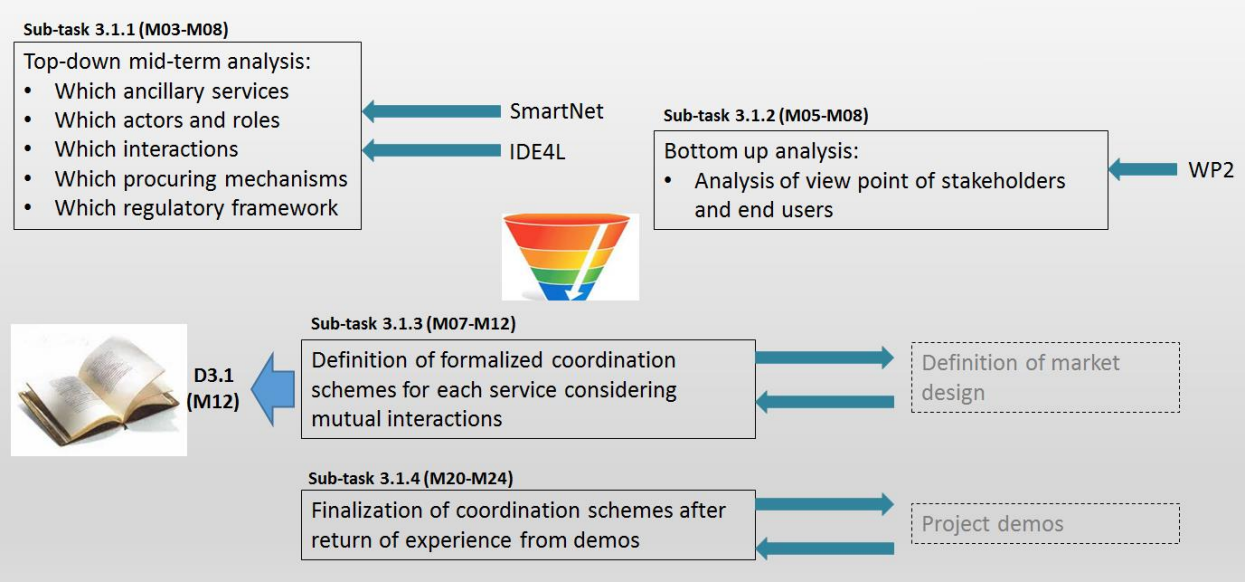


Figure 1: working chain for T3.1

Figure 2 clarifies the methodological pathway adopted in the top-down analysis: for each market framework defined by T3.2 (only some of the indicated market frameworks have been selected as being the most meaningful) and for each of the services which were selected to be described in detail, the interactions were grouped into the main phases of service provision: pre-qualification, reservation of available capacity, activation and settlement. In a separate chapter a comparison of the different implementations carried out in dependency of the different market frameworks is done so as to justify the differences in terms of peculiarities of the different markets.

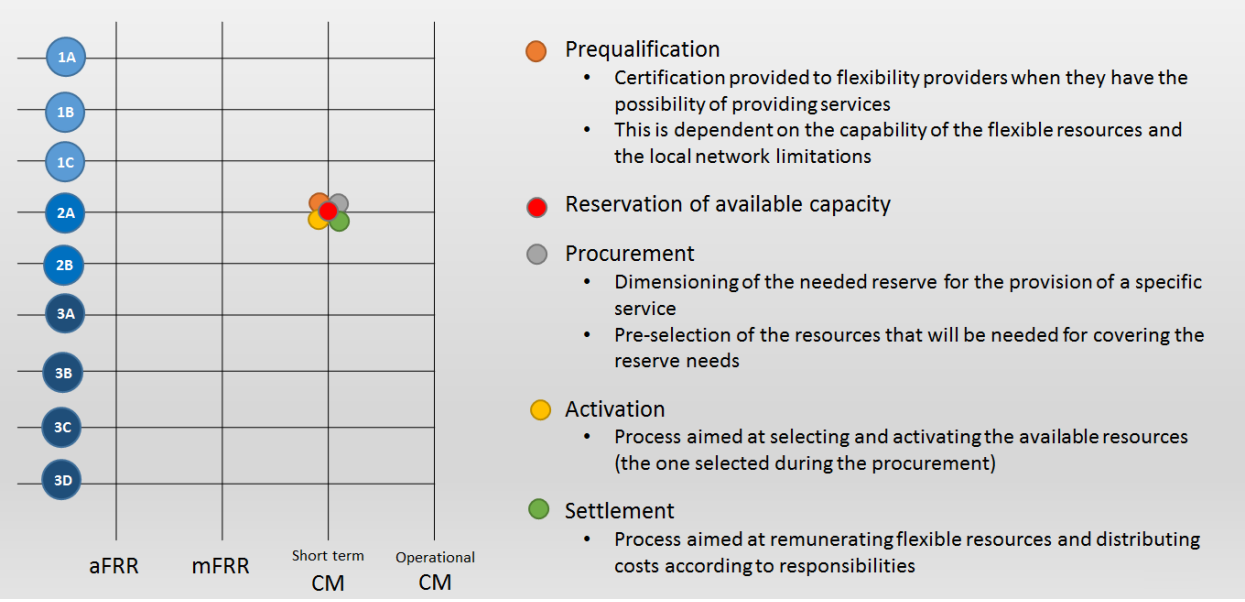


Figure 2: Top-down analysis grid

3 Summary of work from previous EU Projects

This section is an overview of the "state of the art" of the services implemented in the different European Power Systems [4] and, in particular, that are used within the Horizon2020 projects IDE4L **Σφάλμα! Το αρχείο προέλευσης της αναφοράς δεν βρέθηκε.**, SmartNet [3], EU-Sysflex [2] and FutureFlow [1]. New services that are needed by Demonstrators in the INTERRFACE project are also introduced.

This overview has been the starting point of the analysis performed in the subsequent chapters on the services that should be implemented in the IESGA platform and used by the demonstrators. The informations are gathered in a table in which the services are grouped in Market Domains and Subdomains, briefly described and linked to the project of origin.

3.1 Market service list and relation with INTERRFACE demo projects

The following table presents the overview of the services implemented in the different European Power Systems [4], or that have been implemented within the Horizon2020 projects IDE4L **Σφάλμα! Το αρχείο προέλευσης της αναφοράς δεν βρέθηκε.**, SmartNet [3], EU-Sysflex [2] and FutureFlow [1] or that have been suggested by the Demontrators developed in the INTERRFACE project.

The different services are grouped by the market domain in which they are usually traded, which is strictly linked to the purpose of the service provision, and by sub-domain, indicating similarities among the different services, according to the following structure.

- Balancing
  - Standard Frequency Response Services
  - New/Emerging Frequency Response Services
- Congestion Management
  - Intra-zonal
  - Cross-border
- Non-frequency Ancillary Services
  - Reactive Power/Voltage Control
  - System Restoration
- Adequacy
  - Capacity Remuneration Mechanism

For each of the services introduced, a brief description is presented, along with an indication on if it has been used in one of the H2020 projects surveyed and if it will be implemented by one or more of the Demonstrators developed in INTERRFACE. A complete description of the services that will be implemented in the INTERRFACE project will be given in Section 4.

Market domain	Market sub-domain	Service	Description	Projects				
				IDE4L	SmartNet	EU-Sysflex	FutureFlow	Used in INTERRFACE
Balancing markets	STANDARD Frequency Response services	**Frequency Containment Reserves (FCR)**	Frequency containment is an automatic function which aims at stabilising the frequency at a steady-state value within the permissible maximum steady-state frequency deviation after disturbances in the high-voltage grid. By the joint action of all automatic devices, the process ensures the operational reliability in the synchronous area.	X	X	X		X
		automatic Frequency Restoration Reserve (aFRR)	This service is a centralised automatic function intended to replace FCR and restore the frequency to the target frequency – usually 50.00Hz. In contrast to mFRR (see below), aFRR 'can be activated by an automatic control device'. This control device shall be an automatic control device designed to reduce the Frequency Restoration Control Error (FRCE) to zero.	X	X	X	X	X
		manual Frequency Restoration Reserve (mFRR)	Manual Frequency Restoration is a manual change in the operation set-points of the reserve (mainly by re-scheduling), in order to restore system frequency to the set point value frequency and, for a synchronous area consisting of more than one load-frequency control area, to restore power balance to the scheduled value.	X	X	X		X
		Replacement reserves (RR)	The reserve replacement process replaces the activated FRR and/or complements the FRR activation by activation of RR. The replacement reserve process is activated in the disturbed LFC area. Activation is semi-automatic or manual.	X		X		
		Fast frequency reserves (FFR)	Fast Frequency Response is defined as any type of rapid active power increase or decrease by generation or load, in a timeframe of less than 2 seconds, to correct supply-demand imbalances and assist with managing frequency.		X	X		X
	NEW EMERGING Frequency Response services	**Ramp control**	Ramp control or ramping margin is new service that is intended ensure system stability by responding to variations in demand, variable weather forecast errors and plant outages. Its timeframe is longer than a traditional FRR reserves - up to 8-hour ramping period with 8 hours of maintaining level of production.		X			X
		Smoothed production	This service has similarities to mFRR service, but it is aimed to adjust start-up time of generation to follow demand schedule more closely. Several hours in advance of real-time operation, an algorithm is used to detect large structural imbalances to make production schedule adjustments (shifting part of production up to 30 minutes from start of one market period to end of market period before it)		X			
		BRP portfolio balancing	BRP has the obligation to balance his own position. This volume of energy could be produced by generation units in the BPR's portfolio but could also be imported or bought on the market. By balancing his own position, the BRP contributes to the balance of the electricity system.					X
Congestion management	Intra-zonal	**Operational**	Default service criteria same as mFRR, but used internally by TSOs / DSOs for congestion management in operational timeframe (not for balancing markets) and activation decision will be done real-time (during market time unit) manually by a dispatcher.			X		X
		Short-term planning	Default service criteria same as mFRR, but used internally by TSOs / DSOs for congestion management in short-term planning timeframe (not for balancing markets). Activation decision will be done D-1 (grid calculations and congestion check one day in advance for every market time unit) by a short-term planner.					X
		Long term planning	An envisaged service that may serve network reinforcement deferral, network support during construction and planned maintenance, where location-specific flexibility assets are being activated for shaving or shifting peak demand and production in order to compensate for the lack of network connections, loads or production units mainly in the distribution network.					X

Market domain	Market sub-domain	Service	Description	Projects				
				IDE4L	SmartNet	EU-Sysflex	FutureFlow	Used in INTERRFACE
	Cross-border	**Redispatch**	Redispatching is a remedial action, including curtailment, that is activated by one or more TSOs or DSOs by altering the generation, load pattern, or both, in order to change physical flows in the electricity system and relieve a physical congestion or otherwise ensure system security.			X	X	X
		Countertrading	Countertrading means a cross-zonal exchange initiated by system operators between two bidding zones to relieve physical congestion, where the precise generation or load pattern alteration is not predefined. This measure is a market based-solution, where the cheapest bid is selected independently of the geographical location within the bidding zone.					X
Non-frequency ancillary services	Reactive Power and Voltage Control	**Obligatory reactive power service (ORPS)**	The main function is to maintain the voltage profile within the acceptable range and within the tolerance margins. This will allow a minimization of power losses and keep a steady state security.	X	X	X		X
		Enhanced reactive power service (ERPS)	Enhanced reactive power services (ERPS or a like) is voluntary service organised for any service provider, that can absorb or inject reactive power can provide ERPS. Usually this ancillary service is connected with the obligatory system reactive power services, provided by the TSO.	X	X	X		X
		Fault-ride through (FRT) capability	FRT is the capability of electric generators to stay connected in short periods of lower electric network voltage (voltage dip) until the faulted element has been cleared from the transmission system. The fault-ride through capability mostly depends on the reactive power control. The fault ride through specifications for distributed generators, defined by the grid codes, establish the requirements of power supply in the event of short circuits based on the prevailing voltage levels at the grid connection point as a function of time."		X			X
		Local Grid Balancing	In the new electricity framework, the conventional top-down power flows are replaced by local energy production, which are posed to cause a high number of local grid unbalanced situations. System Operators, as a part of their neutral market facilitator role, directly or indirectly will be the entities responsible for validation of traded flexibility related to assets connected to the distribution grid. These issues should be solved through cooperation between the system operators and the market parties (aggregators, energy communities, single end-users) responsible for causing the local imbalances.					X
	System Restoration	**Black Start**	The black start capability is the ability of a power source to support the system restoration after a blackout, through a dedicated auxiliary power source without any electrical energy supply external to the power generating facility.	X				X
		Islanding Operation	Island operation may be performed in customer's network by utilizing standby generation units, uninterruptible power supply and periodization of loads supplied during controlled island operation utilizing the concept of micro-grid to enhance distribution network reliability. DSOs, when able to balance the islanded network, black-start the island after an outage or automatically disconnect the island from the faulted network and resynchronize the island network with or without outage to the grid after fault clearance.	X				X
		Damping of power system oscillations	Damping of power system oscillations is one of the main concerns in the power system operation mainly dealing with the angle stability of power systems. These oscillations, when not well damped, may keep growing until loss of synchronism. These low-frequency oscillations affect the stability and efficiency of the power system.		X			X

Market domain	Market sub-domain	Service	Description	Projects				
				IDE4L	SmartNet	EU-Sysflex	FutureFlow	Used in INTERRFACE
Adequacy	Capacity Remuneration Mechanisms	**Strategic reserve**	Strategic reserves are essentially generating units that are kept exclusively available for emergencies (e.g. when the market is not able to cover demand) and are called upon by an independent body (e.g. the TSO). The strategic reserve is intended to operate only when the market does not provide sufficient capacity to meet the demand.		X			X

References

[1] Vujasinović Z. et al., "*Cross-border balancing and redispatching mechanism tailored to congested border situations and design of a Common Activation Function*", H2020 Project FutureFlow Deliverable 1.2, December 2016

[2] Nolan S. et al., "*Product Definition for Innovative System Services*", H2020 Project EU-SysFlex Deliverable 3.1, June 2019

[3] Merino J. et al., "*Ancillary Services Provision by RES and DSM Connected at Distribution Level in the Future Power System*", H2020 Project SmartNet Deliverable 1.1, December 2016

[4] "*Existing Tools and Services Report*", H2020 Project INTERRFACE Deliverable 2.2

[5] "*Congestion Management in Distribution Networks*", H2020 project IDE4L Deliverable 5.2/3, September 2015

4 Detail description of market services

This chapter contains a detailed description of the main grid services. The list aims at being exhaustive and includes many services which are not then treated in detail by the INTERRFACE project (i.e. not included into the IEGSA specifications).

4.1 Balancing markets services

Balancing services are in the responsibility of TSO. As stated in the "COMMISSION REGULATION (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing" in the Article 2 Definitions: 'balancing' means all actions and processes, on all timelines, through which TSOs ensure, in a continuous way, the maintenance of system frequency within a predefined stability range.

These services are described in this chapter. Thus the balancing services, by definition, are not the services that DSO is going to use.

However the products used for balancing services might be partly be used for DSO services as well. The timeframes and requirements, where DSO would like to use flexibility, might match with the manual Frequency Restoration Reserve product (see 4.1.3). The suitability of mFRR-product for congestion management purposes will be considered in the chapter 4.2.

There are more implications on the market design and TSO/DSO coordination if DSOs are also trading with the balancing market services and in the same market places. These will be discussed more in detail INTERRFACE-deliverable D3.2 Market Design.

Flexibility resources connected to the distribution grid are able to participate the balancing markets organised by TSO. This increases the need for TSO/DSO coordination so that the activation done by the TSO from the system needs doesn't affect negatively the DSO.

4.1.1 Frequency Containment Reserves (FCR)

Short description	Frequency containment is an automatic function which aims at stabilising the frequency at a steady-state value within the permissible maximum steady-state frequency deviation after disturbances in the high-voltage grid. By the joint action of all automatic devices, the process ensures the operational reliability in the synchronous area.
Description	Frequency containment reserves or 'FCR' means the active power reserves available to contain system frequency after the occurrence of an imbalance [1] TSOs and DSOs are obligated to cooperate in order to facilitate and enable the delivery of aFRR by units located in the distribution systems [1]. In addition, the NC obligates TSOs to develop a European platform for the exchange of balancing energy from FCR [2]. As result, the regional project, which currently involves ten TSOs from seven countries was initiated to develop common market for procurement and exchange of FCR (FCR Cooperation) [3].
Existing or New Service?	Existing.

Timeframe	10-30 seconds (full activation)
Assets used	As of 2017, in most countries, only generators provided FCR. In France and Ireland, however, load, pump storage, and batteries also qualify for this service. In recital (8) of the EBGL it is declared that a leveling playing field should be in place for all market participants, including demand-response aggregators and assets located at the distribution level.
Users of the service	TSO
Market-based or regulated tariff?	Mostly market based. In certain countries (France, Germany, Austria, Sweden, Finland, etc.), there is no contract or obligation for a grid user to offer the reserve (before the offer). The grid user can voluntarily participate in the market (e.g. tender, auction, market platform (like PX)) and bid a price or customize his offer (e.g. the volume, timeframe). The market result may lead to a bilateral contract. In others, such as Spain or Italy for instance, generators connected to the grid are obligated to reserve a certain amount of capacity in order to meet TSO requirements, for a fixed price set by TSO, NRA or for free. EU target model is market-based procurement.
Unit of measurement	MWh
Optional: Pricing method	In most cases, the activation of FCR is not remunerated, only its reservation is paid. In case the activation of FCR is not remunerated, FCR is symmetric (offering fast upwards and downward energy), because (short and fast) activations in both directions would lead to payments being cancelled out.
Optional: how is the procured volume defined?	All TSOs of each synchronous area determine, at least annually, the reserve capacity for FCR required for the synchronous area, which covers at least the reference incident. This mean, 3000 MW in positive and 3000 MW in negative direction for CE synchronous area. For the GB, IE/NI, and Nordic synchronous areas, - the largest imbalance that may result from an instantaneous change of active power (e.g. single power generating module, single demand facility, or single HVDC interconnector etc.) The shares capacity is based on the sum of the net generation and consumption of its control area divided by the sum of net generation and consumption of the synchronous area over a period of 1 year [1].
Process overview: (if applicable)	1. **Prequalification**. Each TSO has developed an FCR prequalification process. In general, a potential FCR provider submits a formal application to TSO and must demonstrate that it complies with requirements [1]. For units connected to DSO, the agreement between TSO and DSO should be made to set information exchange and for the delivery of reserves [1]. 2. **Bidding/Selection**: Self-dispatch is implemented in most of countries, although some of those countries require portfolio-based self-dispatch (Germany, Austria, Sweden, etc.) while others allow unit-based dispatch. 3. **Delivery**: For the CE and Nordic synchronous areas, as of triggering the alert state and during the alert state, each FCR provider ensures to activate FCR continuously for a defined time period [1]. FCR is provided as long as the frequency deviation persists. For GB and IE/NI synchronous areas FCR provider ensures the service for the period specified in the synchronous area operational agreement or until it activates its FRR [1]. **4.** **Settlement**. On the EU target approach, TSO-BSP settlement should be based on Marginal Pricing. The compensation between TSOs (TSO-TSO settlement) for imported/exported volumes is at first calculated by using the Cross Border Marginal Price. [4]

	5. **Monitoring**: Monitoring varies across the continent between ex-post checks and a combination of ex-post and real-time monitoring.	
Settlement schemes	☐ TSO-TSO Settlement ☐ TSO-DSO Settlement ☒ TSO-BRP Settlement ☒ TSO-Service Provider Settlement ☐ DSO-DSO Settlement	☐ DSO- BRP Settlement ☐ DSO-Service Provider Settlement ☒ BRP- Service Provider Settlement ☐ No Settlement ☐ Other (describe)
Coordination schemes	☐ TSO-TSO coordination ☒ TSO-DSO coordination ☐ DSO-DSO coordination	☐ No coordination ☐ Other (describe)
Does the service require any changes to current market structures?	No	
TRL level (1-9)	9	
In which demos service is intended to be used?	☐ T5.1 ☒ T5.2 ☒ T5.3 ☐ T5.4	☐ T6.1 ☐ T6.2 ☐ T6.3	☒ T7.1 ☐ T7.2 ☐ T7.3
Suitability to each Scenario		
Needed functional services of IEGSA platform (optional)		
Notes		
Reference	[1] COMMISSION REGULATION (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation. Link. [2] COMMISSION REGULATION (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing. Link. [3] The common market for procurement and exchange of FCR (FCR Cooperation). Link. [4] TSOs' proposal for the establishment of common and harmonised rules and processes for the exchange and procurement of Balancing Capacity for Frequency Containment Reserves (FCR) in accordance with Article 33 of Commission Regulation (EU) 2017/2195 establishing a guideline on electricity balancing. Link.	

4.1.2 automatic Frequency Restoration Reserve (aFRR)

Short description	This service is a centralised automatic function intended to replace FCR and restore the frequency to the target frequency – usually 50.00Hz. In contrast to mFRR (see below), aFRR 'can be activated by an automatic control device'. This control device shall be an automatic control device designed to reduce the Frequency Restoration Control Error (FRCE) to zero.
Description	Frequency restoration reserves or 'FRR' means the active power reserves available

	to restore system frequency to the nominal frequency and, for a synchronous area consisting of more than one LFC area, to restore power balance to the scheduled value [1]. TSOs and DSOs are obligated to cooperate in order to facilitate and enable the delivery aFRR by units located in the distribution systems [1]. aFRR 'can be activated by an automatic control device'. This control device shall be an 'automatic control device designed to reduce the Frequency Restoration Control Error (FRCE) to zero' [1]. The NC obligates TSOs to develop an European platform for the exchange of balancing energy from frequency restoration reserves with automatic activation [4]. As result, the TSOs of Austria, Belgium, France, Germany and the Netherlands have initiated a PICASSO [5] project on the design, implementation and operation of an aFRR Platform, which proposes a Standard aFRR product.
Existing or New Service?	Existing across Europe except in Baltics, IR, GB.
Timeframe	Following NCs, the activation delay must not exceed30 seconds [1]; The full activation time can be divided into a preparation period (during which no energy is delivered) and a ramping period. The requirements for the preparation period vary across Europe as it depends on the mode of activation in use and the local generation structure [2]. Nevertheless, for aFRR the preparation time remains very short as aFRR delivery is an automatic process. TSOs consider that specifying an harmonised full activation time will provide enough quality guarantee to the aFRR product, while the detailed requirements for the preparation period can remain at the national level [2]. Regarding the deactivation period, TSOs consider that the duration of the full activation time is also relevant for deactivation [2].
Assets used	Generators, Storage, Demand Response.
Users of the service	TSO
Market-based or regulated tariff?	Market based.
Unit of measurement	MWh for activated aFRR bids.
Optional: Pricing method	Settlement rule differs between countries. Regulated price in France and Denmark; Pay as bid in Germany, Italy, and most of central Europe; Marginal pricing in Nordic countries, Iberian peninsula, Netherlands, and Romania.
Optional: how is the procured volume defined?	Current framework of tendering is heterogeneous across countries regarding the tendering period as well as the applied tender. Some apply weekly, monthly or even yearly tenders in order to procure the necessary capacity. Procurement methods range from organized auctions to obligations for delivery. Furthermore, the energy and capacity procurement in several countries is combined in one auction (explicit), whereas in other countries the possibility of energy-only bids exists (implicit).
Process overview: (if applicable)	1. **Prequalification**. Each TSO has developed an aFRR prequalification process. In general, a potential aFRR provider submits a formal application to the TSO and must demonstrate that it complies with the aFRR minimum technical availability, ramping rate and the connection requirements [1]. For units connected to DSO, the agreement between TSO and DSO should be made to set information exchange and for the delivery of reserves [1]. 2. **Bidding.** Each aFRR provider submits the standard aFRR balancing energy product bids to the connecting TSO, which submits these bids to the aFRR-Platform to be included in the common merit order lists. In case of central dispatching model, aFRR provider submits integrated scheduling process bids

	to the connecting TSO. TSOs applying a central dispatching model converts integrated scheduling bids received from the BSPs into available standard aFRR balancing energy product bids and then submit these bids to the aFRR-Platform to be included in the common merit order lists [3]. 3. **Activation.** The mode of activation for aFRR is automatic due to the nature of the aFRR process. This means that the LFC-controllers automatically send setpoints for activated bids. During the validity period of their offered bids, the setpoint signals sent to BSP can constantly change their values, depending on the aFRR demand. In Europe two different approaches (Ramping or FAT approach) and their variants are used for the calculation of the setpoint signal which is sent to the BSPs [3]. 4. **Selection**. The bid selection is followed by the common merit order lists and managed via optimisation algorithm, which ensure the optimal usage of cross-zonal capacity to maximise the social welfare of the participating LFC areas by activating the economically efficient bids and ensuring minimisation of costs. The algorithm also aims to minimise the amount of frequency restoration power exchange on each border between LFC areas [5] 5. **Delivery**: - 6. **Settlement** (and/or Measurement): - Settlement varies across countries – in Sweden, Romania, Greece, and the Iberian peninsula, marginal pricing is in use. In contrast, France, Poland and Serbia rely on regulated pricing. In most other central European and Nordic countries, pay-as-bid is the norm. Monitoring is either done in real-time (Germany, Spain, Hungary), through ex-post checks (Netherlands, Belgium) or a combination of both (France, Poland, Sweden, Finland)	
Settlement schemes	☐ TSO-TSO Settlement ☐ TSO-DSO Settlement ☒ TSO-BRP Settlement ☒ TSO-Service Provider Settlement ☐ DSO-DSO Settlement	☐ DSO- BRP Settlement ☐ DSO-Service Provider Settlement ☒ BRP- Service Provider Settlement ☐ No Settlement ☐ Other (describe)
Coordination schemes	☐ TSO-TSO coordination ☒TSO-DSO coordination ☐ DSO-DSO coordination	☐ No coordination ☐ Other (describe)
Does the service require any changes to current market structures?	No	
TRL level (1-9)	9	
In which demos service is intended to be used?	☐ T5.1 ☒ T5.2 ☒ T5.3 ☐ T5.4	☐ T6.1 ☐ T6.2 ☐ T6.3	☒ T7.1 ☐ T7.2 ☐ T7.3
Suitability to each Scenario		
Needed functional services of IEGSA platform (optional)		
Notes		
Reference	[1] COMMISSION REGULATION (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation. Link.	

	[2] Explanatory Document to all TSOs' proposal on a list of standard products for balancing capacity for frequency restoration reserves and replacement reserves in accordance with Article 25(2) of Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing. Link. [3] All TSOs' proposal for the implementation framework for the exchange of balancing energy from frequency restoration reserves with automatic activation in accordance with Article 21 of Commission Regulation (EU) 2017/2195 establishing a guideline on electricity balancing. Link. [4] COMMISSION REGULATION (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing. Link. [5] The Platform for the International Coordination of Automated Frequency Restoration and Stable System Operation (PICASSO). Link.

4.1.3 manual Frequency Restoration Reserve (mFRR)

Short description	Manual Frequency Restoration is a manual change in the operation set-points of the reserve (mainly by re-scheduling), in order to restore system frequency to the set point value frequency and, for a synchronous area consisting of more than one load-frequency control area, to restore power balance to the scheduled value.
Description	Frequency restoration reserves or 'FRR' means the active power reserves available to restore system frequency to the nominal frequency and, for a synchronous area consisting of more than one LFC area, to restore power balance to the scheduled value [1] TSOs and DSOs are obligated to cooperate in order to facilitate and enable the delivery mFRR by units located in the distribution systems [1]. In addition, the NC obligates implement an European platform for the exchange of balancing energy from mFRR. As result, 19 European TSOs decided to work on the design of an mFRR platform, called MARI [4], and standard mFRR product.
Existing or New Service?	Existing
Timeframe	For standard mFRR product, the TSOs foresee using a linear ramp of 10 minutes for the cross-border exchange. Full activation time is set at maximum 12.5 minutes. [3]
Assets used	Several countries enable load participation in mFRR (France, UK, Germany, Nordics for instance) while fewer countries additionally provide for pump storage and batteries participation (Switzerland for instance includes all of the above in addition to generation). Some countries such as Romania and Greece however only allow generation to provide mFRR.
Users of the service	TSO
Market-based or regulated tariff?	Market based.
Unit of measurement	MWh for activated mFRR bids.
Optional: Pricing method	Pay as bid in many continental European countries, and marginal pricing in others.

Optional: how is the procured volume defined?		
Process overview: (if applicable)	1. **Prequalification**. Each TSO has developed a mFRR prequalification process. In general, a potential mFRR A potential mFRR provider submits a formal application to the TSO and must demonstrate that it complies with the mFRR minimum technical availability, ramping rate and the connection requirements [1]. For units connected to DSO, the agreement between TSO and DSO should be made to set information exchange and for the delivery of reserves [1]. 2. **Bidding**; Bids have two types: 'Scheduled only' means bids which can only be activated at the point of scheduled activation; and 'Direct' means bids that can be activated at the point of scheduled activation and anytime during the 15 minutes after the point of scheduled activation. [3] 3. **Activation** of mFRR in most of Europe follows a merit order, whereby available sources are ranked in ascending order of their short run marginal costs of production, so that those with the lowest marginal costs are the first ones to be brought online to meet demand. Quite often, offered products can be partially activated in all directions (France, Iberian Peninsula, Germany, etc.). Activations are also possible for other purposes than for balancing in a number of countries (France, UK, Nordics) 4. **Delivery**: - 5. **Settlement**: Settlement is pay-as-bid in most of continental Europe, whereas elsewhere (Iberian peninsula, Nordics) marginal pricing is used. 6. **Monitoring:** In general, monitoring is done by the system operator to ensure performance of plant. The approach varies across Europe. It can take the form of real-time monitoring (Germany, Romania, Sweden), ex-post check (France, Netherlands, Austria) or hybrid approach (Spain, Norway, Greece).	
Settlement schemes	☐ TSO-TSO Settlement ☐ TSO-DSO Settlement ☒ TSO-BRP Settlement ☒ TSO-Service Provider Settlement ☐ DSO-DSO Settlement	☐ DSO- BRP Settlement ☐ DSO-Service Provider Settlement ☒ BRP- Service Provider Settlement ☐ No Settlement ☐ Other (describe)
Coordination schemes	☐ TSO-TSO coordination ☒TSO-DSO coordination ☐ DSO-DSO coordination	☐ No coordination ☐ Other (describe)
Does the service require any changes to current market structures?	No	
TRL level (1-9)	9	
In which demos service is intended to be used?	☐ T5.1 ☒ T5.2 ☒ T5.3 ☐ T5.4	☐ T6.1 ☐ T6.2 ☐ T6.3	☒ T7.1 ☐ T7.2 ☐ T7.3
Suitability to each Scenario		
Needed functional services of IEGSA platform (optional)		
Notes		

Reference	[1] COMMISSION REGULATION (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation. Link. [2] COMMISSION REGULATION (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing. Link. [3] Explanatory Document to all TSOs' proposal on a list of standard products for balancing capacity for frequency restoration reserves and replacement reserves in accordance with Article 25(2) of Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing. Link. [4] Manually Activated Reserves Initiative (MARI) is the European implementation project for the creation of the European mFRR platform. Link.

4.1.4 Replacement reserves (RR)

Short description	The reserve replacement process replaces the activated FRR and/or complements the FRR activation by activation of RR. The replacement reserve process is activated in the disturbed LFC area. Activation is semi-automatic or manual.
Description	Replacement reserves or 'RR' means the active power reserves available to restore or support the required level of FRR to be prepared for additional system imbalances, including generation reserves [1]. TSOs and DSOs are obligated to cooperate in order to facilitate and enable the delivery of mFRR by units located in the distribution systems [1]. In addition, the NC obligates TSOs to develop a European platform for the exchange of balancing energy from RR [5]. As result, several pilot initiatives have been set up and TERRE project [3] has been appointed among the TSOs to lead the implementation for RR-Platform and Standard RR product.
Existing or New Service?	Existing.
Timeframe	The full activation time of the RR standard product is 30 minutes. The ramping period can be from 0 to 30 minutes. [2]
Assets used	As of end-2017, several countries allow the participation of load in RR.
Users of the service	TSO
Market-based or regulated tariff?	Market based (for most cases). Target model of EB GL is entirely market-based.
Unit of measurement	MWh
Optional: Pricing method	As of end-2017, several countries had put in place marginal pricing (France, Spain, Romania), while others such as the UK, Switzerland, or Hungary have a pay-as-bid settlement system. Finally, a couple countries still have/had regulated prices. Target model is marginal pricing.
Optional: how is the procured volume defined?	For the Nordic and CE synchronous areas a RR capacity should be sufficient to restore the positive and negative FRR. For the GB and IE/NI synchronous areas a RR capacity should be sufficient to restore the positive and negative FCR and FRR. The total volume in each country is reduced following the RR sharing agreement with other load-frequency control blocks (LFC) [1]

Process overview: (if applicable)	1. **Prequalification**. Each TSO of a LFC block which has implemented a reserve replacement process has developed a RR prequalification process. In general, a potential RR provider submits a formal application to TSO and must demonstrate that it complies with the RR technical, availability and connection requirements [1] 2. **Bidding**. The TSOs receive offers from the BSPs. The offers, which are coherent with the RR standard products, are anonymized and forwarded to the RR-Platform. TSOs applying a central dispatching model, convert integrated scheduling process bids received from the BSPs into RR standard products and then submit the RR standard product to the RR-Platform [4]. 3. **Selection**. The RR-Platform executes an algorithm that performs the clearing of the consumer curve against the supply curve. The RR-Platform communicates back to the TSOs the accepted offers, the satisfied needs and the prices. Based upon this allocation of RR, the RR-Platform calculates the cross-zonal flow in the Region. The resulting cross-zonal schedules and updated cross-zonal capacity parameters are sent to the TSOs and schedules in Net Position to the verification platforms operated by ENTSO-E [4]. 4. **Activation/delivery**. Activation is performed by TSOs via manual and scheduled approaches. 5. **Settlement**. There are two settlement processes: TSO-TSO and TSOs-BSPs settlement [4]. 6. **Monitoring**: as of 2017, countries' monitoring approach varied between ex-post checks and a combination of ex-post and real-time monitoring.		
Settlement schemes	☐ TSO-TSO Settlement ☐ TSO-DSO Settlement ☒ TSO-BRP Settlement ☒ TSO-Service Provider Settlement ☐ DSO-DSO Settlement	☐ DSO- BRP Settlement ☐ DSO-Service Provider Settlement ☒ BRP- Service Provider Settlement ☐ No Settlement ☐ Other (describe)	
Coordination schemes	☒ TSO-TSO coordination ☐TSO-DSO coordination ☐ DSO-DSO coordination	☐ No coordination ☐ Other (describe)	
Does the service require any changes to current market structures?	No		
TRL level (1-9)			
In which demos service is intended to be used?	☐ T5.1 ☐ T5.2 ☐ T5.3 ☐ T5.4	☐ T6.1 ☐ T6.2 ☐ T6.3	☐ T7.1 ☐ T7.2 ☐ T7.3
Suitability to each Scenario			
Needed functional services of IEGSA platform (optional)			
Notes			
Reference	[1] COMMISSION REGULATION (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation. Link.		

	[2] Explanatory Document to all TSOs' proposal on a list of standard products for balancing capacity for frequency restoration reserves and replacement reserves in accordance with Article 25(2) of Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing. Link. [3] Trans European Replacement Reserves Exchange (TERRE). Link. [4] The proposal of all Transmission System Operators performing the reserve replacement for the implementation framework for the exchange of balancing energy from Replacement Reserves in accordance with Article 19 of Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing. Link. [5] COMMISSION REGULATION (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing. Link.

4.1.5 Fast frequency reserves (FFR)

Short description	Fast Frequency Response (FFR) is defined as any type of rapid active power increase or decrease by generation or load, in a timeframe of less than 2 seconds, to correct supply-demand imbalances and assist with managing frequency. [5]
Description	The reduction of power system inertia due to the increase of static-power-conversion generation is creating the necessity of new fast services such as fast-frequency-control and inertial response. These services can be operated by generation/load units based on power electronic interfaces, capable of modulating their power output with fast dynamics. The service refers to the fast change of active power in the timeframe following inertial response to reduce further deviations of frequency and to further to help delaying the time to reach frequency nadir [5].
Existing or New Service?	Emerging new service under first implementations or pilots. The need is growing to manage the reduction of inertia in the system, which is caused by the growth of RES and reduction of rotating machines.
Timeframe	Time for full activation (FAT) from 49,6 Hz: 2 seconds. Duration: 30 seconds (i.e. FFR shall be able to be activated for a minimum time of 30 seconds). Resting time 15 min (i.e. FFR should be able to be activated after maximum 15 minutes after previous activation)
Assets used	High variety of assets from synchronous condensers, batteries, demand response, to traditional power plants is proven to be able to provide the Service
Users of the service	TSO
Market-based or regulated tariff?	Market based
Unit of measurement	MWh
Optional: Pricing method	Norway: Capability, as well as potential activation, is remunerated with the prices offered, i.e. "pay as bid", whereas the reserves are to be paid the price of the last bid accepted, i.e. marginal pricing.
Optional: how is the procured volume defined?	The tendering volumes are set according the estimate of central entity, like TSOs
Process overview: (if	1. **Prequalification** - is done in fundamentally different ways, which depends on the specifics of provider (demand response, power plan, hydro power plant

applicable)	etc.), but in all cases to test the triggering and provision of faster response 2. **Bidding/Selection** - 3. **Activation** – automatic frequency triggering point of 49,6 Hz 4. **Delivery** - 5. **Settlement (and/or Measurement)** -	
Settlement schemes	☐ TSO-TSO Settlement ☐ TSO-DSO Settlement ☒ TSO-BRP Settlement ☒ TSO-Service Provider Settlement ☐ DSO-DSO Settlement	☐ DSO- BRP Settlement ☐ DSO-Service Provider Settlement ☐ BRP- Service Provider Settlement ☐ No Settlement ☐ Other (describe)
Coordination schemes	☐ TSO-TSO coordination ☒TSO-DSO coordination ☐ DSO-DSO coordination	☐ No coordination ☐ Other (describe)
Does the service require any changes to current market structures?	No	
TRL level (1-9)		
In which demos service is intended to be used?	☐ T5.1 ☒ T5.2 ☐ T5.3 ☐ T5.4	☐ T6.1 ☐ T6.2 ☐ T6.3 ☐ T7.1 ☐ T7.2 ☐ T7.3
Suitability to each Scenario		
Needed functional services of IEGSA platform (optional)		
Notes	Service is not standardized and might have different requirements in other countries in terms of activation speed, duration, tendering, contracting, payment.	
Reference	[1] Statnett. Fast Frequency Reserves 2018 - pilot for raske frekvensreserver. Link. [2] National Grid. A guide to the services procured by National Grid to control sudden frequency changes on the system. Link. [3] Transgrid. The role of Fast Frequency Response (FFR) in keeping the lights on. Link. [4] Fast Frequency Response with BESS: A Comparative Analysis of Germany, Great Britain and Sweden. Link. [5] EU-Sysflex. Product Definition for Innovative System Services D3.1. Link.	

4.1.6 Ramp control

Short description	Ramp control or ramping margin is a new service that is intended to ensure system stability by responding to variations in demand, variable weather forecast errors and plant outages. Its timeframe is longer than a traditional FRR reserves - up to 8-hour ramping period with 8 hours of maintaining level of production.
Description	Ramp control can be viewed also as ramping restrictions (see notes) [1-3], but more service related is ramping margin – it is new service created by EIRGRID and SONI

	within DS3 program "Delivering a Secure, Sustainable Electricity System". Ramping margin service introduced new product to respond to demand and variable weather forecast errors and plant outages. Its timeframe is longer than traditional FRR reserves [4; 5]. Product example of ramping capability – if production unit is at output level of 40 MW and can reach full availability in 4 hours (in 3 hours 85MW), then for RM3 product that means it qualifies for a ramping margin of 45 MW (85-40), for RM1 15 MW and RM8 60 MW [6]. Similar to the reserve products, there are potential variable costs and foregone profits for providers that [6]: • need to be turned on to be in position to provide ramping; or • allow for some headroom when scheduled. Product now is still in creation phase; qualification trial process is ongoing now. Ramping tool for control center planned by October 2019. It enables Grid Controllers to accurately schedule and dispatch the Ramping Margin services, and manage changing demand and generation profiles, with increased wind integration [7].
Existing or New Service?	New service. EIRGRID and SONI are creating a ramping margin service, in some systems ramping up or down services are supplied by operational reserves or replacement reserves [8].
Timeframe	EIRGRID designed timeframes for RM1: 1h ramping with additional 2 h sustained ramped production level. Accordingly, for RM3, 3h ramping period and 5 h production sustainment and finally RM8: 8h ramping period and 8 h production sustainment [5; 6].
Assets used	Dispatchable assets that are successfully validated in the designated system service test [8; 9].
Users of the service	TSO
Market-based or regulated tariff?	Interim tariff proposal based on "availability" payment rules (different price for each ramping margin product). Market-wide tariff [5; 6].
Unit of measurement	MWh
Optional: Pricing method	Availability payment [5; 6]
Optional: how is the procured volume defined?	Available capacity with capability to fulfil product described.
Process overview: (if applicable)	1. **Prequalification** – Production unit has to pass designated system service test proving its capabilities [9]. 2. **Bidding/Selection** – Not clear (Control center selection) [7]. 3. **Activation** – Dispatched [7]. 4. **Delivery** – Production ramping and sustained production according to production timeframe[9]. 5. **Settlement** (and/or Measurement) – market wide "availability" tariff plus costs plus regulated rate of return (RoR) of incremental investment for meeting the volume (performance) requirement for product [5; 6].
Settlement schemes	☐ TSO-TSO Settlement ☐ TSO-DSO Settlement ☐ TSO-BRP Settlement ☒ TSO-Service Provider Settlement ☐ DSO- BRP Settlement ☐ DSO-Service Provider Settlement ☐ BRP- Service Provider Settlement ☐ No Settlement

	☐ DSO-DSO Settlement	☐ Other (describe)	
Coordination schemes	☐ TSO-TSO coordination ☐TSO-DSO coordination ☐ DSO-DSO coordination	☒ No coordination ☐ Other (describe)	
Does the service require any changes to current market structures?	May be treated as reserve capacity.		
TRL level (1-9)	7-8		
In which demos service is intended to be used?	☐ T5.1 ☐ T5.2 ☐ T5.3 ☐ T5.4	☐ T6.1 ☒ T6.2 ☐ T6.3	☐ T7.1 ☐ T7.2 ☐ T7.3
Suitability to each Scenario			
Needed functional services of IEGSA platform (optional)			
Notes	Ramping refers to a change in power flow (or power generation) from one market period to the next. According to System operation guidelines (SOGL) two synchronous areas may determine combined maximum ramping rate for all HVDC interconnectors connecting one synchronous area to another synchronous area [1]. For Nordics for the day-ahead and intraday markets, all trading across HVDC (high-voltage direct current) cables is subject to a ramping restriction of 600 MW. The restrictions imply that trade plans on all HVDC connections cannot be changed by more than 600 MW from one hour to the next. This restriction can be put on each of the cables individually or on a set of cables [2]. Ramping restrictions is imposed because large changes in production and flow in the grid could create situations when frequency control is very difficult. To reduce this risk ramping restrictions are therefore imposed on HVDC connections by the transmission system operators mitigating risks on security of supply. Without restricting the maximum change of flow per hour (ramping) on interconnectors, very large ancillary services and operational reserves would be needed to handle imbalances within operative hours [3].		
Reference	[1] Commission Regulation (EU) 2017/1485 a guideline on electricity transmission system operation (link). [2] Explanatory document for the Nordic synchronous area proposal for ramping restrictions for active power output (link) [3] NordPool web page (link) [4] EIRGRID, SONI "Ensuring a Secure, Reliable and Efficient Power System in a Changing Environment" (link) [5] DS3 System Services Volumes Methodology Decision Paper (link) [6] Poyry Report Regulated Tariff Methodology for DS3 System Services (link) [7] Strategic Incentives - EirGrid (link) [8] DS3 System Services: Portfolio Capability Analysis (link) [9] DS3 System Services Protocol Regulated Arrangements and Fixed Contracts		

	(link)

4.1.7 Smoothed production

Short description	This service has similarities to mFRR service but it is aimed to adjust start-up time of generation to follow demand schedule more closely. Several hours in advance of real-time operation, an algorithm is used to detect large structural imbalances to make production schedule adjustments (shifting part of production up to 30 minutes) - difference in production between market periods is smoothed out.
Description	This service has similarities to mFRR service but it is aimed to adjust start-up time of generation to follow demand schedule more closely [1; 2]. Generation schedule smoothing is employed several hours in advance of real-time operation, using an algorithm to detect large structural imbalances and suggest schedule adjustments shifting part of production up to 30 minutes [1; 2]. Service is aimed to smoothen transition from one market period to another when differences (structural imbalance) for consumption/generation/exchange are significant and are created from imperfect planning. These structural imbalances negatively affect automatic reserves as it may reduce security margins. In the future there may be less need for smoothed production if market periods become shorter and therefore the difference between market period will be smaller. Smoothed production spreads out change of production. Acceptance of smoothing service should not affect production unit commitment for other ancillary services, but this commitment may be shifted to other production units in the same bidding area. There should be separate production plans and plans for production smoothing. Production smoothing is included as an adjustment in the balance settlement [1; 2; 6]. Similarly, quarterly adjustment is a requirement applied in Finland, Sweden and Norway on the BRP when the hourly production plan changes more than 200 MW at hour shift to reschedule their plan with quarterly steps 15 minutes before hour shift, at hour shift and 15 minutes after hour shift to adjust the plans to better correspond to the consumption pattern [5].
Existing or New Service?	Currently implemented in Norway [1]. Finland and Sweden have similar quarterly adjustments [5].
Timeframe	TSO orders production smoothing at D-1 until 21.30. Supplier send updates up to 45 min. until operational hour. Smoothing duration is up to 30 minutes [1].
Assets used	Flexible power generation with regular (normally weekly) production can change more than 200 MW in only one hour. Assets need an operation center and need to be able handle orders from TSO [1].
Users of the service	Primary target are TSOs, although in future other users such as DSOs could use similar services as well, due to the high shares of variable generation and DER connected the distribution grids.
Market-based or regulated tariff?	Regulated tariff. Voluntary participation. [1]
Unit of measurement	MWh
Optional: Pricing method	1st year compensation for implementing availability of production smoothing. The generator receives a fixed annual additional administration compensation and a variable tariff. Additionally, the generators are compensated for energy deviations by the bets of the day-ahead prices and the Replacement reserve price [1; 4].

Optional: how is the procured volume defined?	TSO orders production smoothing based on analysed needs. Structural imbalances can be estimated in the planning phase when TSO receives day-ahead schedules from generators, HVDC connections and interconnectors [1].		
Process overview: (if applicable)	1. **Prequalification** - Production smoothing is a voluntary solution offered to suppliers that meet the following criteria [1]: • The supplier has regular, usually at least weekly, production changes over an hour shift ≥ 200 MW per power spot area. • The supplier has staffed an operating center and is able to handle orders from Statnett. • Requires flexible power generation. 2. **Bidding/Selection** – selection process is integrated into operational planning. After the suppliersubmits its production schedules, the TSO analyses and determines the needs of production smoothing for all hours of the next day and sends the orders to relevant providers. TSO has the right to cancel / change orders up to 2 hours before the operating hours. When the total system imbalance exceeds chosen threshold values, some of the submitted hourly generation schedules are shifted to quarterly steps. An important premise is that the generators' planned schedule changes are shifted in time but not in size to minimize negative impact on the generators' efficiency [1; 6]. 3. **Activation** – Actors who confirm such participation deliver production smoothing based on orders from TSO according to fixed requirements [1] 4. **Delivery** - If a supplier fails to fulfil its obligations under these terms and conditions due to circumstances within the supplier's control, this is regarded as a breach of the terms. TSO may exclude the supplier from participation in production smoothing [1]. 5. **Settlement (and/or Measurement)** - Participants are compensated for the energy imbalance caused by the generation smoothing. In addition, they are paid annual compensation for administration plus a fixed mark-up per unit smoothed energy volume [1].		
Settlement schemes	☐ TSO-TSO Settlement ☐ TSO-DSO Settlement ☒ TSO-BRP Settlement ☒ TSO-Service Provider Settlement ☐ DSO-DSO Settlement	☐ DSO- BRP Settlement ☐ DSO-Service Provider Settlement ☐ BRP- Service Provider Settlement ☐ No Settlement ☐ Other (describe)	
Coordination schemes	☐ TSO-TSO coordination ☐TSO-DSO coordination ☐ DSO-DSO coordination	☒ No coordination ☐ Other (describe)	
Does the service require any changes to current market structures?	No, it is separate process that may be created regardless of current market structures. Participation can't affect other ancillary service commitments.		
TRL level (1-9)	8-9		
In which demos service is intended to be used?	☐ T5.1 ☐ T5.2 ☐ T5.3 ☐ T5.4	☐ T6.1 ☐ T6.2 ☐ T6.3	☐ T7.1 ☐ T7.2 ☐ T7.3
Suitability to each Scenario			
Needed functional services of IEGSA			

platform (optional)	
Notes	Only applicable in Norway
Reference	[1] Statnett SF - Production Smoothing (Terms of participation, handling and compensation) (link) . [2] Martin André Håberg "Standardprodukter for balansekraft", Norwegian University of Science and Technology, 2015 (link) [3] Capacity adequacy - THEMA 2015 (link) [4] Statnett web-page: System services (link) [5] ENTSO-E: Nordic Balancing Philosophy (link) [6] B. H. Bakken, I. H. Eivik and H. Mæland "New Ancillary Service to Mitigate Deterministic Frequency Deviations", CIGRE 2016, Norway (link)

4.1.8 BRP portfolio balancing

Short description	BRP has the obligation to balance his own position. This volume of energy could be produced by generation units in the BPR's portfolio but could also be imported or bought on the market. By balancing his own position, the BRP contributes to the balance of the electricity system.
Description	The Balancing Responsible Party (BRP) has the obligation to balance his own position. To that end the BRP will forecast the consumption of the consumers in his portfolio and source the required amount of energy to match that consumption. This volume of energy could be produced by generation units in the BPR's portfolio but could also be imported or bought on the market. By balancing his own position, the BRP contributes to the balance of the electricity system. Thus, BRPs have a fundamental and central role in the electricity market.
Existing or New Service?	Existing At present, BRPs utilize several different markets and bilateral trades to balance their portfolios.
Timeframe	The balancing of load or production forecasting errors happens intra-day, typically balancing energy is purchased 0-2 hours ahead of the operation interval. Possibility to purchase balancing services also during the operation interval should be considered.
Assets used	Generators, Storage, Demand Response.
Users of the service	BRP
Market-based or regulated tariff?	Market based
Unit of measurement	MWh
Optional: Pricing method	
Optional: how is the procured volume defined?	

Process overview: (if applicable)	1. **Prequalification** – according to the rules of each market 2. **Bidding/Selection** – to be defined 3. **Activation** 4. **Delivery** 5. **Settlement (and/or Measurement)**	
Settlement schemes	☐ TSO-TSO Settlement ☐ TSO-DSO Settlement ☐ TSO-BRP Settlement ☐ TSO-Service Provider Settlement ☐ DSO-DSO Settlement	☐ DSO- BRP Settlement ☐ DSO-Service Provider Settlement ☒ BRP- Service Provider Settlement ☐ No Settlement ☐ Other (describe)
Coordination schemes	☐ TSO-TSO coordination ☐ TSO-DSO coordination ☐ DSO-DSO coordination	☒ No coordination ☐ Other (describe)
Does the service require any changes to current market structures?	No	
TRL level (1-9)		
In which demos service is intended to be used?	☐ T5.1 ☐ T5.2 ☐ T5.3 ☐ T5.4	☐ T6.1 ☒ T6.2 ☐ T6.3 ☐ T7.1 ☐ T7.2 ☐ T7.3
Suitability to each Scenario	Yes, easy trading with multiple market operators	
Needed Functional services of IEGSA platform (optional)	to be defined	
Notes		
Reference		

4.2 Congestion management

Congestion management (CM) is activating a remedial action to respect operational security limits [1]. In this context, we are focusing on a physical congestion which is defined in [2] as 'any network situation where forecasted or realised power flows violate the thermal limits of the elements of the grid and voltage stability or the angle stability limits of the power system'. In practice congestion management is operated with security margins so that no damage would occur. Extreme solution for congestion management is to limit the power flows in the network, e.g. curtail generation and/or production.

The long term-view of the system operators is that congestion should be solved through market-based allocation when technically feasible and cost-efficient rather than compulsory limitation procedures. It is also expected that the DSOs will have in the future the possibility to procure non-frequency ancillary services in a transparent and market-based way, when this most cost-efficient. [1]

Reference:

[1] COMMISSION REGULATION (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management . Link.

[2] TSO – DSO REPORT AN INTEGRATED APPROACH TO ACTIVE SYSTEM MANAGEMENTWITH THE FOCUS ON TSO – DSO COORDINATION IN CONGESTION MANAGEMENT AND BALANCING. Link.

4.2.1 Congestion management operational

Short description	Congestion management means handling of the situation when the network is physically congested so that operational limits of the elements of the grid and voltage stability or the angle stability limits of the power system are violated. Operational congestion management operates during the market time unit (hour/15minutes).
Description	In order to solve operational hour internal congestions, TSO/DSO could use flexibility with locational information for congestion management. Default service criteria could be the same as mFRR, but used internally by TSOs / DSOs for congestion management operations (not for balancing markets) and activation decision will be done in real-time (during H-1) and manually by a dispatcher. Product definition of the congestion management operational is not necessarily linked to mFRR product and could be something else also. Default mFRR product description is proposed to boost liquidity. Flexibility product of congestion management operational should be sufficiently aligned to permit the market-based allocation of flexibility between these different purposes with the objective of an efficient allocation that maximises the value of flexibility services. Identical products in different markets are not needed, but interoperability would enable exchange between markets. The product should be either an option (available capacity) or direct activation, but availability products have to be designed properly to avoid a decrease in market liquidity due to non-activation of contracted products. To ensure the right balance between availability and market liquidity, DSOs and TSOs will agree on how to coordinate on this. [2] (Page 22-23) Congestion in the distribution network is caused by voltages exceeding the allowed limits or overloading of the network components. Thus congestion management is mitigated by voltage control or by load/generation control. [3] Voltage control can executed also in form of power factor requirements (depending on the size and the type of customer), provision of reactive power, requirements for equipment for continuous voltage regulation and power system stabilizers. These are not market based, rather mandatory requirements in the connection agreements. [4] Flexibility products should be harmonised at least at member state level, An European harmonisation of the products is not required. Possible attributes of the congestion management product are described in [2, page 24]. There might occur real-time needs about emergency action that SO needs to perform in order to keep the system stable, this in not really a service but should be taken into consideration when discussing about congestion management operational.
Existing or New Service?	New. In WP 5.3, we're analysing direct activation and coordination mechanisms between TSO-DSO to ensure that flexibility bids won't cause congestion in TSO / DSO grid.
Timeframe	Activation in operational hour (or market time unit). Procuring options (to have sufficient capacity) could be done day-ahead. To use standard mFRR product - the TSOs foresee using a linear ramp of 10 minutes

	for the cross-border exchange. Full activation time is set at maximum 12.5 minutes [1]		
Assets used	Flexibility, which able to provide the product, likely to be distributed flexibility with locational information.		
Users of the service	TSO / DSO		
Market-based or regulated tariff?	Market based.		
Unit of measurement	MWh		
Optional: Pricing method	Pay as bid		
Optional: how is the procured volume defined?	Forward procurement of options (sufficient capacity) is done based on SO assessment regarding probability and size of congestion.		
Process overview: (if applicable)	1. **Prequalification**. Each TSO and DSO need to develop grid prequalification process [2] (Page 10) 2. **Bidding** Depending on the arrangements of the congestion management market place (combined/separate with TSO/DSO, combined or separate balancing/CM market) bidding procedures vary. A prerequisite for the congestion management markets is that the bid has a locational information that has the relevant accuracy for network location 3. **Activation** 4. **Delivery**: - 5. **Settlement**: 6. **Monitoring:**		
Settlement schemes	☐ TSO-TSO Settlement ☐ TSO-DSO Settlement ☒ TSO-BRP Settlement ☒ TSO-Service Provider Settlement ☐ DSO-DSO Settlement	☒ DSO- BRP Settlement ☒ DSO-Service Provider Settlement ☐ BRP- Service Provider Settlement ☐ No Settlement ☐ Other (describe)	
Coordination schemes	☐ TSO-TSO coordination ☒ TSO-DSO coordination ☐ DSO-DSO coordination	☐ No coordination ☐ Other (describe)	
Does the service require any changes to current market structures?	No / in the future European congestion management market? DSO congestion is local problem and thus the market has to have a local aspect. Target of the European regulation is to allow and provide incentives also for DSOs to procure flexibility services, like congestion management. [5] This is not yet the case in most of the European countries so national regulation is needed.		
TRL level (1-9)	9		
In which demos service is intended to be used?	☒ T5.1 ☐ T5.2 ☒ T5.3 ☐ T5.4	☐ T6.1 ☐ T6.2 ☐ T6.3	☐ T7.1 ☐ T7.2 ☐ T7.3
Suitability to each Scenario			
Needed functional services of IEGSA platform (optional)			

Notes	TSO-DSO coordination - information needs to be coordinated between TSO-DSO (on TSO-DSO coordination module). Possible solutions: 1) TSOs and DSOs will do calculations separately in TSO and DSO systems 2) Congestion (admittance) matrix will be sent by TSOs and DSOs to TSO-DSO coordination module where final calculations will be done 3) Common TSO-DSO use of flexibility (optimization): an algorithm how TSOs / DSOs could use flexibility optimally. Congestion management services are similar to redispatch and counter-trade services. Based on descriptions here, the difference appears to be inter-zonal scope of congestion management services, while redispatch and counter-trade are cross-zonal.
Reference	[1] Explanatory Document to all TSOs' proposal on a list of standard products for balancing capacity for frequency restoration reserves and replacement reserves in accordance with Article 25(2) of Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing. Link. [2] TSO – DSO REPORT AN INTEGRATED APPROACH TO ACTIVE SYSTEM MANAGEMENTWITH THE FOCUS ON TSO – DSO COORDINATION IN CONGESTION MANAGEMENT AND BALANCING. Link. [3] Congestion Management in Distribution Networks. IDE4L project, deliverable 5.2/3. Link [4] Ancillary service provision by RES and DSM connected at distribution level in the future power system. SmartNet project, deliverable 1.1. Link [5] DIRECTIVE (EU) 2019/944 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU. Link

4.2.2 Congestion management short-term planning

Short description	Congestion management short term planning considers the physical congestion that might occur in the timeframe of D-1 (meaning the day before) up to M-1 (month before). Default service criteria same could be the as mFRR, but used internally by TSOs / DSOs for congestion management in short-term planning timeframe (not for balancing markets). Activation decision will be done D-1 (grid calculations and congestion check one day in advance for every market time unit) by a short-term planner.
Description	In order to solve short-term planning timeframe internal congestions, TSO/DSO could use flexibility with locational information for congestion management. Default service criteria could be same as mFRR, but used internally by TSOs / DSOs for congestion management short-term (not for balancing markets). Activation decision will be done D-1 (grid calculations and congestion check one day in advance for every operational hour (market time unit)) by a short-term planner. Possible to start a market auction by TSO /DSO (day ahead, month ahead). Short term planning congestions may rise due to outages, maintenance or production patterns. The procurement of flexibility for congestion management could be seen D-1 until M-1. The earlier procurement of flexibility is relevant for example for maintenance schedule approval, which, depending on SO processes,

	could be done month ahead. Default mFRR product description is proposed to boost liquidity. Flexibility product of congestion management short-term should be sufficiently aligned to permit the market-based allocation of flexibility between these different purposes with the objective of an efficient allocation that maximises the value of flexibility services. Identical products in different markets are not needed, but interoperability would enable exchange between markets. The product should be either an option (available capacity) or direct activation, but availability products have to be designed properly to avoid a decrease in market liquidity due to non-activation of contracted products. To ensure the right balance between availability and market liquidity, DSOs and TSOs will agree on how to coordinate on this. [2] (Page 22-23) Another possibility for the product description is to use intra-day market products which operate within this same timeframe. This approach is used e.g. in ETPA where with adding certain order attributes like location the same bid could be used besides wholesale trading also to TSO and DSO congestion market. [3] In WP 5.3, we're analyzing direct activation and coordination mechanisms between TSO-DSO to ensure that flexibility bids won't cause congestion in TSO / DSO grid.
Existing or New Service?	New
Timeframe	Activation in D-1 (or earlier if relevant). Procuring options (to have sufficient capacity) could be done D-1 up to M-1. To use standard mFRR product - the TSOs foresee using a linear ramp of 10 minutes for the cross-border exchange. Full activation time is set at maximum 12.5 minutes. [1]
Assets used	Flexibility, which is able to provide the product: likely to be distributed flexibility with locational information.
Users of the service	TSO / DSO
Market-based or regulated tariff?	Market based.
Unit of measurement	MWh
Optional: Pricing method	Pay as bid in many continental European countries, and marginal pricing in others.
Optional: how is the procured volume defined?	Forward procurement of options (sufficient capacity) is done based on SO assessment regarding probability and size of congestion.
Process overview: (if applicable)	1. **Prequalification**. Each TSO and DSO need to develop grid prequalification process [2] (Page 10) 2. **Bidding.** Depending on the arrangements of the congestion management market place (combined/separate with TSO/DSO, combined or separate balancing/CM market) bidding procedures vary. A prerequisite for the congestion management markets is that the bid has a locational information that has the relevant accuracy for network location 3. **Activation** 4. **Delivery**: - 5. **Settlement**: 6. **Monitoring:**

Settlement schemes	☐ TSO-TSO Settlement ☐ TSO-DSO Settlement ☒ TSO-BRP Settlement ☒ TSO-Service Provider Settlement ☐ DSO-DSO Settlement	☒ DSO- BRP Settlement ☒ DSO-Service Provider Settlement ☐ BRP- Service Provider Settlement ☐ No Settlement ☐ Other (describe)	
Coordination schemes	☐ TSO-TSO coordination ☒ TSO-DSO coordination ☐ DSO-DSO coordination	☐ No coordination ☐ Other (describe)	
Does the service require any changes to current market structures?	No / in the future European congestion management market? DSO congestion is local problem and thus the market has to have a local aspect. Target of the European regulation is to allow and provide incentives also for DSOs to procure flexibility services, like congestion management [4]. This is not yet the case in most of the European countries so national regulation is needed.		
TRL level (1-9)	9		
In which demos service is intended to be used?	☐ T5.1 ☐ T5.2 ☒ T5.3 ☐ T5.4	☒ T6.1 ☐ T6.2 ☐ T6.3	☐ T7.1 ☒ T7.2 ☐ T7.3
Suitability to each Scenario			
Needed functional services of IEGSA platform (optional)			
Notes	**TSO-DSO coordination -** information needs to be coordinated between TSO-DSO (on TSO-DSO coordination module). Possible solutions: 1) TSOs and DSOs will do calculations separately in TSO and DSO systems 2) Congestion (admittance) matrix will be sent by TSOs and DSOs to TSO-DSO coordination module where final calculations will be done 3) Common TSO-DSO use of flexibility (optimization): an algorithm how TSOs / DSOs could use flexibility optimally Congestion management services are similar to redispatch and counter-trade services. Based on descriptions here, the difference appears to be inter-zonal scope of congestion management services, while redispatch and counter-trade are cross-zonal.		
Reference	[1] Explanatory Document to all TSOs' proposal on a list of standard products for balancing capacity for frequency restoration reserves and replacement reserves in accordance with Article 25(2) of Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing. Link. [2] TSO – DSO REPORT AN INTEGRATED APPROACH TO ACTIVE SYSTEM MANAGEMENTWITH THE FOCUS ON TSO – DSO COORDINATION IN CONGESTION MANAGEMENT AND BALANCING. Link. [3] Flexibility Platforms. USEF White paper, 2018. Link. [4] DIRECTIVE (EU) 2019/944 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU. Link		

Using existing balancing (like mFRR) or intraday products for congestion management services for DSO requires more detailed locational information than is provided nowadays. Locational information at the bidding zone level is not adequate to handle congestion in distribution network

which typically operates inside one bidding zone. However in the same time, customer privacy and compliance with the GDPR regulation must be ensured. Locational information with portfolio bidding must be ensured e.g. with a nomination by the balance service providers how the portfolio schedule is shared between the physical providers [1, p. 33]

Even though using mFRR product for congestion management might increase liquidity for congestion management market, it might also add hurdles from DSO perspective because the technical and prequalification requirements of mFRR-product. These technical requirements are not necessarily required for congestion management purposes at DSO level and the requirements might be a too big obstacle for some of the flexibility resources connected to the distribution network.

When using the same product for multiple purposes, like mFRR-product for both balancing and congestion management, it increases the need for coordination between the system operators since the flexibility resource can be purchased only at one market place at a time, and the activation can cause a positive or a negative impact for the other SO. It should be also considered who has the priority to use the product, e.g. whether the DSO has a priority for the resources connected to distribution grid. TSO/DSO coordination must also consider the sequence of market timeframes and how and when the allocation for the congestion management should take place. E.g. bidding at European balancing market platforms poses limitations (like gate closure times) for the bids to be used for other purposes than the original balancing market.

Congestion management could be organised also as a separate service, not connected to any of the existing market products nor it doesn't necessary have standardised product definition. At the moment in the existing flexibility market pilots, the product definitions for congestion management products vary. Piclo is using their own standardized products. Enera and ETPA products are based on the intra-day product definitions. NODES is not having standard product definitions rather flexibility providers specify their offer for congestion management with range of parameters [2].

Especially if local congestion management market places are established, there will become more and more need for DSO-DSO coordination as well. While distributed energy resources and flexibility service providers are located in various areas across one country, it would beneficial if the processes and interfaces would be similar between the DSOs. [2]

Reference:

[1] TSO – DSO REPORT AN INTEGRATED APPROACH TO ACTIVE SYSTEM MANAGEMENTWITH THE FOCUS ON TSO – DSO COORDINATION IN CONGESTION MANAGEMENT AND BALANCING. Link.

[2] Flexibility markets: Q&A for project pioneers. Link.

4.2.3 Congestion management Long Term Planning

Short description	An envisaged service that may serve network reinforcement deferral, network support during construction and planned maintenance, where location-specific flexibility assets are being activated for shaving or shifting peak demand and production in order to compensate for the lack of network connections, loads or production units mainly in the distribution network.
Description	This service might be classified either within the Congestion management domain or within the Grid capacity management domain, where the latter seems to be considered as business as usual situation for TSO/DSO (no impact on the freedom of dispatch, trade and connect – "copper plate principle"), see USEF [1].

	Capacity management within the scope of Long Term Planning (proactive) is an envisaged service that may serve several purposes including network reinforcement deferral, network support during construction and planned maintenance. The flexibility need therefore comes from a long-term planner, whereas the activator is a short-term planner. Load related reinforcement schemes could use flexibility to defer a planned network upgrade into the future. The benefit is the net present value of deferred capital expenditure [2]. In parts of the network that are planned for reinforcement or maintenance, flexibility could be used to increase the security of the network before completion. The benefit is the reduced impact of a low probability outage event [2]. The point of network connection of activated assets has to be in a feeding area of specific network assets that are highly loaded, e.g. a substation where peak demand is close to the network capacity. The assets are being activated for shaving or shifting peak demand and production. Therefore, locational information in the traded products is essential. The concept of federated power plants [3] may be employed in order that prosumers active in peer-to-peer (P2P) energy trading are included in the foreseen service provision as well. By that concept, a virtual power plant is formed through P2P transactions between self-organizing prosumers and thus, unlocking additional value for P2P energy trading: through the negotiation of P2P energy transactions, the prosumers organise themselves to fulfil the grid service contracts. Such concept may be interesting mainly for providing services on distribution network level. Traditionally congestion management at DSO level is handled via bilateral contracts. Tariff solutions, connection agreements, rule-based solutions and market based solutions are alternative and/or complementary solutions for DSO (and TSO) to undertake congestion management and balancing [7]. For the long term congestion management, one option for purchase are the reservation payments. By long-term contracts the risk of availability is shared between the SO and the market parties. Risk for gaming is also reduced. Long-term reservation payments in some extent affects the short term efficiency of the resources and for the flexibility provider it might be difficult to forecast the availability for longer period.[8] A network tariff is a solution to prevent congestion and not a solution to solve a congested situation. At some extent with tariff design network users are incentivised to use electricity as efficiently as possible. From the tariff structure multiple elements can be used: basis (capacity, energy), timing, direction, location. Similarly connection agreement are one way to prevent congestion. Contractual agreements can introduce a variable network access or flexible connection agreement for certain customers and thus reduce the need for network investment and create a win-win situation for both DSO and customer. A rules-based solution (compulsory rules in network codes and regulation to impose flexibility technical requirements) in also another technique to handle flexibility and this approach could e.g. prescribe limits for feeding electricity when congestion occurs [9]. There is always an alternative solution to handle the congestion by network investment. Depending on the network (voltage) and the congested area, timeframes for the investment could be however several years. The lower the voltage level, typically the timeframe is shorter but locational restrictions might prevent the network investments.
Existing or New Service?	Pilot implementation in UK, see Refs. [2] and [4].

Timeframe	Several months or even years before planned delivery.	
Assets used	All flexibility sources. Flexibility services are provided by any technology or process that can shave or shift peak demand and production as well.	
Users of the service	Primary target are DSOs because of employment of location-specific flexibility sources, although other users such as TSOs could use the service as well.	
Market-based or regulated tariff?	Market-based (implicitly capped – single buyer concept: the total cost of the contracts has to be lower than the benefit to the network)	
Unit of measurement	MWh	
Optional: Pricing method	Service is remunerated as a combination of utilisation payments and availability payments [2].	
Optional: how is the procured volume defined?	Meter data is compared to the baseline (the default baseline methodology has to be defined) to calculate the energy delivered during utilisation events. E.g. the baseline may represent the generation or consumption level of the flexibility unit had it not been providing flexibility services. The flexible power is the level of additional generation or additional reduction in consumption that can be provided relative to this baseline. Availability payments may be reduced by a performance factor derived by comparing the energy delivered to the energy contracted to be delivered during utilisation events.	
Process overview: (if applicable)	For a detailed description of points 1 and 2, please refer to [2]. 1. **Prequalification** - Flexibility providers and their resources within flexibility zones are pre-qualified to participate in the competition. Zones with enough pre-qualified flexible volume can proceed to competition. Note: Mobile storage units are potentially well-placed to participate and would be incentivized to move across zones provided the price delta (consume during low-cost hours and generate during high-cost hours) is high enough. There should be provisions in place for portable and stationary storage assets to participate during pre-qualification process. 2. **Bidding/Selection** - Pre-qualified flexibility providers submit prices into a tender. Flexibility providers are notified of outcome. Flexibility providers successful in the competition deploy their flexible solutions, undertake testing, and start delivery. Each bid consists of variations of capability, fee, and service period parameters. 3. **Activation** - Automatically or manually. 4. **Delivery** – A minimum of delivery period is required - e.g. 30 minutes. 5. **Settlement (and/or Measurement)** – In case of independent aggregator the settlement with affected BRPs should be considered in addition to settlements with TSO/DSO. For measurement: see row "Optional: how is the procured volume defined?"	
Settlement schemes	☐ TSO-TSO Settlement ☐ TSO-DSO Settlement ☐ TSO-BRP Settlement ☒ TSO-Service Provider Settlement ☐ DSO-DSO Settlement	☐ DSO- BRP Settlement ☒ DSO-Service Provider Settlement ☒ BRP- Service Provider Settlement ☐ No Settlement ☐ Other (describe)
Coordination schemes	☐ TSO-TSO coordination ☒ TSO-DSO coordination ☒ DSO-DSO coordination	☐ No coordination ☐ Other (describe)
Does the service require any changes to current market structures?	In general, the product may be devised in a similar manner as mFRR. New product definition: location information is to be included in the product specification.	

	Aggregation model & new market roles to be defined and introduced (e.g. introduction of independent aggregator).		
TRL level (1-9)	TRL 7÷9 [5]		
In which demos service is intended to be used?	☐ T5.1 ☐ T5.2 ☒ T5.3 ☐ T5.4	☒ T6.1 ☒ T6.2 ☐ T6.3	☒ T7.1 ☒ T7.2 ☐ T7.3
Needed functional services of IEGSA platform (optional)	Interfaces needed for integration of flexibility trading platform into existing sequence of organized markets. For details, please refer to [6].		
Notes	**T5.3:** Long-term congestion management services via Single Flexibility Platform or TSOs and DSOs. **T6.1:** DSO view: Identified flexibilities will be used to enable the service. This service is completely supported in modern SCADA, ADMS. For Slovenian demo this will be a new mechanism, because of the existing, more statically used method of long term planning. Assets will have very limited activation possibilities, with a given priority of availability to the DSO. The level of observation: the branch and the node. TSO view: Local markets could potentially offer frequency services to TSO's. A clear security oriented and market conditioned mechanism should ensure that services offered to different operators are not obstructed. **T6.2:** Multiple buyer – multiple seller flexibility trading platform (additional inputs are provided in the service section). **Coordination aspects:** DSO-TSO coordination is needed in order to activate flexibility resources that do not cause further congestions or other problems in the network. In general, there is no need for DSO-DSO coordination. The exception are locations close to DSO-DSO network interconnections. TSO-DSO Information Exchange: Double activation of assets avoidance - One single asset, if pre-qualified, might be able to provide a product both for congestion management in the DSO grid, for congestion management in the TSO grid or for balancing performed by the TSO. Thus, there is a need to be sure that there is coherence between all congestion management and balancing bids. Thus, helping DSOs/TSOs to properly communicate their needs in different timeframes and making sure there is interaction between two merit order lists in order to avoid double activation of same asset is recommended. DSO-DSO Information Exchange: Similar to the above scenario, trade for congestion relief of a DSO's feeder should not contribute to congestion in the network of another involved DSO due to counter trading. Therefore, at least all the affected parties of an ongoing trade should be informed before trade finalization.		
Reference	[1] USEF: Flexibility Value Chain (White Paper), USEF Foundation, Update 2018. Link. [2] UK Power Networks (Operations) Limited, Flexibility Services Invitation to Tender - 2018/19, Reference: PE1-0074-2018 Flexibility Services, Version 1.1 Date: February 2019. Link. [3] T. Morstyn, N. Farrell, S. J. Darby, and M. D. McCulloch, "Using peer-to-peer energy-trading platforms to incentivize prosumers to form federated power plants," Nature Energy, vol. 3, no. 2, pp. 94–101, Feb. 2018. Link. [4] Piclo Flex, Competition Map. Link.		

	[5] HORIZON 2020, Technology readiness levels (TRL). Link. [6] Tim Schittekatte, Valerie Reif, Athir Nouicer and Leonardo Meeus, D2.4 Completed Regulatory Framework, Project INTERRFACE. [7] TSO – DSO REPORT AN INTEGRATED APPROACH TO ACTIVE SYSTEM MANAGEMENTWITH THE FOCUS ON TSO – DSO COORDINATION IN CONGESTION MANAGEMENT AND BALANCING. Link. [8] Tim Schittekatte and Leonardo Meeus. Flexibility markets: Q&A with project pioneers. Link. [9] Flexibility in the Energy Transition – A Toolbox for Electricity DSOs. Link.

4.2.4 Cross-border Redispatch

Short description	Redispatching is a remedial action, including curtailment, that is activated by one or more TSOs or DSOs by altering the generation, load pattern, or both, in order to change physical flows in the electricity system and relieve a physical congestion or otherwise ensure system security
Description	Redispatching is a remedial action, including curtailment, that is activated by one or more TSOs or DSOs by altering the generation, load pattern, or both, in order to change physical flows in the electricity system and relieve a physical congestion or otherwise ensure system security [1]. Specifically, this refers to one or several TSO(s) requesting, when congestion appears, specific generators (or specific consumers) to start or increase production and specific other generators to stop or reduce production, in order to maintain the network security [3]. Redispatch can notably be applied across bidding zone borders, in which case it is implemented as a coordinated TSO process, whereby a redispatch requesting TSO asks one or more TSOs for either downward or upward redispatch in their control zone. The facilitating TSOs then apply, if possible the requested redispatch. Costs are later settled among TSOs. A prerequisite of cross-zonal redispatch is the availability of cross-zonal capacity in order to mitigate the risk of new congestions. Also, downward and upward redispatch need to be in equilibrium to avoid imbalances. [5] DSO is not involved in cross border trading, but similar redispatch market structures could be used for DSO congestion management purposes.
Existing or New Service?	Existing service.
Timeframe	Operational time frame
Assets used	NC CACM Art. 35.3: Each TSO may redispatch all available generation units and loads in accordance with the appropriate mechanisms and agreements applicable to its control area, including interconnectors. [2] Electricity regulation Art. 13.1: The redispatching of generation and redispatching of demand response should be based on objective, transparent and non-discriminatory criteria. It should be open to all generation technologies, all energy storage and all demand response, including those located in other Member States unless technically not feasible. [1] Depending on national legislation, the resources of Core TSOs for Redispatching may be as following: a) conventional power plants; b) loads; c) (pump) storage power

	plants; d) battery storages or other storage technologies; e) renewable energy sources, such as wind, solar, biomass plants etc.; f) resources of the Balancing Market. [4]
Users of the service	TSOs and DSOs
Market-based or regulated tariff?	Following Electricity regulation [1]: Article 13.2 The resources that are redispatched shall be selected from among generating facilities, energy storage or demand response using market-based mechanisms and shall be financially compensated. Article 13.3. Non-market-based redispatching of generation, energy storage and demand response may only be used where: (a) no market-based alternative is available; (b) all available market-based resources have been used; (c) the number of available power generating, energy storage or demand response facilities are too low to ensure effective competition in the area where suitable facilities for the provision of the service are located; or (d) the current grid situation leads to congestion in such a regular and predictable way that market-based redispatching would lead to regular strategic bidding which would increase the level of internal congestion and the Member State concerned either has adopted an action plan to address this congestion or ensures that minimum available capacity for cross-zonal trade is in accordance with Article 16(8).
Unit of measurement	MWh
Optional: Pricing method	NC CACM Art. 35.5: The relevant generation units and loads should give TSOs the prices of redispatching and countertrading before redispatching and countertrading resources are committed. Pricing of redispatching and countertrading shall be based on: (a) prices in the relevant electricity markets for the relevant time-frame; or (b) the cost of redispatching and countertrading resources calculated transparently on the basis of incurred costs. NC CACM Art. 35.5: Generation units and loads shall ex-ante provide all information necessary for calculating the redispatching and countertrading cost to the relevant TSOs and DSOs. This information should be shared between the relevant TSOs and DSOs for redispatching and countertrading purposes only. The Core CCR TSOs' proposal of 24 July 2015 [4] categorizes different pricing mechanisms for redispatching existing in different countries as: - price-related, i.e. based on bids for upward regulation and downward regulation, - cost-related, i.e. based on fuels, CO2, opportunity costs, starting costs, etc, - cost-related plus, i.e. cost related complemented with an additional margin. In a price-related mechanism the costs are known ex-ante. In a cost-related mechanism the full costs are known only ex-post, but indicative prices are determinable. In case of redispatching, each Core TSO has to declare indicative prices/costs of the potential generation units or load units and the time window of its validity (see Art 10)

Optional: how is the procured volume defined?	From Core CCR Methodology Art. 4 [4]: 5. Each Core TSO should define the list of XBRNE (cross-border relevant network elements on which congestions need to be solved) as follows: a. From the list of initial XBRNE, it should remove those internal XBRNE, for which the maximum zone-to-zone power transmission distribution factor (hereafter referred to as "PTDF") is not higher than five percent. The estimation of the zone-to-zone PTDF is described in Annex 1 of this methodology; b. From the remaining list of XBRNE, it should remove those internal XBRNE which are not included in the list of internal XBRNE pursuant to Paragraph 6. This step should not be performed until 30 days after the decision on the proposal for amendment of this methodology defining the list of internal XBRNE to be included in the list of XBRNE pursuant to Paragraph 6 becomes effective. 6. In the amended methodology in accordance with Article 19 Paragraph 4, Core TSOs should jointly develop the criteria for the internal network elements to be excluded from the remaining XBRNE. In this development, Core TSOs will perform an impact assessment of increasing the threshold of maximum zone-to-zone PTDF for exclusion of internal XBRNE pursuant to Paragraph 5.a up to 10% at a later stage.
Process overview: (if applicable)	1. **Exchange of available Redispatching resource and associated estimated pricing as input for the Coordinated Security Analysis,** whereby TSOs inform each other via the RSCs on volumes available for redispatching after the publication of the results of the DAM. For Redispatching, the following features will accompany the volume itself, but are not limited to: a. Identification of Redispatching resources and mapping to nodes in the CGM; b. Specific up-to-date upward and downward regulating availabilities; c. Operational constraints, e.g. ramping constraints, minimum and maximum duration of the delivery period, lead time, Pmin, Pmax; d. Characteristics of standard products; e. If the resource is offered simultaneously to different CCRs or only to the Core CCR. (see Art 9(6)) 2. **Detection that Redispatching and Countertrading is needed** by the Coordinated Security Analysis, where all available non-costly remedial actions do not relieve all identified congestions; The physical congestion can be detected by either a Core TSO or a RSC on its behalf. In all cases where a physical congestion is detected, all involved parties (Core TSOs and RSCs) must contact and provide each other with all the information needed to have a common view on the physical congestion to be solved. 3. **Coordination to decide which RD and CT Measures will be applied,** based on a set of costly and non-costly remedial actions proposed by the CSA. Suggestions are made by the RSCs to solve the congestions; this is then decided on jointly by the relevant Core TSOs. In case of a decision not to implement the recommended action, the respective TSO needs to provide an explanation. **4. Activation of Redispatching and Countertrading:** a. Activation in DA and ID processes: Core TSOs select RD measures to be ordered. Remedial Action Connecting and Transiting TSOs update cross-border schedules accordingly, and review in a coordinated manner intraday cross-border capacities. Finally, all parties abstain from uncoordinated cross-border impacting measures in order to maintain the system within operational security limits. b. Additional request for coordination and reconsideration of ordered redispatch: this can be launched by the RA connecting TSOs in case the

	provider of RD is not able to deliver the amount ordered, or in case of an improved grid situation. c. Fast activation process (where activation cannot wait for the next coordinated security analysis): preventive as well as curative RA activation can be applied. **5. Reporting;** all relevant information and data is recorded by RSCs and is shared with TSOs 6. **Total cost calculation;** carried out by adding up the costs/incomes of connecting TSOs involved in Redispatching. In accordance with Art 35(5) of CACM, the actual prices of the volumes activated for redispatching need to be based on: a. Prices in the relevant electricity markets for the relevant timeframe; or b. The costs of redispatching resources calculated on the basis of incurred costs. 7. **Cost sharing and settlement:** Different principles exist. Regulation demands implementation of "polluter pays" principle [4]	
Settlement schemes	☒ TSO-TSO Settlement ☐ TSO-DSO Settlement ☐ TSO-BRP Settlement ☒ TSO-Service Provider Settlement ☐ DSO-DSO Settlement	☐ DSO- BRP Settlement ☐ DSO-Service Provider Settlement ☐ BRP- Service Provider Settlement ☐ No Settlement ☐ Other (describe)
Coordination schemes	☒ TSO-TSO coordination ☒ TSO-DSO coordination ☐ DSO-DSO coordination	☐ No coordination ☒ Other (describe): TSO-RSC coordination
Does the service require any changes to current market structures?	No	
TRL level (1-9)	9	
In which demos service is intended to be used?	☐ T5.1 ☒ T5.2 ☐ T5.3 ☐ T5.4	☐ T6.1 ☒ T6.2 ☐ T6.3	☐ T7.1 ☐ T7.2 ☐ T7.3
Suitability to each Scenario	Yes, throughout RSC	
Needed functional services of IEGSA platform (optional)		
Notes		
Reference	CACM Art. 35.1. All the TSOs in each capacity calculation region shall develop a proposal for a common methodology for coordinated redispatching and countertrading [2]. CACM Art. 35.2. Each TSO shall abstain from unilateral or uncoordinated redispatching and countertrading measures of cross-border relevance [2].	
	[1] REGULATION (EU) 2019/943 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 5 June 2019 on the internal market for electricity. Link. [2] COMMISSION REGULATION (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management. Link.	

	[3] Explanatory document to the proposal for the coordinated redispatching and countertrading methodology for Capacity Calculation Region Hansa in accordance with Article 35 of the Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a Guideline on Capacity Allocation and Congestion Management. Link. [4] Common methodology for coordinated redispatching and countertrading for the Core CCR in accordance with Article 35(1) of Commission Regulation (EU) 2015/1222 of 24 July 2015. Link. [5] Hirth, Lion; Glismann, Samuel (2018) : Congestion Management: From Physics to Regulatory Instruments, ZBW – Leibniz Information Centre for Economics, Kiel, Hamburg

4.2.5 Cross-border Countertrading

Short description	Countertrading means a cross-zonal exchange initiated by system operators between two bidding zones to relieve physical congestion, where the precise generation or load pattern alteration is not predefined. This measure is a market based-solution, where the cheapest bid is selected independently of the geographical location within the bidding zone.
Description	Countertrading means a cross-zonal exchange initiated by system operators between two bidding zones to relieve physical congestion [1]. Countertrading is therefore considered a measure with the objective to relieve physical congestions between two bidding zones, where the precise generation or load pattern alteration is not predefined. This measure is a market based-solution, where the cheapest bid is selected independently of the geographical location within the bidding zone [5]. The use of countertrading, alongside redispatching, is applied to maintain minimum technical limit for stable operation of a HVDC line, handle fault, failure, or unplanned outage of an interconnector, and/or handle a physical congestion in the AC grid with cross-border relevance. [5] DSO is not involved in cross-border trading but the countertrading service as a structural concept might be needed if it will be defined that the system operator activating the flexibility is responsible for the counterbalancing so that no imbalance will be created. In the ASM-report [7] it is stated the three options to restore the imbalance portfolio: 1) by the service provider, 2) by the system operator using the flexibility product (TSO or DSO), 3) by the TSO. If DSO itself does the correction, it prevents that the correction isn't contradictory to the original product
Existing or New Service?	Existing service.
Timeframe	Intraday and Operational time frame
Assets used	NC CACM Art. 35.3: Each TSO may redispatch all available generation units and loads in accordance with the appropriate mechanisms and agreements applicable to its control area, including interconnectors. Depending on national legislation, resources for countertrading may include having access to a third party to take position in the ID market to buy or sell electricity, resources also considered for redispatching, and resources of the balancing market.
Users of the service	TSOs and DSOs
Market-based or regulated tariff?	Market based [6]
Unit of	MWh

measurement	
Optional: Pricing method	NC CACM Art. 35.5: The relevant generation units and loads shall give TSOs the prices of redispatching and countertrading before redispatching and countertrading resources are committed. Pricing of redispatching and countertrading shall be based on: (a) prices in the relevant electricity markets for the relevant time-frame; or (b) the cost of redispatching and countertrading resources calculated transparently on the basis of incurred costs. [2] NC CACM Art. 35.5: Generation units and loads should ex-ante provide all information necessary for calculating the redispatching and countertrading cost to the relevant TSOs. This information shall be shared between the relevant TSOs for redispatching and countertrading purposes only [2].
Optional: how is the procured volume defined?	From Consentec Final Report [6], page 13: Under countertrading, TSOs coordinate transmission flows using markets for countertrading. The outcome of the transmission allocation is internalised in the market-based mechanisms for clearing the energy markets.
Process overview: (if applicable)	1. **Exchange of available Redispatching resource and associated estimated pricing as input for the Coordinated Security Analysis,** whereby TSOs inform each other via the RSCs on volumes available for redispatching after the publication of the results of the DAM. For Countertrading, the following features will accompany the volume itself, but are not limited to: a. Bidding Zone, or location, if known. b. Product related lead times c. Characteristics of standard products; d. If the resource is offered simultaneously to different CCRs or only to the Core CCR. (see Art 9(7)) 2. **Detection that Redispatching and Countertrading is needed** by the Coordinated Security Analysis, where all available non-costly remedial actions do not relieve all identified congestions; The physical congestion can be detected by either a Core TSO or a RSC on its behalf. In all cases where a physical congestion is detected, all involved parties (Core TSOs and RSCs) must contact and provide each other with all the information needed to have a common view on the physical congestion to be solved. 3. **Coordination to decide which RD and CT Measures will be applied,** based on a set of costly and non-costly remedial actions proposed by the CSA. Suggestions are made by the RSCs to solve the congestions; this is then decided on jointly by the relevant Core TSOs. In case of a decision not to implement the recommended action, the respective TSO needs to provide an explanation. 4. **Activation of Redispatching and Countertrading:** a. Activation in DA and ID processes: Core TSOs select CT measures to be ordered. Remedial Action Connecting and Transiting TSOs update cross-border schedules accordingly, and review in a coordinated manner intraday cross-border capacities. Finally, all parties abstain from uncoordinated cross-border impacting measures in order to maintain the system within operational security limits. b. Additional request for coordination and reconsideration of ordered countertrading: this can be launched by the RA connecting TSOs in case the provider of CT is not able to deliver the amount ordered, or in case of an improved grid situation. c. Fast activation process (where activation cannot wait for the next coordinated security analysis): preventive as well as curative RA activation can be applied. 5. **Reporting;** all relevant information and data is recorded by RSCs and is shared

	with TSOs 6. **Total cost calculation;** carried out by adding up the costs/incomes of connecting TSOs involved in countertrading. In accordance with Art 35(5) of CACM, the actual prices of the volumes activated for countertrading need to be based on: a. Prices in the relevant electricity markets for the relevant timeframe; or b. The costs of redispatching resources calculated based on incurred costs. 7. **Cost sharing and settlement:** According to Article 74(6) of the CACM, the common methodologies for the sharing of countertrading costs between TSOs must: - ensure a fair distribution of costs and benefits between the TSOs involved, - facilitate adherence to the general principles of congestion management under Article 16 of Regulation (EC) No 714/2009, and - comply with the principles of transparency and non-discrimination.	
Settlement schemes	☒ TSO-TSO Settlement ☐ TSO-DSO Settlement ☐ TSO-BRP Settlement ☒ TSO-Service Provider Settlement ☐ DSO-DSO Settlement	☐ DSO- BRP Settlement ☐ DSO-Service Provider Settlement ☐ BRP- Service Provider Settlement ☐ No Settlement ☐ Other (describe)
Coordination schemes	☒ TSO-TSO coordination ☐ TSO-DSO coordination ☐ DSO-DSO coordination	☐ No coordination ☒ Other (describe): TSO-RSC coordination
Does the service require any changes to current market structures?	No	
TRL level (1-9)	9	
In which demos service is intended to be used?	☐ T5.1 ☐ T5.2 ☒ T5.3 ☐ T5.4	☐ T6.1 ☒ T6.2 ☐ T6.3	☐ T7.1 ☐ T7.2 ☐ T7.3
Suitability to each Scenario	TSOs should implement coordinated redispatching of cross-border relevance or countertrading at regional level or above regional level. Redispatching of cross-border relevance or countertrading should be coordinated with redispatching or countertrading internal to the control area [2].	
Needed functional services of IEGSA platform (optional)		
Notes	CACM Art. 35.1. All the TSOs in each capacity calculation region shall develop a proposal for a common methodology for coordinated redispatching and countertrading [2]. CACM Art. 35.2. Each TSO shall abstain from unilateral or uncoordinated redispatching and countertrading measures of cross-border relevance [2].	
Reference	[1] REGULATION (EU) 2019/943 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 5 June 2019 on the internal market for electricity. Link. [2] COMMISSION REGULATION (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management. Link. [3] Report assessing the progressive coordination and harmonization of	

	mechanisms and agreements for redispatching in CCR Nordics in accordance with EU Regulation 1222/2015 article 35(3) link [4] Report assessing the progressive coordination and harmonisation of mechanisms and agreements for redispatching and countertrading link. [5] Explanatory document to the proposal for the coordinated redispatching and countertrading methodology for Capacity Calculation Region Hansa in accordance with Article 35 of the Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a Guideline on Capacity Allocation and Congestion Management. Link. [6] Consentec et al. (2004). Analysis of Cross-border Congestion Management Methods for the EU Internal Electricity Market. Final Report. Link [7] TSO – DSO REPORT AN INTEGRATED APPROACH TO ACTIVE SYSTEM MANAGEMENTWITH THE FOCUS ON TSO – DSO COORDINATION IN CONGESTION MANAGEMENT AND BALANCING. Link.

4.3 Non-frequency ancillary services

4.3.1 Obligatory reactive power service (ORPS)	
Short description	The main function is to maintain the voltage profile within the acceptable range and within the tolerance margins. This will allow a minimization of power losses and keep a steady state security.
Description	The Obligatory Reactive Power Service (ORPS) is the provision of mandatory varying Reactive Power output. At any given output, the synchronous generators may be requested to produce or absorb reactive power to help manage system voltages close to its point of connection. Generally, all transmission connected synchronous generators are required to have the capability to provide this service (except Belgium), as set out in the Grid Code. Concrete modalities are formalized in bilateral contracts (often included in the connection contract) for the lifetime duration of the unit. Voltage regulation is a centrally operated system service, provided by the TSO to all the grid users (production and consumption). It is performed on monthly basis via "Voltage level schedule". According to the Bulgarian grid code for each unit, connected to the transmission grid, provision of voltage regulation at the connection point is obligatory within the limits and set forth in the contract. It is formalized in the connection code and contracts between the producers and TSO is dependent on its individual P-Q diagram. Voltage regulation in the TSO grid is done via static compensation (shunt reactors and condenser batteries), owned by the TSO. DSOs also perform voltage regulation. In the lower voltage levels of distribution network, the effect of the reactive power to voltage is not that significant as in transmission network because of the electrical characteristics of the distribution network. Network tariffs have incentives on the amount of reactive power that is desired both at TSO and DSO level. E.g. in Finland there is limitations (reactive power window) for the DSO connection points where DSO must keep or they have to pay penalties to the TSO [6]. This creates incentives for the DSO to install reactive power controlling equipment or to change the customer behaviour regarding reactive power.
Existing or New	Existing as a mandatory service for generators and mandatory service for the TSO.

Service?			
Timeframe	On monthly basis.		
Assets used	Synchronous generators; power park modules; HVDC converter station, DSOs, shunt reactors and condenser batteries		
Users of the service	TSOs and DSOs		
Market-based or regulated tariff?	Mostly regulated prices (€/MVArh). IN Denmark, Sweden and Bulgaria, the mandatory service is free of charge.		
Unit of measurement	MVAr		
Optional: Pricing method	Mostly regulated prices (€/MVArh). In Denmark and Sweden, the mandatory service is free of charge.		
Optional: how is the procured volume defined?	TSO assessment		
Process overview: (if applicable)	1. **Prequalification** - 2. **Bidding/Selection** - 3. **Activation** - 4. **Delivery** - 5. **Settlement** (and/or Measurement) -		
Settlement schemes	☐ TSO-TSO Settlement ☐ TSO-DSO Settlement ☐ TSO-BRP Settlement ☒ TSO-Service Provider Settlement ☐ DSO-DSO Settlement	☐ DSO- BRP Settlement ☒ DSO-Service Provider Settlement ☐ BRP- Service Provider Settlement ☐ No Settlement ☐ Other (describe)	
Coordination schemes	☒ TSO-TSO coordination ☐ TSO-DSO coordination ☐ DSO-DSO coordination	☐ No coordination ☐ Other (describe)	
Does the service require any changes to current market structures?	No		
TRL level (1-9)			
In which demos service is intended to be used?	☐ T5.1 ☐ T5.2 ☐ T5.3 ☐ T5.4	☐ T6.1 ☒ T6.2 ☐ T6.3	☒ T7.1 ☐ T7.2 ☐ T7.3
Suitability to each Scenario			
Needed functional services of IEGSA platform (optional)			
Notes	TSO-TSO coordination is needed due to voltage level coordination. **Network Codes (Requirements for Generators (RfG)** **Article 17 (2)** Type B synchronous power-generating modules shall fulfil the following additional requirements relating to voltage stability: (a) with regard to reactive power capability, the relevant system operator shall have the right to specify the capability of a synchronous power-generating module to provide		

	reactive power; **Article 18 (2a)** Type C synchronous power-generating modules shall fulfil the following additional requirements in relation to voltage stability: (a) with regard to reactive power capability, the relevant system operator may specify supplementary reactive power to be provided. **Article 20 (2a)** Type B power park modules shall fulfil the following additional requirements in relation to voltage stability: (a) with regard to reactive power capability, the relevant system operator shall have the right to specify the capability of a power park module to provide reactive power; **Article 21 (2)** Type C power park modules shall fulfil the following additional requirements in relation to frequency stability: (d) with regard to reactive power control modes: (e) with regard to prioritising active or reactive power contribution, the relevant TSO shall specify whether active power contribution or reactive power contribution has priority during faults for which fault-ride-through capability is required. If priority is given to active power contribution, this provision has to be established no later than 150 ms from the fault inception; **NC High Voltage Direct Current Code (HVDC Code)** **Article 23.** Taking into account the capabilities of the HVDC system specified in accordance with this Regulation, the relevant TSO shall determine whether active power contribution or reactive power contribution shall have priority during low or high voltage operation and during faults for which fault-ride-through capability is required. If priority is given to active power contribution, its provision shall be established within a time from the fault inception as specified by relevant TSO. **Demand Connection Code** **Article 15 (3).** Without prejudice to point (b) of paragraph 1, the relevant TSO may require the transmission-connected distribution system to actively control the exchange of reactive power at the connection point for the benefit of the entire system. The relevant TSO and the transmission-connected distribution system operator shall agree on a method to carry out this control, to ensure the justified level of security of supply for both parties.
Reference	[1] Commission Regulation (EU) 2016/631 of 14 April 2016 establishing a network code on requirements for grid connection of generators (Text with EEA relevance) link [2] Commission Regulation (EU) 2016/1447 of 26 August 2016 establishing a network code on requirements for grid connection of high voltage direct current systems and direct current-connected power park modules (Text with EEA relevance) link [3] Commission Regulation (EU) 2016/1388 of 17 August 2016 establishing a Network Code on Demand Connection (Text with EEA relevance) link [4] Study on the future design of the ancillary service of voltage and reactive power control link [5] Reactive Power – Obligatory(Synchronous Generation) link [3] План за развитие на преносната електрическа мрежа на България за периода 2018-2027г. link [6] Supply of reactive power and maintenance of reactive power reserves. Fingrid. Link

4.3.2 Enhanced reactive power service (ERPS)

Short description	Enhanced reactive power services (ERPS or a like) is voluntary service organised for any service provider, that can absorb or inject reactive power can provide ERPS. Usually this ancillary service is connected with the obligatory system reactive power services, provided by the TSO.	
Description	In some countries (like UK, Denmark) in addition to mandatory ORPS, the tenders for additional, voluntary Enhanced reactive power services (or a like) are organised for contract periods ranging from 1 hour to multiple months. Any site that has plant or apparatus that can absorb or inject reactive power can provide ERPS. This could be from synchronised plant that provides ORPS and would like to provide a level of voltage support that is above the minimum requirements. It could also be provided by any other private site that has the ability to generate or absorb reactive power (synchronous compensator etc.). Usually this ancillary service is connected with the obligatory system reactive power services, provided by the TSO.	
Existing or New Service?	Existing only in few EU countries	
Timeframe	1 hour to multiple months	
Assets used	Any other site that has the ability to generate or absorb reactive power in compliance with SOs requirements.	
Users of the service	TSOs and DSOs	
Market-based or regulated tariff?	None	
Unit of measurement	MVAr	
Optional: Pricing method		
Optional: how is the procured volume defined?		
Process overview: (if applicable)	1. **Prequalification** - 2. **Bidding/Selection** - 3. **Activation** - 4. **Delivery** - 5. **Settlement** (and/or Measurement) -	
Settlement schemes	☐ TSO-TSO Settlement ☐ TSO-DSO Settlement ☐ TSO-BRP Settlement ☐ TSO-Service Provider Settlement ☐ DSO-DSO Settlement	☐ DSO- BRP Settlement ☐ DSO-Service Provider Settlement ☐ BRP- Service Provider Settlement ☐ No Settlement ☐ Other (describe)
Coordination schemes	☐ TSO-TSO coordination ☐ TSO-DSO coordination ☐ DSO-DSO coordination	☐ No coordination ☐ Other (describe)
Does the service require any changes to current market structures?		

TRL level (1-9)			
In which demos service is intended to be used?	☐ T5.1 ☒ T5.2 ☐ T5.3 ☐ T5.4	☒ T6.1 ☒ T6.2 ☐ T6.3	☒ T7.1 ☐ T7.2 ☐ T7.3
Suitability to each Scenario			
Needed functional services of IEGSA platform (optional)			
Notes	**Commission Regulation (EU) 2016/1388 of 17 August 2016 establishing a Network Code on Demand Connection (Text with EEA relevance)** **Article 27 (2).** Demand facilities and closed distribution systems may provide demand response services [like, demand response reactive power control] to relevant system operators and relevant TSOs. Demand response services can include, jointly or separately, upward or downward modification of demand. **Article 28 (1)** Demand facilities and closed distribution systems may offer demand response active power control, demand response reactive power control, or demand response transmission constraint management to relevant system operators and relevant TSOs.		
Reference	[1] Commission Regulation (EU) 2016/1388 of 17 August 2016 establishing a Network Code on Demand Connection (Text with EEA relevance) link		

4.3.3 Fault-ride through (FRT) capability

Short description	Fault-ride-through' means the capability of electrical devices to be able to remain connected to the network and operate through periods of low voltage at the connection point caused by secured faults [1]. National and SO specific differences might occur in the requirements. Basic principle of the service is similar to DSO and TSO, the requirements for the capability are set in the network connection agreement of the respective SO.
Description	Fault-ride through is a service, provided by the generators at the connection point and is obligatory according to FRT curve set in the contract. It is formalized in the connection code and contracts between the producers and System Operators. Threshold limits for different power generating modules are identified and depending on the type (A, B, C, D) of the power-generating module, different fault-ride through requirements exist. [1]
Existing or New Service?	Existing service
Timeframe	None

Assets used	Synchronous generators		
Users of the service	TSOs and DSOs		
Market-based or regulated tariff?	None		
Unit of measurement	None		
Optional: Pricing method	None		
Optional: how is the procured volume defined?			
Process overview: (if applicable)	1. **Prequalification** - 2. **Bidding/Selection** - 3. **Activation** - 4. **Delivery** - 5. **Settlement** (and/or Measurement) -		
Settlement schemes	☐ TSO-TSO Settlement ☐ TSO-DSO Settlement ☐ TSO-BRP Settlement ☐ TSO-Service Provider Settlement ☐ DSO-DSO Settlement	☐ DSO- BRP Settlement ☐ DSO-Service Provider Settlement ☐ BRP- Service Provider Settlement ☐ No Settlement ☐ Other (describe)	
Coordination schemes	☐ TSO-TSO coordination ☐ TSO-DSO coordination ☐ DSO-DSO coordination	☐ No coordination ☐ Other (describe)	
Does the service require any changes to current market structures?	no		
TRL level (1-9)			
In which demos service is intended to be used?	☐ T5.1 ☐ T5.2 ☐ T5.3 ☐ T5.4	☐ T6.1 ☐ T6.2 ☐ T6.3	☒ T7.1 ☐ T7.2 ☐ T7.3
Suitability to each Scenario			
Needed functional services of IEGSA platform (optional)			
Notes	Article 17 (3) With regard to robustness, type B synchronous power-generating modules shall be capable of providing post-fault active power recovery. The relevant TSO shall specify the magnitude and time for active power recovery. The Fault-ride through of the generators is requirement that has to be fulfilled before starting synchronous and commercial operation. Once set it is active for the lifecycle of the generator.		
Reference	[1] Commission Regulation (EU) 2016/631 of 14 April 2016 establishing a network code on requirements for grid connection of generators (Text with EEA relevance) link		

	[2] National grid code, Bulgaria (Bulgarian) – ПРАВИЛА за управление на електроенергийната система link

4.3.4 Black Start

Short description	The black start capability is the ability of a power source to support the system restoration after a blackout, through a dedicated auxiliary power source without any electrical energy supply external to the power generating facility.
Description	The black start capability is the ability of a power source to support the system restoration after a blackout. At present, the only distributed generators that are likely to be used for black start are large units with capacities in the tens of megawatts that are already designed for blackout service. There are such units at hospitals, airports and other large installations. These installations may be good candidates for black-start service. At present, the penetration of distributed generation units which are capable to provide this service is not big enough to energise the transmission network. However, they might be able to energise parts of distribution grids which can then be operated in islanded mode." In order to be able to operate in island mode, the distributed generation should be dimensioned for the additional load in the distribution network. The NC ER [2] obliges all European transmission system operators to prepare two plans: a system defence plan and a restoration plan. Black start and island operation capabilities are part of the restoration plan. DSOs and other market parties are obliged for cooperation, e.g. DSO shall inform the TSO during emergency, blackout or restoration about network parts in island operation, abilities to synchronize parts of the network and capabilities to build up islands in DSO grid.
Existing or New Service?	Existing
Timeframe	Long term contracts with activation within 24h
Assets used	Thermal or hydro power plants (pump-storage and run-of-river) because of the size and reliability.
Users of the service	TSOs and DSOs
Market-based or regulated tariff?	Both options exist. Mandatory services or procurement via tenders or bilateral agreements are used, with different levels of involvement of the national regulator
Unit of measurement	N/A
Optional: Pricing method	No standardized pricing throughout EU. Many option exists: Pay as bid; Marginal pricing; Bilaterally negotiated prices; Regulated price; Free etc.
Optional: how is the procured volume defined?	Depending on system needs and the characteristics of the system.
Process overview: (if applicable)	1. **Prequalification** - 2. **Bidding/Selection** – 3. **Activation** – 4. **Delivery** - 1. **Settlement** (and/or Measurement) -

Settlement schemes	☐ TSO-TSO Settlement ☐ TSO-DSO Settlement ☐ TSO-BRP Settlement ☐ TSO-Service Provider Settlement ☐ DSO-DSO Settlement	☐ DSO- BRP Settlement ☐ DSO-Service Provider Settlement ☐ BRP- Service Provider Settlement ☒ No Settlement ☐ Other (describe)
Coordination schemes	☒ TSO-TSO coordination ☒ TSO-DSO coordination ☐ DSO-DSO coordination	☐ No coordination ☐ Other (describe)
Does the service require any changes to current market structures?	No	
TRL level (1-9)	9	
In which demos service is intended to be used?	☐ T5.1 ☒ T5.2 ☐ T5.3 ☐ T5.4	☐ T6.1 ☐ T6.2 ☐ T6.3	☐ T7.1 ☐ T7.2 ☐ T7.3
Suitability to each Scenario	N/A		
Needed functional services of IEGSA platform (optional)			
Notes	There is no commonly agreed approach among European TSOs for procuring restoration services		
Reference	[1] Elia. STUDY ON THE REVIEW OF THE BLACK START ANCILLARY SERVICES. Link. [2] COMMISSION REGULATION (EU) 2017/2196 of 24 November 2017 establishing a network code on electricity emergency and restoration. Link		

4.3.5 Islanding Operation

Short description	Island operation may be performed in customer's network by utilizing standby generation units, uninterruptible power supply and periodization of loads supplied during controlled island operation utilizing the concept of micro-grid to enhance distribution network reliability. DSOs, when able to balance the islanded network, black-start the island after an outage or automatically disconnect the island from the faulted network and resynchronize the island network with or without outage to the grid after fault clearance.
Description	Island operation may be performed in customer's network by utilizing standby generation units, uninterruptible power supply and periodization of loads supplied during island operation. Today DG units realizing island operation is typically prohibited; in case of a permanent fault in a radial distribution network, all DG units should be disconnected from the network. But controlled island operation utilizing the concept of micro-grid is an interesting opportunity to enhance distribution network reliability. DSOs, when able to balance the islanded network, black-start the island after an outage or automatically disconnect the island from the faulted network and resynchronize the island network with or without outage to the grid

	after fault clearance. If DSO allows islanding operation in some location in the grid then it must ensure that the DG unit does not cause any network violations for its consumers. When allowing islanding the DSO checks if DG has necessary capacity to ensure demand within the island. If islanding is allowed, then DSO takes responsibility in decoupling the island from the grid. If islanding is allowed, then the DSO takes responsibility in resynchronizing the grid with the island (via synchro check function) at coupling location (if DG has LFSM-O). Most useful assets for islanding operation are synchronous generators. Wind or PV modules require extra automation functionalities. Most common procurement options for islanding operation service are mandatory agreements, market based or bilateral agreements.		
Existing or New Service?	New service (existing service in customer's premise)		
Timeframe	From Real-time to long-term		
Assets used	Synchronous generators; power park modules;		
Users of the service	DSO		
Market-based or regulated tariff?	N/A		
Unit of measurement	MWh		
Optional: Pricing method	N/A		
Optional: how is the procured volume defined?	N/A		
Process overview: (if applicable)	1. **Prequalification** - 2. **Bidding/Selection** - 3. **Activation** - 4. **Delivery** - 5. **Settlement** (and/or Measurement) -		
Settlement schemes	☐ TSO-TSO Settlement ☒ TSO-DSO Settlement ☐ TSO-BRP Settlement ☐ TSO-Service Provider Settlement ☐ DSO-DSO Settlement	☐ DSO- BRP Settlement ☒ DSO-Service Provider Settlement ☐ BRP- Service Provider Settlement ☐ No Settlement ☐ Other (describe)	
Coordination schemes	☒ TSO-TSO coordination ☒ TSO-DSO coordination ☐ DSO-DSO coordination	☐ No coordination ☐ Other (describe)	
Does the service require any changes to current market structures?	N/A		
TRL level (1-9)	3-4		
In which demos service is intended to be used?	☐ T5.1 ☒ T5.2 ☐ T5.3	☐ T6.1 ☐ T6.2 ☐ T6.3	☐ T7.1 ☐ T7.2 ☐ T7.3

	☐ T5.4		
Suitability to each Scenario	N/A		
Needed functional services of IEGSA platform (optional)	N/A		
Notes			
Reference			

4.3.6 Damping of power system oscillations

Short description	Damping of power system oscillations is one of the main concerns in the power system operation mainly dealing with the angle stability of power systems. These oscillations, when not well damped, may keep growing until loss of synchronism. These low-frequency oscillations affect the stability and efficiency of the power system.
Description	Damping of power system oscillations is very important for the system secure and viable operation. Besides the classic Power System stabilisers (PSS) that are widely used as an additional functionality of the AVR of synchronous power-generating modules whose purpose is to damp power oscillations [1], FACTS (Flexibility AC Transmission Systems) devices are also applied to enhance the system stability. The interconnection between distant located power systems is common, which contributes to the increase of the low frequency oscillations, essentially when weak and/or heavy loaded AC interconnection exists. The origin of such oscillations can be triggered by numerous reasons as line faults, switching lines or changes on the generators output. The local damping can be provided by the stabilising control actions which are governed by the PSSs of the conventional generators. However, concerning to inter-areas oscillation damping control a Wide Area Control System (WACS) can be responsible to provide adequate damping for inter area oscillation exploiting not only conventional PSS but also effective FACTS. These oscillations, when not well damped, may keep growing until loss of synchronism. The system stability, the operating efficiency of the power system and restricted capability of the power transmissions are some of the consequences of the low-frequency oscillations in a power system. The Power System stabilisers (PSS), by which a supplementary stabilising signal is added to the excitation system to damp the rotor angle swings, appears as a simple and cost-effective solution. Generally, machine parameters change with loading and the machine behaviour is different at different operating conditions. Hence, PSSs should provide some degree of robustness to the variations in system parameters, loading conditions and configurations. In most cases, the PSS works well in damping oscillations, however, its control has less flexibility if the operating conditions change [2]. Additionally, due to the loss of conventional power suppliers, it may be possible that these oscillations cannot be attenuated this way in the future. Some European projects are addressing this topic, namely FLEXITRANSTORE, where an advanced control for flexible synchronous generating is under development and testing, including flexible and adaptive PSS design in order to fit to the variability of operating conditions due to a growing share of renewables. Controllers such as; high voltage dc (HVDC), thyristor-controlled series capacitors

	(TCSC) and FACTS devices are playing a important role in the operation and control of power systems whilst they can help properly as power oscillation dampers. In the case of FACTS devices, they can be placed in the most convenient place to achieve the finest control results, due to their flexibility. FACTS and PSSs have different operations strategies for damping oscillations purposes and an uncoordinated control of them can cause destabilizations in the system. For that reason it's important to develop control algorithms that can manage in a feasible way PSS and FACTS as presented in the following papers [3] and [4].		
Existing or New Service?	Existing Service (biding for big units with PSS). However, it should have a new service in the market for the new RES and FACTS.		
Timeframe	Operational timeframe		
Assets used	FACTS and Synchronous power generators with PSS		
Users of the service	TSOs and DSOs. Not applicable to all DSOs since power oscillation damping is related to the power system and high voltage operation		
Market-based or regulated tariff?	For big units, nowadays it's tariff based (in Portugal 0€/MW). In the future with the RES and FACTS integration, it should move to market based.		
Unit of measurement	FACTS -> €/MVAR; PSS -> €/MW		
Optional: Pricing method			
Optional: how is the procured volume defined?	TSO assessment		
Process overview: (if applicable)	1. **Prequalification** - 2. **Bidding/Selection** - 3. **Activation** - Automatically. 4. **Delivery** - on event (real time) 5. **Settlement** (and/or Measurement) -		
Settlement schemes	☒ TSO-TSO Settlement ☐ TSO-DSO Settlement ☐ TSO-BRP Settlement ☒ TSO-Service Provider Settlement ☐ DSO-DSO Settlement	☐ DSO- BRP Settlement ☒ DSO-Service Provider Settlement ☐ BRP- Service Provider Settlement ☐ No Settlement ☐ Other (describe)	
Coordination schemes	☒ TSO-TSO coordination ☒ TSO-DSO coordination ☐ DSO-DSO coordination	☐ No coordination ☐ Other (describe)	
Does the service require any changes to current market structures?	Yes, it should be adapted to the FACTS integration		
TRL level (1-9)	TRL 4 (FACTS); TRL 9 (PSS for local oscillations); TRL 5 (PSS with WACS (Wide-Area stability and voltage Control System) for inter-area oscillations)		
In which demos service is intended to be used?	☐ T5.1 ☒ T5.2 ☐ T5.3 ☐ T5.4	☐ T6.1 ☐ T6.2 ☐ T6.3	☐ T7.1 ☐ T7.2 ☐ T7.3
Suitability to each Scenario			

Needed functional services of IEGSA platform (optional)	
Notes	
Reference	[1] - COMMISSION REGULATION (EU) 2016/631 - Establishing a network code on requirements for grid connection of generators, 14 April 2016. [2] – SmartNet D1.1 - Ancillary service provision by RES and DSM connected at distribution level in the future power system [3] – "Simultaneous Coordinated Tuning of PSS and FACTS Controller for Damping Power System Oscillations in Multi-Machine Systems", L.J. Cai, Student Member IEEE and I. Erlich, Member IEEE [4] – "Robust coordinated design of PSS and STATCOM controllers for damping power system oscillation", Saleh M. Bamasak and M.A. Abido

4.4 Adequacy

4.4.1 Strategic reserve

Short description	Strategic reserves are essentially generating units that are kept exclusively available for emergencies (e.g. when the market is not able to cover demand) and are called upon by an independent body (e.g. the TSO). The strategic reserve is intended to operate only when the market does not provide sufficient capacity to meet the demand.
Description	A central entity (TSO or government agency) decides upon the amount of capacity needed a few years in advance and contracts capacity – a strategic reserve – usually through a competitive tender. The contracted power plants or interruptible load units are only activated in case of capacity shortfalls, according to pre-determined criteria.
Existing or New Service?	Strategic reserves are existing services used in Belgium, Finland, Germany, Poland and Sweden. It is a form of State aid, so this Service is a subject to EU State aid rules.
Timeframe	Procurement of capacity annually (or other time period, which may vary nationally). The availability must be ensured during contracted periods and the start up time according to national specifications and contracts.
Assets used	The strategic reserve takes two forms, whose activation produces similar results: • the 'strategic reserve delivered by generation units' • the 'strategic reserve delivered by a reduction in the offtake on the demand side' The service providers must deliver energy to the area defined (usually national control area).
Users of the service	TSO
Market-based or regulated tariff?	Market based, tendering process
Unit of measurement	MW

Optional: Pricing method	Production resources are paid the fixed and variable compensation that are set out in the tender agreement.		
Optional: how is the procured volume defined?	The total amount of required capacity is set centrally, and then procured through a central bidding process in which a central purchaser procures the necessary capacity (a centralised mechanism);		
Process overview: (if applicable)	1. **Prequalification** - 2. **Bidding/Selection** - 3. **Activation** - 4. **Delivery** - 5. **Settlement** (and/or Measurement) -		
Settlement schemes	☐ TSO-TSO Settlement ☐ TSO-DSO Settlement ☒ TSO-BRP Settlement ☒ TSO-Service Provider Settlement ☐ DSO-DSO Settlement	☐ DSO- BRP Settlement ☐ DSO-Service Provider Settlement ☐ BRP- Service Provider Settlement ☐ No Settlement ☐ Other (describe)	
Coordination schemes	☐ TSO-TSO coordination ☐ TSO-DSO coordination ☐ DSO-DSO coordination	☒ No coordination ☐ Other (describe)	
Does the service require any changes to current market structures?	No		
TRL level (1-9)	9		
In which demos service is intended to be used?	☐ T5.1 ☐ T5.2 ☐ T5.3 ☐ T5.4	☐ T6.1 ☒ T6.2 ☐ T6.3	☐ T7.1 ☐ T7.2 ☐ T7.3
Suitability to each Scenario	N/A		
Needed functional services of IEGSA platform (optional)			
Notes			
Reference	[1] Joakim Cejie. The Strategic reserve - why and how? Link. [2] Elia. The strategic reserve – a mechanism to cover structural shortages. Link.		

5 Bottom-up analysis of INTERRFACE demos Business Use Cases

5.1 General Business Use Cases and methodology followed

This chapter provides the inputs from the Demonstrators of the INTERRFACE project in a structured and standardized way. Demos have provided responses to two questionnaires, filled a Business Use Case (BUC) template and prepared Sequence Diagrams for their BUCs. Business Use Cases (BUC) of IEGSA platform and INTERRFACE demo projects follows the structure of SGAM Business Layer, which details the business view on the information exchange. BUC are used to map regulatory and economic (market) structures and policies, business models, business portfolios (products & services) of market parties involved. Also, business capabilities and business processes can be represented in this section. In this way it supports business executives in decision making related to (new) business models and specific business projects (business case) as well as regulators in defining new market models.

The BUCs will act as specifications of the business processes regarding the services that will be implemented by the demonstrators. The aim is to produce these specifications in a standardized way. The BUCs will describe those processes using a stepwise approach including all the steps, the actors, the systems, the components, etc. that will be involved towards the delivery of the service. They will provide the logic behind each of the proposed services and will basically act as a detailed description of the functionalities of the demonstrators.

In order to provide a unified and interoperable solution, the methodology that will be used towards the definition of the use cases, will be compliant to the standardized use case methodology IEC62559. The BUCs contain a detailed description of the business process that governs the demonstrator. An exhaustive list of business roles has been defined by ENTSO-E[1], which is presented in

Table 1. The use-case definition (BUCs) includes the roles presented in the following table. The designed BUCs are eventually produced in a standardized and uniform manner.

Table 1 Roles according to the harmonized electricity market role model[2] [1]

Role Name	**Description**
Balance Responsible Party	A party that has a contract proving financial security and identifying balance responsibility with the Imbalance Settlement Responsible of the Scheduling Area entitling the party to operate in the market. This is the only role allowing a party to nominate energy on a wholesale level. **Additional information:** The meaning of the word “balance” in this context

[1] THE HARMONISED ELECTRICITY MARKET ROLE MODEL, VERSION: 2019-01, ENTSO-E, EFET, ebIX

[2] All TSOs’ proposal for the Key Organisational Requirements, Roles and Responsibilities (KORRR) relating to Data Exchange in accordance with Article 40(6) of Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a Guideline on Electricity Transmission System Operation, 2019-02, ENTSO-E, https://docstore.entsoe.eu/Documents/nc-tasks/SOGL/SOGL_A40.6_180227_KORRR_180314.pdf?Web=0

	signifies that the quantity contracted to provide or to consume must be equal to the quantity really provided or consumed.
Balance Supplier	A party that markets the difference between actual metered energy consumption and the energy bought with firm energy contracts by the Party Connected to the Grid. In addition, the Balance Supplier markets any difference with the firm energy contract (of the Party Connected to the Grid) and the metered production. **Additional information:** There is only one Balance Supplier for each Accounting Point.
Balancing Service Provider	A party with reserve-providing units or reserve providing groups able to provide balancing services to one or more LFC Operators. Based on Electricity Balancing - Art.2 Definitions.
Billing Agent	The party responsible for invoicing a concerned party.
Capacity Trader	A party that has a contract to participate in the Capacity Market to acquire capacity through a Transmission Capacity Allocator. **Note:** The capacity may be acquired on behalf of an Interconnection Trade Responsible or for sale on secondary capacity markets.
Consumer	A party that consumes electricity. **Additional Information:** This is a type of Party Connected to the Grid
Consumption Responsible Party	A party who can be brought to rights, legally and financially, for any imbalance between energy nominated and consumed for all associated Accounting Points. **Additional Information:** This is a type of a Balance Responsible Party
Consent Administrator	A party responsible for keeping a register of consents for a domain. The Consent Administrator makes this information available on request for entitled parties in the sector.
Coordinated Capacity Calculator	Coordinated Capacity Calculator is the entity or entities with the task of calculating transmission capacity, at regional level or above.

	Source: Commission Regulation (EU) 2015/1222 (CACM)
Coordination Centre Operator	A party responsible for the coordination of its Coordination Centre Zone in respect of scheduling, load frequency control, time deviation and compensation of unintentional deviation.
Data provider	A party that has a mandate to provide information to other parties in the energy market. **Note:** For example, due to Article 2 of the European Commission Regulation 543/2013 of the 14th of June 2013, a data provider may be a Transmission System Operator or a third party agreed by a TSO.
Energy Service Company (ESCO)	A party offering energy-related services to the Party Connected to the Grid, but not directly active in the energy value chain or the physical infrastructure itself. The ESCO may provide insight services as well as energy management services.
Grid Access Provider	A party responsible for providing access to the grid through a Metering Point for energy consumption or production to the Party Connected to the Grid. The party is also responsible for creating and terminating Metering Points
Imbalance Settlement Responsible	A party that is responsible for settlement of the difference between the contracted quantities and the realized quantities of energy products for the Balance Responsible Parties in a Scheduling Area. **Note:** The Imbalance Settlement Responsible may delegate the invoicing responsibility to a more generic role such as Billing Agent.
Interconnection Trade Responsible	Is a balance Responsible Party or depends on one. He is recognized by the Nomination Validator for the nomination of already allocated capacity. **Additional Information:** This is a type of Balance Responsible Party
LFC Operator	Responsible for the load frequency control for its LFC Area or LFC Block **Additional Information:** This role is typically performed by a TSO.

Market Information Aggregator	A party that provides market related information that has been compiled from the figures supplied by different actors in the market. This information may also be published or distributed for general use. **Note:** The Market Information Aggregator may receive information from any market participant that is relevant for publication or distribution.
Market Operator	A market operator is a party that provides a service whereby the offers to sell electricity are matched with bids to buy electricity. **Additional Information:** This usually is an energy/power exchange or platform.
Merit Order List Responsible	Responsible for the management of the available tenders for all Acquiring LFC Operators to establish the order of the reserve capacity that can be activated.
Meter Administrator	A party responsible for keeping a database of meters.
Meter Operator	A party responsible for installing, maintaining, testing, certifying and decommissioning physical meters.
Metered Data Aggregator	A party Responsible for the establishment and qualification of metered data from the Metered Data Responsible. This data is aggregated according to a defined set of market rules.
Metered Data Collector	A party responsible for meter reading and quality control of the reading.
Metered Data Responsible	A party responsible for the establishment and validation of metered data based on the collected data received from the Metered Data Collector. The party is responsible for the history of metered data for a Metering Point.
Metering Point Administrator	A party responsible for registering the parties linked to the metering points in a Metering Grid Area. The party is also responsible for registering and making available the Metering Point characteristics.
Nominated Electricity Market Operator	An entity designated by the competent authority to perform tasks related to single day-ahead or single intraday coupling. Source: Commission Regulation (EU) 2015/1222 (CACM). **Additional Information:** A NEMO performs MCO functions. (Market Coupling

	Operator) A NEMO runs a power exchange related to day-ahead or intraday market. A NEMO is a type of Market Operator.
Nomination Validator	Has the responsibility of ensuring that all capacity nominated is within the allowed limits and confirming all valid nominations to all involved parties. He informs the Interconnection Trade Responsible of the maximum nominated capacity allowed. Depending on market rules for a given interconnection the corresponding System Operators may appoint one Nomination Validator.
Party Connected to the Grid	A party that contracts for the right to consume or produce electricity at an Accounting Point.
Producer	A party that produces electricity. **Additional information:** This is a type of Party Connected to the Grid.
Production Responsible Party	A party who can be brought to rights, legally and financially, for any imbalance between energy nominated and produced for all associated Accounting Points. **Additional information:** This is a type of Balance Responsible Party.
Reconciliation Accountable	A party that is financially accountable for the reconciled volume of energy products for a profiled Accounting Point.
Reconciliation Responsible	A party that is responsible for reconciling, within a Metering Grid Area, the volumes used in the imbalance settlement process for profiled Accounting Points and the actual metered quantities. **Note:** The Reconciliation Responsible may delegate the invoicing responsibility to a more generic role such as a Billing Agent.
Reserve Allocator	Informs the market of reserve requirements, receives tenders against the requirements and in compliance with the prequalification criteria, determines what tenders meet requirements and assigns tenders.
Resource Aggregator	A party that aggregates resources for usage by a service provider for energy market services.
Resource Provider	A role that manages a resource and provides production/consumption schedules for it, if required.

Scheduling Agent	The entity or entities with the task of providing schedules. **Source:** System Operation Guideline, Commission Regulation (EU) 2017/1485. **Additional information:** A party that is responsible for the schedule information and its exchange on behalf of a Balance Responsible Party.
Scheduling Area Responsible	A party responsible for the coordination of nominated volumes within a scheduling area. **Additional information:** This role is typically performed by a TSO.

5.1.1 Business Use-Cases Template (BUCs)

A similar approach was followed by the EU-SysFlex H2020 project, where the IEC62559 standard was followed during the design phase of the use-cases. This procedure is elaborately presented in the public Deliverable D3.3: "Business Use Cases for Innovative System Services"[3]. In this document the methodology followed is explicitly described. In order to be compliant with the IEC62559-2 standard the process that is being followed towards the definition of the business use cases includes the following 3 main steps:

1. **Step 1 – Description of the service / market layer:** each demo should provide a description of the market environment for each one of the envisioned services. A narrative should also be provided of how the service works within the defined environment.
2. **Step 2 – Consolidation of a common Role Model:** the various roles involved in each of the services of each demo should be defined according to
3. Table 1
4. **Step 3 – Definition of the Business use cases:** the actual BUCs should be defined for each one of the services.

As part of the Use-Case template, we need to include sequence diagrams, which comprise an illustrative demonstration of each BUC. Similarly to the BUCs, a template for the sequence diagrams has been provided to the demos. Therefore, each BUC is accompanied by the respective sequence diagram.

Table 2 BUC Template (based on IEC62559)

<Type the Name of the Business Use-Case here>		
1. Description of the Use case		
BUC_ID	**Market Time-Frame (real time (system operation),**	**Name of the Use case**

[3] EU-SysFlex Project, Deliverable 3.3 "Business Use Cases for Innovative System Services", Cyril Effantin, Philippe Loevenbruck, 2018, http://eu-sysflex.com/wp-content/uploads/2019/03/D3.3_Business-Use-Cases-for-Innovative-System-Services.pdf

	Intra-day/Day-Ahead (Operational Planning), Months-Years Ahead (Long-term planning))	

2. Scope and Objectives of the Use-Case	
Scope	
Objectives	
3. Narrative of the use-case	
Please provide a narrative description of the "storyline" of the use-case. -What is the context -What problem does it address -How does it solve the problems -Why is it innovative	
4. Complete description	
Please provide the detailed description of the use-case. Provide all the details around the context and how the demo will exactly address the issues raised above. Use a step-wise approach (if applicable). What is the first step? How is the process initiated? Who does what? Describe the next steps leading to the end of the use-case. You may also provide diagrams and figures if necessary or available at the moment.	
5. Assumptions - Prerequisites	
Please provide any assumptions made for simplification or for other reasons. Also any prerequisites that are needed beforehand for the smooth execution of the use case.	
6. Services	
Short description of the services provided through the BUC	
7. Actors	
Please consult the table above containing the list of actors. Mention in the rows below all the actors that are involved within your demonstrator as long as a short description for each one concerning their role.	

Actor Name	**Actor Description**

Moreover, a supplementary table is provided to demos. However, this was not obligatory to be filled, but optionally in case where the demos wanted to provide further info.

Table 3 Summary of one BUCs template

BUC ID	
BUC Name	
Services	
New Mechanism in the demo (even if the service already exists)	
Assets used	
Product	
Market Mechanism	

Next sub-sections provide the Business Use Cases and Sequence Diagrams for each demo, based on the material they have prepared, as well as based on their responses to questionnaires and teleconferences with the Task and Work Package leaders. Finally, the chapter provides comparison tables on the Business Use Cases and Sequence Diagrams among demos.

5.2 Demo 5.1

5.2.1 Business Use Cases of Demo 5.1

5.2.1.1 Congestion management "SO-Supplier" Business Use Case

defined, the process model, the information, application, communication & technical architecture should be derived

Table 4 BUC of Demo 5.1 for Congestion management "SO-Supplier"

Congestion management "SO-Supplier"		
1. Description of the Use case		
BUC_ID	**Market Time-Frame (real time (system operation), Intra-day/Day-Ahead (Operational Planning), Months-Years Ahead (Long-term planning))**	**Name of the Use case**
5.1a	Market Time-Frame: Day-Ahead (Operational Planning) Months-Years Ahead	"SO-Supplier"
2. Scope and Objectives of the Use-Case		
Scope	To provide flexibility by means of power production from programmable DG system (CHP plant)	
Objectives	Provide flexibility in the congestion management - short term	
3. Narrative of the use-case		
The Osimo demosite is a municipal microgrid managed by a local DSO owned by a local utility ASTEA which also manages a 1.2 MWe CHP plant connected to the local district heating network. Osimo demo site is situated in Marche Region, on the Adriatic see. This Region is characterized by the absence of big centralized power plant but there are hundreds of DG PV plant. In order to cope with sudden lacks of power production or during scheduled hours of the day, the TSO/DSO could ask to ASTEA, as local producer/flexibility provider, to provide reserve of capacity from the CHP plant both ramp up (engine switched on) or down (engine switched off). Please note that, since the CHP plant is always switched on in winter it cannot provide flexibility. Hence, this use case can only happen in summer or mid-season, not during heating season. Terna, the TSO, can ask flexibility directly to ASTEA or through an Aggregator (Balancing Service Provider). Theoretically, time scale could be day-ahead until 15-minutes hours before the		

flexibility is required.

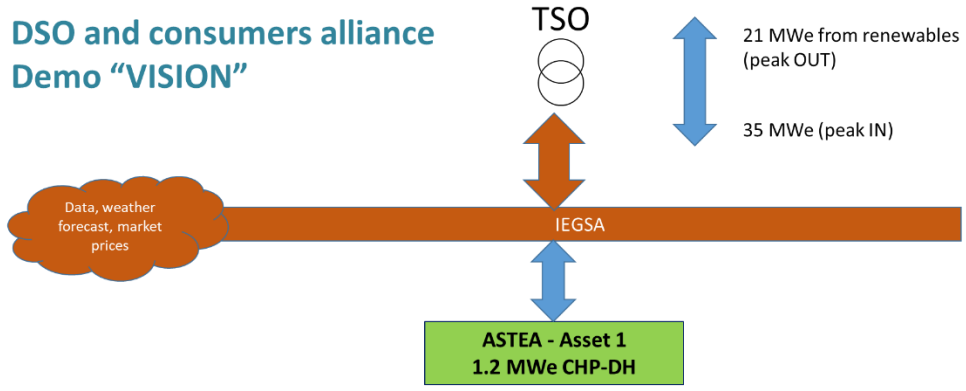
4. Complete description

Assumptions:
Usually the program happens in summer, while the period of availability is from Monday to Friday from 14.00 until 20.00
ASTEA is the electricity producer and it schedules the operations of CHP plant according to the optimal management strategies of the CHP-DH network;
ASTEA schedules production for a whole year (day-ahead, month-ahead and year ahead)

Actions:

- The TSO or the DSO send an order for balancing power (in the period of availability);
- ASTEA, accepts the order to modify its production pattern profile
-
- The TSO/DSO verifies in real time that ASTEA respect the program
- If the case, the TSO/DSO can ask for a change of the program
- When flexibility is not required anymore, the TSO/DSO frees ASTEA via a "release order"
- ASTEA accepts the "release order"
- ASTEA continues to operate with previously scheduled operation

ASTEA is remunerated by an agreed amount for each MWh of flexibility (if program have been correctly carried out)



Congestion management TSO-Supplier

5. Assumptions - Prerequisites

- Since the Italian TSO is not involved in the project we can only simulate the TSO participation
- the period of availability is form Monday to Friday from 14.00 until 20.00
- ASTEA is the electricity producer and it schedules the operations of CHP plant according to the optimal management strategies of the CHP-DH network;

6. Services

Congestion management – short term planning

7. Actors	
Actor Name	**Actor Description**
ASTEA	Supplier/Flexibility Provider
Terna	TSO
DEA	DSO

Table 5 Summary of BUC of Demo 5.1 for "SO-Supplier"

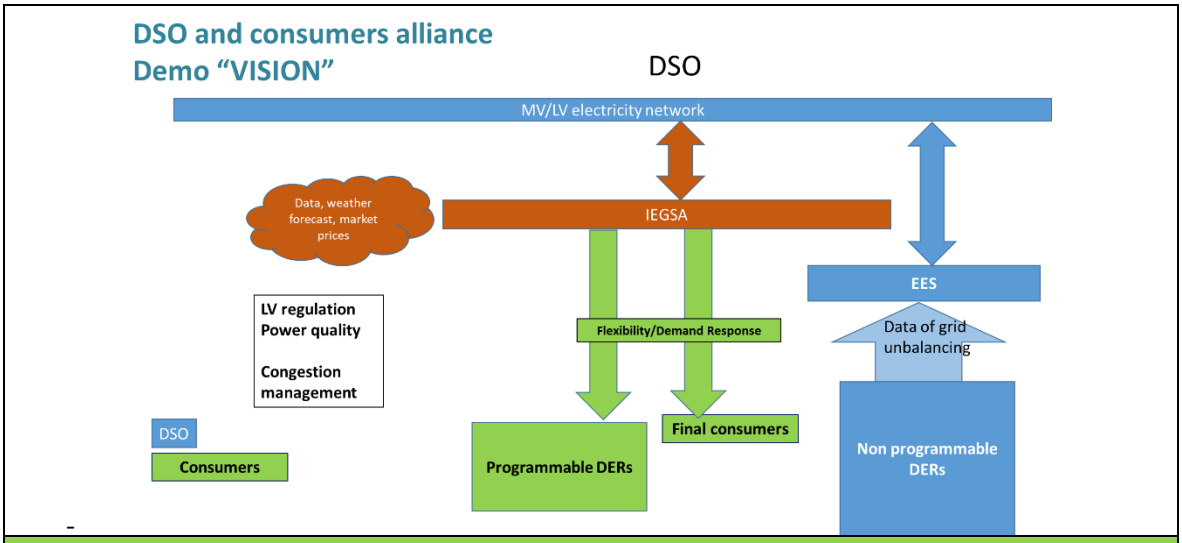
BUC ID	**FI-AP1**
BUC Name	**"SO-Supplier"**
Services	Congestion management – short term planning
New Mechanism in the demo (even if the service already exists)	The mechanism is new in the Demo. ASTEA, as flexibility provider participates to the GPP (management of planned production) platform organized by GSE.
Assets used	CHP plant (coupled with thermal storage)
Product	Capacity
Market Mechanism	Day-ahead

5.2.1.2 Congestion management "LV regulation Power quality" Business Use Case

Table 6 BUC of Demo 5.1 for Congestion management "LV regulation Power quality"

Congestion management "LV regulation Power quality"		
1. Description of the Use case		
BUC_ID	**Market Time-Frame (real time (system operation), Intra-day/Day-Ahead (Operational Planning), Months-Years Ahead (Long-term planning))**	**Name of the Use case**

5.1b	Market Time-Frame (real time (system operation), Intra-day (Operational Planning)	"LV regulation Power quality"
2. Scope and Objectives of the Use-Case		
Scope	Use of battery storage and DR program to optimally exploit the local production of renewable energy	
Objectives	Increase power quality in suburban branches of LV grid with a high share of renewable energy	
3. Narrative of the use-case		
Within the municipal multi energy microgrid the DSO identified some countryside branches characterized by high production of PV plant and poor consumption of electricity. This situation translates in several problem related to power quality. In this use case the DSO asks for flexibility to final users and Programmable DERs as a measure to face LV quality poorness due to high production of non-programmable renewable energy. This use case is applied on specific suburban/countryside branches featured by a high penetration of PV production. The DSO will install EES (100+100 kWh) as buffers in the LV grid in order to deal with renewable energy production. At the same time EES will act as an alarm bell: when it will be close to its maximum operational potential, the DSO will ask, through the IEGSA platform, the final users and programmable DER installed on the branch of the grid, for more flexibility in the grid.		
4. Complete description		
- The DSO monitors in real time the BESS and the quality parameters of the suburban branches - When the SOC of the batteries reach a predefined level the DSO send a request to large final user in order to modify the consumption of their schedulable loads; at the same time, the DSO send a request to small residential final user in order to modify the consumption of their schedulable loads - The DSO monitors that the program is respected by final users - If the program is respected the large user will be rewarder in EUR - If the program is respected the residential users will be rewarded with non-economic incentives		



5. Assumptions - Prerequisites
As in previous use case.
6. Services
Congestion management - operational
7. Actors

Actor Name	**Actor Description**
DEA	Local DSO
ASTEA	Balancing Service Provider (acting as aggregator of large -itself – and residential) users
Final users	Flexibility provider

Table 7 Summary of BUC of Demo 5.1 for "LV regulation Power quality"

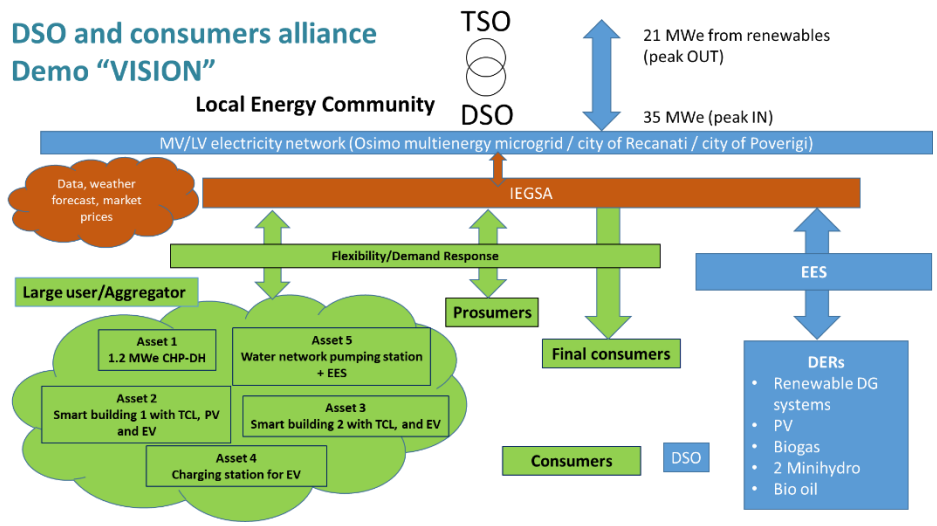
BUC ID	**FI-AP1**
BUC Name	**"LV regulation Power quality"**
Services	Balancing
New Mechanism in the demo (even if the service already exists)	Introduction of an early stage DR program
Assets used	Battery on LV grid (100+100 kWh)
Product	Capacity
Market Mechanism	Demand response

5.2.1.3 Congestion management "Local Energy Community" Business Use Case

Table 8 BUC of Demo 5.1 for "Local Energy Community"

"Local Energy Community"		
1. Description of the Use case		
BUC_ID	**Market Time-Frame (real time (system operation), Intra-day/Day-Ahead (Operational Planning), Months-Years Ahead (Long-term planning))**	**Name of the Use case**
5.1c	Market Time-Frame (real time (system operation), Intra-day (Operational Planning),	"Local Energy Community"
2. Scope and Objectives of the Use-Case		
Scope	Exploit the synergies among energy network in a municipal scale multi energy microgrids in order to maximize the self-consumption of locally produced renewable energy	
Objectives	Increase the flexibility of the microgrid in order to reduce the amount of electricity flow back to the TSO	
3. Narrative of the use-case		
Osimo microgrid operates for more than 650 hours per year in island mode, being able to cover its electricity consumption with renewable energy and CHP. This means that the excess of electricity is injected back to the national grid (TSO). Obviously, the electricity injected back to the TSO differs from season to season: indeed, in winter the amount is lower in terms of both power (about 2 MW) and time (about 2 hours); in summer, the amount is higher in terms of power (peak is 15 MW) and time (about 9 hours). In this use case, the whole municipal microgrid is involved. In this case, the DSO managing all the microgrid asks to all the flexibility providers within the microgrid for more flexibility in order to locally exploit as much renewable energy as possible, by reducing the electricity flow back to the TSO. Among the flexibility providers, ASTEA will act as Flexibility Service Provider by managing all its assets (CHP-TES-DH network, water network pumping stations, EV charging stations, energy flexible buildings).		
4. Complete description		
- Local DSO monitors in real time the local energy production and the electricity withdrawn from the TSO - When excess of local electricity production is foreseen the DSO asks to all the final users within the energy community (ASTEA as an Aggregator of its assets		

and residential users) to modify their consumption patterns



5. Assumptions - Prerequisites

As in previous use case.

6. Services

Congestion management - operational

7. Actors

Actor Name	Actor Description
DEA	DSO
ASTEA	Aggregator/Balancing service provider

Table 9 Summary of BUC of Demo 5.1 for "Local Energy Community"

BUC ID	**FI-AP1**
BUC Name	**"Local Energy Community"**
Services	Congestion management - operational
New Mechanism in the demo (even if the service already exists)	Introduction of an early stage DR-Program
Assets used	Distributed batteries, CHP with thermal energy storage, EV, scheduling of pumping stations, DR in buildings
Product	Capacity
Market Mechanism	Demand Response

5.2.2 Sequence Diagrams of Demo 5.1

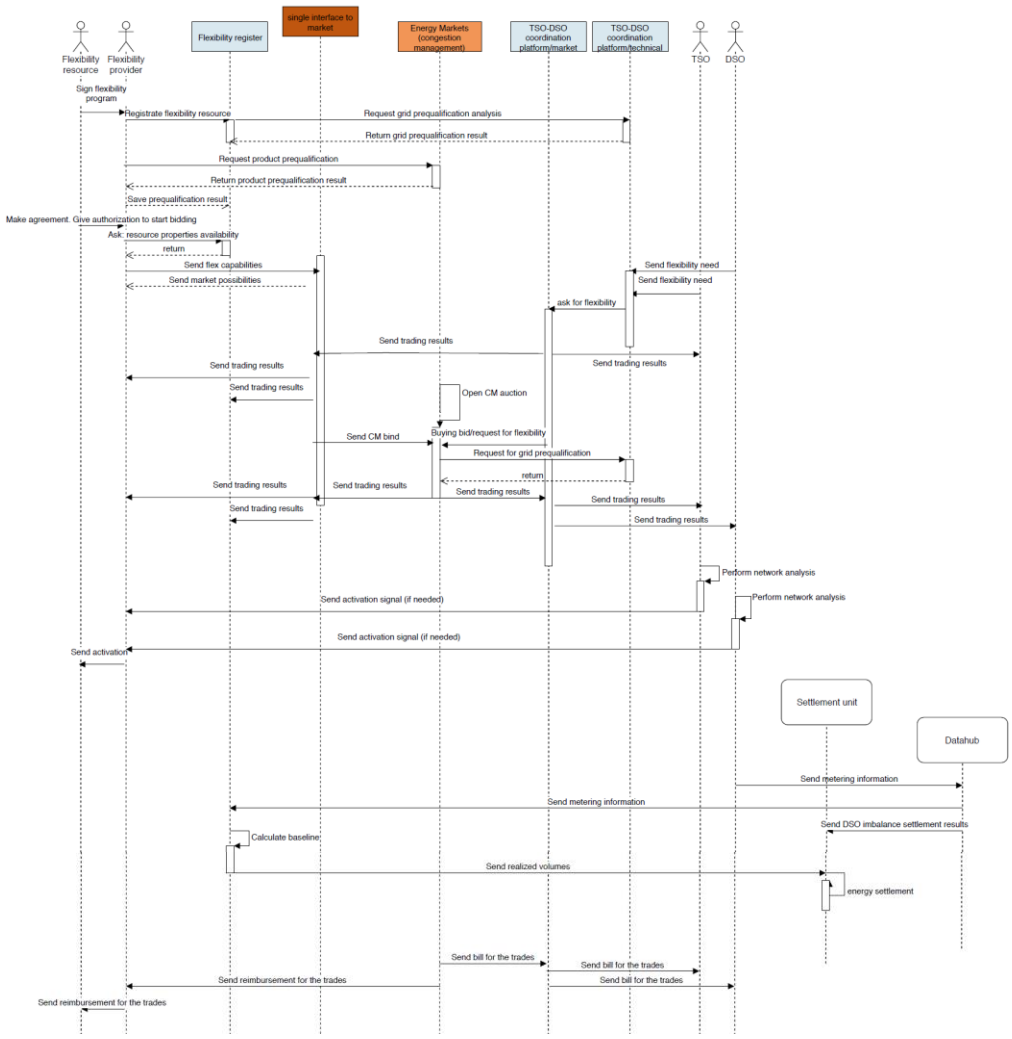


Figure 3: Sequence diagram of demo 5.1 for Congestion Management "TSO supplier"

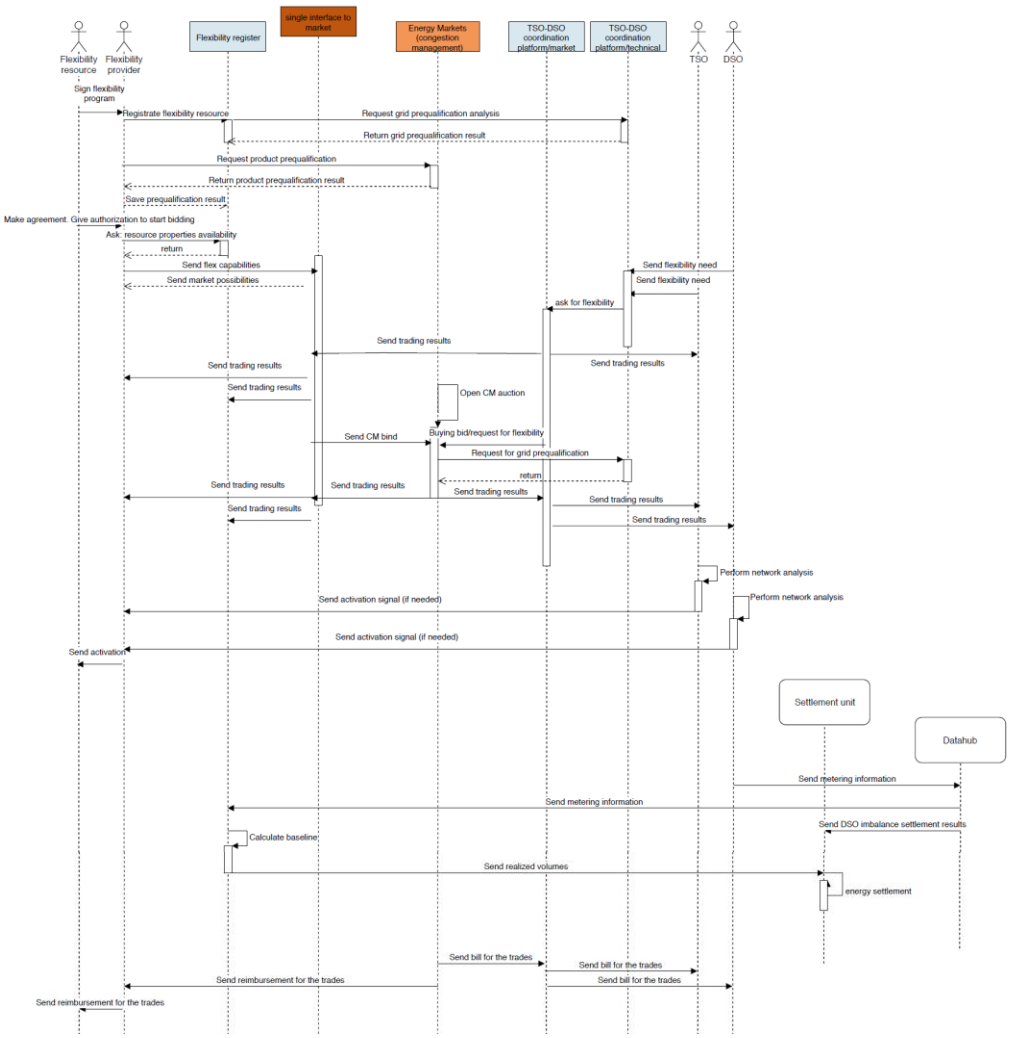


Figure 4: Sequence diagram of demo 5.1 for Congestion Management "LV regulation Power quality"

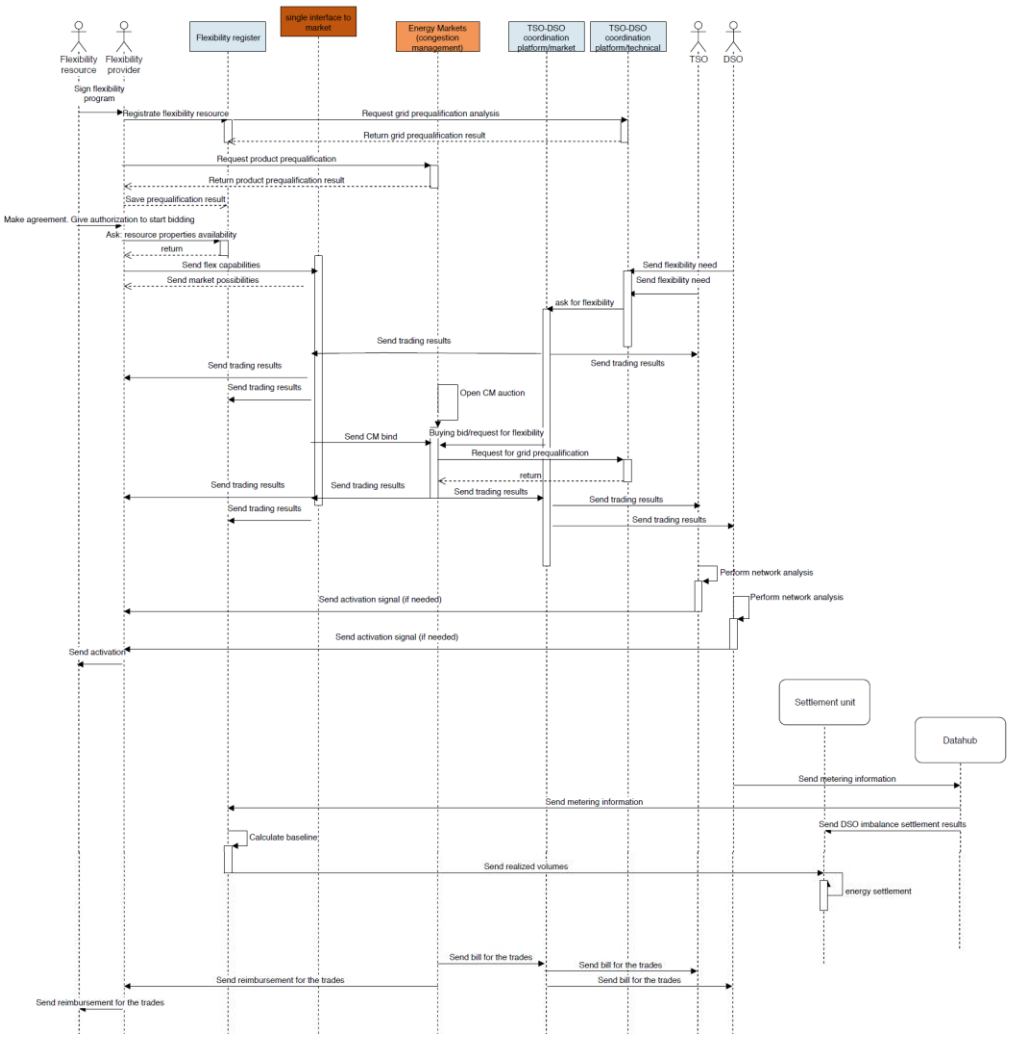


Figure 5: Sequence diagram of demo 5.1 for "Local Energy Community"

5.3 Demo 5.2

5.3.1 Business Use Case of Demo 5.2

Table 10 BUC of Demo 5.2

Aggregated CM service to the TSO/DSO **Fast balancing reserve to the TSO** **Non-frequency ancillary services to the TSO/DSO**		
8. Description of the Use case		
BUC_ID	**Market Time-Frame (real time (system operation), Intra-day/Day-Ahead (Operational Planning), Months-Years Ahead (Long-term planning))**	**Name of the Use case**
5.2	Market Time-Frame (real time system operation), Intra-day/Day-Ahead (Operational Planning)	Aggregated CM to TSO/DSO Balancing mFRR to TSO Non-frequency services to TSO/DSO
9. Scope and Objectives of the Use-Case		
Scope	To provide CM service to the TSO/DSO by using part of the power/energy capacity of one (or more) Battery Energy Storage Systems (BESS) installed in multi-user buildings (or group of homes) with PV and particular loads, such as EV and data centers.	
Objectives	To provide CM services to the TSO/DSO by using battery energy storage system (BESS) integrated in end-user communities (group of households, multi-user building,…) to form an controllable aggregated demand resource.	
10. Narrative of the use-case		
The demonstrator T5.2 will deal with a BESS integrated in a multi-user building, which presents interesting characteristics, since it counts on PV generation, has to charge fleet of EV and requires high-power quality and supply reliability levels, since it has an important data center working 24/7. From the end-user perspective, the BESS will be able to modulate the electricity consumption of the building, in order to reduce electricity cost. Moreover, the BESS would allow improving supply reliability, since it would act as a large UPS with capacity for working as an island in case of outages and resynchronizing to the grid when the service is restored. Moreover, this BESS will be able to provide flexibility and ancillary services to the DSO/TSO. The BESS will count on a quite advanced hierarchical control system, which will offer sophisticated functionalities going beyond conventional requirements in existing grid codes (voltage/frequency regulation, LVRT, …) and regular grid services traded currently in markets (balance, congestion, …).		

It is worth to highlight that even though the demonstrator developed in T5.2 will deal only with a single building-integrated BESS, the hierarchical control system will be enabled to deal with several BESS in an area. This kind of performance will be demonstrated in a real-time HIL simulation lab.

As novelty, the building-integrated BESS developed in T5.2 will be based on 'grid forming' technology, which will allow providing advanced interesting services, such as inertia emulation, power oscillation damping and power quality improvement, as well as operating in island mode, being even able to provide black-start capacity to the DSO.

Moreover, the BESS hierarchical control system will be enabled to interact with its surrounding area by using signals received from a wide-area measurement system (WAMS). These measurements can be provided by the TSO/DSO, or can be provided by additional measuring units installed in the system. The control algorithms developed in at the area level will used the grid model to intelligently evaluate the impact of each service provided by the BESS, which will allow minimizing risks when several services are enquired by the TSO and DSO.

After meetings with the end-user to know its needs, it stated its interest in integrating the BESS to increase the amount of exiting local PV generation and to improve supply reliability, since it experienced several outages in the last years. Actually, the DSO mentioned a substation was reinforced in order to reduce such supply problems. Based on further discussions with the DSO, it stated its interest in testing the performance of the BESS to reduce congestion in the distribution networks, as well as to regulate the voltage profile along the feeder. Regarding discussions with the TSO, it stated its interest in evaluation the performance of distribution-integrated BESS to minimize congestions in the line that connect the Sofia's ring to the rest of the system. He also mentioned that the BESS might be useful for providing fast frequency regulation reserve.

Therefore, as a first estimation, the building integrated BESS developed in T5.2 could be used to provide flexibility products addressed to balancing, congestion management and supply quality services –assuming all these markets are available and ready to qualify the distribution-integrated BESS as flexibility resource.

11. Complete description

The BESS hierarchical control system will present a similar operative procedure for all the services provided by the system. In this regard, we assume the operation of the demonstrator developed in T5.2 can be scheduled according the following steps, which are scheduled in the diagram shown in the attached document:

- Flexibility resource qualification. The flexibility resource provider will request for prequalification from the corresponding system operator (or from a coordination platform) by providing preliminary technical analysis demonstrating the effectiveness of the services and its capacity to properly maintain such services along time.
- Flexibility products prequalification. The flexibility products generated by the BESS will be qualified to participate in their corresponding markets. The products parameters, availability and performance indexes should match the market requirements.
- Flexibility products rating. The energy resource management system (ERMS)

implemented at high-level control layers of the BESS will conduct an optimization process to maximize the BESS outcome according to given objective functions and considering operational constrains. The objective functions can be focused on maximizing the end-user benefit, maximizing renewables penetration, improving given grid performance indexes, etc. The ERMS will enquire to the IEGSA for significant information to solve the optimization problem in each case (exiting resource data, market data, etc). Likewise, the ERMS will require additional predictive data regarding weather, demand, system performance. Additionally, the ERMS will ask to lower-level controllers for information describing the BESS operating conditions.

- Flexibility products biding. The ERMS will solve optimization scenarios with a cadency of several minutes (around 5 min) and will prepare orders based on tendencies analyses to participate in several services markets according to the system operator requirements and end-user parametrization. We assume that the IEGSA will offer a unified interface to access to several service markets (balancing mFRR, CM TSO, CM DSO, and non-frequency), being IEGSA the entity in charge of adapting orders to the required formats and deadlines for each MOL. Likewise, we assume that IEGSA will provide a common interface to the TSO and DSO to set flexibility orders for different markets.
- Flexibility products booking. Once the booked orders are properly cleared in each market, they will be registered and both the TSO/DSO and the resource providers will be reported about trade results. Likewise, the IEGSA will communicate with the BESS controllers to 'program' the services ready to be activated under the TSO/DSO request.
- Flexibility products activation. The TSDO/DSO can activate the grid services (products) programmed in the BESS according to the results from the online technical analyses conducted on the system. This activation enquiry will be registered. The service provider might reject a service activation from the TSO/DSO in case the grid services management system (GSMS), based on local area analyses, raises any operational risk in the system.
- Flexibility products accounting. Once a flexibility product is activated in the BESS, those corresponding system signals will be registered by the service provider and by the TSO/DSO. Information from both actors will be sent for registration once the service provision executed. The registration entity will process all the information and will send final transitive information to the energy settlement unit.
- Flexibility products billing. The energy settlement unit will prepare and send invoices and payment titles.

12. Assumptions – Prerequisites

- Selected information from both the TSO and DSO information system (SCADA) should be available as feedback signals to execute the area-level functionalities programmed in the area-level controller.
- The building-integrated BESS will be operated by several client interfaces, with hierarchical priorities.

- The IEGSA will provide a common interface to markets to the BESS operator
- The IEGSA will provide significant information to run the ERMS and the GSMS

13. Services

- Balancing mFRR
- CM TSO
- CM DSO
- Non-frequency based services.

14. Actors

Actor Name	**Actor Description**
Building end-user	End user
CEZ	DSO
ESO	TSO

5.3.2 Sequence Diagram of Demo 5.2

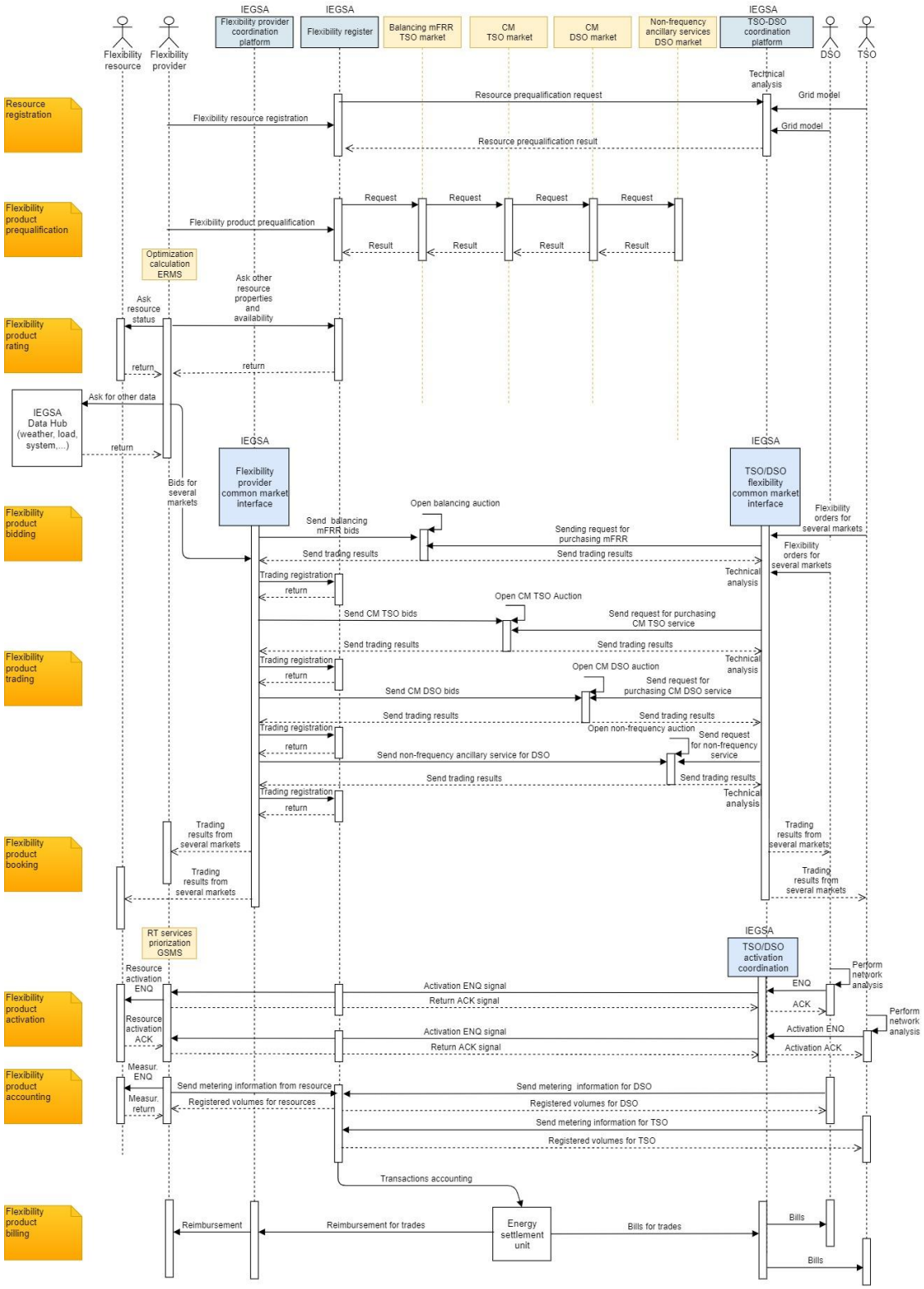


Figure 6: Sequence diagram of demo 5.2 for "Aggregated CM service to the TSO/DSO": "Fast balancing reserve to the TSO" and "Non-frequency ancillary services to the TSO/DSO Local Energy Community"

5.4 Demo 5.3

5.4.1 Business Use Case of Demo 5.3

Tables 11 BUC of Demo 5.3

mFRR demonstration: Single Flexibility Platform		
15. Description of the Use case		
BUC_ID	**Market Time-Frame (real time (system operation)**	**mFRR demonstration: Single Flexibility Platform**
16. Scope and Objectives of the Use-Case		
Scope	mFRR – Estonia, Latvia, Finland	
Objectives	Manual Frequency Restoration is a manual change in the operation set-points of the reserve (mainly by re-scheduling), in order to restore system frequency to the set point value frequency and, for a synchronous area consisting of more than one load-frequency control area, to restore power balance to the scheduled value.	
17. Narrative of the use-case		
mFRR demonstration: Single Flexibility Platform • Flexibility need publication and viewing • Prequalification • Capacity procurement • Energy procurement • Balance Settlement • Financial settlement		
18. Complete description		
User story: https://alf.eurodyn.com/share/page/site/interrface/document-details?nodeRef=workspace://SpacesStore/9a998cdf-7fe7-4c8f-981e-9d69281fb9ae		
19. Assumptions - Prerequisites		
Balancing markets as they exist today. Integration in terms of information exchange is needed between MARI and Single Flexibility Platform. References: [1] COMMISSION REGULATION (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation. Link. [2] COMMISSION REGULATION (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing. Link. [3] Explanatory Document to all TSOs' proposal on a list of standard products for balancing capacity for frequency restoration reserves and replacement reserves in accordance with Article 25(2) of Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a		

guideline on electricity balancing. Link. [4] Manually Activated Reserves Initiative (MARI) is the European implementation project for the creation of the European mFRR platform. Link.
20. Services
mFRR
21. Actors
User story: https://alf.eurodyn.com/share/page/site/interrface/document-details?nodeRef=workspace://SpacesStore/9a998cdf-7fe7-4c8f-981e-9d69281fb9ae

aFRR demonstration: Single Flexibility Platform		
22. Description of the Use case		
BUC_ID	**Market Time-Frame (real time (system operation)**	**aFRR demonstration: Single Flexibility Platform**
23. Scope and Objectives of the Use-Case		
Scope	aFRR – Estonia, Latvia, Finland	
Objectives	Frequency restoration reserves or 'FRR' means the active power reserves available to restore system frequency to the nominal frequency and, for a synchronous area consisting of more than one LFC area, to restore power balance to the scheduled value [1]. TSOs and DSOs are obligated to cooperate in order to facilitate and enable the delivery aFRR by units located in the distribution systems [1]. This service is a centralized automatic function intended to replace FCR and restore the frequency to the target frequency – usually 50.00Hz. In contrast to mFRR, aFRR 'can be activated by an automatic control device'. This control device shall be an 'automatic control device designed to reduce the Frequency Restoration Control Error (FRCE) to zero' [1].	
24. Narrative of the use-case		
aFRR demonstration: Single Flexibility Platform • Flexibility need publication and viewing • Prequalification • Capacity procurement • Energy procurement • Balance Settlement • Financial settlement		
25. Complete description		
User story: https://alf.eurodyn.com/share/page/site/interrface/document-details?nodeRef=workspace://SpacesStore/9a998cdf-7fe7-4c8f-981e-9d69281fb9ae		
26. Assumptions - Prerequisites		

Balancing markets as they exist today. Integration in terms of information exchange is needed between MARI and Single Flexibility Platform. Unit of measurement: MWh for activated bids Existing service Full activation time: 30s to 15 min, PICASSO – 5 min References: [1] COMMISSION REGULATION (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation. Link. [2] Explanatory Document to all TSOs' proposal on a list of standard products for balancing capacity for frequency restoration reserves and replacement reserves in accordance with Article 25(2) of Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing. Link. [3] All TSOs' proposal for the implementation framework for the exchange of balancing energy from frequency restoration reserves with automatic activation in accordance with Article 21 of Commission Regulation (EU) 2017/2195 establishing a guideline on electricity balancing. Link. [4] COMMISSION REGULATION (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing. Link. [5] The Platform for the International Coordination of Automated Frequency Restoration and Stable System Operation (PICASSO). Link.
27. Services
aFRR
28. Actors
User story: https://alf.eurodyn.com/share/page/site/interrface/document-details?nodeRef=workspace://SpacesStore/9a998cdf-7fe7-4c8f-981e-9d69281fb9ae

FCR demonstration: Single Flexibility Platform		
29. Description of the Use case		
BUC_ID	**Market Time-Frame (real time (system operation)**	**FCR demonstration: Single Flexibility Platform**
30. Scope and Objectives of the Use-Case		
Scope	FCR – Estonia, Latvia, Finland	
Objectives	Frequency containment is an automatic function which aims at stabilising the frequency at a steady-state value within the permissible maximum steady-state frequency deviation after disturbances in the high-voltage grid. By the joint action of all automatic devices, the process ensures the operational reliability in the synchronous area. Frequency containment reserves or 'FCR'	

	means the active power reserves available to contain system frequency after the occurrence of an imbalance [1] TSOs and DSOs are obligated to cooperate in order to facilitate and enable the delivery of aFRR by units located in the distribution systems [1].

31. Narrative of the use-case

FCR demonstration: Single Flexibility Platform

- Flexibility need publication and viewing
- Prequalification
- Capacity procurement
- Financial settlement

32. Complete description

User story: https://alf.eurodyn.com/share/page/site/interrface/document-details?nodeRef=workspace://SpacesStore/9a998cdf-7fe7-4c8f-981e-9d69281fb9ae

Balancing / reserve markets as they exist today. Balancing markets as they exist today. Integration in terms of information exchange is needed between MARI and Single Flexibility Platform.

Unit of measurement: MWh

Existing service

Full activation time: 5s-3min

33. Assumptions - Prerequisites

References:

[1] COMMISSION REGULATION (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation. Link.

[2] COMMISSION REGULATION (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing. Link.

[3] The common market for procurement and exchange of FCR (FCR Cooperation). Link.

[4] TSOs' proposal for the establishment of common and harmonised rules and processes for the exchange and procurement of Balancing Capacity for Frequency Containment Reserves (FCR) in accordance with Article 33 of Commission Regulation (EU) 2017/2195 establishing a guideline on electricity balancing. Link.

34. Services

FCR-n

FCR-d

https://www.fingrid.fi/en/electricity-market/reserves_and_balancing/reserve-market-information/frequency-controlled-disturbance-reserve/

35. Actors

User story: https://alf.eurodyn.com/share/page/site/interrface/document-details?nodeRef=workspace://SpacesStore/9a998cdf-7fe7-4c8f-981e-9d69281fb9ae

Congestion management operational demonstration: Single Flexibility Platform		
36. Description of the Use case		
BUC_ID	**Market Time-Frame real-time operation (within operational hour)**	**Congestion management operational demonstration: Single Flexibility Platform**
37. Scope and Objectives of the Use-Case		
Scope	Congestion management operational – Estonia, Latvia, FInland	
Objectives	In order to solve operational hour internal congestions, TSO/DSO could use flexibility with locational information for congestion management. Default service criteria could be the same as mFRR, but used internally by TSOs / DSOs for congestion management operations (not for balancing markets) and activation decision will be done in real-time (during H-1) and manually by a dispatcher. Default mFRR product description is proposed to boost liquidity. Flexibility product of congestion management operational should be sufficiently aligned to permit the market-based allocation of flexibility between these different purposes with the objective of an efficient allocation that maximises the value of flexibility services. Identical products in different markets are not needed, but interoperability would enable exchange between markets. The product should be either an option (available capacity) or direct activation, but availability products have to be designed properly to avoid a decrease in market liquidity due to non-activation of contracted products. To ensure the right balance between availability and market liquidity, DSOs and TSOs will agree on how to coordinate on this. [2] (Page 22-23) In WP 5.3, we're analysing direct activation and coordination mechanisms between TSO-DSO to ensure flexibility bids won't cause congestion in TSO / DSO grid.	
38. Narrative of the use-case		
Congestion management operational demonstration: Single Flexibility Platform • Flexibility need publication and viewing • Capacity procurement • Energy procurement • Counter activation energy procurement • Balance Settlement		

39. Complete description
User story: https://alf.eurodyn.com/share/page/site/interrface/document-details?nodeRef=workspace://SpacesStore/9a998cdf-7fe7-4c8f-981e-9d69281fb9ae
40. Assumptions - Prerequisites
• Congestion management operational is a new service. • Auctions for congestion management, separated from balancing, wholesale markets. • Market based tariff. • Unit of measurement: MWh for activated bids. • As for standard mFRR product, the TSOs foresee using a linear ramp of 10 minutes for the cross-border exchange. Full activation time is set at maximum 12.5 minutes. [1] • Congestion management operational implemented on Single Flexibility Platform, coordination scheme is TSO-DSO coordination. • Difference between congestion management short-term: activation decision will be done real-time (during market time unit) manually by a dispatcher. References: [1] Manually Activated Reserves Initiative (MARI) is the European implementation project for the creation of the European mFRR platform. Link [2] TSO – DSO REPORT AN INTEGRATED APPROACH TO ACTIVE SYSTEM MANAGEMENTWITH THE FOCUS ON TSO – DSO COORDINATION IN CONGESTION MANAGEMENT AND BALANCING. Link.
41. Services
Congestion management operational
42. Actors
User story: https://alf.eurodyn.com/share/page/site/interrface/document-details?nodeRef=workspace://SpacesStore/9a998cdf-7fe7-4c8f-981e-9d69281fb9ae

Congestion management short-term demonstration: Single Flexibility Platform		
43. Description of the Use case		
BUC_ID	**Market Time-Frame real-time operation (within operational hour)**	**Congestion management short-term demonstration: Single Flexibility Platform**
44. Scope and Objectives of the Use-Case		
Scope	Congestion management short-term – Estonia, Latvia, Finland	
Objectives	In order to solve short-term planning timeframe internal congestions, TSO/DSO could use flexibility with locational information for	

	congestion management. Default service criteria could be same as mFRR, but used internally by TSOs / DSOs for congestion management short-term (not for balancing markets). Activation decision will be done D-1 (grid calculations and congestion check one day in advance for every operational hour (market time unit)) by a short-term planner. Possible to start a market auction by TSO /DSO (day ahead, month ahead). Short term planning congestions may rise due to outages, maintenance or production patterns. The procurement of flexibility for congestion management could be seen D-1 until M-1. The earlier procurement of flexibility is relevant for example for maintenance schedule approval, which, depending on SO processes, could be done month ahead. Default mFRR product description is proposed to boost liquidity. Flexibility product of congestion management short-term should be sufficiently aligned to permit the market-based allocation of flexibility between these different purposes with the objective of an efficient allocation that maximises the value of flexibility services. Identical products in different markets are not needed, but interoperability would enable exchange between markets. The product should be either an option (available capacity) or direct activation, but availability products have to be designed properly to avoid a decrease in market liquidity due to non-activation of contracted products. To ensure the right balance between availability and market liquidity, DSOs and TSOs will agree on how to coordinate on this. [2] (Page 22-23) In WP 5.3, we're analysing direct activation and coordination mechanisms between TSO-DSO to ensure that flexibility bids won't cause congestion in TSO / DSO grid.

45. Narrative of the use-case

Congestion management short-term demonstration: Single Flexibility Platform

- Flexibility need publication and viewing
- Capacity procurement
- Energy procurement
- Counter activation energy procurement
- Balance Settlement

46. Complete description

User story: https://alf.eurodyn.com/share/page/site/interrface/document-details?nodeRef=workspace://SpacesStore/9a998cdf-7fe7-4c8f-981e-9d69281fb9ae

47. Assumptions - Prerequisites

- Congestion management short-term is a new service.
- Auctions for congestion management, separated from balancing, wholesale markets.
- Market based tariff.

- Unit of measurement: MWh for activated bids.
- As for standard mFRR product, the TSOs foresee using a linear ramp of 10 minutes for the cross-border exchange. Full activation time is set at maximum 12.5 minutes. [1]
- Congestion management short-term implemented on Single Flexibility Platform, coordination scheme is TSO-DSO coordination.
- Difference between congestion management operational: The procurement of flexibility for congestion management could be seen D-1 until M-1 by short-term planner. Possible to start a market auction by TSO /DSO (day ahead, month ahead). Operational: activation decision will be done real-time (during market time unit) manually by a dispatcher.

References:

[1] Manually Activated Reserves Initiative (MARI) is the European implementation project for the creation of the European mFRR platform. Link

[2] TSO – DSO REPORT AN INTEGRATED APPROACH TO ACTIVE SYSTEM MANAGEMENTWITH THE FOCUS ON TSO – DSO COORDINATION IN CONGESTION MANAGEMENT AND BALANCING. Link.

Congestion management long-term demonstration: Single Flexibility Platform		
48. Description of the Use case		
BUC_ID	**Market Time-Frame months-years ahead (long-term planning)**	**Congestion management long-term demonstration: Single Flexibility Platform**
49. Scope and Objectives of the Use-Case		
Scope	Congestion management long-term – Estonia, Latvia, FInland	
Objectives	An envisaged service that may serve network reinforcement deferral, network support during construction and planned maintenance, where location-specific flexibility assets are being activated for shaving or shifting peak demand and production in order to compensate for the lack of network connections, loads or production units. Therefore in order to solve long-term planning congestions, TSO/DSO could use flexibility with locational information for congestion management. Default service criteria could be same as mFRR, but used internally by TSOs / DSOs for congestion management long-term (not for balancing	

	markets). Default mFRR product description [1] is proposed to boost liquidity. Identical products in different markets are not needed, but interoperability would enable Exchange between markets. The product should be either an option (available capacity) or direct activation, but availability products have to be designed properly to avoid a decrease in market liquidity due to non-activation of contracted products. To ensure the right balance between availability and market liquidity, DSOs and TSOs will agree on how to coordinate on this. [2] (Page 22-23) In WP 5.3, we're analysing direct activation and coordination mechanisms between TSO-DSO to ensure flexibility bids won't cause congestion in TSO / DSO grid.

50. Narrative of the use-case

Congestion management long-term demonstration: Single Flexibility Platform

- Flexibility need publication and viewing
- Capacity procurement
- Energy procurement
- Counter activation energy procurement
- Balance Settlement

51. Complete description

User story: https://alf.eurodyn.com/share/page/site/interrface/document-details?nodeRef=workspace://SpacesStore/9a998cdf-7fe7-4c8f-981e-9d69281fb9ae

52. Assumptions - Prerequisites

- Congestion management long-term is a new service.
- Auctions for congestion management, separated from balancing, wholesale markets.
- Market based tariff.
- Unit of measurement: MWh for activated bids.
- As for standard mFRR product, the TSOs foresee using a linear ramp of 10 minutes for the cross-border exchange. Full activation time is set at maximum 12.5 minutes. [1]
- Congestion management long-term implemented on Single Flexibility Platform, coordination scheme is TSO-DSO coordination.
- Difference between congestion management short-term: need will come from long-term department, activator is a short-term planner. Long-term planning: from Y-3 to M-1.
- Congestion management long-term auction parameters should be flexible (for example two weeks auction one month advance).

References:

[1] Manually Activated Reserves Initiative (MARI) is the European implementation project for

the creation of the European mFRR platform. Link [2] TSO – DSO REPORT AN INTEGRATED APPROACH TO ACTIVE SYSTEM MANAGEMENTWITH THE FOCUS ON TSO – DSO COORDINATION IN CONGESTION MANAGEMENT AND BALANCING. Link.
53. Services
Congestion management long-term
54. Actors
User story: https://alf.eurodyn.com/share/page/site/interrface/document-details?nodeRef=workspace://SpacesStore/9a998cdf-7fe7-4c8f-981e-9d69281fb9ae

5.4.2 Sequence Diagram of Demo 5.3

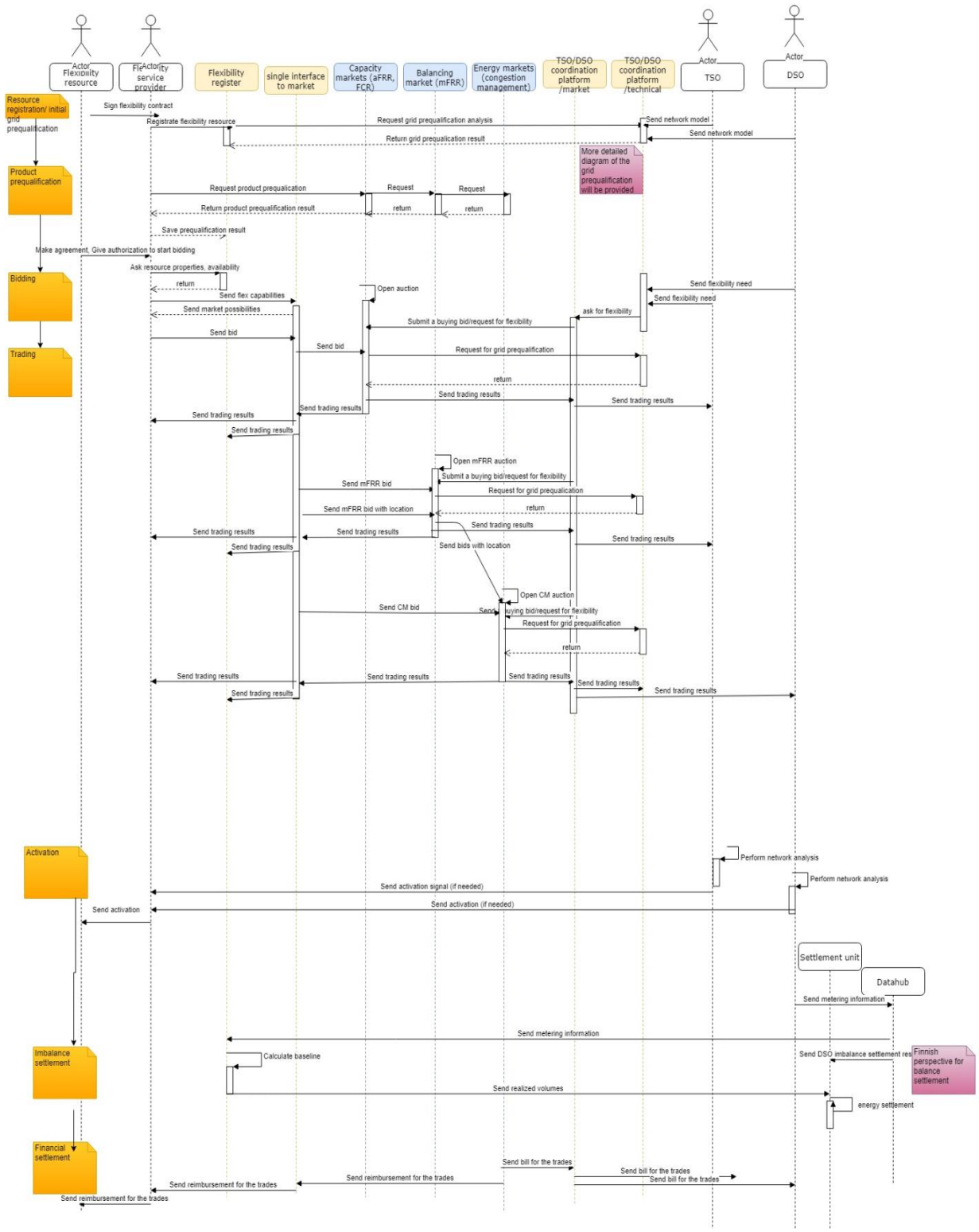


Figure 7: Sequence diagram of demo 5.3 for Congestion Management operational, short-term, long-term (TSO/DSO) and mFRR, aFRR, FCR services (TSO) within a Single Flexibility Platform

5.5 Demo 6.1

5.5.1 Business Use Case of Demo 6.1

Table 12 BUC of Demo 6.1

Distribution grid users participating in P2P local market		
1. Description of the Use case		
BUC_6.1	**Market Time-Frame (real time (system operation), Intra-day/Day-Ahead (Operational Planning), Months-Years Ahead (Long-term planning))**	**Name of the Use case**
6.1	Intra-day time-frame (opening on D-1 and gate closure ~H-1	Distribution grid users participating in P2P local market
2. Scope and Objectives of the Use-Case		
Scope	Enable the market participation of small consumers: mainly households but the P2P local market concept in 6.1 enables the market participation of any low voltage and medium voltage users – consumers, prosumers, distributed generators, storage).	
Objectives	Support the congestion management of the DSO: the increasing penetration of intermittent distributed generation and the electrification (the spread of electric vehicles, more electric appliances) cause problems on the distribution network (e.g. congestion, voltage problems – over/under voltage, asymmetry) - and demands fast grid development. The local market developed in 6.1 tries to help the DSO regarding such problems. Consider the real loadability of grid assets. It will be based on a smart asset management system that considers the type of assets, their age, condition and in some cases their sensored parameters, too.	
3. Narrative of the use-case		
In T6.1 of the INTERRFACE project a new market is developed for distribution grid users. It will be similar to the existing intra-day wholesale market but the trading for smaller users will be enabled and will be restricted to certain specific distribution grid areas. Its innovativeness also lies in the additional locational information of the bids (grid connection point/circuit) of each market participant in order to consider the loading capability of the grid assets (basically lines and transformers) and further grid effects of the trade (e.g. to avoid/decrease congestion and grid loss). In this market concept, a newly proposed dynamic grid usage tariff is going to be tested, as well. From the consumer's point of view, the market concept also considers price incentives for the market participants to support the congestion-free operation of the DSO. The market participants can gain income on the local market trade or in other words could get savings on their electricity bills.		

The DSO's benefit with this indirect (not realized by an activated service) congestion management is the possible investment deferral. Furthermore, a DSO can realize a fairer loss cost allocation.

4. Complete description

The market must be aware of the distribution grid topology where the local P2P market operates. DSO provides this information to the market platform. As a supplement to the local P2P marketplace, there will be an Integrated Asset Condition Management System (IACMS). Both are planned to run on the shared platform of the INTERRFACE project called IEGSA. Both the P2P local market solution and the IACMS must know the asset parameters of the grid that will be provided by the DSOs. The IACMS can also receive metered sensor data from the line through the DSO databases. Based on the asset parameters, the IACMS will provide loadability limits for the P2P local market module.

Based on metering data history, the market module will estimate a base consumption/production for each grid users as if no trading would happen on the additional, optional and voluntary local market. A base case grid flow will be generated on the metering estimation. Then the intra-day continuous energy market will be opened and any grid users can participate on their local markets. They can submit bids (energy sale or purchase offers for each quarter hour of a day) or can hit (in other words select or accept) the bids of other participants until the gate closure. No automatic pairing is expected.

After the real metering data has been gathered by the metering centers of the DSOs, this data is sent to the settlement module, which makes the settlement towards the consumers comparing their real metered consumption with their local market trading.

5. Assumptions - Prerequisites

- Quarter hourly metering is needed for the market concept of T6.1.
    - In the low voltage demonstration areas this means smart metering in practice. The usual remote reading of the metering once per day during the night is adequate. The typical profiled consumers therefore must be equipped with smart meters and conventional metering is not sufficient. Distributed generation at LV level mostly means rooftop PV where only net metering is realized. A few households (prosumers) will also have battery and a few public electric vehicle chargers are also expected.
    - In the medium voltage demonstration area usually all users have remotely read quarter hourly metering (normally not smart meter but a so-called industrial meter). Typical generation on this voltage level in the demonstration areas
- The market algorithm should be aware of the grid topology and preferably the connection point of the market participants (grid users).

6. Services

The P2P market operation can be offered as a service for a certain area by an independent market operator or maybe by the DSO.

Moreover, an automated bidder (product) can be offered for the grid users to support their local market participation.

7. Actors

Actor Name	Actor Description
Consumer	Bidding (trading) at the local market.
Producer	Bidding (trading) at the local market.
Party Connected to the Grid	Bidding (trading) at the local market.
Meter Data Responsible	Providing metering data for settlement and estimation. In the demonstration 6.1 the metering data is provided by the DSOs.
Market Operator	Operating the local P2P market.
DSO	Providing grid topology and congestion prognosis on the distribution grid.

Table 13 Summary of BUC of Demo6.1

BUC ID	FI-AP1
BUC Name	**6.1**
Services	P2P local market
New Mechanism in the demo (even if the service already exists)	Introduction of small-scale distributed assets to existing markets
Assets used	Medium-size battery, distributed batteries, distributed EV stations and homes with smart electric heating installation
Product	Capacity
Market Mechanism	Centralized

5.5.2 Sequence Diagram of Demo 6.1

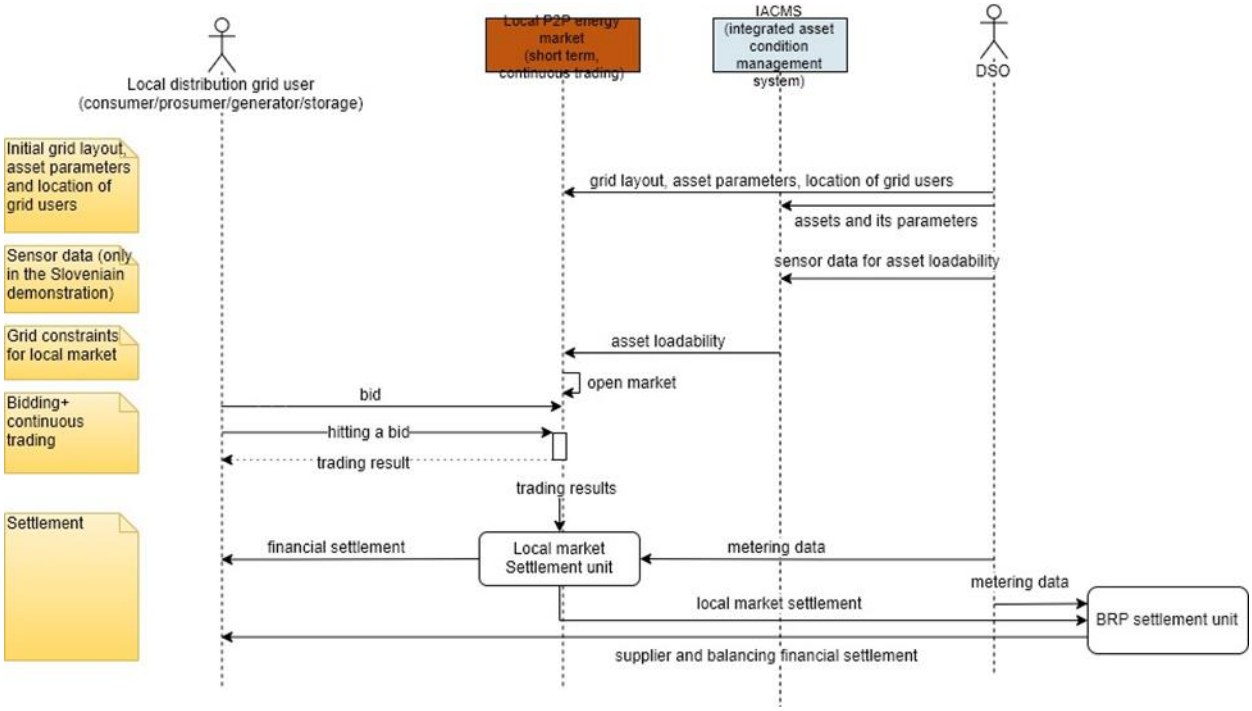


Figure 8: Sequence diagram of demo 6.1 for "Distribution grid users participating in P2P local market"

5.6 Demo 6.2

5.6.1 Business Use Case of Demo 6.2

Table 14 BUC of Demo 6.2

Flexibility services for DSO congestion management and allowing more renewable connection without unreasonable DSO network investments (T6.2 Demo)		
1. Description of the Use case		
BUC_ID	**Market Timeframe (real time (system operation), Intra-day/Day-Ahead (Operational Planning), Months-Years Ahead (Long-term planning))**	**Name of the Use case**
6.2	Months Ahead (Long-term planning)	Flexibility services for DSO congestion management and allowing more renewable connection without unreasonable DSO network investments (T6.2 Demo)
2. Scope and Objectives of the Use-Case		
Scope	The use-case is to be demonstrated in Bulgaria and/or Romania with our TSO-DSO partners (Bulgaria – CEZ, ESO and Romania – DEO, Transelectrica)	
Objectives	Help DSOs organize a decentralized local market for distributed resources connected to DSO-grid in order to solve local-grid constraints, aggregate and offer remaining bids to TSO	
3. Narrative of the use-case		
• **Context:** High feed-in from wind and other renewable generators has led to higher redispatch costs for system operators. The need for re-dispatching comes from the fact that distribution constraints are not adequately taken into account in the existing wholesale and balancing markets. The need for feed-in management has also increased significantly. Together, costs for redispatch and feed-in management indicate current inefficiency of the system and the increasing pressure on the systems stability • **Problems addressed and corresponding solution:** o We understand that there are three stages of congestion stress for DSO: i. The first stage is **Normal** level. The volumes of energy are within the nominal capacity of the hardware. There is no grid congestion and no extra strain on the hardware. In this situation no flexibility is needed. ii. The next stage is **overheating**. The grid runs the risk of increased degradation, but there is no acute outage concern. As components of the		

grid are pushed pass their threshold, their lifespan will be compromised. This could result into accelerated depreciation of hardware. The new costs for transformer can range from 10k€ to 50k€, depending on the capacity.

iii. The final stage is **Power outage**, in which the grid is pushed over its physical limits and malfunctions. The compensation that the DSO is required to pay each connection for an outage is dependent on the duration of the outage. For example, households in the Netherlands are compensated 35 euros after 4 hours of outage. This compensation stays the same up to an 8-hour outage. For each additional 4 hours of outage, there is an additional 20 euros. For businesses the compensation fees are higher. In Romania, households are compensated 7 Euros after 4 hours of outage. For businesses, the compensations are 50 Euros for MV and 60 euros for 110 kV fed customers.

- Our envisaged service may serve several purposes –
  - (a) congestion management of the network
  - (b) network reinforcement deferral,
  - (c) network support during construction and planned maintenance.

  For example, load related reinforcement schemes could use flexibility to defer a planned network upgrade into the future. The benefit is the net present value of deferred capital expenditure. In parts of the network that are planned for reinforcement or maintenance, flexibility could be used to increase the security of the network before completion. The benefit is the reduced impact of a low probability outage event.

- **Innovation Aspect:**

i. We also recognize that congestion management of distribution grids is rather locational and could benefit significantly from more **locational information**.

ii. We enable participation of distributed generators and flexibility assets on the distribution grid level via a **decentralized marketplace** to ensure system stability.

iii. Marketplace (EFLEX) digitizes the procurement process to make it easier for Aggregators and Flexibility Providers to view the local opportunities and to participate in the procurement process.

iv. There are several aspects of trading process where we aim to bring efficiency (e.g. asset registration, validating assets' metering data and settling the associated financial operations could be performed end to end using blockchain based smart contracts and distributed ledger technology)

Below is an example of opening of “on-demand” locational order books on the market using flexibility to defer a planned network upgrade.

Sofia City, Bulgaria

Type	Connection	Buyer
Reinforcement Deferral	11 kV	CEZ

Flexibility Requests (example):

Nov 01 2019 – Feb 28 2020			
16:30 – 17:30, 1.2 MW	17:30 – 18:30, 2.8 MW	18:30 – 19:30, 6.2 MW	19:30 – 20:30, 5.8 MW
Mar 01 2020 – May 31 2020			
16:30 – 17:30, 0.8 MW	17:30 – 18:30, 2.0 MW	18:30 – 19:30, 3.2 MW	19:30 – 20:30, 3.4 MW
June 01 2020 – Aug 31 2020			
16:30 – 17:30, 0.6 MW	17:30 – 18:30, 1.8 MW	18:30 – 19:30, 3.2 MW	19:30 – 20:30, 3.4 MW

Service window (example)

Nov 01 2019 – Feb 28 2020
18:30 – 19:30, 6.2 MW
Service Days

Mon	Tues	Wed	Thu	Fri	Sat	Sun
◉	◉	◉	◉	◉		

Minimum activation time	Maximum activation time	Ramping duration	Estimated dispatch events
00:00:00	00:15:00		

4. *Complete description*

i. **Flexibility Asset Registration:** Flexibility Providers should be able to register themselves and create an account with marketplace

ii. **Pre-delivery test:** The flexibility provider shall provide to DSO reasonable evidence of satisfaction of the post auction milestones. For e.g. provider's ability to a) receive and respond to instructions from the DSO b) deliver its flexible kW or MW by the response time c) sustain its flexible kW or MW for an agreed fixed period

iii. **Need analysis:** DSO analyses the actual state of the distribution grid and forecast the needs for energy flexibility to deal with potential distribution grid-level congestion problems.

iv. **Visibility:** The DSO proposes the request quantity of each sort of flexibility service on the marketplace. Marketplace communicates buyers' zones and size requirements ahead of tenders.

v. **Bidding:** Flexibility providers submit offers along with flexibility unit location to satisfy the corresponding services of DSO. After the end of the call auction phase, there is a call auction freeze phase. Until the call auction freeze phase, Flexibility Providers can enter new orders (or quotes) or modify their existing orders. Transaction takes place after the call auction freeze phase is over.

vi. **Matching:** Offers from flexibility providers are ranked in increasing order and accepted beginning with the least expensive and continuing until the DSO is satisfied. DSO gets the area merit order list and assesses the feasibility of various offers based on Optimal Power Flow (OPF) for congestion management. Finally, the DSO chooses the available offers appropriately from the providers/aggregators, and the standardized contracts are automatically formed according to the market-rules.

vii. **Dispatch:** During the service period, DSO issues and utilization instruction specifying the flexible unit with start and end time of utilization instruction.

viii. **Settlement:** Energy transactions are validated, and flexibility provider's accounts are settled

5. *Assumptions – Prerequisites*

- Main drivers in DSO grids: rapid growth of new hotspots for large scale solar and wind farms, EV charging, heating system, data centers.
- Congestion points have been detected or foreseen in near future
- DSO should be able to use (by regulation) data collected by the smart meters for LV

network technical constraints assessment/management.

- Contractual relationship between retailer and small industrial consumers or aggregators, that allows the sending of control setpoints by the DSO.

6. Services

- CEZ Bulgaria or DEO Romania (both DSO's) could use flexibility to avoid degradation of hardware or outage situation.
- DSO's could also defer a planned network upgrade into the future. The benefit is the net present value of deferred capital expenditure.
- In parts of the network that are planned for reinforcement or maintenance, flexibility could be used to increase the security of the network before completion. The benefit is the reduced impact of a low probability outage event.

7. Actors

Actor Name	**Actor Description**
Market Operator	A market operator is a party that provides a service whereby the offers to sell electricity are matched with bids to buy electricity. Additional Information: This usually is an energy/power exchange or platform.
Resource Aggregator	A party that aggregates resources for usage by a service provider for energy market services.
Resource Provider	A role that manages a resource and provides production/consumption schedules for it, if required.
DSO	The entity responsible for: distribution network planning and development; the safe and secure operation and management of the distribution system; for data management associated with the use of the distribution system; procurement of flexibility services.
TSO	A natural or legal person responsible for operating, ensuring the maintenance of and, if necessary, developing the transmission system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the transmission of electricity. Moreover, the TSO is responsible for connection of all grid users at the transmission level and connection of the DSOs within the TSO control area
Consumer	A party that consumes electricity. Additional Information: This is a type of Party Connected to the Grid

5.6.2 Sequence Diagram of Demo 6.2

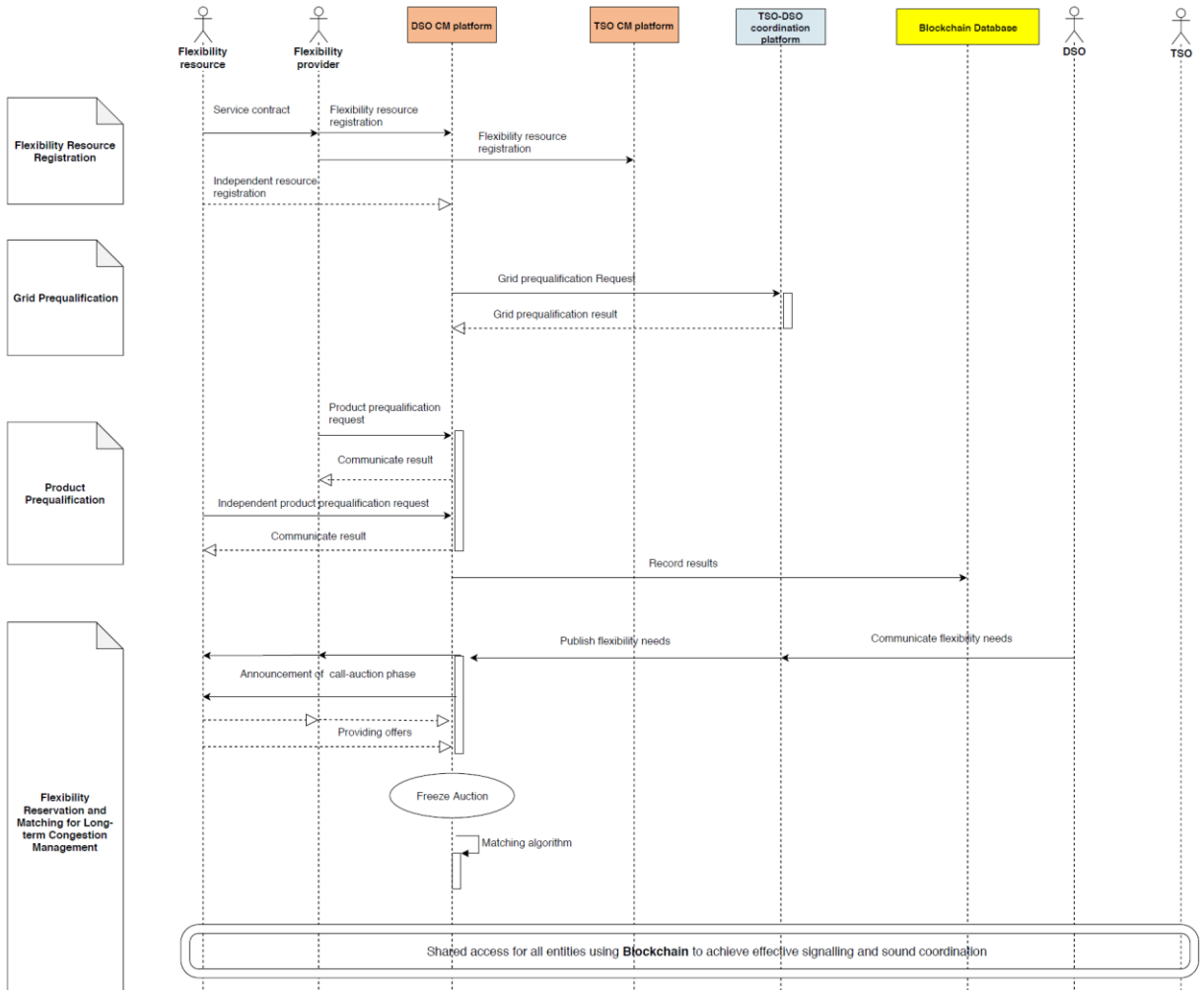


Figure 9: Sequence diagram of demo 6.2 for "Flexibility services for DSO congestion management and allowing more renewable connection without unreasonable DSO network investments"

5.7 Demo 7.1

5.7.1 Business Use Cases of Demo 7.2

5.7.1.1 Inter-zonal provision of FCR, aFRR and mFRR services Business Use Case

Table 15 BUC of Demo 7.1 for Inter-zonal provision of FCR, aFRR and mFRR services

Regional inter-zonal provision of Balancing (FCR, aFRR, mFRR) services in South-East Europe		
1. Description of the Use case		
BUC_ID	**Market Timeframe (real time (system operation), Intra-day/Day-Ahead (Operational Planning), Months-Years Ahead (Long-term planning))**	**Name of the Use case**
7.1a	Day-Ahead (Operational Planning)	**Regional inter-zonal provision of Balancing (FCR, aFRR, mFRR) services in South-East Europe**
2. Scope and Objectives of the Use-Case		
Scope	Market design of the regional inter-zonal provision of Balancing (FCR, aFRR, mFRR) services in the South-East European system. The Use-Case describes the algorithm to be developed for the optimal power market reserves clearing for the provision of FCR, aFRR, and mFRR services.	
Objectives	The Use-Case aims at the regional integration of balancing markets in order to foster, but not limited to, effective competition, non-discrimination, transparency, new entrants and liquidity while preventing un-due distortions. These objectives must be met in consideration of secure grid operation and security of supply. In addition, the proposed market design has the objective of further facilitating the access for smaller market players, improving the investment signals and increasing socio-economic benefits.	
3. Narrative of the use-case		
The reserves services procurement is organized with an optimization model, based on advanced optimization tools, and more specifically mixed integer programming techniques. The reserve services are to be procured through a common auction based on a common merit order list where all TSOs of the regional market pool the offers they have received from the Balancing Service Providers (BSPs) connected to their respective grids. The interaction of the TSOs with BSPs and the contracts between the TSOs and BSPs are handled on a TSO basis. The auction is to be implemented on a daily basis. Regarding the exact timing of the sourcing of reserves in the envisaged daily auctions, the design is to have the closure time as close as possible to the delivery day while respecting the technical constraints		

for a secure operation.

The novel features of the proposed optimization framework are the following: (i) introduction of new market products in the clearing process (hourly offers), block orders, linked block orders, as well as minimum income condition), (ii) assessment of marginal pricing instead of pay-as-bid pricing, (iii) capability of reserve provision through interconnections, namely from providers of all zones, (iv) provision of price signals for mid-term operational planning and long-term strategic investments.

The model outputs determine the optimal daily reserves allocation mix on an hourly basis, the resulting marginal price per service in each hourly time period, highlighting the flexibility sources that can provide each type of reserve in various demand profiles and based on several renewable energy portfolios. A comparative analysis is also to be provided analyzing the impacts of both individual (and sequential) clearing of each market (energy and reserves), and co-optimization of energy and reserves market.

4. Complete description

✓ **Prequalification phase:**

- Each Balancing Service Provider (BSP) gets access to the flexibility (FCR, aFRR, mFRR) of the various resources (by owning them or through contractual agreement).
- The Balancing Service Providers register themselves as reserves providers to the regional TSO.
- The resources must perform regulation tests, every ten years or when services requirements/design change, for the activation of services when needed.
- The reaction of the resources is measured and logged.
- The reaction is sent to the regional TSO for validation.

✓ **Pre-Bidding:**

- The TSO publishes the regional day-ahead reserve requirements (per type: FCR, aFRR, mFRR, considering individual TSO requirements and TSOs coordination).
- IEGSA platform gathers and plots those requirements, as well as zonal power system characteristics.

✓ **Bidding:**

- The Balancing Service Providers (asset operators) send their schedules to the aggregator for the following day based on the results of the day-ahead market and their estimated availability (optional)
- All the market participants assess their availability and create their flexibility services bids for the following day.
- The bids are sent to the regional Flexibility Services Market Operator (FSMO) before the gate closure date.
- IEGSA platform plots info on the bidding strategy of market participants for energy and balancing services.
- The services demand on the market comes from the TSOs, is based on their estimates for the need and the results from the yearly and monthly market.
- The FSMO determines the resources that should reserve the capacity from their bid based on the offer bids and the demand from the TSOs. The reserves contracted under the yearly market are used first. The remaining needs are selected in merit order.
- All the activated reserves providers recalculate the operational set-points of their controllable resources based on the results from the market.

- ✓ **Delivery phase:**
  - The delivery is realized by the different resources based on local frequency measurements.
  - The BSP sends "real-time" (with a 0. MW accuracy) data to the regional TSO. This data consists of the available reserves capacity, the ID of the aggregators considered and time stamps.
- ✓ **Settlement phase:**
  - The Balancing Service Providers send the invoicing data to the regional TSO. It should include unit-specific hourly average power, unit-specific hourly maximum power and the volume of frequency controlled reserves activated during the hour.
  - IESGA platform plots scheduling and distinct prices from energy and balancing services.
- ✓ **Problem to be addressed**

The European electricity markets' integration aims at the market coupling among interconnected power systems and the enhancement of market competitive forces. This process is facilitated by the adoption of a common clearing algorithm among European power exchanges, entitled EUPHEMIA (Pan-European Hybrid Electricity Market Integration Algorithm), which however lacks to capture critical technical aspects of power systems, as done by the unit commitment problem including start-up and shut-down decisions, time constraints (minimum on- and off-times), as well as the consideration of ancillary services. This Use-Case utilizing an optimization-based framework addresses the problem of the optimal day-ahead reserves market clearing algorithm, further utilizing the hourly offers and the block orders module of the EUPHEMIA algorithm. The employed time step is to be hourly. In particular, through the formulation of a mixed integer linear programming (MILP) model and employing an iterative approach, it determines the optimal reserves mix, the resulting market clearing prices, and it calculates the welfares of the market participants. The model incorporates hourly power reserve constraints, as well as introduces new market products such as the option of forming linked groups of power units, aiming at supplying additional flexibility in the decision-making of the market participants. The model applicability is to be assessed in a regional power system, namely the South-East European power system, taking into consideration its inter-zonal interconnections with neighboring power systems. The developed optimization framework can provide useful insights on the determination of the optimal flexibility provision portfolios that address the new market-based operational challenges of contemporary power systems subject to technical and economic constraints.

- ✓ **Market products**

The market products to be considered are the following:

- ✓ Stepwise hourly orders subject to the conditions of minimum income and load gradient (complex orders), providing the option to each power unit to activate them or not.
- ✓ Block orders which are defined by: (i) type (supply), (ii) submitted price limit (uniform across all time periods), (iii) hourly intervals, (iv) volume (can be different in each hourly interval), and (v) minimum acceptance ratio (can be equal to or less than 1, thus including both regular and profile block orders).
- ✓ Linked Block orders (with a "tower"-based parental relationship, in which each parent has up to one linked block, called child block), i.e., the acceptance of individual block orders can be achieved contingent on the acceptance of

other block orders. The block whose acceptance depends on the acceptance of another block is called a "child block", whereas the block that has conditions of acceptance of other blocks is called a "parent block". The rules of acceptance are the same with those provided in the EUPHEMIA Pubic Description Document.

- ✓ Exclusive group of block orders, defined as a set of block orders for which the sum of the accepted ratios of all block orders cannot exceed 1.
- ✓ Flexible Hourly Orders (supply), defined as a block order with a fixed price limit, fixed volume, minimum acceptance ratio of 1, with duration of 1 h.

These market products are expected to increase the flexibility in the market and help integrate renewable energy sources and decentralized sources. Moreover, it will allow for better alignment with scheduled operation of the participating units.

- ✓ **Bid design possibilities**

The minimum bid size is 1 MW and bid resolution is 1 MW (the result of dividing a bid should be a whole number) in all participating countries. TSOs will allow divisible bids together with indivisible bids. Indivisible bids will have a maximum bid size of 25 MW in all the participating countries. The considered market design change may facilitate the participation of smaller BSPs, while larger BSPs will be able to benefit from portfolio pooling.

- ✓ **Auction Allocation Algorithm**

The solution of the MILP model is executed within an iterative process so as to deal with the Paradoxically Accepted/Rejected block orders, and the orders that do not satisfy the minimum income condition. Initially, the MILP problem is solved, and the model determines the hourly market clearing prices of each representative day and for each bidding area, as well as the achieved welfare of each block order. After that, a post-optimization algorithm is employed to check the existence of paradoxically accepted/rejected block and complex orders.

When the final solution does not include any paradoxically accepted block orders and/or hourly offers that do not satisfy the minimum income condition, the model has successfully completed its execution and the final model outputs are provided (all the initial and intermediate solutions are also available).

The considered market design will guarantee that divisible bids below the marginal price will always be fully awarded. In this way, the relevance of the marginal price signal will be strong and will facilitate long term optimization.

Below follows an explanation of Paradoxically Accepted and Rejected Block Orders.

Paradoxically Accepted Block Orders

In case a block order has been accepted and its calculated welfare (implemented in the post-optimization process) is negative, i.e., the required revenues exceed the achieved ones, then this block order is designated as a paradoxically accepted block and it is withdrawn from the Order Book. After that, the model is solved again without considering the paradoxically accepted block order with the least cost-efficient welfare.

Paradoxically Rejected Block Orders

In case a block order has been rejected and its calculated welfare (implemented in the post-optimization process) is positive, i.e., the achieved revenues exceed the required ones, then this block order is designated as a paradoxically rejected block and it is

given another opportunity to be normally accepted by the optimization process, on the grounds that there will be more favorable for acceptance conditions in the next iterations, since some hourly offers/block orders may have been definitely rejected. After that, the model is solved again without considering all the paradoxically accepted block orders.

- ✓ **TSO-BSP settlement**

Instead of a pay-as-bid model, the TSO-BSP Settlement will be based on marginal pricing.

There are two limitations in the reserves market:

- ✓ Core shares, also called import limits,
- ✓ Maximum transfer of capacities also called export limits.

The major features of a marginal pricing scheme will be outlined as follows:

- *Determination of a marginal price for each country:*

For all the countries where the import and export limits are not hit, the marginal prices of all these countries are equal. The marginal price of all these countries is the maximum price of the accepted offers over all these countries where no limitation applies (Cross-Border Marginal Price). If the import limit of a country is hit, then the marginal price of this country is the maximum price of the accepted offers of this country (Local Marginal Price for an importing country). This Local Marginal Price is always greater than or equal to the Cross-Border Marginal Price.

If the export limit of a country is hit, then the marginal price of this country is the maxi-mum price of the accepted offers of this country (Local Marginal Price for an exporting country). This Local Marginal Price is always less than or equal to the Cross-Border Marginal Price.

- *BSP remuneration:*

Each awarded offer of a BSP is remunerated by its connecting TSO at the corresponding marginal price of its country/zone.

Marginal pricing is considered the best solution for gaining economic efficiency and optimal resource allocation. The considered market design can provide better price signals, expose scarcity and give better investment signals to the market. Especially small and new BSPs may benefit from bidding their marginal cost and not having to conduct costly analyses on past price developments.

- ✓ **TSO-TSO settlement**
- ✓ *Case I: no limits hit*

If no import or export limits are hit, each country's target costs are calculated by multiplying its demand in the common auction with the cross-border marginal price.

Each importing TSO has to pay to the exporting TSOs the cross-border marginal price for the imported volume. Similarly, the exporting TSOs will receive the cross-border marginal price for the amount of the volumes they export.

- ✓ *Case II: import and/or export limits hit*

An importing country, whose import limit was hit, has to pay for all its procured volume (locally and cross border) its Local Marginal Price, which is in this case higher than the cross-border marginal price. An exporting country, whose export limit was not hit, gets paid for all his exports the cross-border marginal price. Similarly, all the

BSPs of a country where the export limit was hit, will receive their own country's Local Marginal Price (lower than the cross-border marginal price for the rest of the cooperation), and importing countries pay the common cross-border marginal price for their imports (in this case higher than the Local Marginal Price.

Balance, resulting from volumes paid with Local Marginal Price from one party and compensated with cross-border marginal price for other party (or vice versa), is transferred to a virtual temporary account.

Given that virtual temporary account is not zero, it is distributed among the importing/exporting countries proportionally to the absolute value of their net positions (awarded volumes – country demand).

The proposed method ensures that both importing and exporting countries benefit from a situation where an import or export limit is hit.

5. Assumptions - Prerequisites

Complex orders

Minimum Income Condition

The Minimum Income Condition (MIC) constraint is defined by:

- ✓ A fixed term in Euros. Under the current operation of the European power exchanges, this term is static and fixed, submitted by each market participant.
- ✓ A variable term in Euros per accepted MWh, typically accounting for the minimum average reserve provision cost of each thermal unit plus a desired cost coefficient (can be also zero).

A MIC order, when submitted by a market participant for a thermal unit, includes in its full form the sum of the fixed term with the product of the variable term with the reserve provision of each thermal unit.

During the optimization process, MIC orders are activated or deactivated (as a whole):

In case a MIC order is satisfied, each of the hourly sub-orders of the MIC is treated as any other simple hourly order, which means accepted if they are in-the-money (denoting the achieved revenues exceed the required by the MIC order), and rejected if they are out-of-the-money (denoting the required revenues by the MIC order surpass the achieved ones), and can be either accepted (fully or partially), or rejected when at-the-money (meaning the achieved revenues are equal to the required by the MIC ones).

In case a MIC order is not satisfied, each of the hourly sub-orders of the MIC is fully rejected, even if it is in-the-money. With regard to the units that were initially accepted by the optimization process and did not satisfy the MIC order, the unit with the least cost-efficient achieved welfare is withdrawn from the Order Book and the model is iteratively solved again without incorporating it.

Load Gradient

Complex orders (with their set of hourly sub-orders) on which a Load Gradient condition applies are called Load Gradient Orders. It comprises the second condition that can be applied in the simple hourly orders. The Load Gradient constraint denotes that the amount of reserve provision, per type, that is matched by the hourly sub-orders belonging to a Load Gradient order in one period is constrained by the amount of reserve provision, per type that was matched by the hourly sub-orders in the

previous period. There is a maximum increment/decrement potential, submitted by the market participant, and can be the same value for all periods or can be converted into a dynamic and variable one. Period 1 is constrained by the reserve provision matched in the last hour of the previous day (24th hour of the previous dispatch day). This constraint mimics the ramp up/down constraints, typically used in the unit commitment problems. Note that this constraint is incorporated in the main optimization process (activation/deactivation), thus there is no need for a post-optimization check.

Paradoxically accepted block orders

In case a block order has been accepted and its calculated welfare, a task implemented in the post-optimization control process is negative, namely the required revenues surpass the achieved ones, and then this block order is initially designated as a paradoxically accepted block. As soon as the control has been completed for all blocks, the algorithm implements a sorting among them from the lowest to the highest achieved welfare, and the unit with the worst achieved welfare is withdrawn from the Order Book. After that, the model is solved again without considering that paradoxically accepted block order with the least cost-efficient welfare. This process is successively repeated and it is successfully completed when the final solution contains no paradoxically accepted block orders.

Paradoxically rejected block orders

In case a block order has been rejected in the model solution and its calculated welfare, a task implemented in the post-optimization process is positive, namely the achieved revenues surpass the required ones, and then this block order is initially designated as a paradoxically rejected block. As soon as the control has been completed for all blocks, the algorithm implements a sorting among them from the lowest to the highest achieved welfare, and the unit with the highest achieved welfare is given another opportunity to be normally accepted by the optimization process (forced acceptance of the submitted block order), on the grounds that there may be more favorable for acceptance conditions in the next iterations, since some hourly offers/block orders and/or paradoxically accepted block orders may have been definitely rejected. This process is successively repeated and it is successfully completed when the final solution contains no paradoxically rejected block orders.

Final solution - Solution algorithm

The solution of the proposed MILP model is executed within an iterative process so as to deal with all the paradoxically accepted/rejected block orders, and the orders that do not satisfy the minimum income condition. In each iteration, the MILP problem is solved, and the model determines the hourly market clearing prices of each representative day, time period and bidding area, as well as the achieved welfare of each block order. After that, a post-optimization algorithm is utilized to check the existence of paradoxically accepted/rejected blocks and the satisfaction or not of any submitted complex orders. At the time that the final solution does not include any paradoxically accepted/rejected block orders and/or simple hourly offers that do not satisfy the minimum income condition, the model has been successfully solved.

6. Services
✓ Market-based auction ✓ Day-ahead reserve market ✓ Marginal pricing (zonal) ✓ Coupled system – provision of reserve from providers of all zones

(consideration of imports & exports limits) ✓ Announcement from regional TSO as well as each TSO for the reserve needs, following a regional coordination – Remuneration of each reserve provider from the TSO ✓ Co-optimization and/or distinct optimization	
7. Actors	
Actor Name	**Actor Description**
Balancing Service Provider	A party with reserve-providing units or reserve providing groups able to provide balancing services to one or more LFC Operators. Based on Electricity Balancing - Art.2 Definitions.
Transmission System Operator	✓ Elaborate network development plan (including defining system needs for transmission) ✓ Ensure a transparent and non-discriminatory access to the transmission network for each user ✓ Operate the transmission grid over a specific region in a secure, reliable and efficient way ✓ Secure and manage in real time the physical generation-consumption balance on a geographical perimeter, including ensuring the frequency control service ✓ Optimize transmission system operation from planning to real-time, using available levers (grid expansion, flexibility activation,...) ✓ Assess network status of the transmission grid and broadcast selected information of the network status to eligible actors (e.g., aggregators, other system operators) ✓ Provide data to the interconnection capacity market operator for the management of cross border transactions ✓ In critical situations, implement dedicated actions and deliver alerts during stress events ✓ If necessary, implement emergency measures (e.g. system defence plan) including load shedding
Reserve Allocator (regional TSO)	Informs the market of reserve requirements, receives tenders against the requirements and in compliance with the prequalification criteria, determines what tenders meet requirements and assigns tenders.
Flexibility Services Market Operator (FSMO)	Organize auctions between buyers and sellers concerning flexibility services (balancing and congestion management) and publishes corresponding distinct prices for each service. Manages and operates the market platform for the trading, where bids are collected within gate open and close times. Clears the markets and communicates the results.

5.7.1.2 Inter-zonal provision of congestion management services Business Use Case

Table 16 BUC of Demo 7.1 for Inter-zonal provision of congestion management services

Regional inter-zonal provision of Congestion Management services in South-East Europe		
1. Description of the Use case		
BUC_ID	**Market Timeframe (real time (system operation), Intra-day/Day-Ahead (Operational Planning), Months-Years Ahead (Long-term planning))**	**Name of the Use case**
7.1b	**Day-Ahead (Operational Planning)**	**Regional inter-zonal provision of Congestion Management services in South-East Europe**
2. Scope and Objectives of the Use-Case		
Scope	Market design of the regional inter-zonal provision of Congestion Management services in the South-East European power system. The Use-Case describes the algorithm to be developed for the optimal power market reserves clearing for the provision of Congestion Management services, supplementary to the Balancing (FCR, aFRR, and mFRR) services clearing described in the previous Use Case for Regional Balancing services. Congestion Management services are enrolled as mFRR, amended with zonal information, to enhance coherence with balancing services. The CM bids are to be added to energy and other ancillary services bids towards providing distinct price signal for each service.	
Objectives	The Use-Case aims at the regional integration of congestion management and balancing markets in order to foster, but not limited to, effective competition, non-discrimination, transparency, new entrants and liquidity while preventing un-due distortions. These objectives must be met in consideration of secure grid operation and security of supply. In addition, the proposed market design has the objective of further facilitating the access for smaller market players, improving the investment signals and increasing socio-economic benefits.	
3. Narrative of the use-case		
The reserves services procurement is organized with an optimization model, based on advanced optimization tools, and more specifically mixed integer programming techniques. The reserve services are to be procured through a common auction based on a common merit order list where all TSOs of the regional market pool the offers they have received from the Balancing Service Providers (BSPs) connected to their respective grids. The interaction of the TSOs with BSPs and the contracts between the TSOs and BSPs are handled on a TSO basis. The auction is to be implemented on a daily basis. Regarding the exact timing of the sourcing of reserves in the envisaged daily auctions, the design is to have the fate closure time as close as possible to the delivery day while respecting the technical		

constraints for a secure operation.

The novel features of the proposed optimization framework are extending the novelty from the previous Use Case for Regional Balancing services, with the following: (i) introduction of new market products in the clearing process for congestion management (hourly offers, block orders, linked block orders, as well as minimum income condition), (ii) assessment of marginal pricing instead of pay-as-bid pricing, (iii) capturing the congestion management resources from distribution level, enabling TSO-DSO coordination (iv) capability of congestion management reserve provision through interconnections, namely from providers of all zones, (v) provision of price signals for mid-term operational planning and long-term strategic investments.

The model outputs determine the optimal daily reserves allocation mix on an hourly basis, the resulting marginal price per service in each hourly time period, highlighting the flexibility sources that can provide each type of reserve in various demand profiles and based on several renewable energy portfolios. The CM services, enrolled as mFRR, enable the quantification of their contribution to the whole energy system cost, re-estimation of zonal marginal pricing and scheduling from solution considering only balancing services requirements. A comparative analysis is also to be provided analyzing the impacts of both individual (and sequential) clearing of each market (energy and reserves), and co-optimization of energy and reserves market.

4. Complete description

- **Prequalification phase:**
- Each Balancing Service Provider (BSP) gets access to the flexibility (FCR, aFRR, mFRR) and Congestion Management (CM) of the various resources (by owning them or through contractual agreement). CM at DSO level is captured.
- The Balancing Service Providers register themselves as reserves providers to the regional TSO (TSO acts as coordinator in TSO-DSO coordination process).
- The resources must perform regulation tests, every ten years or when services requirements/design change, for the activation of services when needed.
- The reaction of the resources is measured and logged.
- The reaction is sent to the regional TSO for validation.
- **Pre-Bidding:**
- The regional TSO publishes the regional day-ahead reserve requirements (per type: CM, FCR, aFRR, mFRR, considering individual TSO requirements, DSO requirements and resources, TSOs and TSOS-DSOs coordination).
- IEGSA platform gathers and plots those requirements, as well as zonal power system characteristics.
- A process for transition from distinct DSO CM, TSO CM and TSO balancing markets (case 1A) towards coordinated TSO-DSO CM and TSO balancing markets (case 2A) and finally coordinated TSO-DSO balancing and CM markets (case 3A) is shown in the sequence diagram. CM needs and resources are gradually coordinated with TSO requirements for balancing services. This is enhanced by tackling CM as mFRR.
- **Bidding:**
- The Balancing Service Providers (asset operators) send their schedules to the aggregator for the following day based on the results of the day-ahead market and their estimated availability (optional)
- All the market participants assess their availability and create their flexibility services (CM and balancing) bids for the following day.
- The CM and balancing bids are sent to the regional Flexibility Services Market

Operator (FSMO) before the gate closure date.
- IEGSA platform plots info on the bidding strategy of market participants for energy, balancing and CM services.
- The services demand on the market comes from the TSOs, is based on their estimates for the need and the results from the yearly and monthly market.
- The FSMO determines the resources that should reserve the capacity from their bid based on the offer bids and the demand from the TSOs. The reserves contracted under the yearly market are used first. The remaining needs are selected in merit order.
- All the activated reserves providers recalculate the operational set-points of their controllable resources based on the results from the market.
- **Delivery phase:**
- The delivery is realized by the different resources based on local frequency measurements.
- The BSP sends "real-time" (with a 0. MW accuracy) data to the regional TSO, using relevant data from DSO. This data consists of the available reserves capacity, the ID of the aggregators considered and time stamps.
- **Settlement phase:**
- The Balancing Service Providers send the invoicing data to the regional TSO. It should include: unit-specific hourly average power, unit-specific hourly maximum power and the volume of frequency controlled reserves activated during the hour.
- IESGA platform plots scheduling and distinct prices from energy, balancing and CM services.
- **Problem to be addressed**

The Use Case extends the previous Use Case for Regional Balancing services by considering Congestion Management, supplementary to the balancing services. Enrolling CM as mFRR with the optimization framework, enable the provision of useful insights on the determination of the optimal flexibility provision portfolios that address the new market-based operational challenges of contemporary power systems subject to technical and economic constraints.

- **Market products**

The market products are the same considered for the previous Use Case for Regional Balancing services. But they are applied also to congestion management services. These market products are expected to increase the flexibility in the market and help integrate renewable energy sources and decentralized sources. Moreover, it will allow for better alignment with scheduled operation of the participating units.

- **Bid design possibilities**

The bid design is the same as described in the previous Use Case for Regional Balancing services.

- **Auction Allocation Algorithm**

The allocation algorithm is the same as described in the previous Use Case for Regional Balancing services.

TSO-TSO settlement

The TSO-TSO settlement is the same as described in the previous Use Case for Regional Balancing services.

5. Assumptions - Prerequisites

The assumptions are the same applied for the previous Use Case for Regional

Balancing services, extended to consider congestion management.	
6. Services	
✓ Market-based auction ✓ Day-ahead reserve market ✓ Marginal pricing (zonal) ✓ Coupled system – provision of reserve from providers of all zones (consideration of imports & exports limits) ✓ Considering of CM supplementary to Balancing services ✓ Announcement from regional TSO as well as each TSO for the reserve needs, following a regional coordination – Remuneration of each reserve provider from the regional TSO ✓ Co-optimization and/or distinct optimization	
7. Actors	
Actor Name	**Actor Description**
Balancing Service Provider	A party with reserve-providing units or reserve providing groups able to provide congestion management and balancing services to one or more LFC Operators. Based on Electricity Balancing - Art.2 Definitions.
Transmission System Operator	✓ Elaborate network development plan (including defining system needs for transmission) ✓ Ensure a transparent and non-discriminatory access to the transmission network for each user ✓ Operate the transmission grid over a specific region in a secure, reliable and efficient way ✓ Secure and manage in real time the physical generation-consumption balance on a geographical perimeter, including ensuring the frequency control service ✓ Optimize transmission system operation from planning to real-time, using available levers (grid expansion, flexibility activation,...) ✓ Assess network status of the transmission grid and broadcast selected information of the network status to eligible actors (e.g., aggregators, other system operators) ✓ Provide data to the interconnection capacity market operator for the management of cross border transactions ✓ In critical situations, implement dedicated actions and deliver alerts during stress events ✓ If necessary, implement emergency measures (e.g. system defence plan) including load shedding
Reserve Allocator (regional TSO)	Informs the market of reserve requirements, receives tenders against the requirements and in compliance with the prequalification criteria, determines what tenders meet requirements and assigns tenders.
Flexibility Services Market Operator (FSMO)	Organize auctions between buyers and sellers concerning flexibility services (balancing and congestion management) and publishes corresponding distinct prices for each service.

	Manages and operates the market platform for the trading, where bids are collected within gate open and close times. Clears the markets and communicates the results.

5.7.2 Sequence Diagrams of Demo 7.1

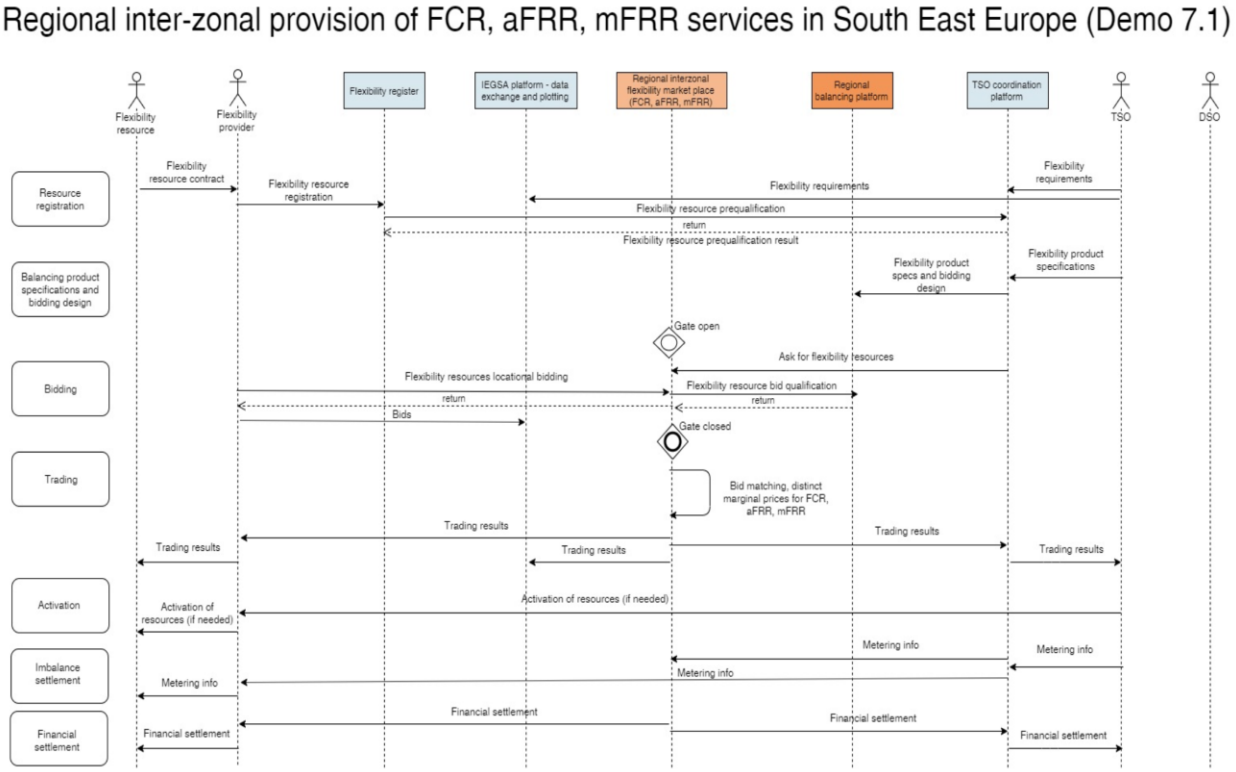


Figure 10: Sequence diagram of demo 7.1 for regional interzonal provision of FCR, aFRR, mFRR services in South East Europe

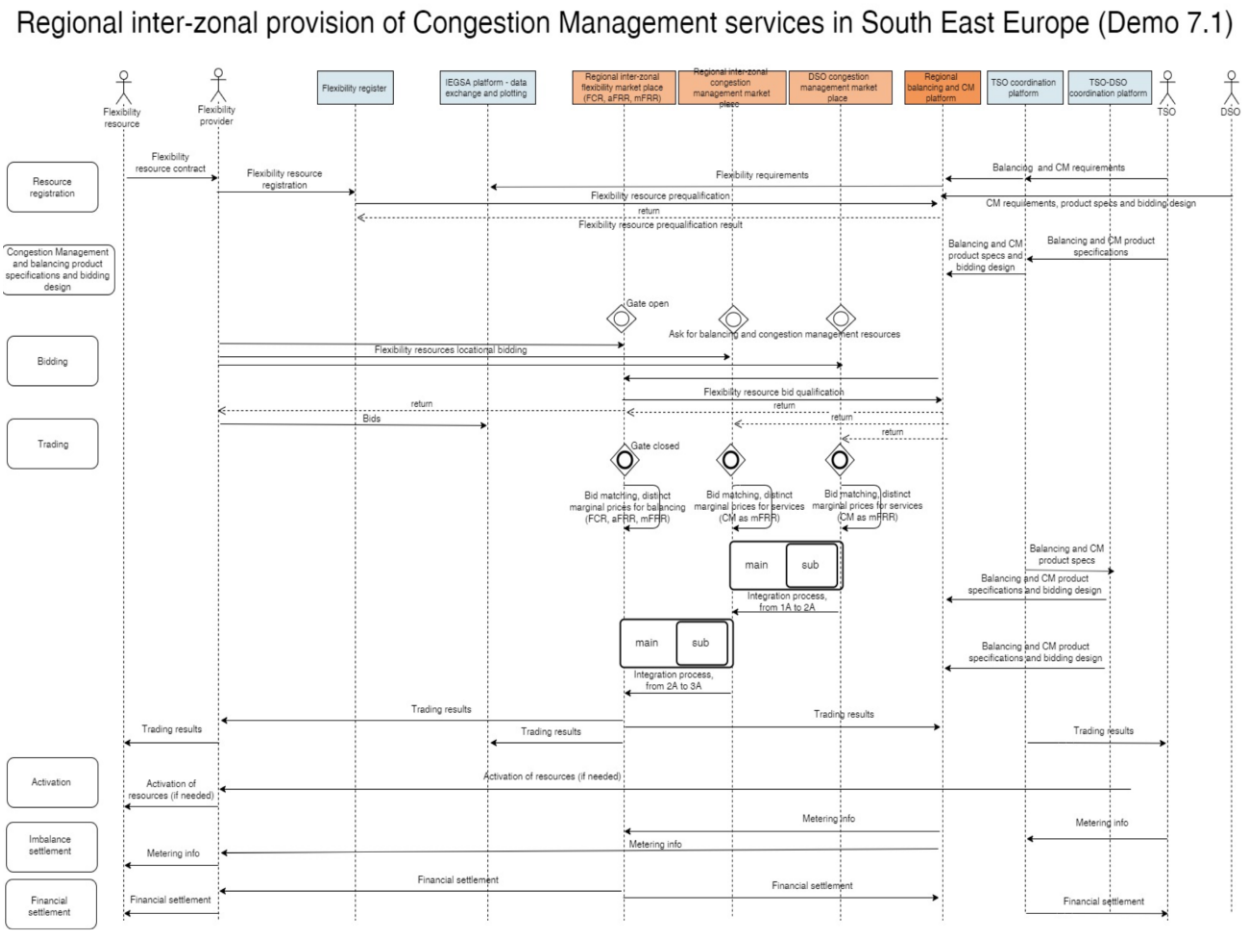


Figure 11: Sequence diagram of demo 7.1 for regional inter-zonal provision of Congestion management services in South East Europe

5.8 Demo 7.2

5.8.1 Business Use Case of Demo 7.2

Table 17 BUC of Demo 7.2

Spatial aggregation of local flexibility using market platform connecting wholesale and local flexibility		
1. Description of the Use case		
BUC_ID	**Market Timeframe (real time (system operation), Intra-day/Day-Ahead (Operational Planning), Months-Years Ahead (Long-term planning))**	**Name of the Use case**
7.2	Enhanced energy market platform on the intraday timeframe	Direct participation of local flexibility on the wholesale market using a single auction based market platform
2. Scope and Objectives of the Use-Case		
Scope	▪ To introduce spatial dimension into the existing wholesale market design ▪ Develop a market tool that facilitate TSO-DSO coordination ▪ Use auction-type market platform that enables incorporating complex constraints ▪ Locational information of the participating bids included – additional aspect to enhance the social welfare attainable ▪ Still, not a multi-zonal approach, but a hierarchical one to enable connection to the existing wholesale market – one single bidding area to cover the whole zone, containing multiple and stacked local areas with flexibility sources	
Objectives	▪ Realize an efficient way of solving grid related constraints through the usage of shadow prices ▪ Manage the introduction of local incentives in a zonal market platform ▪ Provide proper price signals for each area, both DSO and TSO levels, incentivizing flexibility resources to participate ▪ Intra-zonal congestion pricing derived from market results – signals for operational, short-term and long-term network transmission capacity management ▪ Develop use cases for the DSOs to use the intraday flexibility pool as a tool for congestion management ▪ Enhance use cases already available for internal congestion management with proper pricing of locations ▪ Framework compatible with the current, already widely-known EUPHEMIA algorithm to be used to permit easier distribution of the market design ▪ Generalize congestion pricing in hierarchical, stacked bidding areas ▪ Apply PUN concept to enable masking underlying price	

	differentiation for a selected market players (e.g. consumers) enabled by market forces and not tariff socialization

3. Narrative of the use-case

Current EU energy policy aims to aims to change the current market framework, in order to incentivize the participation of the distributed energy resources in the wholesale market. The role of the aggregator is a key to fully utilize this potential, but the aggregation itself is hindered presently, as the market structure cannot represent the local network constraints. Present frameworks are designed for wholesale market participants and consider TSO-level grid as a copper-plate, unconstrained trading platform. However, this does not hold 100% of the time due to intra-zonal congestions, but more severe problems occur locally – DSOs shall deal with real power congestions, voltage issues and with power flow fluctuating by large margins in short time or even reversing power flows.

With the spread of distributed energy sources, this uniform pricing approach do not lead to the desired, market based functioning of short-term trading, as the socialization of the network constraints through system usage tariffs lead to inefficient incentives in market prices. More the share of local resources, the more inefficient is the current copper-plate wholesale zonal approach. Current new features of the wholesale markets, flow-based capacity calculation and allocation and bidding zone splitting are leading to a finer representation of the transmission network. These are considering only the existing types of (zone-to-zone) capacity constraints with an increased number of considered physical constraints.

If the locational information from the distributed sources providing energy and/or new types of flexibility bids can be channeled into the market optimization algorithm, this new aspect can only provide more welfare outcome of the day-ahead/intraday trading platforms. This spatial dimension can be introduced into the current wholesale market design, by the extension of a PUN-like bidding pricing scheme. PUN stands for Prezzo Unico Nazionale (National Uniform Pricing), a feature introduced in the Italian power market which enables a special type of demand bid to be cleared based on average of multiple zonal prices. In this case however, a hierarchical arrangement of different locations will be managed through market pricing. The approach is innovative, as it can provide a market based solution to solve the problem of congestion management in the real, hierarchical power system. Activation of local flexibility provides potential for participating in solving local issue and also providing a way to participate in the wholesale market, simultaneously. DSOs and the TSO in a given bidding area may have different motivation for their available flexibility resources. If we consider all required flexibility demand in a single auctioning platform, the coordination of different TSO and DSO needs can be properly aligned with the usage of incentivizing price determination.

The new market tools, services, use cases developed in this demonstration can be connected to different existing market frameworks, as the current EUPHEMIA-based auction-type order matching is considered as a starting point in the development. Thus, the novel features can be readily generalized in more areas and timeframes.

4. Complete description

The proposed use case is based on an intraday, auction-type market platform that considers the location of bid with high granularity.

This market can be run once a day after day-ahead market processes, but multiple additional rounds of order matching can be implemented to enhance price signals that provides incentives to the flexibility resources to act according to the TSO and DSO needs.

The whole process is initiated by the market operator, with opening the order book for the bids (gate open time – GOT).

This can be preceded by a flexibility resource/product registration that is an effective tool for the TSO and DSOs to control/qualify the participating resources, but this is not really necessary, as we define flexibility in a same product that is already a must for any balance responsible party – keeping the schedules derived from the net energy transactions in line with the 15-min. balancing responsibility.

During the bidding process resource providers - traders, aggregators, producers and system operators – TSO, DSOs both submit their bids. System operators also provide information about available transmission capacity.

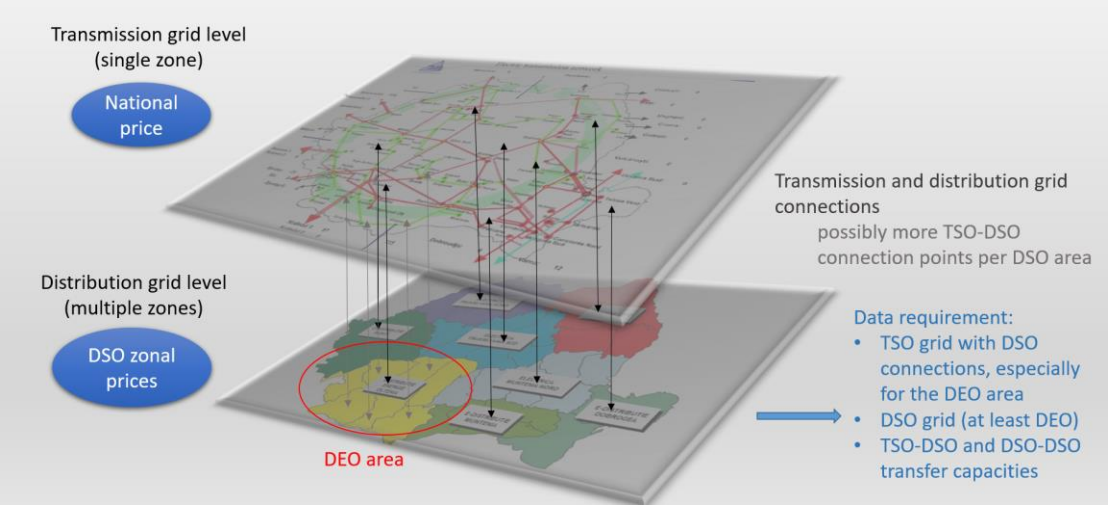
After gate closure, the order matching begins, using a holistic mathematical formulation for optimal market outcomes, linking consumers – DSOs – TSOs. This is being developed, with the following distinctive characteristics:

- Products on the flexibility market: 15-min. energy
- Timeframe of the aggregated flexibility market: intraday
- Type of market platform → auction-based with EUPHEMIA features
- Structure and extent of network representation

Zonal with hierarchy
Only high voltage elements on TSO grid
DSO can form single zone or a more detailed multi-zone area

- Multiple TSO/DSO bidding zone are used, and jointly cleared using PUN-pricing
- The DSO use flexibility (acting like a Balancing Responsible Party) but also aggregates users and provide service for the TSO (acting like a Balancing Service Provider)
- The bids need to include a spatial parameter: the zone of the offer and injection.

Illustration of considering the hierarchical grid in the market:



Connection to existing markets: standalone market with voluntary participation. However, automatic transfer of open bids and other data can be envisioned in the future – e.g. not cleared DAM offers can be redirected in the intraday order book, or in a successive multi-round approach, the validity of bids can cover multiple round of auctions.

DSO flexibility requirement can be formulated as an offer and/or through congestion pricing, but only real power (not reactive) is directly considered, as it is the only global

parameter that is valid on both the wholesale and the local level as well.

After order matching is complete, net transactions are to be implemented similarly to any intraday schedule change. BRPs will be responsible to execute the transactions, if not, balancing energy payment will be due. No direct activation, control is necessary from the TSO or the DSOs.

Note:

- multiple rounds (one in every 4 hours) of successive intraday auctions with a rolling 24-36 hour leading timeframe are possible

5. *Assumptions - Prerequisites*

- ample flexibility sources in the intraday timeframe
- smooth timing between the end of day-ahead process (nominating schedules)
- incentives (e.g. low trading cost) to use the market platform, even for the small-scale flexibility providers
- DSO-to-DSO and TSO-to-DSO transmission capacity can be calculated and updated
- TSO-DSO coordination to channel information from both sides to the market platform
- TSO and DSOs can use the platform for buying flexibility services – they can form their required needs in marketable offers and bids
- multiple settlement prices within a single bidding area can be offset by PUN pricing schemes
- order matching, market settlement is fast and the results are straightforward
- order making is easy and can be automated to provide liquidity even on short-term
- settlement of intraday transactions is compatible with balancing market pricing
- multiple rounds (one in every 4 hours) of successive intraday auctions with a rolling 24-36 hour leading timeframe are possible

6. *Services*

Market operator provides a platform that properly connect TSO and DSO flexibility requirements.

TSO and DSO can tap the intraday flexibility platform – e.g. for local congestion management.

Wholesale approach of market clearing is enhanced with the small scale resources.

Local effects (e.g. voltage issues, grid constraints) are priced consistently within the existing intraday market framework.

PUN pricing – effective tool to provide a market based solution to cover intra-zonal congestion cost markups by using cost averaging for certain type of bids (e.g. large demand).

7. *Actors*

Actor Name	**Actor Description**
Party Connected to the Grid	Either producer, or any grid user capable providing flexibility in a form of energy schedule changes.
Balance Responsible Party	Responsible for 'executing' the transacted energy on the market platform. If the resource providers do not comply, imbalance payments is due.

Resource Provider	Grid connected party's flexibility capability is marketed by this actor, either directly, or through some form of aggregation. Bids are formed, managed in the order book and results are translated as new schedules for the grid connected parties.
Resource Aggregator	Special resource provider that manages some form of control, optimization in their resource portfolio. The decision space for in-house optimization is greatly changed due to the fact that in different locations the settlement prices can be different, even the exchange occurred in a single market platform – due to the spatial dimensions considered
Scheduling Agent	Market Operator provides trading results to scheduling agent, that essentially intra-day schedule changes.
Market Operator	Operates the market platform, manages the order book, performs calculations, post public information.
TSO	Calculates transmission capacity and provides updates on it. Form its flexibility need into market bids. May approves resource to participate in wholesale zones.
DSO	Form its flexibility need into market bids. Indicates local constraints to TSO (e.g. voltage issues). May approves resource to participate in local zones.

5.8.2 Sequence Diagram of Demo 7.2

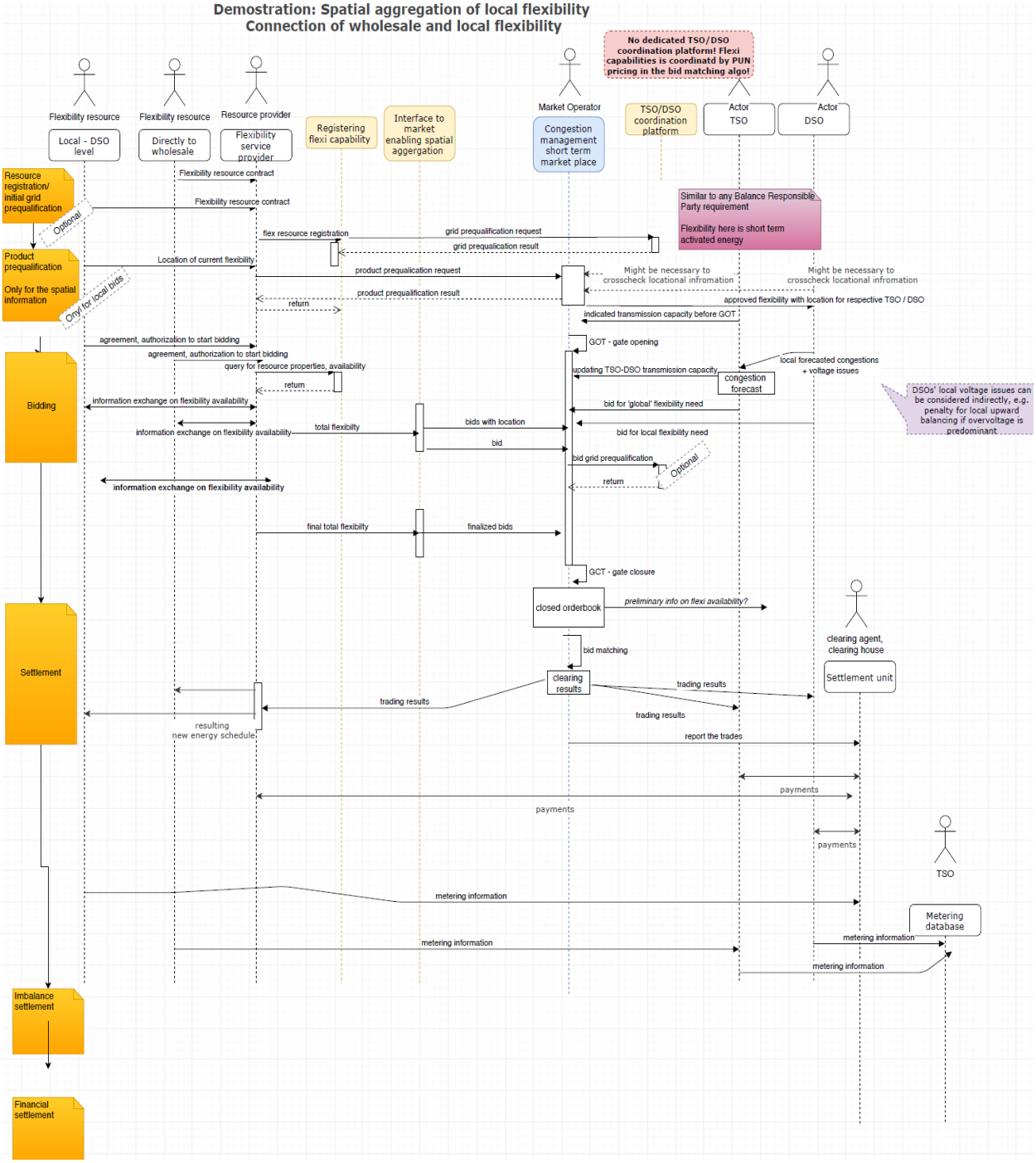


Figure 12: Sequence diagram of demo 7.2 for "Spatial aggregation of local flexibility connection of wholesale and local flexibility"

5.9 Comparison of Demos' Business Use Cases and Sequence Diagrams

In order to understand the demos needs a thorough analysis of the different business use case and sequence diagrams has been conducted. This section gives insights on the following issues gained during this analysis:

- Generic Demos' characteristics
  - The services they implement,
  - Their scope,
  - Their objectives,
  - Their main expected outcomes,
  - Key demo elements,
  - Description of TSO-DSO coordination scheme,
  - Existence of flexibility register,
  - Actors
- Market Design
  - Market design options they follow (1A-3D),
  - Market product description,
  - Timeframe of the market,
  - Available bidding options,
  - Market clearing,
  - Market integration,
  - Communication to market participants

The following Tables provide a comparison of the demos, based on their sequence diagrams and business use cases with a focus on market design process. They provide an overview of the generic characteristics of the demos, as well as on their markets design characteristics.

Table 18: Comparison of business use cases and sequence diagrams of demos 5.1, 5.2 and 5.3

Generic characteristics of demos					
	5.1a	**5.1b**	**5.1c**	**5.2**	**5.3**
Services	Congestion management operational for DSO	Power Quality for DSO	Congestion management operational for DSO	Congestion Management operational for TSO and DSO, mFRR for TSO, non-frequency services	Congestion management operational, short-term, long-term at DSO and TSO mFRR, aFRR, FCR at TSO
Scope	To provide flexibility by means of power production	Use of battery storage and DR program to optimally exploit the	Exploit the synergies among energy network in a municipal	To provide CM service to the TSO/DSO by using part of the	First priorities: congestion management short-term,

	from programmable DG system (CHP plant)	local production of renewable energy	scale multi energy microgrids in order to maximize the self-consumption of locally produced renewable energy	power/energy capacity of one (or more) Battery Energy Storage Systems (BESS) installed in multi-user buildings (or group of homes) with PV and particular loads, such as EV and data centers.	mFRR – Estonia, Latvia, Finland
Objectives	Provide flexibility in the balancing market	Increase power quality in suburban branches of LV grid with a high share of renewable energy	Increase the flexibility of the microgrid in order to reduce the amount of electricity flow back to the TSO	To provide CM services to the TSO/DSO by using battery energy storage system (BESS) integrated in end-user communities (group of households, multi-user buildings) to form a controllable aggregated demand resource.	An envisaged service that may serve network reinforcement deferral, network support during construction and planned maintenance, where location-specific flexibility assets are being activated for shaving or shifting peak demand and production in order to compensate for the lack of network connections, loads or production

					units.
Expected Outcomes	i) improve the reliability and power quality indexes; ii) reduce the flow inversion towards TSO; iii) engage final users in early stage demand response program	i) improve the reliability and power quality indexes; ii) reduce the flow inversion towards TSO; iii) engage final users in early stage demand response program	i) improve the reliability and power quality indexes; ii) reduce the flow inversion towards TSO; iii) engage final users in early stage demand response program	Combination of local congestion management markets with wholesale and balancing markets Ancillary services provision by aggregated end-users, prosumers and distributed generation	Develop regional flexibility solutions for power markets Develop technical procedures to manage grid and system limitations via the aggregated control of consumption and / or generation The platform will provide strong assistance for developing the electricity market and increase market liquidity Implement complete and qualified system (TRL 8)
Key elements	Demonstration to real market Scalability Mechanism already implemented in demo	Demonstration to real market Scalability Introduction of an early stage Demand	Demonstration to real market Scalability Introduction of an early stage Demand Response	Demonstration to real market Scalability and replicability Mature and	Demonstration to real market First priorities: congestion management short-term

	site Pre-agreed tariffs Seasonal needs (summer) Focus on CHP plant with thermal storage	Response program Pre-agreed tariffs Focus on Demand Response	program Pre-agreed tariffs Use of several assets: Distributed batteries, CHP with thermal energy storage, EV, scheduling of pumping stations, DR in buildings	clear process The demo's hierarchical control system will be enabled to deal with several BESS	and mFRR implemented on Single Flexibility Platform Integration with other markets Scalability and replicability Maturity Clear design Direct activation and coordination mechanisms between TSO-DSO to ensure flexibility bids won't cause congestion in TSO/DSO grid.
TSO-DSO coordination	No coordination	No coordination	No coordination	Coordination on CM	Coordination on CM and on Balancing as well as coordination on bid grid prequalification
Flexibility registry	Yes	Yes	Yes	Yes	Yes
Actors	Flexibility provider, TSO, Balancing Service Provider	DSO, Balancing Service Provider (acting also as demand aggregator), Flexibility	DSO, Balancing Service Provider (acting also as demand and renewables aggregator)	TSO, DSO, Flexibility resource provider	Flexibility Service Provider, Aggregator, Balance Responsible Party, Balance Service

		Provider			Provider, Market Operator, Transmission System Operator, Distribution System Operator, Supplier, Billing Agent, Imbalance Settlement Responsible, Flexibility Register, TSO/DSO Coordination Platform
Market design of demos					
	5.1a	**5.1b**	**5.1c**	**5.2**	**5.3**
Market design options	1A for CM	1A for CM	1A for CM	1B and 1C, for CM and mFRR, 3A for non-frequency services	2A, 2B, 3A for CM
Market product	Volume of generation capacity (from CHP)	Volume of demand capacity (from storage)	Volume of generation and demand capacity (from renewables, storage, CHP, EVs, flexible demand)	Volume of demand capacity and non-frequency services (from storage)	Standard mFRR product, (TSOs foresee using a linear ramp of 10 minutes for the cross-border exchange)
Timeframe of the market	Day-ahead, Intra-day, Real-time (up to 15 minutes before	Day-ahead, Intra-day, Real-time (up to 15 minutes before activation)	Day-ahead, Intra-day, Real-time (up to 15 minutes before activation)	Day-ahead, Intra-day	Intra-day, day-ahead, long-term, real-time

	activation)				
Bidding options	Non-priced capacity volume orders, as renumeration tariff is pre-agreed	Non-priced capacity volume orders, as renumeration tariff is pre-agreed	Non-priced capacity volume orders, as renumeration tariff is pre-agreed	Single priced capacity volume orders (stepwise or linear)	Single priced capacity volume orders (stepwise or linear)
Market clearing	Pre-agreed tariff	Pre-agreed tariff	Pre-agreed tariff	Continuous market clearing at the zonal level of service request (TSO, DSO). Pre-agreed tariffs on non-frequency services.	Continuous market clearing at the zonal level of service request (TSO, DSO)
Market integration	CM discrete from balancing	CM discrete from balancing	CM discrete from balancing	CM discrete from balancing	CM integrated to balancing, as CM defined as mFRR
Communication to market participants	TSO or Balancing Service Provider informs the Flexibility provider for the needed service	DSO sends a signal to Flexibility service provider and to Flexibility provider to adjust their consumption	DSO requests from Flexibility service provider, acting also as demand and renewables aggregator, to adjust their consumption and/or generation, in case of high electricity production at DSO level	TSO and DSO define their service needs and Flexibility service provider (storage) provide order for meeting those needs	TSO and DSO define their needs in a Single Flexibility market and Flexibility service providers provide their orders

Table 19: Comparison of business use cases and sequence diagrams of demos 6.1, 6.2, 7.1 and 7.2

Generic characteristics of demos					
	6.1	**6.2**	**7.1a**	**7.1b**	**7.2**
Services	Congestion management operational for DSO	Congestion management for TSO and DSO	FCR, mFRR, aFRR for TSO	Congestion Management for TSO and DSO	Congestion management at DSO and TSO
Scope	Enable the market participation of small consumers: mainly households but the P2P local market concept in 6.1 enables the market participation of any low voltage and medium voltage users – consumers, prosumers, distributed generators, storage).	The use-case is to be demonstrated in Bulgaria and/or Romania with our TSO-DSO partners (Bulgaria – CEZ, ESO and Romania – DEO, Transelectrica)	Market design of the regional inter-zonal provision of Balancing (FCR, aFRR, mFRR) services in the South-East European system. The Use-Case describes the algorithm to be developed for the optimal power market reserves clearing for the provision of FCR, aFRR, and mFRR services.	Market design of the regional inter-zonal provision of Congestion Management services in the South-East European power system, supplementary to the Balancing (FCR, aFRR, and mFRR).	Introduce spatial dimension into the existing wholesale market design, develop a market tool that facilitate TSO-DSO coordination, use auction-type market platform incorporating complex constraint, locational information from local flexibility sources
Objectives	Support the congestion management of the DSO, considering the real loadability of grid assets, by using a smart asset	Help DSOs organize a decentralized local market for distributed resources connected to DSO-grid in order to	Aims at the regional integration of balancing markets, considering also secure grid operation and security of supply and in	Aims at the regional integration of congestion management and balancing markets, considering secure grid operation and	Realize an efficient way of solving grid related constraints through the usage of shadow prices,

	management system to consider assets' type, their age, condition and other parameters.	solve local-grid constraints, aggregate and offer remaining bids to TSO	addition facilitating the access for smaller market players.	security of supply and in addition facilitating the access for smaller market players.	provide intra-zonal congestion price signals for, both DSO and TSO, incentivizing flexibility resources, applying PUN concept.
Expected outcomes	Define the consumers with flexibility capability, demonstrate their flexible behaviour (focus on the active power), simulate/demonstrate how the voltage & congestion problems on LV and MV could be solved by using (active) flexible power.	Validating blockchain application for energy sector Build up a scalable and reliable platform	Develop a prototype and scenarios simulator for wholesale energy and balancing market Provide a mathematical formulation Provide recommendations for system operators (TSOs, DSOs) to give incentives flexibility service providers	Develop a prototype and scenarios simulator for wholesale energy, balancing and congestion management market Provide a mathematical formulation Provide recommendations for system operators (TSOs, DSOs) to give incentives flexibility service providers	Adding a spatial dimension to flexibility bids from distributed sources to enable zonal pricing.
Key elements	Demonstration to real market Integration with other markets Scalability Introduction of small-scale distributed assets to	Demonstration to real market Decentralized marketplace with locational information Integration with other	Clear price signals and clear design Scalability Robust market Simulation Framework compatible with EUPHEMIA	Clear price signals and clear design New market products for CM Scalability Robust market algorithm Mathematical	Clear price signals and clear design Scalability Robust market simulation Framework compatible with

	existing markets Use of several assets: Medium-size battery, distributed batteries, distributed EV stations and homes with smart electric heating installation The developed market algorithm should be aware of the grid topology and preferably the connection point of the market participants (grid users).	markets Scalability and Replicability DSO assesses the feasibility of offers based on Optimal Power Flow for congestion management Address three stages of DSO CM: normal overheating and power outage	algorithm Settlement based on marginal pricing, instead of a pay-as-bid Novel features of optimization framework: (i) introduction of new market products in the clearing process (hourly offers), block orders, linked block orders, as well as minimum income condition), (ii) assessment of marginal pricing instead of pay-as-bid pricing, (iii) capability of reserve provision through interconnections, (iv) price signals for operational planning.	Modelling and Simulation Novel features of optimization framework are expanding the previous cases, by integrating balancing and congestion management services and further incorporating new market products in the clearing process for congestion management	EUPHEMIA algorithm Generalize congestion pricing in hierarchical, stacked bidding areas Develop use cases for the DSOs to use the intraday flexibility pool as a tool for congestion management DSO can form single zone or a more detailed multi-zone area
TSO-DSO coordination	No coordination	No coordination, but aggregated and remaining bids at DSO level are offered to TSO	No coordination	Coordination on CM and Balancing	Coordination on CM and ex-ante proactive re-Balancing
Flexibility registry	Yes	Yes	Yes	Yes	Yes

Actors	Consumer, Producer, Party Connected to the Grid, Meter Data Responsible, Market Operator	Market Operator, Resource Aggregator, Resource Provider, DSO, TSO, Consumer	Balancing Service Provider, Transmission System Operator, Reserve Allocator, Flexibility Services Market Operator (FSMO)	Balancing Service Provider, Transmission System Operator, Reserve Allocator, Flexibility Services Market Operator (FSMO)	Party Connected to the Grid, Balance Responsible Party, Resource Provider, Resource Aggregator, Scheduling Agent, Market Operator, TSO, DSO
Market design of demos					
	6.1	**6.2**	**7.1a**	**7.1b**	**7.2**
Market design options	1A for CM operational	1A for CM long-term	1A for CM	1A, 2A and 3A for CM	3A, 3B, 3C for CM
Market product	Volume of energy (from generation and demand grid users).	Volume of capacity (from generation and demand assets).	The minimum bid size is 1 MW from generating, demand and interconnections capacity. TSOs will allow divisible bids together with indivisible bids. Indivisible bids will have a maximum bid size of 25 MW.	The minimum bid size is 1 MW from generating, demand and interconnections capacity. TSOs will allow divisible bids together with indivisible bids. Indivisible bids will have a maximum bid size of 25 MW.	15-min. energy from generating and demand assets.
Timeframe of the market	Intra-day	Intra-day, Balancing	Day-ahead	Day-ahead	Intra-day
Bidding options	Single priced capacity volume orders	Single priced capacity volume orders (stepwise or linear)	Stepwise hourly orders. Block orders. Linked Block orders. Exclusive	Stepwise hourly orders. Block orders. Linked Block orders. Exclusive	EUPHEMIA PUN orders

			group of block orders. Flexible Hourly Orders. Complex orders (minimum income and load gradient).	group of block orders. Flexible Hourly Orders. Complex orders (minimum income and load gradient).	
Market clearing	Local P2P Market	P2P market at DSO level	Zonal prices	Zonal prices	Zonal prices
Market integration	CM discrete from balancing	CM discrete from balancing	CM discrete from balancing	CM integrated to balancing, as CM defined as mFRR	CM integrated to wholesale markets
Communication to market participants	DSO provides the grid topology information to the market platform. As a supplement to the local P2P marketplace, there will be an Integrated Asset Condition Management System (IACMS). IACMS will provide loadability limits for the P2P local market module and inform market participants, namely local grid users, which provide	DSO analyses the actual state of the distribution grid and forecast the flexibility needs, which are listed on marketplace. Marketplace communicates buyers' zones and size requirements ahead of tenders. Flexibility providers submit offers along with flexibility unit location to satisfy the corresponding services of DSO.	The TSO publishes the regional day-ahead reserve requirements (per type: FCR, aFRR, mFRR, considering individual TSO requirements and TSOs coordination). All the market participants assess their availability and create their flexibility services bids for the following day. The bids are sent to the regional Flexibility Services Market Operator (FSMO) before the gate	The regional TSO publishes the regional day-ahead reserve requirements (per type: CM, FCR, aFRR, mFRR, considering individual TSO requirements, DSO requirements and resources, TSOs and TSOS-DSOs coordination). All the market participants assess their availability and create their flexibility services (CM and balancing) bids for the following day. The CM and balancing bids	The whole process is initiated by the market operator, with opening the order book for the bids. During the bidding process resource providers - traders, aggregators, producers and system operators – TSO, DSOs both submit their bids. System operators also provide information about

	energy bids.		closure date.	are sent to the regional Flexibility Services Market Operator (FSMO) before the gate closure date.	available transmission capacity. After gate closure, the order matching begins, using a holistic mathematical formulation for optimal market outcomes, linking consumers – DSOs – TSOs.

6 Top-down elaboration of IEGSA specifications

According to the description of the demos business use cases reported above, the main addressed services are represented by balancing (provided by mFRR and aFRR) and congestion management. Looking at INTERRFACE project deliverable D3.2[4], different market options can be adopted for the implementation of these services and a schematic view is illustrated in Figure 13, where nine possible market options are provided.

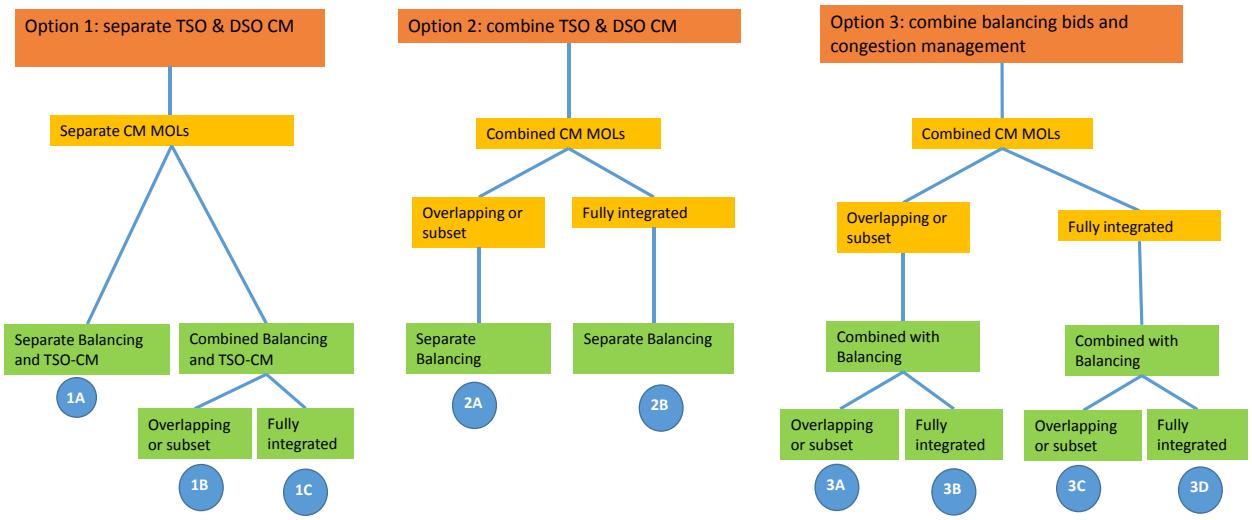


Figure 13: Schematic view of the possible implementation of balancing and congestion management markets

The main difference consists of the way in which services are managed separately or in a joint way. Depending on the adopted architecture, the sequences for the prequalification, capacity reservation, procurement, activation and settlement (reported within the following sub-sections) can be significantly different.

This report concentrates its content in analysing high-level sequence diagrams (considering the harmonized market roles defined by ENTSO-E[5]) of the following market options, which are considered the ones more in line with the next future implementations and with market tools that will be developed within the project:

- Market options in which TSO and DSO congestion management is separated
  The report analyses the differences of market options with respect to the merit order list management (separated – 1A, partially overlapping – 1B, or fully integrated – 1C).
- Market options in which TSO and DSO congestion management is combined
  The report analyses the market option 2B, where TSO and DSO congestions are managed by the same market. This architecture is compared to market option 1A, in which balancing and CM is separated too.
- Market options in which TSO and DSO congestion management can access to balancing resources too
  The report analyses the main differences between market option 3C and market option 2B,

[4] INTERRFACE Project deliverable D3.2 "Definition of new/changing requirements for Market Designs"

[5] ENTSO-E "The Harmonized Electricity Maket Role Model", Version: 2019-01 - https://www.entsoe.eu/digital/cim/role-models/

respectively consisting of a totally separated and partially overlapping of congestion management and balancing markets.

6.1 Market Design Options – 1A

In this option, local Congestion Management (CM) markets are developed as dedicated solutions to DSO congestion management and separated from TSOs congestion management. In addition, TSOs congestion management is separated from balancing. TSOs and DSOs are procuring flexibility separately for each markets using three separated Merit Order lists (MOL). No other markets are integrated and therefore operate in parallel.

The following subsections are listing the main steps of the sequences that characterize balancing and congestion management services. In particular:

- aFRR and mFRR (balancing services) are requesting the submission of dedicated bids and the market activate flexibility resources by accessing to a dedicated MOL.
- Congestion management is divided in short-term and operational. They access to dedicated MOLs, which can be different depending on the area (transmission or distribution) for which bids are submitted.

6.1.1 Balancing mFRR + aFRR

Prequalification

From	To	Action
Transmission Reserve Allocator	Resource Aggregator / Balancing Service Provider	Resources are certified to be capable of contributing to mFRR and/or aFRR (separated prequalification processes: mFRR and aFRR have different technical requirements)
Distribution Nomination Validator	Transmission Reserve Allocator / Nomination Validator	If a candidate resource is located at distribution level, the amount of flexibility that can be exploited without violating known distribution network constraints is communicated to the reserve allocator / nomination validator.
Transmission Reserve Allocator / Nomination Validator	Resource Aggregator / Balancing Service Provider	The amount of flexibility that can be used as balancing reserve (without violating known network constraints) is communicated to the resource aggregators
Transmission Reserve Allocator / Nomination	Resource Aggregator / Balancing Service	Depending on the strategic position/preciousness of a resource, it is requested to be capable of providing regulation reserve mandatorily. In this case, selected resources can be requested to participate to both capacity and balancing markets.

Validator	Provider	

Reservation of available capacity (day ahead)

From	To	Action
Resource Aggregator / Balancing Service Provider	Merit Order List Responsible / Balancing Market Operator	Resource aggregators bid their availability in providing regulation reserve for the day after.
Balancing Reserve Allocator	Merit Order List Responsible / Balancing Market Operator	The market is managed in order to select the resources according to a dedicated merit order list and balancing reserve requirements Bids include information concerning the conflicts in providing both mFRR and aFRR (normally the amount of available mFRR can depend on the amount of selected aFRR, and vice versa).
Merit Order List Responsible / Balancing Market Operator	Resource Aggregator / Balancing Service Provider	The reserve selected by the market is communicated to the resource aggregators and they will be requested to bid their flexibility the day after during the procurement/activation process

Procurement of energy products (intraday)

From	To	Action
Resource Aggregator / Balancing Service Provider	Merit Order List Responsible / Balancing Market Operator	Resource aggregator bids its actual availability (referred to the next hour) in providing mFRR and aFRR regulation. The bids should be in line with the ones selected the day before during the reservation process. Additional resource aggregators can participate even if their flexibility was not preliminarily reserved.
Balancing Reserve Allocator	Merit Order List Responsible / Balancing Market Operator	The market is managed in order to select the resources according to a dedicated merit order list and balancing reserve requirements. The selection of aFRR and mFRR is performed simultaneously since their provision by a single resource can be conflictual (the amount of available mFRR can depends on the amount of selected aFRR, and vice versa). mFRR consists of an active power set-point (step) to be activated at a given time within the market window. aFRR consists of a regulation band that selected resources are requested to provide when the TSO communicates the secondary frequency control signal.
Merit Order List Responsible / Balancing Market Operator	Resource Aggregator / Balancing Service Provider / Load Frequency Control Operator	The reserves/activations (aFRR+mFRR) selected by the market are communicated to the bidding resource aggregators and they are requested to operate/regulate their power plant accordingly.

Activation

From	To	Action
Resource Aggregator / Balancing Service Provider	Balancing Reserve Providing Units/Groups	Information related to the proper activation of the selected reserve are communicated to the involved units and groups. In case of mFRR, the power step characteristics are provided. In case of aFRR the reserve to be guaranteed to the Load Frequency Control Operator is communicated.
Load Frequency Control Operator	Balancing Reserve Providing Units/Groups	Load Frequency Control Operator send the secondary frequency control signal to resources participating to aFRR.

Settlement

From	To	Action
Metered Data Responsible	Balancing Market Information Aggregator	The effective provision of regulation reserve is verified by reading metered data.
Balancing Market Information Aggregator	Resource Aggregator / Balancing Service Provider	Resource aggregators for which balancing bids have been accepted are remunerated according to the effective provision of the requested activation and the price returned by the market clearing algorithm. Penalties are applied in case the service is not provided properly.
Resource Aggregator / Balancing Service Provider	Balancing Reserve Providing Units/Groups	Units and Groups that participated to mFRR and aFRR and provided the requested services are remunerated by the related Resource Aggregator.
Balancing Market Information Aggregator	Imbalance Settlement Responsible	The sources of imbalance are identified and penalties are applied according to the cost of activated balancing reserve.

6.1.2 Short term Congestion Management (transmission)

Prequalification

From	To	Action
Transmission Reserve Allocator	Resource Aggregator	Resources are certified to be technically capable of contributing to congestion management services at transmission level.
Distribution Nomination Validator	Transmission Reserve Allocator / Nomination Validator	If a candidate resource is located at distribution level, the amount of flexibility that can be exploited without violating known distribution network constraints is communicated to the reserve allocator / nomination validator.
Transmission Reserve Allocator / Nomination Validator	Resource Aggregator	The amount of flexibility that can be used as congestion management reserve (without violating known network constraints) is communicated to resource aggregators.
Transmission Reserve Allocator / Nomination Validator	Resource Aggregator	Depending on the strategic position/preciousness of a resource, it is requested to be capable of providing congestion management services mandatorily. In this case, selected resources can be requested to participate to both capacity and balancing markets.

Procurement of energy products (day ahead)

From	To	Action
Resource Aggregator	Merit Order List Responsible / Congestion Management Market Operator	Resource aggregator bids its availability in providing congestion management services for the day after.
Transmission System Operator	Merit Order List Responsible / Congestion Management Market Operator	Congestion forecast is performed in order to identify the transmission network sections in which limits are expected to be likely violated (e.g. 95% of confidence interval).
Merit Order List Responsible / Congestion Management Market Operator	Merit Order List Responsible / Congestion Management Market Operator	The market is managed in order to select the resources according to a dedicated merit order list. The selection is performed after the day-ahead energy market and activations are optimized in order to avoid imbalance.
Merit Order List Responsible / Congestion Management Market Operator	Resource Aggregator	The reserve selected by the market is communicated to the resource aggregators and they will be requested to activate their flexibility the day after during the activation process.

Activation

From	To	Action
Resource Aggregator	Reserve Providing Units/Groups	Information related to the proper activation of the selected congestion management reserve are communicated to the involved units and groups.

Settlement

From	To	Action
Metered Data Responsible	Congestion Management Market Information Aggregator	The effective provision of congestion management reserve is verified by reading metered data.
Congestion Management Market Information Aggregator	Resource Aggregator	Resource aggregators for which congestion management bids have been accepted are remunerated according to the effective provision of the requested activation and the price returned by the market clearing algorithm. Penalties are applied in case the service is not provided properly.
Resource Aggregator	Reserve Providing Units/Groups	Units and Groups that participated to congestion management services are remunerated by the related Resource Aggregator.
Congestion Management Market Information Aggregator	Transmission System Operator	Transmission System Operator is responsible for the costs related to congestion management.

6.1.3 Operational Congestion Management (transmission)

Prequalification

From	To	Action
Transmission Reserve Allocator	Resource Aggregator	Resources are certified to be technically capable of contributing to congestion management services at transmission level.
Distribution Nomination Validator	Transmission Reserve Allocator / Nomination Validator	If a candidate resource is located at distribution level, the amount of flexibility that can be exploited without violating known distribution network constraints is communicated to the reserve allocator / nomination validator.
Transmission Reserve Allocator / Nomination Validator	Resource Aggregator	The amount of flexibility that can be used as congestion management reserve (without violating known network constraints) is communicated to resource aggregators.
Transmission Reserve Allocator / Nomination Validator	Resource Aggregator	Depending on the strategic position/preciousness of a resource, it is requested to be capable of providing congestion management services mandatorily. In this case, selected resources can be requested to participate to both capacity and balancing markets.

Reservation of available capacity (day ahead)

From	To	Action
Resource Aggregator	Merit Order List Responsible / Congestion Management Market Operator	Resource aggregator bids its availability in providing congestion management services for the day after.
Transmission System Operator	Merit Order List Responsible / Congestion Management Market Operator	Congestion forecast is performed in order to identify the transmission network sections in which limits can be expected to be violated with a non-negligible probability.
Merit Order List Responsible / Congestion Management Market Operator	Merit Order List Responsible / Congestion Management Market Operator	The market is managed in order to select the resources according to a dedicated merit order list and considering the optimal location in which the resources should be located to perform the requested service. The selection of resources expected to provide regulation reserve is performed by considering the necessity of making balanced activations (congestion management service with no impact on the system balance).
Merit Order List Responsible / Congestion Management Market Operator	Resource Aggregator	The congestion management reserve selected by the market is communicated to resource aggregators and they will be requested to activate the related flexibility the day after during the procurement/activation process.

Procurement of energy products (intraday)

From	To	Action
Resource Aggregator	Merit Order List Responsible / Congestion Management Market Operator	Resource aggregators bid their actual availability (referred to the next hour) in providing congestion management service. The bids should be in line with the ones selected the day before during the reservation process. Additional resource aggregators can participate even if not preliminarily reserved.
Transmission System Operator	Merit Order List Responsible / Congestion Management Market Operator	Congestion forecast is performed in order to identify the transmission network sections in which limits can be expected to be violated with a non-negligible probability.
Merit Order List Responsible / Congestion Management Market Operator	Merit Order List Responsible / Congestion Management Market Operator	The market is managed in order to select the bids according to a dedicated merit order list. The selection of resources expected to provide regulation reserve is performed by considering the necessity of making balanced activations (congestion management service with no impact on the system balance).
Merit Order List Responsible / Congestion Management Market Operator	Resource Aggregator	The activations selected by the market are communicated to the bidding resource aggregators and they are requested to operate/regulate their resources accordingly.

Activation

From	To	Action
Resource Aggregator	Reserve Providing Units/Groups	Information related to the proper activation of the selected congestion management reserve are communicated to the involved units and groups.

Settlement

From	To	Action
Metered Data Responsible	Congestion Management Market Information Aggregator	The effective provision of congestion management reserve is verified by reading metered data.
Congestion Management Market Information Aggregator	Resource Aggregator	Resource aggregators for which congestion management bids have been accepted are remunerated according to the effective provision of the requested activation and the price returned by the market clearing algorithm. Penalties are applied in case the service is not provided properly.
Resource Aggregator	Reserve Providing Units/Groups	Units and Groups that participated to congestion management services are remunerated by the related Resource Aggregator.
Congestion Management Market Information Aggregator	Transmission System Operator	Transmission System Operator is responsible for the costs related to congestion management.

6.1.4 Short term Congestion Management (distribution)

Prequalification

From	To	Action
Distribution Reserve Allocator	Resource Aggregator	Resources are certified to be technically capable of contributing to congestion management services at distribution level.
Distribution Reserve Allocator / Nomination Validator	Resource Aggregator	The amount of flexibility that can be used as congestion management reserve (without violating known network constraints) is communicated to resource aggregators.
Distribution Reserve Allocator / Nomination Validator	Resource Aggregator	Depending on the strategic position/preciousness of a resource, it is requested to be capable of providing congestion management services mandatorily. In this case, selected resources can be requested to participate to both capacity and balancing markets.

Procurement of energy products (day ahead)

From	To	Action
Resource Aggregator	Merit Order List Responsible / Congestion Management Market Operator	Resource aggregator bids its availability in providing congestion management services for the day after.
Distribution System Operator	Merit Order List Responsible / Congestion Management Market Operator	Congestion forecast is performed in order to identify the distribution network sections in which limits are expected to be likely violated (e.g. 95% of confidence interval).
Merit Order List Responsible / Congestion Management Market Operator	Merit Order List Responsible / Congestion Management Market Operator	The market is managed in order to select the resources according to a dedicated merit order list.
Merit Order List Responsible / Congestion Management Market Operator	Balancing Reserve Allocator	At distribution level, liquidity problems make the balancing of activations difficult. For this reason, the selected actions are communicated to the balancing reserve allocator in order to consider additional balancing reserve.
Merit Order List Responsible / Congestion Management Market Operator	Resource Aggregator	The reserve selected by the market is communicated to the resource aggregators and they will be requested to activate their flexibility the day after during the activation process.

Activation

From	To	Action
Resource Aggregator	Reserve Providing Units/Groups	Information related to the proper activation of the selected congestion management reserve are communicated to the involved units and groups.

Settlement

From	To	Action
Metered Data Responsible	Congestion Management Market Information Aggregator	The effective provision of congestion management reserve is verified by reading metered data.
Congestion Management Market Information Aggregator	Resource Aggregator	Resource aggregators for which congestion management bids have been accepted are remunerated according to the effective provision of the requested activation and the price returned by the market clearing algorithm. Penalties are applied in case the service is not provided properly.
Resource Aggregator	Reserve Providing Units/Groups	Units and Groups that participated to congestion management services are remunerated by the related Resource Aggregator.
Congestion Management Market Information Aggregator	Distribution System Operator	Distribution System Operator is responsible for the costs related to congestion management.
Balancing Market Information Aggregator	Distribution System Operator	The cost of imbalance caused by distribution congestion management is in charge of the Distribution System Operator

6.1.5 Operational Congestion Management (distribution)

Prequalification

From	To	Action
Distribution Reserve Allocator	Resource Aggregator	Resources are certified to be technically capable of contributing to congestion management services at distribution level.
Distribution Reserve Allocator / Nomination Validator	Resource Aggregator	The amount of flexibility that can be used as congestion management reserve (without violating known network constraints) is communicated to resource aggregators.
Distribution Reserve Allocator / Nomination Validator	Resource Aggregator	Depending on the strategic position/preciousness of a resource, it is requested to be capable of providing congestion management services mandatorily. In this case, selected resources can be requested to participate to both capacity and balancing markets.

Reservation of available capacity (day ahead)

From	To	Action
Resource Aggregator	Merit Order List Responsible / Congestion Management Market Operator	Resource aggregator bids its availability in providing congestion management services for the day after.
Distribution System Operator	Merit Order List Responsible / Congestion Management Market Operator	Congestion forecast is performed in order to identify the distribution network sections in which limits can be expected to be violated with a non-negligible probability.
Merit Order List Responsible / Congestion Management Market Operator	Merit Order List Responsible / Congestion Management Market Operator	The market is managed in order to select the resources according to a dedicated merit order list and considering the optimal location in which the resources should be located to perform the requested service.
Merit Order List Responsible / Congestion Management Market Operator	Balancing Reserve Allocator	At distribution level, liquidity problems make the balancing of activations difficult. For this reason, the selected actions are communicated to the balancing reserve allocator in order to consider additional balancing reserve.
Merit Order List Responsible / Congestion Management Market Operator	Resource Aggregator	The congestion management reserve selected by the market is communicated to resource aggregators and they will be requested to activate the related flexibility the day after during the procurement/activation process.

Procurement of energy products (intraday)

From	To	Action
Resource Aggregator	Merit Order List Responsible / Congestion Management Market Operator	Resource aggregators bid their actual availability (referred to the next hour) in providing congestion management service. The bids should be in line with the ones selected the day before during the reservation process. Additional resource aggregators can participate even if not preliminarily reserved.
Distribution System Operator	Merit Order List Responsible / Congestion Management Market Operator	Congestion forecast is performed in order to identify the distribution network sections in which limits can be expected to be violated with a non-negligible probability.
Merit Order List Responsible / Congestion Management Market Operator	Merit Order List Responsible / Congestion Management Market Operator	The market is managed in order to select the bids according to a dedicated merit order list.
Merit Order List Responsible / Congestion Management Market Operator	Balancing Reserve Allocator	At distribution level, liquidity problems make the balancing of activations difficult. For this reason, the selected actions are communicated to the balancing reserve allocator in order to consider additional balancing reserve.
Merit Order List Responsible / Congestion Management Market Operator	Resource Aggregator	The activations selected by the market are communicated to the bidding resource aggregators and they are requested to operate/regulate their resources accordingly.

Activation

From	To	Action
Resource Aggregator	Reserve Providing Units/Groups	Information related to the proper activation of the selected congestion management reserve are communicated to the involved units and groups.

Settlement

From	To	Action
Metered Data Responsible	Congestion Management Market Information Aggregator	The effective provision of congestion management reserve is verified by reading metered data.
Congestion Management Market Information Aggregator	Resource Aggregator	Resource aggregators for which congestion management bids have been accepted are remunerated according to the effective provision of the requested activation and the price returned by the market clearing algorithm. Penalties are applied in case the service is not provided properly.
Resource Aggregator	Reserve Providing Units/Groups	Units and Groups that participated to congestion management services are remunerated by the related Resource Aggregator.
Congestion Management Market Information Aggregator	Distribution System Operator	Distribution System Operator is responsible for the costs related to congestion management.
Balancing Market Information Aggregator	Distribution System Operator	The cost of imbalance caused by distribution congestion management is in charge of the Distribution System Operator

6.2 Market Design Options – 1B

In this option, the local CM markets for DSOs & TSOs are still separated (separate MOLs). TSOs are procuring flexibility for CM by accessing bids specific to the TSOs CM market as well as partly accessing bids of the balancing market via overlapping MOLs of TSOs CM and balancing, which have been extended by local information. This means that, with respect to market option 1A:

- further requirements need to be specified for the prequalification process related to the balancing services (balancing reserve needs to be capable of possibly providing congestion management services);
- balancing market sessions need to consider the fact that some resources of the dedicated MOL are already reserved/activated by the balancing market;
- balancing resources shared with congestion management market can lead to the activation of resources with higher costs.

This affects both the balancing service (mFRR and aFRR) and operational congestion management (the main modifications are highlighted in bold font within the next sub-sections). In particular, the latter accesses to balancing resources only when the allocated congestion management reserve result to be not adequate. Short-term congestion management and distribution markets are not affected.

6.2.1 Balancing mFRR + aFRR

Prequalification

From	To	Action
Transmission Reserve Allocator	Resource Aggregator / Balancing Service Provider	Resources are certified to be capable of contributing to mFRR and/or aFRR (separated prequalification processes: mFRR and aFRR have different technical requirements). **Since resources can be possibly involved to provide CM services, additional requirements might be requested.**
Distribution Nomination Validator	Transmission Reserve Allocator / Nomination Validator	If a candidate resource is located at distribution level, the amount of flexibility that can be exploited without violating known distribution network constraints is communicated to the reserve allocator / nomination validator.
Transmission Reserve Allocator / Nomination Validator	Resource Aggregator / Balancing Service Provider	The amount of flexibility that can be used as balancing reserve (without violating known network constraints) is communicated to the resource aggregators
Transmission Reserve Allocator / Nomination Validator	Resource Aggregator / Balancing Service Provider	Depending on the strategic position/preciousness of a resource, it is requested to be capable of providing regulation reserve mandatorily. In this case, selected resources can be requested to participate to both capacity and balancing markets.

Reservation of available capacity (day ahead)

From	To	Action
Resource Aggregator / Balancing Service Provider	Merit Order List Responsible / Balancing Market Operator	Resource aggregators bid their availability in providing regulation reserve for the day after.
Balancing Reserve Allocator	Merit Order List Responsible / Balancing Market Operator	The market is managed in order to select the resources according to a dedicated merit order list and balancing reserve requirements Bids include information concerning the conflicts in providing both mFRR and aFRR (normally the amount of available mFRR can depend on the amount of selected aFRR, and vice versa).
Merit Order List Responsible / Balancing Market Operator	Resource Aggregator / Balancing Service Provider	The reserve selected by the market is communicated to the resource aggregators and they will be requested to bid their flexibility the day after during the procurement/activation process.

Procurement of energy products (intraday)

From	To	Action
Resource Aggregator / Balancing Service Provider	Merit Order List Responsible / Balancing Market Operator	Resource aggregator bids its actual availability (referred to the next hour) in providing mFRR and aFRR regulation. The bids should be in line with the ones selected the day before during the reservation process. Additional resource aggregators can participate even if their flexibility was not preliminarily reserved.
Balancing Reserve Allocator	Merit Order List Responsible / Balancing Market Operator	The market is managed in order to select the resources according to a dedicated merit order list and balancing reserve requirements. The selection of aFRR and mFRR is performed simultaneously since their provision by a single resource can be conflictual (the amount of available mFRR can depends on the amount of selected aFRR, and vice versa). mFRR consists of an active power set-point (step) to be activated at a given time within the market window. aFRR consists of a regulation band that selected resources are requested to provide when the TSO communicates the secondary frequency control signal. **Since some balancing dedicated resources can be requested to provide CM services, the selection needs to exclude them when already activated/reserved for CM.**
Merit Order List Responsible / Balancing Market Operator	Resource Aggregator / Balancing Service Provider / Load Frequency Control Operator	The reserves/activations (aFRR+mFRR) selected by the market are communicated to the bidding resource aggregators and they are requested to operate/regulate their power plant accordingly.

Activation

From	To	Action
Resource Aggregator / Balancing Service Provider	Balancing Reserve Providing Units/Groups	Information related to the proper activation of the selected reserve are communicated to the involved units and groups. In case of mFRR, the power step characteristics are provided. In case of aFRR the reserve to be guaranteed to the Load Frequency Control Operator is communicated.
Load Frequency Control Operator	Balancing Reserve Providing Units/Groups	Load Frequency Control Operator send the secondary frequency control signal to resources participating to aFRR.

Settlement

From	To	Action
Metered Data Responsible	Balancing Market Information Aggregator	The effective provision of regulation reserve is verified by reading metered data.
Balancing Market Information Aggregator	Resource Aggregator / Balancing Service Provider	Resource aggregators for which balancing bids have been accepted are remunerated according to the effective provision of the requested activation and the price returned by the market clearing algorithm. Penalties are applied in case the service is not provided properly.
Resource Aggregator / Balancing Service Provider	Balancing Reserve Providing Units/Groups	Units and Groups that participated to mFRR and aFRR and provided the requested services are remunerated by the related Resource Aggregator.
Balancing Market Information Aggregator	Imbalance Settlement Responsible	The sources of imbalance are identified and penalties are applied according to the cost of activated balancing reserve. **CM market access to the balancing dedicated merit order list potentially increases the cost of balancing services. This impact needs to be considered within the imbalance settlement.**

6.2.2 Short term Congestion Management (transmission)

Prequalification

From	To	Action
Transmission Reserve Allocator	Resource Aggregator	Resources are certified to be technically capable of contributing to congestion management services at transmission level.
Distribution Nomination Validator	Transmission Reserve Allocator / Nomination Validator	If a candidate resource is located at distribution level, the amount of flexibility that can be exploited without violating known distribution network constraints is communicated to the reserve allocator / nomination validator.
Transmission Reserve Allocator / Nomination Validator	Resource Aggregator	The amount of flexibility that can be used as congestion management reserve (without violating known network constraints) is communicated to resource aggregators.
Transmission Reserve Allocator / Nomination Validator	Resource Aggregator	Depending on the strategic position/preciousness of a resource, it is requested to be capable of providing congestion management services mandatorily. In this case, selected resources can be requested to participate to both capacity and balancing markets.

Procurement of energy products (day ahead)

From	To	Action
Resource Aggregator	Merit Order List Responsible / Congestion Management Market Operator	Resource aggregator bids its availability in providing congestion management services for the day after.
Transmission System Operator	Merit Order List Responsible / Congestion Management Market Operator	Congestion forecast is performed in order to identify the transmission network sections in which limits are expected to be likely violated (e.g. 95% of confidence interval).
Merit Order List Responsible / Congestion Management Market Operator	Merit Order List Responsible / Congestion Management Market Operator	The market is managed in order to select the resources according to a dedicated merit order list. The selection is performed after the day-ahead energy market and activations are optimized in order to avoid imbalance. In case
Merit Order List Responsible / Congestion Management Market Operator	Resource Aggregator	The reserve selected by the market is communicated to the resource aggregators and they will be requested to activate their flexibility the day after during the activation process.

Activation

From	To	Action
Resource Aggregator	Reserve Providing Units/Groups	Information related to the proper activation of the selected congestion management reserve are communicated to the involved units and groups.

Settlement

From	To	Action
Metered Data Responsible	Congestion Management Market Information Aggregator	The effective provision of congestion management reserve is verified by reading metered data.
Congestion Management Market Information Aggregator	Resource Aggregator	Resource aggregators for which congestion management bids have been accepted are remunerated according to the effective provision of the requested activation and the price returned by the market clearing algorithm. Penalties are applied in case the service is not provided properly.
Resource Aggregator	Reserve Providing Units/Groups	Units and Groups that participated to congestion management services are remunerated by the related Resource Aggregator.
Congestion Management Market Information Aggregator	Transmission System Operator	Transmission System Operator is responsible for the costs related to congestion management.

6.2.3 Operational Congestion Management (transmission)

Prequalification

From	To	Action
Transmission Reserve Allocator	Resource Aggregator	Resources are certified to be technically capable of contributing to congestion management services at transmission level.
Distribution Nomination Validator	Transmission Reserve Allocator / Nomination Validator	If a candidate resource is located at distribution level, the amount of flexibility that can be exploited without violating known distribution network constraints is communicated to the reserve allocator / nomination validator.
Transmission Reserve Allocator / Nomination Validator	Resource Aggregator	The amount of flexibility that can be used as congestion management reserve (without violating known network constraints) is communicated to resource aggregators.
Transmission Reserve Allocator / Nomination Validator	Resource Aggregator	Depending on the strategic position/preciousness of a resource, it is requested to be capable of providing congestion management services mandatorily. In this case, selected resources can be requested to participate to both capacity and balancing markets.

Reservation of available capacity (day ahead)

From	To	Action
Resource Aggregator	Merit Order List Responsible / Congestion Management Market Operator	Resource aggregator bids its availability in providing congestion management services for the day after.
Transmission System Operator	Merit Order List Responsible / Congestion Management Market Operator	Congestion forecast is performed in order to identify the transmission network sections in which limits can be expected to be violated with a non-negligible probability.
Merit Order List Responsible / Congestion Management Market Operator	Merit Order List Responsible / Congestion Management Market Operator	The market is managed in order to select the resources according to a dedicated merit order list and considering the optimal location in which the resources should be located to perform the requested service. The selection of resources expected to provide regulation reserve is performed by considering the necessity of making balanced activations (congestion management service with no impact on the system balance).
Merit Order List Responsible / Congestion Management Market Operator	Resource Aggregator	The congestion management reserve selected by the market is communicated to resource aggregators and they will be requested to activate the related flexibility the day after during the procurement/activation process.

Procurement of energy products (intraday)

From	To	Action
Resource Aggregator	Merit Order List Responsible / Congestion Management Market Operator	Resource aggregators bid their actual availability (referred to the next hour) in providing congestion management service. The bids should be in line with the ones selected the day before during the reservation process. Additional resource aggregators can participate even if not preliminarily reserved.
Transmission System Operator	Merit Order List Responsible / Congestion Management Market Operator	Congestion forecast is performed in order to identify the transmission network sections in which limits can be expected to be violated with a non-negligible probability.
Merit Order List Responsible / Congestion Management Market Operator	Merit Order List Responsible / Congestion Management Market Operator	The market is managed in order to select the bids according to a dedicated merit order list. The selection of resources expected to provide regulation reserve is performed by considering the necessity of making balanced activations (congestion management service with no impact on the system balance). **In case the available CM reserve is not adequate for the identified congestions, the market accesses to the balancing merit order lists too.**
Merit Order List Responsible / Congestion Management Market Operator	Resource Aggregator	The activations selected by the market are communicated to the bidding resource aggregators and they are requested to operate/regulate their resources accordingly.

Activation

From	To	Action
Resource Aggregator	Reserve Providing Units/Groups	Information related to the proper activation of the selected congestion management reserve are communicated to the involved units and groups.

Settlement

From	To	Action
Metered Data Responsible	Congestion Management Market Information Aggregator	The effective provision of congestion management reserve is verified by reading metered data.
Congestion Management Market Information Aggregator	Resource Aggregator	Resource aggregators for which congestion management bids have been accepted are remunerated according to the effective provision of the requested activation and the price returned by the market clearing algorithm. Penalties are applied in case the service is not provided properly.
Resource Aggregator	Reserve Providing Units/Groups	Units and Groups that participated to congestion management services are remunerated by the related Resource Aggregator.
Congestion Management Market Information Aggregator	Transmission System Operator	Transmission System Operator is responsible for the costs related to congestion management. **Additional costs due to the balancing merit order list can be experienced.**

6.2.4 Short term Congestion Management (distribution)

Prequalification

From	To	Action
Distribution Reserve Allocator	Resource Aggregator	Resources are certified to be technically capable of contributing to congestion management services at distribution level.
Distribution Reserve Allocator / Nomination Validator	Resource Aggregator	The amount of flexibility that can be used as congestion management reserve (without violating known network constraints) is communicated to resource aggregators.
Distribution Reserve Allocator / Nomination Validator	Resource Aggregator	Depending on the strategic position/preciousness of a resource, it is requested to be capable of providing congestion management services mandatorily. In this case, selected resources can be requested to participate to both capacity and balancing markets.

Procurement of energy products (day ahead)

From	To	Action
Resource Aggregator	Merit Order List Responsible / Congestion Management Market Operator	Resource aggregator bids its availability in providing congestion management services for the day after.
Distribution System Operator	Merit Order List Responsible / Congestion Management Market Operator	Congestion forecast is performed in order to identify the distribution network sections in which limits are expected to be likely violated (e.g. 95% of confidence interval).
Merit Order List Responsible / Congestion Management Market Operator	Merit Order List Responsible / Congestion Management Market Operator	The market is managed in order to select the resources according to a dedicated merit order list.
Merit Order List Responsible / Congestion Management Market Operator	Balancing Reserve Allocator	At distribution level, liquidity problems make the balancing of activations difficult. For this reason, the selected actions are communicated to the balancing reserve allocator in order to consider additional balancing reserve.
Merit Order List Responsible / Congestion Management Market Operator	Resource Aggregator	The reserve selected by the market is communicated to the resource aggregators and they will be requested to activate their flexibility the day after during the activation process.

Activation

From	To	Action
Resource Aggregator	Reserve Providing Units/Groups	Information related to the proper activation of the selected congestion management reserve are communicated to the involved units and groups.

Settlement

From	To	Action
Metered Data Responsible	Congestion Management Market Information Aggregator	The effective provision of congestion management reserve is verified by reading metered data.
Congestion Management Market Information Aggregator	Resource Aggregator	Resource aggregators for which congestion management bids have been accepted are remunerated according to the effective provision of the requested activation and the price returned by the market clearing algorithm. Penalties are applied in case the service is not provided properly.
Resource Aggregator	Reserve Providing Units/Groups	Units and Groups that participated to congestion management services are remunerated by the related Resource Aggregator.
Congestion Management Market Information Aggregator	Distribution System Operator	Distribution System Operator is responsible for the costs related to congestion management.
Balancing Market Information Aggregator	Distribution System Operator	The cost of imbalance caused by distribution congestion management is in charge of the Distribution System Operator

6.2.5 Operational Congestion Management (distribution)

Prequalification

From	To	Action
Distribution Reserve Allocator	Resource Aggregator	Resources are certified to be technically capable of contributing to congestion management services at distribution level.
Distribution Reserve Allocator / Nomination Validator	Resource Aggregator	The amount of flexibility that can be used as congestion management reserve (without violating known network constraints) is communicated to resource aggregators.
Distribution Reserve Allocator / Nomination Validator	Resource Aggregator	Depending on the strategic position/preciousness of a resource, it is requested to be capable of providing congestion management services mandatorily. In this case, selected resources can be requested to participate to both capacity and balancing markets.

Reservation of available capacity (day ahead)

From	To	Action
Resource Aggregator	Merit Order List Responsible / Congestion Management Market Operator	Resource aggregator bids its availability in providing congestion management services for the day after.
Distribution System Operator	Merit Order List Responsible / Congestion Management Market Operator	Congestion forecast is performed in order to identify the distribution network sections in which limits can be expected to be violated with a non-negligible probability.
Merit Order List Responsible / Congestion Management Market Operator	Merit Order List Responsible / Congestion Management Market Operator	The market is managed in order to select the resources according to a dedicated merit order list and considering the optimal location in which the resources should be located to perform the requested service.
Merit Order List Responsible / Congestion Management Market Operator	Balancing Reserve Allocator	At distribution level, liquidity problems make the balancing of activations difficult. For this reason, the selected actions are communicated to the balancing reserve allocator in order to consider additional balancing reserve.
Merit Order List Responsible / Congestion Management Market Operator	Resource Aggregator	The congestion management reserve selected by the market is communicated to resource aggregators and they will be requested to activate the related flexibility the day after during the procurement/activation process.

Procurement of energy products (intraday)

From	To	Action
Resource Aggregator	Merit Order List Responsible / Congestion Management Market Operator	Resource aggregators bid their actual availability (referred to the next hour) in providing congestion management service. The bids should be in line with the ones selected the day before during the reservation process. Additional resource aggregators can participate even if not preliminarily reserved.
Distribution System Operator	Merit Order List Responsible / Congestion Management Market Operator	Congestion forecast is performed in order to identify the distribution network sections in which limits can be expected to be violated with a non-negligible probability.
Merit Order List Responsible / Congestion Management Market Operator	Merit Order List Responsible / Congestion Management Market Operator	The market is managed in order to select the bids according to a dedicated merit order list.
Merit Order List Responsible / Congestion Management Market Operator	Balancing Reserve Allocator	At distribution level, liquidity problems make the balancing of activations difficult. For this reason, the selected actions are communicated to the balancing reserve allocator in order to consider additional balancing reserve.
Merit Order List Responsible / Congestion Management Market Operator	Resource Aggregator	The activations selected by the market are communicated to the bidding resource aggregators and they are requested to operate/regulate their resources accordingly.

Activation

From	To	Action
Resource Aggregator	Reserve Providing Units/Groups	Information related to the proper activation of the selected congestion management reserve are communicated to the involved units and groups.

Settlement

From	To	Action
Metered Data Responsible	Congestion Management Market Information Aggregator	The effective provision of congestion management reserve is verified by reading metered data.
Congestion Management Market Information Aggregator	Resource Aggregator	Resource aggregators for which congestion management bids have been accepted are remunerated according to the effective provision of the requested activation and the price returned by the market clearing algorithm. Penalties are applied in case the service is not provided properly.
Resource Aggregator	Reserve Providing Units/Groups	Units and Groups that participated to congestion management services are remunerated by the related Resource Aggregator.
Congestion Management Market Information Aggregator	Distribution System Operator	Distribution System Operator is responsible for the costs related to congestion management.
Balancing Market Information Aggregator	Distribution System Operator	The cost of imbalance caused by distribution congestion management is in charge of the Distribution System Operator

6.3 Market Design Options – 1C

In this option, the local CM markets for DSOs & TSOs are still separated (separate MOLs), but the balancing market is fully integrated with the TSO CM market meaning there is one combined MOL where bids appear for both balancing and CM purposes on TSO level. With respect to market option 1A, the main differences consist of:

- resources need to be prequalified to provide both balancing and congestion management services (same prequalification process adopted by market option 1B);
- a more optimal solution of both balancing and congestion management (only for the transmission system) is achieved, but the split of balancing/congestion management costs is more critical.

The impacts of these main modifications on this market option are highlighted in bold font within the next sub-sections. Again, this market option has no impact on the short-term congestion management and on distribution markets.

6.3.1 Balancing mFRR + aFRR + Operational CM (transmission)

Prequalification

From	To	Action
Transmission Reserve Allocator	Resource Aggregator / Balancing+CM Service Provider	Resources are certified to be capable of contributing to mFRR and/or aFRR (separated prequalification processes: mFRR and aFRR have different technical requirements). **In this case resources can be requested to provide CM services too and additional requirements have to be satisfied (information on the flexibility location).**
Distribution Nomination Validator	Transmission Reserve Allocator / Nomination Validator	If a candidate resource is located at distribution level, the amount of flexibility that can be exploited without violating known distribution network constraints is communicated to the reserve allocator / nomination validator.
Transmission Reserve Allocator / Nomination Validator	Resource Aggregator / Balancing+CM Service Provider	The amount of flexibility that can be used as balancing **and CM** reserve (without violating known network constraints) is communicated to the resource aggregators
Transmission Reserve Allocator / Nomination Validator	Resource Aggregator / Balancing+CM Service Provider	Depending on the strategic position/preciousness of a resource, it is requested to be capable of providing regulation reserve mandatorily. In this case, selected resources can be requested to participate to both capacity and balancing markets.

Reservation of available capacity (day ahead)

From	To	Action
Resource Aggregator / Balancing+CM Service Provider	Merit Order List Responsible / Balancing+CM Market Operator	Resource aggregators bid their availability in providing regulation reserve for the day after.
Transmission System Operator	**Merit Order List Responsible / Balancing+CM Market Operator**	**Congestion forecast is performed in order to identify the transmission network sections in which limits can be expected to be violated with a non-negligible probability.**
Balancing+CM Reserve Allocator	Merit Order List Responsible / Balancing+CM Market Operator	The market is managed in order to select the resources according to a dedicated merit order list and **balancing+CM** reserve requirements Bids include information concerning the conflicts in providing both **mFRR, CM and aFRR** (e.g. the amount of available mFRR can depend on the amount of selected aFRR, and vice versa).
Merit Order List Responsible / Balancing+CM Market Operator	Resource Aggregator / Balancing+CM Service Provider	The reserve selected by the market is communicated to the resource aggregators and they will be requested to bid their flexibility the day after during the procurement/activation process.

Procurement of energy products (intraday)

From	To	Action
Resource Aggregator / Balancing+CM Service Provider	Merit Order List Responsible / Balancing+CM Market Operator	Resource aggregator bids its actual availability (referred to the next hour) in providing **CM**, mFRR and aFRR regulation. The bids should be in line with the ones selected the day before during the reservation process. Additional resource aggregators can participate even if their flexibility was not preliminarily reserved.
Transmission System Operator	**Merit Order List Responsible / Congestion Management Market Operator**	**Congestion forecast is performed in order to identify the transmission network sections in which limits can be expected to be violated with a non-negligible probability.**
Balancing+CM Reserve Allocator	Merit Order List Responsible / Balancing+CM Market Operator	The market is managed in order to select the resources according to a dedicated merit order list and **balancing+CM** reserve requirements. The selection of **aFRR, mFRR and CM** is performed simultaneously since their provision by a single resource can be conflictual (e.g. the amount of available mFRR can depends on the amount of selected aFRR, and vice versa). mFRR anc CM consist of active power set-points (steps) to be activated at a given time within the market window. aFRR consists of a regulation band that selected resources are requested to provide when the TSO communicates the secondary frequency control signal.
Merit Order List Responsible / Balancing+CM Market Operator	Resource Aggregator / Balancing+CM Service Provider / Load Frequency Control Operator	The reserves/activations (**aFRR+mFRR+CM**) selected by the market are communicated to the bidding resource aggregators and they are requested to operate/regulate their power plant accordingly.

Activation

From	To	Action
Resource Aggregator / Balancing+CM Service Provider	Balancing+CM Reserve Providing Units/Groups	Information related to the proper activation of the selected reserve are communicated to the involved units and groups. In case of **mFRR/CM**, the power step characteristics are provided. In case of aFRR the reserve to be guaranteed to the Load Frequency Control Operator is communicated.
Load Frequency Control Operator	Balancing Reserve Providing Units/Groups	Load Frequency Control Operator send the secondary frequency control signal to resources participating to aFRR.

Settlement

From	To	Action
Metered Data Responsible	Balancing+CM Market Information Aggregator	The effective provision of regulation reserve is verified by reading metered data.
Balancing+CM Market Information Aggregator	Resource Aggregator / Balancing+CM Service Provider	Resource aggregators for which bids have been accepted are remunerated according to the effective provision of the requested activation and the price returned by the market clearing algorithm. Penalties are applied in case the service is not provided properly.
Resource Aggregator / Balancing+CM Service Provider	Balancing+CM Reserve Providing Units/Groups	Units and Groups that participated to CM, mFRR and aFRR and provided the requested services are remunerated by the related Resource Aggregator.
Balancing+CM Market Information Aggregator	Imbalance Settlement Responsible	The sources of imbalance are identified and penalties are applied according to the cost of activated reserve for balancing **(the total reserve cost is split in order to distinguish the balancing and CM portions)**.
Balancing+CM Market Information Aggregator	Transmission System Operator	Transmission System Operator is responsible for the costs related to congestion management **(the total reserve cost is split in order to distinguish the balancing and CM portions)**.

6.3.2 Short term Congestion Management (transmission)

Prequalification

From	To	Action
Transmission Reserve Allocator	Resource Aggregator	Resources are certified to be technically capable of contributing to congestion management services at transmission level.
Distribution Nomination Validator	Transmission Reserve Allocator / Nomination Validator	If a candidate resource is located at distribution level, the amount of flexibility that can be exploited without violating known distribution network constraints is communicated to the reserve allocator / nomination validator.
Transmission Reserve Allocator / Nomination Validator	Resource Aggregator	The amount of flexibility that can be used as congestion management reserve (without violating known network constraints) is communicated to resource aggregators.
Transmission Reserve Allocator / Nomination Validator	Resource Aggregator	Depending on the strategic position/preciousness of a resource, it is requested to be capable of providing congestion management services mandatorily. In this case, selected resources can be requested to participate to both capacity and balancing markets.

Procurement of energy products (day ahead)

From	To	Action
Resource Aggregator	Merit Order List Responsible / Congestion Management Market Operator	Resource aggregator bids its availability in providing congestion management services for the day after.
Transmission System Operator	Merit Order List Responsible / Congestion Management Market Operator	Congestion forecast is performed in order to identify the transmission network sections in which limits are expected to be likely violated (e.g. 95% of confidence interval).
Merit Order List Responsible / Congestion Management Market Operator	Merit Order List Responsible / Congestion Management Market Operator	The market is managed in order to select the resources according to a dedicated merit order list. The selection is performed after the day-ahead energy market and activations are optimized in order to avoid imbalance. In case
Merit Order List Responsible / Congestion Management Market Operator	Resource Aggregator	The reserve selected by the market is communicated to the resource aggregators and they will be requested to activate their flexibility the day after during the activation process.

Activation

From	To	Action
Resource Aggregator	Reserve Providing Units/Groups	Information related to the proper activation of the selected congestion management reserve are communicated to the involved units and groups.

Settlement

From	To	Action
Metered Data Responsible	Congestion Management Market Information Aggregator	The effective provision of congestion management reserve is verified by reading metered data.
Congestion Management Market Information Aggregator	Resource Aggregator	Resource aggregators for which congestion management bids have been accepted are remunerated according to the effective provision of the requested activation and the price returned by the market clearing algorithm. Penalties are applied in case the service is not provided properly.
Resource Aggregator	Reserve Providing Units/Groups	Units and Groups that participated to congestion management services are remunerated by the related Resource Aggregator.
Congestion Management Market Information Aggregator	Transmission System Operator	Transmission System Operator is responsible for the costs related to congestion management.

6.3.3 Short term Congestion Management (distribution)

Prequalification

From	To	Action
Distribution Reserve Allocator	Resource Aggregator	Resources are certified to be technically capable of contributing to congestion management services at distribution level.
Distribution Reserve Allocator / Nomination Validator	Resource Aggregator	The amount of flexibility that can be used as congestion management reserve (without violating known network constraints) is communicated to resource aggregators.
Distribution Reserve Allocator / Nomination Validator	Resource Aggregator	Depending on the strategic position/preciousness of a resource, it is requested to be capable of providing congestion management services mandatorily. In this case, selected resources can be requested to participate to both capacity and balancing markets.

Procurement of energy products (day ahead)

From	To	Action
Resource Aggregator	Merit Order List Responsible / Congestion Management Market Operator	Resource aggregator bids its availability in providing congestion management services for the day after.
Distribution System Operator	Merit Order List Responsible / Congestion Management Market Operator	Congestion forecast is performed in order to identify the distribution network sections in which limits are expected to be likely violated (e.g. 95% of confidence interval).
Merit Order List Responsible / Congestion Management Market Operator	Merit Order List Responsible / Congestion Management Market Operator	The market is managed in order to select the resources according to a dedicated merit order list.
Merit Order List Responsible / Congestion Management Market Operator	Balancing Reserve Allocator	At distribution level, liquidity problems make the balancing of activations difficult. For this reason, the selected actions are communicated to the balancing reserve allocator in order to consider additional balancing reserve.
Merit Order List Responsible / Congestion Management Market Operator	Resource Aggregator	The reserve selected by the market is communicated to the resource aggregators and they will be requested to activate their flexibility the day after during the activation process.

Activation

From	To	Action
Resource Aggregator	Reserve Providing Units/Groups	Information related to the proper activation of the selected congestion management reserve are communicated to the involved units and groups.

Settlement

From	To	Action
Metered Data Responsible	Congestion Management Market Information Aggregator	The effective provision of congestion management reserve is verified by reading metered data.
Congestion Management Market Information Aggregator	Resource Aggregator	Resource aggregators for which congestion management bids have been accepted are remunerated according to the effective provision of the requested activation and the price returned by the market clearing algorithm. Penalties are applied in case the service is not provided properly.
Resource Aggregator	Reserve Providing Units/Groups	Units and Groups that participated to congestion management services are remunerated by the related Resource Aggregator.
Congestion Management Market Information Aggregator	Distribution System Operator	Distribution System Operator is responsible for the costs related to congestion management.
Balancing Market Information Aggregator	Distribution System Operator	The cost of imbalance caused by distribution congestion management is in charge of the Distribution System Operator

6.3.4 Operational Congestion Management (distribution)

Prequalification

From	To	Action
Distribution Reserve Allocator	Resource Aggregator	Resources are certified to be technically capable of contributing to congestion management services at distribution level.
Distribution Reserve Allocator / Nomination Validator	Resource Aggregator	The amount of flexibility that can be used as congestion management reserve (without violating known network constraints) is communicated to resource aggregators.
Distribution Reserve Allocator / Nomination Validator	Resource Aggregator	Depending on the strategic position/preciousness of a resource, it is requested to be capable of providing congestion management services mandatorily. In this case, selected resources can be requested to participate to both capacity and balancing markets.

Reservation of available capacity (day ahead)

From	To	Action
Resource Aggregator	Merit Order List Responsible / Congestion Management Market Operator	Resource aggregator bids its availability in providing congestion management services for the day after.
Distribution System Operator	Merit Order List Responsible / Congestion Management Market Operator	Congestion forecast is performed in order to identify the distribution network sections in which limits can be expected to be violated with a non-negligible probability.
Merit Order List Responsible / Congestion Management Market Operator	Merit Order List Responsible / Congestion Management Market Operator	The market is managed in order to select the resources according to a dedicated merit order list and considering the optimal location in which the resources should be located to perform the requested service.
Merit Order List Responsible / Congestion Management Market Operator	Balancing Reserve Allocator	At distribution level, liquidity problems make the balancing of activations difficult. For this reason, the selected actions are communicated to the balancing reserve allocator in order to consider additional balancing reserve.
Merit Order List Responsible / Congestion Management Market Operator	Resource Aggregator	The congestion management reserve selected by the market is communicated to resource aggregators and they will be requested to activate the related flexibility the day after during the procurement/activation process.

Procurement of energy products (intraday)

From	To	Action
Resource Aggregator	Merit Order List Responsible / Congestion Management Market Operator	Resource aggregators bid their actual availability (referred to the next hour) in providing congestion management service. The bids should be in line with the ones selected the day before during the reservation process. Additional resource aggregators can participate even if not preliminarily reserved.
Distribution System Operator	Merit Order List Responsible / Congestion Management Market Operator	Congestion forecast is performed in order to identify the distribution network sections in which limits can be expected to be violated with a non-negligible probability.
Merit Order List Responsible / Congestion Management Market Operator	Merit Order List Responsible / Congestion Management Market Operator	The market is managed in order to select the bids according to a dedicated merit order list.
Merit Order List Responsible / Congestion Management Market Operator	Balancing Reserve Allocator	At distribution level, liquidity problems make the balancing of activations difficult. For this reason, the selected actions are communicated to the balancing reserve allocator in order to consider additional balancing reserve.
Merit Order List Responsible / Congestion Management Market Operator	Resource Aggregator	The activations selected by the market are communicated to the bidding resource aggregators and they are requested to operate/regulate their resources accordingly.

Activation

From	To	Action
Resource Aggregator	Reserve Providing Units/Groups	Information related to the proper activation of the selected congestion management reserve are communicated to the involved units and groups.

Settlement

From	To	Action
Metered Data Responsible	Congestion Management Market Information Aggregator	The effective provision of congestion management reserve is verified by reading metered data.
Congestion Management Market Information Aggregator	Resource Aggregator	Resource aggregators for which congestion management bids have been accepted are remunerated according to the effective provision of the requested activation and the price returned by the market clearing algorithm. Penalties are applied in case the service is not provided properly.
Resource Aggregator	Reserve Providing Units/Groups	Units and Groups that participated to congestion management services are remunerated by the related Resource Aggregator.
Congestion Management Market Information Aggregator	Distribution System Operator	Distribution System Operator is responsible for the costs related to congestion management.
Balancing Market Information Aggregator	Distribution System Operator	The cost of imbalance caused by distribution congestion management is in charge of the Distribution System Operator

6.4 Market Design Options – 2B

In this option, TSOs and DSOs procure flexibility on a single CM marketplace following integrated market based process where all of the bids can be used by both grid operators (full integration). This results in a single merit order list, but balancing market is separated from CM. With respect to market option 1A, only one difference can be highlighted:

- transmission and distribution congestions are managed by a single market, which access to the same merit order list.

This has a positive impact in terms of congestion management costs and, as described below, it allows an easier rebalancing of activations (congestion management activations need to be selected in order to do not cause imbalance), which can be critical at distribution level (the main modifications are highlighted in bold font within the next sub-sections). Of course, this joint merit order list is considered for both short-term and operational congestion management, and it does not affect balancing services.

6.4.1 Balancing mFRR + aFRR

Prequalification

From	To	Action
Transmission Reserve Allocator	Resource Aggregator / Balancing Service Provider	Resources are certified to be capable of contributing to mFRR and/or aFRR (separated prequalification processes: mFRR and aFRR have different technical requirements)
Distribution Nomination Validator	Transmission Reserve Allocator / Nomination Validator	If a candidate resource is located at distribution level, the amount of flexibility that can be exploited without violating known distribution network constraints is communicated to the reserve allocator / nomination validator.
Transmission Reserve Allocator / Nomination Validator	Resource Aggregator / Balancing Service Provider	The amount of flexibility that can be used as balancing reserve (without violating known network constraints) is communicated to the resource aggregators
Transmission Reserve Allocator / Nomination Validator	Resource Aggregator / Balancing Service Provider	Depending on the strategic position/preciousness of a resource, it is requested to be capable of providing regulation reserve mandatorily. In this case, selected resources can be requested to participate to both capacity and balancing markets.

Reservation of available capacity (day ahead)

From	To	Action
Resource Aggregator / Balancing Service Provider	Merit Order List Responsible / Balancing Market Operator	Resource aggregators bid their availability in providing regulation reserve for the day after.
Balancing Reserve Allocator	Merit Order List Responsible / Balancing Market Operator	The market is managed in order to select the resources according to a dedicated merit order list and balancing reserve requirements Bids include information concerning the conflicts in providing both mFRR and aFRR (normally the amount of available mFRR can depend on the amount of selected aFRR, and vice versa).
Merit Order List Responsible / Balancing Market Operator	Resource Aggregator / Balancing Service Provider	The reserve selected by the market is communicated to the resource aggregators and they will be requested to bid their flexibility the day after during the procurement/activation process

Procurement of energy products (intraday)

From	To	Action
Resource Aggregator / Balancing Service Provider	Merit Order List Responsible / Balancing Market Operator	Resource aggregator bids its actual availability (referred to the next hour) in providing mFRR and aFRR regulation. The bids should be in line with the ones selected the day before during the reservation process. Additional resource aggregators can participate even if their flexibility was not preliminarily reserved.
Balancing Reserve Allocator	Merit Order List Responsible / Balancing Market Operator	The market is managed in order to select the resources according to a dedicated merit order list and balancing reserve requirements. The selection of aFRR and mFRR is performed simultaneously since their provision by a single resource can be conflictual (the amount of available mFRR can depends on the amount of selected aFRR, and vice versa). mFRR consists of an active power set-point (step) to be activated at a given time within the market window. aFRR consists of a regulation band that selected resources are requested to provide when the TSO communicates the secondary frequency control signal.
Merit Order List Responsible / Balancing Market Operator	Resource Aggregator / Balancing Service Provider / Load Frequency Control Operator	The reserves/activations (aFRR+mFRR) selected by the market are communicated to the bidding resource aggregators and they are requested to operate/regulate their power plant accordingly.

Activation

From	To	Action
Resource Aggregator / Balancing Service Provider	Balancing Reserve Providing Units/Groups	Information related to the proper activation of the selected reserve are communicated to the involved units and groups. In case of mFRR, the power step characteristics are provided. In case of aFRR the reserve to be guaranteed to the Load Frequency Control Operator is communicated.
Load Frequency Control Operator	Balancing Reserve Providing Units/Groups	Load Frequency Control Operator send the secondary frequency control signal to resources participating to aFRR.

Settlement

From	To	Action
Metered Data Responsible	Balancing Market Information Aggregator	The effective provision of regulation reserve is verified by reading metered data.
Balancing Market Information Aggregator	Resource Aggregator / Balancing Service Provider	Resource aggregators for which balancing bids have been accepted are remunerated according to the effective provision of the requested activation and the price returned by the market clearing algorithm. Penalties are applied in case the service is not provided properly.
Resource Aggregator / Balancing Service Provider	Balancing Reserve Providing Units/Groups	Units and Groups that participated to mFRR and aFRR and provided the requested services are remunerated by the related Resource Aggregator.
Balancing Market Information Aggregator	Imbalance Settlement Responsible	The sources of imbalance are identified and penalties are applied according to the cost of activated balancing reserve.

6.4.2 Short term Congestion Management (transmission+distribution)

Prequalification

From	To	Action
Transmission and distribution Reserve Allocator	Resource Aggregator	Resources are certified to be technically capable of contributing to congestion management services at transmission and/or distribution level.
Transmission and distribution Reserve Allocator	Resource Aggregator	The amount of flexibility that can be used as congestion management reserve (without violating known network constraints) is communicated to resource aggregators.
Transmission and distribution Reserve Allocator	Resource Aggregator	Depending on the strategic position/preciousness of a resource, it is requested to be capable of providing congestion management services mandatorily. In this case, selected resources can be requested to participate to both capacity and balancing markets.

Procurement of energy products (day ahead)

From	To	Action
Resource Aggregator	Merit Order List Responsible / Congestion Management Market Operator	Resource aggregator bids its availability in providing congestion management services for the day after.
Transmission System Operator	Merit Order List Responsible / Congestion Management Market Operator	Congestion forecast is performed in order to identify the transmission network sections in which limits are expected to be likely violated (e.g. 95% of confidence interval).
Distribution System Operator	Merit Order List Responsible / Congestion Management Market Operator	Congestion forecast is performed in order to identify the distribution network sections in which limits are expected to be likely violated (e.g. 95% of confidence interval).
Merit Order List Responsible / Congestion Management Market Operator	Merit Order List Responsible / Congestion Management Market Operator	The market is managed in order to select the resources according to a dedicated merit order list. The selection is performed after the day-ahead energy market and activations are optimized in order to avoid imbalance. **Thanks to the joint management of transmission and distribution congestions, high liquidity of rebalancing resources can be expected (especially for distribution CM).**
Merit Order List Responsible / Congestion Management Market Operator	Resource Aggregator	The reserve selected by the market is communicated to the resource aggregators and they will be requested to activate their flexibility the day after during the activation process.

Activation

From	To	Action
Resource Aggregator	Reserve Providing Units/Groups	Information related to the proper activation of the selected congestion management reserve are communicated to the involved units and groups.

Settlement

From	To	Action
Metered Data Responsible	Congestion Management Market Information Aggregator	The effective provision of congestion management reserve is verified by reading metered data.
Congestion Management Market Information Aggregator	Resource Aggregator	Resource aggregators for which congestion management bids have been accepted are remunerated according to the effective provision of the requested activation and the price returned by the market clearing algorithm. Penalties are applied in case the service is not provided properly.
Resource Aggregator	Reserve Providing Units/Groups	Units and Groups that participated to congestion management services are remunerated by the related Resource Aggregator.
Congestion Management Market Information Aggregator	Transmission System Operator	Transmission System Operator is responsible for the costs related to transmission congestion management **(the total reserve cost is split in order to distinguish the transmission CM and distribution CM portions)**.
Congestion Management Market Information Aggregator	Distribution System Operator	Distribution System Operator is responsible for the costs related to distribution congestion management **(the total reserve cost is split in order to distinguish the transmission CM and distribution CM portions)**.

6.4.3 Operational Congestion Management (transmission+distribution)

Prequalification

From	To	Action
Transmission and distribution Reserve Allocator	Resource Aggregator	Resources are certified to be technically capable of contributing to congestion management services at transmission and/or distribution level.
Transmission and distribution Reserve Allocator	Resource Aggregator	The amount of flexibility that can be used as congestion management reserve (without violating known network constraints) is communicated to resource aggregators.
Transmission and distribution Reserve Allocator	Resource Aggregator	Depending on the strategic position/preciousness of a resource, it is requested to be capable of providing congestion management services mandatorily. In this case, selected resources can be requested to participate to both capacity and balancing markets.

Reservation of available capacity (day ahead)

From	To	Action
Resource Aggregator	Merit Order List Responsible / Congestion Management Market Operator	Resource aggregator bids its availability in providing congestion management services for the day after.
Transmission System Operator	Merit Order List Responsible / Congestion Management Market Operator	Congestion forecast is performed in order to identify the transmission network sections in which limits can be expected to be violated with a non-negligible probability.
Distribution System Operator	Merit Order List Responsible / Congestion Management Market Operator	Congestion forecast is performed in order to identify the transmission network sections in which limits can be expected to be violated with a non-negligible probability.
Merit Order List Responsible / Congestion Management Market Operator	Merit Order List Responsible / Congestion Management Market Operator	The market is managed in order to select the resources according to a dedicated merit order list and considering the optimal location in which the resources should be located to perform the requested service. The selection of resources expected to provide regulation reserve is performed by considering the necessity of making balanced activations (congestion management service with no impact on the system balance). **Thanks to the joint management of transmission and distribution congestions, high liquidity of rebalancing resources can be expected (especially for distribution CM).**
Merit Order List Responsible / Congestion Management Market Operator	Resource Aggregator	The congestion management reserve selected by the market is communicated to resource aggregators and they will be requested to activate the related flexibility the day after during the procurement/activation process.

Procurement of energy products (intraday)

From	To	Action
Resource Aggregator	Merit Order List Responsible / Congestion Management Market Operator	Resource aggregators bid their actual availability (referred to the next hour) in providing congestion management service. The bids should be in line with the ones selected the day before during the reservation process. Additional resource aggregators can participate even if not preliminarily reserved.
Transmission System Operator	Merit Order List Responsible / Congestion Management Market Operator	Congestion forecast is performed in order to identify the transmission network sections in which limits can be expected to be violated with a non-negligible probability.
Distribution System Operator	Merit Order List Responsible / Congestion Management Market Operator	Congestion forecast is performed in order to identify the transmission network sections in which limits can be expected to be violated with a non-negligible probability.
Merit Order List Responsible / Congestion Management Market Operator	Merit Order List Responsible / Congestion Management Market Operator	The market is managed in order to select the bids according to a dedicated merit order list. The selection of resources expected to provide regulation reserve is performed by considering the necessity of making balanced activations (congestion management service with no impact on the system balance). **Thanks to the joint management of transmission and distribution congestions, high liquidity of rebalancing resources can be expected (especially for distribution CM).**
Merit Order List Responsible / Congestion Management Market Operator	Resource Aggregator	The activations selected by the market are communicated to the bidding resource aggregators and they are requested to operate/regulate their resources accordingly.

Activation

From	To	Action
Resource Aggregator	Reserve Providing Units/Groups	Information related to the proper activation of the selected congestion management reserve are communicated to the involved units and groups.

Settlement

From	To	Action
Metered Data Responsible	Congestion Management Market Information Aggregator	The effective provision of congestion management reserve is verified by reading metered data.
Congestion Management Market Information Aggregator	Resource Aggregator	Resource aggregators for which congestion management bids have been accepted are remunerated according to the effective provision of the requested activation and the price returned by the market clearing algorithm. Penalties are applied in case the service is not provided properly.
Resource Aggregator	Reserve Providing Units/Groups	Units and Groups that participated to congestion management services are remunerated by the related Resource Aggregator.
Congestion Management Market Information Aggregator	Transmission System Operator	Transmission System Operator is responsible for the costs related to transmission congestion management **(the total reserve cost is split in order to distinguish the transmission CM and distribution CM portions)**.
Congestion Management Market Information Aggregator	Distribution System Operator	Distribution System Operator is responsible for the costs related to distribution congestion management **(the total reserve cost is split in order to distinguish the transmission CM and distribution CM portions)**.

6.5 Market Design Options – 3C

In this option, full integration between the TSO and DSO CM markets is achieved. In addition the balancing market is partly integrated which allows the grid operators to manage congestions also by accessing some of the bids specifically submitted for the balancing market. This market option is very similar to 2B and the main difference consists of this partial overlapping between balancing and congestion management merit order lists. As it is happening for market option 1B:

- further requirements need to be specified for the prequalification process related to the balancing services (balancing reserve needs to be capable of possibly providing congestion management services);
- balancing market sessions need to consider the fact that some resources of the dedicated MOL are already reserved/activated by the balancing market;
- balancing resources shared with congestion management market can lead to the activation of resources with higher costs.

This affects both the balancing service (mFRR and aFRR) and operational congestion management (the main modifications are highlighted in bold font within the next sub-sections). In particular, the latter accesses to balancing resources only when the allocated congestion management reserve results to be not adequate. Short-term congestion management is not affected.

6.5.1 Balancing mFRR + aFRR

Prequalification

From	To	Action
Transmission Reserve Allocator	Resource Aggregator / Balancing Service Provider	Resources are certified to be capable of contributing to mFRR and/or aFRR (separated prequalification processes: mFRR and aFRR have different technical requirements). **Since resources can be possibly involved to provide CM services, additional requirements might be requested.**
Distribution Nomination Validator	Transmission Reserve Allocator / Nomination Validator	If a candidate resource is located at distribution level, the amount of flexibility that can be exploited without violating known distribution network constraints is communicated to the reserve allocator / nomination validator.
Transmission Reserve Allocator / Nomination Validator	Resource Aggregator / Balancing Service Provider	The amount of flexibility that can be used as balancing reserve (without violating known network constraints) is communicated to the resource aggregators
Transmission Reserve Allocator / Nomination Validator	Resource Aggregator / Balancing Service Provider	Depending on the strategic position/preciousness of a resource, it is requested to be capable of providing regulation reserve mandatorily. In this case, selected resources can be requested to participate to both capacity and balancing markets.

Reservation of available capacity (day ahead)

From	To	Action
Resource Aggregator / Balancing Service Provider	Merit Order List Responsible / Balancing Market Operator	Resource aggregators bid their availability in providing regulation reserve for the day after.
Balancing Reserve Allocator	Merit Order List Responsible / Balancing Market Operator	The market is managed in order to select the resources according to a dedicated merit order list and balancing reserve requirements Bids include information concerning the conflicts in providing both mFRR and aFRR (normally the amount of available mFRR can depend on the amount of selected aFRR, and vice versa).
Merit Order List Responsible / Balancing Market Operator	Resource Aggregator / Balancing Service Provider	The reserve selected by the market is communicated to the resource aggregators and they will be requested to bid their flexibility the day after during the procurement/activation process.

Procurement of energy products (intraday)

From	To	Action
Resource Aggregator / Balancing Service Provider	Merit Order List Responsible / Balancing Market Operator	Resource aggregator bids its actual availability (referred to the next hour) in providing mFRR and aFRR regulation. The bids should be in line with the ones selected the day before during the reservation process. Additional resource aggregators can participate even if their flexibility was not preliminarily reserved.
Balancing Reserve Allocator	Merit Order List Responsible / Balancing Market Operator	The market is managed in order to select the resources according to a dedicated merit order list and balancing reserve requirements. The selection of aFRR and mFRR is performed simultaneously since their provision by a single resource can be conflictual (the amount of available mFRR can depends on the amount of selected aFRR, and vice versa). mFRR consists of an active power set-point (step) to be activated at a given time within the market window. aFRR consists of a regulation band that selected resources are requested to provide when the TSO communicates the secondary frequency control signal. **Since some balancing dedicated resources can be requested to provide CM services, the selection needs to exclude them when already activated/reserved for CM.**
Merit Order List Responsible / Balancing Market Operator	Resource Aggregator / Balancing Service Provider / Load Frequency Control Operator	The reserves/activations (aFRR+mFRR) selected by the market are communicated to the bidding resource aggregators and they are requested to operate/regulate their power plant accordingly.

Activation

From	To	Action
Resource Aggregator / Balancing Service Provider	Balancing Reserve Providing Units/Groups	Information related to the proper activation of the selected reserve are communicated to the involved units and groups. In case of mFRR, the power step characteristics are provided. In case of aFRR the reserve to be guaranteed to the Load Frequency Control Operator is communicated.
Load Frequency Control Operator	Balancing Reserve Providing Units/Groups	Load Frequency Control Operator send the secondary frequency control signal to resources participating to aFRR.

Settlement

From	To	Action
Metered Data Responsible	Balancing Market Information Aggregator	The effective provision of regulation reserve is verified by reading metered data.
Balancing Market Information Aggregator	Resource Aggregator / Balancing Service Provider	Resource aggregators for which balancing bids have been accepted are remunerated according to the effective provision of the requested activation and the price returned by the market clearing algorithm. Penalties are applied in case the service is not provided properly.
Resource Aggregator / Balancing Service Provider	Balancing Reserve Providing Units/Groups	Units and Groups that participated to mFRR and aFRR and provided the requested services are remunerated by the related Resource Aggregator.
Balancing Market Information Aggregator	Imbalance Settlement Responsible	The sources of imbalance are identified and penalties are applied according to the cost of activated balancing reserve. **CM market access to the balancing dedicated merit order list potentially increases the cost of balancing services. This impact needs to be considered within the imbalance settlement.**

6.5.2 Short term Congestion Management (transmission+distribution)

Prequalification

From	To	Action
Transmission and distribution Reserve Allocator	Resource Aggregator	Resources are certified to be technically capable of contributing to congestion management services at transmission and/or distribution level.
Transmission and distribution Reserve Allocator	Resource Aggregator	The amount of flexibility that can be used as congestion management reserve (without violating known network constraints) is communicated to resource aggregators.
Transmission and distribution Reserve Allocator	Resource Aggregator	Depending on the strategic position/preciousness of a resource, it is requested to be capable of providing congestion management services mandatorily. In this case, selected resources can be requested to participate to both capacity and balancing markets.

Procurement of energy products (day ahead)

From	To	Action
Resource Aggregator	Merit Order List Responsible / Congestion Management Market Operator	Resource aggregator bids its availability in providing congestion management services for the day after.
Transmission System Operator	Merit Order List Responsible / Congestion Management Market Operator	Congestion forecast is performed in order to identify the transmission network sections in which limits are expected to be likely violated (e.g. 95% of confidence interval).
Distribution System Operator	Merit Order List Responsible / Congestion Management Market Operator	Congestion forecast is performed in order to identify the distribution network sections in which limits are expected to be likely violated (e.g. 95% of confidence interval).
Merit Order List Responsible / Congestion Management Market Operator	Merit Order List Responsible / Congestion Management Market Operator	The market is managed in order to select the resources according to a dedicated merit order list. The selection is performed after the day-ahead energy market and activations are optimized in order to avoid imbalance. **Thanks to the joint management of transmission and distribution congestions, high liquidity of rebalancing resources can be expected (especially for distribution CM).**
Merit Order List Responsible / Congestion Management Market Operator	Resource Aggregator	The reserve selected by the market is communicated to the resource aggregators and they will be requested to activate their flexibility the day after during the activation process.

Activation

From	To	Action
Resource Aggregator	Reserve Providing Units/Groups	Information related to the proper activation of the selected congestion management reserve are communicated to the involved units and groups.

Settlement

From	To	Action
Metered Data Responsible	Congestion Management Market Information Aggregator	The effective provision of congestion management reserve is verified by reading metered data.
Congestion Management Market Information Aggregator	Resource Aggregator	Resource aggregators for which congestion management bids have been accepted are remunerated according to the effective provision of the requested activation and the price returned by the market clearing algorithm. Penalties are applied in case the service is not provided properly.
Resource Aggregator	Reserve Providing Units/Groups	Units and Groups that participated to congestion management services are remunerated by the related Resource Aggregator.
Congestion Management Market Information Aggregator	Transmission System Operator	Transmission System Operator is responsible for the costs related to transmission congestion management **(the total reserve cost is split in order to distinguish the transmission CM and distribution CM portions)**.
Congestion Management Market Information Aggregator	Distribution System Operator	Distribution System Operator is responsible for the costs related to distribution congestion management **(the total reserve cost is split in order to distinguish the transmission CM and distribution CM portions)**.

6.5.3 Operational Congestion Management (transmission+distribution)

Prequalification

From	To	Action
Transmission and distribution Reserve Allocator	Resource Aggregator	Resources are certified to be technically capable of contributing to congestion management services at transmission and/or distribution level.
Transmission and distribution Reserve Allocator	Resource Aggregator	The amount of flexibility that can be used as congestion management reserve (without violating known network constraints) is communicated to resource aggregators.
Transmission and distribution Reserve Allocator	Resource Aggregator	Depending on the strategic position/preciousness of a resource, it is requested to be capable of providing congestion management services mandatorily. In this case, selected resources can be requested to participate to both capacity and balancing markets.

Reservation of available capacity (day ahead)

From	To	Action
Resource Aggregator	Merit Order List Responsible / Congestion Management Market Operator	Resource aggregator bids its availability in providing congestion management services for the day after.
Transmission System Operator	Merit Order List Responsible / Congestion Management Market Operator	Congestion forecast is performed in order to identify the transmission network sections in which limits can be expected to be violated with a non-negligible probability.
Distribution System Operator	Merit Order List Responsible / Congestion Management Market Operator	Congestion forecast is performed in order to identify the transmission network sections in which limits can be expected to be violated with a non-negligible probability.
Merit Order List Responsible / Congestion Management Market Operator	Merit Order List Responsible / Congestion Management Market Operator	The market is managed in order to select the resources according to a dedicated merit order list and considering the optimal location in which the resources should be located to perform the requested service. The selection of resources expected to provide regulation reserve is performed by considering the necessity of making balanced activations (congestion management service with no impact on the system balance). **Thanks to the joint management of transmission and distribution congestions, high liquidity of rebalancing resources can be expected (especially for distribution CM).**
Merit Order List Responsible / Congestion Management Market Operator	Resource Aggregator	The congestion management reserve selected by the market is communicated to resource aggregators and they will be requested to activate the related flexibility the day after during the procurement/activation process.

Procurement of energy products (intraday)

From	To	Action
Resource Aggregator	Merit Order List Responsible / Congestion Management Market Operator	Resource aggregators bid their actual availability (referred to the next hour) in providing congestion management service. The bids should be in line with the ones selected the day before during the reservation process. Additional resource aggregators can participate even if not preliminarily reserved.
Transmission System Operator	Merit Order List Responsible / Congestion Management Market Operator	Congestion forecast is performed in order to identify the transmission network sections in which limits can be expected to be violated with a non-negligible probability.
Distribution System Operator	Merit Order List Responsible / Congestion Management Market Operator	Congestion forecast is performed in order to identify the transmission network sections in which limits can be expected to be violated with a non-negligible probability.
Merit Order List Responsible / Congestion Management Market Operator	Merit Order List Responsible / Congestion Management Market Operator	The market is managed in order to select the bids according to a dedicated merit order list. The selection of resources expected to provide regulation reserve is performed by considering the necessity of making balanced activations (congestion management service with no impact on the system balance). **Thanks to the joint management of transmission and distribution congestions, high liquidity of rebalancing resources can be expected (especially for distribution CM).**
Merit Order List Responsible / Congestion Management Market Operator	Resource Aggregator	The activations selected by the market are communicated to the bidding resource aggregators and they are requested to operate/regulate their resources accordingly.

Activation

From	To	Action
Resource Aggregator	Reserve Providing Units/Groups	Information related to the proper activation of the selected congestion management reserve are communicated to the involved units and groups.

Settlement

From	To	Action
Metered Data Responsible	Congestion Management Market Information Aggregator	The effective provision of congestion management reserve is verified by reading metered data.
Congestion Management Market Information Aggregator	Resource Aggregator	Resource aggregators for which congestion management bids have been accepted are remunerated according to the effective provision of the requested activation and the price returned by the market clearing algorithm. Penalties are applied in case the service is not provided properly.
Resource Aggregator	Reserve Providing Units/Groups	Units and Groups that participated to congestion management services are remunerated by the related Resource Aggregator.
Congestion Management Market Information Aggregator	Transmission System Operator	Transmission System Operator is responsible for the costs related to transmission congestion management **(the total reserve cost is split in order to distinguish the transmission CM and distribution CM portions)**.
Congestion Management Market Information Aggregator	Distribution System Operator	Distribution System Operator is responsible for the costs related to distribution congestion management **(the total reserve cost is split in order to distinguish the transmission CM and distribution CM portions)**.

7 Conclusions

The present deliverable has defined in a formal way the interactions between the different players involved in the provision of ancillary services from entities connected to transmission and distribution grids. This work is propaedeutic to elaborating the specifications for the implementation of the same services into the IEGSA platform.

As the INTERRFACE project is going to apply the IEGSA to seven demos (WPs 5, 6 and 7), the creation of the above mentioned interactions description was achieved after polling all the demos for understanding:

- which ancillary services they are going to implement
- what kind of implementation they have in mind.

This process was complicated by the fact that the stage of evolution of the demos during the first project year was not (at least in a few cases) sufficiently advanced. That made it necessary to supplement the "bottom-up" analysis of the demos Business Use Cases with a second phase of "top down" analysis, starting from the services specifications and trying to define an "envelope" of the needs of the different demos while preserving some generality in the implementation of the different services.

The present version of the deliverable (finalized within January 2020) takes into account the present state of implementation of the seven project demos. By end 2020, depending on the higher maturity level of the demos, an update of the deliverable could be done so as to provide a higher level of detail and taking into account more peculiarities of the demos themselves.