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State of the art of Regional Coordination Centres (RCCs) and their impact on security of electricity supply in Europe

Transmission System Regional Coordination in Europe

Foretić, H., Asensio Bermejo, I., Kopustinskas, V., Fulli, G.

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Joint Research Centre

EUR 31922 EN

Contact information
Name: Hrvoje Foretić
Address: Westerduinweg 3, 1755 LE Petten, the Netherlands
Email: Hrvoje.FORETIC@ec.europa.eu
Tel.: +31 2 2456 5227

EU Science Hub
https://joint-research-centre.ec.europa.eu

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Contents

Abstract

Europe boasts one of the largest interconnected electricity networks in the world, which consists of a huge number of generation, transmission and distribution components working together to deliver energy to users. The European power system, in order to fulfil its core mission - i.e. provide uninterrupted electricity supply to consumers - has to function reliably and has to survive a vast number of adverse events.

In order to better manage such a complex machine, which spans across the EU and several other European countries, an increasingly regional (i.e. multi-country) -based organisation of power system and market functions was put forward and implemented over the past decades. This is where Regional Coordination Centres (RCCs) came into play. In recent years the EU was affected by several crises, which among others highly impacted the electricity sector operations. The RCCs were therefore recognised by the European Commission as a tool to tackle security of supply issues from a regional dimension and mitigate the impact on the overall electricity system. The RCCs can provide regional and cross-regional services that no individual country-based transmission system entity is in the position to deliver. This also entails that RCCs might have to reconcile different interests of countries included in a given region and this task can become growingly strategic as well as sensitive, especially during crisis times. Thus, RCCs are one of the key actors in transmission system operation in Europe, considering their regional and cross-regional presence in the system operation areas. For that reason, increasing RCC-RCC cooperation and active involvement in the European decision-making initiatives appear crucial.

Besides the RCC overview this report is delivering, few points of improvements for RCCs tasks with forward looking vision, mainly in relation to the regional electricity crisis scenarios, are pointed out as well. RCCs could provide dedicated assistance to TSOs and ENTSOE in the assessment of the regional electricity crisis scenarios, in particular on cross-border effects, which are the basis for the regional crisis scenarios identification. Altogether they can contribute in defining the risk-preparedness strategy and plans that all Member States have to produce and adopt, and which have to cover past, current and emerging threats. In the system adequacy and operational planning domains, RCCs could contribute with regional overview and simulations of the potential incidents, and show their competence in providing their products stemming from their tasks, such as coordinated actions, reports and recommendations, which are independent of national and TSOs' interests. RCC products will become more valuable over time as the decarbonisation of the electricity system increases and could be established with timely and proper mandates by the European Union bodies.

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1 Introduction

The objective of this report is to provide a general overview of transmission system regional coordination in Europe, more concretely, Regional Coordination Centres (RCCs), and their regional tasks that are provided to Transmission System Operators (TSOs) and other stakeholders in their respective system operation regions (SORs). This report aims to emphasize RCC's current and future-looking roles in the security of electricity supply in Europe. It is of utmost importance to understand their impact now and how the RCCs, as one of the youngest entities in transmission of electricity in Europe, can further assist Member States in regional and cross-regional coordination.

This report consists of seven chapters. After the introduction (Chapter 1), transmission system operation entities in Europe will be briefly presented in the Chapter 2, providing a short description and their respective roles. Then in the Chapter 3 the focus will be shifted, and kept further in the report, to RCCs, first by providing historical facts related to their establishment and finally the legal framework will be then shortly introduced, with a detailed table supporting the Report in Annex. In the Chapter 4 *where* and *when* of the RCCs will be introduced, i.e. the geographical scope of RCCs will be covered, describing where to place them on the map of Europe and how to associate them with different TSOs. A visual representation of various regions that are mentioned throughout the legislation and methodologies will be showed further down in the Report, as well as operational timeframes in which RCCs are operating. In the Chapter 5 the essential overview of all RCC tasks will be presented, by analysing available information related to them. Chapter 6 is featuring the sketch of the adoption process and procedure for the new RCC task(s) both from legal and RCC point of view. The final, Chapter 7, will present the conventional or non-binding RCC tasks, and the possible development of the current tasks, as well as points of improvement from the JRC point of view, finished with the conclusion.

RCCs, as transmission system operation entities, are involved in the reshaping of the energy world in the electricity domain in Europe, strategy which is based on the well-known EU strategy 'Five dimensions of the Energy Union' (Table 1).

Table 1. Five dimensions of the Energy Union.

Energy Security	**Internal Energy Market**	**Energy Efficiency**	**Decarbonisation of the Economy**	**Innovation**
Security of Supply Flexibility, resilience, recovery Solidarity and cooperation	Market Integration Cost Efficiency, Competition Free flow without technical and regulatory barriers	Improving energy efficiency Reducing dependence on energy imports	Lower CO2 emissions Higher share of renewable energy sources	Research Clean energy technologies Competitiveness
SoS	**MI**	**EE**	**D**	**I**

Source: JRC analysis, 2023.

In this report the focus will be mostly on the Energy Security dimension with the security of supply being one of the main topics. A secure supply of electricity is crucial for consumers. By all means, the security of supply is a Member State's responsibility, but the European Union might intervene in national affairs in case of severe need. Moreover, the much needed energy independency has gained importance by being affected not only by the overall energy crises (caused by high energy prices, and increasing consumption), but also by recent geopolitical events that have shaken foundations of once solid electricity system in Europe.

A categorization of the RCC tasks depending on their function and type of operational activity in the transmission system operation (Table 2) is provided. The characterization of the RCC tasks (Chapter 5 of this report) assigns a specific link for each task to these dimensions, based on the impact and contribution.

Table 2. General categories of RCC tasks depending on their purpose.

Operational Security (OS)	Tasks related directly to the security of the transmission system operation, short before and close to real-time, in close coordination with the TSOs, such as different analyses and grid restoration.
Operational Planning (OP)	All tasks related to the planning and preparatory activities for the transmission system operation, such as outage coordination, modelling of the system and regional electricity crisis scenario identification.
System Adequacy (SA)	Tasks related to the transmission system adequacy and in particular to alert on and plan measures for possible inadequate scenarios.
Capacity Allocation (CA)	Everything related to the calculation and allocation of different capacities on the market for different timeframes, from long-term all the way to balancing.
Miscellaneous (Other)	Tasks that could not fit in any other category above.

Source: JRC analysis, 2023.

Last but not least, it is important to note and differentiate two terms that were being used for the same company entity i.e. RCCs and RSCs - Regional Security Coordinators, with former being a new name for the latter one. In some older dated documents, methodologies, guidelines, the *RSCs* can still be found instead of RCCs. This is due to de jure modification from 1 July 2022 that changed not only the name but also added additional "services", now tasks, (Figure 1), which shaped RCCs into being essential part of the regional coordination, if that was not already the case before.

Figure 1. Changes based on Article 35(2) of the Electricity Regulation 2019/943

Source: JRC analysis, 2023.

2 Transmission system operation and regional coordination in Europe

Transmission system operation in Europe is being handled by several entities which are interdependent – TSOs, ENTSO-E and RCCs - from mostly technical point of view, while policy domain is governed by the Member States, European Commission and other EU bodies of which regulatory jurisdiction is handled by NRAs under the surveillance of EU's ACER. They cooperate between each other and coordinate actions in all timeframes, from long-term planning up until real-time operation. The next few paragraphs provide a brief overview of all entities, as well as their respective roles in the transmission system operation, with the exception of RCCs whose description forms part of a separate dedicated section of this report.

2.1 Transmission System Operator (TSO)

The definition in the Article 2, point 35 of the Common rules for the 'Internal market for electricity Directive (EU) 2019/944' (Further in the text 'Electricity Directive') describes a 'transmission system operator' as a:

Box 1. TSO definition

"Natural or legal person who is responsible for **operating**, ensuring the **maintenance** of and, if necessary, **developing** the **transmission system** in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the transmission of electricity;"

TSOs are national regulated entities operating the high-voltage electric grid, and they have to do it independently, non-discriminatory and transparently from other electricity market players such as generators, traders, suppliers, distribution system operators (DSOs) and directly connected customers. Furthermore, TSOs are responsible for the operational security of its control area and they additionally have to (SOGL Regulation, 2017a):

Box 2. Responsibilities of a TSO

- Develop and implement network operation tools that are relevant for its control area and related to real-time operation and operational planning;

- Develop and deploy tools and solutions for the prevention and remedy of disturbances;

- Use services provided by third parties, through procurement when applicable, such as redispatching or countertrading, congestion management services, generation reserves and other ancillary services;

- Comply with the incidents classification scale adopted by ENTSO-E and submit to them the information required to perform the tasks for producing the incidents classification scale (ICS) (Figure 2); and

- Monitor on an annual basis the appropriateness of the network operation tools established pursuant to points (a) and (b) required to maintain operational security. Each TSO shall identify any appropriate improvements to those network operation tools, taking into account the annual reports prepared by ENTSO-E based on the ICS. Any identified enhancement shall be implemented subsequently by the TSO.

Figure 2. ENTSO-E Incident Classification Scale (ICS)

Below scale Anomaly		Scale 0 Noteworthy		Scale 1 Significant incident		Scale 2 Extensive incident		Scale 3 Major incident	
Priority	Short definition (Criterion short code)	Priority	Short definition (Criterion short code)	Priority	Short definition (Criterion short code)	Priority	Short definition (Criterion short code)	Priority	Short definition (Criterion short code)
		#20	Incidents on load (L0)	#11	Incidents on load (L1)	#2	Incidents on load (L2)	#1	Blackout (OB3)
#28	Incidents leading to frequency degradation (FBS)	#21	Incidents leading to frequency degradation (F0)	#12	Incidents leading to frequency degradation (F1)	#3	Incidents leading to frequency degradation (F2)		
		#22	Incidents on network elements (T0)	#13	Incidents on network elements (T1)	#4	Incidents on network elements (T2)		
#29	Incidents on power generating facilities (GBS)	#23	Incidents on power generating facilities (G0)	#14	Incidents on power generating facilities (G1)	#5	Incidents on power generating facilities (G2)		
				#15	N-1 violation (ON1)	#6	N violation (ON2)		
		#24	Separation from the grid (RS0)	#16	Separation from the grid (RS1)	#7	Separation from the grid (RS2)		
#30	Violation of standards on voltage (OVBS)	#25	Violation of standards on voltage (OV0)	#17	Violation of standards on voltage (OV1)	#8	Violation of standards on voltage (OV2)		
		#26	Reduction of reserve capacity (RRC0)	#18	Reduction of reserve capacity (RRC1)	#9	Reduction of reserve capacity (RRC2)		
		#27	Loss of tools, means and facilities (LT0)	#19	Loss of tools, means and facilities (LT1)	#10	Loss of tools, means and facilities (LT2)		

Source: (ENTSO-E, 2022a)

As envisaged by the Article 40 of the Electricity Directive, tasks of the TSOs are shown in the box below:

Box 3. Tasks of TSOs

Each TSO shall be responsible for:

- ensuring the long-term ability of the system to meet reasonable demands for the transmission of electricity, operating, maintaining and developing under economic conditions secure, reliable and efficient transmission system with due regard to the environment, in close cooperation with neighbouring transmission system operators and distribution system operators;

- ensuring adequate means to meet its obligations;

- contributing to security of supply through adequate transmission capacity and system reliability;

- managing electricity flows on the system, taking into account exchanges with other interconnected systems. To that end, the transmission system operator shall be responsible for ensuring a secure, reliable and efficient electricity system and, in that context, for ensuring the availability of all necessary ancillary services, including those provided by demand response and energy storage facilities, insofar as such availability is independent from any other transmission systems with which its system is interconnected;

- providing to the operator of other systems with which its system is interconnected sufficient information to ensure the secure and efficient operation, coordinated development and interoperability of the interconnected system;

- ensuring non-discrimination as between system users or classes of system users, particularly in favour of its related undertakings;

- providing system users with the information they need for efficient access to the system;

- collecting congestion rents and payments under the inter-transmission system operator compensation mechanism, in accordance with Article 49 of Regulation (EU) 2019/943, granting and managing third-party access and giving reasoned explanations when it denies such access, which shall be monitored by the regulatory authorities; in carrying out their tasks under this Article transmission system operators shall primarily facilitate market integration;

- procuring ancillary services to ensure operational security;

- adopting a framework for cooperation and coordination between the regional coordination centres;

- participating in the establishment of the European and national resource adequacy assessments pursuant to Chapter IV of Regulation (EU) 2019/943;

- the digitalisation of transmission systems;

- data management, including the development of data management systems, cybersecurity and data protection, subject to the applicable rules, and without prejudice to the competence of other authorities.

In performing the tasks referred to in the abovementioned Article, TSOs shall take into account the recommendations issued by the RCCs, on which more will be said further in the Report.

On TSOs, the European Court of Auditors (ECA) is stating that they have to manage the security and stability (balancing markets) of high voltage power systems and interconnectors at national or zonal level, derive revenue from network tariffs and network congestion income. They cooperate with each other within the framework of the ENTSO–E, which has to act with a view to establishing a well-functioning and integrated internal market for electricity (European Court of Auditors, 2023).

There are 49 TSOs in Europe operating and owning the transmission grid of their country in Europe, including transcontinental Euro-Asian countries Armenia, Azerbaijan, Georgia, Russia and Türkiye (Next Kraftwerke, a). At least one TSO is present in 26 EU member states (MS), with the exception of Germany divided in four of them (50 Hertz, Amprion, Tennet DE, Transnet BW), and Austria in two (APG, VUEN). Only MS without a TSO is Malta. Related to the transmission system operation activities, some TSOs are in charge of partially operating the grid in the neighbouring country mainly due to practical reasons, such as resources, equipment and better overview, example being Creos' grid (LU) which is operated by both Elia (BE) and Amprion (DE) TSOs.

2.2 The European Network of Transmission System Operators for Electricity (ENTSO-E)

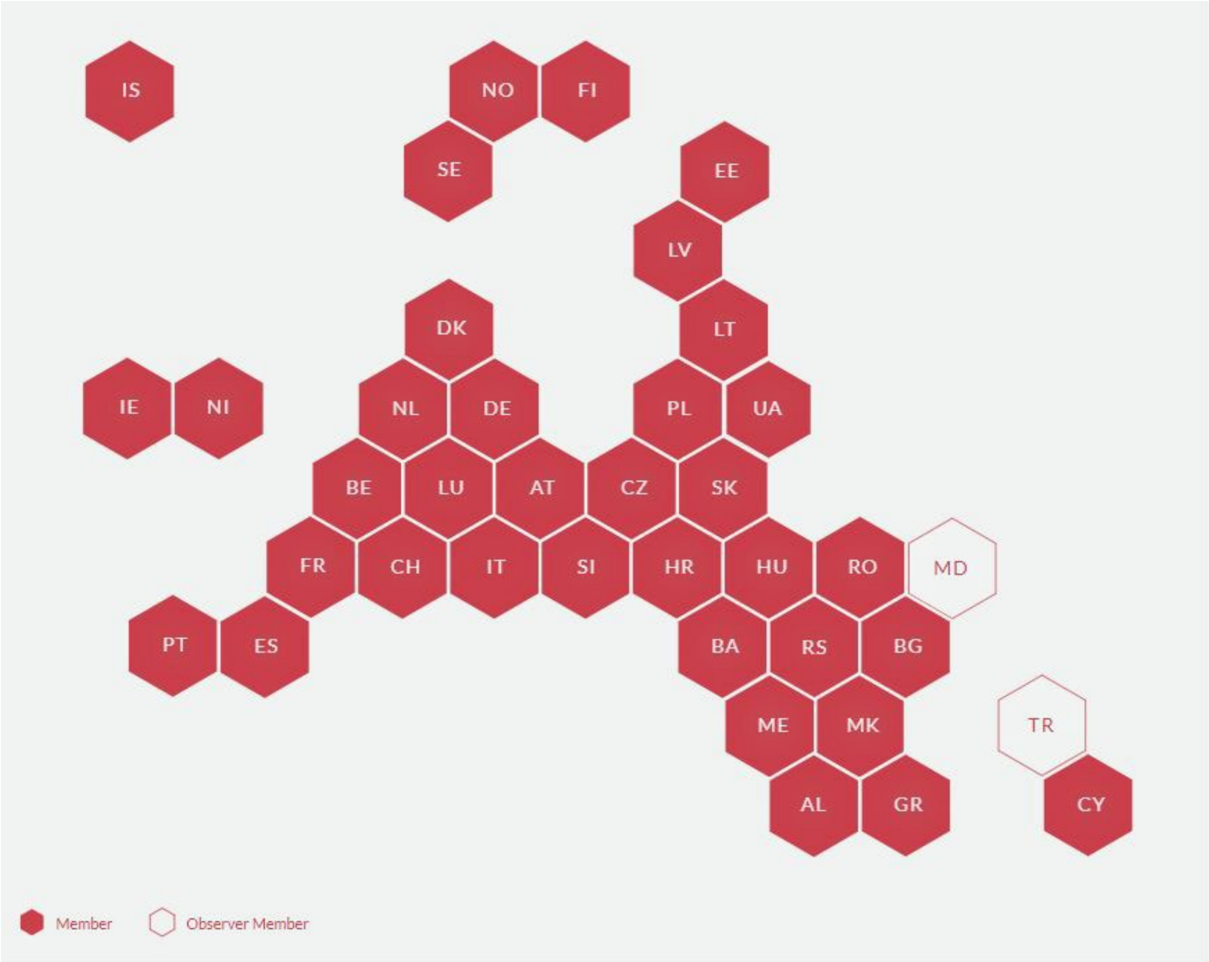
The European Network of Transmission System Operators for Electricity (ENTSO-E) is among other things required to develop network codes and guidelines, platforms and tools to ensure the coordination of the EU's system operators under both normal and emergency conditions (European Court of Auditors, 2023). On the transparency, ENTSO-E, and RCCs, shall operate in full transparency towards stakeholders and the general public. They have to publish all relevant documentation on their respective websites (Electricity Directive). Below is the excerpt on ENTSO-E from the 'Internal market for electricity Regulation (EU) 2019/943' (Further in the text 'Electricity Regulation').

Box 4. ENTSO-E role

"1. Transmission system operators shall cooperate at Union level through the ENTSO-E, in order to promote the completion and functioning of the internal market for electricity and cross-zonal trade and to ensure the optimal management, coordinated operation and sound technical evolution of the European electricity transmission network.

2. In performing its functions under Union law, the ENTSO-E shall act with a view to establishing a well-functioning and integrated internal market for electricity and shall contribute to the efficient and sustainable achievement of the objectives set out in the policy framework for climate and energy covering the period from 2020 to 2030, in particular by contributing to the efficient integration of electricity generated from renewable energy sources and to increases in energy efficiency while maintaining system security. The ENTSO-E shall be equipped with adequate human and financial resources to carry out its duties." (Electricity Regulation, 2019c)

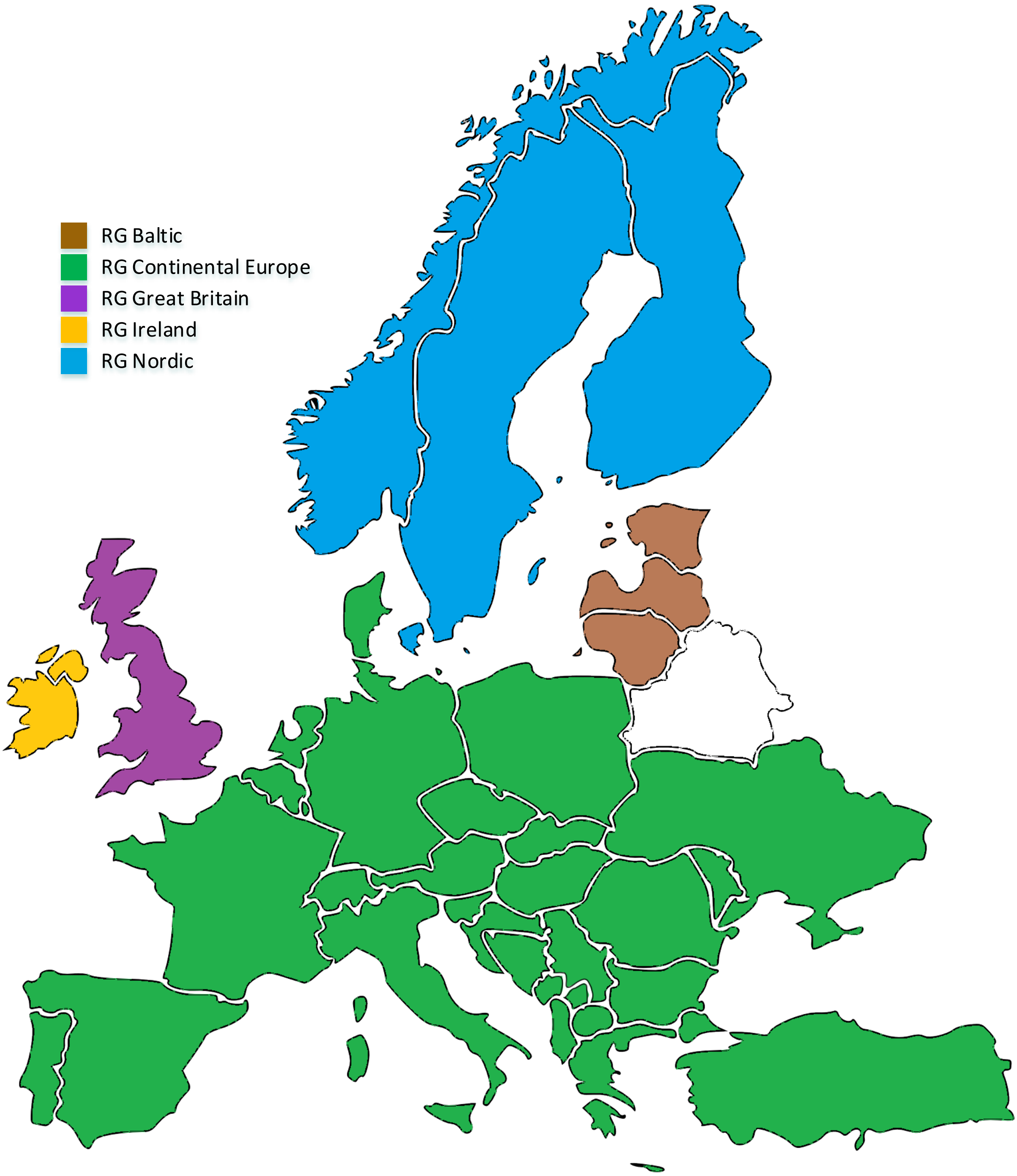
Figure 3. ENTSO-E member and observer member countries



Source: (ENTSO-E, a)

In Figure 3 visual representation of all countries by their country code whose TSO is either member or observer member of ENTSO-E. There are 40 member TSOs from 36 countries, as ENTSO-E obviously extends above EU borders. On 22 November 2023, Moldelectrica, the Moldavian TSO, joined ENTSO-E as Observer Member. In December 2023, Ukrenergo, the Ukrainian TSO, became Member of ENTSO-E after it was successfully synchronized with the Continental Europe regional group (Figure 4) in April 2022. The Observer Membership Agreement passed with TEİAŞ (Turkish TSO) was formalised on 13 December 2022 (ENTSO-E, a).

Figure 4. Synchronous areas of Europe divided in regional groups (RG)



Source: JRC analysis, 2023.

ENTSO-E's operations activities are being monitored by the ENTSO-E System Operations Committee (SOC). The Committee reports to the ENTSO-E Board and Assembly. SOC focuses on the TSOs actions to ensure the secure and optimal real-time operation of the grid, enduring resilience of the transmission system. In addition, SOC serves also as platform for the cooperation between different synchronous areas in Europe (Figure 4). Each synchronous area has a Regional Group which also reports into SOC (Table 3).

Table 3. Countries participating in Regional Groups

Regional Group	Participating Countries
Continental Europe	Austria, Albania, Belgium, Bosnia-Herzegovina, Bulgaria, Czechia, Croatia, Denmark (West), France, Germany, Greece, Hungary, Italy, Luxemburg, Moldova (observer), Montenegro, Netherlands, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Switzerland, Türkiye (observer), Ukraine (observer)
Nordic	Denmark (East), Finland, Norway and Sweden
Baltic	Estonia, Latvia, Lithuania
Ireland/ Northern Ireland	Ireland, Great Britain

Source: (ENTSO-E, b)

The ENTSO-E secretariat supports closely the Regional Group Continental Europe, which is the biggest synchronous area. All SOC activities are closely and in more details followed by Steering Groups (SGs) which are directly reporting into SOC. SG's are usually composed of TSO's and other related entities' employees. The organogram is shown in Figure 5.

Figure 5. Organogram of ENTSO-E's System Operations Committee and its Steering Groups

Source: (ENTSO-E, b)

For the purposes of RCCs, SG Regional Coordination is the Group that focuses on projects related to RCCs and cooperation on a regional level. Steering Group Regional Coordination facilitates, coordinates and develops regional coordination, most notably amongst RCCs and TSOs. The Steering Group steers the business requirements, business development, implementation, rollout and operation of the RCC tasks where a pan-European or cross-regional approach is legally required or is requested by TSOs. For regional RCC tasks, it facilitates cooperation and coordination among the regions and RCCs and monitors the performance of those tasks (ENTSO-E, b).

2.3 EU energy policy and regulatory authorities

2.3.1 European Commission (EC)

In the European Commission (EC), the Directorate-General for Energy (DG ENERGY) is responsible for developing and implementing European energy policy. This includes ensuring the operation of the energy market, ensuring the security of energy supply within the EU, and promoting the interconnection of energy networks (European Court of Auditors, 2023). The Commission's role is to:

- Propose policy documents/strategies and legislative measures as required;
- Enforce compliance with EU law, by checking that the energy packages are correctly transposed into national law and applied effectively by the Member States (MSs);
- Adopt network codes and guidelines.

DG ENER is also convenor of the Electricity Coordination Group (ECG), whose mission is to provide a platform for strategic exchanges between MSs, national regulators, ACER, ENTSO-E and the EC on electricity policy. Its tasks are to assist the EC in relation to the implementation of existing EU legislation, preparation of delegated acts and coordination with MSs on various topics.

2.3.2 National regulatory agencies (NRAs)

National regulatory agencies (NRAs) are established by the national legislator and must be fully independent of national governments. Among other tasks, NRAs are responsible for ensuring domestic compliance with EU network codes and guidelines. NRAs have enforcement powers within their jurisdiction, can carry out investigations, and impose penalties. They also have a general obligation to promote the internal market for electricity within the EU (European Court of Auditors, 2023).

In relation to the duties and powers of regulatory authorities with respect to RCCs, the regional regulatory authority of the system operation region in which RCC is established shall, among other points:

- Approve the cooperative decision-making process;
- Ensure that the RCCs are equipped with all the necessary human, technical, physical and financial resources for fulfilling their obligations under this Directive and carrying out their tasks independently and impartially;
- Propose jointly with other regulatory authorities of a system operation region possible additional tasks and additional powers to be assigned to the RCCs by the Member States of the system operation region;
- Ensure compliance with the obligations under the Electricity Directive and other relevant Union law, in particular as regards cross-border issues, and jointly identify non-compliance of the RCCs with their respective obligations.

Furthermore, for the purposes of carrying out duties in an efficient and expeditious manner, the regulatory authorities shall have at least the following powers:

- to request information from the RCCs;
- to carry out inspections, including unannounced inspections, at the premises of the RCCs;
- to issue joint binding decisions on the RCCs.

In addition to the above, the regional regulatory authority located in the Member State in which an RCC has its seat shall have the power to impose effective, proportionate and dissuasive penalties on the RCC where it does not comply with its obligations under the Electricity Directive (Regulation (EU) 2019/943) or any relevant legally binding decisions of the regulatory authority or of ACER, or shall have the power to propose that a competent court impose such penalties (Electricity Directive, 2019d).

2.3.3 The European Union Agency for the Cooperation of Energy Regulators (ACER)

The European Union Agency for the Cooperation of Energy Regulators (ACER) is an EU agency, which promotes the completion of the internal electricity and gas markets and coordinates the work of NRAs on issues with cross-border relevance. ACER is committed to enable a high-level of security of supply in a cost efficient and non-discriminatory manner (European Court of Auditors, 2023). ACER's tasks include:

- Advising the Commission, ENTSO-E and the NRAs on energy market design and the security of supply,
- Detecting and preventing abuse in trading wholesale energy products, and
- Monitoring how for example network codes / guidelines are implemented in the electricity and gas markets.

ACER also has executive powers to issue decisions in specific areas. These decisions are directly binding on the NRAs or market participants to whom they are addressed. ACER's decision-making body, the Board of Regulators, is composed of representatives from each Member State's NRAs.

As far as RCCs are concerned, their compliance is governed by NRAs, but will at the request of one or more regulatory authorities or at its own initiative, issue a reasoned opinion as well as a recommendation to the RCCs, and if needed also to ENTSO-E, the EU DSO entity, with regard to compliance with their obligations. Where a reasoned opinion of ACER identifies a case of potential non-compliance of an RCC with their respective obligations, the regulatory authorities concerned shall unanimously take coordinated decisions establishing whether there is non-compliance with the relevant obligations and, where applicable, determining the measures to be taken by the RCC to remedy that non-compliance (ACER Regulation, 2019b).

2.3.4 Nominated Electricity Market Operators (NEMOs)

Nominated Electricity Market Operators (NEMOs) are national entities designated by NRAs to ensure that power exchanges in the EU are interconnected and work properly for the day-ahead and intraday timeframes (European Court of Auditors, 2023). CACM Regulation defines them as an entity designated by the competent authority to perform tasks related to single day-ahead or single intraday coupling.

2.4 Other voluntary cooperation structures

2.4.1 Pentalateral Energy Forum (AT, BE, DE, FR, LU, NL)

In the national energy and climate plan (NECP) MSs are also called to describe the efforts in place to establish effective regional agreements with other MSs. In the NECP of Belgium, it dedicates a section to the activities undertaken under the voluntary cooperation with some European countries. In 2015 Belgium, the Netherlands, Luxemburg, France, and Germany set up the Pentalateral energy forum (PLEF), a regional voluntary initiative aimed at fostering actions towards security of supply in the region. Switzerland takes part to the PLEF as an observer. It needs to be acknowledged that the PLEF sets out already some of the elements of the Risk-preparedness Regulation in terms of regional agreements, like for example, the willingness to cooperate to foster safety and security of supply, cross-border cooperation, a better assessment of the costs of the electricity as signals to new investments (Spisto A. et al., 2021).

2.4.2 European Commission's DG Energy – High level groups

Within the European Commission (EC), the mission of the EC's DG Energy High level groups is to provide strategic steering and policy guidance, monitor progress of projects of common interest in priority regions. These groups are (*Source*: DG ENERGY website):

- **The North Seas Energy Cooperation (NSEC)** (BE, DK, FR, DE, IE, LU, NL, NO, SE)
    - The North Sea cooperation framework translates into concrete actions for the common interest of some central and north European Member States to jointly develop wind energy projects. The objectives of this agreement combine a sustainable, secure and affordable offshore renewable energy supply in the North Sea with a cost-effective use of cross-border connection of offshore wind farms to the grid, and on corresponding market arrangements" the Netherlands, Luxemburg, France, Germany, The United Kingdom, Ireland Denmark, Norway and Sweden are part of this initiative, with participation from the European Commission (Spisto A. et al., 2021).
- **Interconnections for South-West Europe** (ES, FR, PT)
    - The overall objective of this group is to ensure regular monitoring of the progress of the key infrastructure projects identified in the Madrid Declaration signed in 2015, by France, Spain, Portugal and European Commission. It also aims to provide adequate support to avoid potential delays in the implementation of the projects of key importance.

- To integrate the Iberian Peninsula the group aims to:
    - Raise the capacity of electricity exchanges between Spain and France to 8000 MW in 2020 (as of 2023, the exchange capacity between Spain and France is 2800 MW, expected to increase to 5000 MW by 2027[1]);
    - Carry out assessments in order to complete the Eastern gas axis between Portugal, Spain and France;
    - Ensure that the projects identified in the Madrid Declaration are implemented in a timely manner.

— **Central and South Eastern Europe energy connectivity (CESEC)** (AT, BG, HR, GR, HU, IT, RO, SK, SI)

- The Central and South Eastern Europe energy connectivity (CESEC) project is an initiative aimed at accelerating to integration of gas and electricity markets in the South Eastern European Region. The CESEC high-level working group was set up by Austria, Bulgaria, Croatia, Greece, Hungary, Italy, Romania, Slovakia and Slovenia and the EU in February 2015.
- The aims of the group include:
    - Coordinating efforts to facilitate the swift completion of cross-border and trans-European projects that diversify gas supplies to the region;
    - Developing regional gas markets and implement harmonised EU rules to ensure the optimal functioning of the energy infrastructure;
    - Consider a joint approach on electricity markets, energy efficiency and renewable development;
    - A list of priority projects to build an interconnected regional electricity market;
    - Specific actions to boost renewables and investment in energy efficiency in a region with vast growth potential in these areas.

— **Baltic Energy Market interconnection Plan (BEMIP)** (DK, DE, ES, LV, LT, PL, FI, SE)

- The primary objective of the Baltic energy market interconnection plan (BEMIP) High-Level Group is to achieve an open and integrated regional electricity and gas market between EU countries in the Baltic Sea region. The BEMIP also aims to end energy isolation in the Baltic region. The BEMIP members are Denmark, Germany, Estonia, Latvia, Lithuania, Poland, Finland and Sweden. Norway participates as an observer.
- The first Memorandum of Understanding (MoU) on the BEMIP initiative was signed on 17 June 2009 and focused on electricity and gas markets, infrastructure and power generation. As the three Baltic States' electricity grid still operates synchronously with the Russian and Belarusian systems, a dedicated BEMIP working group steers the work to achieve, by February 2025, the synchronisation of the Baltics' grid with the continental European network.
- On 30 September 2020, the Energy Ministers for the 8 EU countries in the Baltic Sea region and DG ENER Commissioner signed a declaration committing themselves to closer cooperation on offshore wind in the Baltic Sea. On 28 October 2021, the BEMIP high-level group adopted a work programme for offshore wind development in the region, kick-starting the implementation of this programme by establishing the BEMIP Offshore Wind Working Group.

2.4.3 Energy Community

The Energy Community is an international organisation which brings together the European Union and its neighbours to create an integrated pan-European energy market. The organisation was founded by the Treaty establishing the Energy Community signed in October 2005 in Athens, Greece, in force since July 2006. The key objective of the Energy Community is to extend the EU internal energy market rules and principles to countries in South East Europe, the Black Sea region and beyond on the basis of a legally binding framework.

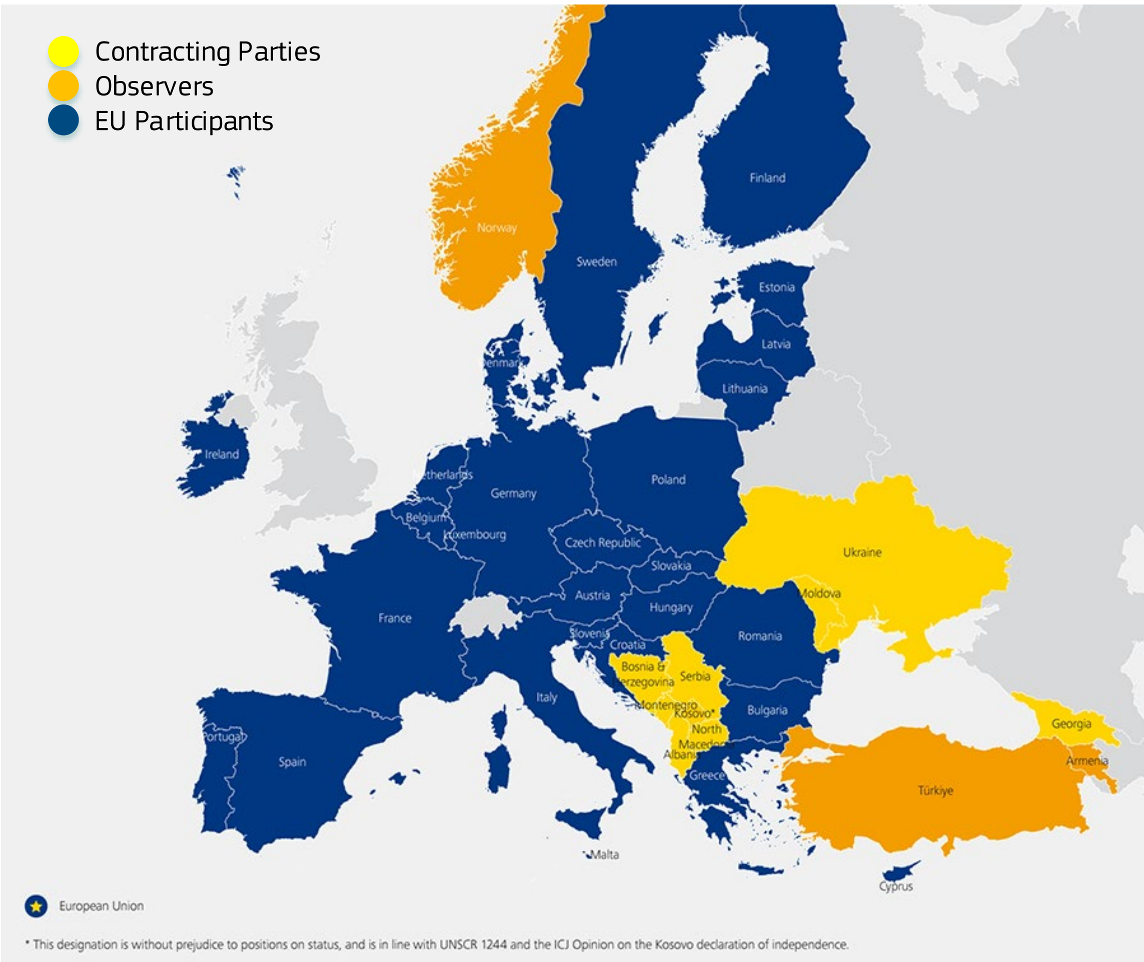
[1] https://www.euractiv.com/section/electricity/news/france-spain-announce-breakthrough-in-undersea-power-link/, https://energy.ec.europa.eu/system/files/2022-12/Infrastructure_factsheet_WestEurope.pdf

The Energy Community has nine Contracting Parties - Albania, Bosnia and Herzegovina, Kosovo[2], North Macedonia, Georgia, Moldova, Montenegro, Serbia and Ukraine. Armenia, Norway and Türkiye take part as Observers (Figure 6.) (*Source*: Energy Community website).

The mission of the Energy Community Treaty is to:

- Establish a stable regulatory and market framework capable of attracting investment in power generation and networks;
- Create an integrated energy market allowing for cross-border energy trade and integration with the EU market;
- Enhance the security of supply to ensure stable and continuous energy supply that is essential for economic development and social stability;
- Improve the environmental situation in relation with energy supply in the region and foster the use of renewable energy and energy efficiency; and
- Develop competition at regional level and exploit economies of scale.

Figure 6. Energy Community membership map



Source: (Energy Community)

[2] This designation is without prejudice to positions on status, and is in line with the UNSCR 1244 and the ICJ Opinion on the Kosovo declaration of independence.

2.4.4 Med-TSO

An interesting example of cooperation between EU MSs and Southern and Eastern Mediterranean countries is Med-TSO an association of TSOs of the Mediterranean Sea operating the High Voltage Transmission Networks of 19 Mediterranean Countries. They cooperate on the integration of the regional power systems. The activity of Med-TSO is supported by the European Union.

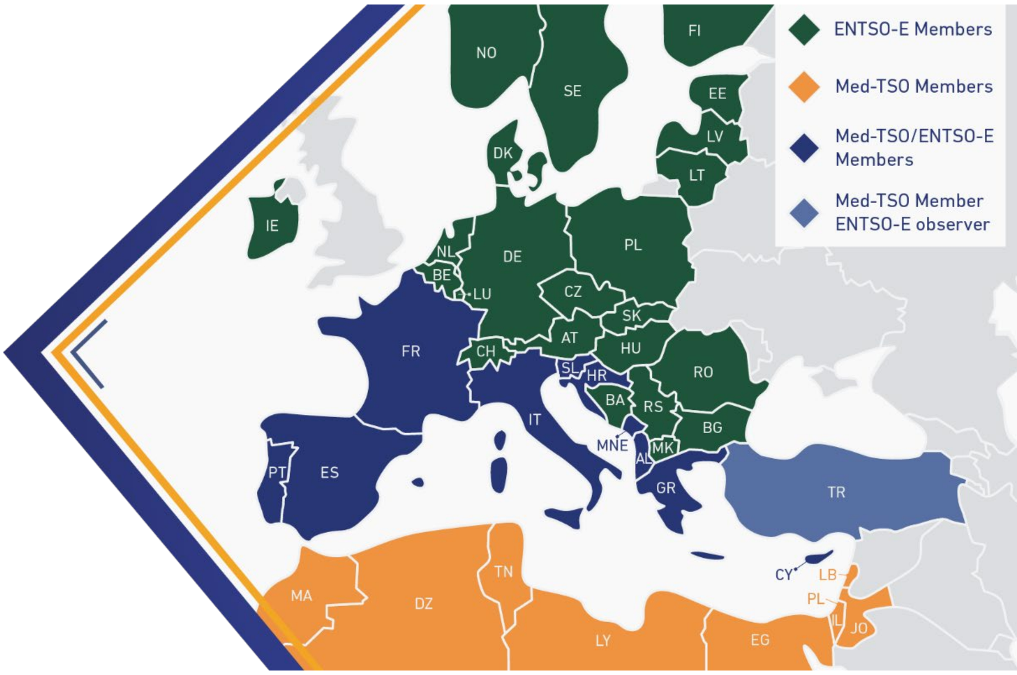
Med-TSO member countries (TSOs) are: Albania (OST), Algeria (SONELGAZ), Croatia (HOPS), Cyprus (TSOC), Egypt (EETC), France (RTE), Greece (IPTO), Israel (IEC), Italy (TERNA), Jordan (NEPCO), Lebanon (EDL), Libya (GECOL), Montenegro (CGES), Morocco (ONEE), Palestine (PETL), Portugal (REN), Slovenia (ELES), Spain (REE), Tunisia (STEG), Türkiye (TEIAŞ) (Figure 7.).

They share the primary objective of promoting the creation of a Mediterranean energy market, ensuring its optimal functioning through the definition of common methodologies, rules and practices for optimizing the operation of the existing infrastructures and facilitating the development of new ones (*Source*: Med-TSO website).

Med-TSO contributes to the achievement of this objective by promoting:

- The coordination among the Med-TSO Countries of their National Transmission Network Development Plans and of their Power System operation, studying the development of an integrated, secure and sustainable Mediterranean Power System and promoting cross-border projects aiming at facilitating the integration of new energy sources (especially from RES), increasing security and quality of power supply;
- The use of common criteria and harmonized, transparent and non-discriminatory technical rules for guaranteeing the interoperability of the interconnected Power Systems;
- Training, knowledge sharing and technical assistance in the Region, facilitating the exchange of information, analyses and experiences among the Associates, including the R&D sector;
- Enhanced communication and consultation with stakeholders for improving TSOs operation transparency and facilitating the public acceptance of transmission infrastructures;
- The cooperation among the Mediterranean TSOs and coordinated approach towards the Institutions (in particular with the association of the Mediterranean Regulators for energy, MEDREG, ENTSO-E);
- The role of TSOs at regional level, analysing and taking common positions on issues that can have an impact on the development and operation of transmission systems.

Figure 7. Med-TSO membership map

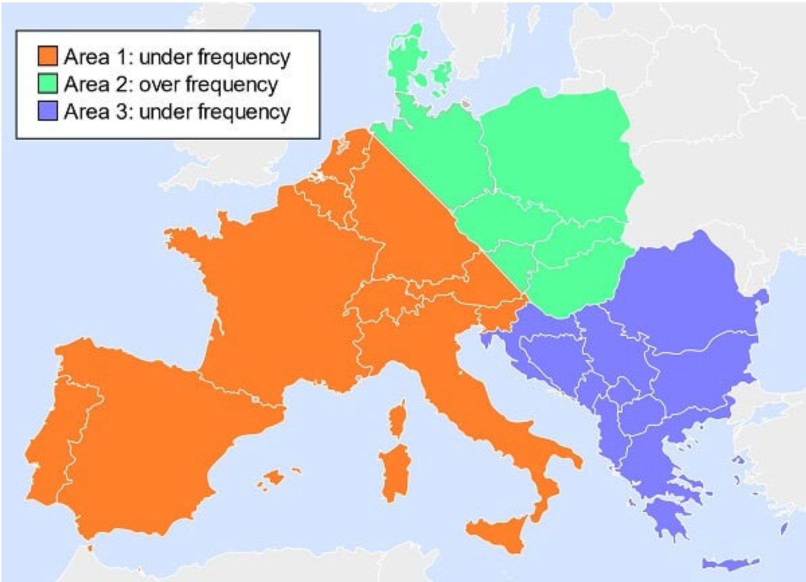


Source: (Med-TSO)

3 Establishment of RCCs and legal framework

Following a significant power disruption in Europe on 4 November 2006, 15 million people were left without power when the synchronous area of Union for the Co-ordination of Transmission of Electricity (UCTE) (now known as Continental Europe) was divided into three frequency sub-areas (Figure 8.). This happened due to a lack of coordination between Transmission System Operators (TSOs) in the Central Western Europe (CWE) area. The European Commission, together with TSOs, started to look into ways to improve coordination between TSOs to guarantee the safe operation of the interconnected system with a view to maintaining security of electricity supply.

Figure 8. UCTE area split on 4 November 2006.



Source: SCC

The outcomes of the 2006 European blackout investigation, as well as the continued increase in cross-border exchanges and variable power from Renewable Energy Sources (RES), were the main reasons for some EU TSOs to improve operational coordination by establishing Regional Security Coordination Initiatives (RSCIs) (*Source:* SCC website).

In 2008, two RSCIs were established on voluntary basis – Coreso in West Europe and TSCNET in Central Europe, established in Brussels, Belgium and Munich, Germany, respectively. RSCIs were the forerunners of today's Regional Security Coordinators (RSCs), while Coreso and TSCNET are the pioneers in terms of regional coordination between TSOs in Continental Europe. They were followed by Security Coordination Centre (SCC), which started its operation in Belgrade in 2015. On 10 December 2015, ENTSO-E TSOs signed a Multilateral Agreement on Participation in RSCIs (RSCI MLA) that required all TSOs to participate in RSCs in order to receive five core services from them Common Grid Model, Security Analysis, Capacity Calculation, Outage Planning Coordination and Short and Medium Term Adequacy Assessment (Figure 9.). This event caused the creation of two new RSCs during 2016: Baltic RSC, headquartered in Tallinn, Estonia, and Nordic RSC, Copenhagen, Denmark, which covered regions of the same name.

Figure 9. Five core RSC services

Source: TSCNET

In the mid-2017, RSCs are recognised by EU law, when the SOGL Regulation, one of the main EU network codes, was implemented. In May 2020, the last RSC to join the group was SEleNe CC (Southeast Electricity Network Coordination Center) based in Thessaloniki, Greece. With the establishment of SEleNe CC total number of RSCs in Europe was six (Source: SCC website). Following the approval of the regulatory authorities in the EU, on 1 July 2022, RCCs replaced the regional security coordinators (RSCs) pursuant to the SOGL Regulation and were pursuant to Article 35 of the Electricity Regulation. Furthermore, services were renamed tasks, and increased from the initial five to now sixteen (which will be presented in the next chapters of the report). This does not include SCC, which resides in Europe but is not yet part of the EU, thus technically it is still considered an RSC (Table 4). Today RCCs (and RSC) are one of the main entities in the EU transmission system operation, alongside TSOs and ENTSO-E.

Table 4. European RCCs and RSC

	RCCs / RSC	In function since	Headquarters
1.	**Baltic RCC**	2016	Tallinn, Estonia
2.	**Coreso**	2008	Brussels, Belgium
3.	**Nordic RCC**	2016	Copenhagen, Denmark
4.	**SCC RSC**	2015	Belgrade, Serbia
5.	**SEleNe CC**	2020	Thessaloniki, Greece
6.	**TSCNET Services**	2008	Munich, Germany

Source: JRC analysis, 2023.

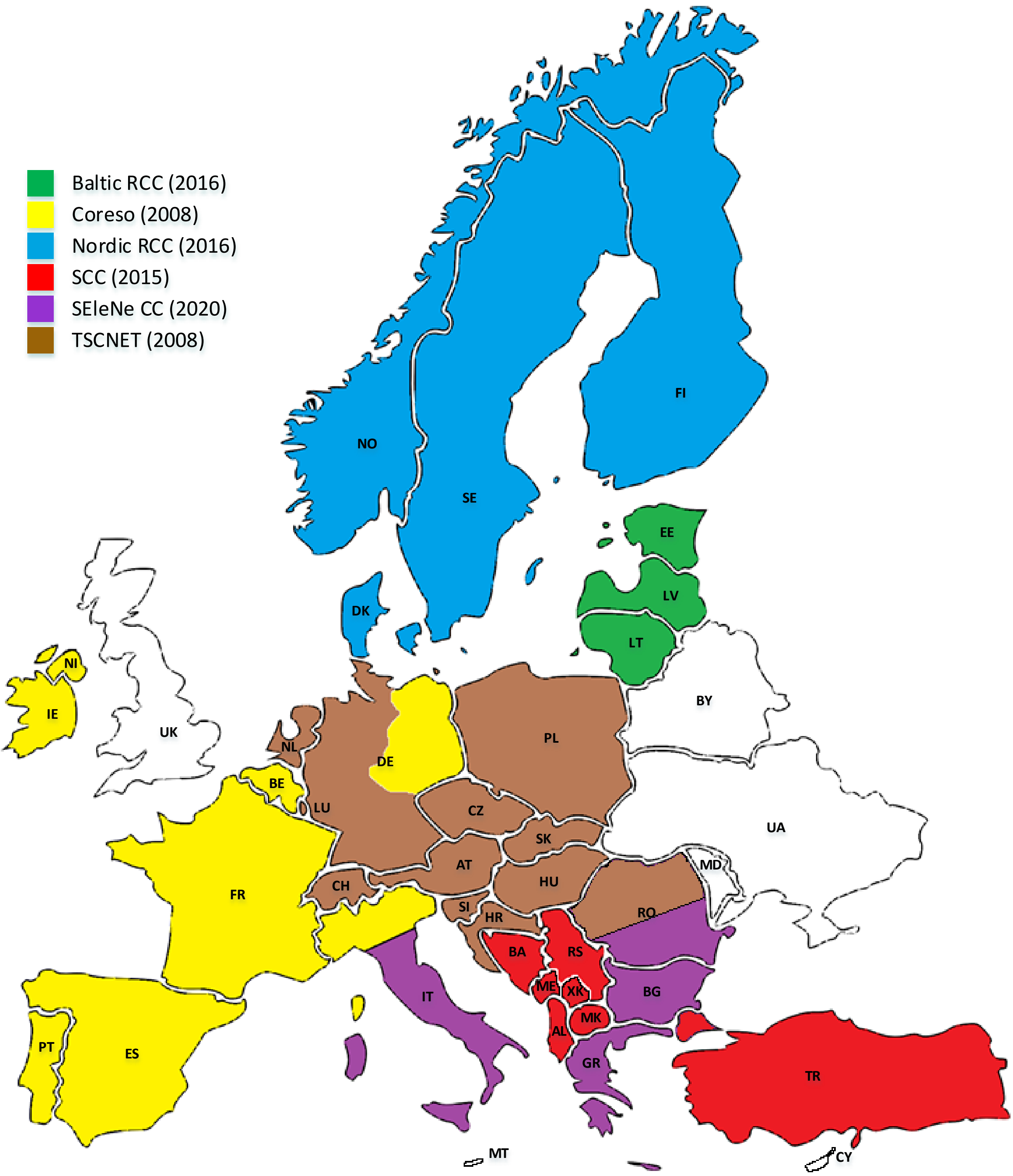
It was also mandated that in performing their tasks under EU legislation, RCCs should act independently of individual national interests and independently of the interests of TSOs. RCCs will complement the role of TSOs by performing tasks of regional relevance that were assigned to them. TSOs will however be responsible for managing electricity flows, taking into account exchanges with other interconnected systems and ensuring a secure, reliable and efficient electricity system. The detailed list of all related EU legislative acts, methodologies, guidelines and links guiding to each document is laid out in the Table 25. in Annex, which will be pointed out to a number of times further in the report.

4 Geographical scope of RCCs and operational timeframes

In this chapter *when* and *where* of the RCCs will be roughly introduced. On the map of Europe in Figure 10 it is shown which countries and their respective TSOs are shareholders and/or service users of which RCC, according to the information provided by RCCs on their websites. As stated earlier, SCC is still technically an RSC as it is not yet based in the EU, however it is worthy to mention it below.

- **Baltic RCC** is evidently operating in the Baltic countries in the Baltic synchronous area covering AST (LV), Elering (EE) and Litgrid (LT) TSO's.
- By being situated in Brussels, **Coreso** took over a role of regional coordination of most West and Southwest European TSOs, these being 50 Hertz (DE), EirGrid (IE), Elia (BE), National Grid ESO (UK), REE (ES), REN (PT), RTE (FR), SONI (NI) and Terna (IT).
- **Nordic RCC** takes care of Scandinavian TSOs Energinet (DK), Statnett (NO) and Svenska Kraftnät (SE) including Fingrid in Finland, latter three being part of Nordic synchronous area and Denmark part of Continental Europe.
- Western Balkan TSO's namely EMS (RS), CGES (ME), NOS BIH (BA) and OST (AL) use services of **SCC RSC**, and on the far Southeast Turkish TSO TEIAŞ also benefits from SCC as a service user.
- Rest of the Southeast Europe is covered with **SEleNe CC**, the youngest RCC, which gathers ESO (BG), IPTO (GR/EL), Terna (IT) TSOs. The latter is also part of Coreso which is due to the different regional inclusion of which more will be shown later in the report. Since official RCC establishment, Transelectrica (RO) still benefits from SEleNe CC as a service user.
- **TSCNET** involves the rest of the mostly Central European TSOs such as: 50 Hertz (DE) (also part of Coreso), Amprion (DE), APG (AT), Creos (LU), ČEPS (CZ), ELES (SI), HOPS (HR), MAVIR (HU), PSE (PL), SEPS (SK), Swissgrid (CH), TenneT (DE), TenneT (NL), TransnetBW (DE), Transelectrica (RO), and VUEN (AT).

Figure 10. RCC and RSC coverage map



Source: JRC analysis, 2023.

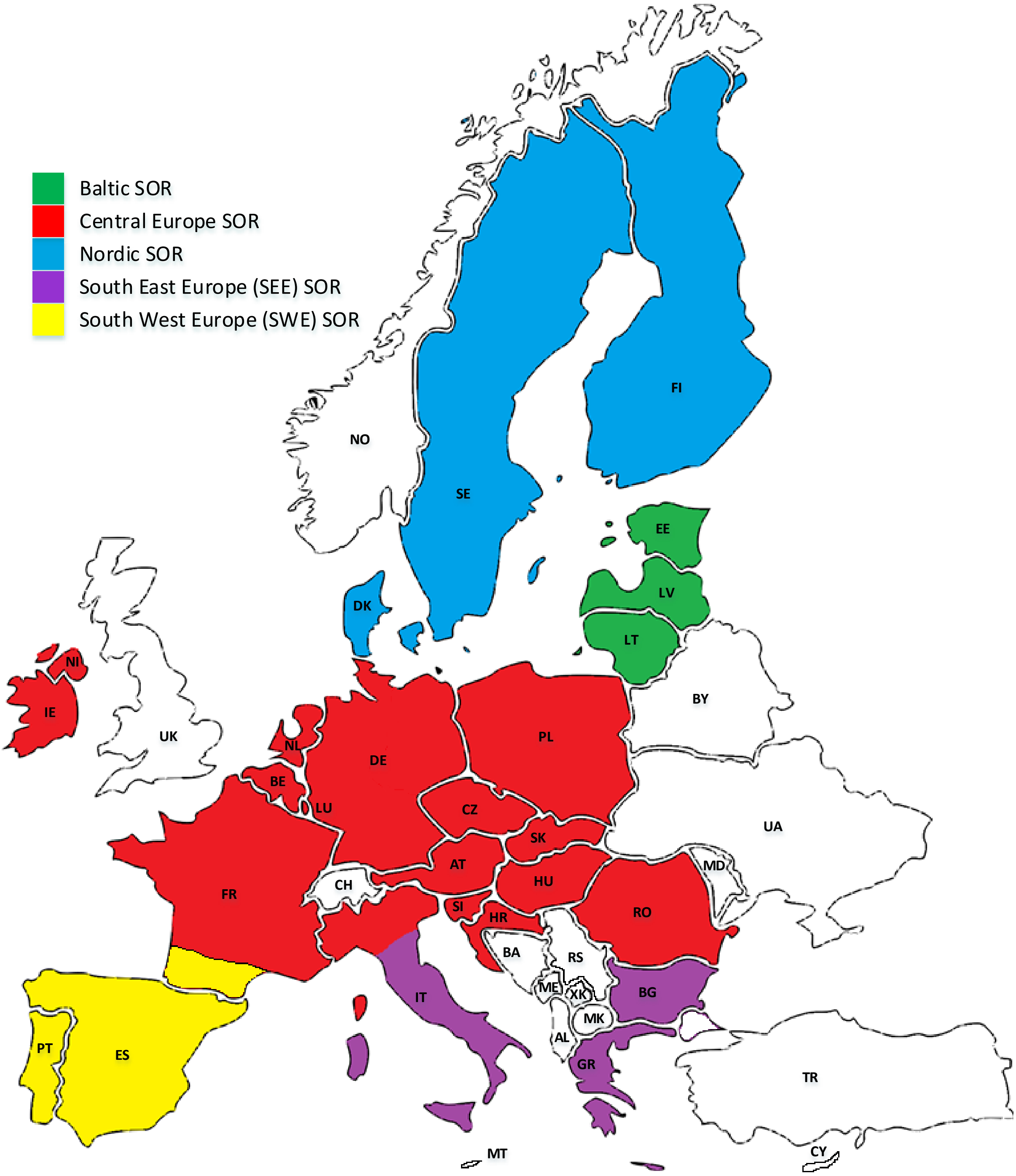
4.1 System Operation Regions (SORs)

Based on the ACER's Decision on SO, Definition of System Operation Regions (No. 27 of Table 25. Annex), in accordance with the Electricity Regulation, system operation regions (SOR) are defined taking into account grid topology, degree of interconnection and interdependency of the electricity system in terms of flows and the size of the region covering at least one capacity calculation region (CCR). SORs include TSOs that have been designated or assigned with responsibilities which are relevant for system operation, such as, but not limited to: calculation of cross-border capacities, assessment of needed remedial actions to ensure security of the whole system, coordination of all the outages to ensure security of supply and efficiency, adequacy assessment and tasks related to the provision of system balancing (ACER, 05/2022).

TSOs of a SOR participate in and use services of the Regional Coordination Centre (RCC) established in that region, except where the control area of a TSO is part of various synchronous areas (Figure 4.) TSO may participate in two RCCs. For the Continental Europe synchronous area, where the activities of two RCCs may overlap in a SOR, the TSOs of that SOR shall decide to either designate a single RCC in that region to perform certain tasks or the two RCCs will carry out some or all of the tasks of regional relevance in the entire SOR on a rotational basis, while other tasks are carried out by a single designated RCC (Electricity Regulation, 2019c). As of 2022, there are five SORs in Europe (Figure 11.):

1. Baltic
2. Central Europe
3. Nordic
4. South East Europe (SEE)
5. South West Europe (SWE)

Figure 11. System Operation Regions (SORs) in Europe (EU)



Source: JRC analysis, 2023.

4.2 Capacity Calculation Regions (CCRs)

Box 5. Relevant definitions – CCRs

(21) 'Capacity calculation region' means the geographic area in which the coordinated capacity calculation is applied (Electricity Regulation, 2019c);

(65) 'Bidding zone' means the largest geographical area within which market participants are able to exchange energy without capacity allocation (Electricity Regulation, 2019c);

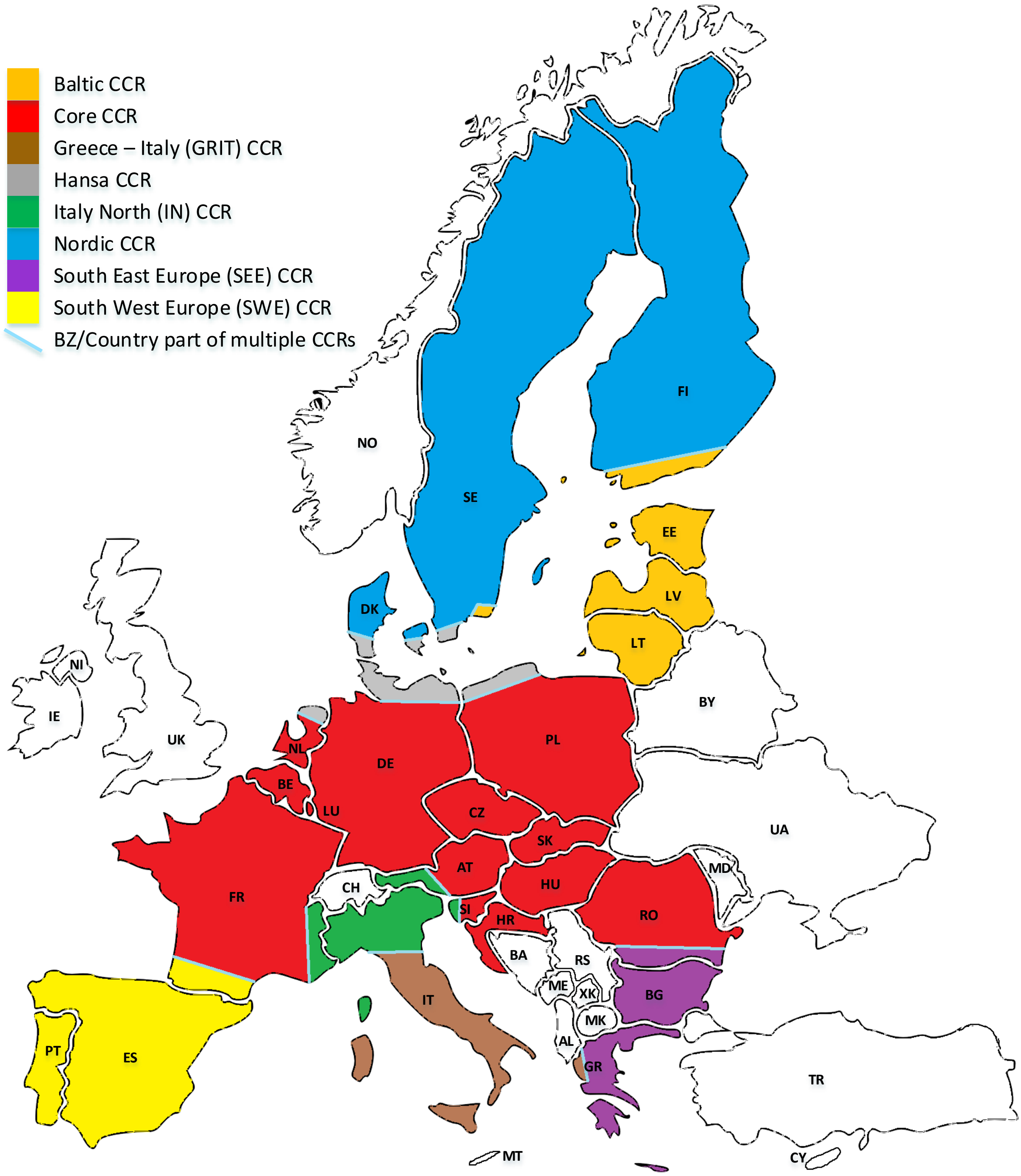
As defined in ACER's Decision 04/2021 on Determination of Capacity Calculation Regions (No. 27 of Table 25. Annex), as of 2022 there are 8 capacity calculation regions (CCRs) in Europe and these are (Figure 12):

1. Baltic
2. Core[3]
3. GRIT
4. Hansa
5. Italy North[3]
6. Nordic
7. South-East Europe (SEE) and
8. South-West Europe (SWE).

All EU member states (MSs), and their respective Bidding Zones (BZs), are part of at least one CCR. Those that have been included in multiple CCRs are mostly due to geographical position (e.g. France, Denmark and Romania) or economical-high capacity reasons (e.g. Italy). MSs that are part of three CCRs are: France (Core, Italy North and SWE), Poland (Baltic, Core and Hansa), and Sweden (Baltic, Hansa, Nordic); MSs that are part of two CCRs are: Austria (Core and Italy North), Denmark (Nordic and Hansa), Finland (Nordic and Baltic), Germany (Core and Hansa), Greece (SEE and GRIT), Italy (Italy North and GRIT), and The Netherlands (Core and Hansa), while all the rest are part of one single CCR.

[3] Based on their Decision No 04/2024, ACER has approved the amendments to the Core and Italy North CCRs. The Core and Italy North CCRs will be merged and form a new CCR called Central Europe. Initially, this merger will only apply to the day-ahead capacity calculation process. It will improve the coordination and efficiency of capacity calculation and allocation processes in continental Europe. For this to become operational, The TSOs have to submit the day-ahead flow-based capacity calculation methodology for the newly formed Central Europe CCR by January 2025.

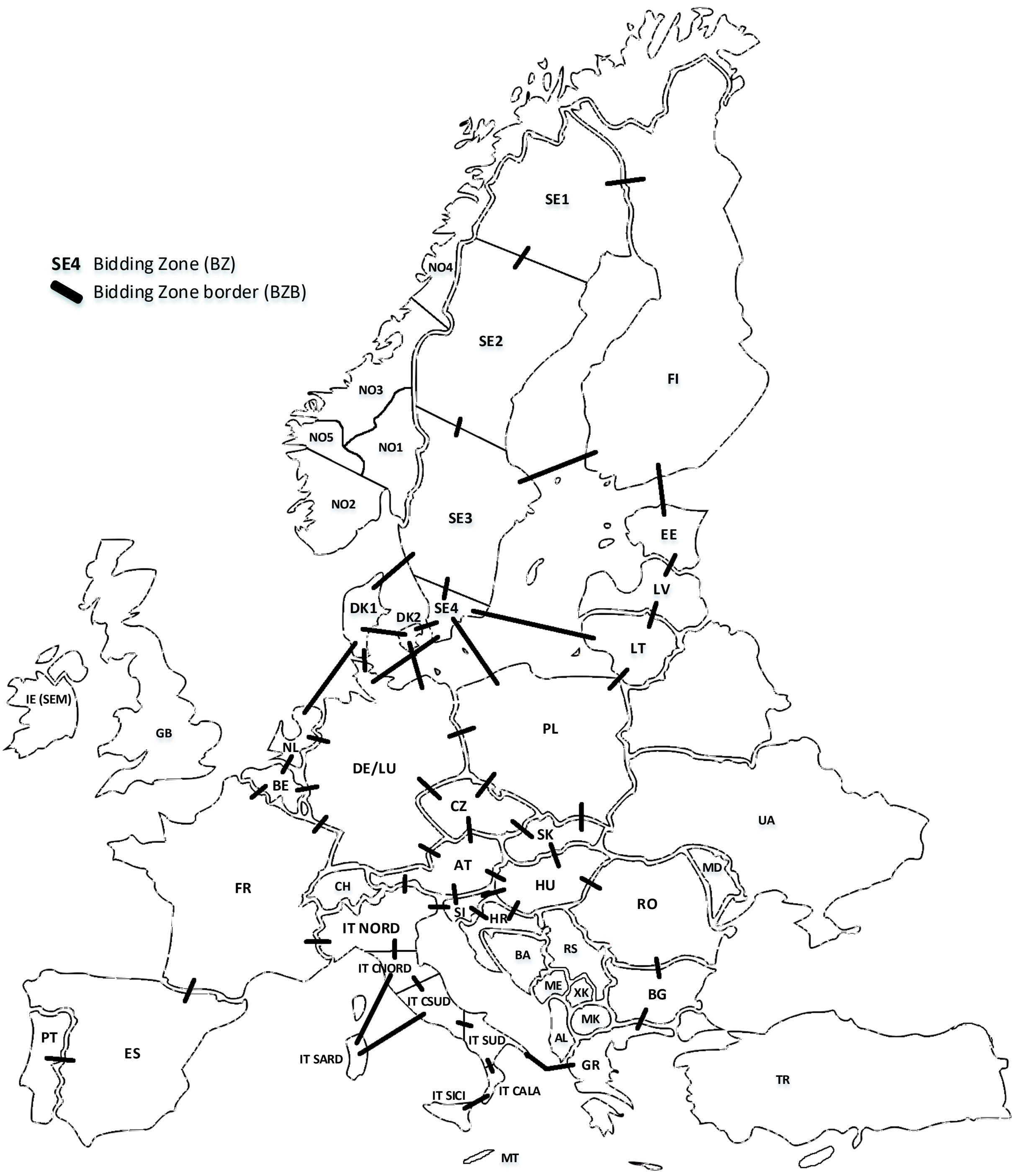
Figure 12. EU Member States divided in Capacity Calculation Regions (CCRs)



Source: JRC analysis, 2023.

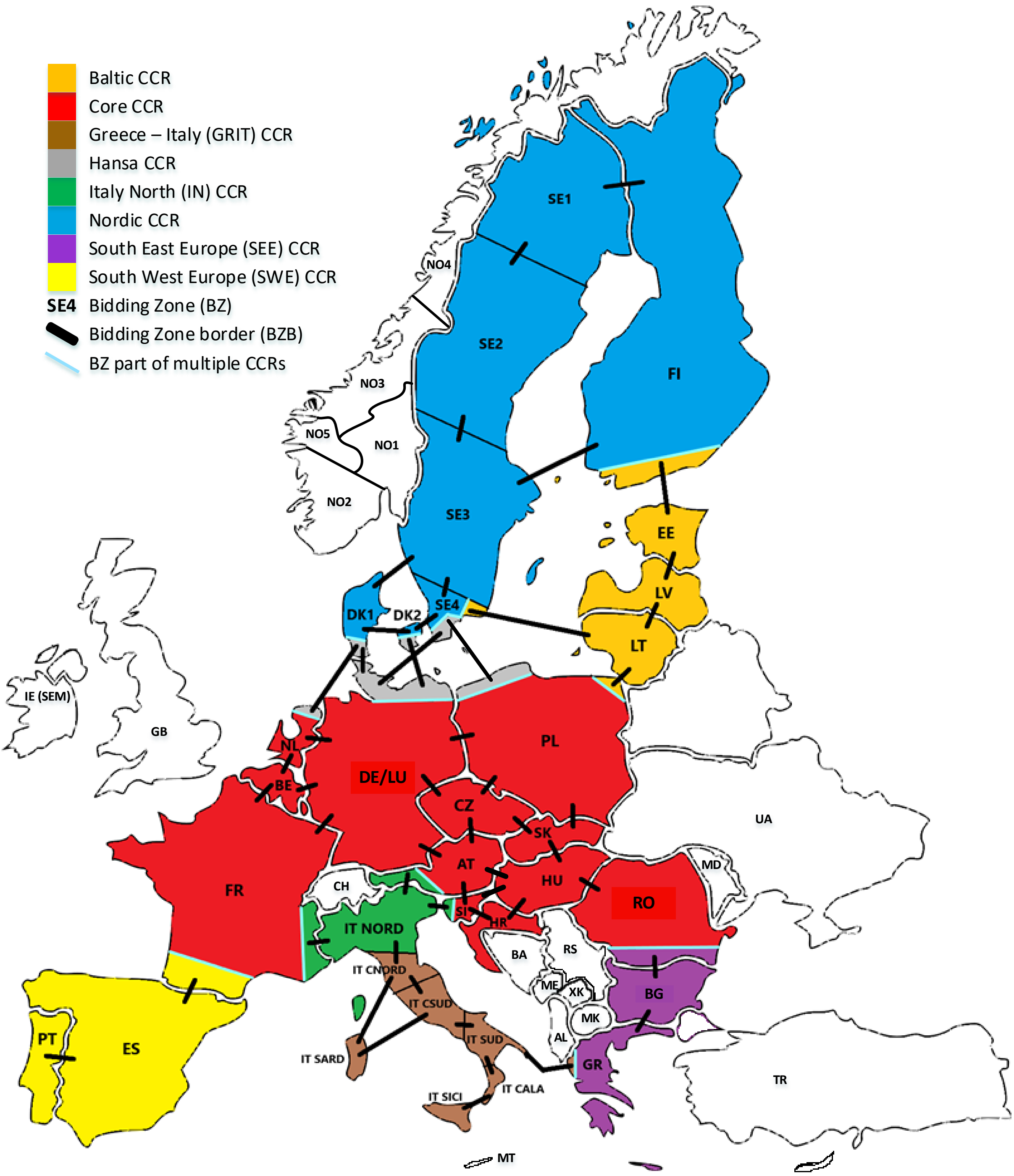
Related to the market participation, BZs in Europe are mostly defined by national borders. However, the existing European electricity target model requires defining bidding zones based on network congestions. Some MSs are divided in multiple BZs such as Italy in seven (North, Central North, Sardinia, Central South, South, Calabria and Sicily), Denmark in two and Sweden in four. Due to simplicity Germany and Luxembourg are conjoined into one BZ DE/LU (Figure 13.). A CCR further defines the set of bidding zone borders (BZBs) among which the tasks of capacity calculation are coordinated by the TSOs. Figure 14 then consolidates all CCRs, BZs and BZBs and their division between MSs.

Figure 13. Bidding Zones (BZs) in Europe and borders between Member States' BZs



Source: JRC analysis, 2023.

Figure 14. Capacity Calculation Regions (CCRs), Bidding Zones (BZ) and Bidding Zone Borders (BZBs) in Europe



Source: JRC analysis, 2023.

4.3 Operational and market timeframes

After introducing *where* the RCCs have been performing their tasks, before giving an overview on all RCC tasks, it is of utmost importance to introduce *when* of the tasks. All actors in the power transmission system operation – ENTSO-E, TSOs and RCCs – operate and perform tasks in multiple timeframes. However, most of the operational planning can be divided in three general types, long-, medium- and short-term, which consists of eight operational planning timeframes prior to the real-time (RT) operation (Figure 15):

- Long-term:
  1. Ten-year-ahead (10YA)
- Medium-term:
  2. Year-ahead (YA)
  3. Six-months-ahead (6MA)
- Short-term:
  4. Month-ahead (MA)
  5. Week-ahead (WA)
  6. Day-ahead (DA)
  7. Intraday (ID)
  8. Close to real-time (C2RT)

Figure 15. Operational planning timeframes

Source: JRC analysis, 2023.

In order to understand which timeframe describes the considered interval, few definitions can be found in the Box 6 below. *Time_period*-ahead explains as the *time_period* prior to the calendar *time_period* of operation.

Box 6. Relevant definitions – Operational Timeframes

(92) 'Week-ahead' means the week prior to the calendar week of operation (SOGL Regulation, 2017a);

(93) 'Year-ahead' means the year prior to the calendar year of operation (SOGL Regulation, 2017a);

For example, if the adequacy of the system has to be calculated in the day-ahead timeframe, it means that the planning and performing of the task will occur on the day before the operational day, i.e. today for tomorrow. Same works for all other time periods.

Related to the concept of electricity market timeframes an overview can be seen in Figure 16. In sequential order, energy can be traded from year(s) before the delivery (Forward and Future Markets) up to the day before the actual delivery (Day-ahead market) and between the day-ahead market the delivery of electricity (Intraday Markets). While in the day-ahead market energy is traded one day before real time, the intraday market enables market participants to correct their nominations on the delivery day itself.

Other definitions extracted from related EU legislative acts can help clarify some shorter-term market timeframes, such as the day-ahead, intraday and close to real-time.

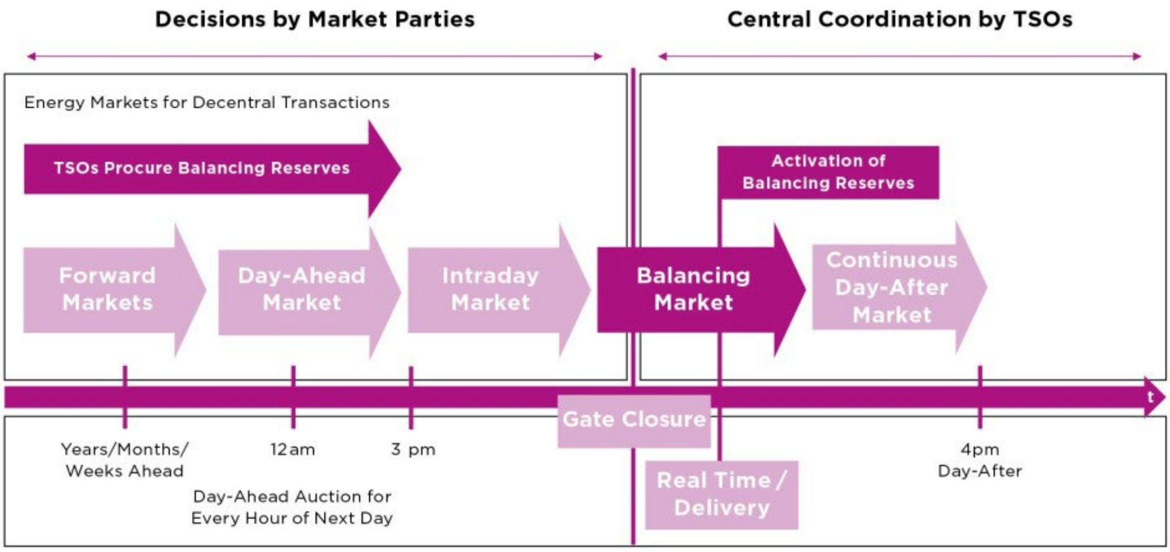
Box 7. Relevant definitions – Market timeframes

34. 'day-ahead market time-frame' means the time-frame of the electricity market until the day-ahead market gate closure time, where, for each market time unit, products are traded the day prior to delivery (CACM Regulation);

37. ‘intraday market time-frame’ means the time-frame of the electricity market after intraday cross-zonal gate opening time and before intraday cross-zonal gate closure time, where for each market time unit, products are traded prior to the delivery of the traded products (CACM Regulation, 2015);

(72) ‘Close to real-time’ means the time lapse of not more than 15 minutes between the last intraday gate closure and real-time (SOGL Regulation, 2017a);

Figure 16. Overview of different timeframes of the wholesale and balancing markets



Source: (Amprion)

5 Tasks of Regional Coordination Centres

As of 1 July 2022, Regional Coordination Centres (RCCs) became regulated entities having to progressively meet additional requirements to those already established for the Regional Security Coordinator (RSC), as set out in the Electricity Regulation. One of the keystones of becoming an RCC, is the responsibility to fully implement and execute new tasks overtime (in an RSC so called ‘services’) in addition to five historical core tasks. The entry into force of the RCC does not imply the implementation of all new tasks by 1 July 2022, but an implementation schedule is foreseen for these additional tasks. In conclusion:

— Five historical core tasks: Coordinated Capacity Calculation, Coordinated Security Analysis, Common Grid Model, Outage Planning Coordination and Short-Term Adequacy Assessment.

— Regarding the new (11) tasks, ENTSO-E is mandated to develop a proposal for each of these, and to submit them to the Agency for the Cooperation of Energy Regulators (ACER). As of November 2022, seven of them have been already submitted (2 of them in implementation stage), while 4 methodologies are still in development. The timeframe for the implementation of the new tasks will be set out in each of the approved proposals (Coreso, 2022).

The TSOs have to provide RCCs with the information necessary to carry out their tasks. On the other hand, RCCs have to provide TSOs of the SOR with all the information necessary to implement the coordinated actions and recommendations issued by them. TSOs have to develop the procedure to revise and adopt coordinated actions and recommendations made by RCCs, which have to adopted with certain exceptions and obligations based on Article 42 of Electricity Regulation. More on this can be found at the end of this chapter introduction.

As defined in Article 37.1 [(a) to (p)] and Annex I [(1) to (16)] of the Electricity Regulation each RCC is carrying out, at least, the following tasks of regional relevance in the entire SOR where it is established, set out in Table 5.

Table 5. List of RCC tasks

No.	Tasks of Regional Coordination Centres (RCCs)	Category by operational activity	Timeframe	Methodology development status	Degree of implementation in an RCC process*
1-a	Coordinated capacity calculation (CCC)	CA	DA and ID	Developed	High
2-b	Coordinated security analysis (CSA)	OS	DA and ID	Developed	High
3-c	Creation of common grid models (CGM)	OP	YA to ID	Developed	High
4-d	Supporting the TSOs in defence and restoration plans’ consistency assessment	OP	Upon submission from TSOs	Developed	Medium
5-h	Supporting the TSOs in the coordination of regional restoration	OS	C2RT. Upon request from TSOs.	In development	Unknown
6-i	Post-operation and post-disturbances analysis and reporting	Other	Conditional. Upon request from TSOs.	Developed	Medium
7-j	Regional sizing of reserve capacity	CA	DA and/or ID	In development	Unknown
8-k	Facilitating the regional procurement of balancing capacity	CA	DA and/or ID	In development	Unknown
9-e	Short-term adequacy (STA) assessment	SA	WA to DA	Developed	High
10-f	Regional outage planning coordination (OPC)	OP	YA, (MA), WA	Developed	High
11-l	Supporting the TSOs in the inter-	Other	Upon request	Developed	Unknown

	transmission system operators settlements		from TSOs		
12-g	Training and certification of RCC staff	Other	When needed	Developed	Medium
13-m	Tasks related to identification of regional electricity crisis scenarios	OP	Upon request from ENTSO-E. Every 4 years.	Developed	Unknown
14-p	Identification of needs for new transmission capacity and supporting the ten-year network development plan (TYNDP)	OP	Upon request from TSOs. Every 2 years.	In development	Unknown
15-o	Calculation of maximum entry capacity for foreign capacity	CA	Upon request from TSOs	Developed	Unknown
16-n	Tasks related to the seasonal adequacy assessments	SA	Upon request from ENTSO-E. Two times per year.	Developed	Unknown

Source: JRC analysis, 2023.

*status in June 2022

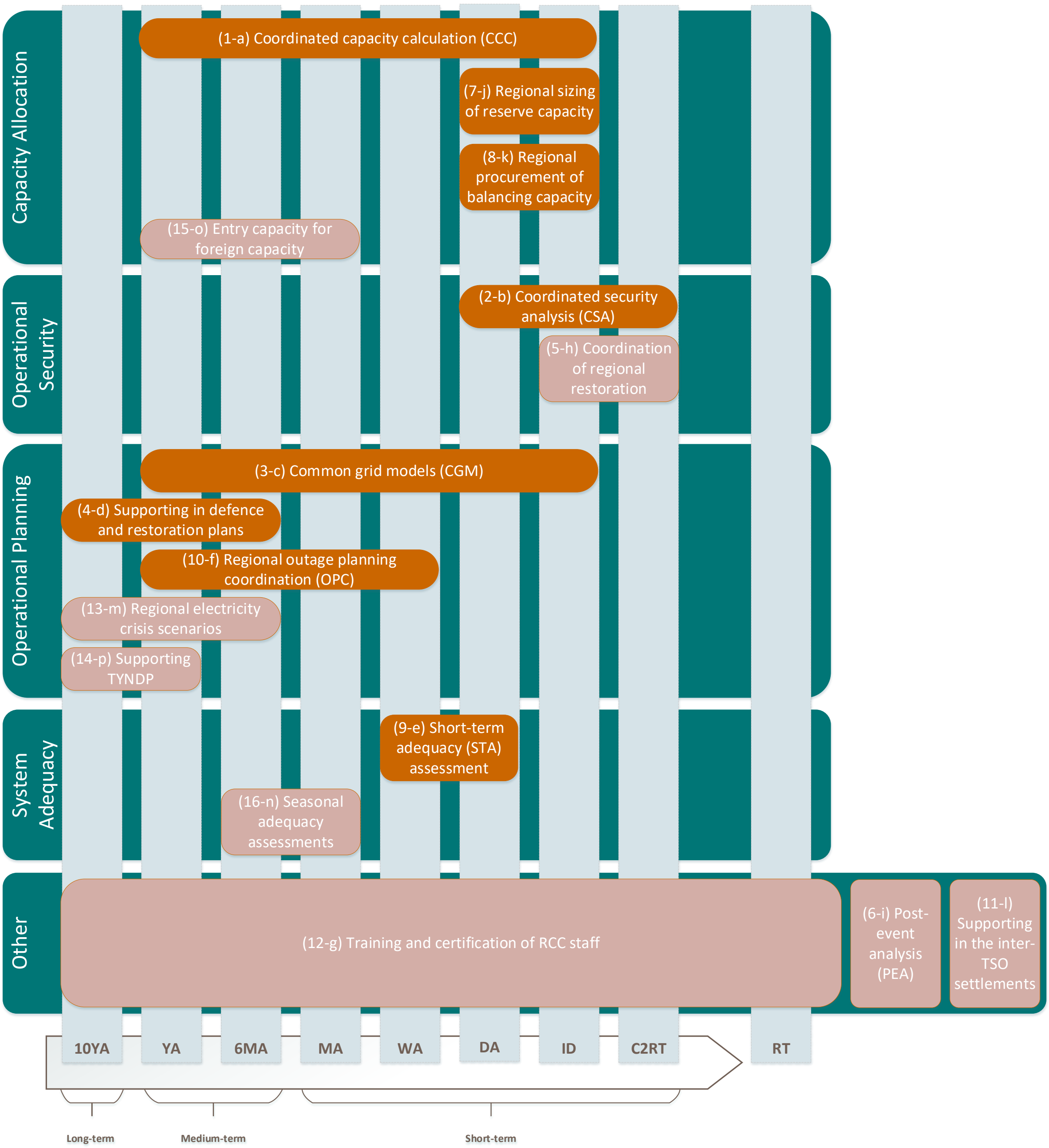
Category by operational activity	Timeframe
OS – Operational Security	YA – Year-ahead
OP – Operational Planning	MA – Month-ahead
SA – System Adequacy	WA – Week-ahead
CA – Capacity Allocation	DA – Day-ahead
Other – miscellaneous	ID – Intraday
	C2RT – Close to real-time

The categorization mentioned in Chapter 1 was made based on the nature of the task and the type of service it offers (category by operational activity, JRC source). The methodology development status is mentioned, where it can be seen that most of the tasks are already covered, meaning that the task is either already fully implemented into RCC business or is one step closer. This information, particularly on “new tasks”, was based on the update provided by Nordic RCC and ACER during the 5th Regional Coordination Conference on 18 November 2022, held online and hosted by SCC and SEleNe CC. Note that the column ‘Degree of implementation in an RCC process’ is interpreted with the status in June 2022 based on aforementioned conference presentations, and annual reports from Coreso and Nordic RCC, i.e. before RCCs officially entered into force, thus it does not possibly correspond to the current status of business processes in the RCCs, including likely differences in the degree of implementation between different RCCs. It could happen that by now some RCCs have implemented some tasks in a more complete way while some other did not.[4]

In the following Figure 17 a different overview of all RCC tasks depending on the timeframe in which they are to be performed is shown. Tasks are sorted into categories already mentioned with solid coloured tasks being ones that are obligatory and performed on a regular basis, thus lighter coloured ones are the tasks activated upon request from certain entity or when needed depending on the initiating event.

[4] In March 2024 ACER has published its first monitoring report on RCC’s reporting obligations for year 2022. In that report additional key performance indicators for each RCC, degree of implementation and respective tasks can be found, as reported by RCCs.

Figure 17. Visual representation of RCC tasks



Source: JRC analysis, 2023.

It is important to once again mention that RCCs, in performing their tasks under Union law, shall act independently of individual national interests and independently of the interests of transmission system operators, as stated in Electricity Regulation's Article 35 chapter 4.

Based on Article 42 (1, 2 and 3) of the Electricity Regulation, the TSOs in a SOR shall develop a procedure for the adoption and revision of coordinated actions and recommendations issued by RCCs. Thus:

— RCCs shall issue coordinated actions to the TSOs in respect of the tasks 1-a 'Coordinated Capacity Calculation' and 2-b 'Coordinated Security Analysis' (Table 5).

— TSOs shall implement the coordinated actions except where the implementation of the coordinated actions would result in a violation of the operational security limits defined by each TSO in accordance with the system operation guideline adopted on the basis of Article 18(5) of Regulation (EC) No 714/2009.

— Where a TSO decides not to implement a coordinated action for the reasons set out in the above paragraph, it shall transparently report the detailed reasons to the RCC and the TSOs of the SOR region without undue delay. In such cases, the RCC shall assess the impact of that decision on the other TSOs of the SOR and may propose a different set of coordinated actions subject to the TSO's procedure set out in paragraph 1 of the Article.

Furthermore:

— RCCs shall also issue recommendations to the TSOs in relation to all the other (or new advisory) tasks, 3 to 16 (c to p), listed in Table 5.

— Where a TSO decides to deviate from a RCCs recommendation as referred to in paragraph 1 of the Article 42, it shall submit a justification for its decision to RCCs and to the other TSOs of the SOR without undue delay.

On the monitoring and reporting on which the RCCs are obliged, Article 46 of the Electricity Regulation states:

Box 8. RCC's monitoring and reporting

1. The RCCs have to establish a process for the continuous monitoring where they would monitor at least:

- their operational performance;

- the coordinated actions and recommendations issued, the extent to which the coordinated actions and recommendations have been implemented by the TSOs and the outcome achieved;

- the effectiveness and efficiency of each of the tasks for which they are responsible and, where applicable, the rotation of those tasks.

2. RCCs shall account for their costs in a transparent manner and report them to ACER and to the regulatory authorities in the system operation region.

3. RCCs shall submit an annual report on the outcome of the monitoring provided for in paragraph 1 and information on their performance to the ENTSO for Electricity, ACER, the regulatory authorities in the system operation region and the Electricity Coordination Group.

4. RCCs shall report any shortcomings that they identify in the monitoring process under paragraph 1 to the ENTSO for Electricity, the regulatory authorities in the system operation region, ACER and the other competent authorities of Member States responsible for the prevention and management of crisis situations. On the basis of that report, the relevant regulatory authorities of the system operation region may propose measures to address the shortcomings to the RCCs.

5. Without prejudice to the need to protect security and the confidentiality of commercially sensitive information, RCCs shall make public the reports referred to in paragraphs 3 and 4.

In the next subchapters all current RCC tasks will be laid out into more details, providing additional information on objectives, legal framework and methodologies, but also for some of them visually describing an RCC business process in a simplified manner.

5.1 Coordinated capacity calculation (CCC)

Box 9. Relevant definitions – Task (1)

(65) 'Bidding zone' means the largest geographical area within which market participants are able to exchange energy without capacity allocation (Electricity Regulation, 2019c);

(66) 'Capacity allocation' means the attribution of cross-zonal capacity (Electricity Regulation, 2019c);

(69) 'critical network element' or CNE means a network element either within a bidding zone or between bidding zones taken into account in the capacity calculation process, limiting the amount of power that can be exchanged (Electricity Regulation, 2019c);

(70) 'Cross-zonal capacity' means the capability of the interconnected system to accommodate energy transfer between bidding zones (Electricity Regulation, 2019c);

3. 'Capacity calculation region' means the geographic area in which coordinated capacity calculation is applied (CACM Regulation, 2015);

5. 'Net position' means the netted sum of electricity exports and imports for each market time unit for a bidding zone (CACM Regulation, 2015);

6. 'Allocation constraints' means the constraints to be respected during capacity allocation to maintain the transmission system within operational security limits and have not been translated into cross-zonal capacity or that are needed to increase the efficiency of capacity allocation (CACM Regulation, 2015);

7. 'Operational security limits' means the acceptable operating boundaries for secure grid operation such as thermal limits, voltage limits, short-circuit current limits, frequency and dynamic stability limits (CACM Regulation, 2015);

8. 'Coordinated net transmission capacity (NTC) approach' means the capacity calculation method based on the principle of assessing and defining ex ante a maximum energy exchange between adjacent bidding zones; (CACM Regulation, 2015; Electricity Regulation, 2019c);

9. 'Flow-based (FB) approach' means a capacity calculation method in which energy exchanges between bidding zones are limited by power transfer distribution factors and available margins on critical network elements (CACM Regulation, 2015);

11. 'Coordinated capacity calculator' or CCC means the entity or entities with the task of calculating transmission capacity, at regional level or above (CACM Regulation, 2015);

12. 'Generation shift key' or GSK means a method of translating a net position change of a given bidding zone into estimated specific injection increases or decreases in the common grid model (CACM Regulation, 2015);

Table 6. Coordinated capacity calculation task summary

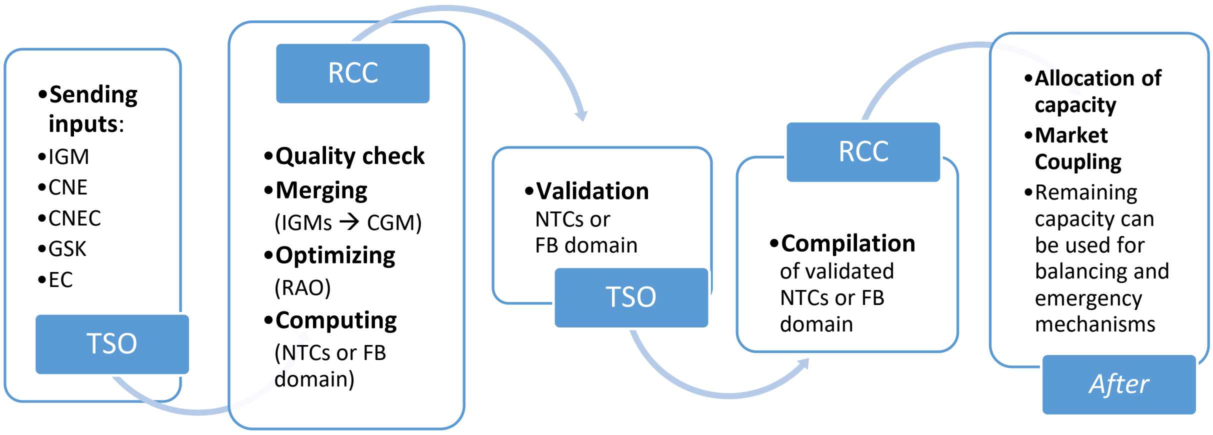
RCC task	**(1-a) Coordinated Capacity Calculation (CCC)**
Category	Capacity Allocation (CA)
Contributing to	Market Integration (MI), Security of Supply (SoS)
Objective	— RCCs have to carry out the coordinated calculation of cross-zonal capacities that can be allocated to the day-ahead and intraday markets. — RCC is coordinated capacity calculator and have to ensure an efficient congestion management in accordance with the general principles of congestion management. — When calculating cross-zonal capacities RCCs have to: ● use generation shift keys (GSKs) to calculate the impact of changes in bidding zone net positions and of flows on direct current lines; ● ignore those critical network elements (CNEs) that are not significantly influenced by the changes in bidding zone net positions according to the CCR methodologies; ● ensure that all sets of bidding zone net positions and flows on direct current lines not exceeding cross-zonal capacity comply with reliability margins and operational security limits and take into account previously

	allocated cross-zonal capacity; — CCC method differs per capacity calculation regions (CCRs), for example, in SWE CCR coordinated net transmission capacity (NTC) approach is being used, while in Core CCR flow-based (FB) approach is applied, therefore CCC results will provide NTCs and/or FB domains, respectively (Figure 18). — RCCs shall calculate cross-zonal capacities respecting operational security limits using data from transmission system operators including data on the technical availability of remedial actions, not including load shedding. — Where RCCs conclude that those available remedial actions in the capacity calculation region or between capacity calculation regions are not sufficient to reach the linear trajectory or the minimum levels of capacities while respecting operational security limits, they may, as a measure of last resort, set out coordinated actions reducing the cross-zonal capacities accordingly. — TSOs shall implement those coordinated actions. — TSOs may deviate from coordinated actions in respect of coordinated capacity calculation (and coordinated security analysis) only where the implementation of the coordinated actions would result in a violation of the operational security limits defined by each transmission system operator in accordance with the system operation guideline (Electricity Regulation, 2019c). — Where a TSO decides not to implement a coordinated action for the reasons set out by the RCCs it shall transparently report the detailed reasons to the RCC and the TSOs of the SOR without undue delay. — In such cases, the RCC shall assess the impact of that decision on the other TSOs of the SOR and may propose a different set of coordinated actions subject to the TSOs procedure set out in paragraph 1 of Article 42 of Electricity Regulation, 2019c. — TSOs shall not limit the volume of interconnection capacity to be made available to market participants as a means of solving congestion inside their own bidding zone or as a means of managing flows resulting from transactions internal to bidding zones. Except for certain derogations, the following minimum levels of available capacity for cross-zonal trade (Electricity Regulation, 2019c): o (a) for borders using a coordinated net transmission capacity approach, the minimum capacity shall be 70 % of the transmission capacity respecting operational security limits after deduction of contingencies, as determined in accordance with the capacity allocation and congestion management guideline adopted on the basis of Article 18(5) of Regulation (EC) No 714/2009; o (b) for borders using a flow-based approach, the minimum capacity shall be a margin set in the capacity calculation process as available for flows induced by cross-zonal exchange. The margin shall be 70 % of the capacity respecting operational security limits of internal and cross-zonal critical network elements, taking into account contingencies, as determined in accordance with the capacity allocation and congestion management guideline adopted on the basis of Article 18(5) of Regulation (EC) No 714/2009.
Timeframe	The process starts in 2 days-ahead (2DA) for Day-ahead (DA) and Intraday (ID) timeframes.
Legal framework	— Article 37(1)(a) and Annex I (1) of the Electricity Regulation 2019/943 — Section 4, Article 29 of the CACM Regulation 2015/1222 — Article 18(5) of Regulation (EU) No 714/2009

Methodology and business process related documents	— ACER, 2021: Decision on the Determination of Capacity Calculation Regions (CCRs) (No. 21 of Table 25. Annex) — ENTSO-E: CCR Methodologies per region (No. 38 of Table 25. Annex) — ENTSO-E, 2019: CCC implementation guide (No. 32 of Table 25. Annex) — ENTSO-E, 2021: CACM list of information to ACER implementation guide (No. 33 of Table 25. Annex)
Link with other tasks	Task (3) – Creation of Common Grid Model (CGM) – CCC will be performed based on CGM.

Source: JRC analysis, 2023.

Figure 18. Coordinated capacity calculation process example



Source: JRC analysis, 2023.

5.2 Coordinated security analysis (CSA)

Box 10. Relevant definitions – Task (2)

(26) 'Redispatching' means a measure, including curtailment, that is activated by one or more transmission system operators or distribution system operators by altering the generation, load pattern, or both, in order to change physical flows in the electricity system and relieve a physical congestion or otherwise ensure system security (Electricity Regulation, 2019c);

(27) 'Countertrading' means a cross-zonal exchange initiated by system operators between two bidding zones to relieve physical congestion (Electricity Regulation, 2019c);

(50) 'Operational security analysis' means the entire scope of the computer based, manual and automatic activities performed in order to assess the operational security of the transmission system and to evaluate the remedial actions needed to maintain operational security (Electricity Regulation, 2019c);

(67) 'Control area' means a coherent part of the interconnected system, operated by a single system operator and shall include connected physical loads and/or generation units if any (Electricity Regulation, 2019c);

(2) 'Constraint' means a situation in which there is a need to prepare and activate a remedial action in order to respect operational security limits (SOGL Regulation, 2017a);

7. 'Operational security limits' means the acceptable operating boundaries for secure grid operation such as thermal limits, voltage limits, short-circuit current limits, frequency and dynamic stability limits (CACM Regulation, 2015);

10. 'Contingency' means the identified and possible or already occurred fault of an element, including not only the transmission system elements, but also significant grid users and distribution network elements if relevant for the transmission system operational security (CACM Regulation, 2015);

13. 'Remedial action' or RA means any measure applied by a TSO or several TSOs, manually or automatically, in order to maintain operational security (CACM Regulation, 2015);

(4) 'Contingency list' means the list of contingencies to be simulated in order to test the compliance with the operational security limits (SOGL Regulation, 2017a);

(14) '(N-1) criterion' means the rule according to which the elements remaining in operation within a TSO's control area after occurrence of a contingency are capable of accommodating the new operational situation without violating operational security limits (SOGL Regulation, 2017a);

(15) '(N-1) situation' means the situation in the transmission system in which one contingency from the contingency list occurred (SOGL Regulation, 2017a);

(27) 'Contingency analysis' means a computer based simulation of contingencies from the contingency list (SOGL Regulation, 2017a);

— 'Total Transfer/Transmission Capacity' or 'TTC' is the maximum transmission of active power in accordance with the system security criteria which is permitted in transmission cross-sections between the subsystems/areas or individual installations (Nord Pool, 2020).

— 'Transmission Reliability Margin' or 'TRM' is a security margin that copes with uncertainties on the computed TTC values arising from:

a) Unintended deviations of physical flows during operations due to physical functioning of load-frequency regulation,

b) Emergency exchanges between TSOs to cope with unexpected unbalanced situations in real-time,

c) Inaccuracies, e.g. in data collection and measurements (Nord Pool, 2020).

— 'Net Transfer/Transmission Capacity' or 'NTC' is the maximum total exchange program between two adjacent bidding zones complying with security standards, and taking into account the technical uncertainties on future network conditions (Nord Pool, 2020).

$$NTC = TTC - TRM$$

Table 7. Coordinated security analysis task summary

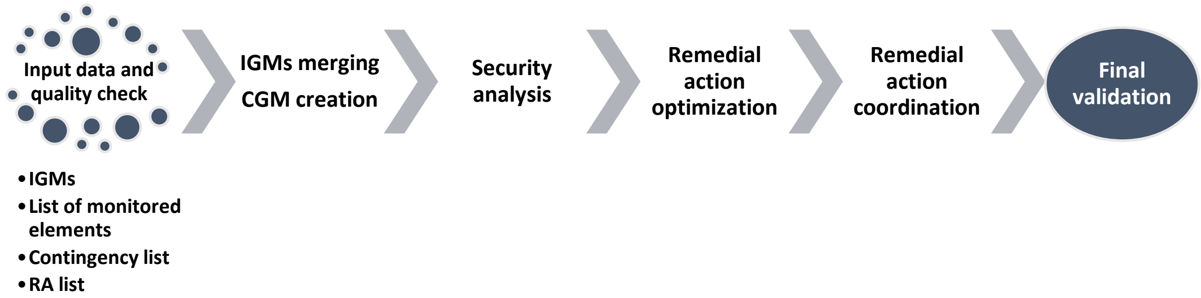
RCC task	(2-b) Coordinated security analysis (CSA)
Category	Operational Security (OS)
Contributing to	Security of Supply (SoS)
Objective	— RCCs have to carry out a CSA aiming to ensure secure system operation. — N-1 / N-2 contingency analysis are performed for designated contingency list provided by the TSOs. — If the possible constraint is detected, RCCs will propose remedial actions taking into account effectiveness and economic efficiency. — RCCs will share the results of the CSA with at least the TSOs in the SOR. — RCCs shall issue coordinated actions to the TSOs in respect of the coordinated security analysis task. — TSOs shall implement the coordinated actions except where the implementation of the coordinated actions would result in a violation of the operational security limits defined by each TSO in accordance with the system operation guideline adopted on the basis of Article 18(5) of Regulation (EC) No 714/2009 (Electricity Regulation, 2019c). — Where a TSO decides not to implement a coordinated action for the reasons set out by the RCCs it shall transparently report the detailed reasons to the RCC and the TSOs of the SOR without undue delay. — In such cases, the RCC shall assess the impact of that decision on the other TSOs of the SOR and may propose a different set of coordinated actions subject to the TSOs procedure set out in paragraph 1 of Article 42 of Electricity Regulation, 2019c.
Timeframe	All operational timeframes between year-ahead and intraday (YA, WA*, DA, and ID).
Legal framework	— Article 37(1)(b) and Annex I (2) of the Electricity Regulation 2019/943 — Article 75 of SOGL Regulation (EU) 2017/1485 — Article 18(5) of Regulation (EU) No 714/2009
Methodology and business process related documents	— ACER, 2019: Decision on/ and Methodology for coordinating operational security analysis (CSAM) (Annex I and II) (No. 11 of Table 25. Annex) — ACER, 2021: Decision on/ and the Amendment of the Methodology for coordinating operational security analysis (Annex I and Ia) (No. 22 of Table 25. Annex) — ENTSO-E, 2018: All TSOs' proposal for a methodology for coordinating operational security analysis (No. 31 of Table 25. Annex) — ACER, 2020: Decision on/ and Methodology for coordinated redispatching and countertrading for the Core CCR (RDCT Methodology – Annex I to II) (No. 19 of Table 25. Annex) — ENTSO-E, 2022: CSA Data Exchange Specification (No. 40 of Table 25. Annex)
Link with other tasks	Task (3) – Creation of Common Grid Model (CGM) – CSA shall be performed using the CGMs.

	Task (10) – Outage planning coordination

*Week-ahead individual and common grid models: Where two or more TSOs consider it necessary, they shall determine the most representative scenarios for coordinating the operational security analysis of their transmission system for the week-ahead time-frame and shall develop a methodology for merging the individual grid models.

Source: JRC analysis, 2023.

Figure 19. Coordinated security analysis process example



Source: JRC analysis, 2023.

As required by Article 33 of the SOGL Regulation, each TSO has to establish its own contingency list, including internal and external contingencies of its observability area. This list will be used to assess whether any of those contingencies endanger the operational security limits of the TSOs control area. This contingency list has to include both ordinary and exceptional contingencies as shown in the Table 8. below.

Table 8. Classification of contingencies

Ordinary contingencies (N-1)	Loss of a single line / cable;
	Loss of a single transformer;
	Loss of a single phase-shifting transformer (PST);
	Loss of a single voltage compensation device;
	Loss of a single component of a HVDC system such as a line or a cable or a single HVDC converter unit;
	Loss of a single power generation unit;
	Loss of a single demand facility.
Exceptional contingencies (Dependent N-2, N-k)	Loss of network elements having common fault mode, meaning that a single fault (such as a fault on a busbar, HVDC grounding system, circuit breaker, measurement transformer etc.) will lead to the loss of more than one network element;
	Loss of overhead lines built on same tower;
	Loss of underground cables built in same trench;
	Loss of grid users having common process mode, meaning that the total or partial

	sudden loss of one grid user will lead to the total or partial loss of the others (for example: Combined cycle units etc.);
	Loss of network elements/users simultaneously disconnected as a result of the operation of a Special Protection Scheme;
	Loss of multiple generation units (including solar and wind farms) disconnected because of a voltage drop on the network or system frequency deviation.
Out-of-range contingencies (Independent N-2, N-k)	Loss of two or more independent lines;
	Loss of two or more independent cables;
	Loss of two or more independent transformers or phase shifter transformers;
	Loss of two or more independent grid users (power generating unit or demand facility);
	Loss of two or more independent voltage compensation devices;
	Loss of two or more independent busbars;
	Loss of two or more independent components of a HVDC system such as lines, cables or HVDC converter units.

Source: (ACER, 07/2019)

To resolve specific contingencies, remedial actions (RAs) can be taken by the TSOs which will depend on the type of the contingency, duration, location, effect, automatism, environmental conditions, etc. Each TSO will be providing a list of RAs, of which most of them can be divided in two main categories – costly and non-costly remedial actions. Depending on the time of usage of the RA, some RAs can be performed as a preventive measure, before the contingency happens so that the impact of the event is mitigated or lessened, or the RA will be taken after the occurrence of the event, so called in curative, to correct the violations that have occurred. Some examples of TSOs RAs are provided below in the Table 9.

Table 9. Examples of TSOs remedial actions

Non-costly remedial actions	**Grid**	Topological measure impacting the impedance of the grid – manual or automatic: - Opening or closing of a line, cable, transformer, busbar coupler. - Switching of a network element from one busbar to another. - Any other change in the topology of the grid.
		Modification of the tap position of a phase shifter transformer (PST) – manual or automatic: - Decreasing/ increasing power flow on the line of the same voltage level - Decreasing/ increasing power flow between two different voltage levels (e.g. 380 kV to 220 kV)
	Cross-border capacity	Modification of the set point on HVDC system (*can be costly*)

Costly remedial actions	**Generation**	In a TSOs control area	Redispatching: - Changing the output of generators (dedicated contracts with producers) - Rescheduling of the generation mix
			Optimized use of the pump storage and hydro generation
			Restart of the mothballed generating units
			Purchasing/ activation of balancing energy
			Use of strategic reserve or peak load reserve
		Outside of TSOs control area	TSO-TSO dedicated contracts to change generation in their control area
			Shared reserves or mutual emergency assistance service (MEAS) contracts
	Cross-border capacity	Countertrading: - Changing the net position / commercial cross-zonal exchanges between two bidding zones to relieve physical congestion	
		Changing import/ export cross-border capacities	
		Modification of set point on HVDC system (*can be non-costly*)	
	Load	Disconnecting interruptible load	
		Use of pump storage units	
		Load shedding	
	Grid	Cancellation or postponement of planned outages: - Generating units - Lines - Transformers	

Source: JRC analysis, 2023.

In order to identify whether a remedial action (RA) is cross-border relevant i.e. affects another TSO(s), TSOs have to define which grid elements are cross-border relevant network elements (XNEs). These elements should be all critical network elements (CNEs) and network elements above the voltage level predefined by TSOs, except for those elements for which all TSOs in a CCR agree that they are not cross-border relevant. TSOs and RCCs will use quantitative and qualitative analysis in order to detect possible cross-border influence.

In case of quantitative approach, the cross-border relevance of RAs will be assessed with the RA influence factor. The RA influence factor is calculated for at least each XNE and each contingency – XNEC – as a simulated flow deviation on a XNEC resulting from simulated application of a RA, normalised by the permanent load of the associated XNE. For the quantitative approach, at least those RAs for which the RA influence factors for at least one XNEC is higher than a threshold, defining a significant cross-border impact shall be considered as cross-border relevant. This threshold shall be equal to 5% unless a different threshold (ACER, 07/2019).

5.3 Creation of common grid models (CGM)

Box 11. Relevant definitions – Task (3)

1. 'individual grid model' or IGM means a data set describing power system characteristics (generation, load and grid topology) and related rules to change these characteristics during capacity calculation, prepared by the responsible TSOs, to be merged with other individual grid model components in order to create the common grid model (CACM Regulation, 2015);

2. 'common grid model' or CGM means a Union-wide data set agreed between various TSOs describing the main characteristic of the power system (generation, loads and grid topology) and rules for changing these characteristics during the capacity calculation process (CACM Regulation, 2015);

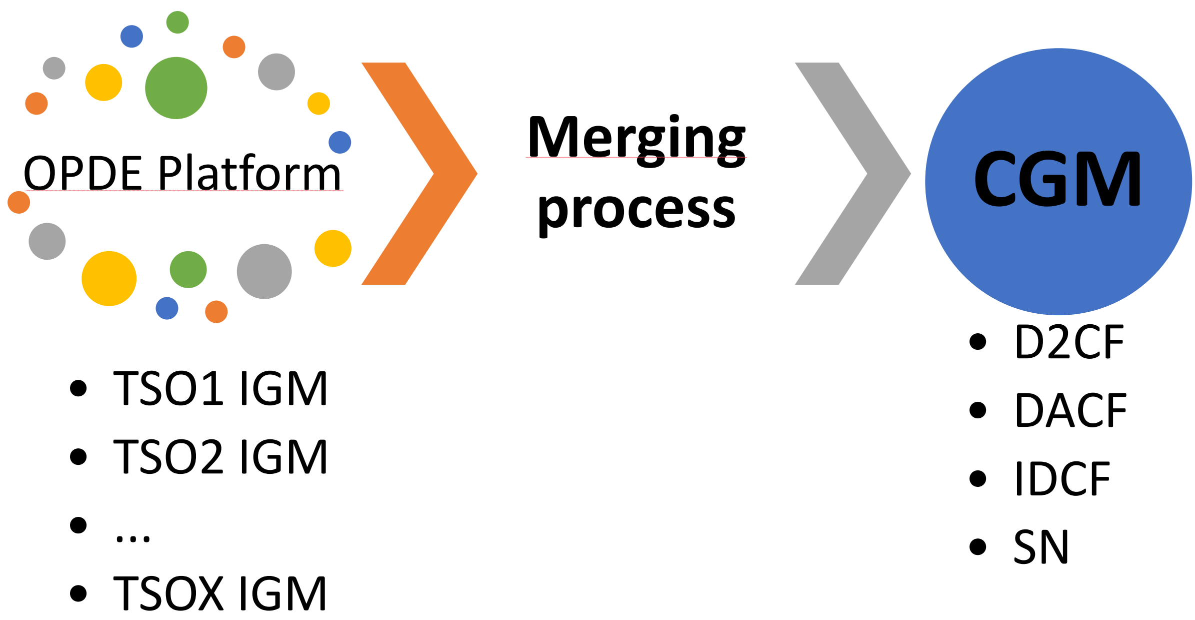
Table 10. Creation of common grid models task summary

RCC Task	**(3-c) Creation of common grid models (CGM)**
Category	Operational Planning (OP)
Contributing to	Security of Supply (SoS), Market Integration (MI)
Objective	— RCCs have processes and possess tools to create common grid models (CGMs), based on individual grid models (IGMs) prepared by the TSOs. — The model datasets will correspond to the operational planning timeframe (Figure 20): o 2-days-ahead Congestion Forecast (D2CF) file(s) o Day-ahead Congestion Forecast (DACF) file(s) o Intraday Congestion Forecast (IDCF) file(s) o Snapshot (SN) file(s) — TSOs can appoint one RCC to build the EU-wide CGM. — CGMs are available to all RCCs, TSOs, and ENTSO-E and, upon request, to ACER.
Timeframe	All operational planning timeframe between year-ahead and intraday (YA, WA, DA, and ID).
Legal framework	— Article 37(1)(c) and Annex I (3) of the Electricity Regulation 2019/943 — Title 1 of Part III and Article 70 of SOGL Regulation 2017/1485 — Section 2 (Chapter 1, Title II) and Article 17 of CACM Regulation 2015/1222 — Section 3 of FCA Regulation 2016/1719 — Article 18(5) of Regulation (EU) No 714/2009
Methodology and business process related documents	— ENTSO-E, 2018: All TSOs' proposal for a common grid model methodology (No. 30 of Table 25. Annex) — ENTSO-E, 2021: CGMA data exchange implementation guide (No. 36 of Table 25. Annex)
Relevant standards and data formats	UCTE data exchange format (Link) IEC 61970-600-1:2021: Common Grid Model Exchange Standard (CGMES) (Link)
IT environments and tools	ENTSO-E IT platforms:

	— CGMES Library (Link) — Electronic Data Interchange (EDI) Library – (Link) — Communication and Connectivity Service Platform (ECCoSP) – (Link) — Operational Planning Data Environment (OPDE) Platform The Common Grid Model (CGM) Go-Live is putting in place an operational CGM business process for mandated timeframes for TSOs and RCCs using the Physical Communication Network (PCN), ENTSO-E's Operational Planning Data Environment (OPDE) Platform, including ENTSO-E's Communication and Connectivity Service Platform (ECCoSP), and relevant business applications for secure pan-European data exchange, compliant with security requirements and data quality standards (ENTSO-E, 2021c).
Link with other tasks	CGMs include relevant data for efficient operational planning in tasks: Task (1) – Coordinated capacity calculation Task (2) – Coordinated security analysis Task (9) – Short-term adequacy assessment Task (10) – Outage Planning Coordination

Source: JRC analysis, 2023.

Figure 20. Creation of common grid model process example



Source: JRC analysis, 2023.

5.4 Supporting TSOs in defence and restoration plans' consistency assessment

Box 12. Relevant definitions – Task (4)

(5) 'Restoration plan' means all technical and organisational measures necessary for the restoration of the system back to normal state (EER Regulation, 2017c);

(22) 'Blackout state' means the system state in which the operation of part or all of the transmission system is terminated (SOGL Regulation, 2017a):

(37) 'Emergency state' means the system state in which one or more operational security limits are violated (SOGL Regulation, 2017a);

(38) 'Restoration state' means the system state in which the objective of all activities in the transmission system is to re-establish the system operation and maintain operational security after the blackout state or the emergency state (SOGL Regulation, 2017a);

(63) 'System defence plan' means the technical and organisational measures to be undertaken to prevent the propagation or deterioration of a disturbance in the transmission system, in order to avoid a wide area state disturbance and blackout state (SOGL Regulation, 2017a);

Table 11. Supporting the TSOs in defence and restoration plans' consistency assessment task summary

RCC Task	**(4-d) Supporting the TSOs in defence and restoration plans' consistency assessment**
Category	Operational Planning (OP)
Contributing to	Security of Supply (SoS)
Objective	— RCCs shall support TSOs in the SOR in carrying out the consistency assessment of TSOs' defence and restoration plans. — All TSOs shall agree on a threshold above which the impact of remedial actions of one or more TSOs is considered significant for other TSOs synchronously or non-synchronously interconnected, in the emergency, blackout or restoration states. — In providing support to the TSOs, the RCC shall: • Identify potential incompatibilities; • Propose mitigation actions. — TSOs shall assess and take into account the proposed mitigation actions.
Timeframe	Upon submission of the measures from TSOs. Since 18 December 2018, and within three months after the submission, the technical report from RSCs (now RCCs) have had to be delivered to the relevant TSOs. TSOs have to then provide the report to the relevant NRAs and ENTSO-E (Table 12).
Legal framework	— Article 37(1)(d) and Annex I (4) of the Electricity Regulation 2019/943 — Article 6 and procedures set out in the Article 11, Article 23, Article 50 of the EER Regulation 2017/2196 — SOGL Regulation 2017/1485 — Article 32 of the ACER Regulation 2019/942
Methodology and business process related documents	— ENTSO-E Library - Emergency & Restoration National Implementation (No. 43 of Table 25. Annex) — ENTSO-E RSC Coordination Template – Link — ACER, 2021: Implementation Monitoring Report of the Network Code on

	Emergency and Restoration (No. 42 of Table 25. Annex)
Link with other tasks	Task (5) – Supporting the TSOs in the coordination of regional restoration Task (6) – Post-operation and post-disturbances analysis and reporting (*threshold*)

Source: JRC analysis, 2023.

Table 12. Process of regional coordination, in accordance with Article 6 of ERR Regulation 2017/2196

Step	When	By	To / With	Legal basis
1 – Submission of the measures	By 18 December 2018	Each TSO	To RCCs	Article 6(3)
2 – Drafting of a technical report	Within three months after the submission	RCCs	With the assistance of relevant TSOs	Article 6(3)
3 – First report from RCCs to the TSOs	Without delay, after the report is completed	RCCs	To the relevant TSOs	Article 6(4)
4 – First report from TSOs to NRAs	Without delay, after the report is received	Each TSO	To the relevant NRA and ETNSO-E	Article 6(4)

Source: ACER's Implementation Monitoring Report of the Network Code on Emergency and Restoration, 2021.

5.5 Supporting the TSOs in the coordination of regional restoration

Box 13. Relevant definitions – Task (5)

(9) ‘Resynchronisation’ means synchronising and connecting again two synchronised regions at the resynchronisation point (EER Regulation, 2017c);

(10) ‘Frequency leader’ means the TSO appointed and responsible for managing the system frequency within a synchronised region or a synchronous area in order to restore system frequency back to the nominal frequency (EER Regulation, 2017c);

(12) ‘Resynchronisation leader’ means the TSO appointed and responsible for the resynchronisation of two synchronised regions (EER Regulation, 2017c);

Table 13. Supporting the TSOs in the coordination of regional restoration task summary

RCC Task	**(5-h) Supporting the TSOs in the coordination of regional restoration**
Category	Operational Security (OS)
Contributing to	Security of Supply (SoS)
Objective	— Each relevant RCC shall support TSOs appointed as frequency leaders and the resynchronisation leaders to improve the efficiency and effectiveness of system restoration. — The TSOs in the SOR shall establish the role of the RCC relating to the support to the coordination and optimisation of regional restoration. — TSOs may request assistance from RCCs if their system is in a blackout or restoration state. — RCCs shall be equipped with the close to real-time supervisory control and data acquisition systems with the observability defined by applying the threshold referred to in Task (4) under Objective.
Timeframe	C2RT. Upon request from TSOs.
Legal framework	— Article 37(1)(h) and Annex I (5) of the Electricity Regulation 2019/943. — Chapter III of EER Regulation 2017/2196 — SOGL Regulation 2017/1485
Methodology and business process related documents	— *Methodology in development* — ENTSO-E Library - Emergency & Restoration National Implementation (No. 43 of Table 25. Annex) — ACER, 2021: Implementation Monitoring Report of the Network Code on Emergency and Restoration (No. 42 of Table 25. Annex)
Link with other tasks	Task (4) – Supporting the TSOs in defence and restoration plans’ consistency assessment

Source: JRC analysis, 2023.

5.6 Post-operation and post-disturbances analysis and reporting

Table 14. Post-operation and post-disturbances analysis and reporting task summary

RCC Task	**(6-i) Post-operation and post-disturbances analysis and reporting**
Category	Other
Contributing to	Security of Supply (SoS), Innovation (I)
Objective	— RCCs shall investigate and prepare a report on any incident above the threshold referred to in Task (4) under Objective. — The regulatory authorities in the SOR and ACER may be involved in the investigation upon their request. — RCCs shall publish report, upon which ACER may issue recommendations aiming to prevent similar incidents in future.
Timeframe	Conditional activation based on incidents and/ or upon request.
Legal framework	— Article 37(1)(i) and Annex I (6) of the Electricity Regulation 2019/943.
Methodology and business process related documents	— ACER, 2022: Decision on/ and Methodology on the Regional Coordination Centre Post-Operation and Post-Disturbances Analysis and Reporting Methodology (No. 26 of Table 25. Annex)
Link with other tasks	Task (4) – Supporting the TSOs in defence and restoration plans' consistency assessment (*threshold*) All other tasks if and when requested.

Source: JRC analysis, 2023.

5.7 Regional sizing of reserve capacity

Box 14. Relevant definitions – Task (7) (6) 'Frequency containment reserves' or 'FCR' means the active power reserves available to contain system frequency after the occurrence of an imbalance (SOGL Regulation, 2017a); (7) 'Frequency restoration reserves' or 'FRR' means the active power reserves available to restore system frequency to the nominal frequency and, for a synchronous area consisting of more than one LFC area, to restore power balance to the scheduled value (SOGL Regulation, 2017a); (8) 'Replacement reserves' or 'RR' means the active power reserves available to restore or support the required level of FRR to be prepared for additional system imbalances, including generation reserves (SOGL Regulation, 2017a); (19) 'Reserve capacity' means the amount of FCR, FRR or RR that needs to be available to the transmission system operator (Electricity Regulation, 2019c);

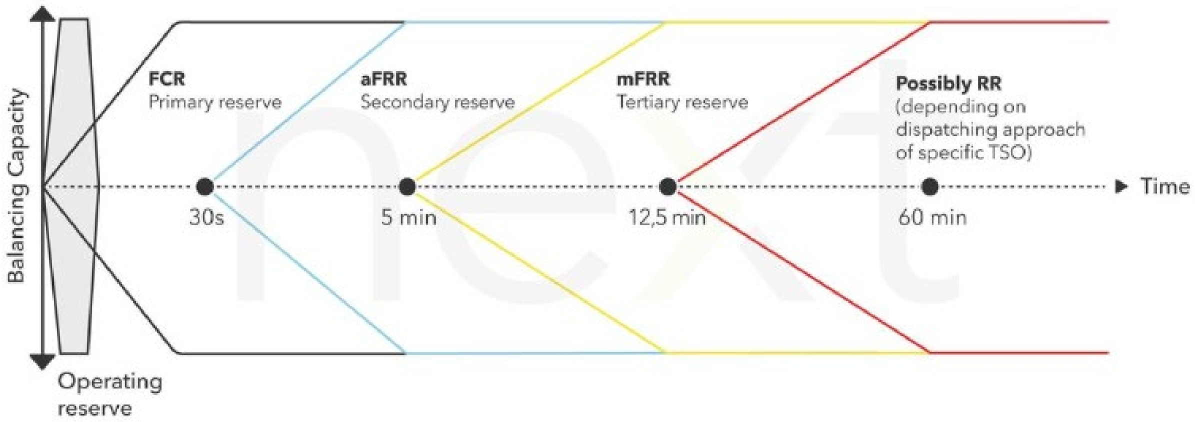
Table 15. Regional sizing of reserve capacity task summary

RCC Task	**(7-j) Regional sizing of reserve capacity**
Category	Capacity Allocation (CA)
Contributing to	Security of Supply (SoS), Market Integration (MI)
Objective	RCCs shall calculate the reserve capacity requirements for the SOR. The determination of reserve capacity requirements shall: — Pursue the general objective to maintain operational security in the most cost effective manner; — Be performed at the day-ahead or intraday timeframe, or both; — Calculate the overall amount of required reserve capacity for the system operation region; — Determine minimum reserve capacity requirements for each type of reserve capacity (FCR, aFRR, mFRR, RR) (Figure 21 and Figure 22); — Take into account possible substitutions between different types of reserve capacity with the aim to minimise the costs of procurement; — Set out the necessary requirements for the geographical distribution of required reserve capacity, if any.
Timeframe	Day-ahead and/or intraday (DA and/or ID)
Legal framework	— Article 37(1)(j) and Annex I (7) of the Electricity Regulation 2019/943 — Title 5, 6 and 7 of the SOGL Regulation 2017/1485
Methodology and business process related documents	— Methodology in development. ENTSO-E proposal for the RCC task 'regional sizing of reserve capacity' (No. 48 of Table 25. Annex) — ENTSO-E: aFRR – Platform for the International Coordination of Automated Frequency Restoration and Stable System Operation (PICASSO) (Link) — ENTSO-E: RR – The Trans European Replacement Reserves Exchange (TERRE) project (Link) — ENTSO-E: mFRR – Manually Activated Reserves Initiative (MARI) Project/ Platform (Link) — ENTSO-E: Frequency Containment Reserves (FCR) project (Link)

Link with other tasks	Task (8) – Regional procurement of balancing capacity

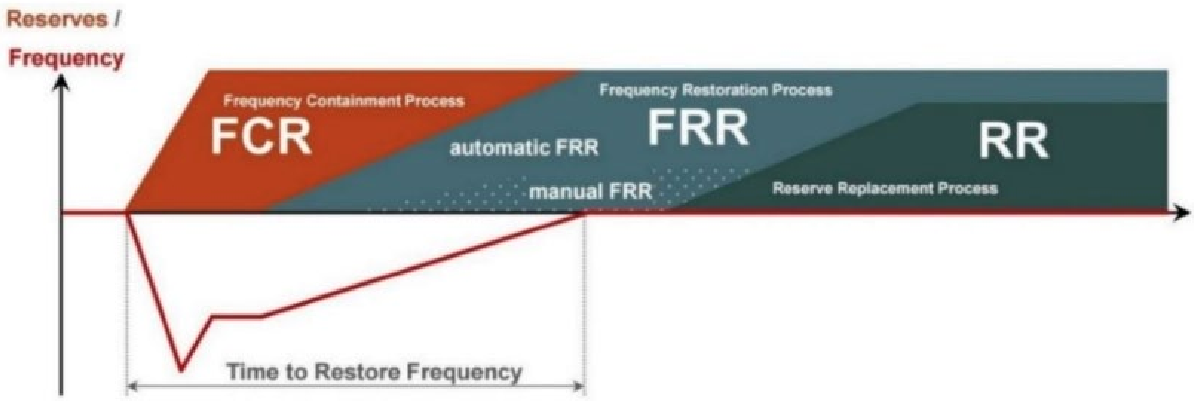
Source: JRC analysis, 2023.

Figure 21. Balancing services according to the system envisaged by ENTSO-E



Source: (Next Kraftwerke, b)

Figure 22. A frequency drop and the reserve activation structure



Source: Elia and TenneT, 2014

5.8 Facilitating the regional procurement of balancing capacity

Box 15. Relevant definitions – Task (8)

(1) 'Balancing' means all actions and processes, on all timelines, through which TSOs ensure, in a continuous way, the maintenance of system frequency within a predefined stability range as set out in Article 127 of Regulation (EU) 2017/1485, and compliance with the amount of reserves needed with respect to the required quality, as set out in Part IV Title V, Title VI and Title VII of Regulation (EU) 2017/1485 (Balancing Regulation, 2017b);

(5) 'balancing capacity' means a volume of reserve capacity that a balancing service provider has agreed to hold and in respect to which the balancing service provider has agreed to submit bids for a corresponding volume of balancing energy to the TSO for the duration of the contract (Balancing Regulation, 2017b);

Table 16. Facilitating the regional procurement of balancing capacity task summary

RCC Task	**(8-k) Facilitating the regional procurement of balancing capacity**
Category	Capacity Allocation (CA)
Contributing to	Security of Supply (SoS), Market Integration (MI)
Objective	RCCs shall support the TSOs in the SOR in determining the amount of balancing capacity that needs to be procured. The determination of the amount of balancing capacity shall: — Be performed at the day-ahead or intraday timeframe, or both; — Take into account possible substitutions between different types of reserve capacity with the aim to minimise the costs of procurement; — Take into account the volumes of required reserve capacity that are expected to be provided by balancing energy bids, which are not submitted based on a contract for balancing capacity.
Timeframe	Day-ahead and/or intraday (DA and/or ID)
Legal framework	— Article 37(1)(k) and Annex I (8) of the Electricity Regulation 2019/943 — Chapter 2 of Balancing Regulation 2017/2195
Methodology and business process related documents	— Methodology in development. ENTSO-E proposal for the RCC task 'Facilitating the regional procurement of balancing capacity" (No. 49 of Table 25. Annex) ENTSO-E submitted proposal for approval to ACER by 17 March 2023 (ENTSO-E, 2022b). — ACER, 2020: Methodology for a list of standard products for balancing capacity for frequency restoration reserves and replacement reserves (No. 15 of Table 25. Annex) — ACER, 2020: Methodology on the common and harmonised rules and processes for the exchange and procurement of aFRR balancing capacity for the Nordic LFC Block (No. 16 of Table 25. Annex) — ACER, 2021: Methodology for the market-based allocation process of cross-zonal capacity for the exchange of balancing capacity for the Core CCR (No. 23 of Table 25. Annex)
Link with other tasks	Task (7) – Regional sizing of reserve capacity

Source: JRC analysis, 2023.

5.9 Short-term adequacy (STA) assessment

Box 16. Relevant definitions – Task (9)

(68) 'Adequacy' means the ability of in-feeds into an area to meet the load in that area (SOGL Regulation, 2017a);

13. 'Remedial action' means any measure applied by a TSO or several TSOs, manually or automatically, in order to maintain operational security (CACM Regulation, 2015);

l. 'Energy Not Served' (ENS) means, in a given zone and during a given time period, the energy not supplied due to insufficient resources to meet demand needs (ACER, 08/2020).

Net Transfer Capacity or NTC is the maximum total exchange program between two adjacent bidding zones complying with security standards, and taking into account the technical uncertainties on future network conditions (Nord Pool, 2020).

Monte Carlo method, statistical method of understanding complex physical or mathematical systems by using randomly generated numbers as input into those systems to generate a range of solutions. The likelihood of a particular solution can be found by dividing the number of times that solution was generated by the total number of trials. By using larger and larger numbers of trials, the likelihood of the solutions can be determined more and more accurately (*Source*: Encyclopaedia Britannica website).

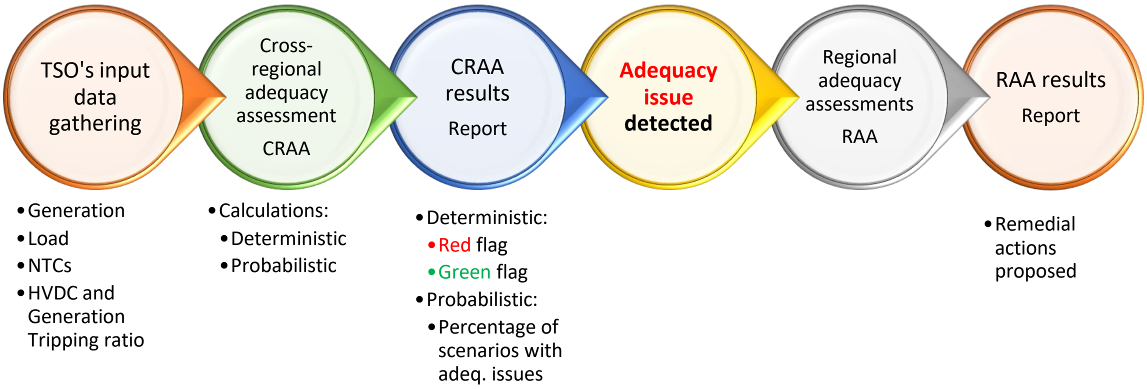
Table 17. Short-term adequacy (STA) assessment task summary

RCC Task	**(9-e) Short-term adequacy (STA) assessment**
Category	System Adequacy (SA)
Contributing to	Security of Supply (SoS)
Objective	— RCCs shall carry out week-ahead to at least day-ahead regional adequacy assessments. — To detect situations where a lack of adequacy is expected in any of the control areas or at regional level. — The calculations will be performed based on the input data (generation, load, NTCs, HVDC and generation tripping ratio) provided by the TSOs of SOR, taking into account possible cross-zonal exchanges and operational security limits. — The process will be monitored by adequacy assessment agent (AAA), i.e. one RCC on Pan-European level on a rotational basis with other RCC as backup. — There are two phases of the process**:** cross-regional and regional adequacy assessment (Figure 23). — In a cross-regional process, deterministic and probabilistic calculations will be performed successively in the STA tool, thus providing results for all participating countries for all timestamps in the next seven days. — The main quantitative metric in the results is the so called 'remaining capacity' (RC), which is the difference between 'reliably available capacity' and 'load' (Figure 24). RC can be either negative, null or positive. If it is positive there is a sufficient generation capacity in the country to cover the load, in which case the export of the surplus output is possible i.e. adequacy issue is not detected. If this value is negative, the load exceeds the reliable available capacity and in this scenario the country may depend on the import to satisfy their load i.e. adequacy issue is detected (German Energy Agency, 2022). — The results of the deterministic calculation will appear in the form of red (RC<0) or green flag (RC≥0) for a timestamp(s) and a country(ies), i.e. adequacy issue is detected or it is not detected, respectively. Amount of

	Energy Not Supplied (ENS) will be shown accordingly. — The results of the probabilistic calculations of different scenarios using Monte Carlo approach will be shown as a percentage of scenarios in which adequacy issue may occur in the form of green, orange or red flag (ENTSO-E, 2020). — Depending on the timestamp in which adequacy issue is identified in the deterministic calculation, the second phase of the process, regional adequacy assessment, can be triggered. — Regional adequacy assessment will be triggered automatically for the timestamps in the scope of the next three days. However, any TSO can trigger a regional STA process whenever it identifies the need and independently of the timeframe (ENTSO-E, 2022c). — Each RCC shall coordinate the regional system adequacy assessments in close coordination with the TSO facing the adequacy issue, their impacting neighbours and other RCCs. — They will agree on the remedial actions to reduce risks of lack of adequacy, and share the results to the TSOs in the SOR and to other RCCs (Table 9). — If the remedial actions proposed after the regional adequacy assessment cannot solve or mitigate adequacy issues, the critical grid situation (CGS) (more details in Chapter 7.2 of this Report) may be triggered.
Timeframe	Weak-ahead to day-ahead (WA to DA)
Legal framework	— Article 37(1)(e) and Annex I (9) of the Electricity Regulation 2019/943 — Article 81 and Article 107 of the SOGL Regulation 2017/1485 — Article 8 of Risk-preparedness Regulation 2019/941
Methodology and business process related documents	— ACER, 08/2020: Methodology for Short-term and Seasonal Adequacy Assessments (No. 14 of Table 25. Annex) — ENTSO-E, 2020: Explanatory note – Short-term and Seasonal Adequacy Assessments Methodology (No. 44 of Table 25. Annex) — ENTSO-E, 2021: Short term adequacy forecasts (STA) implementation guide (No. 34 of Table 25. Annex) — ACER. 24/2020: Methodology for the European resource adequacy assessment (ERAA) (No. 18 of Table 25. Annex)
IT environments and tools	— ENTSO-E Operational Planning Data Environment (OPDE) platform for data exchange — ENTSO-E Pan-European STA tool for process calculations RCCs and TSOs use the same STA tool owned by ENTSO-E for all pan-European STA-related activities: delivery of STA input data & quality check, monitoring of STA calculation process, creation and downloading of STA reports (ENTSO-E, 2022c).
Link with other tasks	Task (10) – Outage Planning Coordination Task (16) – Seasonal adequacy assessments

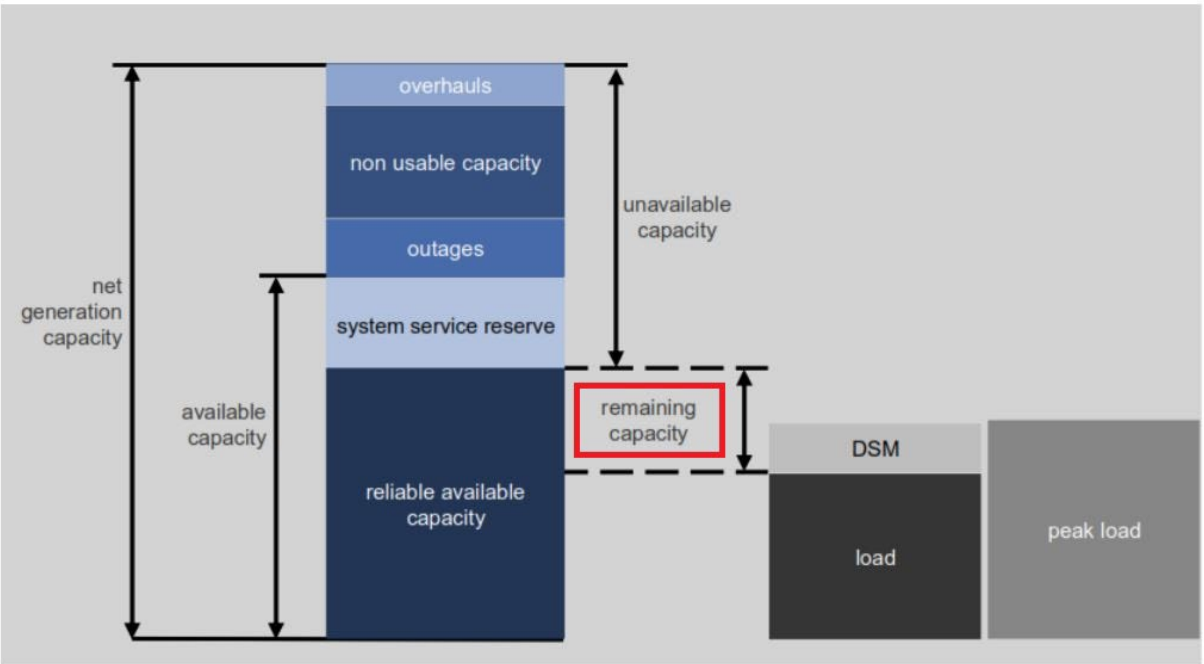
Source: JRC analysis, 2023.

Figure 23. Example of the STA week-ahead process



Source: JRC analysis, 2023.

Figure 24. Quantitative metrics in the power system adequacy calculations



Source: German Energy Agency (dena), 2022.

5.10 Regional outage planning coordination (OPC)

Box 17. Relevant definitions – Task (10)

a. 'Planned Outage' means a state of an asset when it is not available in the power system but this outage was planned in advance, including maintenance, mothballing and any other non-availabilities known in advance (ACER, 08/2020).

(82) 'outage coordination region' means a combination of control areas for which TSOs define procedures to monitor and where necessary coordinate the availability status of relevant assets in all time-frames (SOGL Regulation, 2017a);

Outage Coordination Region – Within the Outage Coordination Region, an RCC is appointed and his role is to facilitate, coordinate and perform tasks and provide recommendations for the outage planning process. TSOs ensure their participation by providing outage planning inputs in the specific outage coordination region (ENTSO-E, 2021b).

(86) 'outage planning incompatibility' means the state in which a combination of the availability status of one or more relevant grid elements, relevant power generating modules, and/or relevant demand facilities and the best estimate of the forecasted electricity grid situation leads to violation of operational security limits taking into account remedial actions without costs which are at the TSO's disposal (SOGL Regulation, 2017a);

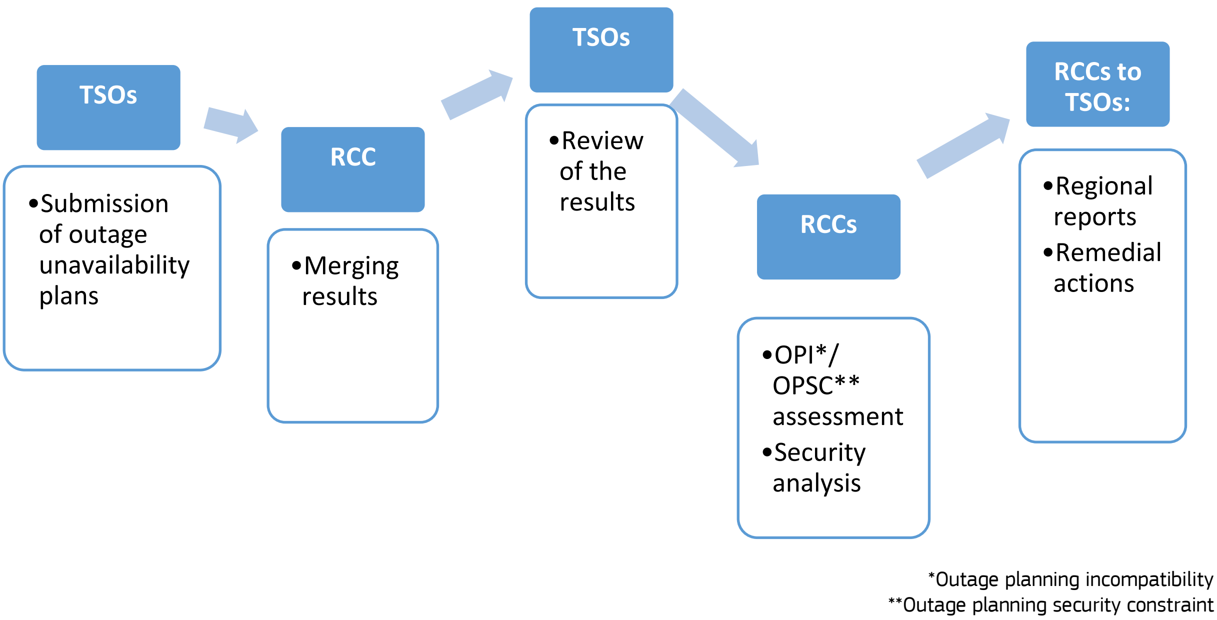
Table 18. Regional outage planning coordination (OPC) task summary

RCC Task	**(10-f) Regional outage planning coordination (OPC)**
Category	Operational Planning (OP)
Contributing to	Security of Supply (SoS)
Objective	— RCCs shall carry out regional OPC in order to monitor the availability status of the relevant assets and coordinate their availability plans to ensure the operational security of the transmission system, while maximising the capacity of the interconnectors and the transmission systems affecting cross-zonal flows. — Each RCC shall maintain a single list of relevant grid elements, power-generating modules, demand facilities of the system operation region, and make it available on the ENTSO-E operational planning data environment (OPDE). — Each RCC shall carry out the following activities related to outage coordination in the SOR, outage coordination region: ● Assess outage planning compatibility using all transmission system operators' year-ahead availability plans; ● Provide the TSOs in the SOR with a list of detected outage planning incompatibilities (OPIs) and the solutions it proposes to solve them.
Timeframe	Year-ahead, (month-ahead), week-ahead (YA, (MA), WA)
Legal framework	— Article 37(1)(f) and Annex I (10) of the Electricity Regulation 2019/943. — Article 80 of the SOGL Regulation 2017/1485.
Methodology and business process related documents	— ACER, 08/2019: Methodology for assessing the relevance of assets for outage coordination (No. 12 of Table 25. Annex). — ENTSO-E, 2021: Outage planning coordination implementation guide (No. 35 of Table 25. Annex).
IT environments and tools	— ENTSO-E OPDE platform for data exchange — ENTSO-E Pan-European OPC tool for process The pan-European OPC tool facilitates the coordination of outages, sharing the

	element list and maintaining of the database for the relevant assets. A coordinated procedure ensures the quality and consistency of the data, e.g. via the validation of information about the planned status of the cross-border lines of the TSOs (ENTSO-E, 2022c).
Link with other tasks	Task (2) – Coordinated Security Analysis Task (3) – Common Grid Model Task (9) – Short-term Adequacy

Source: JRC analysis, 2023.

Figure 25. Example of the OPC process



Source: JRC analysis, 2023.

5.11 Supporting the TSOs in the inter-transmission system operators' settlement

Box 18. Relevant definitions – Task (11)

a. 'Calculation of costs', as the technical part of cost sharing, means the process of calculating all costs and revenues of redispatching and countertrading actions per bidding zone/TSO which are eligible for the regional cost sharing process under the cost sharing methodologies per each CCR. This process comprises the collection of input data, the calculation of the cost sharing key and the aggregation of the monthly total costs per bidding zone and/or TSO. At the request of TSOs, the calculation of costs and revenues resulting from redispatching and countertrading actions can be delegated to one or several RCCs (ACER, 13/2022);

c. 'Financial Settlement' means the act of creating the invoicing documents per bidding zone and/or TSO on redispatching and countertrading costs and revenues. Financial Settlement ends with the completion of invoicing (ACER, 13/2022);

g. 'Inter-TSO Settlement' means the financial settlement of the costs and revenues of TSOs of the same CCR resulting from non-overlapping XRA according to Article 74 of the CACM Regulation. If eligible for cost-sharing, a non-overlapping XRA must follow the cost sharing process as defined in the regional methodology of its CCR. Inter-TSO cost sharing is subject to the present methodology (ACER, 13/2022);

(26) 'redispatching' means a measure, including curtailment, that is activated by one or more transmission system operators or distribution system operators by altering the generation, load pattern, or both, in order to change physical flows in the electricity system and relieve a physical congestion or otherwise ensure system security (Electricity Regulation, 2019c);

16. 'Congestion income' means the revenues received as a result of capacity allocation (CACM Regulation, 2015);

Table 19. Supporting the TSOs in the inter-transmission system operators' settlement task summary

RCC Task	**(11-l) Supporting the TSOs in the inter-transmission system operators' settlement**
Category	Other
Contributing to	Market Integration (MI), Cost Efficiency (CE)
Objective	— The TSOs in the SOR may jointly decide to receive support from the RCC in administering the financial flows related to settlements between TSOs involving more than two TSOs, such as: ● Redispatching costs ● Congestion income ● Unintentional deviations ● Or reserve procurement costs. — Support will be offered in optimisation of inter-transmission system operator compensation mechanisms.
Timeframe	Upon request from TSOs.
Legal framework	— Article 37(1)(l) and Annex I (11) of the Electricity Regulation 2019/943.
Methodology and business process related documents	— ACER, 13/2022: Methodology for the Optimisation of Inter-TSO Settlements related to Redispatching and Countertrading (No. 29 of Table 25. Annex).

Source: JRC analysis, 2023.

5.12 Training and certification of RCC staff

Box 19. Relevant definitions – Task (12)

a. 'RCC Training Programme' means a general framework of all aspect related to training (including Training Modules and RCC annual Training Plan) and certification. The RCC Training Programme is made per each RCC (ACER, 07/2022);

f. 'RCC Operators' means all staff which operate one or more of the tasks carried out by RCCs according to Article 37 of Regulation (EU) 2019/943, with the exception of the task under Article 37(1)(g) of Regulation (EU) 2019/943. Each RCC may define one or more types of RCC Operators (ACER, 07/2022);

Table 20. Training and certification of RCC staff task summary

RCC Task	**(12-g) Training and certification of RCC staff**
Category	Other
Contributing to	Security of Supply (SoS)
Objective	— RCCs shall prepare and carry out training and certification programmes focusing on regional system operation for the personnel working for RCCs, such as RCC operators. — The training programs shall cover all the relevant components of system operation where the RCC performs tasks, including scenarios of regional crisis.
Timeframe	When the need arises.
Legal framework	— Article 37(1)(g) and Annex I (12) of the Electricity Regulation 2019/943
Methodology and business process related documents	— ACER, 07/2022: Regional Coordination Centre Training and Certification of Staff Methodology (No. 28 of Table 25. Annex).
Link with other tasks	All tasks.

Source: JRC analysis, 2023.

5.13 Tasks related to identification of regional electricity crisis scenarios

Box 20. Relevant definitions – Task (13)

(9) 'Electricity crisis' means a present or imminent situation in which there is a significant electricity shortage, as determined by the Member States and described in their risk-preparedness plans, or in which it is impossible to supply electricity to customers (Risk-preparedness Regulation, 2019a);

(13) 'Crisis coordinator' means a person, a group of persons, a team composed of the relevant national electricity crisis managers or an institution tasked with acting as a contact point and coordinating the information flow during an electricity crisis (Risk-preparedness Regulation, 2019a);

(18) 'Early warning' means a provision of concrete, serious, reliable information indicating that an event may occur which is likely to result in a significant deterioration of the electricity supply situation and is likely to lead to electricity crisis (Risk-preparedness Regulation, 2019a);

(h) 'Electricity crisis scenario' means a description of an event or a chain of events that will (or is expected to) lead to a deterioration of security of supply of electricity affecting a community or whole society. An electricity crisis scenario may include more than one region or subgroup defined by Member States or may include parts of two or more regions or subgroups (ACER, 07/2020);

(i) 'Regional electricity crisis' means a present or imminent situation in which more than one Member State has declared an electricity crisis at the same time (simultaneous crisis in two or more Member States) (ACER, 07/2020);

Table 21. Tasks related to identification of regional electricity crisis scenarios summary

RCC Task	**(13-m) Tasks related to identification of regional electricity crisis scenarios**
Category	Operational Planning (OP)
Contributing to	Security of Supply (SoS)
Objective	— If the ENTSO for Electricity delegates this function, RCCs shall identify regional electricity crisis scenarios. — The identification of regional electricity crisis scenarios shall be performed in accordance with the methodology. — RCCs shall support the competent authorities of each SOR upon their request in the preparation and carrying out of biennial crisis simulation.
Timeframe	Upon request from ENTSO-E. Every 4 years unless circumstances requires more frequent updates.
Legal framework	— Article 37(1)(m) and Annex I (13) of the Electricity Regulation 2019/943. — Article 5, Article 6(1) and Article 12(3) of Risk-preparedness Regulation 2019/941.
Methodology and business process related documents	— ACER, 07/2020: Methodology for Identifying Regional Electricity Crisis Scenarios (No. 13 of Table 25. Annex). — Update of the above methodology is in progress in which RCCs could play an even more important role in providing their expertise of regional coordination to entities involved in the process. — Role specifically related to cross-border dependencies between Member States and the regional impact of (regional) electricity crisis scenarios.
Link with other tasks	Task (6) – Post-operation and post-disturbances

Source: JRC analysis, 2023.

5.14 Identification of needs for new transmission capacity and supporting the ten-year network development plan (TYNDP)

Box 21. Relevant definitions – Task (14)
The 10-year network development plan (TYNDP) that ENTSO-E publishes every two years presents how to develop the power grid in the next 10 to 20 years so that it can effectively contribute to achieving these different and sometimes competing goals. The TYNDP is the outcome of a two-year process, starting with the development of scenarios or visions of how the European power system might look in 2030 and 2040 (ENTSO-E, c).

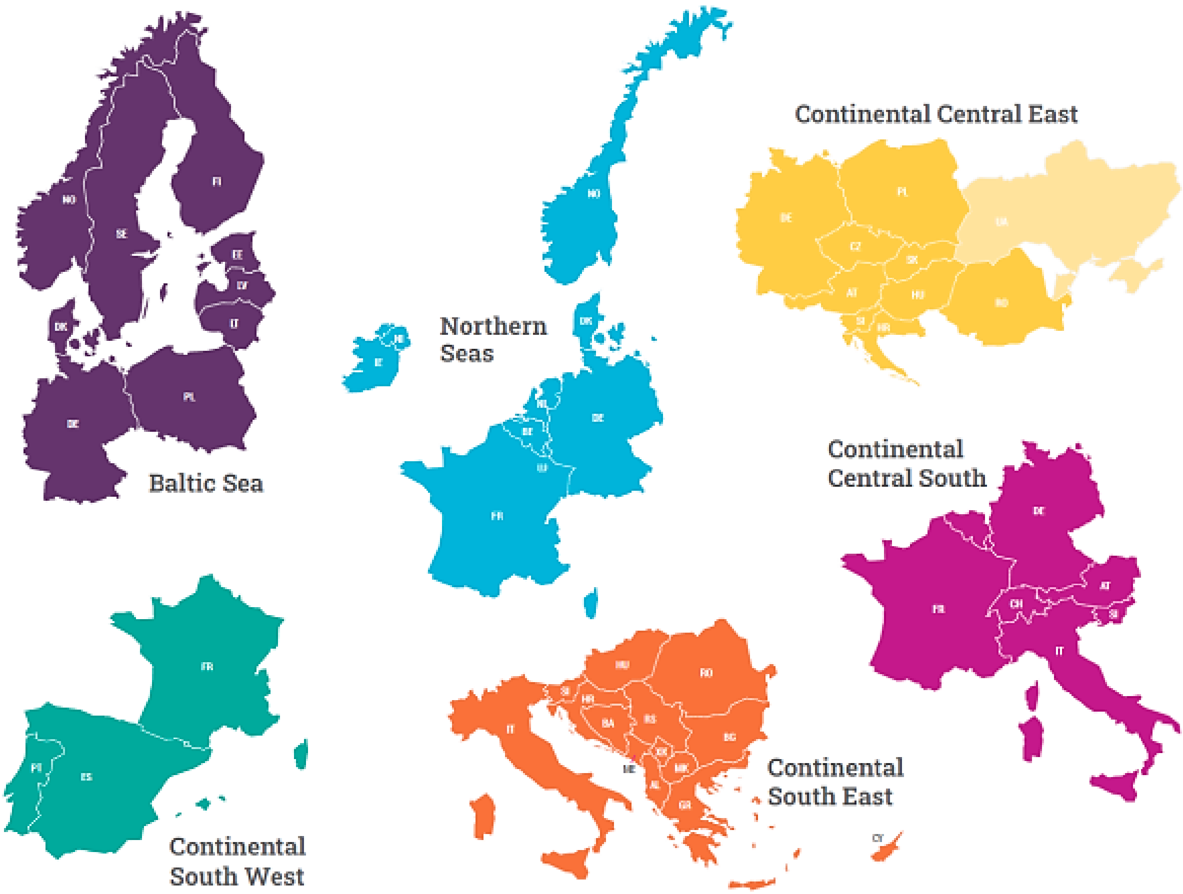
Table 22. Identification of needs for new transmission capacity and supporting the ten-year network development plan (TYNDP) task summary

RCC Task	**(14-p) Identification of needs for new transmission capacity and supporting the ten-year network development plan (TYNDP)**
Category	Operational Planning (OP)
Contributing to	Security of Supply (SoS), Market Integration (MI), Energy Efficiency (EE), Decarbonisation (D), Innovation (I)
Objective	— RCCs shall support TSOs in the identification of needs for new transmission capacity, for an upgrade of existing transmission capacity or for their alternatives. — To be submitted to the regional groups and to be included in the ten-year network development plan. — ENTSO-E Regional Groups (Figure 26.): • Northern Seas (BE, DE, DK, FR, IE, LU, NI, NL, NO) • Continental South West (ES, FR, PT) • Continental South East (AL, BA, BG, CY, GR, HR, IT, ME, MK, RO, RS, SI) • Continental Central South (AT, CH, DE, FR, IT, SI) • Continental Central East (AT, CZ, DE, HR, HU, PL, RO, SK, SI) • Baltic Sea (DE, DK, EE, FI, LV, LT, NO, PL, SE).
Timeframe	Upon request from TSOs. Every two years.
Legal framework	— Article 37(1)(p) and Annex I (14) of the Electricity Regulation 2019/943. — Regulation 347/2013 – Guidelines for trans-European energy infrastructure, repealed by Regulation (EU) 2022/869. — Article 51 of Electricity Directive (EU) 2019/944.
Methodology and business process related documents	— *Methodology in development* — ENTSO-E, 2022: 3rd ENTSO-E Guideline for cost-benefit analysis of grid development projects (No. 45 of Table 25. Annex). — ENTSO-E, 2023: Implementation Guidelines for TYNDP 2022 based on 3rd ENTSO-E guideline for cost benefit analysis of grid development projects (No. 46 of Table 25. Annex). — ENTSO-E, 2023: Implementation Guidelines for System Needs Study (No. 47 of Table 25. Annex).

Link with other tasks	Task (3) – Common Grid Model

Source: JRC analysis, 2023.

Figure 26. ENTSO-E's System Development regions. Each region is covered by one Regional Investment Plan.



Source: (ENTSO-E, 2023)

5.15 Calculation of the maximum entry capacity for foreign capacity

Box 22. Relevant definitions – Task (15)

(22) ‘capacity mechanism’ or CM means a temporary measure to ensure the achievement of the necessary level of resource adequacy by remunerating resources for their availability, excluding measures relating to ancillary services or congestion management (Electricity Regulation, 2019c);

(r) ’entry capacity’ means any kind of cross-zonal access rights, which can be allocated to enable eligible foreign capacity providers to participate in a CM for a given delivery period (ACER, 36/2020).

(u) ‘Foreign’ relates to a Member State, bidding zone or control area where a capacity provider (or a CMU) is located. This Member State, bidding zone or control area is outside the Member State(s) applying the CM, in which the capacity provider intends to participate (ACER, 36/2020).

(v) ‘Foreign capacity provider’ is the capacity provider that offers foreign CMU(s) in the (domestic) CM (ACER, 36/2020).

(w) ‘Foreign TSO’ is the TSO of a Member State, bidding zone or control area outside the Member State(s) applying the CM, where a capacity provider (or a CMU) is located (ACER, 36/2020).

(y) ’Maximum entry capacity’ means the maximum allowed entry capacity on a given CM border for a given delivery period (ACER, 36/2020).

(hh) ‘System stress’ refers to a time of system stress in line with Article 22(1) of the Electricity Regulation 2019/943. System stress may refer to either:

- A forecast of system stress events for a target year when calculating the maximum entry capacity

or

- A system stress event formally notified by the CM operator within the operation of a given CM (ACER, 36/2020).

The European Resource Adequacy Assessment (ERAA) is a pan-European monitoring assessment of power system resource adequacy of up to 10 years ahead. Building on the work done with the Mid-term Adequacy Forecast (MAF), the ERAA is a leap forward in system modelling. It is based upon state-of-the-art methodologies and probabilistic assessments, aiming to model and analyse possible events which can adversely impact the balance between supply and demand of electric power. It will be an important element for supporting qualified decisions by policy makers on strategic matters such as the introduction of capacity mechanisms (CMs) (ENTSO-E, d).

Table 23. Calculation of the maximum entry capacity for foreign capacity task summary

RCC Task	**(15-o) Calculation of the maximum entry capacity for foreign capacity**
Category	Capacity Allocation (CA)
Contributing to	Market Integration (MI), Security of Supply (SoS)
Objective	— RCCs shall support TSOs in calculating the value of the maximum entry capacity available for the participation of foreign capacity in capacity mechanisms taking into account the expected availability of interconnection and the likely concurrence of system stress between the system where the mechanism is applied and the system in which the foreign capacity is located. — The calculation shall be performed in accordance with the methodology. — RCCs shall provide a calculation for each bidding zone border covered by the SOR. — RCCs will issue a recommendation to the TSOs. — TSOs shall set the maximum entry capacity available for the participation of foreign capacity based on the recommendation of the RCCs on an annual basis. — ERAA data shall be shared between ENTSO-E and RCCs. In particular, for each ERAA, ENTSOE shall provide RCCs with all the relevant information for the calculation, on annual basis, of the maximum entry capacity available

	for cross-border participation in capacity mechanisms.
Timeframe	Upon request from TSOs.
Legal framework	— Article 26(7), Article 26(11)(a), Article 37(1)(o) and Annex I (15) of the Electricity Regulation 2019/943
Methodology and business process related documents	— ACER, 36/2020: Technical specifications for cross-border participation in capacity mechanisms (No. 20 of Table 25. Annex) — ACER, 24/2020: Methodology for the European resource adequacy assessment (ERAA) (No. 18 of Table 25. Annex)
Link with other tasks	Task (9) – Short-term adequacy assessment Task (14) – Identification of needs for new transmission capacity and supporting the ten-year network development plan (TYNDP) Task (16) – Tasks related to the seasonal adequacy assessments

Source: JRC analysis, 2023.

5.16 Tasks related to the seasonal adequacy assessments

Box 23. Relevant definitions – Task (16)

(68) 'Adequacy' means the ability of in-feeds into an area to meet the load in that area (SOGL Regulation, 2017a);

j. 'Loss of Load Expectation' (LOLE) means, in a given zone during a given time period, the expected number of hours during which resources are insufficient to meet the demand needs (ACER, 08/2020).

k. 'Loss of Load Probability' (LOLP) means, in a given zone and during a given time period, the probability that resources would be insufficient to meet the demand needs (ACER, 08/2020).

l. 'Energy Not Served' (ENS) means, in a given zone and during a given time period, the energy not supplied due to insufficient resources to meet demand needs (ACER, 08/2020).

m. 'Expected Energy Not Served' (EENS) means, in a given zone and during a given time period, the energy which is expected not to be supplied due to insufficient resources to meet demand needs (ACER, 08/2020).

n. 'Adequacy probability metric' (APM) means, in a given study zone and in a given time period, the probability of resources being sufficient to cover demand with supply. The sum of APM and LOLP yields 100% (ACER, 08/2020).

Monte Carlo method, statistical method of understanding complex physical or mathematical systems by using randomly generated numbers as input into those systems to generate a range of solutions. The likelihood of a particular solution can be found by dividing the number of times that solution was generated by the total number of trials. By using larger and larger numbers of trials, the likelihood of the solutions can be determined more and more accurately (Encyclopaedia Britannica).

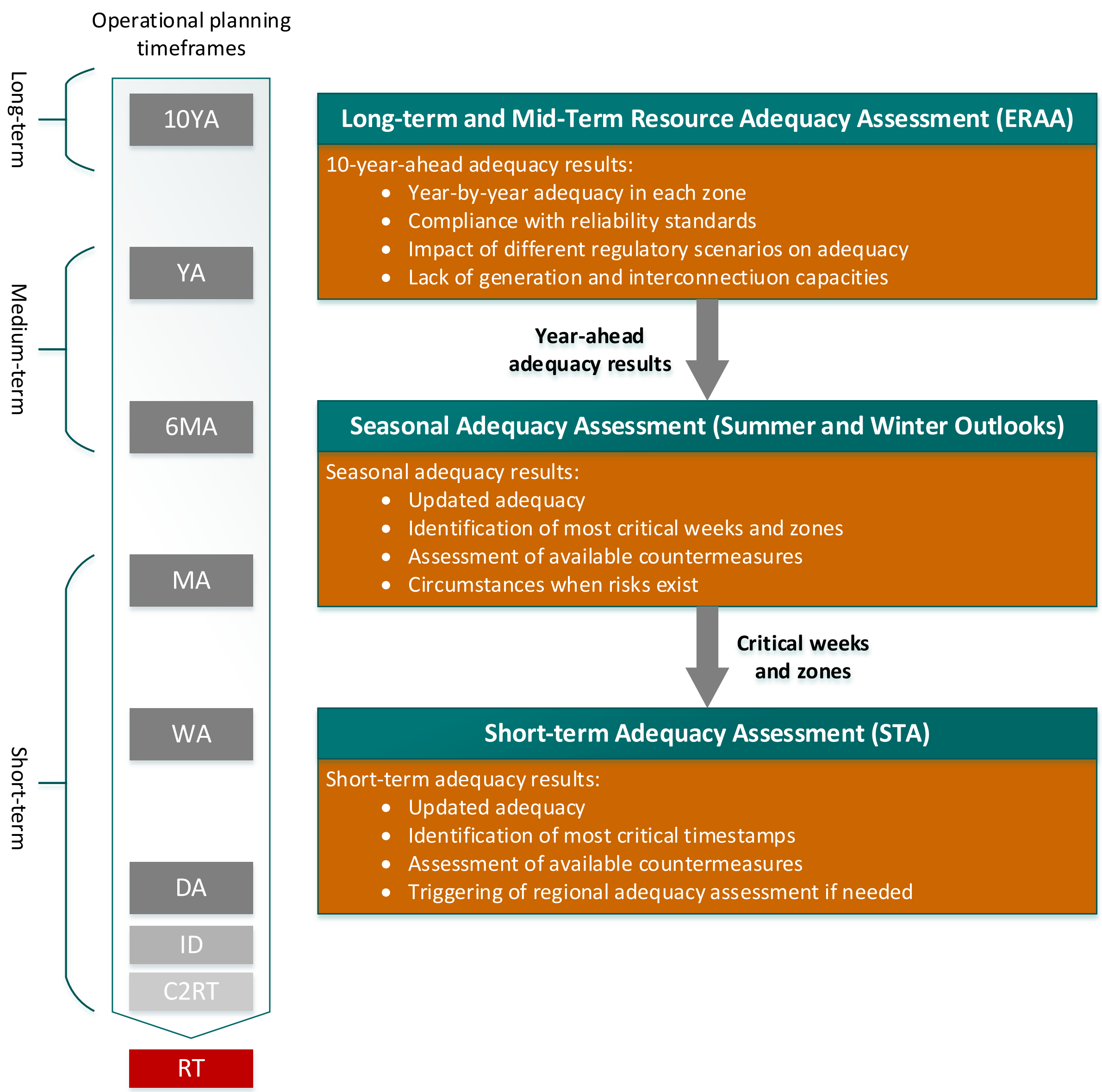
Table 24. Tasks related to the seasonal adequacy assessments summary

RCC Task	**(16-n) Tasks related to the seasonal adequacy assessments**
Category	System Adequacy (SA)
Contributing to	Security of Supply (SoS)
Objective	— The seasonal adequacy assessment will be performed in the form of winter and summer outlooks with the purpose of alerting MSs, TSOs and all other relevant stakeholders of adequacy-related risks that might occur in the following six months. — To carry out the regional seasonal adequacy assessments, ENTSO-E can delegate the function to the RCCs. — Both the short-term and seasonal adequacy assessments shall use a probabilistic methodology to assess adequacy for the concerned periods (Figure 27). — The methodology follows a Monte Carlo method to reflect the variability of weather as well as the randomness of supply and transmission unplanned outages.
Timeframe	Upon request from ENTSO-E. Two times per year.
Legal framework	— Article 37(1)(n) and Annex I (16) of the Electricity Regulation 2019/943. — Article 8 and Article 9 of Risk-preparedness Regulation 2019/941
Methodology and business process related documents	— ACER, 08/2020: Methodology for Short-term and Seasonal Adequacy Assessments (No. 14 of Table 25. Annex) — ENTSO-E., 2020: Explanatory note on Short-term and Seasonal Adequacy Assessments Methodology (No. 44 of Table 25. Annex) — ACER, 24/2020: Methodology for the European resource adequacy assessment (ERAA) (No. 18 of Table 25. Annex)

Link with other tasks	Task (9) – Short-term adequacy assessment Task (15) – Calculation of the maximum entry capacity for foreign capacity

Source: JRC analysis, 2023.

Figure 27. High-level information flow between adequacy assessments in different time horizons



Source: JRC analysis, 2023 (Based on ACER, 08/2020).

6 Approval procedure for (new) RCC task and expansion proposals

In this chapter, the approval procedure for new RCC task and the methodology proposal for already existing tasks will be presented from two perspectives. First, procedural and legislative point of view will be given, with defined deadlines, according to the EU Regulations. And secondly, RCCs point of view will be provided to better understand to what extent process change, or new task, affects their business, shown from the perspective of one established RCC, which could reflect situation in other RCCs. As a final note in this Report, the points of improvement will be tackled that reflect recent needs, focusing on one of the tasks related to the (regional) electricity crisis scenarios, and possibility for the adoption of new security of electricity supply tasks.

6.1 Legislative point of view

As seen in the previous chapters, the list of all RCC tasks, five core and all new tasks, are mandated by the EU legislation and particularly based on the Article 37(1) and Annex I of the Electricity Regulation. For the tasks set out in that Article, also listed in Chapter 5 of this Report, and all new possible advisory tasks, where those tasks and methodologies are not already covered by the relevant network codes or guidelines, the ENTSO-E shall develop a proposal in accordance with the procedure set out in the Article 27 of the Regulation, described further in this chapter.

In order to assign RCCs with new advisory tasks, Article 37(2) of the Electricity Regulation describes the prerequisites for this to happen:

1. Proposal for new advisory task to RCCs has to be made by the European Commission or a Member State.
2. On the basis of the proposal under 1, Committee, composed of representatives of the Member States and established by Article 68 of Electricity Directive 2019/944[5], shall issue an opinion on the assignment of new advisory tasks to RCCs.

Committee issues a favourable opinion on the new advisory task **and** for tasks and methodologies not already covered by the relevant network codes or guidelines:

3. ENTSO-E submitting proposal for methodology:
    (a) It shall carry out a consultation involving all relevant stakeholders, including regulatory authorities and other national authorities.
    (b) It shall consider the results of the consultation in its proposal.
4. Within three months of the date of receipt of the proposal, ACER shall either or approve it or amend it:
    (a) If amended – ACER shall consult the ENTSO for Electricity before approving the amended proposal.
    (b) Following an approval – ACER shall publish the approved proposal on its website.
    (c) Optional – ACER may request changes to the approved proposal at any time. Within six months of the date of receipt of such a request, the ENTSO-E shall submit a draft of the

[5] Article 68 of Electricity Directive 2019/944 - Committee procedure

1. The Commission shall be assisted by a committee. That committee shall be a committee within the meaning of Regulation (EU) No 182/2011.
2. Where reference is made to this paragraph, Article 4 of Regulation (EU) No 182/2011 shall apply.

Article 3(2) of Regulation (EU) No 182/2011 – Common provisions

2. The Commission shall be assisted by a committee composed of representatives of the Member States. The committee shall be chaired by a representative of the Commission. The chair shall not take part in the committee vote.

Article 4 of Regulation (EU) No 182/2011 – Advisory procedure

1. Where the advisory procedure applies, the committee shall deliver its opinion, if necessary by taking a vote. If the committee takes a vote, the opinion shall be delivered by a simple majority of its component members.
2. The Commission shall decide on the draft implementing act to be adopted, taking the utmost account of the conclusions drawn from the discussions within the committee and of the opinion delivered.

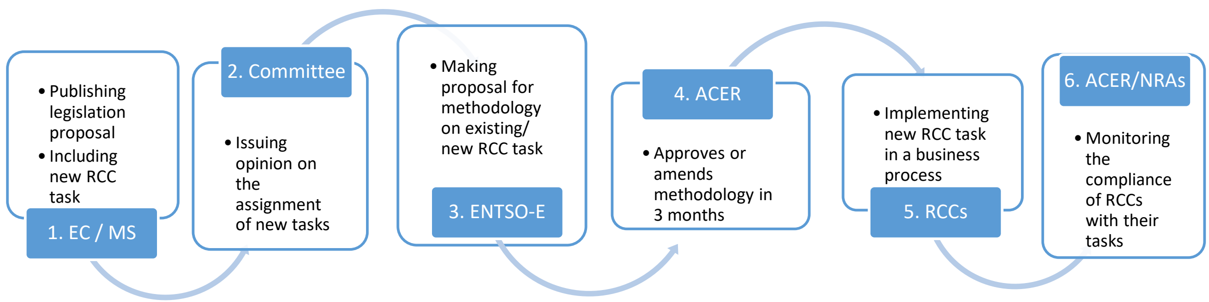
proposed changes to ACER. Within three months of the date of receipt of the draft, ACER shall amend or approve the changes and publish those changes on its website.

5. RCCs shall carry out those tasks based on the proposal following its approval by ACER.

6. Regulatory entities (ACER, NRAs) will monitor the compliance of RCCs with their tasks.

The complete process is displayed in the Figure 28. It is worth noting that the steps 3-6, related to ENTSO-E's proposals for methodologies, were already made or are in progress for many of the existing 16 RCC tasks since 1 July 2022. The development status of these methodologies is mentioned in the Table 5 of Chapter 5 and its subchapters.

Figure 28. Approval procedure for existing/ new RCC task(s)



Source: JRC analysis, 2023.

6.2 RCC's business point of view

In order to implement the mandated new task in the RCC day-to-day business, each RCC likely follows certain internal procedure on how to do it in the most efficient way. During the 2022's 5th Regional Coordination Conference on 18 November 2022, held online and hosted by SCC and SEleNe CC RCCs, some RCCs mentioned that for some tasks it took several and more years to become fully operational, especially more developed and complicated ones such as the first five core tasks.

Certainly for the new mandated tasks, the time for implementation will highly depend on the task and methodologies that have yet to be developed for a number of them. The procedure for implementing new RCC task in the RCC business is essentially provided in the Figure 29, based on presentation "Process for making a new task" by Nordic RCC during the Conference.

1. First and foremost would be to plan a budget required for adopting new task.

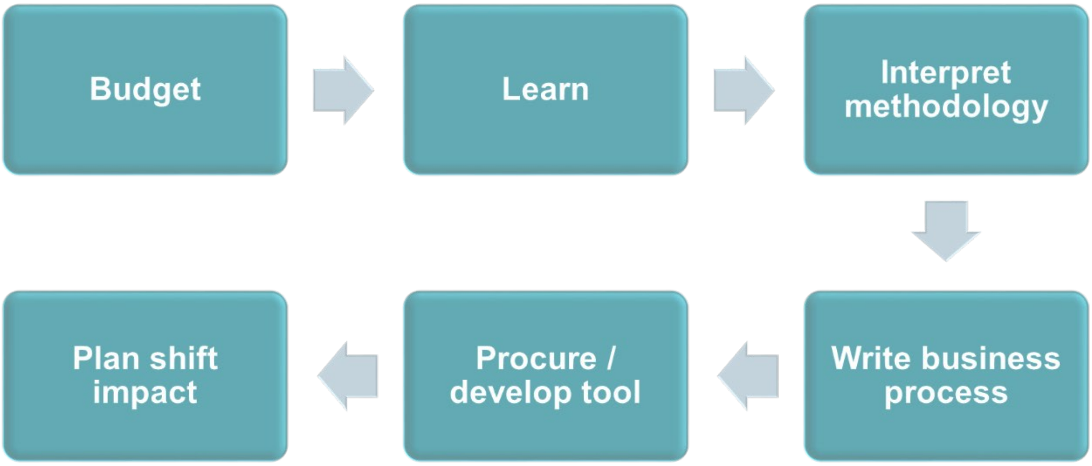
2. Then they have to plan the human resources to be able to develop task in an RCC process. That includes finding experts in the area, cooperating with experts from different stakeholders such as other RCCs, TSOs and ENTSO-E, but also interpreting all the details from the methodology developed by ENTSO-E and approved by ACER.

3. When the broader coordination is done, the RCCs will have to think how to implement this into their own specific business.

4. Writing business process require setting up detailed procedures on how to perform the task, but more importantly, how the task will be integrated in the existing IT and legal infrastructure.

5. Related to the tools needed for the task, either the existing ones will be upgraded or they will have to be developed from the beginning, also it will depend whether it will be implemented at the European or at a Regional level.
6. Last but not least, not all RCCs have the human resources needed to perform the new tasks. That includes training and certification of operators (see Chapter 5.12) able to perform certain tasks.

Figure 29. Implementation of task in the RCC business



Source: JRC analysis, 2022 (based on Nordic RCC, 2022).

7 Proposals for expanding existing RCC task(s) and for new security of electricity supply tasks

In this final chapter the points of improvement and expansion proposals will be presented. In recent years, EU has recognized the needs to rely on RCCs expertise, thus expanding some of their tasks related to the security of electricity supply (SoS) and system adequacy areas. In the sphere of SoS there are two additional points related to Critical Grid Situation (CGS) and System Modification Advice RequesT (SMART) Study, which will be presented in short paragraphs. These are also called "non-binding" RCC tasks/services, that were used sometimes in the past and mentioned in certain documentation. It is important to note that there is not much information available on these specific tasks. Reason for that could be that they are historical tasks provided alongside, and as a complement to, once 5 core RSC services, and possibly contractual (bilateral) tasks between specific RCCs and TSOs, as their shareholders. Moreover, few proposals were made with forward-looking vision based on recent needs, these are related to regional flexibility and data learning.

7.1 RCCs support to national and regional electricity crisis scenarios

Considering experience in recent years, geopolitical situation, coupled with the first set of Risk-preparedness plans (RPPs), Member States and the Electricity Coordination Group (ECG) have recognized needs for deeper analyses, especially in relation to the national electricity crisis scenarios where these were missing. For an RPP to be considered satisfactory, identification of regional crisis scenarios will have to be commonly assessed as a starting point. The objective in the development of these regional electricity crisis scenarios is to provide adequate information that will allow the creation of efficient RPPs. The effects of simultaneous crisis scenarios and cascading effects based on simulations also cannot be omitted. Based on RPPs, MSs should be able to design effective measures that will be cross-checked with the neighbouring countries and regional participants.

In this respects, ENTSO-E started in 2023 the process of revision of the methodology for the identification of regional electricity crisis scenarios conducted as per the requirement expressed in Article 7 of the EU Regulation 2019/941 on Risk Preparedness Plans. The new methodology has been reviewed to enhance the roles and responsibilities of all relevant stakeholders at each stage of the process, from the establishment of the list of regional electricity crisis scenarios candidates, to the compilation of a final list, the simulation of simultaneous regional scenarios when possible and in a progressive manner, and its final evaluation including the cross-border impacts.

For already existing RCC task (13) *identification of electricity crisis scenarios* (Chapter 5.13), the revision of the methodology enhances the role of the RCCs in the assessment of the cross-border dependencies in regional electricity crisis scenarios and in its assistance to ENTSO-E and TSOs throughout all the process. At an early stage, RCCs would support ENTSO-E in the establishment of a list of regional electricity crisis scenario candidates and the compilation of the final list of regional electricity crisis scenarios prior to their assessment. Then, RCCs could step in to enhance the simulation and evaluation of the regional aspect and cross-border dependencies, and their impact in the system operation regions (SORs). RCCs role could be to ensure consistency among countries, by assisting TSOs to carry out deeper qualitative and quantitative assessments and simulations based on the input data they provided.

In building the scenarios, TSOs would, among other sources, use information related to historical events and results of the *post-operation and post-disturbances analysis (post event analysis task* (6)) performed by RCCs, but also critical situations and incidents detected during daily *coordinated security analysis (CSA) (task 2)* with corresponding results and actions, and results from regional adequacy assessment of *short-term adequacy task (9)*, if such situation arises.

The above mentioned activities would be performed based on the ENTSO-E's methodology to identify regional electricity crisis scenarios, which is approved and published by ACER, and updated at least every 4 years. This methodology contains all necessary guidelines and especially for the use of common and comparable data, and if need arise, it will serve as basis for designing the common tool(s) that will be used throughout the process.

7.2 Critical Grid Situation (CGS) coordination

Critical Grid Situation (CGS) is a coordination service performed by RCCs in order to facilitate a regional or cross-regional coordination in critical grid situations. CGS is defined as a critical situation which cannot be solved solely at national level. To solve the situation, coordination between one or more TSOs is needed.

Box 24 Critical grid situation definition

A Critical Grid Situation is a potential emergency state, c.f. SOGL article 18(3), identified in the operational planning phase, when all the available regular countermeasures (Remedial Actions) are exhausted and therefore TSOs are required to take regionally coordinated extraordinary countermeasures (*Source*: Nordic RCC).

The CGS service is not mandated by European legislation, but requested by ENTSO-E and is agreed between TSOs. The CGS was defined as a service delivered by the RCCs at a SOC (System Operation Committee) meeting in September 2017.

The main purpose of this RCC task is to facilitate a regional or cross-regional coordination. The core of the CGS process is to facilitate and support exchange of information between relevant TSOs and RCCs. If a potential Critical Situation occurs, the necessary steps to facilitate the situation must be taken. This situation is identified as a Critical Grid Situation when the normal, national relevant remedial actions are exhausted and extraordinary measures are needed. Each CGS is unique, and a CGS can be triggered by a TSO or by a different task, such as short-term adequacy assessment as seen in the Chapter 5.9 of this report. TSOs often act proactively, using the CGS service to avoid a potential critical situation. The exchanged information can be a description of the expected operational situation, forecast for production, consumption and capacities for relevant corridors, weather forecast and its impact on the situation and the availability of the grid. When the situation is solved, the RCCs will document the process for the actual situation (*Source*: Nordic RCC website).

CGS could provide good basis for future quantitative (and qualitative) simulation exercises of national and regional crisis scenarios, firstly because these situations are realistic example of what could happen and what actions had to be taken in everyday system operation, coordinated among other TSOs and RCCs in order to avoid a critical grid situation which may result in electricity crisis, and secondly because the complete data (load, generation, flows) is already available and archived, including complete grid during CSA task. This data can then be further used and investigated with power flow tools and thus creating (even worse) electricity crisis scenarios, while impacting on generation (water, wind, solar, etc.), increase of load, and/or impacting on grid elements (loss of interconnection lines, transformers, etc.). On top of that, RCCs could be included, or even lead the simulation of electromagnetic pulse (EMP) risks which could affect huge swathes of electricity grid at once with a single triggering event, for which cause can be either natural (coronal mass ejection, geomagnetic solar storm, e.g. Carrington Event) or artificial i.e. man-made (nuclear or non-nuclear EMP). RCCs as the independent entities could, in cooperation with ENTSO-E and TSOs, for example simulate the impact and the risks of disconnection (and later reconnection-reenergising) of power grid elements and users (i.e. producers and consumers) in case of both natural and artificial phenomenon, thus proposing the best approach and remedial actions to be taken, and likely anticipate operational planning.

CGS coordination is a type of task that could potentially be mandated legally with the aim to bring more security of supply certainty enhanced with regional coordination. It would be aimed at the intraday (ID) and close to real-time (C2RT) timeframes after all regular countermeasures have been exhausted and TSOs have to reach out for an exceptional and/or regional measure. TSOs could rely on separate entities but taking RCCs as a middleman who should have a better overview on the regional situation and impact of certain CGS agreed remedial actions could be beneficial. These actions are taken to avoid leaving difficult situations in (C2)RT which could become alert or emergency states if not taken care of.

7.3 System Modification Advice RequesT (SMART) study

TSOs may request System Modification Advice Requests, or SMART studies, from RCCs to deeper investigate specific grid situations in close to real-time (C2RT) (Coreso, 2017). Examples could be calculating amount of redispatching, assessing impact of new forced outage(s) that happened in ID which were not covered with earlier studies, etc.

RCCs could then support TSOs in case of any system state other than normal or crisis level is triggered (alert or emergency state, early warning), by executing assessments including the grid in the modelling (for these particular cases), and providing remedial action recommendations.

SMART is a task that could be further examined as a potential new task or as an addition to ones already established, as it could help TSOs in difficult and tense C2RT situations, where lack of resources, whether time or human, could impact decision making. Since RCCs could already possess the tools, this task could be developed based on the needs/ requests from the TSOs, preferably agreed on ENTSO-E level.

7.4 Modelling of new needs of regional flexibility

Flexibility tools like demand-side response have demonstrated their effectiveness in meeting the demand reductions mandated by EC Regulation 2022/1854. They are expected to continue playing a pivotal role in the near future, as outlined in the reform of the electricity market design (European Council, 2023). The recently adopted reform emphasizes the importance of these tools by stating that, based on the national flexibility assessment, Member States should define an indicative national objective for non-fossil flexibility, including the respective specific contributions of both demand side response and energy storage to that objective, which should also be reflected in their integrated national energy and climate plans in accordance with Regulation (EU) 2018/1999. In particular, the reform of the electricity market design calls the Member States to request system operators to design a peak shaving product enabling additional demand response in order to contribute to decreasing consumption in the electricity system.

Preserving these tools not only bolsters the ability to tackle national electricity crisis, but they could also be used to extend support to other Member States. According to findings of the Ember study for a decarbonised European electricity system by 2035, the demand for flexibility, particularly on daily and weekly timescales, will undergo significant growth. This surge is primarily driven by the integration of solar PV and wind energy, with projected increases of up to twice by 2030 and six fold by 2050 compared to current levels (Ember, 2022).

The composition of flexibility portfolios will undergo a profound shift, transitioning away from dispatchable conventional thermal power plants (many of which are subject to phase-out strategies in several countries) to a more prominent role of cross-border exchanges, storage and demand side flexibility.

As renewables become more prevalent, the necessity for flexibility will be also required to maintain grid stability against unforeseen events, such as forced outages, due to the reduced inertia of the power system, and to maintain system balance against uncertainties in forecasts and renewable generation forecast errors.

These flexibility needs are currently satisfied explicitly through balancing reserves. New products, such as faster reserves or inertia, or increasing volumes of reserves could be required in the future, with special focus on activating and integrating flexibility, in particular from small electricity generators, demand side response and storage. Regional cooperation is a key enabler for a cost-efficient integration of renewable energy, with interconnections enabling to reduce flexibility needs across states and market coupling facilitating liquidity and efficiency of markets. According to the report “Power System Flexibility in the Penta region – Current State and Challenges for a Future Decarbonised Energy System” from the Pentalateral Energy forum, regional cooperation could play a key role by bringing benefits at all time frames, as flexibility needs could be reduced between 10% and 20% depending on the time horizon and flexibility time frame in the Pentalateral Region (Penta, 2023).

As part of their task 7 (Regional Sizing of Reserve Capacity), RCCs could also do specific assessment of the regional flexibility and suggest recommendations for dealing with this new electricity market scenario, where large scale renewable energy producers and other participants could be also subject to balancing responsibility. Having into account the relevance of the flexibility for the New Electricity Market, the RCCs could also contribute to assess the cross-border effects of this flexibility, as well as its use at regional level.

7.5 Data learning

Data learning can significantly enhance the capabilities of RCCs by leveraging advanced analytics and machine learning algorithms to analyze vast amounts of data related to electricity market dynamics, security threats, and operational challenges.

RCCs could provide decision making tools for data learning based on information related to historical events, demand forecasts and results of the *post-operation and post-disturbances analysis post event analysis task* (6) performed by RCCs, but also critical situations and incidents detected during daily *coordinated security analysis (CSA) (task 2)* with corresponding results and actions, and results from regional adequacy assessment of *short-term adequacy task (9)*. These tools enable RCCs to anticipate market dynamics and identify the most effective remedial actions when required, such as managing imbalances, optimizing demand response programs, and implementing risk management strategies.

Through this data learning, RCCs could develop and implement early warning systems that alert TSOs and ENTSO-E to potential threats or emergencies in the electricity sector. These systems may utilize advanced technologies, data analytics, and predictive modelling to provide timely and accurate information for decision-making.

This tool could allow RCC to support Member States in elaborating new threat scenarios to conduct the biennial simulation of electricity crisis, required by the Risk Preparedness Regulation (Article 12).

Additionally, RCCs could identify vulnerabilities or critical parts in the grid and promote infrastructure upgrades, enhancing the resilience of the power sector to improve grid reliability, reduce downtime, and minimize the risk of disruptions in market operations.

8 Conclusions

The Regional Coordination Centres (RCCs) can provide regional and cross-regional services that no individual country-based transmission system entity is in the position to deliver. This also entails that RCCs might have to reconcile different interests of countries included in a given region and this task can become growingly strategic as well as sensitive, especially during crisis times. Thus, RCCs are one of the key actors in transmission system operation in Europe, considering their regional, and cross-regional, presence in the system operation regions (SORs).

As seen at the beginning of this report, not all RCCs have been established recently, as some of them have been contributing to the European electricity transmission system governance for more than a decade, under the brand of RSCs – regional security coordinators. Having gained experience through past years' massive electricity system changes, these more experienced RCCs possess the expertise needed to provide guidance not only to TSOs and ENTSO-E (e.g. on methodology review or task structuring processes), but also to more recently established RCCs. For that reason, increasing RCC-RCC cooperation and active involvement in the European decision-making initiatives appear crucial. An example of good practice is the yearly Regional coordination conferences, where RCCs present their activities, highlight their achievements and offer outlooks to other entities and Member States.

This report provides an overview of RCCs, their tasks and their interactions with TSOs and other power system entities. Five core tasks, namely coordinated capacity calculation (1), coordinated security analysis (2), creation of common grid model (3), short-term adequacy (9) and outage planning coordination (10) are being performed on a daily basis without major issues. They have been established in the RCC's shift-based business process, with proper procedures, methodologies and guidelines for a considerable amount of time. Needless to say, these tasks are constantly evolving to match the current and updated methodologies and regulations, and their amendments. Clear communication in regional coordination between TSOs and cross-regional coordination between RCCs are essential. In tasks (1) and (2), TSOs should take into consideration RCCs' coordinated actions, recommendations and outcomes of the tasks' processes, while the regulating authorities will address the compliance of RCCs' tasks with legislative framework, methodologies and guidelines. Of the other eleven "new" tasks, it can be safely assumed that the training and certification of RCC staff (12) is being carried out based on the human resource and expertise needs. Post-operation and post-disturbance analysis and reporting (6) is taking the big entry and is already much-established. For the remaining 9 there are few tasks that do not require services on a continuous basis or are conditional; two of those are support to TSOs in defence and restoration plans' consistency assessment (4) and supporting the TSOs in the coordination of regional restoration (5), others are supporting the TSOs in the inter-transmission system operators settlements (11), and tasks in support to ENTSO-E related to the seasonal adequacy assessments (16), support to ten-year network development plan (14) and identification of regional electricity crisis scenarios (13), with the latter revised in Chapter 7.1. Other tasks, where the associated methodologies are still in development status, are: regional sizing of reserve capacity (7) and regional procurement of balancing capacity (8), with task calculation of maximum entry capacity (15) being conditional, but with the methodology ready.

RCCs, together with TSOs and ENTSO-E, have started to form a backbone on which the whole European transmission power system can rely upon. Nevertheless, few points of improvements for RCCs tasks with forward looking vision, in relation to the regional electricity crisis scenarios, critical grid situation coordination, flexibility and data learning, were pointed out. RCCs could provide dedicated assistance to TSOs and national electricity crisis scenarios identification, which are the basis for the regional ones. Altogether they can serve as an essential part of the overall important risk-preparedness strategy and plans that all Member States have to produce and adopt, as these have to cover past, current and emerging threats. In the system adequacy and operational planning domains, RCCs could contribute with regional overview and simulations of the potential incidents, and show their competence in providing their products such as services, reports and recommendations. RCC products will become more valuable over time as the decarbonisation of the electricity system increases, and could be established with timely and proper mandates by the European Union bodies.

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List of abbreviations and definitions

a/mFRR	Automatic/Manual Frequency Restoration Reserves
ACER	The European Union Agency for Cooperation of Energy Regulators
APM	Adequacy Probability Metric
BZ	Bidding Zone
BZB	Bidding Zone Border
C2RT	Close to real-time
CA	Capacity Allocation
CCC	Coordinated Capacity Calculation
CCR	Capacity Calculation Region
CGM	Common Grid Model
CGMES	Common Grid Model Exchange Standard
CGS	Critical Grid Situation
CNE	Critical Network element
CM	Capacity Mechanism
CRAA	Cross-regional Adequacy Assessment
CSA	Coordinated Security Analysis
D	Decarbonisation of the Economy
DA	Day-ahead
D2CF	Day-ahead Congestion Forecast
DACF	2-days-ahead Congestion Forecast
DSO	Distribution System Operator
EC	European Commission
ECA	European Court of Auditors
ECG	Electricity Coordination Group
EE	Energy Efficiency
ENS	Energy Not Served
EENS	Expected Energy Not Served
ENTSO-E	The European Network of Transmission System Operators for Electricity
ERAA	European Resource Adequacy Assessment
EU	European Union
FCR	Frequency Containment Reserves
I	Innovation
ID	Intraday
IDCF	Intraday Congestion Forecast
IGM	Individual Grid Model
JRC	Joint Research Centre
LOLE	Loss of Load Expectation
LOLP	Loss of Load Probability

MA	Month-ahead
MI	Market Integration
MS	Member State
NEMO	Nominated Electricity Market Operator
NRA	National Regulatory Agency
NTC	Net Transfer/Transmission Capacity
OP	Operational Planning
OPC	Operational Planning Coordination
OPDE	Operational Planning Data Environment
OS	Operational Security
PST	Phase Shifting Transformer
RCC	Regional Coordination Centre
RA	Remedial Action
RAA	Regional Adequacy Assessment
RG	Regional Group
RR	Replacement Reserves
RSC	Regional Security Coordinator
RT	Real-time
SA	System Adequacy
SN	Snapshot
SOC	System Operations Committee
SOR	System Operation Region
SoS	Security of Supply
STA	Short-term Adequacy
TRM	Transfer Reliability Margin
TSO	Transmission System Operator
TTC	Total Transfer/Transmission Capacity
TYNDP	Ten-year Network Development Plan
UCTE	Union for the Co-ordination of Transmission of Electricity
WA	Week-ahead
XNE	Cross-border Relevant Network Element
XNEC	Cross-border Relevant Network Element Contingency
YA	Year-ahead

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Annex

Table 25. European legislative framework

No.	Type	Entity	Year/Number Number/Year	Links	Full name	In the Report
1	Regulation	EC	2013/**347**	Link	Guidelines for trans-European energy infrastructure	
2	Regulation / Network Code (Market)	EC	2015/**1222**	Link	Guideline on capacity allocation and congestion management	CACM Regulation
3	Regulation / Network Code (Market)	EC	2016/**1719**	Link	Guideline on forward capacity allocation	FCA Regulation
4	Regulation / Network Code (Operations)	EC	2017/**1485**	Link	Guideline on electricity transmission system operation	SOGL Regulation
5	Regulation / Network Code (Market)	EC	2017/**2195**	Link	Guideline on electricity balancing	Balancing Regulation
6	Regulation / Network Code (Operations)	EC	2017/**2196**	Link	Network code on electricity emergency and restoration	ERR Regulation
7	Regulation	EC	2019/**941**	Link	Risk-preparedness in the electricity sector and repealing Directive 2005/89/EC	Risk-preparedness Regulation
8	Regulation	EC	2019/**942**	Link	Establishment of European Union Agency for the Cooperation of Energy Regulators	ACER Regulation
9	Regulation	EC	2019/**943**	Link	Internal market for electricity	Electricity Regulation
10	Directive	EC	2019/**944**	Link	Common rules for the internal market for electricity and amending Directive 2012/27/EU	Electricity Directive
11	Decision / Methodology	ACER	**07**/2019	Link 1 Link 2	Decision (Link 1) on the all TSO's proposal for the/ and Methodology (Link 2) for coordinating operational security analysis	/

12	Decision / Methodology	ACER	**08**/2019	Link 1 Link 2	Decision (Link 1) on the all TSO's proposal for the/ and Methodology (Link 2) for assessing the relevance of assets for outage coordination	/
13	Decision / Methodology	ACER	**07**/2020	Link 1 Link 2 Link 3	Decision (Link 1) on/ and Methodology (Link 2) for Identifying Regional Electricity Crisis Scenarios (Annex I and II – Link 3)	/
14	Decision / Methodology	ACER	**08**/2020	Link 1 Link 2	Decision (Link 1) on/ and Methodology (Link 2) for Short-term and Seasonal Adequacy Assessments	/
15	Decision / Methodology	ACER	**11**/2020	Link 1 Link 2	Decision (Link 1) on/ and Methodology (Link 2) for a list of standard products for balancing capacity for frequency restoration reserves and replacement reserves	/
16	Decision / Methodology	ACER	**19**/2020	Link 1 Link 2	Decision (Link 1) on/ and Methodology (Link 2) on the common and harmonised rules and processes for the exchange and procurement of aFRR balancing capacity for the Nordic LFC Block	/
17	Decision / Methodology	ACER	**23**/2020	Link 1 Link 2	Decision (Link 1) on/ and Methodology (Link 2) for calculating the value of lost load, the cost of new entry, and the reliability standard	/
18	Decision / Methodology	ACER	**24**/2020	Link 1 Link 2	Decision (Link 1) on/ and Methodology (Link 2) for the European resource adequacy assessment (ERAA)	/
19	Decision / Methodology	ACER	**35**/2020	Link 1 Link 2	Decision (Link 1) on/ and Methodology (Link 2) for coordinated redispatching and countertrading for the Core CCR (RDCT Methodology – Annex I to II)	/
20	Decision / Technical specifications	ACER	**36**/2020	Link 1 Link 2	Decision (Link 1) on/ and Technical specifications (Link 2) for cross-border participation in capacity mechanisms	/
21	Decision / Definition	ACER	**04**/2021	Link 1 Link 2	Decision (Link 1) on/ and the Determination (Link 2) of Capacity Calculation Regions	/
22	Decision / Methodology	ACER	**07**/2021	Link 1 Link 2	Decision (Link 1) on/ and Amendment (Link 2) of the Methodology for Coordinating Operational Security Analysis	/

23	Decision / Methodology	ACER	**11**/2021	Link 1 Link 2	Decision (Link 1) on/ and Methodology (Link 2) for the market-based allocation process of cross-zonal capacity for the exchange of balancing capacity for the Core CCR	/
24	Decision / Methodology	ACER	**14**/2021	Link 1 Link 2	Decision (Link 1) on/ and Long-term capacity calculation methodology (Link 2) of the Core capacity calculation region	/
25	Decision / Review	ACER	**02**/2022	Link 1 Link 2 Link 3	Decision (Link 1) on the European Resource Adequacy Assessment (ERAA) for 2021; Detailed ERAA 2021 Review (Link 2); Summary of Recommendations (Link 3)	/
26	Decision / Methodology	ACER	**04**/2022	Link 1 Link 2	Decision (Link 1) on/ and Methodology (Link 2) on the Regional Coordination Centre Post-Operation and Post-Disturbances Analysis and Reporting Methodology	/
27	Decision / Definition	ACER	**05**/2022	Link 1 Link 2	Decision (Link 1) on/ and the Definition (Link 2) of System Operation Regions (+Annex Ia-V)	/
28	Decision / Methodology	ACER	**07**/2022	Link 1 Link 2	Decision (Link 1) on the Regional Coordination Centre Training and Certification of Staff Methodology (Link 2)	/
29	Decision / Methodology	ACER	**13**/2022	Link 1 Link 2	Decision (Link 1) on/ and Methodology (Link 2) for the Optimisation of Inter-TSO Settlements related to Redispatching and Countertrading	/
30	All TSO's proposal / Methodology	ENTSO-E	2018	Link	Methodology for building the common grid models; All TSOs' proposal for a common grid model methodology in accordance with Articles 67(1) and 70(1) of Commission Regulation (EU) 2017/1485 - SOGL.	/
31	All TSO's proposal / Methodology	ENTSO-E	2018	Link	Methodology for coordinating operational security analysis; All TSOs' proposal for a methodology for coordinating operational security analysis in accordance with Article 75 of Commission Regulation (EU) 2017/1485 - SOGL.	/
32	Implementation guide	ENTSO-E	2019	Link	Coordinated capacity calculation implementation guide	/

33	Implementation guide	ENTSO-E	2021	Link	CACM list of information to ACER implementation guide	/
34	Implementation guide	ENTSO-E	2021	Link	Short term adequacy forecasts (STA) implementation guide	/
35	Implementation guide	ENTSO-E	2021	Link	Outage planning coordination implementation guide	/
36	Implementation guide	ENTSO-E	2021	Link	CGMA data exchange implementation guide	/
37	Network Code (Cybersecurity)	ENTSO-E EU DSO E	2022	Link	Network Code for cybersecurity aspects of cross-border electricity flows (NCCS)	/
38	Methodology	ENTSO-E	/	Link	Capacity Calculation Region (CCR) Methodologies	/
39	Review	ENTSO-E	/	Link	Bidding Zone Review (BZR)	/
40	Specification	ENSTO-E	2022	Link	Coordinated Security Analysis (CSA) Data Exchange Specification	/
41	Methodology	ACER	/	Link	Latest approved redispatching and countertrading methodologies of the respective CCRs	/
42	Implementation monitoring report	ACER	2021	Link	Implementation Monitoring Report of the Network Code on Emergency and Restoration	/
43	Library	ENTSO-E	/	Link	Emergency & Restoration National Implementation	/
44	Explanatory note	ENTSO-E	2020	Link	Short-term and Seasonal Adequacy Assessments Methodology – Explanatory note	/
45	Guideline	ENTSO-E	2022	Link	3rd ENTSO-E Guideline for cost-benefit analysis of grid development projects	/
46	Implementation guideline	ENTSO-E	2023	Link	Implementation Guidelines for TYNDP 2022 based on 3rd ENTSO-E guideline for cost benefit analysis of grid development projects	/
47	Implementation guideline	ENTSO-E	2023	Link	Implementation Guidelines for System Needs Study	/
48	Proposal	ENTSO-E	2022	Link	ENTSO-E Proposal for the Regional Coordination Centres' task 'regional sizing of reserve capacity'	
49	Proposal	ENTSO-E	2022	Link	ENTSO-E proposal for the Regional Coordination Centres' task "Facilitating the regional procurement of balancing capacity"	

Source: JRC analysis, 2023.

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