Deliverable D1.1

Market and regulatory analysis: Analysis of current market and regulatory framework in the involved areas

V1.0

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Executive summary

Power systems are going through significant changes. At the distribution grid, Distributed Energy Resources (DER), including Demand Response (DR) and Distributed Generators (DG)[1] are already selling energy into wholesale markets, and in some countries, are already providing services to Transmission System Operators (TSO)[2] and Distribution System Operators (DSO). At the same time, DSOs are expected to move from a "fit-and-forget" approach to an active management of the grid. Flexibility from small DER is likely to be aggregated and to help in grid management both at the distribution and transmission level. These evolutions call for greater coordination between TSO and DSOs.

The CoordiNet Deliverable 1.1 aims to identify the main gaps, barriers, and drivers for TSO-DSO coordination in the three countries in which CoordiNet demo activities will take place, specifically Greece, Spain, and Sweden. In order to carry out this analysis, firstly, an assessment of the European view on TSO-DSO coordination is done, by analyzing the most recent European regulation and initiatives, namely the Clean Energy Package, the Network Codes, and the European Balancing Platforms, as well as position papers from key policy stakeholders, such as ACER, CEER, ENTSO-E and EDSO. Secondly, an assessment of the current national regulations addressing TSO-DSO coordination topics is provided. This assessment is focused on the three focus countries of CoordiNet. However, it is also supplemented by a survey of additionally EU-28 countries. This survey was answered by Austria, Belgium, Cyprus, Czechia, Germany, Italy, the Netherlands, and Poland. Figure 1 illustrates the methodology adopted for the development of Deliverable 1.1.

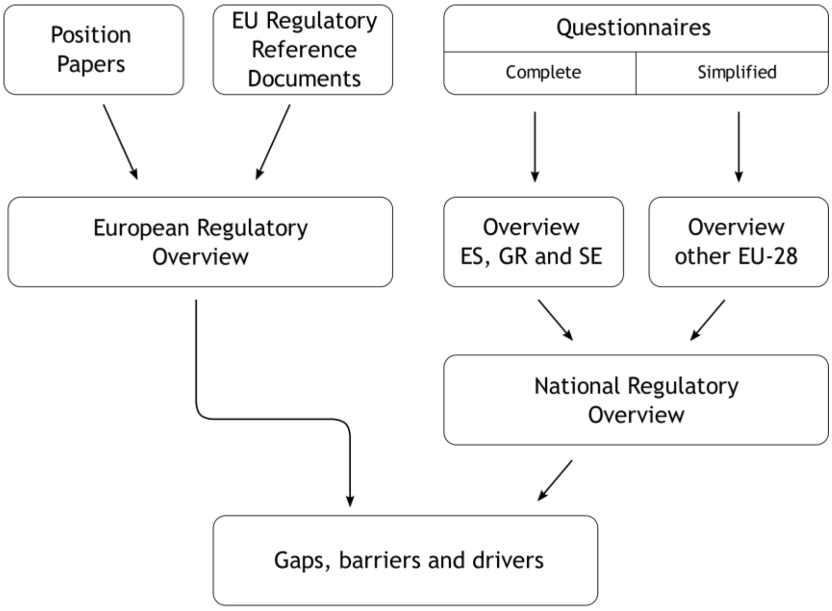

Figure 1: Methodology of Deliverable 1.1

[1] Definitions for the different types of DER are provided in section 1.4.
[2] In this deliverable, the TSO is understood as both the grid owner and the system operator. This is the common function of TSOs in Europe. In other countries, a separation may be found between the grid owner and the system operator.

Policymakers already acknowledge the need for TSO-DSO coordination. In Europe, the Network Codes and the Clean Energy Package already highlight the need for further coordination between TSOs and DSOs. The Electricity Directive of the Clean Energy Package states that “distribution system operators shall exchange all necessary information and coordinate with transmission system operators in order to ensure the optimal utilization of resources, ensure the secure and efficient operation of the system and facilitate market development” (European Commission, 2017b). This statement is very illustrative to understand the view of the European Commission towards the need for coordination. The Commission highlights three main objectives. Firstly, the optimal utilization of resources, meaning better exploitation of the potential offered by flexible resources. According to the Clean Energy Package, the utilization of the different types of alternative resources, such as demand response and storage, and their participation in the wholesale market should happen on equal terms with the utilization of conventional units. Secondly, the secure and efficient operation of the system is mentioned. In this context, besides ensuring the security of operation, efficiency should also be pursued by avoiding that the activation of DER by the TSO for balancing purposes creates local congestion for the DSO (and vice-versa). Thirdly, the Directive points to the need to facilitate market development. This can be interpreted as to foster the integration of DER into energy and services markets. Figure 2 summarizes the objectives of TSO-DSO coordination in the Clean Energy Package.

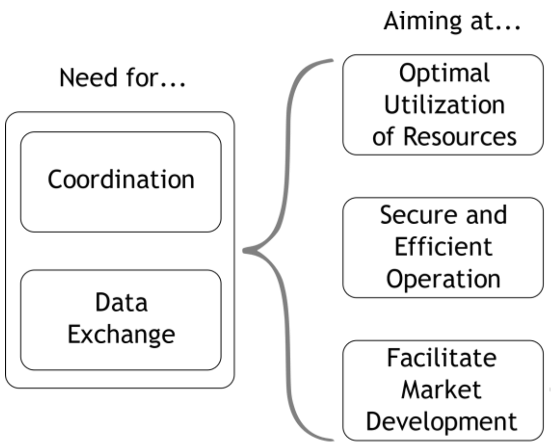

Figure 2: TSO-DSO Coordination in the Electricity Directive of the Clean Energy Package

European countries have advanced in the harmonization of the electricity markets, achieving important milestones such as the implementation of market coupling for the day-ahead market and the continuous intraday market. The organization of balancing markets, however, still varies significantly across the EU countries, but agreements are being made as requested by the Guideline on Electricity Balancing (EBGL) (European Commission, 2017a). The EBGL “lays down a detailed guideline on electricity balancing including the establishment of common principles for the procurement and the settlement of frequency containment reserves, frequency restoration reserves, and replacement reserves and a common methodology for the activation of frequency restoration reserves and replacement reserves.” This regulation shall be applied to all TSOs, DSOs, and national regulatory authorities (NRA) in the European Union.

The implementation of the EBGL requires that the TSOs or group of TSOs at pan-European or regional level develop methodologies and submit the proposals that describe these methodologies to NRAs for approval. For this purpose, different implementation projects are in place to define the methodologies for the procurement of the different balancing services and products. These Initiatives include the following common platforms for procuring and exchanging services among countries: MARI platform (for manual Frequency Restoration Reserves - mFRR), PICASSO platform (for automatic Frequency Restoration Reserves - aFRR), TERRE platform (for Replacement Reserves - RR), and a platform to net energy imbalance between the countries and avoid the simultaneous activation of Frequency Restoration Reserves in opposite directions (IN-IGCC). All these Initiatives set harmonized products for balancing services that need to be considered in the development of the CoordiNet project.

The country analysis shows that there are still many barriers for the achievement of the objectives set by the Clean Energy Package, as summarized in the table below and further explained based on the results from the consulted countries.

Table 1: Main drivers and barriers for DSO-TSO cooperation

Objective	Main Drivers	Main Barriers
Optimal Utilization of Resources	- DER flexibility is already used by many TSOs	- DSOs still do not use DER flexibility - DER provision of services to TSOs is still limited to certain types and sizes of DER - DSOs may lack economic incentives to use DER flexibility
Secure and Efficient Operation	- Information exchange is already taking place in demos countries.	- Coordination and procedures will be required as DSOs start to use DER flexibility and have to account for impacts on the TSO. Additionally, the activation of DER by TSOs might also lead to distribution system constraint violations
Facilitate Market Development	- Implementation of the Network Codes has started and may bring harmonization of products and services, as well as inclusive product characteristics for DER flexibility provision.	- Aggregation is still incipient, and rules for aggregation are unclear - Product definitions and market mechanisms need to be developed

The optimal utilization of resources will be achieved when both TSOs and DSOs are able to make efficient use of flexibility provided by DER. In this sense, the country survey showed that most TSOs could already procure services from DER; however, the same is not true for DSOs.

DSO procurement of DER services is still incipient particularly for DERs connected at low voltage levels. Considering the three demo countries, in none of them, DSOs can directly procure services for grid management. In Spain, the DSO can request the redispatch of generating units to the TSO to solve congestions in distribution networks. In Greece, the general terms for DSO to procure DER flexibility are already in place, but not applied since detailed specifications are still to be defined. While in Sweden, regulation is yet to be defined.

At DSO level, new services and products have to be clearly defined in a technology-neutral manner to enable the participation of different kinds of DERs. The organization of these services, and how their procurement and activation will be done, will be addressed in later stages of CoordiNet.

On the TSO side, however, DERs already participate in service provision, but in a somehow limited manner. In general, balancing is the main product offered by DER. However, although DERs are already participating in these markets, the participation is still limited to certain types and sizes of DER. For instance, DR is still not allowed in some balancing markets, and the DGs that participate are usually connected at HV levels.

Additionally, TSOs and DSOs need to have proper incentives to procure services from DERs in a non-discriminatory way in comparison with traditional investments (also known as “wires” solutions) or the provision by traditional agents (e.g., large generation units). In the Clean Energy Package, it is stated that regulatory frameworks should encourage the procurement of these services and compensate expenses related to the procurement of flexibility. For this to become a reality, the definition of standardized products and the development of market platforms to procure these products will be a key element for DER’s participation directly or through an aggregator. In addition, these functions have to be acknowledged by regulation. Roles, responsibilities, and appropriate remuneration have to be properly in place. CoordiNet aims to provide insights on these relevant aspects and formulate recommendations at the countries where the demonstrations will be run as well as for the overall development of the European Internal Energy market.

The secure and efficient operation of power systems has always been the biggest priority for grid operators. In the context of DER flexibility provision, this also means that TSOs and DSOs will have to cooperate for the planning and the operation of their grids. As of today, TSOs and DSOs already cooperate and exchange information. However, when DSOs start using DER flexibility, this cooperation and exchange will have to be enhanced to guarantee efficient use of resources and secure operation of the system.

During the planning phase, the implications of new resources connected at both TSO and DSO networks have to be properly accounted for as well as the impact of demand growth that may affect the reinforcement requirements of networks. If done in a coordinated manner and by utilizing local flexibility, reinforcement need may actually be reduced for both grid operators. At the operational phases, continuous updates of load and generation forecasts will be required and this information will be relevant for both TSO and DSO to take actions on their systems. Finally, remedial actions, activations of services and emergency procedures will become an increasingly relevant topic, as the change of the energy profiles of different types of DER does not only affect the DSO but also the overall system, for instance in terms of balancing the system. Clear rules and priorities have to be established to guarantee a coordinated and secured operation.

The current implementation of the Network Codes and the developments taking place in the European Balancing Platforms are a positive driver in this regard. Although some market design aspects of today’s national regulations in the demo countries are not favouring TSO-DSO related issues, respondents to the regulatory questionnaire acknowledged that market rules are currently under review due to the implementation of the network codes. This implementation will contribute to the standardisation of procedures.

The Clean Energy Package recommends that, to the extent possible, procurement of services by TSOs and DSOs should be market-based. This is still a barrier for many products and services, especially at the DSO side. Additionally, it is important to note that aggregators are expected to play an important role in unlocking the potential of small DER.

Independent aggregation is at an incipient stage, specifically for the three countries where the CoordiNet demonstrations will take place. Therefore, the lack of concrete specifications for the roles and responsibilities for aggregation of flexible resources connected at DSO networks becomes a barrier for service provision from DERs for both grid operators. A pending aspect to enable aggregation would be to define rules for accounting energy imbalances from resources under the aggregator control but which are represented in the energy market by a third party such as the retail company in the case of demand resources or by a generation representative company. The revision of the current market design rules will be key, in particular, the imbalance settlement rules currently in place in the different countries. A level playing field for all resources has to be guaranteed independently where they are connected, the technology used, the size or other characteristics. From the countries reviewed, Austria, Belgium, Germany, and the Netherlands are more advanced on enabling the role of an independent aggregator, especially for providing balancing services. On the TSO side, although DERs are already allowed to participate in balancing, other markets are yet to be developed. For instance, voltage control is non-remunerated in many countries.

Furthermore, in order to enable the full implementation of markets, operational procedures have to be established providing detailed rules on when and how to mobilize flexibility from resources connected to the distribution networks. For this, schemes for the coordination of the provision of services by DSOs and TSOs have to be in place to utilize flexibility from DERs. These include the computation of forecasts of the output of DER and demand, establishing the priorities to consider when activating these resources (e.g., priority of addressing local congestion over system balancing needs[3]), the definition of the curtailment rules to apply, and the coordination of the emergency actions to implement when necessary, among others. CoordiNet will define and demonstrate different aspects of the mobilization of the flexibility provided by DER related to these challenges.

[3] This is specially an issue when the coordination scheme does not aim to finding a jointly (and therefore global) optimized solution.

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Abbreviations and Acronyms

Acronym	Description
aFRR	Frequency Restoration Reserves with automatic activation
aFRRIF	Frequency Restoration Reserves with automatic activation Implementation Framework
AS	Ancillary Service
AUR	Additional Upward Reserve
BSP	Balancing Service Provider
CACM	Capacity Allocation and Congestion Management
CAPEX	Capital Expenditure
CDSO	Closed distribution system operator
Cecoel	Electricity Control Centre (in Spain)
Cecre	Control Centre of Renewable Energies (in Spain)
CEP	Clean Energy Package
DA	Day-ahead
DAS	Day-ahead scheduling
DCC	Demand Connection Code
DER	Distributed Energy Resource
DG	Distributed Generation
DR	Demand Response
DSO	Distribution System Operator
EC	European Commission
EGBL	Guideline on Electricity Balancing
EHV	Extra High Voltage
Elbas	Intraday market in Nord Pool
Elspot	Spot market in Nord Pool
EnEx	Energy Exchange Group
ESS	Energy Storage Systems
EU	European Union
EV	Electric Vehicles
FAT	Full Activation Time
FCR	Frequency Containment Reserves
FiP	Feed-In Premium
GCC	Grid Control Cooperation
GCT	Gate Closure Time
GL	Guideline
HEDNO	Hellenic Electricity Distribution Network Operator - Greek DSO

HEMS	Home Energy Management Systems
HV	High Voltage
HVDC NC	High Voltage Direct Current Connections
ID	Intraday
IGCC	International Grid Control Cooperation
IN	Imbalance Netting
INIF	European platform for the Imbalance Netting Implementation Framework
LFC	Load-Frequency Control
LV	Low Voltage
MARI	Manually Activated Reserves Initiative
mFRR	Frequency Restoration Reserves with manual activation
mFRRIF	Frequency Restoration Reserves with manual activation Implementation Framework
MV	Medium Voltage
NC	Network Code
NRA	National Regulatory Authority
PICASSO	The Platform for the International Coordination of Automated Frequency Restoration and Stable System Operation
POD	Point of delivery
PV	Photovoltaic
R&I	Research and Innovation
REE	Red Eléctrica de España - Spanish TSO
RfG NC	Requirements for Generators Network Code
RR	Replacement Reserves
RRIF	Replacement Reserves Implementation Framework
RTBEM	Real-Time Balancing Market
SOGL	Guideline on System Operation
T&C	Terms & Conditions
TERRE	Trans European Replacement Reserves Exchange
ToE	Transfer-of-Energy
TSO	Transmission System Operator
XBID	European Continuous Intraday Market

1. Introduction

1.1. The CoordiNet project

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

1. To demonstrate to which extent coordination between TSO/DSO will lead to a cheaper, more reliable and more environmentally friendly electricity supply to the consumers through the implementation of three demonstrations at large scale, in cooperation with market participants.
2. To define and test a set of standardized products and the related key parameters for grid services, including the reservation and activation process for the use of the assets and finally the settlement process.
3. To specify and develop a TSO-DSO-Consumers cooperation platform starting with the necessary building blocks for the demonstration sites. These components will pave the way for the interoperable development of a pan-European market that will allow all market participants to provide energy services and opens up new revenue streams for consumers providing grid services.

In total, eight demo activities will be carried out in three different countries, namely Greece, Spain, and Sweden. In each demo activity, different products will be tested, in different time frames and relying on the provision of flexibility by different types of Distributed Energy Resources (DER). Figure 3 presents a preliminary set of product characteristics, periods for contracting the services, and types of DER in each demo activity[4]. Grey boxes represent demo activities in Greece, while red boxes represent demo activities in Spain, and finally pink boxes represent demonstrations in Sweden.

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

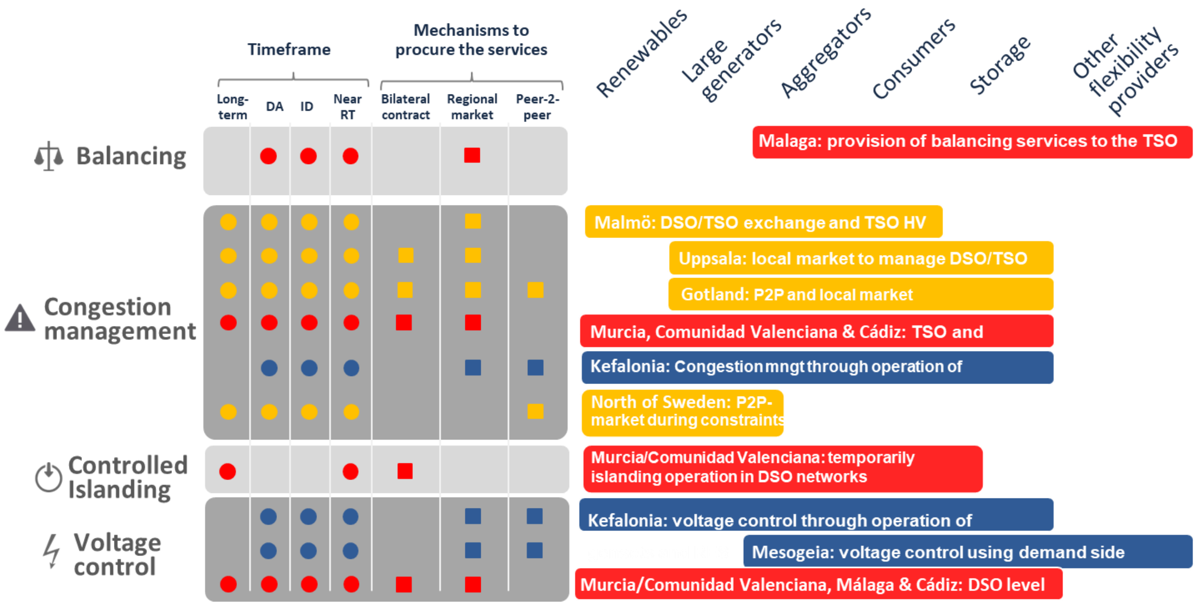


Figure 3: Characteristics of products to be tested in the demos

1.2. Objective and scope

Deliverable 1.1 aims at providing an analysis of the current market and regulatory framework in the countries in which demo activities will take place.

Therefore, the objective of this report is twofold: providing a review of current regulation touching TSO-DSO coordination topics on both the European level as well as the national regulation, identifying possible gaps between national regulations and the European view for TSO-DSO coordination stated in Clean Energy Package and the Network Codes.

1.3. Methodology

In order to achieve the objectives stated in section 1.2, different sources are used. To assess the current EU regulatory framework, desk research is carried out having as references the most recent and important Regulations and Directives (e.g., from the Clean Energy Package and the Network Codes). Reports from relevant stakeholders such as ACER, CEER, ENTSO-E are also referred. These “position papers” contribute to understand the debate that preceded the Clean Energy Package.

To assess the national regulatory frameworks, questionnaires were used. Two types of questionnaires were circulated among different stakeholders. Firstly, a comprehensive version of the questionnaire was circulated among CoordiNet’s partners to capture the regulation in the focus countries of the project, in which demos will take place, namely Greece, Spain, and Sweden.

Beyond the three demo countries, this deliverable also aimed at capturing the experience in other EU Member States. Therefore, a simplified questionnaire was prepared and made available online. This questionnaire was circulated among stakeholder from countries other than the three focus countries.

Answers were received for eight European countries, namely Austria, Belgium, Cyprus, Czech Replublic, Germany, Italy, the Netherlands, and Poland.

Once European and National regulatory views are properly mapped, possible gaps, barriers, and drivers between them have been identified.

Figure 4 illustrates the methodology applied in this Deliverable 1.1.

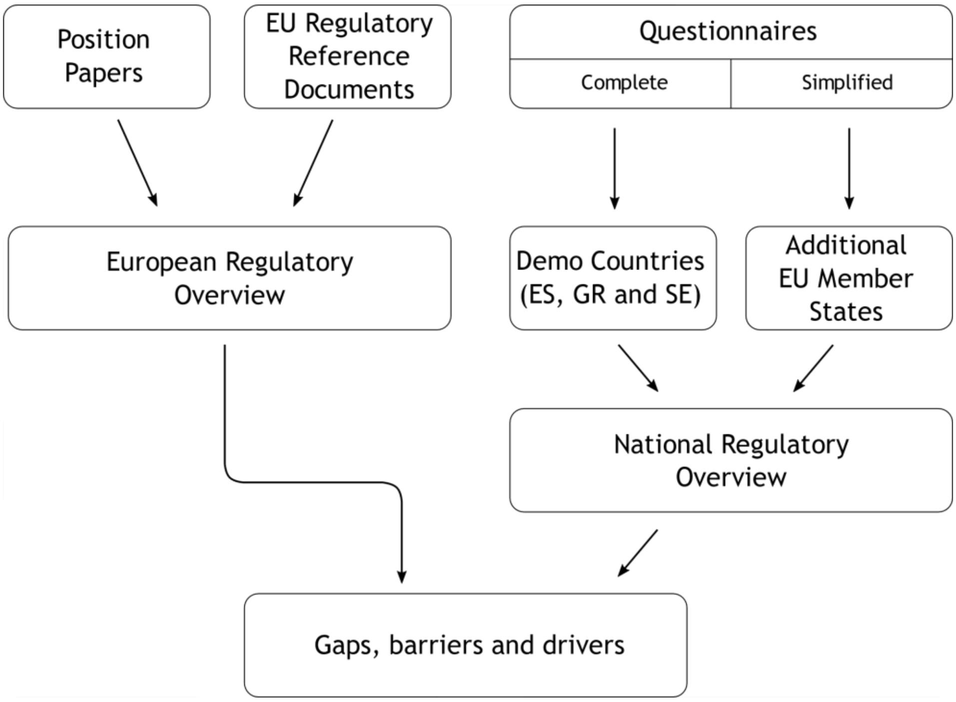


Figure 4: Methodology adopted in Deliverable 1.1

1.4. Definitions

The TSO-DSO coordination discussion is usually done using concepts and definitions that are often not harmonized across different countries. Therefore, this section aims at providing a general understanding of key concepts used throughout this deliverable.

1.4.1. Flexibility

Flexibility can be defined as the possibility of modifying generation and/or consumption patterns in reaction to an external signal (price or activation signals) to contribute to the power system stability or portfolio management in a cost-effective manner (Villar, Bessa, & Matos, 2017).

Flexibility can be also seen as the characteristic that makes it possible for (generation or consumption) resources to supply services defined by grid operators to manage the network. Additionally, other agents can benefit from flexibility services. That is the case for Balance Responsible Parties (BRP), for instance, that can use flexibility to reduce imbalance cost. Therefore, Flexibility Services can be defined as the use of flexibility to provide services to different parties, such as DSOs, TSOs, BRPs, retailers and others. Flexibility Service Providers (FSP), the agents providing flexibility, may be connected to the distribution or to the transmission grid.

1.4.2. Distributed Energy Resources

Distributed Energy Resources is a concept used to encompass the multiple types of **end-users connected to the distribution grid, capable of providing energy and/or services to the grid** by **mobilizing** the **flexibility** they have available. The DER falls within the concept of the energy resources, in general meaning all those end-users that may provide services to the grid or system.

Several different types of DER exist. In this deliverable, we make the distinction between four types of DER. Firstly, generators connected to the distribution grid or to the consumer who must be supplied, which are termed Distributed Generation (DG) (Gharehpetian & Agah, 2017). Secondly, the active demand, that is also considered a DER, named Demand Response (DR). Thirdly, storage systems, named Energy Storage Systems (ESS). In this category, batteries are also included. Finally, Electric Vehicles (EV), that act as a type of ESS with some specific features. Due to their potential importance and connection availability, EV is considered separately from ESS.

It is also important to consider at which voltage level in the distribution grid the resources are connected. For example, a DG connected at the distribution high-voltage (HV)[5] level could be a wind farm of 10MW of installed capacity, while a DG connected at the low-voltage (LV) level can be a rooftop solar panel system with an installed capacity of 10kW or less. Therefore, these two DGs are clearly very different. The same can be said for DR being provided by a residential consumer or a large industrial consumer. Figure 5 summarizes the general definition of DER.

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

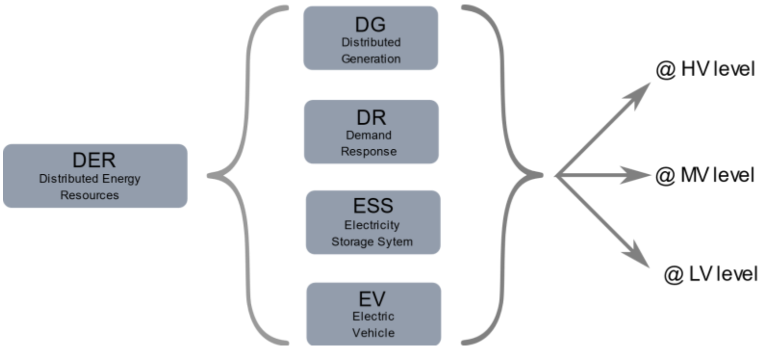


Figure 5: Classification of DER according to their nature and voltage level

1.4.3. Services for TSOs and Services for DSOs

The nomenclature to define services that can be provided to TSOs and DSOs is often unharmonized among regulatory documents and literature. The Clean Energy Package, for instance, defines such services as Ancillary Services (AS), meaning "*a service necessary for the operation of a transmission or distribution system including balancing and non-frequency ancillary services but not congestion management*[6]". This concept of AS includes balancing, includes other "non-frequency" services (e.g. voltage control, fast reactive current injections, inertia and black start), but excludes congestion-management. However, congestion management could be considered an ancillary service.

Therefore, for the sake of simplification, in this deliverable, the distinction of services is made between **services for the TSO**, and **services for the DSO**. These services are also referred as "grid services". The CoodiNet project will refer to the following services.

- Services for TSO: frequency control (balancing), congestion management, voltage control, inertia and black start.
- Services for DSOs: local congestion management, voltage control, and islanded operation.

These preliminary definitions will be updated with the CoordiNet project in order to provide a common and comprehensive understanding of products and services. For further details, please refer to Deliverable D1.3.

1.4.4. Frequency Control

In order to harmonize the nomenclature employed when referring to Frequency Control services, we use the definitions given by the Network Codes, in the Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a Guideline on electricity transmission System Operation (SOGL). These definitions, however, may not be fully implemented in all countries. For this reason, we refer to Table 2 as a general reference.

[6] Electricity Directive, Article 2(17).

Table 2: Terms for reserve products. Source: (Schittekatte, Reif, & Meeus, 2019)

	Frequency containment process	Frequency restoration process		Reserve replacement process
Operational reserves defined by SOGL	**Frequency Containment Reserve (FCR)**	**Automatic Frequency Restoration Reserves (aFRR)**	**Manual Frequency Restoration Reserves (mFRR)**	**Replacement Reserve (RR)**
ENTSO-E CE Operation handbook	Primary Control	Secondary Control	Tertiary Control	Tertiary Control

2. TSO-DSO Coordination: Regulation in the European Context

2.1. Review of the TSO-DSO regulatory discussion

Power systems are going through significant changes. During the past two decades, two main objectives started guiding decisions in the power sector, namely the need for clean electricity and for competition in electricity markets. In Europe, the targets for a renewable generation have pushed countries to promote clean technologies, mainly wind and photovoltaic (PV) power. This push has also reduced the cost of such technologies and enabling their installation by end-users in the form of DG. Demand response and the introduction of electric vehicles are also becoming a reality. While these trends are leading to lower carbon power systems, challenges are being posed to the management of the sector, especially to the management of the networks and the electricity system as a whole, affecting both TSO and DSO activities.

On the one hand, TSOs have to deal with the higher intermittency generated by variable renewables (i.e., high variability in their output – wind and solar PV). To address this new characteristic of generation, TSOs may have to procure more or different kinds of Ancillary Services to adjust the real-time demand-generation balance quickly. On the other hand, DSOs are experiencing an increasing number of generating units being connected to the distribution network. This is the case in Germany, for instance, where around 98% of the more than 1 million PV panels are connected to the distribution grid (Perez-Arriaga, 2016). This means that both grid operators will have to assume new roles and improve network planning and operation.

The new roles for DSOs, such as active grid management, will only be fully realized with the deployment of smart grid technologies. As of today, there is still a considerable part of power grids DSOs are blind to. Table 3 summarizes a few of the key characteristics of transmission and distribution networks in terms of infrastructure, observability, and operation. Medium and low voltage levels have a higher density of grid-connected users and installations while they still are not optimally monitored and have limited operation flexibility. For DSOs to assume the new roles for them foreseen, it is important to enhance (local) service procurement, observability and operation of the grid by means of flexibility (Rivero Puente, Gerard, & Six, 2018).

Table 3: Typical characteristics of transmission and distribution networks, where (-) indicates a poor/low level, and (+) indicates a robust/high level

Network		**Infrastructure**	**Typical operation**	**No. of users**	**No. of installations**	**Operational flexibility**	**Monitoring degree**
Transmission (Security of supply) (400, 275, 220kV)		Meshed	Meshed	--	-	+++	++
Distribution (Quality of supply)	High Voltage (132, 45, 66kV)	Meshed	Meshed / Radial	-	++	+	++
	Medium voltage (20, 15kV)	Meshed/ Radial	Radial	++	+++	-	+
	Low voltage (400, 380V)	Meshed / Radial	Radial	+++	+++	---	--

Novelties are taking place at every step of the electricity value chain, from the centralized generation to the final electricity user. On the centralized generation side, the rise of intermittent renewables in the generation mix is increasing the need for AS for TSOs. On the DSO side, the new roles and the active management of the grid by means of flexibility procurement will also call for coordination, as DSOs will also be interested in procuring flexibility from DER. Finally, end users are contributing for the rise in DER usage (including ESS and EV), and experiencing the increase possibilities for DR through new Home Energy Management Systems (HEMS) and the participation of aggregators that may manage their flexibility.

The active management of the distribution grid will not only allow the integration of a larger number of DER into the system but may potentially reduce total costs of distribution companies, as investments may be substituted by services provided by DER to the DSO (Ulian, Sebastian, Bartolucci, & Gutschi, 2014). DERs may also provide services for the transmission operator. In fact, many European countries already allow the TSO to contract balancing services from resources connected to the distribution grid (Gerard, Rivero, & Six, 2016).

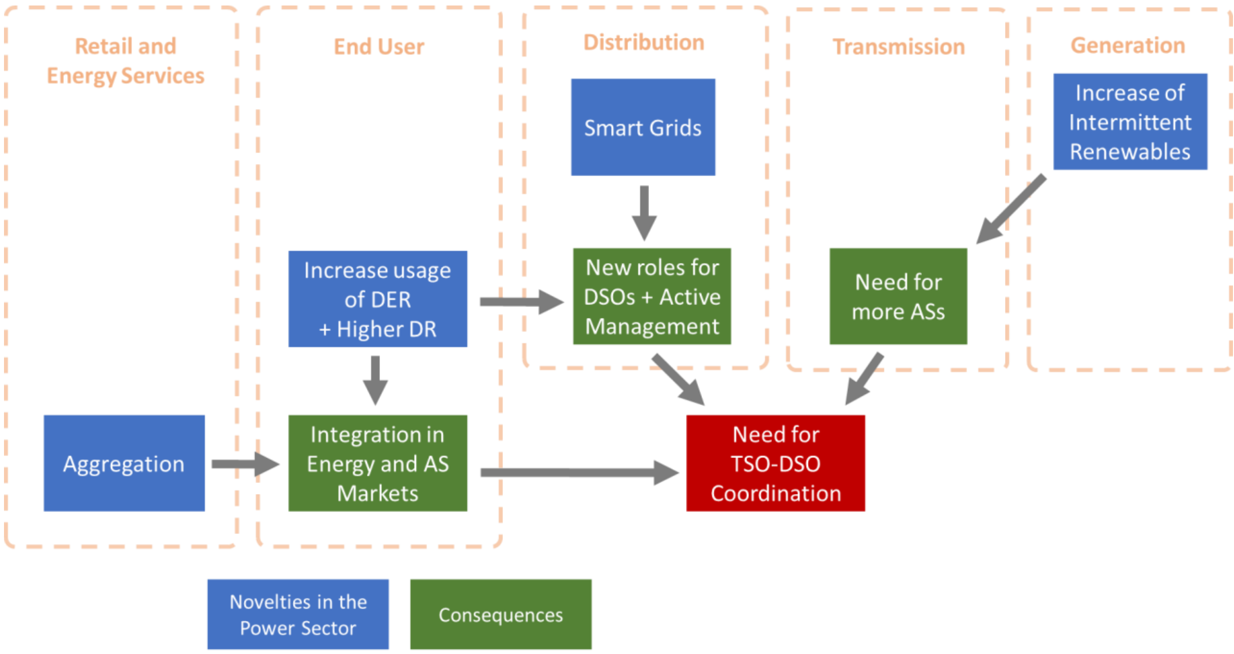


Figure 6: Reasons for Increased TSO-DSO Coordination

TSO-DSO coordination is already an important topic for policymakers in Europe. The European Commission (EC), for instance, when launching a consultation for what would become the Clean Energy Package, stated that "Closer cooperation between DSOs and TSOs on issues around network planning and operations is therefore paramount and should be pursued further" (European Commission, 2015). ACER, in the report "European Energy Regulation: A Bridge to 2025" also highlights the importance of closer interaction between the TSO and DSO (ACER, 2014).

ACER (2014) highlights the need for DSOs to manage their networks actively, including increasing the need for cooperation between TSO-DSO. CEER has carried out a comprehensive consultation to evaluate the future roles of DSOs, resulting in more than 100 responses (CEER, 2014, 2015). The conclusions point out five main aspects that should be improved in the coming years: (i) a whole system approach, especially in network planning and investment, (ii) greater coordination between TSO-DSO concerning the procurement of system services, operational and network planning/development/investment, (iii) data exchange between grid operators, (iv) use of flexibility from DER, and (v) fairer cost sharing. CEER (2016a) has also highlighted the need for clear governance between TSO and DSO, establishing shared responsibilities, a clear framework, and processes. Eurelectric (2016) also states its view for the roles of the DSO in the future, pointing out that DSOs will have a broader role as neutral market facilitator. The positioning of European institutions and associations bring general concerns and objectives for the future role of DSOs, but they do not offer concrete rules for the achievement of such objectives.

Data exchange is also a major concern for TSO-DSO cooperation. The most relevant work done so far on this topic is the report by (CEDEC, EDSO, ENTSO-E, Eurelectric, & GEODE, 2016). Having as a starting point the harmonised role model published by ENTSO-E (ENTSO-E, 2015), the report on TSO-DSO data management discusses data requirements for several use cases, including congestion management and balancing, considering the use of DER flexibility. The report classifies flexibility data into three groups, namely grid data, meter data, and market data. The first type covers technical data such as voltage, power quality, reactive powered frequency, etc., collected by network assets (e.g., sensors in the network). This group is especially needed for local congestion management, for instance. The second type (meter data) covers end-user consumption and production data. This data is relevant for balancing purposes. The third type (market data) covers financial data such as energy spot prices, for example. This kind of data, depending on the coordination scheme adopted[7], may be relevant and necessary to be exchanged.

2.2. European Energy Policy: towards 2030

Considering the challenges imposed by the changes in the power sector, new European regulations published address many of the issues mentioned above. The two most relevant and comprehensive sets of regulations are the Network Codes[8] and the Clean Energy Package[9]. The former was published between 2015 and 2017 and are currently being implemented. The latter was first proposed by the EC late in 2016[10], and is now in at the last stage of political approval.

Both sets of regulations bring important definitions for the TSO-DSO cooperation discussion. When definitions are not provided, general directions are given. In this sense, these regulatory documents are important for Research and Innovation (R&I) projects like CoordiNet to inform them about the view of the EC and the European Parliament on topics related to TSO-DSO coordination.

2.2.1. The Clean Energy Package

The “Clean energy for all Europeans” package, or simply Clean Energy Package (CEP), is the most recent and relevant set of European regulations to be released since the so-called “Third Package”. First proposed by the European Commission in November of 2016, the CEP has just reached a political agreement by negotiators from the Council, the European Parliament and the European Commission (European Commission, 2018). From this point on, the CEP should be translated into all European languages, formally approved by the Parliament, and later move to the implementation phase in the Member States.

The CEP is an update of the already existing European legislation. Regarding the topics concerning TSO-DSO cooperation, the most relevant pieces of legislation in the CEP are the Electricity Regulation (European

[7] A set of potential coordination schemes can be found in (Rivero Puente, Gerard, & Six, 2018) but further revised in CoordiNet.
[8] https://www.entsoe.eu/network_codes/
[9] https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/clean-energy-all-europeans
[10] As the Clean Energy package was first proposed in November of 2016, it is also known as the “Winter Package”.

Commission, 2017c) and the Electricity Directive (European Commission, 2017b). Both documents have clearly expressed the need for enhanced coordination between grid operators.

2.2.1.1. Electricity Regulation

Article 53 of the Electricity Regulation addresses the TSO-DSO coordination issue, as quoted integrally below.

> *"Article 53*
>
> *Cooperation between distribution system operators and transmission system operators*
>
> *1.Distribution system operators shall cooperate with transmission system operators in planning and operating their networks. In particular, transmission and distribution system operators shall exchange all necessary information and data regarding the performance of generation assets and demand side response, the daily operation of their networks and the long-term planning of network investments, with the view to ensure the cost-efficient, secure and reliable development and operation of their networks.*
>
> *2.Transmission and distribution system operators shall cooperate in order to achieve coordinated access to resources such as distributed generation, energy storage or demand response that may support particular needs of both the distribution system and the transmission system."*

Article 53 highlights two main things. Firstly, the need for **data exchange**, and secondly, the need to **allow DER to provide services for both the TSO and DSO**. Regarding data exchange, the legislation also details that this data exchange should serve both planning and operation purposes and should be done in the different time-steps of power systems operation.

Besides Article 53, other topics concerning TSO-DSO interaction are also present in the Regulation. In particular, the new roles for DSOs are especially emphasized throughout the CEP. In the Explanatory Memorandum of the Regulation, the EC states that *"Allowing Distribution System Operators (DSOs) to manage some of the challenges associated with variable generation more locally (e.g. by managing local flexibility resources) could significantly reduce network costs."* The Regulation also recognizes that for the active management to happen, the proper incentives have to be in place. Article 16(8) states that *"regulatory authorities shall provide incentives to distribution system operators to procure services for the operation and development of their networks and integrate innovative solutions in the distribution systems."*

On the one hand, the Regulation states the need for DSOs to procure services and use flexible resources. On the other hand, the Regulation also establishes principles for flexibility providers to be able to provide these services in a transparent and non-discriminatory way. That is, the case when the Regulation states that charges for access to networks *"shall not discriminate against energy storage and shall not create disincentives for participation in demand response"*. Moreover, *"they shall be applied in a way which does not discriminate between production connected at the distribution level and production connected at the transmission level, either positively or negatively"*.

Finally, the Regulation also defines the creation of the "EU DSO entity", which could be compared to what ENTSO-E is for TSOs. The first task defined for the EU DSO entity is to ensure *"coordinated operation and planning of transmission and distribution networks"* (Article 51(1)).

In summary, we can say that the Regulation clearly states the need for TSO-DSO cooperation, by means of data exchange and enabling DER to be accessed by both the TSO and DSO. It also emphasizes the fact that DSOs should be financially incentivized to use DER. The creation of the "EU DSO entity" should also help to ensure the coordination between TSOs and DSOs.

2.2.1.2. Electricity Directive

The Electricity Directive is equally important for enhancing TSO-DSO interaction. Firstly, it reinforces the need for DER integration in energy and service markets. Secondly, it highlights once more the need to allow and incentivize DSOs to procure local services, from DER, in a transparent, non-discriminatory and market-based fashion.

The only direct mention to TSO-DSO coordination is made in the Article 32, paragraph 1, stating that *"distribution system operators shall exchange all necessary information and coordinate with transmission system operators in order to ensure the optimal utilization of resources, ensure the secure and efficient operation of the system and facilitate market development."* Although this mention is short, it is very illustrative to understand the view of the Commission towards the need for enhanced coordination. It highlights three main objectives. Firstly, the optimal utilization of resources, meaning better exploitation of the potential offered by flexible resources. Secondly, the secure and efficient operation of the system is mentioned. In this context, besides ensuring the security of operation, efficiency should also be pursued by avoiding circular causality of operation problems. For example, the activation of DER by the TSO for balancing purposes may create local congestion for the DSO, and the elimination of the local congestion by the DSO could jeopardize the ability of the TSO to activate certain DER for balancing purposes. Thirdly, the Directive points to the need to facilitate market development. This can be interpreted as fostering the integration of DER into energy and services markets. Figure 7 illustrates the view on the need for TSO-DSO data exchange set by Article 32.

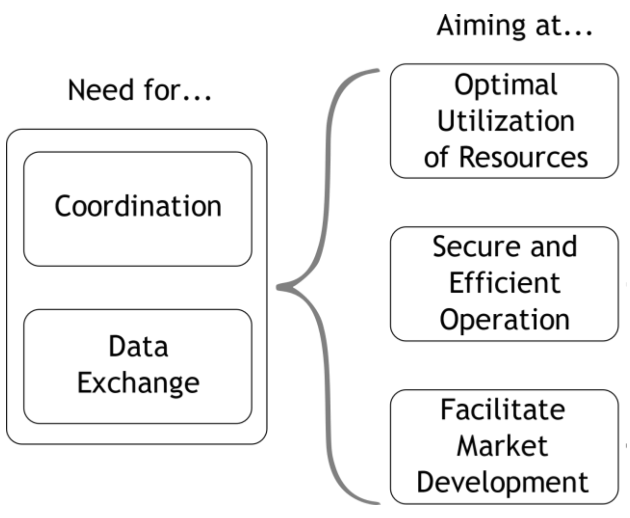


Figure 7: Objectives of TSO-DSO Coordination it the Electricity Directive

Regarding the use of services provided by DER to DSOs, Recital 42 of the Directive expresses the Commission's view clearly:

> *"Distribution system operators have to cost-efficiently* ***integrate new electricity generation*** *especially generating installations using renewable energy sources and new loads such as heat pumps and electric vehicles. For this purpose* ***distribution system operators should be enabled and incentivised to use services from distributed energy resources*** *such as demand response and energy storage, based on market procedures, in order to efficiently operate their networks and avoid costly network expansions. Member States should put in place appropriate measures such as national network codes and market rules, and incentivise distribution system operators through network tariffs which do not create obstacles to flexibility or to the improvement of energy efficiency in the grid. Member States should also introduce network development plans for distribution systems in order to support the integration of generating installations using renewable energy sources, facilitate the development of storage facilities and the electrification of the transport sector, and provide to system users adequate information regarding the foreseen expansions or upgrades of the network, as currently such procedure does not exist in the majority of Member States."*

On the use of services provided by DER, the Directive states that DSOs should procure services *"according to transparent, non-discriminatory and market-based procedures, whenever it has such a function"*. The text complements saying that *"unless justified by a cost-benefit analysis, the procurement of non-frequency ancillary services by a distribution system operator shall be transparent, non-discriminatory and market-based ensuring effective participation of all market participants including renewable energy sources, demand response, energy storage facilities and aggregators."*

Moreover, Article 32 gives more details on how DSOs should use the flexibility from DER. It states that the Member States should provide the necessary regulatory framework to allow and incentivize DSOs to use such services when such services cost-effectively supplant the need to upgrade or replace electricity capacity and which support the efficient and secure operation of the distribution system. It also mentions that either NRAs or DSOs with NRA approval should define standardized products in a transparent and participatory process that includes all relevant system users and the TSO in order to ensure the participation of all market players, especially DER. DSOs should also be remunerated for the procurement of the services provided by market participants. On the planning side, DSOs should submit a network development plan to regulators every two years. This plan should also contain information on how the DSO is using DER as an alternative to expansion. Article 32(1a) states as follows:

> "*1a. Distribution system operators subject to an approval by the regulatory authority, or the regulatory authority itself, shall in a transparent and participatory process that includes all relevant system users and the transmission system operator, define the specifications for the flexibility services procured and, where appropriate, standardised market products for such services at least at national level. The specifications shall ensure an effective and non-discriminatory participation of all market participants including renewable energy sources, demand response, energy storage facilities and market participants engaged in aggregation. Distribution system operators shall exchange all necessary information and coordinate with transmission system operators in order to ensure the optimal utilisation of resources, ensure the secure and efficient operation of the system and facilitate market development. Distribution system operators shall be adequately remunerated for the procurement of such services in order to recover at least the corresponding reasonable costs, including the necessary information and communication technologies expenses and infrastructure costs."*

On the integration of DER into energy and service markets the Commission also expresses its view in Recital (26):

> *"All customer groups (industrial, commercial and households) should have access to the energy markets to trade their flexibility and self-generated electricity. Customers should be allowed to make full use of the advantages of aggregation of production and supply over larger regions and benefit from cross-border competition. Aggregators are likely to play an important role as intermediaries between customer groups and the market. Transparent and fair rules should be established to also allow independent aggregators to fulfil this role. Products should be defined on all organised energy markets, including ancillary services and capacity markets so as to encourage the participation of demand response."*

Moreover, Article 17 lay down principles for demand response, highlighting even further the need for the integration of DER in energy services and market. Article 17(1) states that "*Member States shall ensure that national regulatory authorities encourage final customers, including those offering demand response through aggregators, to participate alongside generators in a non-discriminatory manner in all organised markets*". Additionally, "*Member States shall ensure that transmission system operators and distribution system operators when procuring ancillary services, treat demand response providers, including independent aggregators, in a non-discriminatory manner, on the basis of their technical capabilities.*"

It is worth mentioning that the Directive also defines roles for DSOs regarding the EV charging stations and storage facilities ownership. In both cases, DSOs are not supposed to own and operate these types of facilities (although exceptions exist).

The Directive also mentions about the tasks of the DSO in data management. However, regarding this, the Directive is brief and does not point to one specific data management model (e.g., DSO vs. independent data-hub). The Directive is limited to state that all measures should be taken to *"ensure that all eligible parties have non-discriminatory access to data under clear and equal terms."*

2.2.2. The Network Codes

The Network Codes and Guidelines are a set of European regulations co-developed by ENTSO-E and ACER in order to harmonize procedures across Europe and contribute to the integration and efficiency of the European electricity market (ENTSO-E, 2019).

The development of the Network Codes and Guidelines was established already in the Third Energy Package in 2009. It defined areas in which Network Codes should be developed and the process for that. In 2017, after four years of development, eight network codes and guidelines were published (Meeus & Schittekatte, 2017). These codes are divided into three families, namely the connection codes, the operation codes, and the market codes. Table 4 lists the eight codes, their families, acronyms used in this report and their type.

There are two different types of regulations, Network Codes (NC) or Guidelines (GL). Both share the same legal value and are directly applicable to the Member States. The main differences are in the development and implementation processes (Meeus & Schittekatte, 2017). The GLs include processes in which a set of TSOs at Pan-European or Regional level must develop a methodology, carry a public consultation and submit it to national regulators for approval. Examples of such process are the development of the European Balancing Platforms, discussed in section 2.2.3. The NCs, however, do not include these processes and are ready for implementation. In this sense, one may argue that the NCs are more detailed while the GLs are more flexible and leave some aspects to be defined later, such as the functioning of the balancing platforms.

Table 4: The Network Codes and Guidelines

Family	Code	Acronym	Type
Connection	Demand Connection Code	DCC	NC
	Requirements for Generators	RfG NC	NC
	High Voltage Direct Current Connections	HVDC NC	NC
Operation	Emergency and Restoration	ER	NC
	Transmission System Operation	SOGL	GL
Market	Capacity Allocation and Congestion Management	CACM	GL
	Electricity Balancing	EBGL	GL
	Forward Capacity Allocation	FCA	GL

The Network Codes are mostly devoted to pan-European grids and markets and therefore more related to the transmission networks. Nevertheless, some NCs are relevant for the TSO-DSO coordination discussion. Title III of the DCC, for instance, sets the connection rules for demand units that may provide demand response services to system operators. In addition, it also includes the concept of the closed distribution system operator (CDSO), which may also offer demand response services to the market as well as to system operators for grid management.

The SOGL is also relevant for TSO-DSO coordination. According to Article 1, one of the objectives of the SOGL is to establish "*rules and responsibilities for the coordination and data exchange between TSOs, **between TSOs and DSOs**, and between TSOs or DSOs and SGUs, in operational planning and in close to real-time operation*". Moreover, some of the coordination aspects defined in the SOGL are:

- In coordination with the DSO, the TSO should be able to operate reactive power resources, including low voltage demand disconnection, in order to maintain operational security limits.
- Related to data exchange between TSO and DSOs[11]: DSOs should provide both structural and real-time information to the TSO. Structural data should be updated at least every 6 months.

[11] In this report we often mention the coordination between "TSO and DSOs". We assume the typical case of one TSO per country with several large DSOs connected to them. This is not always the case, as in Germany, that has 4 different TSOs. Moreover, there are cases where a DSO is connected to another DSO and therefore, more complex coordination will be required.

The SOGL also establishes that TSOs and DSOs should cooperate in the case of reserve providing units or groups[12] connected to the DSO grid. Article 182 sets guidelines on the prequalification process, establishing that:

- The necessary information exchange regarding the providing units should be agreed between TSO and DSOs.
- The prequalification process shall rely on the agreed timeline and rules concerning information exchanges and the delivery of active power reserves between the TSO, the reserve connecting DSO and the intermediate DSOs. The prequalification process shall have a maximum duration of 3 months from the submission of a complete formal application by the reserve providing unit or group.
- DSOs, in cooperation with the TSO, shall have the right to set limits to or exclude the delivery of active power reserves located in its distribution system, based on technical reasons such as the geographical location of the reserve providing units and reserve providing groups.
- Each DSO shall have the right, in cooperation with the TSO, to set, before the activation of reserves, temporary limits to the delivery of active power reserves located in its distribution system. The respective TSOs shall agree with their reserve connecting DSOs and intermediate DSOs on the applicable procedures.

The EBGL is equally important for the TSO-DSO discussion as it paves the way for the definitions of balancing products and services. Although the EBGL does not address the provision of balancing services by DER, it does encourage it by stating that the rules governing balancing shall *"ensure adequate competition based on a level-playing field between market participants, including demand-response aggregators and assets located at the distribution level"*.

The biggest relevance of the EBGL for TSO-DSO coordination is in the fact that it sets the rules for TSOs to develop pan-European platforms for balancing provision. Besides integrating balancing markets across Europe, these European Balancing Platforms will also help define balancing products and services, as described in 2.2.3.

2.2.3. The European Balancing Platforms

European countries have advanced in the harmonization of the electricity markets, achieving important milestones such as the implementation of market coupling for the forward, day-ahead market and the continuous intraday market through the FCA and the CACM Guidelines. The balancing markets, however, still diverge significantly among the EU countries, but agreements are being made as requested by the EBGL (European Commission, 2017a). The EBGL *"lays down a detailed guideline on electricity balancing including the establishment of common principles for the procurement and the settlement of frequency containment reserves, frequency restoration reserves and replacement reserves and a common methodology for the activation of frequency restoration reserves and replacement reserves"*. This regulation applies to all TSOs, DSOs, and regulatory authorities in the European Union. In the end, the EBGL should help to increase the security of supply, limit emissions and diminish costs to customers.

The implementation of the EBGL requires that the TSOs or group of TSOs at pan-European or regional level develop methodologies for final implementation. These initiatives have not involved DSOs. For this purpose, different implementation projects are put in place to define the methodologies for the different balancing

[12] According to the SOGL, a 'reserve provider' means a legal entity with a legal or contractual obligation to supply FCR, FRR or RR from at least one reserve providing unit or reserve providing group

services. The projects require different processes including the drafting of the proposal, public consultations, NRA preparation, approval and publication, implementation and derogation. Figure 8 shows the planning of implementation of the European Balancing Platforms that are under development and are further described in the next sections. The proposed standard product characteristics of the European Balancing Platforms, which are on the high level described in the implementation frameworks, are still subject to regulatory approval.

These European Balancing Platforms are relevant for CoordiNet because they define harmonized balancing products considering different aspects, which are relevant for products definition beyond the ones related to balancing. Lessons learnt on alternatives products definition, implementation procedures and considered procurement methods and algorithms will be of considered relevance for CoordiNet.

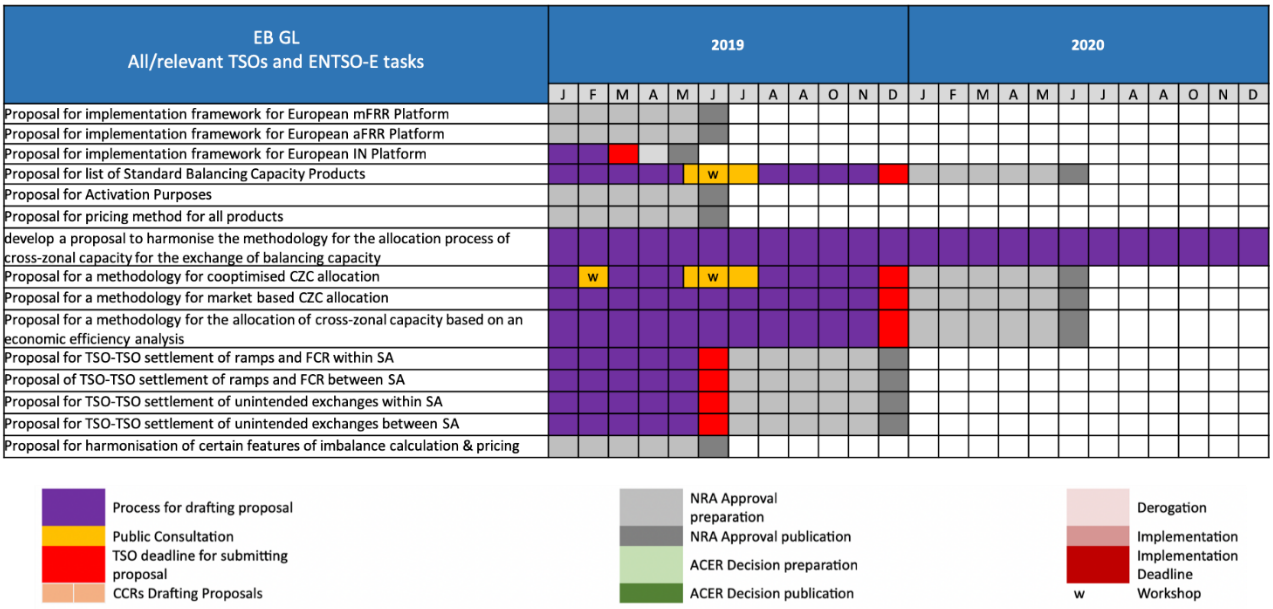


Figure 8: Development of relevant TSOs and ENTSO-E tasks according to the EBGL. Source: (ENTSO-E, n.d.-a)

2.2.3.1. Platform for IN – IGCC

2.2.3.1.1. Description and objectives

The International Grid Control Cooperation (IGCC) (ENTSO-E, n.d.-c) is the implementation project chosen by ENTSO-E in February 2016 to become the future European Platform for the imbalance netting (IN) process, which is defined in Article 3 §128 of the SOGl as "a process agreed between TSOs that allows avoiding the simultaneous activation of FRR in opposite directions, taking into account the respective Frequency Restoration Control Errors (FRCEs) as well as the activated FRR and by correcting the input of the involved Frequency Restoration Processes (FRPs) accordingly". The relevant Article in the EBGL Article 22 (European Commission, 2017a). All TSOs of the Continental Europe synchronous area performing the aFRR process are responsible for the implementation of the IN-Platform (as described in Article 1 of the implementation framework for a European platform for the imbalance netting (INIF) (ENTSO-E, 2018e)).

IGCC was launched in October 2010 as a regional project and has grown to cover 24 countries (27 TSOs) [13] across continental Europe, including all those that need to implement the IN-Platform according to the EBGL.

IGCC is working towards meeting the requirements of the EBGL by facilitating the accession of the remaining continental European TSOs, to further increase efficiency and operational security in the European power system. More precisely, this initiative allows to avoid the simultaneous activation of FRR in opposite directions by considering the respective frequency restoration control errors and the activated FRR in different control areas, and therefore incorporating it as input of the involved frequency restoration processes in the involved control areas.

2.2.3.1.2. Participating countries

IGCC counts 20 member TSOs – Austria (APG), Belgium (Elia), Switzerland (Swissgrid), Czech Republic (ČEPS), Germany (50Hz, Amprion, TenneT DE, TransnetBW), Denmark (Energinet), Greece (ADMIE), France (RTE), Croatia (HOPS), Italy (Terna), The Netherlands (TenneT NL), Poland (PSE), Portugal (REN), Romania (Transelectrica), Serbia (EMS), Slovenia (ELES) and Spain (REE) – and 3 observer TSOs – Bulgaria (ESO), Hungary (MAVIR) and Slovakia (SEPS). In addition, seven TSOs are observers to IGCC (ENTSO-E, n.d.-c).

IGCC member TSOs are either operational members, also known as participating TSOs (i.e. those physically connected to the IGCC through communication lines that perform the imbalance netting process via the platform), or non-operational members (i.e. those actively taking part on the IGCC decision making but not yet performing the imbalance netting process). There are 13 operational members and 7 non-operational members. The operational members are the TSOs of Germany, Denmark, the Netherlands, Switzerland, Czech Republic, Belgium, Austria, France, Croatia and Slovenia. The latter two became operational on 1 February 2019.

[13] Macedonia, Bosnia-Herzegovina, Montenegro and Luxembourg are displayed as observer countries in Figure 9, but not mentioned in the text in (ENTSO-E, n.d.-c).

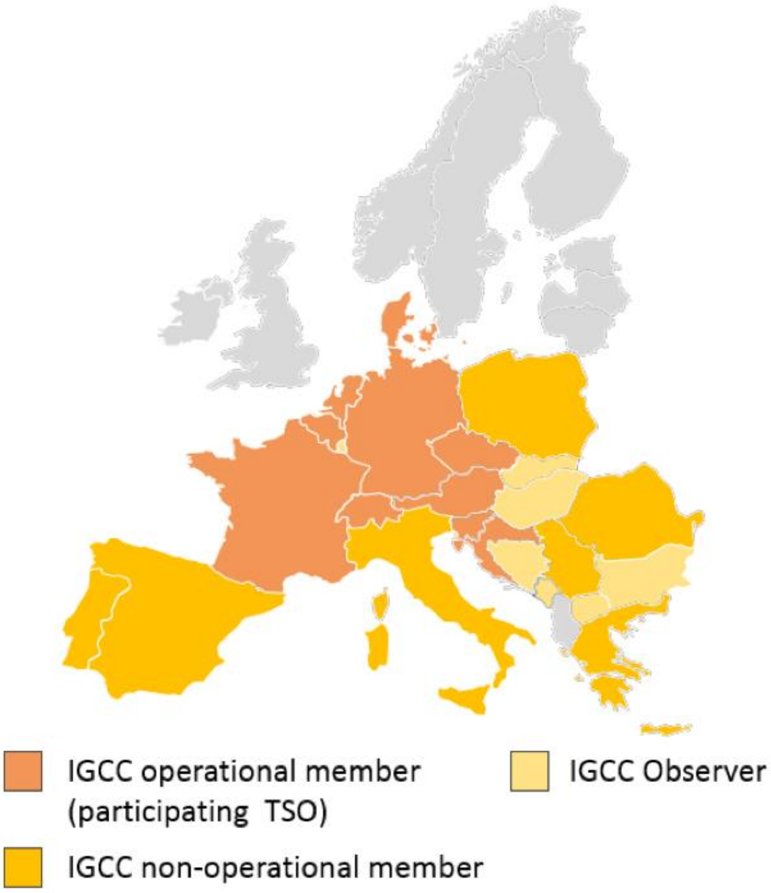


Figure 9 IGCC Member and observer TSOs (ENTSO-E, s.f.)

2.2.3.1.3. Implementation schedule

The implementation of the first development phase of the Grid Control Cooperation (GCC) between German TSOs made it possible to implement the imbalance netting process, which was originally established in 2010 to avoid the counter-activation of automatic Frequency Restoration Reserve (aFRR) in Germany. Shortly after, the German cooperation was expanded to other countries and the GCC evolved into the International Grid Control Cooperation (IGCC). Imbalance netting across Load-Frequency Control areas (LFCs) enables all participating TSOs to decrease the use of balancing energy while increasing system security. In 2018, nine TSOs became IGCC members by signing a so-called light accession agreement, allowing them to take part in the decision-making process of IGCC while not yet becoming operational (i.e. not performing the imbalance netting process) (ENTSO-E, n.d.-c).

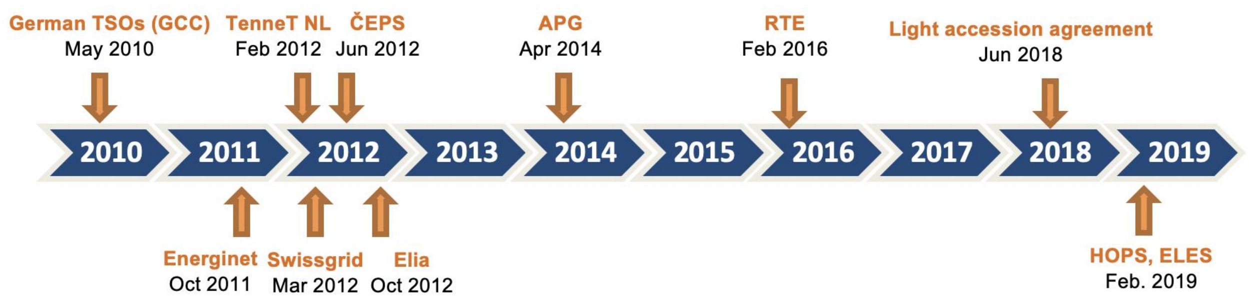


Figure 10. Historical evolution of IGCC (ENTSO-E, s.f.)

The accession of TSOs to IGCC is planned in accordance with the following time plan. IGCC and ENTSO-E share this time plan for informative purposes only so it does not, in any case, represent a firm, binding or definitive position of IGCC on the content.

Table 5. Time plan for the accession of TSOs to IGCC (ENTSO-E, s.f.)

Country	TSO	Quarter of accession
Slovenia	ELES	Q1 2019
Croatia	HOPS	Q1 2019
Serbia	EMS	Q2 2019
Bulgaria	ESO	Q3 2019
Greece	ADMIE	Q3 2019
Poland	PSE	Q3/Q4 2019
Spain	REE	Q3/Q4 2019
Portugal	REN	Q3/Q4 2019
Romania	Transelectrica	Q4 2019
Hungary	MAVIR	Q4 2019
Italy	TERNA	Q4 2019
Slovakia	SEPS	Q4 2019

2.2.3.1.4. Main agreements reached

The imbalance netting process is the process that aims to minimize the amount of activated aFRR, by avoiding their simultaneous counter activation. The process does not require any activation of standard neither specific product for balancing energy. Furthermore, in accordance with Article 1 of the Implementation Framework (ENTSO-E, 2018b), common settlement rules for the TSO-TSO settlement will be proposed and defined pursuant to Article 50 of the EBGL. Thus, all TSOs consider that there is no need for harmonization of terms and conditions related to balancing for the establishment of the IN-Platform (ENTSO-E, 2018e).

This initiative has limited implications to the TSO-DSO coordination challenges, main aspect of this initiative is the netting of energy imbalances between the participating TSOs and therefore, the reduction of need of procurement of balancing sources.

2.2.3.2. Platform for RR – TERRE

2.2.3.2.1. Description and objectives

Trans European Replacement Reserves Exchange (TERRE) is the European implementation project for exchanging replacement reserves (RR) in line with Article 19 of EBGL (European Commission, 2017a). This type of reserves is defined in Article 3 §8 of the SOGL as “the active power reserves available to restore or support the required level of FRR to be prepared for additional system imbalances, including generation reserves”. The aim of TERRE is to build the RR platform and set up the European RR balancing energy market in order to create a harmonized playing field for the market participants (ENTSO-E, n.d.-f).

To support the implementation of the EBGL, several pilot initiatives have been set up. The aim of such initiatives is the implementation of European platforms for the trading of balancing services and to define the treatment for balancing market parties (balancing rules). **Having started in 2016, the TERRE project is the most advanced project in these European Balancing Platforms**.

Although TERRE’s main aim is to create the European platform for the exchange of balancing energy from RR, it is also aiming to share its experience and best practices with other European balancing projects. Therefore, it is being closely monitored by the different NRAs and ACER.

At present, the TERRE project has launched the implementation phase under a cooperation agreement between the TSOs. This phase includes the development of the common European RR platform, the follow-up of the local implementation by the participants, the preparation for the parallel testing and the Go-live.

The TSOs are developing an IT platform (and algorithmic optimization), named LIBRA, which will support the European RR market. The LIBRA platform will be owned by the TSOs and can be used in the framework of other balancing processes.

Last December 14, 2018[14], the relevant NRAs have approved the Replacement Reserves Implementation Framework (RRIF) in which the principles of the market design are included and explained.

2.2.3.2.2. Participating countries

Currently, 9 TSOs are members of the TERRE project and there are 5 external observers, as shown in Figure 11. It is expected that in the future additional TSOs, using the RR product will join the project as well.

Figure 11: TERRE members and observers (ENTSO-E, n.d.-f)

2.2.3.2.3. Implementation schedule

Figure 12 shows the timeline of the TERRE project according to the EBGL. The orange square indicates the date of the RRIF proposal, the green one the deadline for the platform implementation and the red one the deadline in case there is a request of derogation by a TSO which should justify not applying the agreed solutions following the procedures established in the EBGL.

Figure 12: Project TERRE timeline according to EBGL (A. Dusol, ENTSOE, September 2017)

[14] After that, each NRA has provided individual approval of the RRIF to the corresponding TSO, until January 2019.

2.2.3.2.4. Main agreements

The main agreement reached so far, regarding a standard product for balancing energy from RR is detailed in Article 6 of the RRIF (ENTSO-E, 2018g):

1) The RR-Platform will only trade the standard product for balancing energy from RR.
2) From a commercial point of view, the RR standard product is a scheduled block product that can be activated for one or several fixed quarter(s) of an hour, respecting the minimum and maximum duration of the delivery period.
3) The full activation time (FAT) of the RR standard product is 30 minutes. The ramping period can be from 0 to 30 minutes.
4) The main characteristics of the product are presented in Table 6 below.
5) Whenever the BSP is mentioned in paragraph (4), in case of a central dispatching model[15] it means that the connecting TSO may define or determine the relevant RR standard product characteristic based on integrated scheduling process bids submitted by BSPs following the national rules for converting of bids in the central dispatching model.

Table 6. Characteristics of the RR standard product

Mode of activation	Scheduled with manual activation
Preparation period	From 0 to 30 minutes
Ramping period	From 0 to 30 minutes
FAT	30 minutes
Deactivation period	Under national responsibility
Minimum quantity	1 MW
Maximum quantity	In case of divisible bids, no maximum is requested, only technical limit. In case of indivisible bids, national rules will be implemented.
Minimum duration of delivery period	15 minutes
Maximum duration of delivery period	60 minutes[16]
Location	At least the smallest of Load-Frequency Control (LFC) area or bidding area. More detailed locational information is under national responsibility.
Validity period	Defined by the Balancing Service Provider (BSP) and respecting the minimum and maximum delivery period
Recovery period	The recovery period (minimum duration between the end of deactivation period and the following activation) is determined by the BSPs
Divisibility	Divisible and/or indivisible bids allowed

[15] Central dispatch means a scheduling and dispatching model where the generation and consumption schedules as well as dispatching of power generating and demand facilities are determined by a TSO. As an alternative, a self-dispatch model means a scheduling and dispatching model where generating and demand facilities define their own generation schedules or consumption schedules. This model can be portfolio-based (aggregated) or unit-based. In Europe, most countries adopt the self-dispatch model, such as Spain and Sweden. Greece however adopts a central dispatch model.

[16] The maximum delivery period depends on the number of daily gates. The RR-Platform will start with 24 daily gates (one optimization that will cover 60 min balancing duration) and maximum delivery period of 60 min. For example, in case of moving the RR-Platform to 48 gates, the maximum delivery period will be 30 min (for 96 daily gates, maximum delivery period will be 15 min).

Price and resolution of the bid	Price is defined by the BSPs; the resolution is 0.01 €/MWh
Timeframe resolution	15 minutes

According to Article 7 of the RRIF, the gate closure time for the submission of bids to the connecting TSOs by BSPs will be 55 minutes before the activation period (although for an interim period of no more than twelve months after the entry into operation of the RR platform, the gate closure time will be 60 min). For TSOs applying a central dispatching model, the balancing energy gate closure time for integrated scheduling process bids shall be defined according to Articles 24.5[17] and 24.6 of the EBGL.

Additionally, the gate closure time for the submission of bids to the common merit order lists by the connecting TSO shall be 40 minutes before the activation period. The TSOs will send the RR balancing energy need to the RR platform and cross zonal capacities before the TSO energy bid gate closure time for RR (Article 8 of RRIF (ENTSO-E, 2018g)).

Finally, the Article 9 of RRIF (ENTSO-E, 2018g) details the common merit order lists to be organized by the activation optimization function:

1) Each BSP in self-dispatch system shall submit the bids to the connecting TSO.
2) Each BSP in central-dispatch system shall submit integrated scheduling process bids to the connecting TSO who shall convert integrated scheduling process bids received from BSPs into bids.
3) The format possibilities of the bids are:
   a) Fully divisible, divisible or indivisible;
   b) Exclusive in volume or time and/or multi-part in volume and price;
   c) Linked in time.
4) The format possibilities of the RR balancing energy needs are:
   a) Fully divisible;
   b) Linked in time;
5) The connecting TSO shall submit the bids to the common merit order lists.
6) The common merit order lists shall comprise of two common merit order lists that shall contain all involved bids and all the RR balancing energy needs submitted by the TSOs:
   a) First merit order lists shall include upward bids and downward RR balancing energy needs sorted in ascending order of price;
   b) Second merit order lists shall include downward bids and upward RR balancing energy needs sorted in descending order of price.

2.2.3.2.5. Discussion topics / Future developments

The roadmap for the implementation of the RR-platform is detailed in Article 4 of the Replacement Reserves Implementation Framework (RRIF) (ENTSO-E, 2018g):

1) Twelve months after the approval of the RRIF (December 2018), the implementation project shall fulfill all requirements defined in RRIF and further requirements of the EBGL and therefore constitute the RR platform.
2) The timeline for the implementation considers several steps:

[17] By two years after entry into force of this Regulation, each TSO applying a central dispatching model shall define at least one integrated scheduling process gate closure time.

a) Six months after the approval of RRIF proposal, all TSOs performing the RR process shall designate the proposed entity or entities entrusted with operating the European platform.
b) All RR TSOs which have, at least, one interconnected neighboring RR TSO shall implement and make operational the RR-Platform for the exchange of balancing energy for RR no later than one year after the approval of the proposal for the RRIF for RR-Platform. A TSO may request a derogation from this requirement to its regulatory authority (Article 62 of the EBGL). The request shall be duly justified.
c) The Implementation project aims at establishing the functioning of the RR Platform:
    i) In parallel to the central platform development, the local implementation will take place, to ensure readiness for the exchange with the RR platform, once operational. The adjustment of the national RR processes to integrate with the RR platform are not in the scope of the RRIF and are implemented at a local level.
    ii) The implementation project includes the main aspects of the RR market harmonization, in order to establish a level playing field for the market participants in the region.
    iii) The parallel run phase will encompass the participation of the RR TSOs and the national BSPs if needed. This phase is the “end to end testing” which will challenge the readiness of the RR platform, the TSOs, and the local BSPs. The communication, exchange of information, fall-back procedures and incidental processes will be verified.
    iv) This parallel run phase is foreseen to take place in the 2nd half of 2019.
    v) The go-live of the RR-Platform shall take place no later than one year after the approval of the RRIF.
    vi) Future evolutions of the RR-Platform are described in Articles 7, 11.5 and 13.3 of the RRIF.

2.2.3.3. Platform for mFRR – MARI

2.2.3.3.1. Description and objectives

Manually Activated Reserves Initiative (MARI) (ENTSO-E, n.d.-d) is the European implementation project for the creation of the European manual Frequency Restoration Reserve (mFRR) platform, where technical details, common governance principles, and business processes are developed by the involved TSOs in the project. Furthermore, MARI shall implement and make operational the European platform, where all standard mFRR balancing energy product bids shall be submitted, and the exchange of balancing energy from mFRR shall be performed (ENTSO-E, 2018d).

The EBGL (European Commission, 2017a), which was approved by the Electricity Cross-Border Committee on March 16th, 2017 and entered into force on December 18th, 2017, defines tasks and a timeline for the implementation of a European platform for the exchange of balancing energy from mFRR. The EBGL defines the framework for common European technical, operational and market rules for a cross border balancing market. This market serves the purpose to secure economically efficient purchase and in time activation of regulation energy by simultaneously ensuring the financial neutrality of the TSOs. Important means to achieve these goals are the harmonization of the balancing energy products and a close cooperation of the TSOs on regional and European level.

Given the importance of an efficient balancing mechanism for an integrated electricity market, 19 European TSOs decided to work on the design of an mFRR platform in order to address pending issues and questions connected with the establishment of such a platform as soon as possible. These TSOs decided to work on a technical solution, which does not only reflect the views of the founding parties but could also be acceptable for potential new parties joining the initiative. The 19 TSOs signed a Memorandum of Understanding on April 5th, 2017, which outlines the major cornerstones of the cooperation. Since then, additional TSOs joined the project, both as members and as observers, and the project was designated as the European implementation project for the mFRR platform by all TSOs.

2.2.3.3.2. Participating countries

Currently, the number of members is 25 and there are 5 external observers plus ENTSO-E. In Figure 13 the members, observers, as well as their geographic location, are detailed.

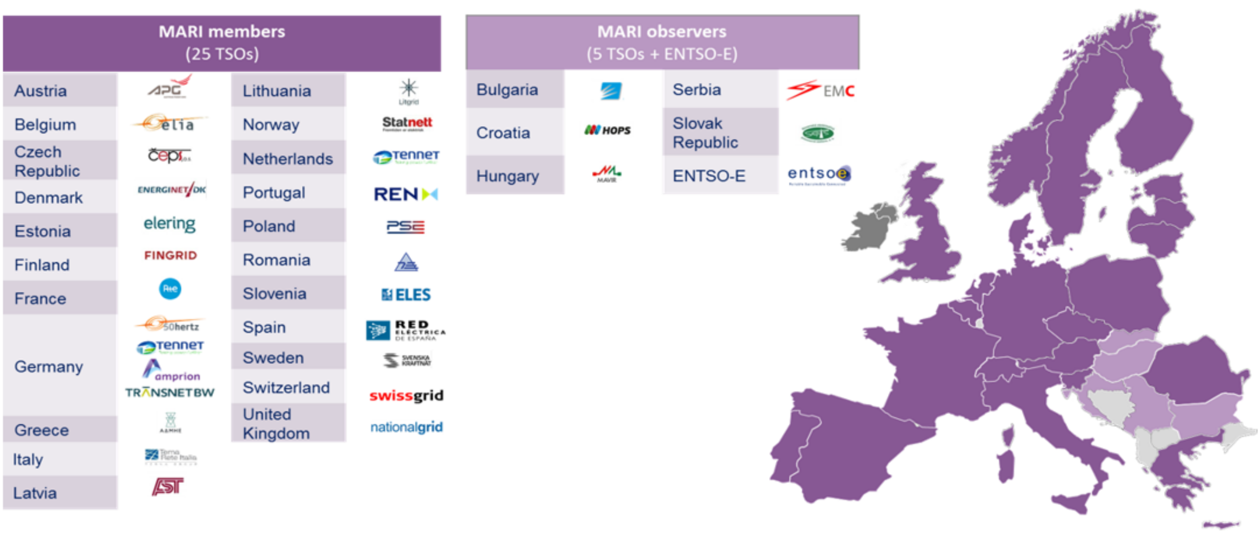


Figure 13: MARI members and observers (ENTSO-E, n.d.-d)

2.2.3.3.3. Implementation schedule

Figure 14 shows the timeline set by the EBGL for the implementation of a common mFRR platform.

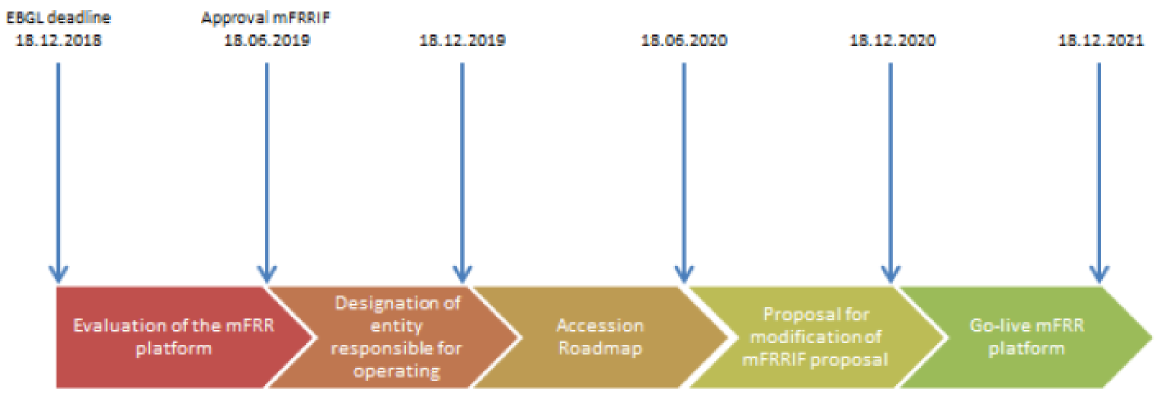


Figure 14: Project MARI timeline according to EBGL (ENTSO-E, 2018d)

The timeline for implementation is mostly described by the requirements in the EBGL (Articles 20.4, 20.5 and 20.6). These indicate that full operation of the platform is expected 30 months after the approval of the mFRR implementation framework (mFRRIF). To achieve this target, six months after the approval of the mFRRIF the entity that will operate the platform shall be designated. Since the mFRR Platform may need change during its implementation, EBGL governs the process for any future amendments of the mFRRIF. In case approval of the mFRRIF is given without a request for amendments and without escalation to ACER, this approval is due 6 months after the delivery of the mFRRIF to the NRAs. The whole timeline then runs until December 2021, when the current project planning aims to have the mFRR Platform operational (ENTSO-E, 2018d). It should be however pointed out that the above-mentioned timeline, as well as the deadlines for the other platforms and the relevant proposals, is only indicative; NRAs may request an amendment of a proposal within 6 months from the proposal submission. In this case, TSOs need to resubmit the amended proposal within 2 months after the request for amendment of the NRAs and the final approval of the proposal has to take place within 2 months after the submission of the amended proposal. Additionally, even in the case that there is no request for amendment, the approval date is either 6 months after the proposal official submission date, according to the provisions of the EBFL, or 6 months from the date that the last NRA received the proposal. Hence, additional delays are possible to occur.

According to Article 62 of the EBGL, a TSO may request a derogation from the deadlines by which a TSO shall use the European mFRR platform. In this case, the TSO should request the derogation at the latest six months prior to the day of application, so, in this case, the deadline for the derogation request is June 2021. The derogation may be granted only once and for a maximum period of two years. Therefore, for these specific cases, the operation of the mFRR platform would run until December 2023 (European Commission, 2017a).

2.2.3.3.4. Main agreements

The standard product of the mFRR Platform is defined by the standard bid characteristics, the variable bid characteristics and the bid characteristics defined in the terms and conditions for BSPs. Given the variety of intrinsic differences between local markets, TSOs' management of the system, and pre-qualification requirements defined in the terms and conditions (T&C) for BSPs, bid characteristics defined in the terms and conditions for BSPs cannot easily be harmonized across Europe. Therefore, for the moment, they will be left at the discretion of the terms and conditions for Balancing Service Providers (BSPs) (ENTSO-E, 2018d).

The Article 7 of (ENTSO-E, 2018b) establishes the main characteristics of the standard mFRR balancing energy product. The main characteristics to be fulfilled are:

1) Static characteristics:

Table 7. Static characteristics of the mFRR product

Mode of activation	Manual
Activation type	Direct or scheduled
Full activation time (FAT)	12.5 minutes
Minimum quantity	1 MW
Bid granularity	1 MW
Maximum quantity	9 999 MW
Minimum duration of delivery period	5 minutes
Resolution of the bid	0.01 €/MWh
Validity period	A scheduled activation can take place at the point of scheduled activation only. A direct activation can take place at any time during the 15 minutes after the point of scheduled activation

2) Variable characteristics: During the prequalification or when submitting the standard mFRR balancing bid, the BSPs will determine the variable characteristics which shall be, at least:
   a) The following parameters:

Table 8. Variable characteristics of the mFRR product

Price	Defined by BSPs, in €/MWh
Location	At least the smallest of Load Frequency Control (LFC) area or bidding area
Divisibility	BSPs are allowed to submit divisible bids, with an activation granularity of 1 MW, and also to submit indivisible bids
Technical linking between bids	BSPs are required to provide information on technical linking between bids submitted in consecutive quarter hours and within the same quarter of an hour
Economic link	Child with parent[18] and exclusive group orders will be allowed

   b) The volume of the bid.
   c) The direction of the bid: upward or downward.
   d) The bid price (positive, negative or zero) shall be defined according to the sign convention in
   e) Table 9.

[18] Meaning that links between offers are considered.

Table 9. Sign conventions for mFRR bid prices.

Direction of the bid	Balancing price +	Balancing price -
Upward	Payment from TSO to BSP	Payment from BSP to TSO
Downward	Payment from BSP to TSO	Payment from TSO to BSP

3) The following bid characteristics shall be defined in the T&C for BSPs, including, but not limited to:

Table 10. Minimum characteristics of bids to be included in T&C for BSPs

Location	More detailed locational information
Preparation period	Defined in the T&C for BSPs, as long as it is compliant with the requirements set on the FAT
Ramping period	Defined in T&C for BSPs, as long as it is compliant with the requirements set on the FAT
Deactivation period	Defined in T&C for BSPs, as long as it is compliant with the requirements set on the FAT and on the minimum duration of delivery period
Maximum period of delivery period	Defined in T&C for BSPs, due to different requirements on preparation period, ramping period and deactivation period
Indivisible bids	Maximum size of indivisible bids is defined according to T&C for BSPs
Minimum duration between the end of deactivation and the following activation	Defined in T&C for BSPs

Regarding the gate opening/closure times for the submission of a standard mFRR bid to the connecting TSOs by BSPs, Article 8 (ENTSO-E, 2018b) set the following:

1) The balancing energy gate opening time shall be no later than 12:00 CET for all validity periods of the next day.
2) The balancing energy gate closure time shall be 25 minutes before the beginning of the quarter hour for which the BSPs place the respective standard mFRR balancing energy product bid. The same balancing energy gate closure time applies for specific product bids converted into standard mFRR balancing energy product bids.
3) For TSOs applying a central dispatching model, the balancing energy gate closure time for integrated scheduling process bids shall be defined according to Articles 24.5[19] and 24.6 of the EBGL.

Additionally, the gate closure time for the submission of available standard mFRR bids by the connecting TSOs to the activation optimization function of the mFRR platform is specified in the Article 9 (ENTSO-E, 2018b):

1) The TSO energy bid submission gate closure shall be 12 minutes before the quarter hour for which the BSPs place the respective standard mFRR balancing energy product bid.

[19] By two years after entry into force of this Regulation, each TSO applying a central dispatching model shall define at least one integrated scheduling process gate closure time.

2) The connecting TSO shall have the possibility after the gate closure time, including during the validity period, to modify the bid in accordance with Article 29.9 of the EBGL or to change the availability status of the bid in accordance with Article 29.14 of the EBGL (European Commission, 2017a) (e.g. due to security restrictions, internal congestions, etc.

Finally, Article 10 of (ENTSO-E, 2018b) details the common merit order lists to be organized by the activation optimization function:

1) Each BSP shall submit the standard mFRR bid to the connecting TSO.
2) Each BSP connected to a TSO applying a central dispatching model shall submit integrated scheduling process bids to the connecting TSO.
3) The connecting TSO shall submit the standard mFRR bids to the mFRR-Platform in order to be included in the common merit order lists.
4) TSOs applying a central dispatching model will convert integrated scheduling bids received from the BSPs into standard mFRR bids and then submit these bids to the mFRR-Platform to be included in the common merit order lists.
5) The mFRR-Platform shall create two common merit order lists (one for bids in upward direction and one for bids in downward direction) for each quarter hour, that shall contain all the available standard mFRR submitted by the participating TSOs.
6) These two common merit order lists shall be used for scheduled activation.
7) The two common merit order lists to be used in the scheduled activation shall be sorted based on the following criteria:
   a) the upward common merit order list shall contain all the available standard mFRR bids in upward direction and shall be sorted in ascending order of price.
   b) the downward common merit order list shall contain all the available standard mFRR bids in a downward direction and shall be sorted in descending order of price.
8) For the direct activation, the two common merit order lists remain with all the available and not yet activated direct activatable bids submitted by each participating TSO.
9) The remaining common merit order lists shall be used in the direct activation, continuously updated and sorted based on the following criteria:
   a) the upward common merit order list shall contain all the available direct activatable bids in upward direction submitted by the participating TSOs and sorted in ascending order of price.
   b) the downward common merit order list shall contain all the available direct activatable bids in downward direction submitted by the participating TSOs and sorted in descending order of price.
10) All available standard mFRR balancing energy product bids submitted to the mFRR-Platform by the participating TSOs shall be used in the common merit order lists for the activation.

2.2.3.3.5. Discussion topics / Future developments

The mFRRIF (and aFRRIF) was submitted to the national regulators as of December 2018, the following steps and timelines are defined in such a document to be used as the guide for the implementation of the mFRR platform (Article 5.4 in (ENTSO-E, 2018b)):

a) All member TSOs shall designate the entity responsible for operating the functions of the mFRR Platform within six months after the approval of the mFRRIF.
b) All member TSOs shall develop new processes and amend existing ones related to mFRR exchange, activation purposes, pricing and settlement in accordance with the mFRRIF at the latest for the deadline of the mFRR platform implementation and operation (December 2021).
c) All member TSOs shall agree on an mFRR platform accession roadmap within 3 months after the approval of the mFRRIF and review it at least annually. The accession roadmap shall foresee timelines related to:
   i. Implementation and adaption of T&C for BSPs by each member TSO.
   ii. The development of the functions.

iii. Interoperability tests between each TSO and the mFRR platform.
iv. Operational tests.
v. Connection of each TSO to the mFRR platform.
vi. Making the mFRR platform operational.
vii. Connection of all TSOs that have been granted a derogation by their respective regulatory authorities in accordance with Article 62 of the EBGL.

d) The accession roadmap shall start after its finalization by all member TSOs and end no later than the mFRR Platform is used by all TSOs.
e) TSOs shall consult stakeholders with any amendments to the mFRRIF after its approval.

2.2.3.4. Platform for aFRR – PICASSO

2.2.3.4.1. Description and objectives

The **P**latform for the **I**nternational **C**oordination of **A**utomated Frequency Restoration and **S**table **S**ystem **O**peration (PICASSO (ENTSO-E, n.d.-e)) originated as a regional project initiated by eight TSOs from five countries (Austrian TSO APG, the Belgian TSO Elia, the Dutch TSO Tennet, the French TSO RTE, and the German TSOs). The establishment of the automatic frequency restoration reserves (aFRR) Platform is organized via the implementation project PICASSO, where technical details, common governance principles, and business processes are developed by the TSOs involved.

The main targets of the project are:

- Design, implement and operate an aFRR Platform compliant with the approved versions of the EBGL, SOGL and CACM, as well as other regulations.
- Enhancing economic and technical efficiency within the limits of system security.
- Integrating the European aFRR markets while respecting the TSO-TSO model.

2.2.3.4.2. Participating countries

The Austrian TSO APG, the Belgian TSO Elia, the Dutch TSO Tennet, the French TSO RTE and the German TSOs – 50Hertz, Amprion, Tennet, TransnetBW – agreed to initiate a project on the design, implementation, and operation of a Platform for aFRR.

Since inception, the project has grown to include as members the following TSOs: the Czech TSO ČEPS, the Danish TSO Energinet, the Finish TSO Fingrid, the Hungarian TSO MAVIR, the Norwegian TSO Statnett, the Slovenian TSO ELES, the Spanish TSO Red Eléctrica de España and the Swedish TSO Svenska kraftnät.

There are currently 10 observers to the project: the Bulgarian TSO ESO, the Croatian TSO HOPS, the Greek TSO IPTO (aka ADMIE), the Italian TSO Terna, the Polish TSO PSE, the Portuguese TSO REN, the Romanian TSO Transelectrica, the Slovak TSO SEPS, the Swiss TSO Swissgrid and ENTSO-E (updated on 25 April 2018).

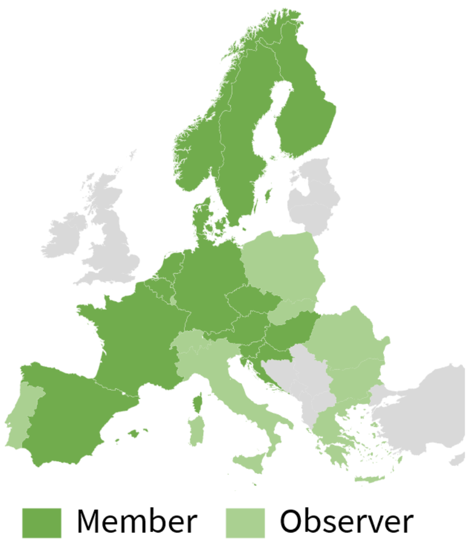


Figure 15. TSOs that are currently PICASSO members or observers (ENTSO-E, n.d.-e).

2.2.3.4.3. Implementation schedule

The timeline for the implementation of the PICASSO project is defined in Article 5 of the implementation framework of the frequency restoration reserves with automatic activation (aFRRIF) (ENTSO-E, 2018a) according to Articles 21.4, 21.5 and 21.6 of the EBGL.

Article 5.1 of the aFRRIF indicates that the aFRR-Platform shall fulfill every requirement defined in the aFRRIF and further requirements according to Articles 30 and 50 of the EBGL. In order to achieve this target, six months after the approval of the aFRRIF the entity or entities that will operate the platform shall be designated (Article 5.4.a of the aFRRIF).

In case approval of the aFRRIF is given without a request for amendments by the NRAs and without escalation to ACER, this approval is due 6 months after the delivery of the aFRRIF to ACER. The whole timeline then runs until December 2021, by which time the current project planning aims to have the aFRR-Platform operational and all member TSOs using the platform (ENTSO-E, 2018c).

The complete timeline, with tentative dates, is briefly presented in Figure 4. It also describes the steps required to achieve the timeline, as well as the interaction between the aFRR Platform and the IGCC, which is described in Section 2.2.3.1.

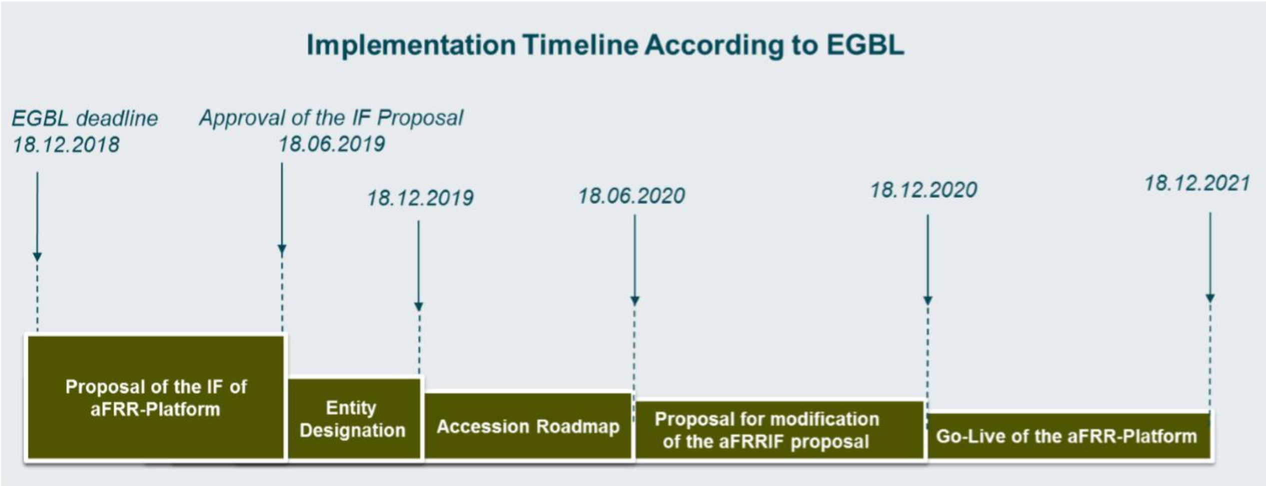


Figure 16. High-level implementation of the aFRR-Platform according to EBGL (ENTSO-E, 2018).

2.2.3.4.4. Main agreements reached

On December 18, 2018 a common proposal developed by all TSOs regarding the development of an IF for a European platform for the exchange of balancing energy from aFRR (aFRR Platform) was released. Such proposal is based on the requirements of Article 21.1 of the EBGL.

The EBGL sets up certain requirements for standard products in Articles 25.4 and Article 25.5. Article 25.4 sets out the technical parameters (optional), whereas Article 25.5 lays down the obligatory parameters for standard products.

For a common aFRR market a certain degree of harmonization is necessary. However, experience from other markets, e.g. the energy spot-market, shows that a full harmonization of the regulatory and legal framework is hard to achieve, and not strictly necessary to form a common market and provide an acceptable level playing field. Based on these considerations PICASSO TSOs analyzed the differences in the existing aFRR markets and propose a suitable target model for a common aFRR market. As is detailed in Article 7 of the aFRRIF (ENTSO-E, 2018a), the following characteristics of the standard aFRR balancing energy product bid have been defined [20]:

1) Each standard aFRR balancing energy product bid shall fulfill the following static characteristics:
   a) Each TSO shall define the full activation time (FAT) for the period until 17th December 2025 in their T&C for BSPs. The full activation time shall be 5 minutes starting from 18th December 2025.
   b) Deactivation period: not be longer than the FAT.
   c) Minimum quantity and granularity: 1 MW.
   d) Maximum quantity: 9,999 MW.
   e) Validity period: 15 minutes. The first validity period of each day shall begin right after 00:00 CET. The validity periods shall be consecutive and not overlapping.
   f) Activation type: automatic.
   g) Price resolution: 0.01 €/MWh.
2) The variable characteristics to be determined by the BSPs shall be at least:
   a) The volume of the bid.
   b) The direction of the bid: upward or downward balancing energy.
   c) The price of the bid (in €/MWh): shall be defined in accordance with Table 11 (positive, zero or negative).
   d) The Load Frequency Control (LFC) area to which the aFRR providing units and/or aFRR providing groups shall deliver the aFRR standard balancing energy.

Table 11. Sign conventions for aFRR bid prices.

Direction of the bid	Balancing energy price positive	Balancing energy price negative
Upward	Payment from TSO to BSP	Payment from BSP to TSO
Downward	Payment from BSP to TSP	Payment from TSO to BSP

3) In case of a central dispatching model, the variable characteristics may be determined by the connecting TSO based on integrated scheduling process bids submitted by BSPs following the rules for converting bids in a central dispatching model into standard aFRR balancing energy product bids pursuant to Article 27 of the EBGL.
4) Each standard aFRR balancing energy product bid:
   a) Shall be divisible which means that the activation request can be lower than the volume of the bid defined in Article 7.2.a of the aFRRIF;
   b) Can be activated and deactivated at any moment within the validity period. No minimum delivery time shall be permitted.
5) Each BSP shall submit additional information in accordance with terms and conditions for BSPs of the connecting TSO. The connecting TSO may include the possibility to link the bids to the state of activation of reserves from another balancing process in accordance with their terms and conditions for BSPs.

Regarding the balancing energy gate opening and closure times for the submission of a standard aFRR balancing energy product bid to the connecting TSO by BSPs Article 8 of the aFRRIF establishes that:

1) The balancing energy gate opening time shall be no later than 12:00 CET for all validity periods of the next day.

[20] PICASSO TSOs consider the preparation period, the ramping period and the deactivation period as not applicable to the aFRR process.

2) The balancing energy gate closure time for the submission of a standard aFRR balancing energy product bid to the connecting TSO by BSPs shall be 25 minutes before the beginning of the validity period of the respective standard aFRR balancing energy product bid. The same balancing energy gate closure time applies for specific product bids converted into standard aFRR balancing energy product bids.
3) For TSOs applying a central dispatching model, the balancing energy gate closure time for integrated scheduling process bids shall be defined pursuant to Articles 24.5 and 24.6 of the EBGL.

Additionally, TSO energy bid submission gate closure time for the submission of the available standard aFRR balancing energy product bids to the activation optimization function of the aFRR Platform by the connecting TSO is defined in Article 9 of the aFRRIF:

1) The TSO energy bid submission gate closure shall be 10 minutes before the beginning of the validity period of the respective standard aFRR balancing energy product bid.
2) The connecting TSO shall have the possibility at all times after the balancing energy gate closure time for the submission of a standard aFRR balancing energy product bid (including within the validity period of the bid) to modify the bid in accordance with Article 29.9 of the EBGL or to change the availability status of the bid in accordance with Article 29.14 of the EBGL.

Finally, the Article 10 of the aFRRIF details the common merit order lists to be organized by the activation optimization function:

1) Each BSP shall submit the standard aFRR balancing energy product bids to the connecting TSO.
2) Each BSP connected to a TSO applying a central dispatching model shall submit integrated scheduling process bids to the connecting TSO.
3) The connecting TSO shall submit the standard aFRR balancing energy product bids to the aFRR Platform in order to be included in the common merit order lists.
4) TSOs applying a central dispatching model will convert integrated scheduling bids received from the BSPs into standard aFRR balancing energy product bids and then submit these bids to the aFRR Platform to be included in the common merit order lists.
5) The aFRR Platform shall create two common merit order lists (one for bids in upward direction and one for bids in downward direction) for each validity period that shall contain all the available standard aFRR balancing energy bids submitted by the participating TSOs.
6) The upward common merit order list shall contain all the available standard aFRR balancing energy product bids in upward direction submitted by the participating TSOs and sorted in ascending order of price.
7) The downward common merit order list shall contain all the available standard aFRR balancing energy product bids in downward direction submitted by the participating TSOs and sorted in descending order of price.
8) All available standard aFRR balancing energy product bids submitted to the aFRR Platform by the participating TSOs shall be used in the common merit order lists for the activation.
9) The activation optimisation function shall contain the continuously updated common merit order lists that shall include all available standard aFRR balancing energy product bids.

2.2.3.4.5. Discussion topics / future developments

The following steps and timeline shall be used as the roadmap for the implementation of the aFRR Platform (Article 5.4 of the aFRRIF) (ENTSO-E, 2018a):

a) All TSOs shall designate the entity responsible for operating the functions of the aFRR-Platform within six months after the approval of this aFRRIF.
b) All member TSOs shall develop new processes and adapt existing ones related to aFRR activation, pricing and settlement in accordance with this aFRRIF at the latest December 2021.

c) All member TSOs shall agree on an aFRR Platform accession roadmap within 3 months after the approval of this aFRRIF and review it at least annually. The accession roadmap shall foresee timelines related to:
   i) Implementation and adaption of terms and conditions for BSPs by each member TSO.
   ii) The development of the functions.
   iii) Interoperability tests between each TSO and the aFRR-Platform.
   iv) Operational tests.
   v) Connection of each TSO to the aFRR-Platform.
   vi) Making the aFRR-Platform operational.
   vii) Connection of all TSOs that have been granted a derogation by their respective regulatory authorities in accordance with Article 62 of the EBGL.
d) The accession roadmap shall start after its finalization by all member TSOs and end not later than the aFRR-Platform is used by all TSOs using aFRR.
e) TSOs shall consult stakeholders with any amendments to this aFRRIF after its approval.

2.2.3.5. Frequency Containment Reserves (FCR)

2.2.3.5.1. Description and objectives

The EBGL (European Commission, 2017a), does not foresee the creation of a European Platform or a Regional Initiative for FCR. Anyway, on a voluntary basis TSOs may develop initiatives in order to establish a common market for procurement and exchange of frequency containment reserves (FCR) (ENTSO-E, n.d.-b) taking into account the objectives of effective competition, non-discrimination, transparency, new entrants and increase liquidity while preventing undue distortions.

These objectives must be met in consideration of secure grid operation and security of supply.

2.2.3.5.2. Participating countries

This regional project currently involves 10 TSOs from 7 countries. These are the TSOs from Austria (APG), Belgium (Elia), Switzerland (Swissgrid), Germany (50Hertz, Amprion, TenneT DE, TransnetBW), Denmark[21] (Energinet), France (RTE) and the Netherlands (TenneT NL).

[21] Only the Western Denmark control area is included in the project

Figure 17. TSO currently participating in the FCR cooperation (ENTSO-E, n.d.-b).

2.2.3.5.3. Implementation schedule

The TSOs involved in the common market for FCR Procurement developed a draft proposal, which was amended, following the requests by some NRAs. The initial schedule is presented in Figure 18. However, the amendments delayed the first implementation from 26 November 2018 to 1 July 2019.

Figure 18. Public consultation and approval process (ENTSO-E, 2018)

2.2.3.5.4. Main agreements reached

The main agreements regarding the evolution of FCR cooperation market design are the following (ENTSO-E, 2018f):

- The auction frequency will be changed from weekly auctions to D-1 daily auctions. As an intermediate step, D-2 daily auctions on working days only (Article 4) will be introduced.
- The product duration will be changed from weekly to 4h-products. As an intermediate step, daily products (Article 5) will be introduced.
- The product will be symmetric (Article 5).

- Indivisible bids will be allowed after 1 July 2019 and the maximum bid size of an indivisible bid will be limited to 25 MW (Article 6). There will be no paradoxically[22] rejected divisible bids as of 1 July 2019 (Article 7).
- The current minimum bid size of 1 MW will be maintained (Article 6).
- Exclusive bids will not be allowed (Article 6).
- TSO-BSP settlement will use marginal pricing as of 1 July 2019 (Article 8).
- The TSO-TSO settlement will be used and it will be compliant with TSO-BSP settlement as of 1 July 2019 (Article 11).

Most of the changes proposed consider various date-dependant steps:

1) Until (and included) 30 June 2019.
2) As of 1 July 2019.
3) As of 1 July 2020.

As an example, Article 5 (ENTSO-E, 2018f) details the product:

1) Until (and including) 30 June 2019: the product duration is one week. The product is symmetric.
2) The product duration will then be changed in two distinct steps.
   a) As of 1 July 2019 (delivery day), a product duration of one day (24h) will be implemented.
   b) As of 1 July 2020 (delivery day), the product duration will be 4h, with 6 independent products in a day (0-4h, 4-8h, 8-12h, 12-16h, 16-20h, 20-24h).

2.2.3.5.5. Discussion topics / future developments

In accordance with Article 5.5 of EBGL, the proposed common and harmonized rules and processes will be implemented in three independent consistent steps as follows (Article 11.1 (ENTSO-E, 2018f)):

1. As of 1 July 2019 (delivery day): The introduction of daily auctions on working days only with D-2 gate closure time (GCT) and daily products;
2. As of 1 July 2019 (delivery day): Introducing indivisible bids in all countries of the FCR Procurement process, removing exclusive bids in Switzerland, changing the TSO-BSP settlement to Marginal Pricing and making the TSO-TSO settlement compliant with the TSO-BSP settlement.
3. As of 1 July 2020 (delivery day): Implementing daily auctions all days with D-1 GCT and 4h products.

All entry-into-force dates are based on the provision of approval of the FCR Proposal by 18 December 2018 at the latest. In the case of later approval, all entry into force dates will be postponed with the same delay time (Article 11.2).

The implementation period includes the time needed to adapt national contracts and rules, in cooperation with NRAs, where applicable. All NRAs will be asked to commit explicitly to the extended implementation timeline pursuant to Article 5.5 of EBGL.

[22] Paradoxically rejected bids means the bids that are rejected although the bid price was lower than the marginal price.

All the European Balancing Platforms previously described provide some guidelines for the product characteristics that will the addressed in detailed in CoordiNet D1.3. Furthermore, the development of these platforms shows the complexity of the harmonization of products and the long-term implementation process that have to be considered for the EU-wide implementation. CoordiNet intends to provide some initial insights on the development additional products for both TSOs and DSOs, which can be potentially considered for the implementation EU-wide level.

3. Assessment of current regulation and market design in the three focus countries

In this section, we present an overview of the regulation and market design in the several EU Member States. As described in section 1.3, the assessment of the regulation in the different countries is made through questionnaires distributed among national stakeholders, including DSOs, TSOs, research institutes, etc. Two types of questionnaires were distributed among partners and stakeholder, as described in section 1.3.

The following subsections present an assessment of the current regulations regarding TSO-DSO cooperation in the three demo countries and eight additional EU Member States. For each topic, firstly Greece, Sweden, and Spain are discussed in detail, followed by an overview of Austria, Belgium, Cyprus, Czechia, Germany, Italy, Netherlands, and Poland.

3.1. Overview of the Market Design

The way markets are organized in different countries may provide more or fewer opportunities for DER to participate. Here we refer to existing markets where DER (can) participate, especially the wholesale markets such as the day-ahead market and the intraday market, as well as the AS markets organized by the TSOs.

3.1.1. Greece

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

There is no separate balancing market. Instead, the Greek TSO IPTO (ADMIE)[23] clears the imbalance of the DAS through a special imbalance settlement mechanism in which deviations from the DAS are charged or compensated for, based on the imbalance price. In Greece, the TSO is also responsible for the dispatch schedule, for real-time dispatch instructions, and for the settlement of all other charges or payments in the system.

Being a centrally dispatched system, the Greek electricity market does not have attributes such as complex bids, as the dispatching algorithm considers the specificities of the generating units. EnEx computes the system marginal price and it is based on declared marginal cost values submitted by generators. The ex-post clearance price corresponds to the uniform market clearing price. An administratively defined maximum value of offers (price cap) applies in the wholesale market. The cap was equal to 150 €/MWh until 15 July 2016 and then it was increased to 300 €/MWh with RAE's Decision 208/2016. There is an additional cap for the primary and secondary reserves' offers, which are the ancillary services that are currently remunerated in Greece. This cap was equal to 10 €/MW and was recently increased to 50 €/MW with RAE's Decision 405/2018, starting from October 1st, 2018. The mandatory pool is offering only limited degrees of

[23] IPTO stands for Independent Power Transmission Operator, while ADMIE is the equivalent acronym in Greek.

freedom to market participants. It does not allow bilateral contracts, for instance, and limits long-term hedging to over-the-counter financial products.

It should be mentioned, however, that Greece is in the process of reforming its Electricity Market by designing four new markets, namely, an Energy Financial Market, a Day-ahead Market, an Intra-day Market and a Balancing Market, under the provisions of the Target Model and towards the establishment of the European Internal Electricity Market. The Day-ahead and the Intra-day Markets will be operated by HEnEx whereas the Balancing Market will be operated by ADMIE. These markets will be monitored by RAE. The Energy Financial Market will be operated by HEnEx, whereas it will be monitored by the Hellenic Capital Market Commission. The go-live and internal operations of the new energy markets are expected to happen in the first quarter of 2010, whereas the coupling with Italy and Bulgaria in the Greece-Italy (GRIT) and South-east Europe (SEE) regions, respectively, will follow.

3.1.2. Spain

In Spain, most of the energy and balancing services are contracted one day before delivery, 80% of the electricity supplied in Spain and Portugal is traded through OMIE, the market operator. The share of bilateral contracts in the Spanish electricity market, for instance, is significantly less than in the UK or in Belgium (OMIE, 2017).

The Spanish day-ahead market opens at 10 a.m. on the day before delivery (although bids can be sent upfront) and closes two hours later at 12 p.m. as shown in Figure 19. In the day-ahead market, the demand side is not allowed to submit complex bids, meaning that only price-quantity bids are allowed. After the schedule is published, market agents have the possibility to change their schedules in the MIBEL Hybrid Intraday Market (European continuous trading complemented with six Iberian implicit auctions). Each Iberian implicit intraday auction interrupt the European continuous trading during ten minutes and generally are open for 45 minutes (except the first session which is open for 105 minutes) and close a couple of hours before the delivery hour. The Iberian market (MIBEL) joined the European Continuous Intraday Market (XBID) in June 2018. XBID gives the opportunity to market parties continuously update energy schedules in an integrated European market up to 60 minutes before real time.

As OMIE does not take into account any technical constraints, the Spanish TSO, Red Eléctrica de España, runs a congestion management market to solve the possible technical problems coming from the Day Ahead market. In this technical congestion management market, which is only open for generators, participants are remunerated following the pay-as-bid system. Moreover, the TSO might find it appropriate to contract additional reserves and run therefore the Additional Upward Reserve (AUR) market if reserves are expected to be low. This market opens at 4 p.m. of the day before when low reserve margins are detected and closes 20 minutes later.

Subsequently the secondary (4 – 5.30 p.m.) and tertiary reserves (up until 20 min before real time) are contracted. As all the prequalified generators with available tertiary reserve are obliged to provide their capacity[24] in this last market, there is only energy contracted in this market. For secondary reserve, capacity (band) and the energy is remunerated. For tertiary reserves, only the energy activated is remunerated.

[24] Only the available online capacity is considered.

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

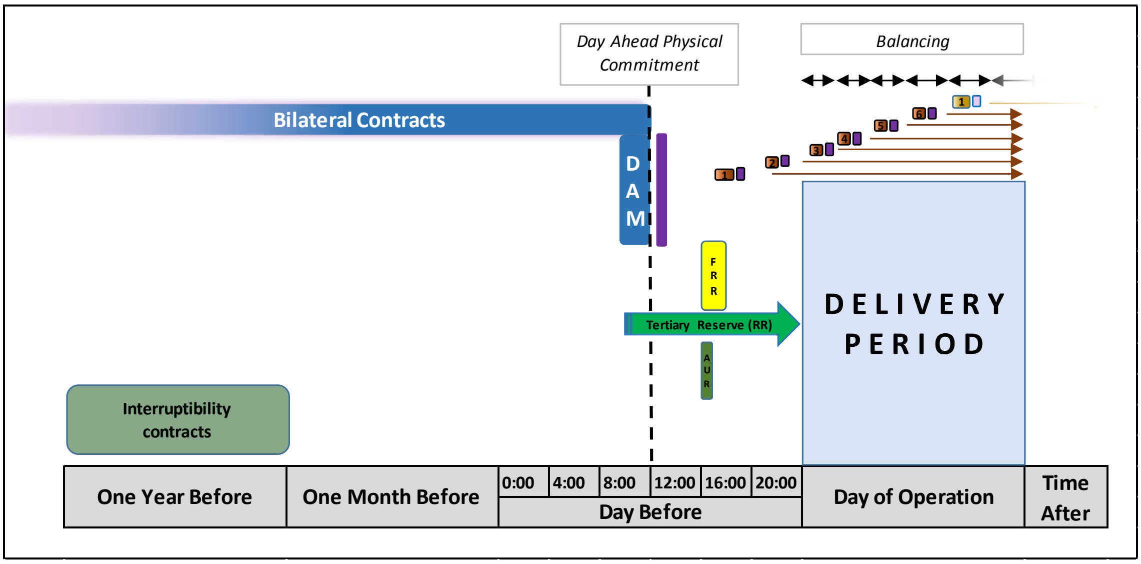


Figure 19: Spanish Electricity Markets

3.1.3. Sweden

Sweden is part of Nord Pool, the common power exchange for Denmark, Sweden, Norway, Finland, Estonia, Latvia, Lithuania, and the UK. Similarly to other European countries, the gate closure of the spot market (Elspot), and therefore for the Swedish market, is at 12 p.m, as shown in Figure 20. Four types of products can be traded in the day-ahead market: single hourly orders, block orders, exclusive groups and flexi orders (Nord Pool, 2017).

The intraday market is a continuous market, and it closes 60 minutes before delivery. A new mechanism is being proposed in which three additional auctions will be organized (at 3 p.m. and 10 p.m. the day before delivery, and at 10 a.m. on the day of delivery) in which energy will be traded.

As of today, around 90% of the Swedish yearly production is sold in the wholesale market – Nord Pool. The minimum volume for all the products in Sweden is 0.1 MW, while prices asked/bid can vary between €0/MWh and €5000/MWh.

Primary reserves are contracted in two steps. A first tender is held a couple of days before the delivery period (D-2) and ends at 3 p.m. the day before Elspot closes. After the gate closure of Elspot, a second tender for primary reserve is open. Secondary reserves are contracted one week ahead, which means that they are contracted before the primary reserves. Together with Elbas, the intraday market, a market for regulating power is run. This regulating power has the function of tertiary reserve and can be contracted until 45 minutes before real-time. It is also worth mentioning that the balancing market is jointly operated by the four Nordic countries, namely Denmark, Sweden, Norway, and Finland.

Sweden has an additional temporary peak load reserve that is designed for situations with a shortage of electricity due to extreme weather conditions (Svenska Kraftnät, 2017). Eventually, these reserves may also be used for other purposes during certain circumstances. The Swedish peak load reserve has been used for congestion management and countertrade.

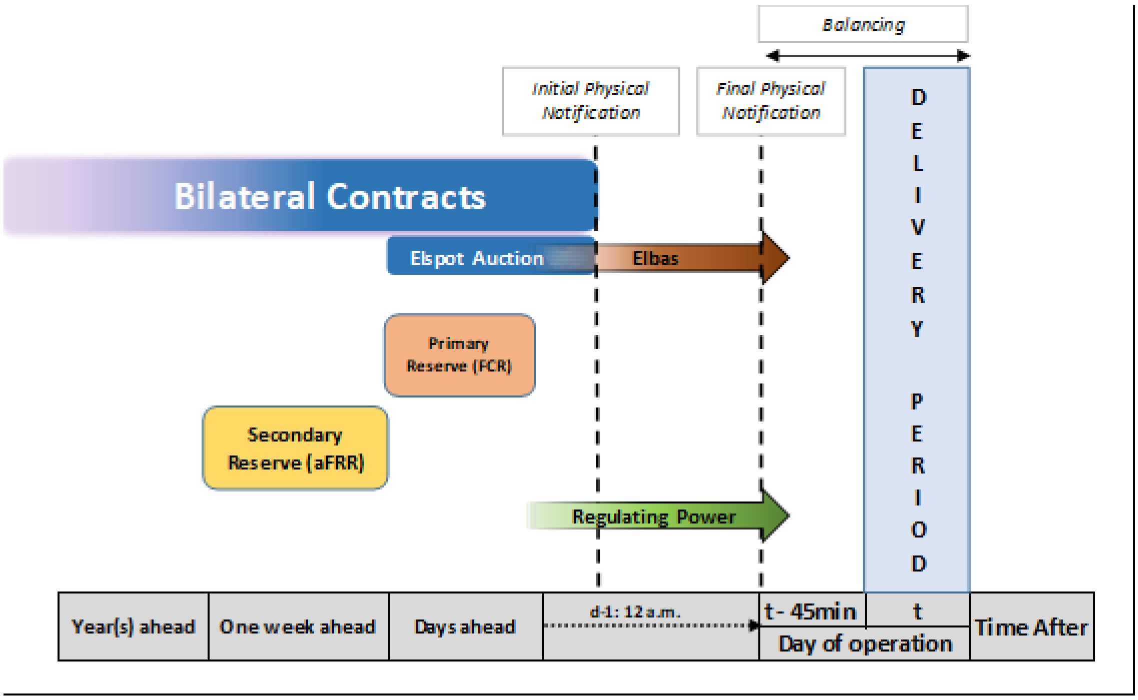


Figure 20: Swedish Electricity Markets

3.2. DER Flexibility Integration in Ancillary Services

As discussed in section 2.1, the coordination between TSO and DSO will be needed at several stages of power systems planning and operation. During the operational phase, the clearest case in which coordination will be required is when both the TSO and DSO are due to procure the same resources connected at the distribution network. When TSOs procure resources at the transmission grid, little interaction is needed, as DSOs are not affected. However, when both TSO and DSO procure flexibility from DER, coordination is necessary. Both the procurement and activation processes should be coordinated somehow.

Therefore, in this section, we explore which are the current possibilities for DER to provide services to the grid operators in the different countries surveyed. Firstly, we assess the provision of flexibility services for the TSO, followed by the service provision for DSOs.

3.2.1. DER provision of Ancillary Services for TSOs

3.2.1.1. Greece

In Greece, as of today, there is no regulatory framework which allows the participation of DER in ancillary services. Only conventional units participate in the AS market. Although, ancillary services are foreseen to be provided also by DER in the near future. That is planned to be in operation until the end of 2019. According to the survey, DER will be able to participate in FCR, aFRR and mFRR provision.

In Greece, interruptible contracts[25] exist but do not include resources connected at the distribution grid, and the TSO can only activate these resources for security reasons. However according to the Target Model, in the near future expected Real-Time Balancing Market (RTBEM) there would be a clearing engine which will be responsible for DER's curtailments. Specifically, DER's curtailments in real-time shall be allowed not only for security reasons but also for economic reasons (upon a decision of the TSO, who shall issue the respective Dispatch Instruction). In such case, the curtailed DER's shall be remunerated with the downward Balancing Energy marginal price obtained in the RTBEM (or pay-as-bid in specific cases).

3.2.1.2. Spain

In Spain, DER can already provide some services to the TSO. Since 2016, DG is able to provide any type of voluntary balancing services as long as they passed the prequalification tests and the offered volume (after aggregation) exceeds 10 MW. In fact, in February 2019 more than 14 GW of wind power connected to both transmission and distribution grids have been prequalified to deliver mFRR and RR. Around 250 MW of wind power has also been prequalified to provide aFRR. FCR provision is compulsory for all generation units including DG.

Other types of DER such as DR and small-scale storage (other than hydro-pump units) are not able to provide these services. However, an important adaptation is currently being discussed. A public consultation[26] is ongoing to define a work plan for the participation of demand and storage in balancing markets. This adaptation is due to the necessity to implement the Network Codes, more specifically the EBGL, which contemplates the provision of balancing services by generation, demand, and storage through the T&Cs related to Balancing. However, although DER can provide balancing services to the TSO in Spain, balancing markets have minimum bid size that can limit the participation of DER. Agents that want to become a Balance Service Provider (BSP), must pass a prequalification process and have a minimum capability of 10 MW. The prequalification process is done at the physical unit level or for several physical units together not exceeding 1000 MW in total. At the time of bidding, the minimum bid size is 0.1 MW for all balancing services currently. The only exception is in the market for aFRR capacity, for which there is also a minimum bid size of 0.1 MW, but there is a minimum matched bid size of 1 MW. That is, for a bid, in order to be matched, a provider needs to have at least bids for 1 MW sent at a price equal or lower than the marginal price for that hour. In order to adapt to EBGL, the balancing products offered in the future to the balancing platforms will have a minimum bid size of 1 MW. Demand and storage (which are not BSP as of today), will be able to become BSPs when the T&Cs related to Balancing are approved in Spain.

Another type of service that some DER can provide to the TSO is the Interruptible service. This service is more consolidated. According to the TSO, "interruptibility service is a demand management tool to provide a rapid and efficient response to the electric system needs according to technical criteria (system security) and economic criteria (reducing system costs)" (REE, n.d.). This service is provided by large consumers and is allocated with a competitive mechanism (auctions). These consumers can be connected to the distribution network.

[25] Countries were also asked if there is any form of interruptible contract DER can sign with the TSO. By signing interruptible contracts, agents would be entering in a non-firm capacity contract with the TSO, allowing the system operator to reduce the connection capacity in order to alleviate grid congestion.
[26] https://www.esios.ree.es/es/pagina/propuestas-de-procedimientos-de-operacion

Aggregation is also permitted for DER to provide certain types of AS to the TSO, as it is the case for balancing services. Although this topic is covered in more detailed in the following sections, Table 12 provides a general view of the aggregation of resources for the provision of services to the TSO.

Table 12: DER and AS to the TSO provision in Spain

Type of DER / Service	Balancing Services (RR/mFRR/aFRR)	Interruptible Service
Small DER (LV and MV)	BSP must have at least 10MW of capacity. Aggregation is therefore necessary.	Minimum size 5 MW. Aggregation not allowed.
Large DER (HV)	Large DER (producers) can participate aggregated or not	Large customers (minimum bid size 5 MW). Two types of products: 5MW and 40MW Aggregation not allowed

Voltage control, in Spain, is a mandatory, but a non-remunerated service. Certain DER, depending on the size, have to provide voltage control as well. Table 13 summarizes the services which DER can provide.

Table 13: Characteristics of AS products in Spain

	Can DER participate?	If yes, do they receive payment for reservation [€/MW]	If yes, do they receive payment for activation [€/MWh]
FCR	X	A mandatory service provided by generators. Not remunerated	
aFRR	X	X	X
mFRR	X		X
RR	X	X	X
Voltage Control	X	A mandatory service provided by generators. Not remunerated	
Congestion Management	X		X
Interruptible service	X	X	X

In order to provide services for to the TSO, DERs have to pass a prequalification process. This process is the responsibility of the TSO. Nevertheless, the TSO checks with the affected DSO if the prequalified unit may impose problems on the distribution network. According to the SOGL (Art 182(4) and 182(5)), if during the prequalification process of a unit connected to the distribution grid or during real-time activation of the service, a DSO identifies the need for limitation due to the security in their network, the DSO would indicate this limitation to the TSO. The TSO will take the DSO limits into account during prequalification and real-time activation. Up to now, the TSO has not received any request for limiting or banning the participation of DER in balancing mechanisms due to distribution constraints.

Lastly, it is worth mentioning that the Spanish TSO can curtail units connected at the distribution network for security reasons. However, this can only be used in extreme conditions, if market-based redispatching is insufficient to solve the constraint detected but giving priority to non-dispatchable renewable generation cogeneration and waste-to-energy, curtailing these types of generation the latest. Such a situation has not happened so far since 2016 when renewable resources participate in the congestion management market.

Congestion management in the transmission and distribution network and balancing are performed using market-based mechanisms, using the bids provided by the BSPs for both the mFRR and the congestion management markets. For example, the 14 GW of wind power that participate in the mFRR market are obliged to send downward bids. If an excess generation situation appears in real time, it is currently solved in the mFRR market by assigning those downward bids which are normally placed at a very low price, close to 0 €/MWh or even at 0 €/MWh. In the case that two BSPs bid at the same price, the bid coming from a non-manageable renewable generation unit will be redispatched the latest.

The TSO uses a similar procedure for congestion management, both in the transmission and distribution grid. In order to integrate the maximum amount of generation from renewable energy sources into the electricity system, whilst ensuring quality levels and security of supply, in 2006 Red Eléctrica de España (REE) designed and started the operation of the Control Centre of Renewable Energies (Cecre). Cecre is a pioneering centre, of world reference regarding the monitoring and control of renewable energies and integrated in the Electricity Control Centre (Cecoel). The Cecre monitors production from renewable generation facilities, or groups of facilities, with a power capacity greater than 1 MW and can deliver setpoints or limits to groups or units with a power capacity greater than 5 MW connected either to the transmission or the distribution network. The TSO can perform real-time redispatch or curtailment of renewable by issuing setpoints or limits, if needed, through control centres for security reasons via the Cecre.

3.2.1.3. Sweden

In Sweden, DER can provide Ancillary Services to the TSO. Svenska Kraftnät, the Swedish TSO, aims to be technology neutral where the same requirements apply for any provider. However, it is not possible to provide aFRR from consumers (DR) today. For mFRR, there are no limitations for DR. FCR will be open to consumers (DR) in Q2 2019 according to current planning. When the FCR market is open for consumers (DR), initially there will be a limit on the total volume provided by DR centrally controlled and/or stepwise controlled. The limit is initially 20 MW for FCR-Normal and 40 MW for FCR-Disturbance[27].

Bids for congestion management are ordered from the same marketplace as mFRR, the Nordic Regulating Power Market (RPM). If disturbances such as electricity production outages or transmission grid faults occur, and the bids on the regulating power market are not able to solve the disturbance, the "disturbance reserve" ("Störningsreserv") is used. The disturbance reserve shall be able to activate within 15 minutes and is today mainly provided by gas turbines. If there are no commercial bids available, the disturbance reserve is used to manage congestions between and inside price areas.

Table 14 presents the requirements and size of each ancillary service in Sweden. Voltage Control is not a remunerated service in Sweden.

[27] In Sweden, balancing products are defined slightly differently as the ones defined in the SOGL. FCR is divided into two types: FCR-D and FCR-N. aFRR and mFRR are equivalent to the ones in the SOGl, while RR is not used in Sweden, neither will be implemented in the near future.

Table 14: Requirements and Size for Ancillary Service in Sweden

	Minimum Size	Technical Requirements	Monitoring and control capabilities	Other relevant requirements
FCR-Normal	0.1 MW	63% within 60s, 100% within 3 min	Real-time measurements	Confirmed prequalification, electronic communication
FCR-Disturbance	0.1 MW	50% within 5s, 100% within 30 s		
aFRR	5 MW	100 % within 120s		
mFRR (Congestion Management)	10 MW, (5 MW in SE4)	15 min activation time		
RR	N.A.			
Voltage Control	Not a remunerated service in Sweden.			

Table 15 details the characteristics of each balancing product and how the price is formed for each one of them.

Table 15: Characteristics of Balancing Products in Sweden

Product	Capacity based/energy based	Direction (up/down)	Activation	Monitoring	Pricing
FCR-N	Both	Up and down jointly	Automatic based on frequency	Real-time	Pay as bid for capacity and upward/downward regulating price for energy
FCR-D	Capacity	Up	Automatic based on frequency	Real-time	Pay as bid for capacity
aFRR	Both	Up and down separately	Pro-rata	Real-time	Pay as bid for capacity and upward/downward regulating price for energy
mFRR	Energy	Up and down separately	Merit order	Real-time	Upward/downward regulating price for energy (marginal pricing)

In case of disturbances or planned outages, the TSO has the right to curtail the transmission connected units. The TSO can also curtail DER in case of disturbances or planned outages.

3.2.1.4. Additional Survey Countries

Apart from the three demo countries, stakeholders in other seven countries also participated in the CoordiNet survey. Table 16 summarizes the possibilities for DER to participate in TSO services.

Table 16: Ancillary Services open for DER flexibility provision to the TSO

	Germany	*Austria*	*Poland*	*Czech R.*	*Cyprus*	*Italy*	*Netherlands*	*Belgium*
Frequency Control[28]	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Voltage Control	Yes	No	No	Yes	Yes	No	Yes	No
Congestion Management	Yes	No	No	No	Yes	No	Yes	No

According to the answers received, Poland is the only country in which no service can be provided by DER to the TSO. However, Poland expects this to change soon as the Network Codes are being implemented.

When asked which type of DER can provide services to the TSO, the rules in the different countries are diverse. In Germany, "all technologies may provide frequency control services. For a few big size industrial consumers in EHV grid or close to it, DR (reducing consumption) is possible, and DG can provide congestion management". The respondent also states that in Germany, storage can provide frequency control. The Italian respondent highlighted that all types of DER can participate in Italy, but it is mandatory for them to be aggregated (i.e. through a BSP), in the auctions associated with the experimental projects pursuant to Resolution 300/2017. In the Netherlands, interviewee mentions that the possibility for different types of DER may vary depending on the AS.

Table 17: Types of DER that can provide AS to the TSO

Consumers (DR)	Yes	No	No	Yes	No	Yes	Yes
Prosumers (DR + DG)	Yes	No	No	Yes	Yes	Yes	Yes
DG only	Yes	Yes	Yes	Yes	No	Yes	Yes
Storage facilities (including batteries)	Yes	Yes	No	Yes	Yes	Yes	Yes

[28] For harmonization purposes, the frequency control category treats the balancing services (reserves) jointly for the rest of the countries analyzed.

It is also relevant to highlight the role that the DSO may have in order to enable DER provision of services to the TSO. In Belgium, for instance, the DSO is the responsible to prequalify the possible FSP (excluded for FCR provision). Request for qualification is sent to the DSO by the FSP. This request contains info on the connection point in question, the type of flexibility (injection/offtake, increase/decrease of power, islanding mode), the modulating power, times or hourly schedule when flexibility is available, and information on possible rebound effects of flexibility activation. The network flexibility studies are carried out each 3 months (in March, June, September and December of each year). During each study, existing qualifications, new requests for qualifications are taken into account, together with network configuration changes, new network connections. A colour code per network zone is assigned because of the network study:

- Green: no risks for operational safety (when flexibility is activated). In this case, flexibility can be activated without any limitations.
- Red: possible risks for operational safety, measures should be taken. A zone becomes red for minimum 1 year. During this period, the DSO will impose limitations on the use of flexibility.

3.2.2. DER provision of Local Services for DSOs

3.2.2.1. Greece

In Greece, the regulatory basis for the DSO to procure DER flexibility for local grid management already exists, but it has not been implemented yet.

Demand Response

A regulatory basis for the activation of distributed Demand Response by the DSO has already been established under Article 28 of the Hellenic Electricity Distribution Network Code. This Article foresees the possibility for the Hellenic Electricity Distribution Network Operator (HEDNO/DEDDIE) to conclude "Demand Control Contracts" with individual electricity consumers in network areas that are considered as congested. The Demand Control Contracts shall allow HEDNO to set limits or even to interrupt, at its own initiative, the supply to the facilities of the contracted consumers, subsequent to their notification, in the periods specified in the contracts. This mechanism is similar to the "interruptible contracts" that some TSOs have with large consumers in some countries (e.g. Spain).

The details of this DR mechanism are supposed to be described in the Access Manual of the Hellenic Electricity Distribution Network Code which is currently under preparation. Thus "Demand Control Contracts" have not been implemented yet.

Distributed Generators

According to the Hellenic Electricity Distribution Network Code, the DSO has the right to request from distributed generators to contribute to voltage control by managing injected/absorbed reactive power by including these requirements in the Connection Agreement (Article 77 of the Hellenic Electricity Distribution Network Code). Also, active power of a distributed generator can be limited by the DSO as long as this is included in its connection agreement (Article 78 and Article 68 of the Hellenic Electricity Distribution Network Code). It should be noted though that the above provision of the network code has not yet been implemented in the Greek distribution network.

Therefore, according to Regulation, DER can already provide **local congestion management** and **voltage control**, although it is still not a practice for the DSO.

In order to provide services to the DSO in the future, DR will have to be equipped with smart meters capable of being remotely controlled. The DSO can define additional requirements to allow remote controlled or automated demand response. With regard to reactive and active power control of distributed generators, technical requirements are included in their Connection Agreement.

In the case of service provision to the DSO, DR will be remunerated according to bilateral contracts. According to the Hellenic Electricity Distribution Network Code, the DSO will be able to directly sign Demand Control Contracts with Consumers (bilateral contract). A standard contract will be included in the Access Manual of the Hellenic Electricity Distribution Network Code which is currently under preparation. With regards to DG, the DSO has the right to directly request the contribution of generators connected to the distribution network to voltage control by absorbing/injecting reactive power or by curtailing active power, according to their Connection Agreement. There is no compensation to the producers in that case.

Curtailment of DER by the DSO is also foreseen in the Hellenic Electricity Distribution Network Code. The DSO has the right to curtail DER under the following circumstances:

- When this is demanded by the TSO according to the System Operation Code
- Under emergency situations
- In case of faults or maintenance or in order to perform necessary operations on the network.
- If such an option is explicitly included in the Connection Agreement and/or Sales Agreement.

Curtailment is usually happening on non-interconnected islands. In this case, a rotating rolling curtailment of RES units is followed in a monthly or yearly basis, aiming at achieving equal treatment of all RES units. In any case, the TSO-DSO is obliged to absorb the maximum possible amount of RES energy. However, curtailment of DER is only possible for those connected through a remotely controlled switch.

3.2.2.2. Spain

In Spain, DSOs can use DER, more specifically DG, to solve congestions in the same way the TSO does. This process, however, is done through the TSO. Once congestions in the distribution grid are identified as well as the generation units that have an impact on the congestion, the needs for change in the dispatch are sent from the DSO to the TSO who accesses the bids and calculates the necessary redispatch to ensure solving the detected constraints[29]. In case DG is redispatched, it will be remunerated according to the market rules also applicable to larger generators connected at the transmission grid. In addition to congestion management, DSOs may also request a change to the TSO in the power factor range instructions sent to generation units with an installed capacity larger than 5 MW.

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

Therefore, as of today, the DSO could use DG for **local congestion management** and **voltage control** through the TSO. As these requests are sent by the DSO to the TSO, ultimately is the TSO that solves the constraints and instructs the DER.

Regarding the size of DER able to provide services (congestion management and voltage control) to the DSO, there are no limitations with respect to the voltage level that providers are connected. Participation is currently only allowed for generation units, which can aggregate with other units of the same technology connected anywhere in the system to form a BSP that shall have a minimum capability of 10 MW. Demand and storage other than hydro-pump units will be able to participate as well when the EB GL is effectively implemented.

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

For security reasons, renewables can be redispatched through the CECRE at the request of the DSO. Starting in February 2016, all redispatch due to congestion management in the DSO or TSO network is done via market mechanisms (PO 3.2). DG has to pay the downward bid price which is generally very close to 0 €/MWh so they get to keep almost 100% of the market marginal price that they have received for selling their production in that hour. Thus, renewable generation reductions can happen because of market outcome in the congestion management or balancing market. As a last resort, if still needed in real time, the TSO and DSO can curtail renewable generation for security reasons. However, since 2016 all congestion management situations have been solved through these market-based mechanisms.

3.2.2.3. Sweden

In Sweden, the DSO can procure flexibility from DER, but regulation is not specific, leaving freedom of action to the DSO. In dialogue with the Swedish regulator *Energimarknadsinspektionen* and in their report (Energimarknadsinspektionen, 2016), the regulator has highlighted the option for the DSO to use flexibility from DER by controlling distributed generation and demand response through bilateral contracts.

Some issues have been raised by DSOs whether contracts for production and consumption steering is coherent with today's legislation regarding interruptions. According to the regulator, the use of DER flexibility is not considered as a curtailment.

Another concern for Swedish DSOs on using the flexibility is regarding the economic incentives they may have. Today's revenue regulation incentivizes grid reinforcements more than the usage of "local services". Although the regulation for better usage of the grid is already in place, CAPEX revenue incentives are far more attractive.

Flexibility should be used when it is most cost-effective. However, according to the Swedish electricity act, it is treated as a cost, subject to efficiency targets. This year only the regulation specified that financial compensation for congestion management when the overlaying grid operator does not raise subscription for underlaying grid operator will be treated as a pass-through cost in the next regulatory period, starting in 2020 and ending in 2023.

Regarding the type of DER that can possibly provide services to the DSO, there is still no regulation providing such a definition. As of today, DR and DG are the types of DER having agreements with DSOs. One DSO in

Sweden is also using services from an aggregator. The regulation does not establish limits and technical requirements either. It is up to the DSO to define the requirements.

As of today, DSOs sign bilateral contracts between DSO and DER, that defines the possibilities for the DSO to increase power production of DG and to decrease load from big heating pumps, industries and datacentres with one-hour notice.

One important caveat in Sweden, and especially for the CoordiNet demo development, is that in one part of the country, the DSO is responsible for balancing. That is the case on the island of Gotland, where demo activities will be carried out. The 58 000 inhabitants island is a synchronous system connected to the mainland through HVDC links. The Swedish TSO has no connection to the island with 400 kV or 220 kV high-voltage grids. Therefore, the Vattenfall DSO is the owner of the HVDC links 150 kV and is acting as system operator responsible for keeping managing frequency in the island. Today no ancillary services are bought on the island, the balancing is managed by the HVDC-link and rotating wheels.

3.2.2.4. Other countries

Five out of the seven countries surveyed answered that DER can already provide some service to the DSO. Austria, Poland and Italy, on the contrary, do not have this possibility yet. In Poland, no regulation nor market exists so far. In addition, it is highlighted that there are technical limitations for Polish DSOs to procure services from DER (no communication to all DER and therefore limited possibilities to control them). In Italy, the reason is the lack of specific regulation. But, there is a strong expectation that this will change in the future in Italy, through the future regulation that will derive from the entry into force of the Clean Energy Package. Table 18 displays the answers for the different countries.

Table 18: DER provision of services to DSOs in seven EU countries

	Germany	*Austria*	*Poland*	*Czech R.*	*Cyprus*	*Italy*	*Netherlands*	*Belgium*
"As of today, can the DSO procure DER flexibility for local grid management purposes?"	Yes	No	No	Yes	Yes	No	Yes	No

When asked which type of service DER can provide services to the DSO, the predominant answers were local congestion management and voltage control. No respondent mentioned islanded operation or other types of services. Table 19 presents the answers.

Table 19: Services that can be provided by DER to DSOs

	Germany	Czech R.	Cyprus	Netherlands
Local congestion management	Yes	No	Yes	Yes
Voltage Control	Yes	Yes	Yes	No
Islanded Operation	No	No	No	No

When asked which types of DER can provide services, answers were diverse. In Germany, it was highlighted that DR in the LV level can be used for congestion management and that DER are entitled to a compensation of the opportunity cost for the provision of the service. Regarding Italy, although no procurement of DER flexibility by DSO is currently possible, it was mentioned, however, that presumably all types of DER will be allowed to participate – directly or through aggregators - under the condition of being compliant with the specific technical requirements, regarding supervision and protection interface systems, that will be defined by the technical bodies. Table 20 summarizes which types of DER can provide services to the DSO.

Table 20: Types of DER that can provide services to the DSO

	Germany	Czech R.	Cyprus	Netherlands
Consumers (DR)	Yes	No	No	Yes
Prosumers (DR + DG)	No	Yes	No	Yes
DG Only	Yes	No	Yes	Yes
Storage systems (including batteries)	Yes	No	No	Yes

3.3. Aggregation

Aggregation is also expected to play an important role in TSO-DSO coordination. Most probably the aggregator will participate in energy and service markets on behalf of small DER. In this case, some definitions and rules are needed to ensure the proper participation of aggregators, especially regarding their relationship with retailers and BRPs. As market participants, aggregators are expected to be a BRP or have a contract with a BRP.

3.3.1. DER aggregation rules

3.3.1.1. Greece

The regulatory basis for the establishment of RES aggregators already exists according to law 4414/2016. However, considering that the Greek market design is centralized, no aggregators are currently active. In the future, RES that will be developed with a Feed-In Premium (FiP) contract will be able to participate in energy markets via an aggregator. However, the wholesale market in Greece is operated as a mandatory pool and currently, the day-ahead market is the only one operating. Greece is committed towards the EU target model, which consist of four markets (day-ahead, intraday, forward and balancing markets). In the new electricity market model aggregated RES and DR will be able to participate in the balancing market and, possibly, in the Day-ahead and Intra-day markets.

In Greece, there are still no rules on how aggregators will interact with BRPs.

3.3.1.2. Spain

In Spain, there are still no independent aggregators. However, aggregation is allowed in the sense that representatives or retailers can aggregate resources in the different markets, but the concept of the independent aggregator, as defined by the European regulation (e.g. Clean Energy Package) is still not considered in the Spanish regulation. Recently an association was created to foster aggregation in Spain[30]. Generators can, however, be aggregated with a market representative and renewable sources can provide balancing services and participate in the market to solve network constraints since 2016, independently if they are connected to transmission or distribution networks.

The generation control centres have sufficient control, command and monitoring capacity to act as aggregators of information, which are authorized as interlocutors with the TSO to provide the CECRE with real-time information every 12 seconds about each facility. These control centres provide real-time telemetry regarding the connection status, the production of both active and reactive power, as well as the voltage at the connection point.

In Spain, there are still no definitions regarding the relationship between aggregators and BRPs.

3.3.1.3. Sweden

In Sweden, independent aggregators are not allowed to act consent from BRP delivering services to existing markets (e.g. a retailer). There is at least one local exception: an independent aggregator providing services

[30] https://elperiodicodelaenergia.com/nace-entra-la-primera-asociacion-para-la-agregacion-y-flexibilidad-en-el-mercado-electrico-en-espana/

for one DSO through a bilateral contract. As an exception for this pilot, issues surrounding balance responsibility and settlement are not addressed for this local initiative (Upplands Energi, n.d.).

According to the Swedish Electricity Act, there must be a BRP in every point of delivery (POD) with consumption or generation. The supplier/retailer has to be the BRP at the POD. Moreover, to be active in the balancing market, you need to be a BRP. If aggregators are not BRP themselves, they can cooperate with a BRP to provide flexibility.

3.3.1.4. Other Countries

Survey countries were firstly posed with the following open question: “Are there independent aggregators allowed in your country? Are they active? What type of services are they providing? What type of resources are they managing?” In most of the countries, aggregators are allowed (Table 21), but their participation is restricted to some services or not many details on the participation were provided.

Table 21: Aggregation in the survey countries

	Germany	*Austria*	*Poland*	*Czech R.*	*Cyprus*	*Italy*	*Netherlands*	*Belgium*
“Are there independent aggregators allowed in your country?	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes

In Germany, aggregation is allowed for all market-based processes such as procurement of energy to consumers, carrying out balance group responsibility, marketing of DG energy and providing aggregation of resources for frequency reserve. In Austria and Cyprus, aggregators are allowed for providing balancing services. In the Netherlands, aggregation mainly provides primary reserve power (emergency power) through CHP and frequency Control (FCR) with batteries. In Belgium, the TSO Elia specifically gives access to independent aggregators in order to create a framework for the participation of flexibility at all voltage levels. In this sense, Art. 19bis of the Belgian Electricity Law relative to the organization of the electricity market of 29 April 1999, was amended on 13th of July 2017 to allow independent aggregators. The following products can be delivered through an (independent) aggregator: R1/FCR, R3/aFCR.

Countries were also asked about the relationship between aggregators and BRPs. In general, aggregators need to have a contract with a BRP. When asked if the aggregator has to sign some kind of contract with the retailer’s BRP (in the case that the aggregator and the retailer of a certain DER are not the same company), answers diverged.

In Cyprus, for instance, a contract is necessary. It was reported that “there is always a contract, but not always with Transfer-of-Energy (ToE). If necessary, there is a bilateral agreement that states that there is a fee.” On the other hand, in the Netherlands, no contract is necessary. However, “the customer that delivers the flexibility may have to depend on his contract with its BRP (not the aggregator)”. In this case, the responsibility would lay on the DER to settle possible imbalance problems.

In Belgium, the aggregator needs to have a financial compensation arrangement with the supplier of the concerned delivery point regarding transferred energy between the aggregator and the supplier. In the absence of an agreement with regard to the financial compensation scheme, standard formulas apply for determining the standard transfer price of the transferred energy.

3.4. Current TSO-DSO interaction

The current level of TSO-DSO interaction in the three focus countries and in the additional surveyed countries are also explored. On one hand, we aimed at understanding the interaction for planning and operational procedures. On the other hand, the data exchange procedures between both operators were explored in more detail.

3.4.1. TSO-DSO planning and operation coordination

3.4.1.1. Greece

In Greece, **grid planning** is coordinated between the DSO and TSO. On one hand, the DSO receives all necessary data from the TSO in order to set up its 5-year Network Development Plan (NDP). On the other hand, the DSO sends information data to the TSO. These data include:

- Load and DG forecasting for the next 10 years on an annual basis.
- DSO needs for HV network reinforcements (existing HV substations, HV disconnectors etc).
- DSO provides the TSO with any data required for the design, the construction and the operation of new connection points (HV substations) to the transmission system in order to:
  - Face increased demand
  - Improve power quality
  - Facilitate new DG connections
- DSO identifies any weak points on its network, which are caused by the Transmission System inadequacies and proposes expansions of the Transmission System.

The TSO and the DSO also exchange information with regard to the progress of construction of projects of common interest. The TSO is also cooperating with the DSO with regard to the planning of new interconnections with the non-interconnected islands of Greece. In that case, common working groups are formed in order to study the new interconnections.

Regarding **grid operations**, the scope of the coordination is the secure, reliable and economic operation of the power system. Coordination between TSO and DSO is mainly focused on the following areas:

- Load Shedding, which is performed by the DSO after the request of the TSO, under critical System conditions. When the TSO issues an alert state, the DSO shall be well prepared to perform load shedding if requested.
- Information exchange and TSO –DSO cooperation in power system restoration procedures
- Active power output limitation of DGs, when requested by the TSO.
- Maintenance Scheduling. The DSO is notified with regard to the maintenance schedule of the TSO. The DSO takes into account the maintenance schedule of TSO in order to schedule distribution network maintenance. The DSO can also request modifications of the TSO’s maintenance schedule.
- Protection coordination and interlocking arrangements. The TSO may request complementary protection on the distribution network

- With regard to Under Frequency Load Shedding, there is coordination between the TSO and the DSO to set up the thresholds
- The DSO can also request the contribution of the TSO in case of maintenance and repair of high voltage distribution lines and HV/MV substations.
- When the DSO is about to perform switchings[31] that can lead to load reduction of more than 10 MW on a connection point of the distribution network to the transmission system, then the TSO must be informed.

It is also important to note that the TSO has priority over the DSO for load curtailments.

3.4.1.2. Spain

For future **planning of the grid**, meetings are organized where DSOs indicate to the TSO needs and preferences for grid planning in the distribution network based on connections that are foreseen in order to fulfil generation or demand expectations. These needs are evaluated in the preparation of the planning of the grid, which is submitted to the NRAs for approval. In addition, an update of the Regulation is ongoing (new proposal of Operational Procedure 13.2) in order to review the process for the coordination for the transmission and distribution grid planning.

Regarding **grid operation**, Spanish Operational Procedure 9.0 includes structural, scheduled and real-time data exchange between all involved parties (TSO, DSOs, Power Exchanges, market parties). Information is shared between TSO and DSOs on a regular basis for operational purposes. This information exchange includes (but is not limited to):

1) Communication of the Daily Operation Plan. In the case the DSO realizes a problem may occur in the distribution network due to the Daily Operation Plan, the DSO can request an adaptation to the TSO. (Frequency: daily)
2) Data of generating units (of more than 1MW). The TSO keeps a database of generating units of more than 1MW connected to the distribution network. The DSO can request this information. (Frequency: on demand)
3) Real-time data of generating units or aggregations with an installed capacity greater than 1 MW. This data is currently received by the TSO from the generation control centers and it is sent in real-time to the DSO to which the generator is connected.

As mentioned before, DGs above 5MW are monitored by the CECRE, which manages technical constraints of connected renewable sources. This aspect of coordination between TSOs and DSOs for grid operation is also being reviewed in the framework of the National implementation of the SOGL (currently in process).

3.4.1.3. Sweden

The main coordination actions for **grid planning** in Sweden are:

- Where TSO/DSO grid is connected (400 kV/130 kV) and when construction takes place jointly, mutual planning and coordination are done.

[31] Switchings are the change in the status of sectionalizing switches (opening or closing them) to reconfigure the network.

- When the DSO has a big power customer that wants to connect or wants to raise subscription a dialogue is initiated with the TSO.
- When the System development plan and Ten Year Network Development Plan are made, the TSO communicates the planned measures to the DSO. Yearly plans for capacity are published (Nord Pool).
- The “Planeringsråd” is a forum for close stakeholders.

Regarding **grid operation**, several interactions happen according to the time step. Table 22 summarizes them.

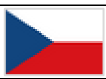
Table 22: DSO-TSO coordination for grid operation in Sweden

Time-Step	Coordination Measures
Long term	Outage planning coordination (OPC): yearly communication between respective operational planning unit (TSO/DSO). TSO dialogue with DSO representatives about consequences for different operational modes and outages.
Medium term	Exchange of switching schedules of common interest.
DA, ID near real-time	TSO in dialogue with relevant DSO about consequences for various operational modes and outages, overloads and disturbances. In the short-term, there is communication between grid control centers.

Generally, there is a mutual consideration between TSO and DSO for grid operation. However, according to the Swedish Electricity Act, the TSO has a stronger mandate (i.e. cancel outages).

3.4.1.4. Other Countries

Surveyed countries were asked: “is there any coordination between TSOs and DSOs for grid planning and operation? If yes, what is the scope of this coordination and how is it organized (e.g., a hierarchy of decisions)?”

	*TSOs and DSOs cooperate in planning their grids, where appropriate and necessary. Additionally, TSOs are obliged to carry out a public consultation, including DSOs, for national grid development plans on EHV level. DSOs must publish their grid development plans on HV level and show which alternatives they have taken into consideration.*
	*Yes, there is a two-year planning cycle for grid improvements with the TSO together with the DSOs. For grid operation, interaction focus on the measured values for the interchange substations.*
	*There is no coordination between DSO and TSO on grid planning. TSO only collect DSOs plans of network modernizations.*
	*Yes, TSO coordinates development plan with DSO.*

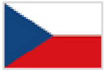
	*Yes. There is development consultation grid planning between TSO DSO on a systematic basis. Investment plans of the TSO are consulted and the DSO must have plans approved by the regulator.*
	*There is coordination but without hierarchy of decisions. In particular, technical coordination in planning activities is focused on TSO-DSO interconnection facilities.* *Grid operation:* *Emergency actions carried out on distribution network generally consist in load shedding.* *A first classification can be made on type of actuation basis.* *Systems based on manual activation are:* *• Interruptible Clients Shedder (BMI);- within few milliseconds* *• Emergency Load Shedder (BME) - within few milliseconds* *• Emergency plan for national system's security (PESSE) – Activated with 24 hour advance notice* *Systems based on automatic devices are:* *• Frequency load shedding relays (EAC) - near real-time* *• Critical sections controller (EDA) - near real-time*
	*This is in a startup phase. DSOs and TSO are coordinating on congestion bids on the GOPACS platform. Grid operators can notify if the connection limits are being reached, the GOPACS platform takes these limits into account when accepting bids for congestion management for other grid operators.*
	*The DSO informs the TSO of new connections.*

3.4.2. TSO-DSO data exchange

In order to assess the current level of TSO-DSO data exchange, countries were asked if data is exchanged for each time-step, including long-term, day-ahead, intraday, near real-time and ex-post, and which data is exchanged. Table 23 presents the data exchange per country.

Table 23: Information Exchange between TSOs and DSOs in the Surveyed Countries

	Long-term	Day-ahead	Near-real time	Real-time	Ex-post
	*Load Profiles, Load Projections, DER Measurements, Network Topology, Network Development Plan of DSO, Ten year development plan of TSO, Maintenance Schedules, Ex-ante shares of suppliers (every month) Protection coordination and interlocking arrangements. TSO may request complementary protection on the distribution network with regard to Under Frequency Load Shedding, there is a coordination between the TSO and the DSO to set up the thresholds.*	*When the DSO is about to perform switchings that can lead to load reduction more than 10 MW on a connection point of the distribution network to the transmission system, then the TSO must be informed.*	*Request for load/generation shedding under critical situation. Information exchange and TSO - DSO cooperation in power system restoration procedures. Active power output limitation of DGs, when requested by the TSO. When the DSO is about to perform switchings that can lead to load reduction more than 10 MW on a connection point of the distribution network to the transmission system, then the TSO must be informed.*	*Request for load/generation shedding under critical situation. Information exchange and TSO - DSO cooperation in power system restoration procedures. Active power output limitation of DGs, when requested by the TSO.*	*DSO provides every month the ex-post shares of suppliers.*
	*The TSO will inform the structural data of installations that participate in balancing services.*	*The TSO sends to the DSO the daily schedule. The DSO can evaluate and request modifications due to congestion in the distribution network. The TSO will inform the DSO the schedules for DER providing balancing services. The schedules (PDVP) after the ID market session are published as soon as they are available*	*Real-time schedules are published as soon as they are available by both operators.*	*Installations that are not obliged to be attached to generation control centre can be monitored by the DSO control centre. The units must be connected to the observable network of DSOs. The information must be provided by physical unit.*	*Three days after real time, balancing schedules (aggregated per type of generation) are published. 3 months after real time, all information is public.*
	*Outage planning coordination (OPC): yearly communication between respective operational planning unit (TSO/DSO). TSO dialogue with DSO representatives about consequences for different operational modes and outages.*	*Exchange of switching schedules of common interest.*	*TSO in dialogue with relevant DSO about consequences for various operational modes and outages, overloads and disturbances. In short-term there is communication between grid control centres.*		
		*Information exchange based on GLDPM: forecast of schedules at grid connection points and electrical values*	*Reactive power management (only if necessary), RES curtailment, update of schedules etc. if applicable*	*Reactive power management, RES curtailment, update of schedules etc. if applicable*	

		of grid assets within observability area.			
	*Forecast and schedules for the interchange substations.*	*Forecast and schedules for the interchange substations.*		*Measured values for the interchange substations. SCADA-to-SCADA coupling for the generation units in question.*	*Measured values for the interchange substations.*
	*Grid modernization plans.*	*Switching plans for planned maintenance work.*	*Switching actions done by dispatchers.*	*Switching actions done by dispatchers.*	*Switching actions done by dispatchers.*
	*Planned outages.*		*Curtailment management*		
	*Installed power of loads and DERs in service and forecasted installed power of loads and DERs (planned units) & - long term forecasts loads and DERs*			*Power measurements HV/MV transformer and congestion indicators*	*Metering data loads >5MVA and all DER units > 400kVA & - Ad hoc data for incident analysis*
	*Yes*	*Yes*	*Yes*		
	*Yes. Maintenance and grid planning*	*Yes. Transportation prognosis from DSO to TSO Congestion Limits*	*Yes. Congestion Limits*	*None*	*Energy settlement and measuring data*
	*DSO informs TSO on new connections*				

4. Discussion and Conclusions

In this Deliverable 1.1, the European goals and views established in the Clean Energy Package and the Network Codes have been described, as well as the European Balancing Platforms that aim to harmonize the balancing products in Europe. Additionally, an extensive survey was conducted to assess the regulatory landscape with regard to topics concerning TSO-DSO coordination in the three demos countries and other EU member states.

The Clean Energy Package foresees that TSO-DSO coordination and data exchange is needed in order to achieve three main objectives, namely optimal utilization of resources, secure and efficient operation, and to facilitate market development. For each of these three objectives, we observe different drivers and barriers in the countries discussed in this deliverable.

Optimal Utilization of Resources

The optimal utilization of resources will be achieved when both TSOs and DSOs are able to make efficient use of flexibility provided by DER. In this sense, and the country survey showed that most TSOs could already procure services from DER; however, the same is not true for DSOs.

DSO procurement of DER services is still incipient particularly for DERs connected at low voltage levels. Considering the three demo countries, in none of them, DSOs can directly procure services for grid management. In Spain, the DSO can request the redispatch of generating units to the TSO to solve congestions in the distribution network. In Greece, the general terms for DSO to procure DER flexibility are already in place but is not applied since detailed specifications are still to be defined, while in Sweden, regulation is yet to be defined. At DSO level, new services and products have to be clearly defined in a technology-neutral manner to enable the participation of different kinds of DERs. The organization of these services, and how their procurement and activation will be done, will be addressed in later stages of CoordiNet.

Besides the lack of regulatory definition, there is still a lack of economic incentives for DSOs to procure services for grid management. Regulation is still thought for the “fit-and-forget” approach paradigm. The Clean Energy Package, however, already points to the new direction, stating that regulatory frameworks should incentivize and compensate expenses with the procurement of flexibility, as well as show how flexibility can be used as an alternative to expand the grid in the planning stage of distribution grids. On the national level, however, regulatory frameworks are still being adapted to the new reality.

On the TSO side, however, DER already takes place in service provision, but somehow limited. In general, balancing is the main product offered by DER. However, although DER is already participating in these markets, the participation is still limited to certain types and sizes of DER. For instance, DR is still not allowed in some balancing markets, and the DG that participates is usually connected at HV levels. Both grid operators may need to have incentives to procure services from DERs in a non-discriminatory way in comparison with “wires” solutions or the provision by traditional agents (e.g., large generation units). For this to become a reality, the definition of products that take into account the characteristics of DER and development and maintenance of market platforms to procure will be a key element for DERs participation directly or through an aggregator. CoordiNet aims to provide insights on these relevant aspects, which may contribute to set regulatory recommendations for the countries where the demonstrations will take place as well as for the overall development of the European Internal Energy market.

Secure and Efficient Operation

The secure and efficient operation of power systems has always been the biggest priority for grid operators. In the context of DER flexibility provision, this also means that TSOs and DSOs will have to cooperate for the planning and the operation of their grids. As of today, TSOs and DSOs already cooperate and exchange information. However, when DSOs start using DER flexibility, this cooperation and exchange will have to be enhanced to guarantee efficient use of resources and secure operation of the system.

During the planning phase, the implications of new resources connected at both TSO and DSO networks have to be properly accounted for as well as the impact of demand growth that may affect the reinforcement requirements of networks. If done in a coordinated manner and by utilizing local flexibility, reinforcement need may actually be reduced for both grid operators. At the operational phases, continuous updates of load and generation forecasts will be required and this information will be relevant for both TSO and DSO to take actions on their systems. Finally, remedial actions, activations of services and emergency procedures will become an increasingly relevant topic, as the change of the energy profiles of different types of DER does not only affect the DSO but also the overall system, for instance in terms of balancing the system. Clear rules and priorities have to be established to guarantee a coordinated and secured operation.

The current implementation of the Network Codes and the developments taking place in the European Balancing Platforms are a positive driver in this regard. Although some market design aspects of today's national regulations in the demo countries are not favouring TSO-DSO related issues, respondents to the regulatory questionnaire acknowledged that market rules are currently under review due to the implementation of the network codes. This implementation will contribute to the standardisation of procedures.

Facilitate Market Development

The Clean Energy Package recommends that, to the extent possible, procurement of services by TSOs and DSOs should be market-based. This is still a barrier for many products and services, especially at the DSO side. Additionally, it is important to note that aggregators are expected to play an important role in unlocking the potential of small DER.

Independent aggregation is at an incipient stage, especially for the three countries where the CoordiNet demonstrations will take place. Therefore, the lack of concrete specifications for the roles and responsibilities for aggregation of flexible resources connected at DSO networks becomes a barrier for service provision from DERs for both grid operators. A pending aspect to enable aggregation would be to define rules for accounting energy imbalances from resources under the aggregator control but which are represented in the energy market by a third party such as the retail company in the case of demand resources or by a generation representative company. The revision of the current market design rules will be key, in particular, the imbalance settlement rules currently in place in the different countries. A level playing field for all resources has to be guaranteed independently where they are connected, the technology used, the size or other characteristics. From the countries reviewed, Austria, Belgium, Germany, and the Netherlands are more advanced on enabling the role of an independent aggregator, especially for providing balancing services. On the TSO side, although DERs are already allowed to participate in balancing, other markets are yet to be developed. For instance, voltage control is not remunerated in many countries.

From the countries reviewed, Germany, Austria, and the Netherlands are frontrunners on enabling the role of an independent aggregator, especially for providing balancing services. The aggregator, however, cannot provide non-frequency services in almost any country.

On the TSO side, although DER is already allowed to participate in balancing, other markets are yet to be developed. For instance, voltage control is still not remunerated in many countries.

Furthermore, in order to enable the full implementation of markets, operational procedures have to be established providing detailed rules on when and how to mobilize flexibility from resources connected to the distribution networks. For this, schemes for the coordination of the provision of services by DSOs and TSOs have to be put in place regarding several aspects of the utilization of flexibility from DERs. These include the computation of forecasts of the output and demand of DER, establishing the priorities to consider when activating these resources (e.g., priority of addressing local congestion over system balancing needs[32]), the definition of the curtailment rules to apply, and the coordination of the emergency actions to implement when necessary, among others. CoordiNet will define and demonstrate different aspects of the mobilization of the flexibility provided by DER related to these challenges.

Table 24 summarizes the main drivers and barriers.

Table 24: Main drivers and barriers for DSO-TSO cooperation

Objective	Main Drivers	Main Barriers
Optimal Utilization of Resources	- DER flexibility is already used by many TSOs	- DSOs still do not use DER flexibility - DER provision of services to TSOs is still limited to certain types and sizes of DER - DSOs may lack economic incentives to use DER flexibility
Secure and Efficient Operation	- Information exchange is already taking place in demos countries.	- Coordination and procedures will be required as DSOs start to use DER flexibility and have to account for impacts for the TSO. Additionally, the activation of DER by TSOs might also create constraints to the DSOs, and have to be coordinated.
Facilitate Market Development	- Implementation of the Network Codes has started and may bring harmonization of products and services, as well as inclusive product characteristics for DER flexibility provision.	- Aggregation is still incipient, and rules for aggregation are unclear - Product definitions and market mechanisms need to be developed

[32] This is specially an issue when the coordination scheme does not aim to finding a jointly (and therefore global) optimized solution.

5. References

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