ENTSO-E Position on Offshore Development

System Operation & Governance

2 July 2021

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ENTSO-E Mission Statement

Who we are

ENTSO-E, the European Network of Transmission System Operators for Electricity, is the **association for the cooperation of the European transmission system operators (TSOs)**. The 42 member TSOs, representing 35 countries, are responsible for the **secure and coordinated operation** of Europe's electricity system, the largest interconnected electrical grid in the world. In addition to its core, historical role in technical cooperation, ENTSO-E is also the common voice of TSOs.

ENTSO-E **brings together the unique expertise of TSOs for the benefit of European citizens** by keeping the lights on, enabling the energy transition, and promoting the completion and optimal functioning of the internal electricity market, including via the fulfilment of the mandates given to ENTSO-E based on EU legislation.

Our mission

ENTSO-E and its members, as the European TSO community, fulfil a common mission: Ensuring the **security of the interconnected power system in all time frames at pan-European level** and the **optimal functioning and development of the European interconnected electricity markets**, while enabling the integration of electricity generated from renewable energy sources and of emerging technologies.

Our vision

ENTSO-E plays a central role in enabling Europe to become the first **climate-neutral continent by 2050** by creating a system that is secure, sustainable and affordable, and that integrates the expected amount of renewable energy, thereby offering an essential contribution to the European Green Deal. This endeavour requires **sector integration** and close cooperation among all actors.

Europe is moving towards a sustainable, digitalised, integrated and electrified energy system with a combination of centralised and distributed resources.

ENTSO-E acts to ensure that this energy system **keeps consumers at its centre** and is operated and developed with **climate objectives** and **social welfare** in mind.

ENTSO-E is committed to use its unique expertise and system-wide view – supported by a responsibility to maintain the system's security – to deliver a comprehensive roadmap of how a climate-neutral Europe looks.

Our values

ENTSO-E acts in **solidarity** as a community of TSOs united by a shared **responsibility.**

As the professional association of independent and neutral regulated entities acting under a clear legal mandate, ENTSO-E serves the interests of society by **optimising social welfare** in its dimensions of safety, economy, environment, and performance.

ENTSO-E is committed to working with the highest technical rigour as well as developing sustainable and **innovative responses to prepare for the future** and overcoming the challenges of keeping the power system secure in a climate-neutral Europe. In all its activities, ENTSO-E acts with **transparency** and in a trustworthy dialogue with legislative and regulatory decision makers and stakeholders.

Our contributions

ENTSO-E supports the cooperation among its members at European and regional levels. Over the past decades, TSOs have undertaken initiatives to increase their cooperation in network planning, operation and market integration, thereby successfully contributing to meeting EU climate and energy targets.

To carry out its **legally mandated tasks**, ENTSO-E's key responsibilities include the following:

- Development and implementation of standards, network codes, platforms and tools to ensure secure system and market operation as well as integration of renewable energy;
- Assessment of the adequacy of the system in different timeframes;
- Coordination of the planning and development of infrastructures at the European level (Ten-Year Network Development Plans, TYNDPs);
- Coordination of research, development and innovation activities of TSOs;
- Development of platforms to enable the transparent sharing of data with market participants.

ENTSO-E supports its members in the **implementation and monitoring** of the agreed common rules.

ENTSO-E is the common voice of European TSOs and provides expert contributions and a constructive view to energy debates to support policymakers in making informed decisions.

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Executive Summary

System operation is defined by a set of generic tasks. These tasks are similar whether they are performed offshore or onshore, although the technical nature of the systems differ. As the European power system is interlinked, system operation and operational planning is, to a growing extent, coordinated regionally among TSOs through RSCs / RCCs / SAMs. However, these tasks are performed by the national TSOs and regulated by national jurisdictions. The motives and obligations of the TSOs to engage in regional coordination are equally valid onshore and offshore.

System operation is based on common European principles, and the tasks related to system operation and coordination are all regulated by the Clean Energy Package (CEP) and the corresponding network codes and guidelines. The current regulatory setup is suitable for facilitating efficient offshore system operation during the expected stepwise and organic development of offshore grid infrastructure. The offshore grid infrastructure will, in some cases, connect networks of EU and non-EU countries, and will therefore also have to be operated according to agreements between related TSOs.

Onshore system operation solutions are extended to offshore systems, as there are no boundaries between the onshore and offshore power systems. The security of supply and system operation will be managed at the national level by TSOs within the framework of regional coordination, where roles and responsibilities are clearly defined. Market parties remain responsible for their imbalances, and TSOs remain responsible for the real-time balancing of the system.

In order to cope with new challenges linked to the integration of large amounts of offshore wind power, TSOs need to have access to significantly more flexibility resources to balance the interconnected power systems and ensure to fulfill their primary role, i.e. provide electricity to customers at any time during day and night. To balance the system at all times, TSOs rely on flexibilities provided by market actors, today mainly onshore: the need for a major increase of flexibility sources in the future, including large scale storage technologies, should be better acknowledged. This will be further developed through ENTSO-E ongoing work on the 2050 horizon and long term scenarios.

The principles applied in the solutions used for onshore and offshore system operation are European. The guiding principle is to act locally, coordinate regionally and think European.

1. Offshore System Operation Helps Facilitate the Green Deal

System operation is at the very core of the energy transition, since it deals with the time frame in which power generation and consumption meet, and in which emissions and resource efficiency become visible. Offshore system development, markets and interoperability are all means to ensure the efficient future operation of offshore systems, and each of these issues has been addressed in an individual position paper.

These position papers have identified a variety of offshore grid configurations using single-purpose and dual / multi-purpose solutions, measures to ensure the interoperability of multi-terminal, multi-vendor HVDC projects, and the use of Offshore Bidding Zones, which appear to be the most efficient solution for ensuring the integration of markets and system operation across onshore and offshore locations[1]. This paper addresses the issue of governance for offshore system operation. The issues of system development, markets, interoperability, and system operation governance are closely interlinked and should be viewed as one combined effort to deliver secure, affordable, and clean electricity to all Europeans.

This holistic perspective is the running theme throughout the ENTSO-E offshore position papers. This current paper, on the governance of offshore system operation, builds on the previous position papers. All papers build on the one-system approach based on the seamless integration of system development, markets and system operation across land and sea, as also communicated by the ENTSO-E Vision 2030. All offshore papers expect a stepwise development, also recognising that the increase in demand driven by electrification will need to be offset by production both onshore and offshore.

System operation is ongoing while the power system continues to change significantly, however gradually. The changes proceed through many small and sometimes bigger steps. In the foreseeable future, the changes in system operation will be based on stepwise development and the improvement of existing solutions. Furthermore, the offshore power system, which connects member states, must also efficiently integrate third countries. Defining end-game solutions for 2050, for example, is difficult at this stage, since new knowledge and technology will emerge along the way, introducing solutions not yet envisaged. In the future, there might also be offshore assets which are able to contribute to the system balancing task, such as offshore consumption like hydrogen electrolysers, for example, being added to the offshore system.

For the renewable energy transition to succeed, a stepwise market-driven development that balances demand and production is needed. Clear responsibilities must be given to market players, TSOs and DSOs to ensure the steady development of the required flexibility and balancing resources. One implication, as foreseen in the EC offshore strategy, is that all market players must be responsible for their own imbalances, both onshore and offshore. Another implication is that TSOs remain responsible for ensuring the necessary reserves in their control areas, even when a large bulk of the production moves offshore. The distance to onshore balancing resources will be significant, and efficient coordination as well as practical arrangements are required to manage frequency and balancing. Achieving this requires holistic planning and the coordinated development of onshore and offshore transmission infrastructure, as communicated in the ENTSO-E Position on Offshore Development, May 2020. With increased offshore production, onshore transmission grids must be enforced (over time) to be able to cope with the increased demand for robust transmission capacity.

1 ENTSO-E Position on Offshore Development, May 2020
ENTSO-E Position on Offshore Development, Market and Regulatory Issues, October 2020
ENTSO-E Position on Offshore Development, Interoperability, January 2021

2. Governance Pillars for Offshore System Operation

This section identifies four key pillars on which to build the governance structure for offshore system operation in the European seas.

Pillar 1

Local responsibility to coordinate and deliver secure system operation

The European power system is interconnected from Finland to Portugal, from Ireland to Greece. However, the security of the electricity supply and system operation is at the core of the national responsibility given to TSO(s) in each member state. From a system operation perspective, the state of the power system evolves quickly as incidents and unforeseen events impact the different areas of the system, and operators must respond in real time in a fast, decisive, dynamic, and coordinated manner. While fast, efficient communication among many local actors applies the local language, coordination across national borders applies international terminology.

System security benefits significantly from regional coordination, for example through Regional Security Centres (RSCs), future Regional Coordination Centres (RCCs) and Synchronous Area Monitors (SAMs). Existing regulations provide the TSOs with an obligation to exploit these opportunities and to coordinate system operation regionally.

Key offshore governance principles related to securing system operation include the following:

- The responsibility to ensure efficient balancing and system operation rests with the TSOs, both onshore and offshore, based on national jurisdictions.
- The motives and obligations of the TSOs to engage in regional coordination is equally valid onshore and offshore, across the whole power system.

Pillar 2

Market players are responsible for their own imbalances

Market players are incentivised to balance their positions by trading energy in the energy markets (day ahead and intraday) and they are financially responsible for their imbalances. This is a prerequisite for efficient system operation both onshore and offshore. The imbalances in the system are ultimately managed by the TSOs in real time.

Key offshore governance principles related to market player balancing include the following:

- Market players are responsible for their imbalances, independent of their location (onshore or offshore).
- Intraday markets offshore and onshore must be integrated to grant offshore market players access to the flexibility resources onshore that they can use to balance their positions.

Pillar 3

Market-based balancing

For market-based balancing, the same rules apply onshore and offshore: After gate closure of the day-ahead and intraday energy markets, the TSOs use additional dispatching flexibility provided by market players in the balancing markets as part of their real-time system operation.

Key governance principles related to market-based balancing include the following:

- Market-based dispatch of flexibility is used according to merit order lists.
- The TSOs are responsible for ensuring the availability of reserves.
- The responsible TSO should enable the offshore market players to participate in European balancing markets by collecting the bids and adding them to the European balancing platforms.
- Offshore imbalances will be managed by each responsible TSO. For this purpose, the resources of European balancing platforms are available to the TSOs. In addition to the current onshore resources, in the future these platforms may also include prequalified offshore facilities, such as hydrogen electrolysers.

Pillar 4

Offshore Bidding Zones (OBZ)

The OBZ appears to provide an efficient solution for ensuring the efficient integration of markets and system operation across onshore and offshore systems, as communicated in the ENTSO-E Position on Offshore Development, Market and Regulatory Issues, 15 October 2020.

A key offshore governance principle related to OBZs is as follows:

- Well-defined OBZs, with clear responsibilities for TSOs for secure system operation and market-based imbalance management, limit the need for TSOs to intervene in the market.

3. Defining the Offshore System Operation Framework

The offshore system operation framework can build on the solid onshore framework. Examples include defining the OBZs, the necessary standards and system requirements, and the structure for regional cooperation, as defined by Capacity Calculation Regions (CCRs) and System Operation Regions (SORs).

Table 1 identifies potential issues and proposes corresponding solutions. The solutions are already defined in existing regulations, with some minor exceptions. Thus, the overarching structure for system operation used onshore can be extended to offshore, promoting the one-system approach and the stepwise development of offshore power systems.

It should be noted that, as defined by the SO GL, there is no one-to-one relationship between bidding zones and LFC (Load-Frequency Control) areas / blocks. Bidding zones refer to market concepts, while LFC blocks refer to operation concepts. The interdependencies on a process level between bidding zones and LFC areas / blocks will evolve over time to ensure clear, well-defined processes. Technically, the responsibility of real-time balancing is assigned to the TSOs operating their respective LFC areas / blocks. Some further descriptions related to real-time balancing are found in chapter 5.

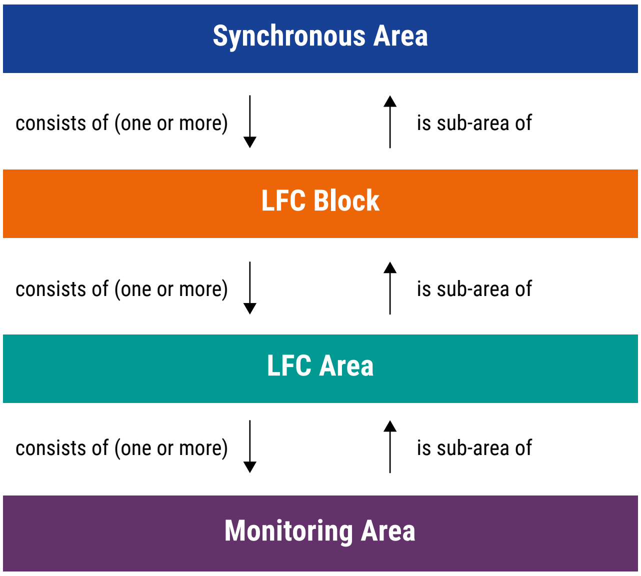

Figure 1: The relationship between Monitoring Area, LFC Area / Block and Synchronous Area.

System Definitions	Issues	Solution	Regulation / code
Definition of Bidding Zones offshore	› Reflect offshore congestions to ensure efficient competition and utilisation of resources across onshore and offshore › Respect TSOs control area, national borders / EEZ also offshore and the need to ensure clear responsibilities in offshore real-time system operation › Promote a stepwise change to an integrated / meshed system	› Member states determine the Bidding Zones, also offshore	› Already defined in CEP article 14 › CACM article 33 (1)
Definition of Capacity Calculation Regions	› Stepwise development and inclusion of new installations and new grid in the capacity calculation in existing regions › Evaluate frequency of CCR re-evaluation › Ensure efficient integration to processes in onshore BZs	› TSOs propose › ACER decides	› Already defined in CACM article 15
Definition of System Operation Regions	› Stepwise development and inclusion of new grids in existing SORs based on a technical approach	› TSOs propose amended SOR configuration taking into account the grid topology, the degree of interconnection and of interdependency in terms of flows, in order to lay the basis for an optimal coordination of the system within a SOR › RCCs facilitate the coordination of the interfaces between SORs › ACER decides	› Already defined in CEP article 36
Definition of standards and system requirements	› Need for harmonisation / standards together with system requirements that promote interoperability and efficient system operation › Requirement of data exchange standards together with generator settings and other system settings for protections schemes etc.	› TSOs define requirements	› Not fully covered in HVDC Connection code, as Meshed DC grid is, among others, not included

Table 1: System definitions

4. Defining the Tasks of Offshore System Operation

The tasks of system operation offshore are the same as those performed onshore. However, the technical nature of the offshore system differs. This section identifies the specific tasks related to system operation, both related to operational planning (table 2) and to real-time system operation (table 3); market operational tasks are also described in table 3.

System operation both onshore and offshore is performed in close cooperation between TSOs and between TSOs, RSCs / RCCs and SAMs. Thus, system operation offshore is closely integrated into system operation onshore, facilitating a stepwise development and a one-system approach.

Coordination in operational planning and security assessment is necessary to ensure secure system operation. Offshore as well as onshore networks are currently coordinated in some of the tasks of RSCs / RCCs, most notably Outage Planning Coordination (OPC) and Coordinated Security Analysis (CSA). These tasks already consider offshore connections as well as meshed onshore networks and can be extended to meshed offshore grid infrastructure, utilising existing processes and tools developed by RSCs / RCCs or ENTSO-E.

System Operation Tasks (Operational Planning)	Issues	Solution	Regulation / code
Outage Planning Coordination	› Coordination within Outage Coordination Region (OCR) and between OCRs (SOGL) › Expansion of task and more complexity, but no change of task compared to onshore coordination › New offshore interconnectors added to the process in the same way as new onshore interconnectors	› TSOs collect and report › RCCs carry out regional outage coordination in order to monitor the availability status of the relevant assets and coordinate their availability plans to ensure the operational security	› SO GL
Capacity Calculation Coordination	› Calculation of Day ahead and Intraday capacities for all BZ onshore and offshore in designated CCR(s)	› RCCs calculate capacities between BZ › TSOs check security limits and validate the results › Capacity calculation is being developed for optimising HVDC capacities together with the neighbouring AC grids (Advanced hybrid coupling)	› CACM
Coordinated (Operational) Security Analyses	› Coordination of remedial actions within and between CCRs. All bidding zones, also offshore, will belong to a CCR.	› TSOs manage congestions by operating topological changes, redispatching and countertrading › RCCs perform coordinated security analysis	› SO GL (art. 75 – 78) › Coordinated action recommendations in CEP › CACM art. 15 (2) (b)
Forecasting (CSAm)	› Depending on the existence of independent control areas offshore there may be a need for common understanding of wind forecasts across CCRs	› Each TSO is responsible for forecasts (and / or schedules) within its control area › Short-term adequacy forecast	› Forecasts defined in CSAm › Scheduling process defined in SOGL article 110 › SO GL & CEP (RPP) for STA

Table 2: System operation tasks (operational planning)

System Operation Tasks (Market And Operation)	Issues	Solution	Regulation / code
Market performance and input	› Day ahead and Intraday markets provide necessary input for operation per BZ and OBZ	› Market actors are responsible for their imbalances	› CACM › CEP › EBGL
Reserves Dimensioning	› Reserves needs and responsibilities need to be clearly defined › Clarification of the definition of LFC blocks and synchronous areas in the SO GL is needed › Development of offshore LFC areas / blocks (islands) with demand leads to discussions of sharing of responsibilities among TSOs	› TSOs are responsible for reserves within their control area onshore and offshore › TSOs perform reserves dimensioning for their LFC block (including offshore parts) › RCCs facilitate regional sizing › Slight adaptation of definitions to include offshore grid in existing synchronous areas in the SO GL	› SOGL LFC&R › CEP article 6 › Definition #18 in SOGL › EBGL
Real time System Operation	› Offshore development introduces more interaction › Different technical solutions will evolve and may lead to different solutions in the future	› TSOs are responsible for the real-time system operation within their control area	› SOGL Art 38 and 39
Real time Balancing	› How to deal with synchronous areas (islands) needs to be developed further	› European balancing platforms are important tools for market based dispatch onshore as well as offshore	› EB GL
Coordinated Security Analyses – Cost Sharing	› Remedial actions cost sharing between TSOs and CCRs	› Regional approach › Inter-regional approach	› CACM

Table 3: System operation tasks (market and operation)

5. Managing Frequency and Real-Time Balancing Offshore

The European TSOs have many years of experience in the operation of meshed AC grids, as well as experience in the operation of HVDC interconnectors. Therefore, the TSOs can transfer existing processes and concepts to meet the technical challenges of the meshed DC offshore grid infrastructure.

European TSOs expect that the development of offshore grid infrastructure and offshore generation will have a significant impact on the management of frequency and imbalances. Onshore, there are operational agreements between all TSOs in the same synchronous area in which the principles of balancing and responsibilities are described. These agreements will have to be extended to include the offshore systems.

Offshore grid infrastructures may introduce the need for technical and practical adaptations as well as clarification on how issues are handled, such as frequency management in potential offshore AC parts. Some general considerations are listed below:

› Wind energy behind a converter will be perceived from the onshore system just like any other DC connection. The onshore system needs to be able to withstand a sudden loss of any DC connection.

› Wind energy being AC-connected to potential offshore energy hubs will run on a frequency; the AC part behind a converter is similar to an island. The type of frequency support for that AC part depends on whether the island is AC or DC connected to the onshore system(s).

Significant real-time imbalances caused by tripping or forecast errors, for example, need to be mitigated as well. Current legislation provides sufficient rules and flexibility for TSOs to dimension and share / exchange their reserves accordingly across the energy systems.

Furthermore, the existing regulatory framework in the Clean Energy Package, Network Codes and Guidelines can easily be applied to offshore grid infrastructure. The rules currently governing the operation of meshed, onshore networks will gradually be extended to offshore grid infrastructures, as they evolve from bilateral connections between two TSOs, or offshore wind farms to TSOs, to meshed networks connecting multiple offshore power generating facilities and TSOs. In addition, the offshore grid infrastructure will, in some cases, connect both EU and non-EU TSOs. This will of course be a challenge, but it can be managed according to system operation agreements between the relevant EU and third country TSOs. Moreover, the current EU regulations are already functioning well with third countries.

6. Act Locally, Coordinate Regionally and Think European

The task of system operation is performed locally by the TSOs. However, the task is, to a growing extent, coordinated regionally among TSOs, through RSCs / RCCs and SAMs, and is based on common European principles. System operation and coordination tasks are regulated in the CEP and the corresponding network codes and guidelines. A sensible approach is to extend onshore solutions offshore, as there are no boundaries between onshore and offshore.

In other words, secure system operation will be managed at national level (TSOs) using the regional coordination framework, where roles and responsibilities are clearly defined.

Main takeaways:

- **EU Regulations define system operation tasks, which must be performed both off- and onshore. CEP, together with the network codes and guidelines, defines roles and responsibilities to be used onshore as well as offshore.**
- **There are no fundamental differences between the general tasks related to onshore and offshore system operation. TSOs can transfer existing processes and concepts to meet the technical challenges of a meshed DC offshore grid infrastructure.**
- **Offshore developments will impact the processes involved in managing imbalances offshore and onshore. Market parties remain responsible for their imbalances and TSOs for balancing the system in real time.**
- **In order to cope with new challenges linked to the integration of large amounts of offshore wind power, TSOs need to have access to significantly more flexibility resources to balance the interconnected power systems and ensure to fulfill their primary role, i.e. provide electricity to customers at any time during day and night. To balance the system at all times, TSOs rely on flexibilities provided by market actors, today mainly onshore: the need for a major increase of flexibility sources in the future, including large scale storage technologies, should be better acknowledged. This will be further developed through ENTSO-E ongoing work on the 2050 horizon and long term scenarios.**
- **Offshore developments will require TSOs' close regional coordination of system operation together with RCCs.**
- **The current regulatory setup is suitable for coping with the stepwise development of offshore grid infrastructure. Moreover, stability in the regulatory design for system operation will facilitate secure and stable operation, as TSOs and RCCs can continue to coordinate efficiently, building on experience gained by using a well-established coordination model.**

Abbreviations

Acronym	Meaning
ACER	Agency for the Cooperation of Energy Regulators
CACM	Capacity Allocation and Congestion Management
CEP	Clean Energy Package
CCR	Capacity Calculation Regions
CSA	Coordinated Security Analysis
EB GL	Electricity Balancing Guidelines
ENTSO-E	European Network of Transmission System Operators for Electricity
LFC	Load-Frequency Control
OBZ	Offshore Bidding Zone
OCR	Outage Coordination Region
RCC	Regional Coordination Centres
RSC	Regional Security Centres
SAM	Synchronous Area Monitor
SO GL	System Operation Guideline
SOR	System Operation Region
TSO	Transmission System Operator

Way forward

ENTSO-E is prepared to contribute to offshore development and to be involved in upcoming debates about how this can best be organised. This position paper, which contains the ENTSO-E position on offshore development – system operation and governance issues – will be followed in the upcoming months by further publications.

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