Report for ENTSO-E

OPTIONS FOR THE FUTURE OF POWER SYSTEM REGIONAL COORDINATION

8 December 2016

FTI CONSULTING | COMPASS LEXECON

ENERGY

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Report for ENTSO-E

OPTIONS FOR THE FUTURE OF POWER SYSTEM REGIONAL COORDINATION

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Context and objectives of the study

The ongoing transformation of the electricity industry with the development of decentralised generation, storage, smart grids and active consumer participation, together with the implementation of the Internal Energy Market (IEM), are having a significant impact on the functioning of the European power system – and more specifically on system operations.

The Third Legislative Package[1] established the cooperation of TSOs through a European entity, ENTSO-E (European Network of Transmission System Operators – Electricity), of regulators, through the European Agency for the Cooperation of Energy Regulators (ACER) and initiated the development of Network Codes and Guidelines.

The system operation guideline (SOGL)[2] – and indirectly the Capacity Allocation and Congestion Management (CACM) guideline[3] – foresees the roll-out of Regional Security Coordinators (RSCs), which will provide five core services to TSOs in the field of operational planning and capacity calculation by 2018. **Substantial benefits for system operation are expected from the roll-out of RSCs and, more generally, from the implementation of the guidelines.**

With the growing penetration of intermittent RES and the subsequent changes in the generation mix, market participants optimise their portfolio closer to real time and increasingly trade across borders. Consequently, the different generation patterns, in combination with extensive trading, lead to increasing power flows across Europe, creating challenges for system operators and market trading in some parts of Europe due to significant unscheduled (loop and transit) flows. A sustainable and long-lasting solution is the implementation of improvements to market design, accompanied by the relevant development of the transmission infrastructure needed to sustain the level of RES. As far as market design is concerned, the first step already anchored in CACM is the implementation of coordination of capacity calculation on the borders of appropriately defined bidding zones, which may help to better use the limited grid capacities. Regarding transmission development, there are plans to reinforce existing infrastructures, with 150 b€ of planned investment across Europe over the next decade. However, these infrastructure developments are often slowed down by local opposition which generates delays and additional costs, or even sometimes the cancellation of projects.

1) Directive 2009/72/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC available at: http://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX%3A32009L0072 and Regulation (EC) No 714/2009 of the European Parliament and of the Council of 13 July 2009 on conditions for access to the network for cross-border exchanges in electricity and repealing Regulation (EC) No 1228/2003 available at: http://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX%3A32009R0714

2) Provisional final version of the Commission Regulation establishing a guideline on electricity transmission system operation, available at: https://ec.europa.eu/energy/sites/ener/files/documents/SystemOperationGuideline%20final%28provisional%2904052016.pdf

3) Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management available at: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32015R1222

Given the profound and rapid transformation of the electricity industry and of the IEM, the European Commission is considering the future of system operation, in order to foster cooperation at the regional level. In this context, ENTSO-E has commissioned an independent study from FTI-Compass Lexecon Energy (hereafter "FTI-CL Energy") to analyse potential practical options for the future of system operation regional coordination in the next decade, with the objective of looking beyond the SOGL and identifying a number of practical recommendations to enhance regional cooperation.

Prerequisites to regional cooperation for system operation

System operation is intrinsically linked with a wider set of policies, regulations, and governance issues. A range of alternative high level options for regional cooperation of TSOs have been brought forward, which would require radical changes to the current policy and regulatory framework. More specifically, a number of prerequisites to the implementation of further regional coordination have been identified:

- **The harmonisation or the coordination of policies and regulation are necessary steps to improve the overall functioning of the power market and to facilitate the tasks of TSOs and RSCs, allowing them to further improve system operations.** In practice, some of the concerns with the perceived barriers to efficient operation are mostly due to differences in national regulations and market designs, or to the negative impact of certain public policies.
- **The existing synergies and dependencies in terms of decision-making under different time frames for system operation should be preserved.** These synergies and dependencies guarantee that the close interrelation between different TSO tasks is well considered to maintain security of supply and optimise the operation and the development of the network.
- **An evolutionary approach and gradual implementation based on safe evolutionary migration** is necessary in order to allow for regulatory and legal frameworks to adapt and for TSOs and RSCs to establish a new organisation for system operations.

The analysis of high level options for the regional coordination of TSOs shows that no options perform better than RSCs in addressing these challenges and concerns in a reasonable time frame. Indeed, the RSC model has the flexibility to evolve both in terms of roles performed but also in terms of the supporting regulatory framework.

Options which require a transfer of liability to entities other than TSOs – such as Regional Centres for Before Real-Time operations (BRT-RCs)[1], or Regional Independent System Operators (Regional ISOs) – would likely face concerns by Member States associated with the loss of control of security of supply on a national basis and would induce such deep changes in the legal and regulatory frameworks that they could likely not be implemented in the medium term.

A disruptive legal and regulatory framework would result in a major change in the organisation of operations across Europe, with impacts in terms of human resources, regulations, contractual arrangements with grid users etc., while a separation of activities entails risks in terms of operational security and could break the synergies between TSOs' activities and dis-optimise the planning and operation of the power grid. Moreover, in order to implement such changes while maintaining security of supply, a long transition period would likely be required, during which operational risks may increase as the new responsible entities would face a steep learning curve to acquire the requisite expertise and ability to manage complexity, and would need to develop adequate procedures and IT systems, which TSOs have developed and upgraded continuously over decades at the national, regional and European levels.

1) In the preliminary impact assessment, the EC uses the term Regional Operational Centres (ROCs) as well, but the definition seems to differ from the description provided in this study. Therefore, to avoid any confusion, we renamed the option BRT-RC, which stands for Regional Centres for Before Real-Time operations.

A proposal for an Enhanced Regional Coordination framework

FTI-CL Energy **suggests following an incremental and modular approach evolving the concept of RSCs and based on the five pillars** presented in Figure 1:

- **A stronger regional cooperation for policy and regulation.** Divergence and gaps in policies and regulations, as well as market design, are either (i) hurdles for further integration or (ii) causes of inefficiencies in operations or market functioning. Moreover, solving these issues is often a prerequisite for strengthening further coordination in system operation and for any form of operational coordination to be efficient.
- **RSCs as regional coordinators for system operation.** RSCs are the natural entities to perform coordinated tasks at regional level for the TSOs. They are gradually increasing their skills and expertise and becoming a trusted counterpart to TSOs for carrying out sensitive security analysis and various other services.
- **A governance and decision-making process allowing RSCs to efficiently support TSOs tasks pursuing system security and social welfare optimisation at the regional or European level.** The governance of RSCs should be improved to ensure the transparency and enable an efficient monitoring of their activities by NRAs. Gradual improvements in the governance and evolutions in the scope of interventions could be useful to improve decision processes and create competence to perform trusted analyses and services, which would be aimed at system security, but also at regional optimisation and social welfare maximisation.
- **RSCs as natural bodies to coordinate additional services as regionally needed.** As their expertise and experience increases, RSCs will be able to extend their scope of services to TSOs to other tasks related to operational planning, and also to other activities for which coordination would provide added benefits.
- **A geographical modularity focused on efficiency gains.** Situations differ depending on the regions and their specificities. To account for these differences, some modularity could allow geographical differences to coexist efficiently and the extension of the scope of RSCs to certain regions/activities could be motivated by the quantification of costs and benefits.

Figure 1: Pillars of the Enhanced Regional Coordination concept. Source: FTI-CL Energy

The ERC approach needs to be supported by stronger regional cooperation for policy and regulation

To foster stronger cooperation for policy and regulation, **FTI-CL Energy supports a concept of policy regions, based on a three-layer coordination forum** presented in Figure 2:

- **Coordination of policy makers.** A first forum of policy makers would involve member states and national energy regulators, as well as TSOs to the extent necessary, focusing on cooperation at the political level and on the coordination and harmonisation of policies and regulations to facilitate market integration and improve the efficiency of these policies, taking a regional point of view. Institutions such as the European Commission or ACER could also participate in this forum.
- **Consultation of stakeholders.** A second group would organise the adequate consultation of all relevant stakeholders, through dedicated meetings and workshops as well as public consultations. Stakeholder engagement is indeed a necessity to the concept of policy regions, to ensure a smooth and satisfactory implementation.
- **Cooperation of TSOs.** A third layer would focus on the coordination of TSOs in system and market operations and all TSO activities, for which regional coordination would be valuable, and examine the impact of policies on system and market operation and the operational implementation of such policies, if necessary. This forum would, in particular, involve RSCs and other relevant service providers or project partners (e. g. power exchanges, the Joint Auction Office etc.).

In addition to building the convergence of policies and regulations, the role of policy regions would also be to coordinate all the necessary decisions at national and regional levels to allow and facilitate the improvements of the regional cooperation of TSOs. In particular, they would have to remove all regulatory barriers and agree on necessary methodologies or processes such as cost sharing, etc.

For the operational cooperation between TSOs, FTI-CL Energy proposes a concept which builds upon RSCs and fully integrates the challenge of policy and regulation coordination, while allowing for an incremental

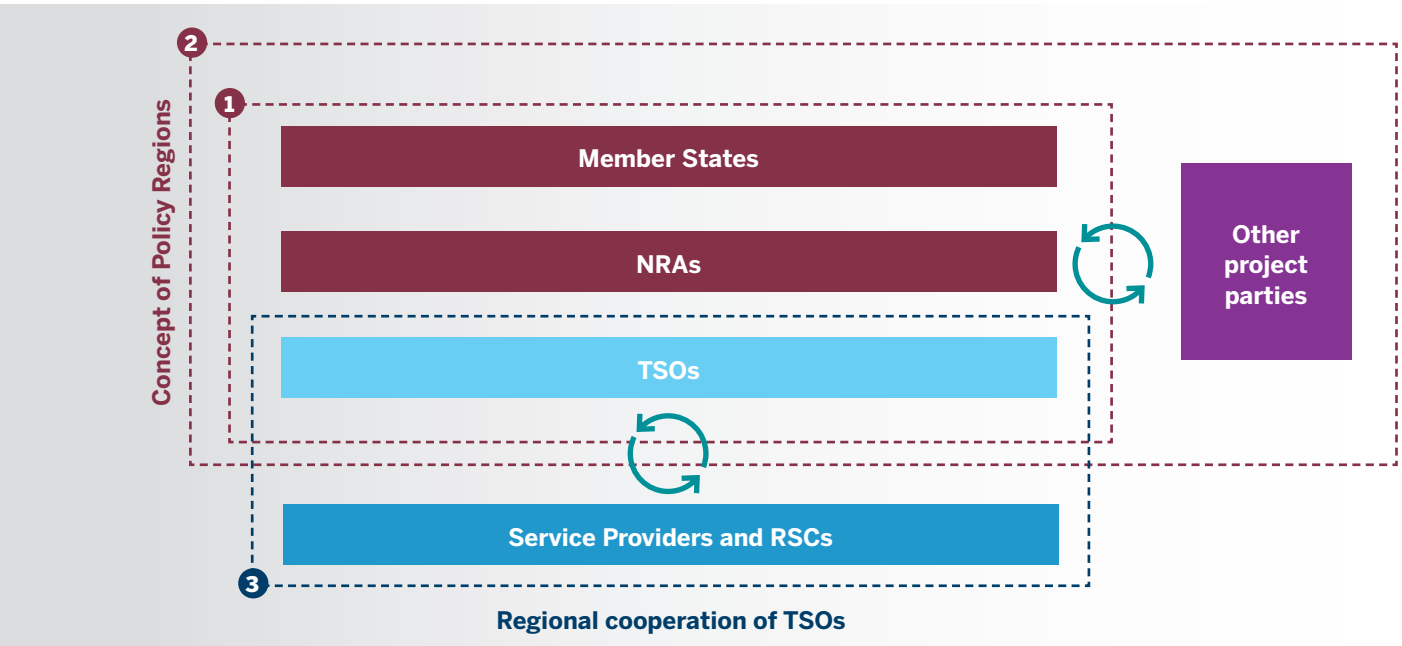


Figure 2: Three-layer regional coordination framework for policies and regulations. Source: FTI-CL Energy

and modular, but ambitious, enhancement of regional coordination in SO activities.

In the ERC concept, the allocation of responsibility is clear and **the TSOs remain fully responsible for operational security**. Thus, provided that coordination of regulations and policies is also improved, the proposed concept enables **RSCs to enhance TSOs' coordination, to provide complementary analyses and to perform new coordination services, when they are considered of added value in the region**. However, the allocation of responsibility and the governance ensures that the TSOs could perform analyses and remain in a position to prevent any action which could jeopardise operational security.

Economic efficiency and the maximisation of social welfare at the wider regional or European scope is the driver for this approach. The proposed framework for policy regions with effective regulatory coordination and the proposed framework for RSCs, with the evolution of governance and decision-making process specifically, aim to **foster more efficient decisions and align national preferences with regional optimisation**. The ERC approach should therefore improve economic efficiency. Moreover, the extension of RSCs' scope of activity, motivated by Cost Benefit Analysis (CBAs) where relevant, also contributes to higher economic efficiency.

FTI-CL Energy's ERC proposal **does not require major changes in the institutional and regulatory framework** as it is based on the approach set in the new regulation. However, its **evolution intrinsically integrates the necessary evolutions in policies, regulations and market design**.

Finally, the concept of Enhanced Regional Coordination (ERC) does not preclude any further evolution beyond 2030 towards other long-term solutions. Our proposed ERC approach is a no-regret solution, which is compatible with any option and which would, in any case, be a useful step should one decide in the future to opt for one of these options, as illustrated in Figure 3 below.

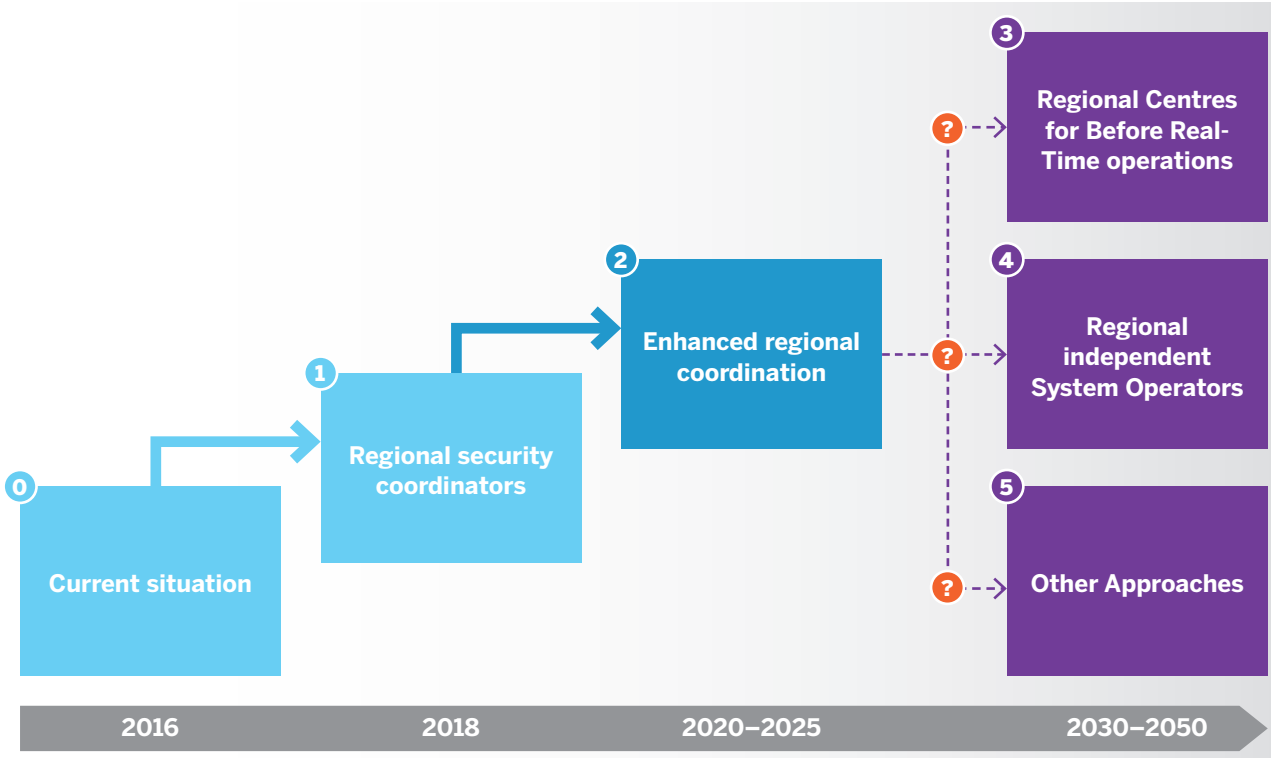


Figure 3: The concept of ERC as an evolutionary model for coordination. Source: FTI-CL Energy

Section 1

Introduction: Context and objectives of the study

Context of the study

EU energy policy drives major changes in the power system

Over the past 20 years, the European energy policy has changed the functioning of the power system in depth, as shown in Figure 4:

- **The liberalisation process** engaged at the end of the 1990s has gradually ended vertically integrated monopolies and enabled the emergence of competition both in the generation and retail sides. High voltage network activities are now independent from generation and supply activities, and an increasing number of stakeholders are connected to the grid or are active in the market.
- **The creation of a European Internal Energy Market**, although still in progress and incomplete, enables trading across the whole of Europe and closer to real time, with a strong increase of intraday trades in particular.
- **The significant penetration of renewables** has been enabled by national public policies and subsidies. The development of renewables supported by out-of-market mechanisms, combined with the stable to decreasing power demand in many countries, is gradually crowding out conventional fossil fuel plants. Moreover, most of the development was achieved on the part of wind and solar power, connected to a large extent to the distribution grids. In addition, these energy sources are intermittent, insofar as their generation output depends on wind and solar conditions, which increases the need for system flexibility.
- **The empowerment of consumers** is under way. Consumers are gradually having increased access to more information on their consumption, thanks to smart meters or services developed by aggregators. For instance, demand side management services can use information technologies to remotely control and optimise consumers‘ consumption. In addition, the development of “prosumers” who invest in their own generation – mostly photovoltaic panels, or in storage capacities (e. g. with electric vehicles) – creates new challenges.

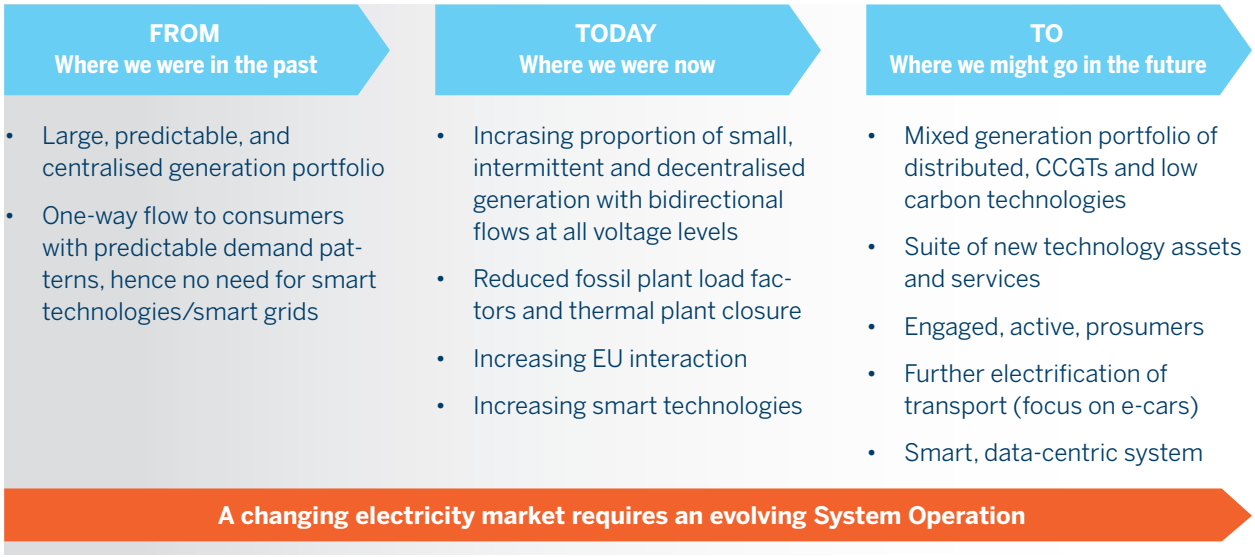


Figure 4: Electricity system changes: past, present and future. Source: FTI-CL Energy

As a result of these changes – most notably the development of intermittent renewable energy sources (RES), which are generally located in distribution grids – system operation is required to adapt to the increased and higher fluctuations of cross-border trading, the impact of changed generation patterns and increasing and uncertain power flows (including loop flows and transit flows), all of that resulting in substantially increased volatility.

Transmission System Operators (TSOs) have historically built up together the synchronous and coordinated European network and developed voluntarily common or compatible standards based on common analysis and sharing of best practices (e. g. Continental Europe Operational Handbook). The motivation ever since[1)] has been to increase security, share reserves and enhance economic efficiency. Nevertheless, the TSOs have been operating their systems based on largely national approaches, as a result of the historic development of national power systems and their operations.

The previously described changes in interconnected system operating conditions, resulting in occurrences of unforeseen serious disturbances – most notably the well-known system split observed in the continental synchronous area on 4 November 2006 – have led to the first Regional Security Coordination Initiatives (RSCIs, now RSCs) and the establishment of Coreso and TSC back in 2008. These developments have allowed TSOs to further coordinate not only system operations but also network planning, system adequacy analysis, market facilitation etc.

The "Third legislative Package"[2)] generalises efforts to develop further coordination between TSOs, with, for example, the creation of the "European network of transmission system operators for electricity" (ENTSO-E) and the establishment of common rules for the IEM. Eight network codes or guidelines[3)] were drafted by ENTSO-E and have now been turned into binding EU regulation through the comitology process. The full implementation of these guidelines will take place over the next few years –probably continuing beyond 2020 for balancing – and is expected to deliver substantial benefits for the IEM.

1) First UCPTE rules emerging in the 1950s

2) Directive 2009/72/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC available at: http://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX%3A32009L0072 and Regulation (EC) No 714/2009 of the European Parliament and of the Council of 13 July 2009 on conditions for access to the network for cross-border exchanges in electricity and repealing Regulation (EC) No 1228/2003 available at: http://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX%3A32009R0714

3) Whereas both network codes and guidelines are binding EU law (once passed through Parliament), the difference lies in the character of provisions: in the network codes these must be final, in the guidelines it is possible to amend the initial ones with further detailed items like methodologies or other specifications after the guideline is legally endorsed.

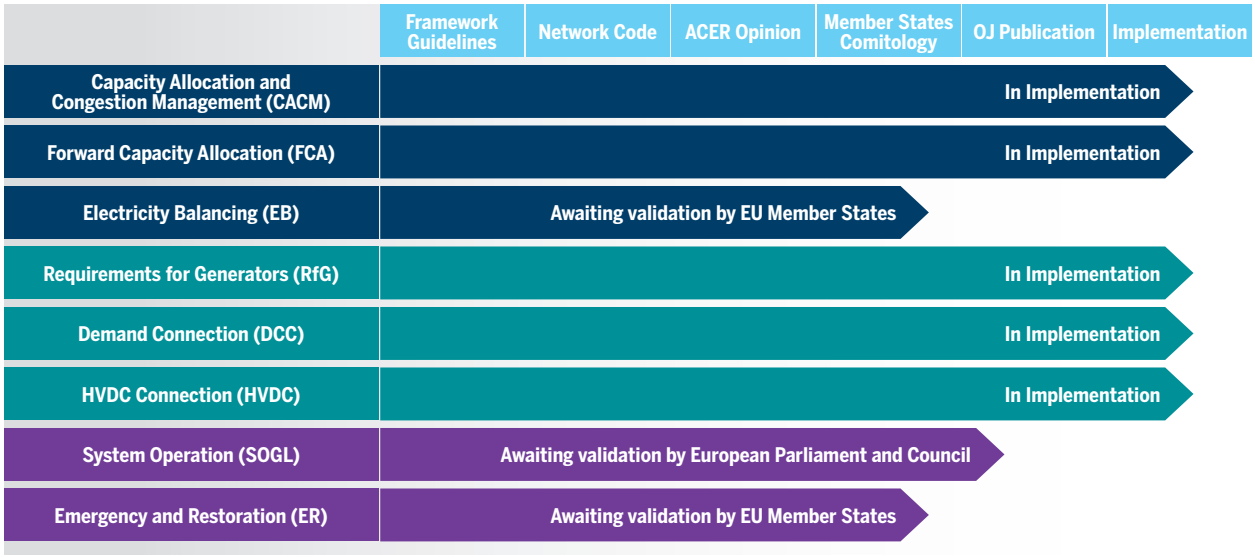


Figure 5: Development of network codes/guidelines. Source: FTI-CL Energy, based on ENTSO-E, as of October 2016.

More precisely, the system operation guideline provides for the roll-out of RSCs, to perform coordinated services for TSOs at the regional level.[1] The RSC concept, stemming from a voluntary initiative of TSOs, is therefore a concrete example of this enhanced coordination and is fully integrated into ENTSO-E's strategy in terms of regional coordination.

1) Provisional final version of the Commission Regulation establishing a guideline on electricity transmission system operation, available at: https://ec.europa.eu/energy/sites/ener/files/documents/SystemOperationGuideline%20final%28provisional%2904052016.pdf

The decarbonisation and security of supply challenges

However, given the challenges faced by the electricity industry in Europe, one may wonder whether the pace of developments in regulation and market design, system operations and system planning can keep up with the pace of change in the electricity system.

The recent initiative on the Energy Union has given a new impetus to the construction of the IEM, which is a strategy built on five pillars: (i) ensuring security of supply; (ii) building a single internal energy market; (iii) improving energy efficiency; (iv) decarbonising national economies; and (v) promoting research and innovation. In this context, the European Commission (EC) is working on a package of proposals aimed at addressing some of the issues associated with energy security and the IEM (the "Winter Package" expected to be published at the end of 2016).

Amongst other topics, the EC has been investigating various options to strengthen coordination between TSOs. The EC considers that "Transmission system operation will need to become much more integrated to meet the challenges of the transformed energy system. The European Networks of Transmission System Operators for Electricity and Gas (ENTSO-E/ENTSOG), which were also set-up by the 3rd Internal Energy Market Package, need to be upgraded to fulfil such a role. Regional operational centres will have to be created, so that they can effectively plan and manage cross-border electricity and gas flows."[2]

The EC published, in December 2015, a report commissioned from consultants on the "Options for future

2) EC, 2016, European Union Package, "A framework strategy for a resilient Energy Union with a forward-looking climate change policy", available at: https://ec.europa.eu/energy/sites/ener/files/publication/FOR%20WEB%20energyunion_with%20_annex_en.pdf

European electricity system operation".[1] The EC report develops a target model for transmission system operations for implementation in 2020. Based on the analyses of future requirements and current obstacles, the report proposes centralisation of TSO network planning functions by a pan-European body (e. g. ENTSO-E) and centralisation of the System Operations performed before the real time through Regional Operation Centres (BRT-RCs)[2], while keeping a national TSO focus for the real-time operations.

ENTSO-E responded to the report commissioned by the EC (hereafter referred to as the BRT-RC approach) on 1 March 2016.[3] Although ENTSO-E shares the high-level objectives of the study for the regional cooperation in the power system, ENTSO-E considers that the network codes and the ongoing roll-out of RSCs can achieve these objectives with lower costs and less risk than the solution presented in the EC's study.

Objectives of the study

In this context, ENTSO-E has commissioned an independent study from FTI-CL Energy in order to assess future options with regard to the coordination of system operators in Europe, and most specifically:

- To provide some fact-based evidence into the policy debate on the pros and cons as well as the practical and institutional feasibility of various coordination approaches;
- To conduct a high level impact assessment of the options for the regional integration of system operation; and
- To propose a practical and modular approach for the future coordination of system operation in the next decade, with the objective of looking beyond the SOGL and identify a number of practical recommendations to enhance regional cooperation.

To evaluate these options, we have defined, in accordance with ENTSO-E, four main criteria:

- The **operational security criterion** focuses on security of supply and its assessment. We evaluate whether the implementation of either option helps to maintain operational security while allowing flexible evolutions to meet future system challenges, as well as managing the transition towards the target in terms of regional cooperation.
- The **economic efficiency criterion** analyses whether implementing a given option will generate more benefits than costs and contribute to maximising social welfare. More specifically, it considers the impact on cost efficiency of system operations, looking at synergies and redundancies and at the efficiency gains or losses for operations, resource procurement or investment. We also consider the impact on market integration.
- The **governance criterion** focuses on the decision making process and on the allocation of risks and liability. For each option, we assess to what extent the balance defined between the liability of different entities and their weight in the decision-making process may be considered as efficient.
- The **political and institutional feasibility criterion** assesses to what extent the implementation of either option is feasible (in the short/medium term). In particular, we consider whether the implementation requires changes in national and EU-wide legislation and whether those changes would likely be politically acceptable and practically feasible in terms of time and resources needed.

1) Ecorys, DNV-GL and ECN, December 2015, "Options for future European electricity system operation", commissioned by the EC, available at: https://ec.europa.eu/energy/sites/ener/files/documents/15-3071%20DNV%20GL%20report%20Options%20for%20future%20System%20Operation.pdf

2) In the preliminary impact assessment, the EC uses the term Regional Operational Centres (ROCs) as well, but the definition seems to differ from the description provided in this study. Therefore, to avoid any confusion, we renamed the option BRT-RC, which stands for Regional Centres for Before Real-Time operations.

3) https://www.entsoe.eu/Documents/SOC%20documents/160301_ENTSO-E_Response%20to%20EC_%20on%20ROC_study.pdf

Our approach for this study

To address these challenges, we worked closely with ENTSO-E and used the following process.

A meeting was organised with the EC at the beginning of the study, in order to understand their objectives in assessing options for further coordination of system operations. In addition, we reviewed the available studies and position papers to identify the options on the table, the arguments raised to support and challenge these options and to understand the points of view of the different stakeholders.

This allowed us to identify a set of critical issues which required a more in depth discussion. We therefore circulated a questionnaire to all TSOs, to which 19 TSOs have replied, and we interviewed several RSCs and TSOs. The questionnaire and the interviews sought to obtain facts and opinions from each TSO on three key topics:

- Review the current system operation organisation by understanding how system operations are currently organised within each entity and establishing how key SO activities are performed;
- Understand the potential for regional cooperation in system operations by identifying what would be beneficial from each TSO's view regarding regional cooperation; and
- Assess the proposal of Regional Centres for Before Real-Time operations in the EC study by asking for opinions on the pros and cons of the BRT-RC proposal of the EC study vs. the regional service provider concept currently pursued by ENTSO-E initiatives.

On the basis of these findings, we analysed the various options put forward by consultants, academics and some key stakeholders, and we prepared our initial proposal for the improvement of regional cooperation. This proposal was presented and discussed with the European Commission, ACER, Eurelectric, which whom we organised meetings in July 2016. The meetings provided us with useful feedback, which we integrated into our proposal.

In order to discuss further some of the key elements of our proposal, in September 2016 we organised with ENTSO-E an internal workshop with around 40 TSO representatives, which pursued the following objectives:

- Develop further and expand the concept of Enhanced Regional Cooperation, to make it more ambitious and address stakeholders' feedback;
- Strengthen and develop new arguments to support key messages; and
- Identify/develop case studies and concrete examples to substantiate arguments.

During the workshop, TSO representatives actively contributed to the reflection on how to further enhance regional coordination.

This process has allowed us to develop a practical and modular approach to enhancing regional coordination, building on the concept of RSCs and successful experiences of regional coordination.

Structure of the report

The present report is structured as follows:

- Section 2 presents the state of play and recent developments in regional coordination of system operations;
- Section 3 describes and assesses the main high level coordination options that are being discussed at the moment, in a high level manner;
- Section 4 presents our proposed approach for future regional cooperation; and
- Section 5 presents the conclusion.

The present report also contains several appendixes:

- Appendix A summarises the BRT-RC approach and identifies open questions for this approach;
- Appendix B provides the summary of the interviews and questionnaires we carried out with TSOs and RSCs; and
- Appendix C is our bibliography for the study.

Section 2

State of play in regional cooperation for system operation

Introduction: new challenges for system operation

The transformation of the electricity industry is having a significant impact on the functioning of the European power system and more specifically on the role of system operations. This impact can be divided into five main categories:

- **Generation adequacy.** Concerns have emerged on how the adequate level of security of supply can be maintained in a competitive environment. The rapid development of RES has further highlighted these concerns, as it has changed the merit order for plant dispatch. Conventional gas and coal power plants are subsequently less utilised and their profitability has dropped over the past few years. However, the generation output of wind and solar power depends on meteorological conditions and may not provide comparable contributions to thermal plants when needed. As a result, concerns about the security of supply have been rising in some member states, who have implemented or are implementing different forms of capacity mechanisms to guarantee the adequate level of security of supply to their consumers.
- **Short-term operational security.** The intermittency of RES creates short-term fluctuations that need to be balanced either by market participants – to the extent that it is possible up to intraday markets – or by TSOs, reinforcing the need for flexibility. Moreover, trading is necessary closer to real time, as market participants adapt and re-balance their portfolio when forecasts are updated and more accurate. At the same time, for similar reasons as those explained above, fewer conventional plants may contribute towards flexibility resources and inertia of the system.
- **Increased uncertainties and changed power flows on the grid.** The changes in the power system have a strong impact on flows on the grid. New bottlenecks are appearing and relevant congestion management processes and significant grid reinforcements are needed. The changes and the uncertainties in the generation patterns and the increasing cross-border trades tend to increase the uncertainty of unscheduled (loop and transit) flows. System operators need to address the uncertainties of schedules ahead of real time and be prepared to react quickly in real time.

- **Grid capacity.** The European extra high voltage grid was mostly built for the "old" structure of electricity industry. With RES, the generation is shifted to different regions and from centralised large synchronous generators directly connected to the extra high voltage grid to small units connected to the distribution grid. In combination with the increasing European energy market, this leads to total different load flows that exceed grid capacity in many regions. Therefore, grid capacity needs to be adapted to the changed system by new investments. As long as enough grid capacity is unavailable, TSOs have to manage the limited capacity to ensure grid security and allow the market the best use of them.

- **Coordination with the distribution grid.** Wind and solar power, together with new flexibility resources such as storage or demand-side response, are to a large extent connected to the distribution grids. Consequently, flows are changing between transmission and distribution grids: while networks were mostly conceived for the flow of electricity from generation facilities (connected to the transmission grid) to load centres (connected to distribution grid), electricity sometimes now flows back from the distribution to the transmission grid to be transported across long distances there. TSOs and DSOs therefore need to increase their coordination to ensure that TSOs have adequate information on distribution systems and vice versa. In addition to that, TSOs will use increasingly system services from providers connected to the distribution grid, which has to be coordinated with the DSOs.

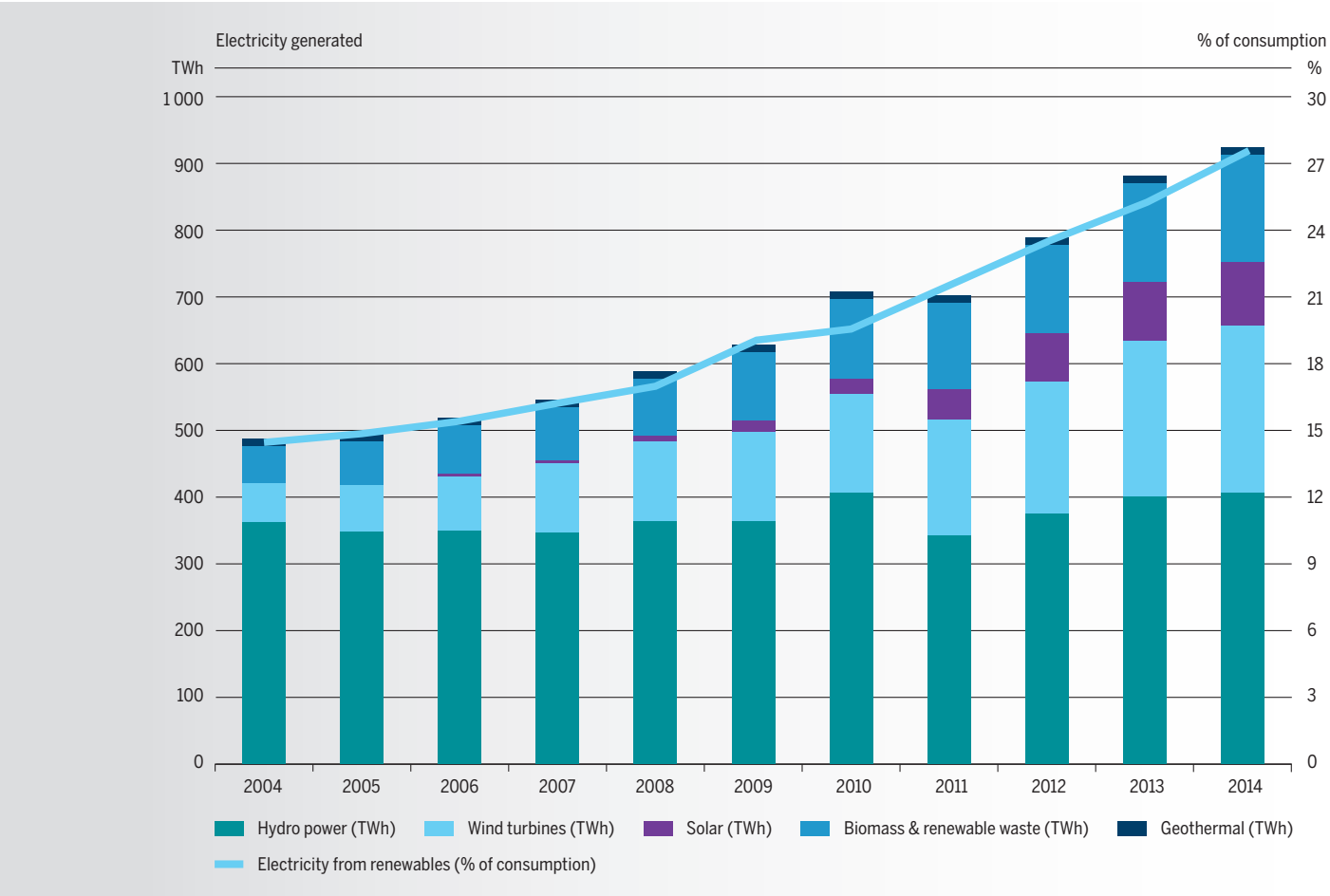


Figure 6: Development of renewable energy sources for electricity production in Europe. Source: Eurostat

These changes reinforce the need to bring closer market design and system operation, in a pan-European perspective, to integrate markets at the European level and to facilitate exchanges amongst member states, in order to share resources and be able to perform this transition and operate the system in the most efficient way. System operation is a key cornerstone of the power system: as has historically been the case, system operation will need to be gradually adapted to these changes, and system needs will need to be translated into traded products. Besides this, continuously improving and adapting TSO processes and enhancing coordination between TSOs will contribute to managing challenges in the more efficient way and to facilitating market integration and renewable integration.

This section presents the state of play of regional coordination in system operations, using the following approach:

- First, we present the role of TSOs as well as the activities they need to perform, as well as the evolution of the regulatory and the progress made in terms of regional coordination.
- Then, we analyse the expected impact of the implementation of RSCs as provided for the system operation guideline (SOGL), using the assessment criteria defined in Section 1.
- Finally, we highlight the remaining challenges for regional coordination.

Recent developments in system operations

Role and responsibilities of TSOs in Europe

A transmission system operator (TSO) is an entity entrusted with transporting electrical power on a national level from power plants to large industrial consumers and distribution grids and from/to interconnections. The role of the TSO is to manage the security of the power system from long term to real time and co-ordinate the supply of and demand for electricity, in a manner that avoids fluctuations in frequency or interruptions of supply.

TSOs have a number of activities to perform across a number of time frames, from long term to short term and real-time actions. Figure 7 presents main TSO activities, though it is difficult to clearly allocate tasks to specific time frames. For instance, a security analysis is performed through the whole timeline. These activities are strongly interacting and interdependent.

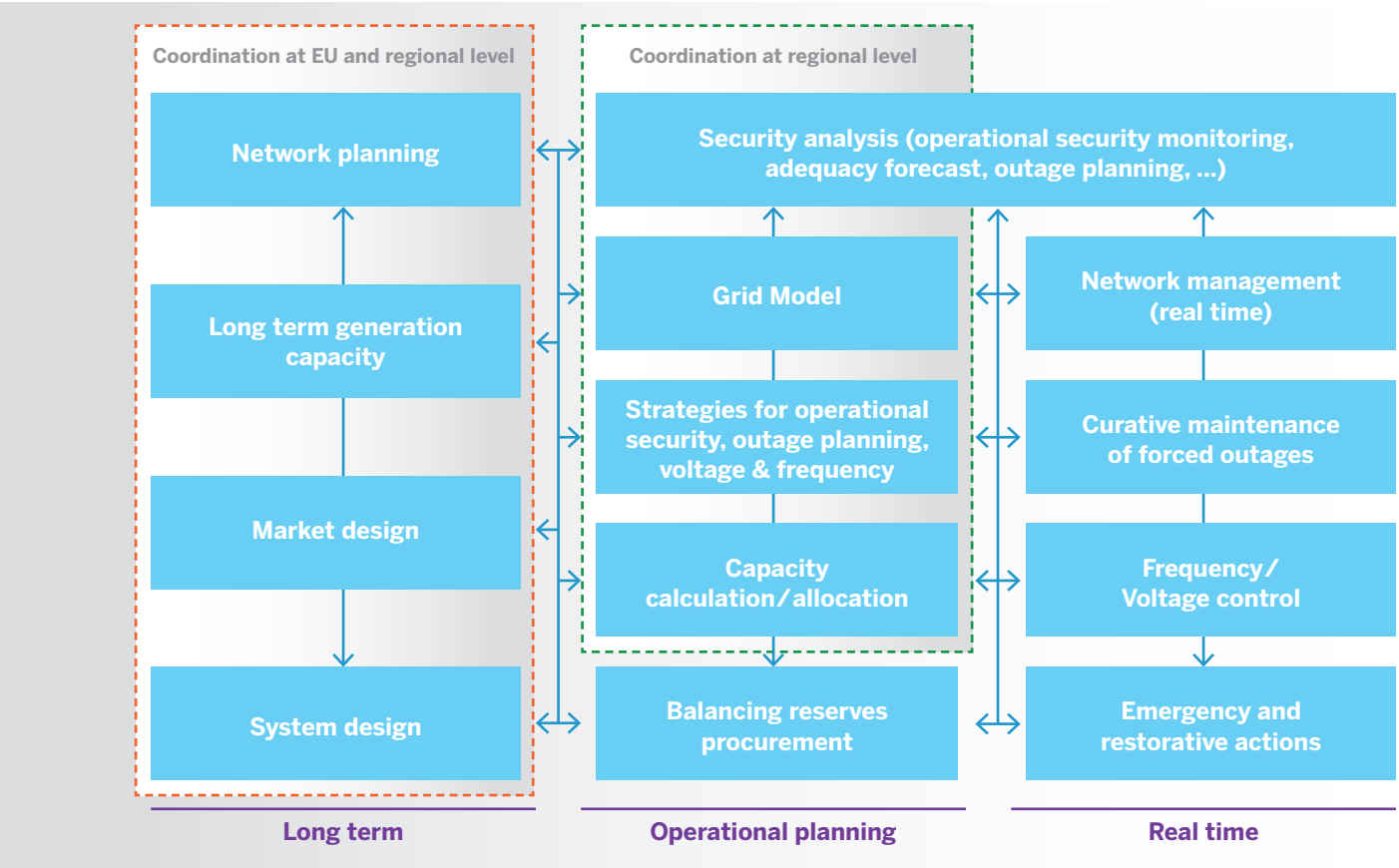


Figure 7: Mapping and interactions between main TSO tasks. Source: FTI-CL Energy

We classified these activities along three main time frames:

- **Long-term activities.** These activities typically cover a time frame that goes beyond one year. These activities are partly coordinated at European level, through ENTSO-E. They need, however, to be implemented with subsidiarity both (sketched) at pan-European level and (refined) at regional level,
  - These relate mainly to the **planning and the development of the network** to adapt to long-term needs. TSOs carry out a number of analyses, using their operational experience as well as prospective scenario and modelling, in order to identify all necessary investments for maintaining or expanding the transmission grid.
  - Given the need to develop long-term scenarios for network planning, TSOs are entrusted with **long-term generation adequacy assessment**. The time frame for these assessments is generally 5 to 15 or 25 years.
  - Over time, as they operate interconnections and balancing markets, TSOs have also acquired a central role in **market design**. They are in charge of drafting a number of market and grid access rules, such as for capacity allocation, balancing and scheduling or the provision of balancing services. They are also often involved in the design and operation of capacity mechanisms.
  - For the operation of the grid and all the related tasks, TSOs also have to design and develop IT **systems and operational procedures**.

- **Operational planning activities.** These activities typically cover anywhere from one-year ahead to close to real time (typically up to one hour before real time). Operational planning activities are closely linked to real-time operations as it constitutes the actual "preparation and forecast" of real conditions which will emerge in real time. Regional coordination is established and its rollout prescribed in the SOGL within this time frame.
  - During this time frame, TSOs carry out a number of security analyses, which include operational security monitoring, the short-term adequacy assessment and all other necessary analyses for preparing for real-time operations. **Security analyses** continue up to real time operations.
  - To perform these analyses, TSOs rely on **grid models**, which are regularly updated and consider best estimates with regard to the location and the level of load and generation, as well as the situation of the grid. For coordination with other TSOs, TSOs create common grid models and exchange real time measurements, in order to prepare system operation in real time and to have the adequate observability of the system influencing their control area.
  - On the basis of these analyses, TSOs develop their **operational strategies** to manage operational security, prepare for frequency and voltage control, dimension reserves and plan maintenances and outages. For instance, they may contract with grid users to provide balancing reserves or reactive power, or to secure availability of resources located in specific parts of the grid to manage congestions.
  - TSOs are also in charge of **calculating and allocating available cross-border capacities**. On the basis of the grid model, TSOs calculate and coordinate to determine the level of exchange capacity, which can then be allocated to market participants. This is typically performed in several time frames: e. g. year-ahead, month-ahead, day-ahead and intraday.
  - TSOs prepare for frequency and voltage control by **assessing their needs and procuring for balancing reserves and other ancillary services**. This is in direct relation to their operational analyses and strategies.

- **Real-time operations.** These cover all actions that are taken by TSOs to manage the grid in real time or close to real time to address operational issues identified by security analyses and monitoring.
  - TSOs act to implement remedial actions needed, notably those identified in the operational planning phase; such remedial actions are implemented as late as possible considering the time requested for their secure application, hence they can be applied to cope with a risk identified for several hours later or for immediate need.

- TSOs may manage **network assets in real time** to adapt configurations/topologies (e. g. phase shifter transformers) to the evaluated needs, e. g. for allowing realisation of planned outages for maintenance.
- TSOs react in real time to forced outages and deploy **curative maintenance**.
- TSOs **activate balancing resources and other ancillary services** to maintain frequency or voltage at required levels and manage constraints on the grid.
- TSOs proceed to **emergency and restoration actions**, as prepared in operational planning phase, in case the situation requires it.

It is important to note that this division in the activities based on the time frame is somewhat artificial as many of these activities are interdependent. Synergies exist between many of the activities and information flows go back and forth between teams in charge of most of these activities. The same operators or employees may be performing several of these tasks, along different time frames, making use of cross-activity expertise and knowledge.

Long-term generation adequacy and estimates of future relative prices form the basis for network planning. In addition, analyses performed for operational planning and real-time issues are also feeding into the network planning and identification of necessary projects: e. g. voltage issues are becoming more and more important, and are generally not grasped in traditional planning assessment (need detailed local analysis). Network planning also interacts with market design (capacity calculation, bidding zones, system adequacy mechanisms)

All of these activities require strong relationships with local stakeholders outside of the TSO. These include DSOs, generators and now aggregators and demand side players.

The new EU framework for regional coordination of system operation

The coordination of TSOs is a central topic in the European energy policy. The Third Package has organised the cooperation of TSOs through a European entity, ENTSO-E, and of regulators, through ACER. It also provides for a new process to make regulations converge at EU level on a number of key topics – such as cross-border trading and market design, grid connection, system operations – through the "network code/guideline" process. In this framework, the EC has recently issued two guidelines providing for increased coordination between the TSOs.

The Capacity Allocation and Congestion Management (CACM) guideline[1] entered into force in August 2015. The guideline stipulates that "to implement single day-ahead and intraday coupling, the available cross-border capacity needs to be calculated in a coordinated manner by the Transmission System Operators".[2] Furthermore, "capacity calculation for the day-ahead and intraday should be coordinated at least at regional level".[3]

Therefore, the CACM guideline foresees the creation of different capacity calculation regions based on a proposal jointly defined by the TSOs.[4] In particular, within each capacity region:

- TSOs should define a common capacity calculation methodology. The different capacity calculation methodologies corresponding to different regions are expected to be harmonised by the end of 2020.[5]
- TSOs should define a common methodology for merging individual grid models into a common grid model.[6]

In 2015, the European Commission, ACER and ENTSO-E agreed to merge the three operational network codes into a single System Operation Guideline. The guideline has been published as a provisional version validated in the Electricity Cross-Border Committee by the Member states as of May 2016.[7] It formally defines a body, named the Regional Security Coordinator, which should perform coordination tasks in operational planning for a group of TSOs, while these TSOs keep the decision-making power.[8] Each TSO should belong to at least one RSC, with a maximum of six RSC to cover the entire European Union scope.

In particular, each RSC's role is to be in charge of providing the following services:[9]

- Regional operational security coordination;
- Building of common grid model;
- Regional outage coordination; and
- Regional adequacy assessment (short-term).

RSCs will also be in charge of coordinating capacity calculation within capacity calculation regions.

Beyond the coordination of TSOs for operational planning, TSOs also coordinate their network development.

The modification of the European energy mix induces major changes in flows and requires the power grid to be adapted. Given the pan-European and/or regional importance of these investments, TSOs have been coordinating to jointly identify the need for investments and build common projects. More specifically, according to the Regulation 714/2009,[10] ENTSO-E adopts a non-binding Community-wide ten-year network development plan (TYNDP).

1) Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management available at: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32015R1222

2) CACM, §4 of the introduction.

3) CACM, §6 of the introduction.

4) CACM, article 15.

5) CACM, article 21.

6) CACM, article 17.

7) The Guideline still has to get formal approval by the European Parliament and Council before entering into force.

8) SO GL, article 78, §4.

9) SO GL, article 77, §3.

10) Regulation (EC) No 714/2009 of the European Parliament and of the Council of 13 July 2009 on conditions for access to the network for cross-border exchanges in electricity and repealing Regulation (EC) No 1228/2003 (Text with EEA relevance), available at: http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32009R0714

These provisions have been significantly upgraded by Regulation 347/2013.[1)]

The TYNDP 2016 comprises €150 billion investments of pan-European significance, of which €80 billion is for projects already endorsed in national plans and/or intergovernmental agreements by 2030. Most of these transmission investment needs are linked to the integration of RES.[2)]

The TYNDP process and outcome are being regularly reviewed by ACER, which provides public opinion and identifies leads for improvements.[3)] The TYNDP organises the coordination of TSOs through six regional subgroups, which develop regional investment plants.

This planning process relies upon future European scenarios regarding the development of generation and demand. ENTSO-E hence also develops, in cooperation with TSOs, outlook scenarios. These scenarios were, until 2015, presented in the scenario outlook and adequacy forecast (SOAF).[4)]

1) Regulation (EU) No 347/2013 of the European Parliament and of the Council of 17 April 2013 on guidelines for trans-European energy infrastructure and repealing Decision No 1364/2006/EC and amending Regulations (EC) No 713/2009, (EC) No 714/2009 and (EC) No 715/2009 Text with EEA relevance, available at: http://eur-lex.europa.eu/legal-content/en/TXT/?uri=celex%3A32013R0347

2) ENTSO-E, 2016 TYNDP, available at: http://tyndp.entsoe.eu/

3) ACER, 2015, "Opinion on the ENTSO-E draft ten-year network development plan 2014", available at: http://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Opinions/Opinions/ACER%20Opinion%2001-2015.pdf
ACER, 2016, "Opinion on the implementation of investments in electricity transmission networks", available at: http://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Opinions/Opinions/ACER%20Opinion%2008-2016.pdf

4) ENTSO-E scenario outlook and adequacy forecasts are available at: https://www.entsoe.eu/publications/system-development-reports/adequacy-forecasts/Pages/default.aspx

Progress accomplished so far and implementation challenges

Regional security cooperation initiatives among TSOs members of ENTSO-E have been formalised by signing a Multilateral agreement between TSOs and ENTSO-E in December 2015. The agreement relies on the principles laid down in the CACM and SO guidelines presented above.

The Multilateral agreement supposes every TSO member to be part of, or to procure, services by at least one RSC. As of October 2016, all TSO members have signed the Multilateral agreement.

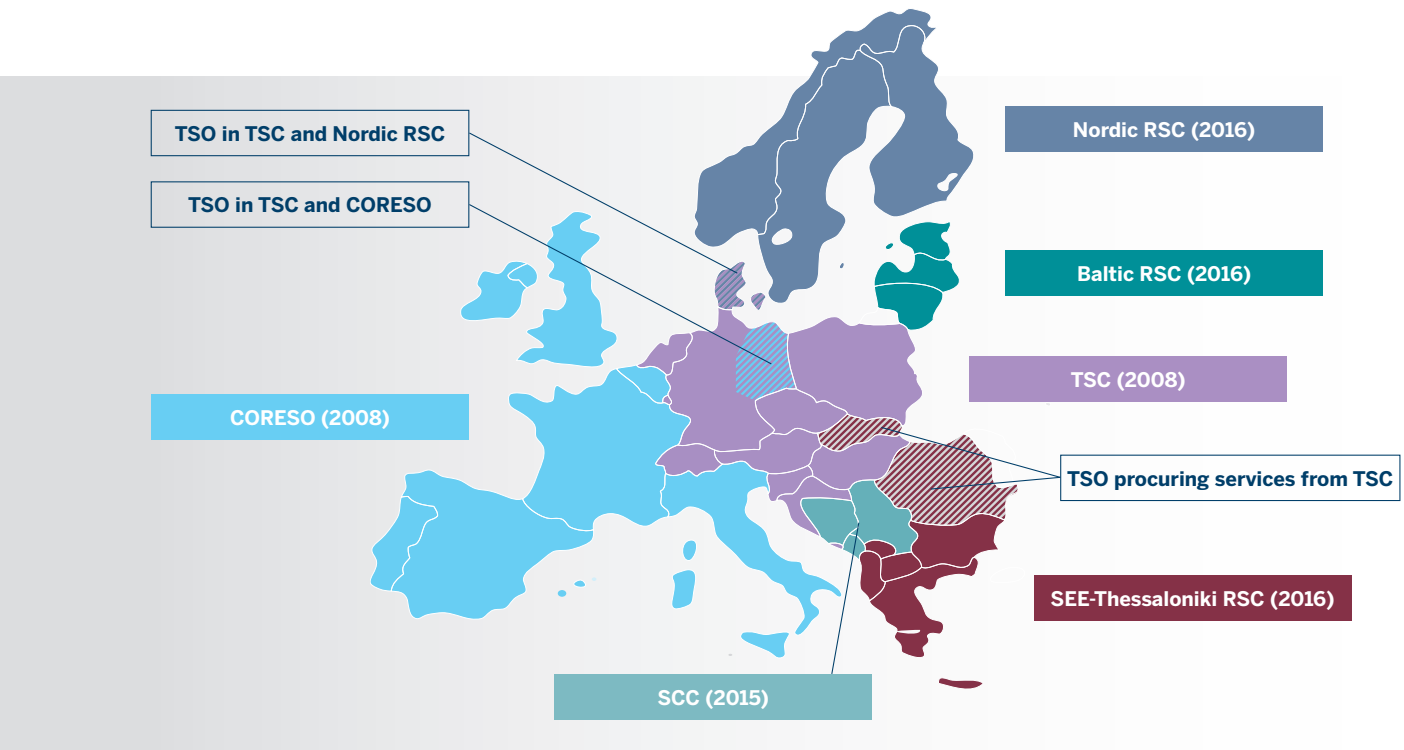


Figure 8: Expected structure of the six RSCs by end of 2017. Source: FTI-CL Energy based on ENTSO-E
Notes: Year when the RSC became, or is to become, established is shown in brackets.

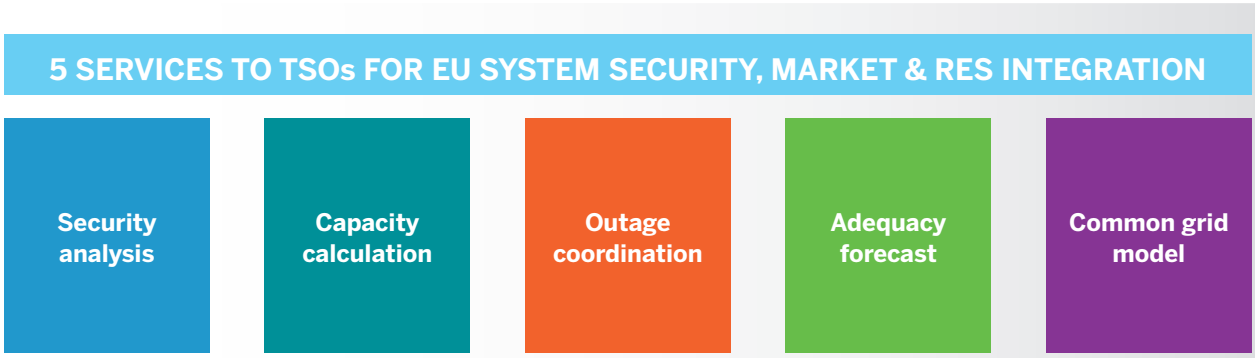


Figure 9: Services provided by RSCs to TSOs. Source: FTI-CL Energy based on ENTSO-E

Consequently, three new RSCs have been established and are expected to be operational in 2018: Nordic RSC, Baltic RSC and a second one in South East Europe, located in Thessaloniki. Figure 8 shows the simplified geographical coverage of European member states by RSCs.[1)]

By 2018, all RSCs are meant to be fully operational and be able to provide five core services, presented in Figure 9, which combine the tasks outlined in the SOGL and the capacity calculation preconized in the CACM,[2)] namely:

- Operational planning security analysis, which aims to identify risks of operational security in the interconnected systems and the most efficient remedial actions to cope with them.
- Outage planning coordination, which aims to coordinate planned outages of grid assets (overhead lines, generators, etc.) having influence on neighbouring networks.
- Coordinated capacity calculation, computing maximum available electricity transfer capacity across borders.
- Short and medium term adequacy forecasts, which would allow for the identification of situations at risk at regional level using consumption, available production and grid status forecasts in week ahead, helping TSOs to prepare adequate measures.
- Common Grid Model merged from individual grid models for all time frames (from year ahead to hours ahead).

Coreso offers the flow-based capacity calculation,[3)] CGM merging and security analysis with suggestions of remedial actions to its members. TSC offers similar services but uses a different, bottom-up approach, offering a tool for their coordination and acting as a moderator. None of the RSCs have fully implemented the outage coordination nor the adequacy forecast as yet, although both Coreso and TSC have already had practical experience with regional aspects of these services that are in development.

With regards to the governance issues, the SOGL and the multilateral agreement keep the liability with the TSO while the RSC offers services and recommendations. Each RSC is governed by the TSOs, who are regulated by the relevant NRAs and who define the governance rules and the methodology for security analysis and for remedial actions preparation.

1) For instance, it does not show the overlap of TSC and Coreso.

2) The deadline of 31 December 2017 is indicated in the Multilateral agreement, Annex 5. However, the Annex is subject to be amended, with reviewed deadlines "After establishing the RSCIs".

3) Flow-based capacity calculation is currently applied only in the CWE region composed of Belgium, France, Germany, Luxemburg and the Netherlands.

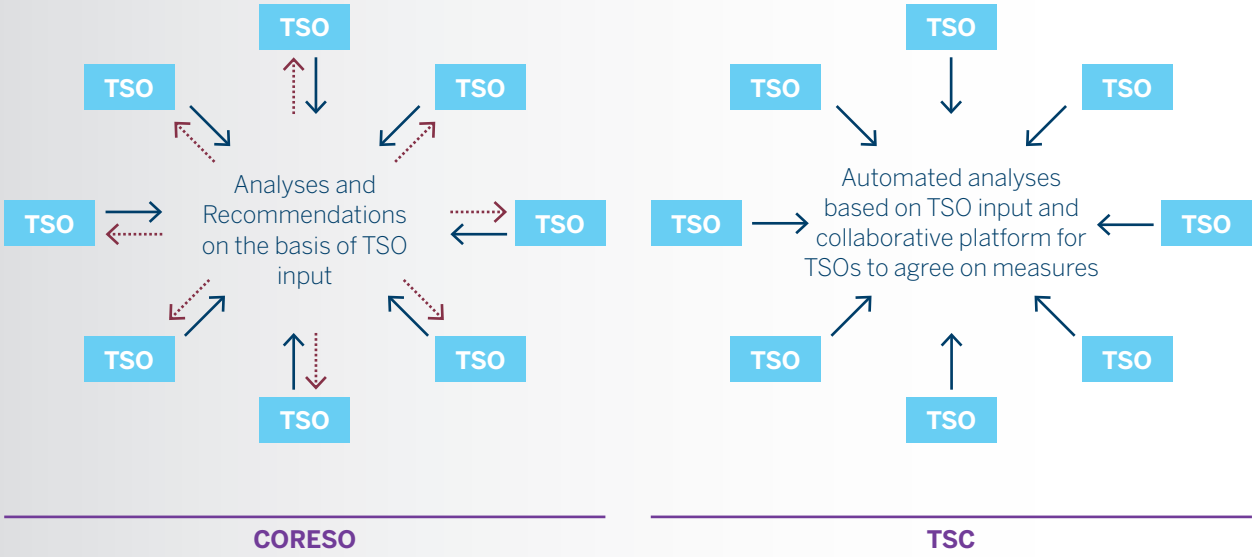


Figure 10: Comparison of Coreso and TSC approaches. Source: FTI-CL Energy

Challenges for the full roll-out of RSC services

The implementation of the SOGL and the full roll-out of RSC services will be challenging for the next two years.

The RSCs, who are in the process of becoming operational, will need to set up all contractual aspects, to procure an office and set up appropriate IT resources and human resources, and, in parallel, the services will need to be developed. All of this will have to be done in a limited period, to be up and running by 2018.

Then, even for RSCs which have already developed some of the services, they will still need to extend their scope of services to perform outage planning coordination (OPC) and short- and medium-term adequacy forecasts (SMTA). For instance, for the SMTA, everything so far is developed in a prototyping mode and the scope is still being extended as additional TSOs join the initiative. The data needed and made available by each TSO will gradually increase the functional value of the computations. An example of this difficulty is that, since SMTA is focused on week-ahead adequacy assessment, the RSC needs the availability of an Individual and Common Grid Models (IGMs/CGM) built for this horizon, to assess the correlation between available network elements and needs for export/import to support countries, which are too short. But such weekly IGMs do not exist for the majority of TSOs, since the uncertainty of input data (mainly generation in renewables) is too high in that time frame, so TSOs and RSCs will have to establish a new methodology (scenario-based) to set up those IGMs, in order to build weekly CGMs.

Expected impact of the ongoing efforts towards greater regional coordination

The current experience with the long-established RSCs indicates that the RSC concept significantly enhances the operation of the system. The full-scale implementation of RSCs intends to generalise these benefits in all regions. In the following section, we analyse the new European framework for regional coordination of system operation based on the CACM and SOGL and the RSC model against the evaluation criteria set out in the introduction.

Operational security

CACM and SOGL provide clear roles for TSOs and RSCs to improve their cooperation at the regional level in order to adapt to system changes. As roles are clearly defined, it facilitates interactions between involved parties in operations. The gradual evolution towards RSC will allow for maintaining a high level of operational security by a systematic sharing of information between TSOs, leading to a common vision of the grid by all.

In addition, as the licensed entity, the TSO remains the decision-making body, it can avoid implementing measures that may jeopardise system security, for instance due to constraints or issues at lower voltage or discrepancies between the CGM and the actual situation.

Besides, the RSC model is flexible and adapts to regional specificities, maintaining the degree of coordination as required to maintain or improve operational security, while ensuring pan-European consistency of decisions and therefore enhancing security.

Economic efficiency

RSCs will allow and strive to make the operation of the system more efficient and to harvest synergies in various processes through the regionalisation of the common tasks (e. g. capacity calculation, operational security, etc.).

Experience shows that RSCs are able to deliver good quality services, as illustrated in the text below.

Illustrative figures on the performance of Coreso in 2015[1)]

- 365/365 days when 24 merged timestamps were successfully published in the day-ahead process.
- 63 studies were performed additionally to the normal processes to provide special assistance in stressed situations: 49 SMART* (System Modification Advice RequesT) requests and 14 intraday studies for coordination of Remedial Actions in Central West Europe.
- 3 operational processes were completely replaced or underwent major changes to adapt to the needs of member TSOs.
- 100 % Flow-based merged datasets were provided to CWE Common System 100 % of the time, meaning the 225 business days of 2015 after Go Live.
- Coreso provided results for the intraday Capacity assessment for 224 of the 225 business days performed in 2015 in Central West Europe.

1) Coreso, Operational review 2015.

Governance

As the RSCs have been established by the TSOs as service providers through the MLA signed on 10 December 2015, the governance of each RSC is arranged by the TSOs, i.e. services provided by RSCs are based on the processes agreed in advance by all involved TSOs. The general framework for reporting, governance and decision-making processes between the TSOs, RSCs, NRAs and ACER has been established in the SOGL. The ENTSO-E structures, such as the System Operation Committee, are the mechanism through which the possible developments on governance for regional cooperation can be discussed further and will ensure that they evolve as the guidelines are implemented and processes between TSOs and RSCs are being rolled out.

Evolution of existing governance structures are expected for TSOs, RSCs, NRAs, ACER and possibly policy makers, within a certain region or at European level, to establish an adequate policy and regulatory framework. Notable examples are the need to establish cost sharing principles to support efficient regional remedial actions or the need to ensure suitable monitoring and arbitration at regional level.

In line with SO guidelines, the RSC scheme will ensure European consistency in terms of approaches and operations. Furthermore, as the monitoring of RSCs by the System Operation Committee of ENTSO-E and the reporting towards NRAs and ACER should also streamline an efficient coordination of TSOs and RSCs and foster gradual harmonisation, while identifying issues to be solved, for instance related to regulatory alignment or differences.

The decision to implement remedial actions will remain a TSO decision. According to TSOs and RSCs, experience shows though that, after a learning process period, the coordination process goes smoothly and recommendations fit with finally adopted solutions when it concerns non-costly remedial actions.

Political and institutional feasibility

The approval of the SO guideline solves the question of the institutional feasibility for RSCs and clarifies roles and responsibilities of the scheme of coordination based on RSCs.

Remaining challenges for regional coordination and system operations

The ongoing initiatives and the implementation of the guidelines will already deliver substantial benefits, and regional coordination is an integrated component of the target model for the IEM. Several examples could be mentioned:

- Wholesale markets are gradually integrated thanks to the implementation of CACM and forward capacity allocation guidelines. Market coupling is already covering two-thirds of Europe. Further progress is expected with the extension of market coupling and flow based capacity calculation, the development of intraday trading or the harmonization of forward capacity allocation rules.
- The coordination of capacity calculation within capacity calculation regions – where RSCs have a crucial role to play – and the implementation of flow-based where relevant should improve operational security and capacity calculation to adapt it to the needs and changes of the power system.
- The standardisation of balancing products and the sharing of balancing bids through common merit order lists within the coordinated balancing areas is expected to substantially reduce balancing costs. Several pilot projects are already in operation and delivering high benefits, such as the German Grid Control Coordination (GCC) and its international extension (IGCC), the BALIT project or the Nordic balancing market.[1)]
- The creation of a Common Grid Model (CGM) and the coordination of capacity calculation and security analysis, short-term adequacy assessment and outage planning by RSCs, will likely improve security of supply and foster more efficient operation of the grid.

Beyond these already achieved or upcoming developments, it is still possible to envisage further developments in various processes and TSO activities enabled by regional coordination. More specifically, we have been instructed to focus on the practical approaches for reform that could be implemented once RSCs are up and running (after 2018) and most network codes are implemented and that would deliver some welfare gains in the medium term (Figure 11). For these evolutions to be effective, these developments should be preferably accompanied, guided and monitored by a proper political and regulatory framework, which can be foreseen in new upcoming regulation.

1) https://www.entsoe.eu/major-projects/network-code-implementation/cross-border-electricity-balancing-pilot-projects/Pages/default.aspx

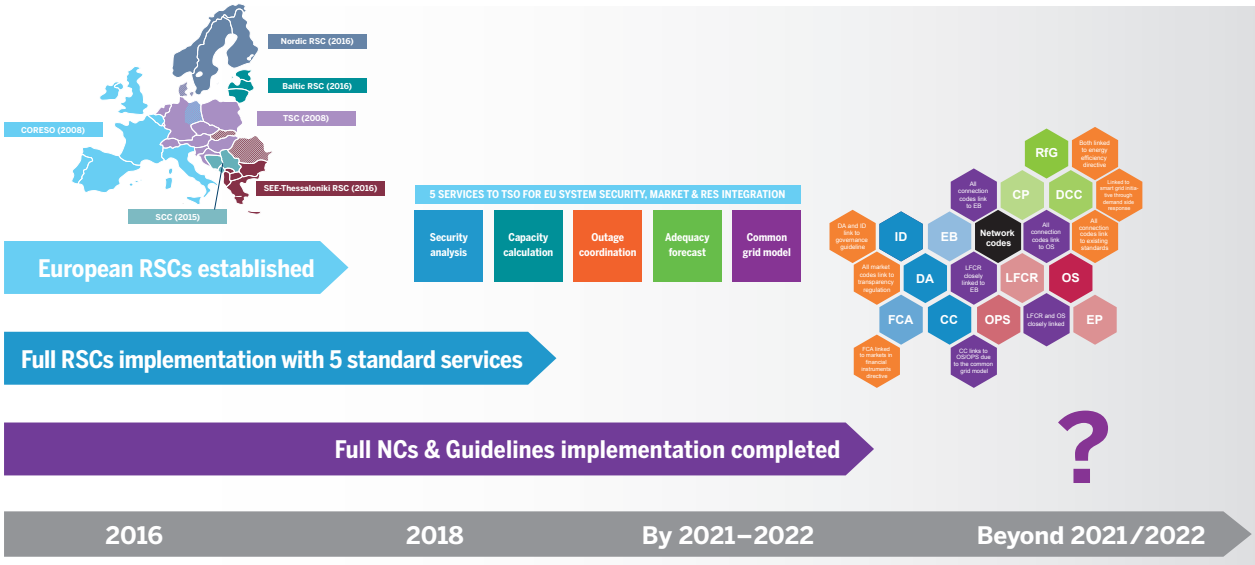


Figure 11: Evolution of regional coordination from 2016 over 2021/2022 and beyond. Source: ENTSO-E

For instance, some stakeholders, such as the ACER or Eurelectric, have also voiced their concerns and called for improved coordination.[1)] They mainly consider that:

- **The lack of harmonisation in operations undermines market integration.** While recognising the benefits of the network code process, they fear that some differences may remain that limit the benefits, even after the implementation of the guidelines. As an example, diverging national approaches to balancing could prevent harmonisation of balancing regimes and market integration.[2)]
- **Better coordination or improving operations could lead to a more optimal use of the network.** Stakeholders consider that some TSOs may be pushing internal constraints to the borders, reducing exchanges' possibilities or making decisions at national or bilateral levels with limited consideration to European or regional social welfare impact. Moreover, market participants fear that cross-border capacity may decrease.

These concerns should be reduced once proper coordination of capacity calculation is implemented within relevant regions with properly defined bidding zones, which is foreseen by CACM. Capacity reductions will happen only in cases in which this is needed for system security (currently due to uncoordinated capacity calculation capacities on some borders that are too high, leading to insecure operation on other borders).

In practice, these concerns are mostly due to differences in regulations and market designs, or to the negative impact of certain public policies (apart from the above mentioned uncoordinated TSO actions, which will disappear with the proper implementation of CACM). **The harmonisation or the coordination of national and regional policies and regulation are therefore necessary steps to facilitate the tasks of TSOs and RSCs, allowing them to further improve system operations.**

Despite the ongoing process of harmonisation through network codes and guidelines, the lack of coordination in policies and regulation largely persists across Europe. This stems from divergences and gaps at different levels:

- **Policies.** Even though the European institutions have given a common framework and common objectives for energy policy, national governments still decide on many of the practical terms of their implementation. In that respect, decisions on the generation mix may have a significant impact across borders, as for instance illustrated by the

1) Eurelectric, June 2016, "Optimal use of the transmission network: a regional approach", available at: http://www.eurelectric.org/media/278462/eurelectric_report_congestion_management_-2016-2210-0009-01-e.pdf

2) ACER, 2016, "Annual Report on the Results of Monitoring the Internal Electricity Markets in 2015", available at: http://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/ACER%20Market%20Monitoring%20Report%202015%20-%20ELECTRICITY.pdf

Mott MacDonald and Sweco, 2013, "Impact assessment on European electricity balancing market" for the EC, available at: https://ec.europa.eu/energy/sites/ener/files/documents/20130610_eu_balancing_master.pdf.

nuclear moratorium in Germany, the introduction of a carbon price floor in the UK or the large-scale deployment of renewable energy sources in some Member States.[1] The latter is often cited because of its impact (in combination with not properly defined bidding zones) on unscheduled (loop and transit) flows, and due to the priority dispatch given to RES in some countries, which may influence system operations and have consequences on market functioning.[2]

- **Regulation.** The current regulatory framework, such as incentive schemes, mostly gives a national focus on TSOs to ensure security of supply and reduce costs. The evolution of such a regulatory framework towards a more regionally oriented one is necessary in order to implement efficiently regional processes that lead to an optimisation at regional level. Otherwise, the regional coordination of TSOs would be biased by national regulatory frameworks, which could act as a barrier for implementation of regional coordinated proposals. TSOs could have, in that situation, the impossibility or the disincentive to accept regional recommendations and their associated costs – especially if there is no fair regional sharing of costs.
- **Market design.** Network codes and guidelines leave room for national differences in market design, e. g. with regard to balancing models or intraday markets. Moreover, these regulations do not cover the full spectrum of market design issues at regional and European levels. The most commonly quoted issue is the uncoordinated implementation of system adequacy mechanisms in numerous countries.[3]

1) See, for instance, FTI-CL Energy, "Assessment of the impact of the French capacity mechanism on electricity markets", 30 June 2016, available at: http://www.fticonsulting.com/fti-intelligence/research/eu-power-markets/the-french-capacity-mechanism

2) https://www.entsoe.eu/about-entso-e/market/integration-of-renewable-energy-sources/Pages/default.aspx

3) See for instance the European Commission's sector inquiry on electricity capacity mechanisms (http://europa.eu/rapid/press-release_IP-16-1372_en.htm) or the ACER report on capacity remuneration mechanisms and the internal market for electricity published in July 2013 available on its website

Case study – Illustration of regulatory gap: cost-sharing methodology for cross-border remedial actions

Differences in national policies or in regulatory regimes can prevent increased cooperation between TSOs. One example is the cost sharing on the so-called "multilateral cross-border remedial actions".

In TSC, multilateral redispatch[4] has recently been used frequently, as a last resort, i.e. when all others countermeasures, including bilateral redispatch, are exhausted. Applying this action naturally raises the question of cost allocation: should it be the TSOs regulating up and down, the TSOs experiencing congestions or maybe the TSOs which allowed schedules leading to the congestions?

After five years of tough discussions, involving relevant NRAs, TSC TSOs are currently using, as of September 2015, a temporary approach, where 50 % of these costs is borne by the TSO which experiences congestion, while the remaining 50 % is shared among other participating TSOs, which agreed on cross-border schedules leading to the given congestion according to so called simple tie line decomposition (STD) method.

Having the fair cost sharing key for multilateral redispatch would open its use for cases when it is optimal from the regional point of view replacing combination of bilateral redispatch actions (contrary to the current situation when used only as a last resort measure) and thus would lead to gains in social welfare at the regional level. This is nonetheless prevented by the fact that there is still no consensus among the TSOs and NRAs involved on fair cost sharing key of multilateral redispatch.

4) I.e. redispatch where regulating up and/or down is performed by generators located in third TSOs not experiencing congestions

These differences complicate the integration of the energy market, which would be easier with more harmonised practices. Differences induce caveats in regulations and target models, sometimes to the detriment of efficiency at the regional and/or Europe level.

Several studies have estimated the economic impact of the lack of coordination in policies and regulations:

- The optimisation of RES deployment across the EU, which could be enabled thanks to cooperation mechanisms, could deliver benefits ranging from 5.8 b€ to 11.7 b€ p. a.;[1)]
- Improved coordination for generation investment, through a European approach, could reduce costs by 1 to 7.5 b€ p. a.;[2)] other analyses show that the coordination of capacity targets at EU level could reduce costs by 0.6 to 2.4 b€ p. a.;[3)]
- The coordination of network and generation investment, through price signals transmitted by network charges or locational market signals, could provide substantial benefits. Whilst difficult to extrapolate to the EU level, given the differences in electricity systems, a study estimated the benefits for the UK to be 1.3 b€ p. a.;[4)]
- The lack of demand response – mostly due to the absence of the smart metering and the inadequate regulatory framework and market design[5)] – prevents potential gains ranging from 0.5 b€ to 5 b€ p. a.[6)]

Fostering the coordination of policies and regulations should therefore be a priority: first, it could deliver tremendous efficiency gains that would benefit consumers and, second, it would also remove some of the barriers for further coordination between TSOs.

1) FTI-CL Energy, 2015, "toward the target model 2.0". Available at: http://www.fticonsulting.com/fti-intelligence/energy/research/eu-power-markets/toward-the-target-model-2. Other studies found similar results, see for instance: Booz & Co, 2013, "Benefits of an Integrated European Energy Market", and Ecofys (2014), Cooperation between EU Member States under the RES Directive.

2) Booz & Co, 2013, "Benefits of an Integrated European Energy Market".

3) FTI-CL Energy, 2015, "toward the target model 2.0".

4) Gammons S., Druce R. and Pr. Strbac G., "Locational Transmission Charging in Decarbonised Power Markets", in Energy Market Insight, issue No. 9, NERA Economic Consulting, September 2011.

5) See for instance SEDC, 2015, "Mapping demand response in Europe today" available at : http://www.smartenergydemand.eu/wp-content/uploads/2015/09/Mapping-Demand-Response-in-Europe-Today-2015.pdf

6) Booz & Co, 2013, "Benefits of an Integrated European Energy Market".

The development of new legislations and regulations at EU level shows, however, the difficulties of such an exercise. This is why stronger cooperation at regional level could constitute a more pragmatic way forward to facilitate convergence and harvest most of the benefits – as a first step towards greater European cooperation.

We therefore recommend that the implementation and continuous improvement of RSC services and the coordination scheme should be done in parallel to the improvement of coordination of regulations and policies, which is commonly advocated by stakeholders and TSOs.

In this framework of political and regulatory cooperation, various areas could be considered. For instance, current concepts for RSC functions with regard to operational planning and capacity calculation could be investigated to improve the process and address some of the stakeholders' concerns. Other new services could also be further coordinated at regional level, and regional entities could provide helpful support to make this coordination more efficient. These potential extended services will be discussed in greater detail in section 4.

Section 3

Comparison of high level approaches to enhance regional coordination

Introduction: Potential benefits and implementation issues

This study focuses on the practical approaches to enhance further regional coordination, which could be implemented in a reasonable time frame, once the RSCs are operational and network codes enforced. This means that evolutions towards these options should be feasible by 2025, which excludes some theoretical options which would require radical changes and a long transition period.

A number of approaches for regional coordination have been identified and discussed so far in studies and European fora. Our scope of work is not to perform a detailed assessment of all these options, but rather to analyse to what extent they respond to the key objectives and criteria set out in the introduction and that we have defined based on our review of the key stakeholders' concerns.

More specifically, these options must be analysed against the criteria defined in Section 1 and bearing in mind the following key issues:

- **Strong synergies and dependencies in terms of decision-making for system operation** exist between the key functions performed by TSOs across different time frames. Maintaining these synergies and dependencies seems important to ensure that TSOs are able to operate efficiently and securely the power system in the short, medium and long term. This implies that particular attention needs to be paid when thinking about new approaches for system operation to preserving these synergies as they enable TSOs to be more efficient in the way they operate and deliver improvements to the network.

- **A smooth and gradual implementation based on safe evolutionary migration** is necessary in order to allow for a gradual evolution of the regulatory and legal frameworks and for TSOs and RSCs to establish a new organisation for system operations. In contrast, a radical shift of TSOs and RSCs responsibilities would require major changes to the legal and regulatory framework, such that the implementation process would likely not be compatible with the time frame considered in this study.

In this section, after discussing in greater detail these two key aspects, we present these high level options and we analyse them comparatively against these predefined criteria.

Interactions between operational planning and other activities

Tasks relating to system operation for a delivery period occur across different time frames. For instance, to prepare for real-time operations, TSOs perform security analyses and elaborate operational strategies. This preparation starts largely ahead of real time, as TSOs start performing analyses at least a year ahead to plan outages to maintain the grid or allow for new line constructions, and possibly coordinate with generators where necessary. This phase therefore considers network development plans for the year to come. It also considers seasonal adequacy outlooks, so that impacts on transmission constraints and generation do not jeopardise security of supply during tighter periods.

During the operational planning, TSOs regularly update their grid model and perform capacity calculation, taking into account pre-identified constraints. Conversely, as remedial actions may be considered in capacity calculation, operational strategies need to integrate this possibility.

This phase prepares for real time operations, where the predeveloped operational strategies are deployed. However, there is a constant interaction between the situation which is monitored in real time and security analysis and operational strategies. This feedback loop is crucial for updating and adapting operational planning, as well as integrating real-time issues and additional information – in particular for the next periods of operations, whether next quarter, next hour, next day, etc.

Operations issues need to reflect back to long-term activities. The identification of real-time issues, which may not be adequately reflected in the long-term modelling of the power grid, can thus still be considered and may induce new investments, changes in IT systems, procedures or market design, or updates in adequacy assessment.

Figure 12 illustrates these interactions in order to account for the fact that not only is information transfer across activities important for end results (e. g. dispatch plan), but also feedback from the process itself is important.

When making system operations evolve, it is therefore essential to maintain these synergies and to make sure that adequate flows of information can be established between entities involved in the process.

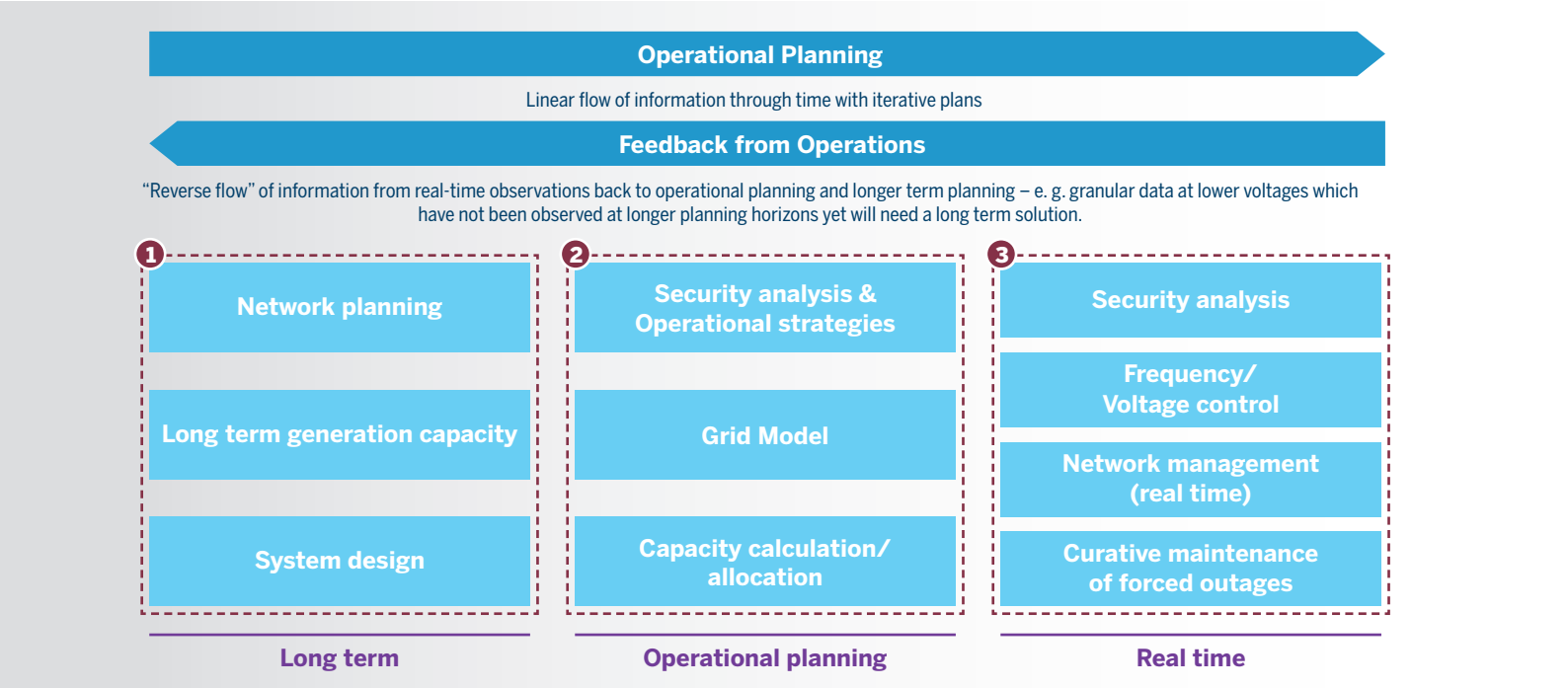


Figure 12: Illustration of interdependencies between time frames and TSO activities. Source: FTI-CL Energy

Case study – Interactions between operations and network planning

At the end of the 2000s, RTE, the French TSO, was facing a very difficult situation with the risk of voltage collapse for a single outage (N-1) on several generators, when load was very high.[1)] As a result, operators in dispatch centres had to resort to preventive actions on load (e. g. transformers tap changer blocking or tap changer set-point reduction) to limit the risk. Those situations could also result in capacity reductions on some boundaries.

However, when assessing the benefits of a new asset, the method and decision criteria used by RTE was not able to (i) identify the need for a MVAR support to avoid the risk of voltage collapse on a broad region; and thus (ii) make the decision of investment. In other words, the cost-benefit analysis was not revealing enough value to support the investment decision.

Operation and Development divisions conducted an in-depth analysis to understand the level of risk. They concluded that it was absolutely necessary to review the development method: new case studies and tools have been taken into account in the development method and decision criteria have been adapted. As a result, it became possible to decide the investment of several thousands of MVAR on high voltage and extra high voltage networks, including the installation of some hundreds of MVAR in the form of thyristor-based controlled Static VAR Compensators providing fast dynamic response.

RTE explains that this was achieved swiftly thanks to the close collaboration of operation engineers, economists, and asset management experts, who were involved in the same project teams. This therefore shows the synergies and benefits of exchanges between activities/teams, which are facilitated when they are in the same company.

Another example of these interactions is the required coordination of planning and operation teams to integrate renewables in Germany.

Due to the high amount of renewable generation, especially in Northern Germany, and the lack of sufficient transmission infrastructure, high amounts of remedial actions are required to provide system security. The timely extension and strengthening of the transmission grid requires a fundamental reconstruction of many network parts over many years.

As asset projects are building on each other, their correct implementation sequence is key, especially under the influence of changing environmental conditions. 50Hz explained that the coordination of asset projects' feasibility between the TSO departments (asset, planning, operations) was successfully implemented as an iterative management task starting with long- and medium-term planning stage several years ahead and ending on day-ahead, when concrete operational decisions for an operation day need to be executed. This coordination task also integrates projects and impacts from underlying distribution grids where network security also needs to be guaranteed by the numerous involved parties.

50Hz considers that this approach proves successful by avoiding blockages in transmission and distribution grid development under conditions of congestion but therefore requires full control on projects and operations.

1) Load is highly dependent on temperature in France: in the winter, a decrease in temperature makes load increase significantly.

Time frame and implementation challenges

A radical change in the allocation of responsibilities between TSOs, regional and European entities would likely not be implemented in the time frame which this study addresses (i. e. until 2025-2030).

The responsibilities of TSOs are defined today in European and national legislation, with wide ramifications in terms of regulatory frameworks and contractual arrangements. Any substantial changes of the organisation of system operations which would lead to a shift of liability from TSOs to other entities would need adaptations of the legal framework from the highest level (European Treaty) down to European directives and national laws, regulations and operational rules and processes. Such a reform would require strong political support. It would engage significant resources at all levels to carry on these changes and it would therefore likely take a significant amount of time.

Moreover, to take over significant new responsibilities, involved parties should be well-prepared: they need adequate IT, procedures, staff and a financial solidity. They should also acquire technical skills and knowledge of the details of all individual power systems where they perform these activities.

All in all, a radical change of system operation arrangements, which would alter responsibility allocation significantly, would likely require a long time to be agreed upon, organised and implemented. In addition, the implementation of changes to system operation should be smooth and gradual to maintain the high degree of operational security across Europe. Therefore, it seems unrealistic to implement too radical changes in the predefined time frame identified in the scope of this study.

In the next subsection, we review the different approaches for enhanced regional cooperation in the light of these considerations as well as the assessment criteria presented in section 1.

Presentation of the possible options for enhanced regional cooperation

Status quo (no SOGL implementation)

We consider the current situation remaining unchanged as our counterfactual scenario. Currently, the cooperation level is not harmonised throughout the whole Europe, and varies strongly from one region to another.

Cross-border cooperation in system operation has been established and developed further for a long time, mostly within synchronous areas, in order to manage frequency at the synchronous area level, sharing resources and aiming at a higher economic efficiency[1]. All that happened with the clear sharing of responsibilities between TSOs. Moreover, cooperation at European, regional or bilateral level has developed on a case by case basis. For instance, Nordic countries have a regional approach to balancing, which is coordinated through TSOs directly, and without a common or central entity.

More recently, Regional Security Coordination Initiatives have emerged to perform coordinated tasks for TSOs. However, these initiatives do not cover yet the whole of Europe and their activities and organisation may differ substantially.

RSC (full implementation of RSC concept as in SOGL)

As presented in Section 2, RSCs correspond to the implementation of the System Operation Guideline, recently voted positively by Member States in the Electricity Cross-Border Committee. RSCs will provide a number of services to TSOs, the full decision-making responsibility will however remain with the TSOs. They will cover the whole of Europe. It is very important to realise that the full implementation of all new functionalities from SOGL and CACM is itself a huge effort and will require a lot of resources and time, most probably longer than envisaged in the above guidelines.

Most TSOs consider that the full implementation of the five services will significantly change the way interconnected systems are operated and satisfy most of the stakeholders' wishes.

BRT-RCs

Regional Centres for Before Real-Time operations (BRT-RCs) correspond to an option which emerged as a result of a study made by DNV-GL, Ecorys and ECN for the EC. Contrary to RSCs, BRT-RCs would have a dominant decision-making role over TSOs, not just in the area of system operation, but also in grid development and market "before real time", and therefore get the full responsibility for these activities.[2]

Regional ISO

The last option is the creation of regional independent system operators (ISOs). These regional ISOs would take over all the responsibilities related to system operation and all other transmission business such as grid development and market enabling at regional level. Transmission ownership would remain in the hands of national TSOs where that applies, as would maintenance and local switching.

Regional ISOs would therefore be in charge of operational planning, real-time operations including balancing, network development planning, etc. It could also contribute to other activities such as generation adequacy assessment, market design etc., although these activities might be transferred fully at European level.

It is also worth noting that this option could also be conceived with a EU-wide perspective. The EC is considering an option for the creation of a European ISO in its impact assessment for the winter package.

1) Cf. First UCPTE rules and goals for interconnection declared there in the 1950s

2) The study divides the system operation into three time periods: long-term planning, the real time (15 minutes before the gate closure) and the "before real time" which encompasses the period between the long term and the real time.

High level assessment of the coordination options

Limits of the exercise

In this section, we perform a high level review of different approaches, which may be envisaged – or is being implemented as for RSC – to foster regional coordination in system operation. However, several issues complicate this exercise, especially with regard to BRT-RCs and Regional ISOs:

- **First,** the precise definition of the options and their efficiency would depend on the evolution of the legal and regulatory framework. Numerous prerequisites would be necessary to implement these options, especially BRT-RCs or regional ISOs, in an efficient manner, as close as possible to the theory.
- **Second,** the implementation of such options would likely take a long time, as many skills and responsibilities would need to be transferred from the TSOs to the regional entities. The smoothness of the process is a key variable for the success of these options: the process should allow for transferring skills, expertise and knowledge, as well as responsibilities, while keeping a high standard of operational security. During the transition phase in such a radical process, the risks for security of supply would likely increase. Any major disruption would be highly negatively perceived and could jeopardise the implementation of such options due to the political sensitivity of security of supply.
- **Third,** given the long timespan for the likely implementation and operation of these options, which could hardly be fully implemented before 2025–2030, there are a lot of uncertainties on the evolution of the power system which could modify the relative costs and benefits of such a radical change. Indeed, retrospectively, we can see how much, how fast and how unexpectedly the power system has changed in the past decade. For instance, the growing role of the local level and of distribution systems could question the right geographical scope for the operators of the transmission system. It is therefore important to factor in this uncertainty in the analysis and to make sure that the implementation process is flexible enough to adapt to changing circumstances. It follows that – effectively – even the implementation of the SOGL over the next few years might well be overtaken by the reality and adjustments, in the sense of decentralized generation, e-mobility and storage being required earlier than expected.
- **Fourth,** the specificities of the BRT-RC option, as defined in the BRT-RC study by the consultants working for the EC, are not defined in detail. These uncertainties in the definition of the option may also have an impact on the assessment, and have led us to make some assumptions on how this approach could be implemented in practice.

Comparative assessment by criteria

Operational security

As illustrated earlier in the section, a strong interaction between time frames is necessary to maintain operational security at the right standard, e. g. security assessment is performed throughout time frames and is a continuous information process to prepare real-time operations, taking into account practical experience in real time. In their organisation and scope today, TSOs benefit from these dependencies. However, evolutions in cross-border flows and uncertainties require them to have a wider understanding of flows in the power system, taking into account cross-border interactions, and therefore to coordinate.

The gradual evolution of the RSC option will ensure a high level of operational security by a systematic sharing of complex and inter-dependent information between TSOs, leading to a common vision of the grid by all. Building upon the expertise of TSOs of its local grid, it gradually creates a common vision of the regional interactions shared by all. The RSC progressively accumulates knowledge, experience and expertise, which allows for efficient evolution of today envisaged and further services in line with regional needs.

The relocation of responsibilities on regional entities – whether BRT-RCs or Regional ISOs – requires building trust amongst involved parties (TSOs, regional entities, but also the national regulatory authorities involved, as well as Member States) to make this transfer acceptable and to ensure it maintains high level of operational security. This transfer raises the question of the transition period, during which these entities should first build up sufficient knowledge, experience and expertise, and train adequate staff and deploy robust IT systems and procedures, and then take over the corresponding responsibility. During such an important transition phase, the risk for security of supply likely increases. Moreover, given the large geographical scope, at least in some potential regions, strong coordination needs to be ensured with TSOs and/or local control centres. As such, we expect a gradual transition to minimise risks during the period: this implies that RSCs are a necessary first step and that, if more integrated solutions are deemed desirable, coordination between RSCs and TSOs should be strengthened even further than according to SOGL before any transfer of responsibilities.

In addition, the sharing of liability between several parties may create inefficiencies and risks. If the TSOs would no longer ultimately bear the liability, then one must be very careful in order not to dilute responsibilities and make sure every involved party has a clear scope of responsibility and intervention.

With regard to BRT-RCs, the separation of activities and responsibilities between "before real time" and "real time" raises a number of concerns. Indeed, real-time operation strongly depends on operational security analyses and all the various activities performed before real time, which basically prepare real-time operation. Strong interactions are necessary between the corresponding teams. The 15-minutes boundary seems arbitrary and the separation of responsibilities could create inefficiencies in the process and undermine operational security. In that sense, should this option be implemented, it would be important to clarify the sharing of responsibilities between parties and to adopt a clear and functional decision-making process.

Moreover, most of the new challenges for TSOs concern the integration of decentralised resources: TSOs will need to interact further and further with DSOs and, directly or indirectly, with local generators or grid users. However, at this stage, regional centres only look at very high voltage with an EU vision, but diving into lower voltage grids at the EU level will raise computational issues and time constraints, and therefore cannot fully take into account lower voltage, or only in an aggregated manner. If the regional entity needs to interact with numerous and local parties, there is a question of the management of many communication interfaces including language used, etc.

Economic efficiency

The strong interaction between time frames is also important with regard to the economic efficiency of SO activities, as it allows to benefit from synergies and to optimise operations and planning. Current synergies under the TSO model could become less effective if the role of the regional entity is not well-calibrated.

Moreover, the economic efficiency of the different approaches strongly depends on (i) the precise regulatory and market environment of the period considered – which is highly uncertain – and (ii) on the practicalities of the implementation.

Thus, while RSCs are very likely to make the operation of the system more efficient and to harvest synergies, the artificial 15-minute boundary and the unclear split of responsibilities in the BRT-RC may undermine these synergies. This is particularly true if the unclear sharing of responsibilities obliges TSOs to duplicate BRT-RCs' analyses, hence raising costs rather than optimising them.

Furthermore, the economic efficiency of the BRT-RCs or Regional ISOs would likely be impacted by the transition costs, which could be substantial. Indeed, at least during the transition phase, these entities would have to develop their own highly qualified teams, while TSOs would have to maintain their own teams, for substantial parts of their activities. This also raises a number of questions in terms of human resource management for the companies involved. Again, regional differences are relevant in this aspect, since the duplication of analysis between RSCs and TSOs is not foreseen in the case of analysis of strong interrelations and interdependencies between borders –those analyses will be performed by RSCs, to complement TSOs bilaterally coordinated analysis-, while the analysis performed by RSCs in much less interdependent regions will be complementary, in a different way, to those from TSOs.

In addition, the regulation and policies need to be strongly harmonised and adapted to establish efficient BRT-RCs or Regional ISOs, while RSCs can better adapt to existing differences. National differences could have a severe impact on the theoretical efficiency of improved coordination through these models.

Finally, the ISO model – and in a similar manner the BRT-RC model – raises the question of how to provide adequate incentives for an efficient operation by such entities.

Focus on the ISO model

Several studies advocate for the introduction of ISOs:

- A study of the Florence School of Regulation[1] considers that, once policy makers have taken a path to decarbonisation and integration, TSOs need to adapt from two perspectives: hardware (network planning and development) and software (system operations and market design). The change required is a total or partial shift of critical SO functions from national TSOs to other entities (supra national, including DSOs) and more formal cooperation between major actors to adapt governance & regulatory mechanisms.
- A study of the Imperial College of London and Cambridge University[2] analyses the benefits and issues associated with the independence of the system operator from the transmission asset owner. According to this study, an ISO option can potentially resolve some conflicts of interest arising from the growing roles of TSOs as well promote innovation and stakeholder engagement through an advanced transmission planning and delivery process. However, the study points out that ISOs in practice can be very risk averse and favour conservative system planning and operational approaches because of the lack of commercial incentives. An ISO would also have to establish a set of contracts to utilise existing asset flexibility which could raise some issues associated with contract imperfections. The paper suggests that, on balance in the UK case, an ISO appears to be the favoured approach in the long term, but that implementation is likely to involve a gradual stepwise change which includes increasing the independence of current TSOs.

In addition, our review of the US experience with ISOs shows some major differences of context with Europe which may affect the evaluation of the potential costs and benefits associated with ISOs in Europe. The following features are worth pointing out:

- **Gradual expansion over a long period:** the expansion of ISOs was progressive and took several decades;
- **Voluntary approach:** the ISOs were built on a voluntary basis with regions getting extended on a case by case basis using extensive cost–benefit analysis;
- **Differences in market design/regulatory framework:** the legal and regulatory framework and the market design differ significantly between Europe and the US. For instance, nodal prices provide location signals in energy markets; and
- **ISOs face a number of issues:** the US experience with the ISO model seems to have some important drawbacks for the applicability within Europe. First, institutional behaviour of US ISOs can result in a conservative approach. Some US ISOs seem indeed to be rather conservative regarding security of supply and not very innovative. In addition, the governance model that characterizes the US ISOs, despite being inclusive, may lead to slow decision making processes. Finally, the difficulty to provide high powered incentives to not for profit organisations like ISOs can be an issue as it may not lead to efficiency gains over time.

In conclusion, ISOs seem in practice to have their own drawbacks which need to be carefully weighed against their potential benefits. Moreover, even a "perfect ISO" would not be in a position to resolve the key challenges of today's electricity sector in Europe, such as: (i) long licensing proceedings for grid development (building new lines); (ii) lack of well-coordinated and harmonized RES support schemes across the national borders; (iii) lack of incentives for flexibility to integrated variable generation, etc.

1) Florence School of Regulation, European University Institute, Glachant, Vasconcelos, Rious, 2015, "A conceptual framework for the evolution of the operation and regulation of electricity transmission systems towards a decarbonised & increasingly integrated electricity system in the EU".

2) Imperial College of London and Cambridge Univeristy, 2013, "Integrated Transmission Planning and Regulation Project: Review of System Planning and Delivery".

Governance

The decision-making process is a key component for a successful coordination of operation using a regional entity: there should be a clear correspondence between the liability of the different entities and their weight in the decision-making process. If the TSOs remain liable, it implies that the decision power stays with the TSOs and that they should have a say on the actions proposed or decided by the regional entity and decide on the final, definite action. If a regional entity (BRT-RC) is liable, and the TSO will only implement BRT-RC decisions, a significant change to the current legal and regulatory framework is required.

In any case, the decision-making process should allow for proposing or taking rapid and good decisions and, as such, should be efficiently organised:

- Governance approach of a centralised model is typically more market-led with the central entity acting as a moderator with members who have a "seat at the table", and who ultimately will decide and justify different criteria to adopt a proposal;

- Governance approach of a more automated service based on TSO inputs and common platforms could improve the rapidity and acceptability of decisions, but will require equally stronger work and agreement (or even ex-post assessment) of criteria employed for designing the automated analysis.

Furthermore, the governance issue is intrinsically linked with the liability: TSOs need to maintain a higher control on regional actions if they ultimately have the responsibility for these actions.

With RSCs, as TSOs remain liable, they keep control of services provided (by accepting in advance all the rules behind) and key decisions: for instance, they may decide not to follow an RSC's recommendations, especially, for example, if security of supply risks being endangered.

In the BRT-RC study, the concept of BRT-RCs does not clarify how liability would be managed and how BRT-RCs would be regulated/incentivised. The governance of BRT-RC and the decision-making process represent critical issues as decisions by BRT-RC might interfere with local situations and actions. These aspects would need to be defined in detail if BRT-RCs were to be implemented, with the consequences it may have in terms of operational security and synergies, as explained before. For example, TSOs may no longer be able to control their performances with regard to the own incentives they may have through their regulation (e. g. incentive regulation on quality of supply at national level etc.) and a different incentive scheme for measuring and incentivising quality and security of supply or efficiency shall be established at the adequate level.

Therefore, BRT-RCs or Regional ISOs would probably need to be directly regulated. The regulation framework, and especially the incentive regime, would be crucial to ensure an efficient operation of the system. Significant changes in national and European legislation would therefore be necessary to implement an adequate regulatory framework and ensure that there are appropriate authorities to perform those tasks at regional level. At present, no model of regional regulation exists in Europe so far.

Political and institutional feasibility

For the time being, TSOs are liable with regard to security of supply and are subject to a national regulatory framework that provides incentives for operational efficiency.

The transfer of responsibility of system operations' key tasks raises fundamental legal, institutional and political questions: the compatibility with the EU framework (including the Lisbon Treaty) needs to be ensured. In particular, the creation of Regional ISOs – and of BRT-RCs to a lesser extent – induces major changes in laws and regulations, at the European and national levels, and requires the establishment of a regional form of regulation. Such measures shall not affect a Member State's right to determine the conditions for exploiting its energy resources, its choice between different energy sources and the general structure of its energy supply, without prejudice to Article 192(2)(c).

They would therefore need strong political support. In addition, such a radical change in regulations and legal frameworks would likely be very costly: the corresponding implementation costs should also be considered when analysing the economic efficiency of such measures.

On the other hand, the RSC approach is already foreseen in regulation and allows for a pragmatic and gradual evolution of SO coordination at regional level. It is an upgradable model, which may build trust gradually while its benefits are experienced in practice, facilitating a gradual reinforcement of coordination. The RSC itself is a young concept and a big leap forward from the situation as it is today, such that there is significant scope for incremental improvement building on this concept. Finally, an evolutionary approach building on RSCs does not preclude any further evolution beyond 2030 towards other long-term solutions.

Conclusions on the assessment of the coordination options

The assessment of the different coordination options confirms that the implementation of RSCs is a no-regret and, in any case, a necessary step towards other, more centralised, coordination options such as BRT-RCs or Regional ISO, if they would appear necessary in the end.

On the other hand, BRT-RCs and Regional ISOs require numerous prerequisites, which go largely beyond only system operations. These prerequisites and their implementation would likely require significant time and effort for all stakeholders to converge, especially for ISOs, which makes it unlikely that these models could be in place in the medium term. These options are therefore out of the scope of our study focusing on short term practical approaches.

Even though all the prerequisites to BRT-RCs and Regional ISOs would be met, the implementation of these options would likely be complex and would need to be gradual and well-managed. The transfer of liability in particular from the TSOs to a regional entity has many of implications and risks.

At the same time, the benefits of BRT-RCs and Regional ISOs, as well as possible and yet unknown risks they may induce, are still not clear: the power system is facing major uncertainties and has entered a period of rapid technological change which may lead to revisiting the pros and cons of alternative options for system operation. For instance, the de-centralisation of resources, including demand-side response, renewable energy sources, distributed storage, and electric vehicles, may force operations to be coordinated at a more local level requiring more of a focus on enhancing such cooperation between TSOs and DSOs.

To conclude, our assessment highlighted the importance of addressing issues related to policies, regulations and market design as a priority for further regional cooperation. First, coordination and improvements in policies, regulations and market design would provide substantial benefits, which would likely exceed largely potential benefits from further coordination in system operations. Second, major changes are necessary as a prerequisite to enable TSOs to further cooperate and improve system operations.

Given these uncertainties, we recommend focusing on the development of a pragmatic and gradual approach for regional cooperation, building on the concept of RSCs and focusing on the coordination of policies and regulations, ensuring pan-European consistency but allowing for regional specificities to be addressed, in such a way to ensure the maximum efficiency. Our proposed approach is described in more detail in the next section of the report.

Section 4

Our suggested approach to expand regional cooperation

Introduction: a pragmatic and evolutionary approach

The high level analysis of the main coordination options that have been discussed to date has led us to conclude that regional coordination could further evolve after the implementation of RSCs, as foreseen in SOGL. High level concepts do not guarantee that the actual problems would be tackled and would respond to the challenges of the evolution of the power system. Moreover, the prerequisites to implement the most "ambitious" options are challenging, whereas their consequences are not fully understood and controlled, given the uncertainties that are faced by TSOs regarding the future of power system.

Therefore, we argue that a modular and step-by-step approach is the most pragmatic and efficient way forward. This approach – the Enhanced Regional Coordination or ERC model – is designed in order to avoid impeding any further coordination at a later stage; on the contrary, it identifies a number of prerequisites to gradually reinforce coordination at regional and European level, which would be necessary, in any case, to address in the other options.

In this section, we present our ERC approach to enhance regional coordination, developing further the concept of RSCs and successful experiences of regional coordination:

- First, we present the main principles of our proposal of Enhanced Regional Coordination, (ERC);
- Second, we develop a cooperation framework to foster the coordination of policies and regulations;
- Third, we envisage ideas to adapt the regulatory framework and the governance regime;
- Fourth, we suggest possibilities to extend the services and improve the competence of RSCs; and
- Lastly, we assess the advantages and challenges of this approach.

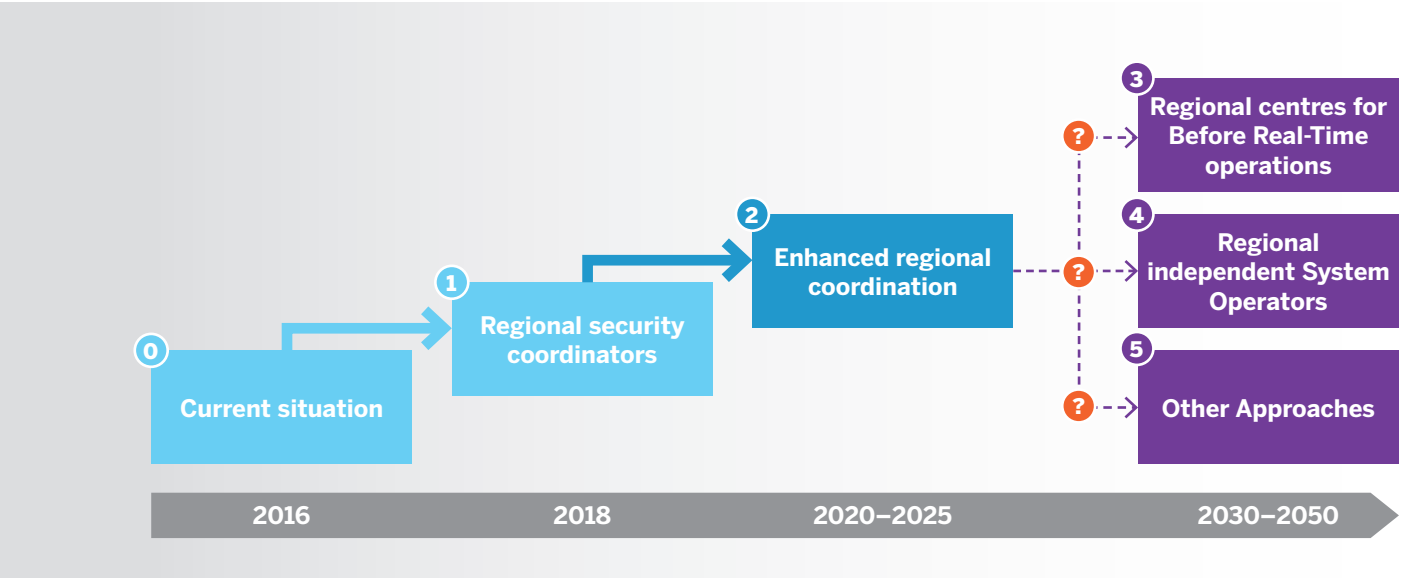


Figure 13: The concept of ERC as an evolutionary model for regional coordination. Source: FTI-CL Energy

Main principles of our proposal for Enhanced Regional Coordination

Our proposed approach is a pragmatic and gradual evolution of existing structures and ongoing initiatives. It aims to address the main issues according to their priorities, without a "big bang" which could jeopardise security of supply – especially during the transition phases – if the required preconditions are not fully met.

One of the core principles of the ERC is to focus operations not only on system security, but also on the **maximisation of social welfare at the European or regional level**,[1)] thus removing national barriers and going beyond national interests. To achieve this goal, we propose to develop an approach which addresses policy and regulation obstacles and which places European or regional social welfare, together with operational security, as a key objective. More specifically, TSOs will take advantage of regional analyses and recommendations performed by RSCs which allows the pursuit of regional optimisation while keeping liability at the TSO level

This approach is based on five pillars, which are also presented in Figure 14:

- **A strong regional cooperation for policy and regulation.** Divergence and gaps in policies and regulations, as well as market design, are either (i) hurdles for further integration or (ii) causes of inefficiencies in operations or market functioning. Moreover, solving these issues is often a prerequisite for strengthening further coordination in system operation. It should, therefore, be one of the key focuses for cooperation at regional and European level. Furthermore, Member States should agree on solidarity principles and harmonise the policy environment in the region, especially with cost recovery/allocation agreed at regional level, as this is a prerequisite for any form of operational coordination to be efficient.

1) The goal is European social welfare and security of supply, but for operational reasons, RSCs might focus their analyses at the regional level. Coordination at European level may be to envisage when implications in terms of costs and benefits are clearly European.

- **RSCs as regional coordinators for system operation.** RSCs are the natural entities to perform coordinated tasks at regional level for the TSOs. They are gradually growing skills and expertise and becoming a trusted counterpart to TSOs for carrying out sensitive security analysis and various other services. The long-term model should build on these entities.
- **A governance and decision-making process allowing RSCs to efficiently fulfil their tasks pursuing system security and social welfare optimisation at the regional or European level.** Significant change to the role and responsibilities of TSOs has inherent risks which could affect the structure of responsibilities at EU level and therefore security of supply. It is therefore important that the TSOs remain the liable bodies. The governance of RSCs should be improved to ensure the transparency and allow for an efficient monitoring of their activities by NRAs.[1)] Gradual improvements in the governance and evolutions in the scope of interventions of RSCs could be useful to improve decision processes, create competence and guarantee neutrality to perform trusted analyses and services, which would be aimed at system security, but also at regional optimisation and social welfare maximisation.
- **RSCs as natural body to coordinate additional services as regionally needed.** As their expertise and experience grow, RSCs will be able to extend their scope of services to TSOs to other tasks related to operational planning, and also to other activities for which coordination would provide added benefits.
- **A geographical modularity focused on efficiency gains.** Situations differ depending on the regions and their specificities, especially the structure of the networks; more meshed networks require more operational coordination. To account for these differences, regions may not have to coordinate all the same activities. Some modularity could allow geographical differences to coexist efficiently. To ensure this, the extension of the scope of RSCs to certain regions/activities should be motivated by the quantification of costs and benefits. Without recommending systematic cost-benefit analyses (CBAs) – which can be costly and time-consuming – we would suggest allowing TSOs in certain regions to choose not to coordinate certain activities through the extension of RSC services, even if other regions decided to coordinate them, provided the coordination of this activity would not provide benefits and the decision not to coordinate would not cause substantial inefficiencies in other regions; this decision should be supported by detailed evidence (e. g. CBA).

1) A similar degree of transparency as TSOs and a certain monitoring of their activities by NRAs should be introduced, in such a way that comparative indexes can show up the challenges and needs of different regions and support further evolution in regulation

Figure 14: Pillars of the Enhanced Regional Coordination concept. Source: FTI-CL Energy

Addressing a lack of coordination in policies and regulation

A regional framework for regional cooperation of policies and regulations

To reach the objectives of the EC, coordination must go beyond only system operations, to cover policies and regulations and foster necessary harmonisation of rules and market design. Different coordination groups already exist at EU level,[1] but they were not sufficient for effectively inducing more convergence at European level. Local or regional differences are often claimed and block the process at EU level. Therefore, promoting the coordination of policies and regulations at the regional level may lead to better results; the fewer the number of involved parties, with more limited differences and facing more similar issues and challenges, the more likely they are to agree on common approaches.

The coordination of policies and regulations at regional level should focus on those with the most important impact on cross-border investment, cross-border trade, system operation and security of supply. Consequently, there is a need for a robust and flexible coordination framework to foster the cooperation of member states and regulators, involving the relevant stakeholders.

Because most of the successes in the last few years came from regional bottom-up developments and were inspired by successful initiatives, such as the Pentalateral Energy Forum, we, together with ENTSO-E, have imagined a concept of policy regions,[2] based on a three-layer coordination forum presented in Figure 15:

1) See for instance the Electricity Coordination Group or the Electricity Security Group: http://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupDetail&groupID=2735 https://www.energy-community.org/portal/page/portal/ENC_HOME/INST_AND_MEETINGS?event_reg.category=E14300

2) ENTSO-E, April 2016, "Regional cooperation and governance in the electricity sector", available at; https://www.entsoe.eu/Documents/Publications/Position%20papers%20and%20reports/entsoe_pp_regions_1604_web.pdf

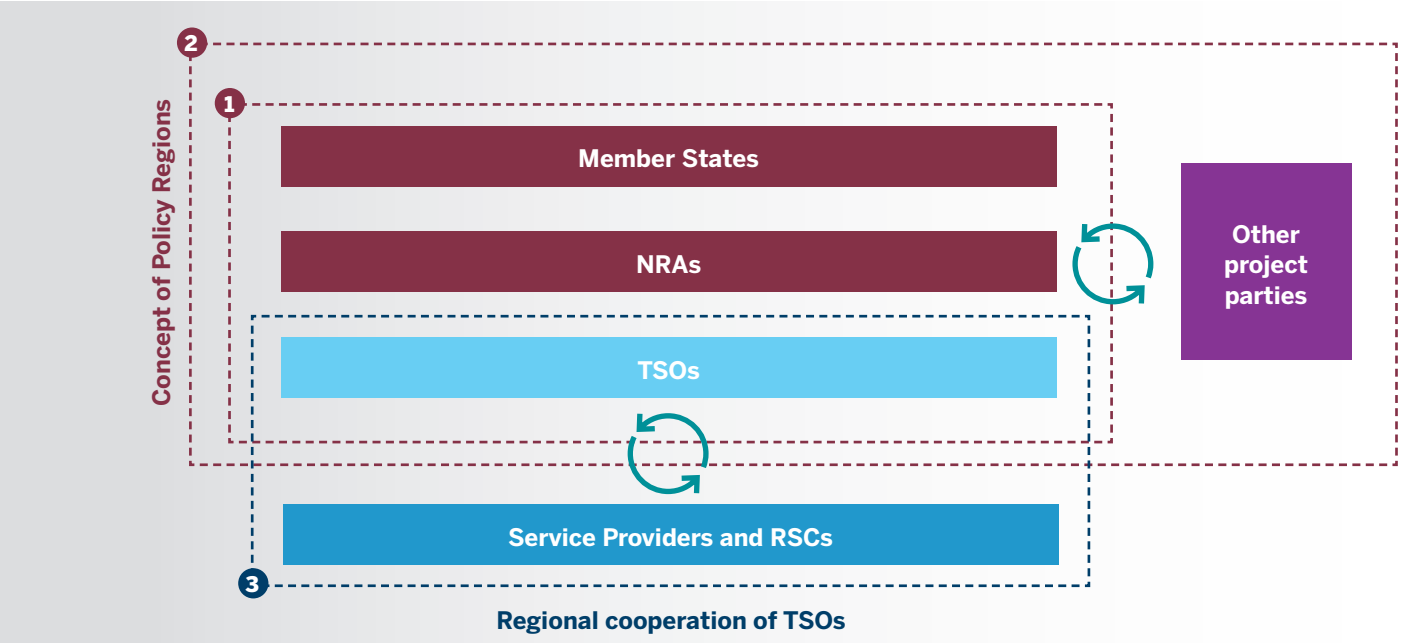


Figure 15: Three-layer regional coordination framework for policies and regulations. Source: FTI-CL Energy

- **Coordination of policy makers.** A first forum of policy makers would involve member states and national energy regulators, as well as TSOs to the extent necessary, for focusing on the cooperation at the political level and on the coordination and harmonisation of policies and regulations to facilitate market integration and improve the efficiency of these policies taking a regional point of view. Institutions such as the European Commission or ACER could also participate in this forum.
- **Consultation of stakeholders.** A second group would organise the adequate consultation of all relevant stakeholders, through dedicated meetings and workshops as well as public consultations. Stakeholder engagement is indeed a necessity to the concept of policy regions, to ensure a smooth and satisfactory implementation.
- **Cooperation of TSOs.** A third layer would focus on the coordination of TSOs in system operations and all TSO activities, for which regional coordination would be valuable, and examine the impact of policies on system operation and at the operational implementation of such policies, if necessary. This forum would, in particular, involve RSCs and other relevant service providers or project partners (e. g. power exchanges, JAO etc.).

In addition to building the convergence of policies and regulations, the role of policy regions would also be to coordinate all the necessary decisions at national and regional levels to allow and facilitate the improvements of the regional cooperation of TSOs. In particular, they would have to remove all regulatory barriers and agree on necessary methodologies or processes such as cost sharing, etc.

Adapting the regulatory framework to foster regional coordination of system operators

A model based on regional security coordinators

The analysis of the various options for the coordination of TSOs led us to favour a model based on the concept of regional security coordinators. This model stems from RSCIs started back in 2008 with the creation of Coreso and TSC. These initiatives have shown their efficiency as platforms for the coordination of TSOs and have gradually developed their experience and expertise.

The draft Regulation establishing a guideline on transmission system operation – the "system operation guideline" or SOGL – generalises the concept of RSCs across all capacity calculation regions in Europe and specifies the minimum requirements and five core services that RSCs will provide to TSOs.[1)]

The RSC concept allows for a clear allocation of tasks between TSOs and RSCs, as the RSCs have well-defined tasks in operational planning to perform, and do not question the responsibilities and the liability of the TSOs. This characteristic facilitates the implementation as it limits profound changes in the legislation and structure of the TSOs, and is well adapted to the current development of RSCs. For these reasons, our approach keeps the concept of RSCs and builds upon it, following the key principles of safe and evolutionary migration, to develop an ambitious coordination model.

In terms of governance and regulation, the goal of our proposed reform is to gradually build more valuable and competent RSCs, who would be able, both technically and in terms of governance, to elaborate well-suited and neutral operational recommendations aiming at regional (or European, where this is in the interest of security and market and when it can be technically and economically justified) optimisation of security

1) The draft Regulation establishing a guideline on system operation received a positive vote in comitology on 4 May 2016 and is available at: https://ec.europa.eu/energy/sites/ener/files/documents/SystemOperationGuideline%20final%28provisional%2904052016.pdf

and social welfare. To do so, RSCs shall improve their processes progressively, in coordination with TSOs, gaining experience and expertise to become trusted and competent entities. The decision-making process should seek the implementation of recommendations to improve social welfare and security of supply at regional or EU level. These improvements and changes are obviously dependent on the establishment of a proper national and regional regulatory framework and monitoring.

It is also worth noting that, given the differences in situations between regions, the evolution of RSCs needs to be differentiated and adapted to regional needs and technical specificities, even though the objective to pursue regional social welfare optimisation remains valid in all regions and RSC development can contribute to that objective. For instance, in less meshed regions, regional coordination may bring limited or no added value for some services, while it may bring significant value in others. This is why we recommend a flexible and gradual approach, where additional services would be decided if the added value is identified and the prerequisites are met.

Decision-making processes

Today, two main decision-making processes are in place:

- **A "centralised" process**, where the RSC provides services and makes recommendations, which are then accepted or not by TSOs;
- **A more "decentralised" or "collaborative" process**, where the RSC organises a platform of coordination between TSOs, who will decide on the way forward to solve an operational constraint.

In both cases, a single TSO has the possibility to refuse to implement a coordinated action. The system operation guideline provides that in case the recommendation is refused, the concerned TSO "shall inform the RSC of the reasons"[1] and the RSCs shall monitor "the number of instances where TSOs refuse to apply the remedial actions recommended by the regional security coordinator and the reasons thereof".[2] The reasons that a TSO may invoke to justify a rejection are, however, not explained in details.

1) See article 78 of the system operation guideline.

2) See article 17 of the system operation guideline.

We suggest a progressive convergence to a structure where RSCs would make recommendations to TSOs, who could issue refusals under specific conditions, mainly because of security reasons or if the recommendation is not efficient at regional or European level:

- Such a refusal should be thoroughly justified by the concerned TSO, with a detailed analysis or report, possibly provided at a later stage.
- The reasons for which the RSC has not identified the (security) concerns should be investigated. In particular, all data and models (including assumptions and remedial actions available) should be shared with the RSC to analyse the reasons of the differences in the analysis, and to allow the RSC to further develop its technical capabilities to better respond to such situations.
- Measures should be implemented to avoid the reoccurrence of this issue in the future. In case of repeated deviations, a detailed cost-benefit analysis may be required to assess alternative measures to address the issue.
- In order to avoid situations when TSOs reject a recommendation because of regulatory issues such as cost recovery or cost sharing, these matters should be addressed in advance and agreed upon in the context of the policy regions. Addressing these issues is a prerequisite for an efficient and fair implementation of the approach.

Governance and regulatory oversight

Even if the role of the RSCs is to provide services to TSOs, the services they provide and the related responsibilities and consequences are such that RSCs cannot be considered as any other service providers and should keep a tight relationship with TSOs. Consequently, we would suggest – as is currently the case with all mature and newly established RSCs – that the RSCs would be daughter companies of TSOs.

RSCs must be in a position to produce analyses and recommendations in a neutral way, aiming at interests and objectives (security of supply, regional/European social welfare) which require overcoming possible national or individual TSO objectives. As such, the governance and the structure of RSCs should provide them with sufficient competence and neutrality to ensure that analyses and recommendations effectively aim at improving social welfare at the regional or EU level while maintaining security of supply, which includes:

- RSCs should be transparent and be evaluated against performance indicators and RSCs reports; in relation with already established SOGL requirements, exigencies shall be established based on harmonised regulatory agreed indicators, allowing for continuous efficiency gain and sharing best practices, as well as addressing properly regional differences.[1)]
- Their financial structure should give RSCs the means to carry out their tasks and gradually develop their tools and expertise.
- RSCs should report to a board of shareholders, composed of TSO representatives. The board would guide strategic decisions and development. The voting system should be designed in such a way that facilitates efficient decisions towards secure operations and social welfare optimisation at regional or EU level, while considering regulatory and legal constraints at national level. Inconsistencies and dis-optimisation stemming from differences in these legal constraints should be addressed in the context of policy and regulation coordination.

Conversely, as the responsibilities and consequences related to their activities would likely increase, an adequate contractual framework with the TSOs should be designed, and may need to evolve over time to pre-empt

1) It is important to note that there are different challenges in different regions but indicators can be introduced on minimum service levels expected.

possibilities of penalties or other consequences in case of failures. A multilateral framework agreement could be concluded between all TSOs and RSCs, possibly after the opinion of ACER; it would define the general principles of the cooperation, the role and responsibilities, the coordination between regions, etc. A second layer of agreement could exist at the regional level to operationally develop the principles and address regional specificities, including differences in provided services, differences in regulations and market designs, etc. Finally, standard bilateral contracts may be signed between RSCs and TSOs. This approach is actually close to the approach used by ENTSO-E with the Multilateral agreement signed in 2015, but would need to be adapted to the evolutions of RSCs in terms of governance and decision-making as well as scope of interventions.

With regards to regulatory oversight, at this stage, it seems necessary to foresee a certain regulation of RSCs by NRAs, even if RSCs are controlled by TSOs, and therefore indirectly regulated. A regulatory oversight by NRAs and ACER could be organised, through monitoring and reporting.[1)] NRAs and/or ACER may provide recommendations or issue opinions on RSCs, whether related to budget or activities and procedures. More specifically, the implementation of certain processes or methodologies – as it is the case for instance with the capacity calculation methodology according to CACM –, which may involve RSCs, may need to be subject to the approval or opinion of NRAs: this would also ensure adequate regulatory oversight.

It is worth noting that the governance needs to be adapted to the regulatory framework and the legal constraints laid on TSOs. To allow for improvements, NRAs and/or policy makers must work regionally and harmonise the regulatory framework and the policies.

To allow for an efficient and smooth approval process, NRAs decision making procedures should be improved, especially to approve rules and methodologies. For the regional level, ACER could organise regional task forces or subgroups to monitor the developments in each region. Regional decisions – e. g. on a specific RSC or on the approval of a regional methodology – could be made by a subgroup of the ACER board of regulators (BoR) constituting the NRAs of the region. The voting rules may need to be adapted, adopting the standard double-majority voting system applied in Europe and within ENTSO-E, for instance. To facilitate the coordination of decisions between regions, other NRAs may participate in the BoR debates and be observers for the decisions.

1) With regards to reporting, one should bear in mind, though, that it should be rationalised to avoid the multiplication of time-intensive procedures and reporting, which could lead to high and unnecessary costs.

Incentives

A gradual approach appears to be a necessity for ensuring (a) that the coordination of activities at the regional level is indeed efficient and provides benefits; and (b) that TSOs and RSCs have developed adequate tools and experience to perform those tasks in a secure and efficient manner. Differences between regions may exist.

Consequently, top-down requirements, such as EU regulations, which would be very specific on what should be coordinated and how, might not be the most appropriate way forward for fostering the adequate level of regional coordination. In addition, the process to draft such regulations or guidelines can be long and may not be efficient for allowing TSOs to adapt rapidly and gradually improve coordination.

On the other hand, one could envisage introducing incentives for TSOs to integrate regional/European social welfare in their decision-making processes and therefore to coordinate further at regional level and collaborate with RSCs as much as necessary. These incentives could be set on improvements of social welfare at the European or regional level with identical security level: TSOs may perceive premiums based on gains of social welfare enabled by efficient coordination. However, it is important to avoid introducing conflicting incentives at regional and national levels.

It is also important to ensure that RSCs – whose role is likely to expand – also have adequate incentives to develop efficient services, tools, and expertise while remaining cost-efficient. Options to provide these incentives to RSCs should be investigated.

Regional specificities for the scope of RSCs

Regional specificities exist across Europe, stemming from various types of differences:

- **Network differences.** First, different synchronous systems exist in Europe. Moreover, the meshing of the network varies significantly: while the central Europe is heavily meshed, some areas or countries are connected to the rest of the continent by only a limited number of lines, which may reduce interdependencies and needs for coordination for some activities. Also, (at least historically) grid constraints may be more frequent and important in some countries or areas than others, which has induced differences in market designs and operational processes.

Case study – Specificities of load frequency control in the Iberian Peninsula

Within the Continental Europe synchronous area, peripheral and shortly interconnected regions, such as the Iberian system, have a limited interconnection capacity with the rest of Europe. The interconnection on the Spain-France border is the only one and is limited to a few cross-border lines.

As frequency containment reserves (FCR) are shared across the whole synchronous area, 90 % of the FCR support comes through the France-Spain interconnection. In case of contingency in the peninsular system, this interconnection could therefore be overloaded until the automatic frequency restoration reserve (aFRR) located in the Iberian system reacts and compensates the imbalance. This flow of power after a large imbalance must be very carefully considered when calculating the commercial capacity available for market purposes. If the flow becomes too large and the interconnection overloads, a cascading incident ending in system splitting could occur and isolate the Iberian system from the rest of the Continental Europe system. The Iberian system would then need to operate as an island with a net imbalance equal to the net exchange before contingency, consequently leading to a brownout, after de under-frequency load-shedding relays solve the imbalance by disconnecting demand.

A clear illustration of that reality can be found in the general and specific requirements applying to TSOs for solving scheduled exchanges deviation. For instance, as the risk of isolation of the Iberian System increases significantly if large deviations are sustained across the France-Spain border, as any further deviation afterwards in the interconnection would become critical, the Spanish TSO (REE) needs to operate with stricter requirements.

More stringent global behaviour in peripheral and weakly interconnected regions (Iberian system) has historically implied the need for higher frequency response standards to grid users (generators). In the Spanish system, national law (P.O. 7.2)[1] requires 95 % of the required aFRR response to be within 5 minutes, which is faster than most of the other Continental Europe countries.

Since prolonged deviations in the interconnection are critical for system security the Spanish TSO runs manual FRR reserve sizing and procurement processes close to real time in order to ensure: a) availability resources to meet operational security and adequacy and b) with efficiency (cost) criteria. This requires access to market schedules, potential unexpected outages, TSO forecasts (for demand, RES etc.) and forecasted errors, which reduce as the calculation is performed closer to real time.

This example shows that it is therefore important to capture these specificities and to ensure that coordination at regional level does not entail operational risks and overall losses of efficiency compared to these tailored approaches, well-adapted to local situations.

It also shows that TSOs, at national level, innovate and develop efficient measures to adapt to specific needs or circumstances. The regional coordination should be arranged and governed to allow and facilitate, and not to restrain, TSOs to innovate and develop more efficient solutions.

1) Procedimientos de Operación 7.2 – Servicio complementario de regulación secundaria, available at: http://www.ree.es/sites/default/files/01_ACTIVIDADES/Documentos/ProcedimientosOperacion/PO_resol_30jul1998_b.pdf

- **Generation mix differences.** Some regions or countries may present specificities in terms of generation mix, due to large proportions of inflexible generation, intermittent RES or hydro power. These specificities have implications on how the operation of the system can be managed and have historically induced differences in system operations.
- **Regulatory and market design differences.** Despite a willingness to harmonise market design and regulations at European level, major differences remain between countries and regions in terms of policies, regulatory framework and market design. Regional cooperation regarding policies and regulations may allow neighbouring countries within a region to gradually converge on some aspects, but regional differences will likely remain over time, either due to different priorities, different needs, or different starting points.

Because of these differences, the needs and benefits from regional coordination – and the associated priorities – vary from one region to another, and these differences are likely to remain – at least in the medium term when they are only related to historical choices or regulatory aspects, but perhaps even in the longer term if they stem from more long-lasting aspects, such as network differences, etc.

As a result, for the various additional services we investigate, it is possible that the coordination at the regional level might not be valuable or may not be a priority in all regions; for instance, in some regions, such as peninsulas or islands, given the limited interconnection or the low meshing of the network, it is possible that a lower level of coordination, compared to other regions, would be optimal (at least with regard to some specific aspects).

In addition, in the various ongoing regional processes, different regional configurations coexist: the electricity regional initiatives, the capacity calculation regions, the TYNDP regions, and the possible coordinated balancing areas (or the geographical scope covered by pilot projects at least) may not fully coincide. In the short term, a pragmatic approach should be considered and we may consider that these divergences may coexist.

In the longer term, it could be useful to align the geographical scope covered by RSCs for the different tasks and services they provide. Indeed, as for TSOs, there are synergies across time frames and activities within RSCs. RSCs can capitalise on experience and expertise, especially with regard to the detailed knowledge of the regional power system, to develop more efficiently a range of services. That being said, differences in scope per services may remain if necessary.

In the long term, we should not exclude the possibility that these entities may have to coordinate or even merge to provide more global services at cross-regional or EU levels, while keeping regional centres for other services. The harmonisation of the geographical scope for different services and the governance of these structures should allow for an evolving scope.

Expanding regional coordination of system operators

TSOs have already developed a strong regional or European coordination of their main activities:

- RSCs are – or will be – performing coordinated services in relation to (i) the common grid model construction; (ii) security analysis; (iii) capacity calculation; (iv) outage coordination; and (v) adequacy forecast;
- Coordination between TSOs, whether at regional or European levels, exists with the TYNDP process or for medium-term adequacy forecast;
- Pilot projects between TSOs are reinforcing cooperation for balancing, which will be generalised due to the upcoming electricity balancing guideline.

These areas of coordination were not decided top-down, but emanated from the identified needs or potentialities of the TSOs, which may have been then included in regulations. New needs for coordination, and new possibilities of improvements emerge regularly and should be seized by TSOs to enhance system operation and development.

At this stage, we consider that RSCs are well suited entities to further develop the cooperation of TSOs for other activities, but this requires a flexible approach, which is progressive and adaptable to evolving circumstances and regional specificities.

TSOs might voluntarily experiment with new RSC services, based on necessity for coordination or based on identified benefits and these services may then be extended where appropriate if experiments are successful. A detailed cost-benefit analysis may not be systematically necessary. It is also worth noting that RSCs are obviously natural candidates to take over these new coordinated services and activities and it is important to gather these activities within the same entities in order to benefit from the gained expertise and develop synergies. However, we do not exclude the possibility that some activities might be performed by other parties, e. g. the Joint Auction Office (JAO) or power exchanges, when it comes to market or auction services.

In the following subsections, we present various ideas and suggestions where we have identified interesting ideas for expanded coordination and identify their prerequisites. Given the scope and timing of the project, however, it was not possible to elaborate on detailed cost-benefit analyses for each of these suggestions.

Enhanced operational planning

Motivations

Due to RES development and cross-border flows optimised in a dynamic way and closer to real time, system operators need to cope with the uncertainties of schedules ahead of real time and be prepared to react quickly in real time and in a coordinated way with neighbouring TSOs. RSCs already have an important role in the operational planning time frames, through the provision of the five key services.

Despite these substantial improvements, many stakeholders consider that:

- The rapid changes and the increasing uncertainties of the power system may lead to lower cross-border capacity offered to the market; and
- TSOs adopt a very conservative approach for capacity calculation, taking excessively high security margins, pushing constraints at the borders and limiting domestic costs to the detriment of regional social welfare.

To illustrate that, Eurelectric recently published a position paper,[1)] in which they consider that TSOs have "confusing incentives [which] do not allow for an optimal use of the European infrastructure and do not capture maximum social welfare" and they "observe that cross-border capacity limitations are used as a non- costly way to deal preventively with potential congestions". To support their views, they take several concrete examples:

1) Eurelectric, June 2016, "Optimal use of the transmission network: a regional approach", available at: http://www.eurelectric.org/media/278462/eurelectric_report_congestion_management_-2016-2210-0009-01-e.pdf

- Belgian Winter Measures. Eurelectric considers that "TSOs tackled potential internal congestion problems [due to massive loop flows] anticipatively by withdrawing commercial cross-border transmission capacity from the market" and that "this was done without considering the welfare these commercial exchanges would have generated with respect to extra redispatching costs for handling the anticipated flows with other means".
- Curtailment on the interconnector between Germany and Denmark. Due to the increasing share of intermittent renewables, TenneT has had to frequently resort to capacity limitations. A detailed case study, presented in the text box below, explains the capacity reduction observed on this border and the impact on social welfare.
- Remaining available margins on the interconnectors between Germany and the Netherlands. The introduction of flow-based has increased exchange capacity with the Central-Western Europe region. However, Eurelectric considers that the total volume of allocated capacity – which is harder to analyse in a flow-based environment – has been decreasing on that border recently.

Case study – capacity calculation between Denmark 1 and Germany

TenneT TSO GmbH (TenneT) and Energinet.dk (ENDK) jointly operate the Denmark West – Germany (DK1-DE) interconnector from Kassø to Audorf. In recent years, the increasing share of intermittent renewable feed-in has induced drastic changes in the availability of the cross-border capacities. As a result, TenneT has had to frequently resort to limitations of the interconnector capacities over at least six years. In 2014 and 2015, the ratio between available net transfer capacities (NTC) and aggregated thermal capacity of the DK1-DE interconnector was less than 10 % for a transfer from Denmark to Germany, and less than 30 % for the opposite direction. NTC was reduced in every hour of the beginning of 2016. From 2014 to 2015, tradable capacities (i. e. import and export possibilities in terms of MW) on the DK1-DE line dropped by 53.7 %.[1)]

1) ACER, 2016, "Annual Report on the Results of Monitoring the Internal Electricity Markets in 2015", available at: http://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/ACER%20Market%20Monitoring%20Report%202015%20-%20ELECTRICITY.pdf

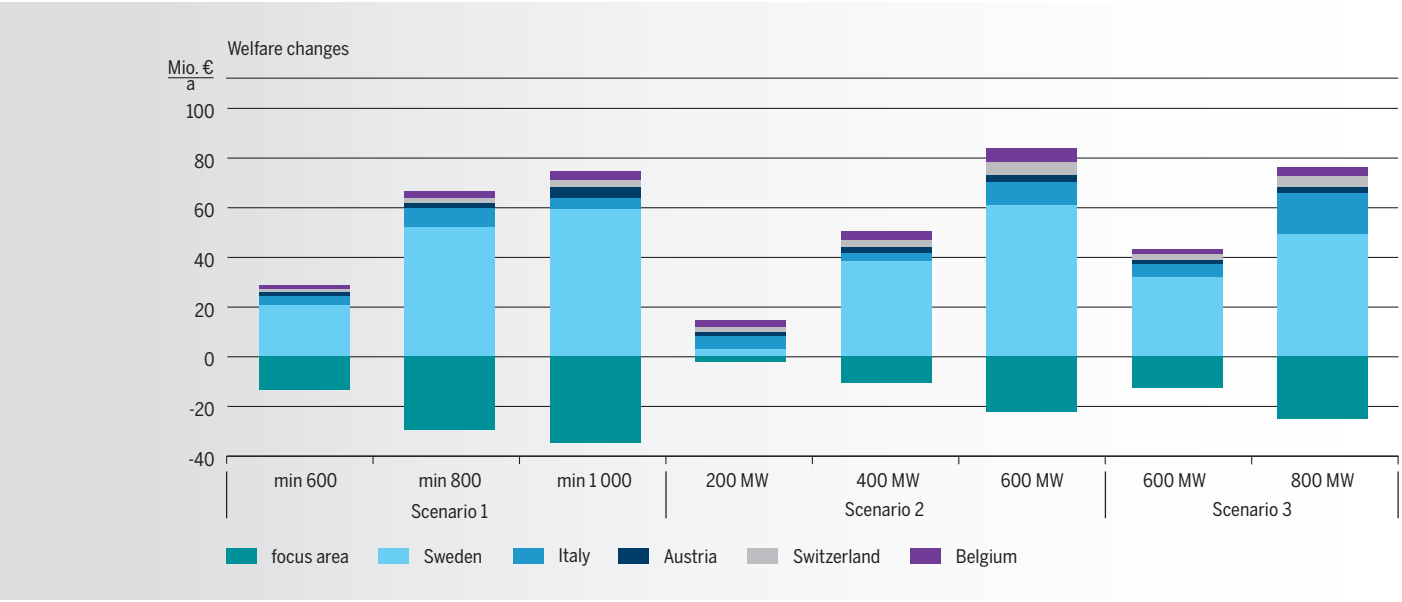


Figure 16: Welfare changes compared to Base case (situation as-is). Source: RWTH, Aachen University (2014)
Note: 'Focus area' refers to a common effect for Germany and Denmark.

To curb the observed trend, a possible approach would be to release more transmission capacity in the day-ahead market and use the intraday resources in the redispatch processes to ensure a secure transmission system operation if needed. A study performed by the Institute for Power Systems and Power Economics/ RWTH Aachen University[1] for Danish TSO Energinet.dk and the German TSO TenneT quantifies the impact of an increase in available DE-DK1 interconnection capacity, considering potential need – and costs – for redispatching, on the welfare of the European electricity system in general and separately for each country. The total impact accounts for changes in consumer surplus, producer surplus, congestion rent and also in re-dispatch costs. As illustrated in Figure 16, in all three considered scenarios, **increased DE-DK1 interconnection capacities, thanks to the potential use of redispatching,[2] had a negative effect on net social welfare for Germany and Denmark, while the overall effect for the European electricity system would always be positive.**

ACER proposes various solutions to the problem of decreasing tradable capacity on the DK1-DE interconnector, such as infrastructure investments, the creation of bidding zones and cross-border redispatching/ countertrade.[3]

1) RWTH, Aachen University , 2014, "Investigation of welfare effects of increasing cross-border capacities on the DK1-DE interconnector", available at: http://www.energinet.dk/SiteCollectionDocuments/Engelske%20dokumenter/EI/Report_TenneT_Socio_Economic_DK1_DE_interconnector%20PDF.pdf

2) Assuming redispatching costs would be borne by TenneT and Energinet.dk.

3) ACER, 2016, "Annual Report on the Results of Monitoring the Internal Electricity Markets in 2015".

The main concerns that Eurelectric explains in this paper and through these examples are lack of coordination or adequate incentives for TSOs towards maximising the cross-border capacity. In the opinion of Eurelectric, this may sometimes cause inefficiencies and impact downward possibilities for trading. The basic framework provided in CACM for TSOs to take decisions in favour of overall European/regional social welfare is based on the criteria of calculating and allocating capacity respecting operational security criteria and without entailing unaffordable risks or subsequently redispatching costs to compensate settled trading positions incompatible with security criteria. Stakeholders emphasise the fact that market design, regulations, policies etc. can be the root cause of these issues, and their improvement and harmonisation could facilitate TSOs' work and solve many of the issues pointed out by Eurelectric.

Possible additional services

To address these concerns, consistent with our general proposals, we suggest that RSCs' services, and most specifically capacity calculation, can consequently evolve to solve such issues. As a regional body, RSCs could perform some of these tasks with a "natural" regional point of view, whereas national TSOs have national oversight and scope. RSCs would be required to perform these tasks in order first to manage operational security and second to maximise social welfare at the European level, or at least at the regional level.

RSCs' key role is to provide security analyses to TSOs in the operational planning phase and, in case they identify a constraint or any other network issue, they should provide possible remedial actions to address the issue in an optimal way at the regional level. As they gain expertise and experience, they could further optimise the selection of remedial actions at regional level and between regions, provided they had access to all information about relevant remedial action possibilities, including information about relevant costly remedial actions. Taking into account efficiency with regard to the constraint and costs of all possible remedial actions, they could analyse which remedial actions would be the most efficient solution to address the constraint.[4]

With regard to capacity calculation, at this stage, RSCs have a coordination role, which is mainly to merge TSOs' inputs and perform computations out of these aggregated data. The calculation process is very much driven by these inputs of individual TSOs. In particular, the

4) TSOs are exploring today these possibilities in order to identify and develop services evolution and cross-region coordination. An example is that projects have been launched to see the possibilities of phase-shifter transformer and HVDC coordination as well as the extraction of adapted concepts from a review of TSOs' best practices.

capacity calculation process may integrate the possibility of activating (mainly non-costly) remedial actions in case of the materialisation of pre-identified possible constraints. These remedial actions are preselected by TSOs. The integration of these remedial actions improves social welfare, which is an objective set out in the CACM guideline.

To further enhance capacity calculation and aim at maximising social welfare at the regional or European level, RSCs could provide useful analysis for capacity calculation. More specifically, once they have acquired a detailed knowledge of the regional power system, they could build up the capacity to compute and provide the inputs, statistics and sensibilities useful to the capacity calculation (e. g. remaining margins, critical branches/ critical outages, power transmission distribution factors, generation shift keys etc.), based on TSO measurements and data when necessary.

In addition, if RSCs had access to adequate information on all available remedial actions, and corresponding costs,[1)] they could integrate remedial actions further in the calculation process. Subject to regulatory agreement in the region, these could include (costly) remedial actions, provided that their inclusion would generate a net benefit in terms of social welfare at the regional or European level, while maintaining operational security at required standards. To do so, RSCs may perform analyses to assess (i) the likelihood that a (costly) remedial action integrated in the capacity calculation will effectively need to be activated; (ii) the potential impact on capacity levels; and (iii) the potential impact on regional or European social welfare. As a prerequisite, TSOs and RSCs need to develop a methodology – to be approved by NRAs – to determine how to integrate (costly) remedial actions in the capacity calculation, so that it has a net positive impact on regional or European social welfare. In addition, whilst this approach could deliver benefits, it would require further research to evaluate the impact on the security of operation and energy market.

1) Costs might not be known in advance, especially during the capacity calculation process, but they may be able to develop estimations.

Prerequisites

As explained in the governance section, the RSCs should first gain sufficient expertise and build up trust. Once the adequate governance is in place, the RSCs should provide insightful recommendations especially in terms of remedial actions and capacity calculation which TSOs' would assess recognising that the TSO may not be in a position to implement for justifiable reasons related to security of supply concerns and, where applicable, regulatory gaps as long as they are not solved. Each case of rejection should be analysed to develop solutions and avoid future instances. Potential discrepancies between TSOs and RSCs in terms of efficiency analyses should be analysed, in order to gradually avoid their occurrence.

Moreover, the cost recovery and the cost sharing should be agreed upon by relevant NRAs ex-ante in order to ensure that no TSO is prejudiced. At this stage, we consider that the key cost sharing should take into account the repartition of the net benefits at the national level, so that no grid users of any countries are disadvantaged compared to the others. Fairness and pragmatism should drive the development of the exact methodology.

Finally, the regulatory framework should guarantee that the RSC coordination scheme performances are high and effectively aim at enhancing social welfare at European or regional level. RSCs should act in a non-discriminatory manner towards any member states/TSOs. To do so, one may envisage that the methodologies followed by the RSCs would be defined by TSOs, with the support of RSCs as their experience grows and/or the regulatory framework evolves, and approved by NRAs. In addition, incentives for RSCs' performances could be introduced by the TSOs on the basis of the applicable national and/or regional regulatory framework.

Balancing

Motivations

The development of RES and the reliance on cross-border exchanges also reinforce the need and benefits resulting from the balancing coordination. Several studies have identified significant potential for economies and efficiency gains related to balancing.[1)] For instance, based on these studies – whose assumptions and methodologies may be subject to discussion – the coordination of balancing energy procurement could deliver important efficiency gains.[2)]

In this context, the network code on electricity balancing (NCEB) defines an ambitious target model for balancing, especially regarding the coordination of energy balancing.[3)] However, the electricity balancing guideline to be adopted is still under discussion. In that field, coordination of TSOs will be important and is likely to provide large benefits. As the detailed functioning of the approach is being designed at the moment, it is important to investigate potential organisation approaches that allows for a smooth coordination of TSOs – as this will be real-time or close-to-real-time operations – and exploit possible synergies with other coordinated activities and regional bodies when relevant.

In addition, the NCEB allows for the exchange of balancing capacity as well as the allocation (or reservation) of cross-border capacity under certain conditions for the transfer of balancing capacity. It also provides that "each TSO shall at least every two years assess the opportunities to perform sharing of reserves".[4)] The potential for cost reductions and efficiency gains in the dimensioning and procurement of reserves – even if it raises complicated issues in terms of coordination, risk management and interactions with wholesale market – could be substantial and should be further investigated. The text box below presents the efficiency gains obtained through the coordination of balancing reserve dimensioning and procurement in Germany. It should be mentioned that the described case reflects the potential of coordination between TSOs within the same Member State, in a situation without congestions and with the same procurement rules. Such efficiency gains would be harder to obtain in Europe, however, due to the existence of congestions and the differences in regulatory frameworks.

1) Booz & Co, 2013, "Benefits of an Integrated European Energy Market". ACER, 2016, "Annual Report on the Results of Monitoring the Internal Electricity Markets in 2015". Mott MacDonald and Sweco, 2013, "Impact assessment on European electricity balancing market" for the EC, available at: https://ec.europa.eu/energy/sites/ener/files/documents/20130610_eu_balancing_master.pdf.

2) According to ENTSO-E, a significant part of the benefits can be captured by the imbalance netting process, which is being extended in Continental Europe.

3) http://www.acer.europa.eu/en/electricity/fg_and_network_codes/pages/balancing.aspx

4) The sharing of reserves is a mechanism in which more than one TSO take the same reserve capacity into account to fulfil their respective reserve requirements resulting for their reserve dimensioning processes.

Case study – coordination of reserve dimensioning and procurement in Germany

The Grid Control Cooperation (GCC) was implemented from 2008 by three German TSOs – TenneT, TransnetBW and 50Hertz –, then joined by Amprion, in order to optimise the coordination of regulating power across control areas. It enables technical and economic synergies in a fictive single control area while maintaining the historic German structure of four control areas.[1)]

GCC consists of four modules, which were launched successively between December 2008 and October 2009. The German Federal Network Agency (Bundesnetzagentur) issued an order in March 2010[2)] which made GCC compulsory for the four German TSOs starting in May.

The second module has enabled a reduction of the reserve procurement costs through the **mutual provision of regulating reserves** (both secondary and tertiary reserves) and their **common dimensioning**. In practice, each TSO puts its available regulating reserves at the disposal of others in situations where one area's reserves are fully used. Consequently, the dimensioning need of balancing reserves at the individual TSO level and the corresponding costs are substantially lowered.

1) Source: https://www.regelleistung.net/ext/static/gcc

2) Bundesnetzagentur, "BK6-08-11 – Festlegung zum Einsatz von Regelenergie" and associated press release

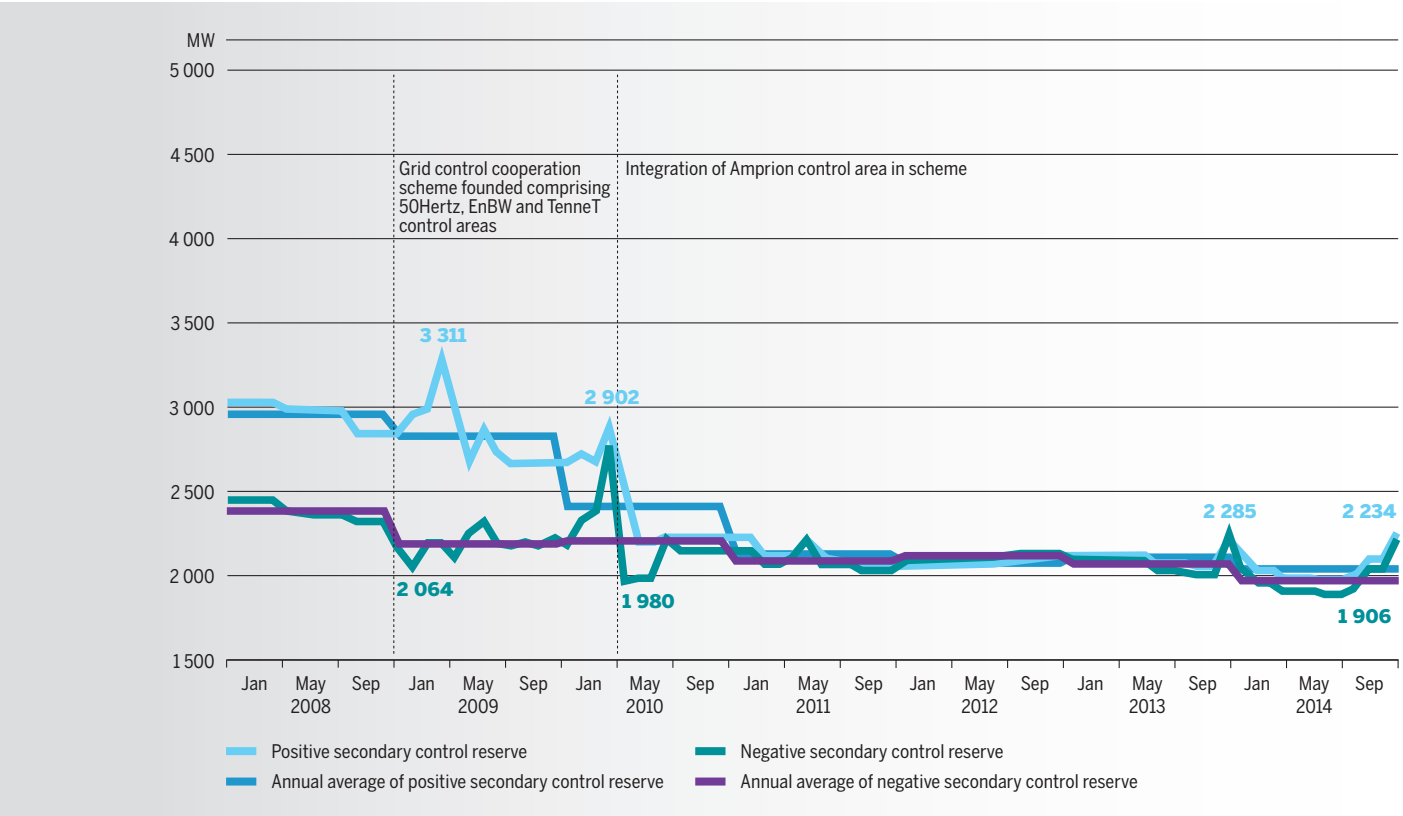


Figure 17: Total volume of secondary reserve tendered in Germany (MW)
Source: Bundesnetzagentur, Market monitoring report 2015

According to the German Federal Network Agency, supported by a study led by TU Dortmund and E-Bridge, GCC enables **long-term cost savings of about 200M€ p.a.** and increases system stability and security. The second module alone was estimated to result in cost savings of about 140M€ pa.[1)]

In practice, **reserve volumes tendered by the four German TSOs were substantially reduced between 2008 and 2010**.[2)] Positive secondary reserves went from c.3,000MW to 2,200MW, i.e. a decrease of 23 %, and negative secondary reserves went from c.2,400MW to 2,100MW, i.e. a decrease of 11 %. The coordination of reserve dimensioning and procurement therefore enables the reduction of reserve volumes while ensuring security of supply, even with an increasing penetration of renewable energy sources.

It must be pointed out that the absence of congestions between the participating control areas and a common regulatory framework facilitated such intensive cooperation.

Across borders, the "International Grid Control Cooperation" (IGCC) was founded, which currently has 11 member TSOs from 8 countries, which will serve as the nucleus for the European imbalance netting process. It is based on an aFRR-Optimization System for the avoiding of the counter activation of aFRR and hence avoids unnecessary procurement of secondary control energy. The IGCC is based on a decentralised operational model with a multilateral agreement signed among the participating TSOs.

1) P. Zolotarev, 2010, "GCC – Coordination of Secondary Control", cited by S. Jaehnert (2011), "Merging of control areas in Germany"

2) K. Flinkerbusch, 2011, "Der Markt für Sekundärregelenergie – Eine Bewertung des Regelenergieeinsatzes im Rahmen des Netzregelverbundes"

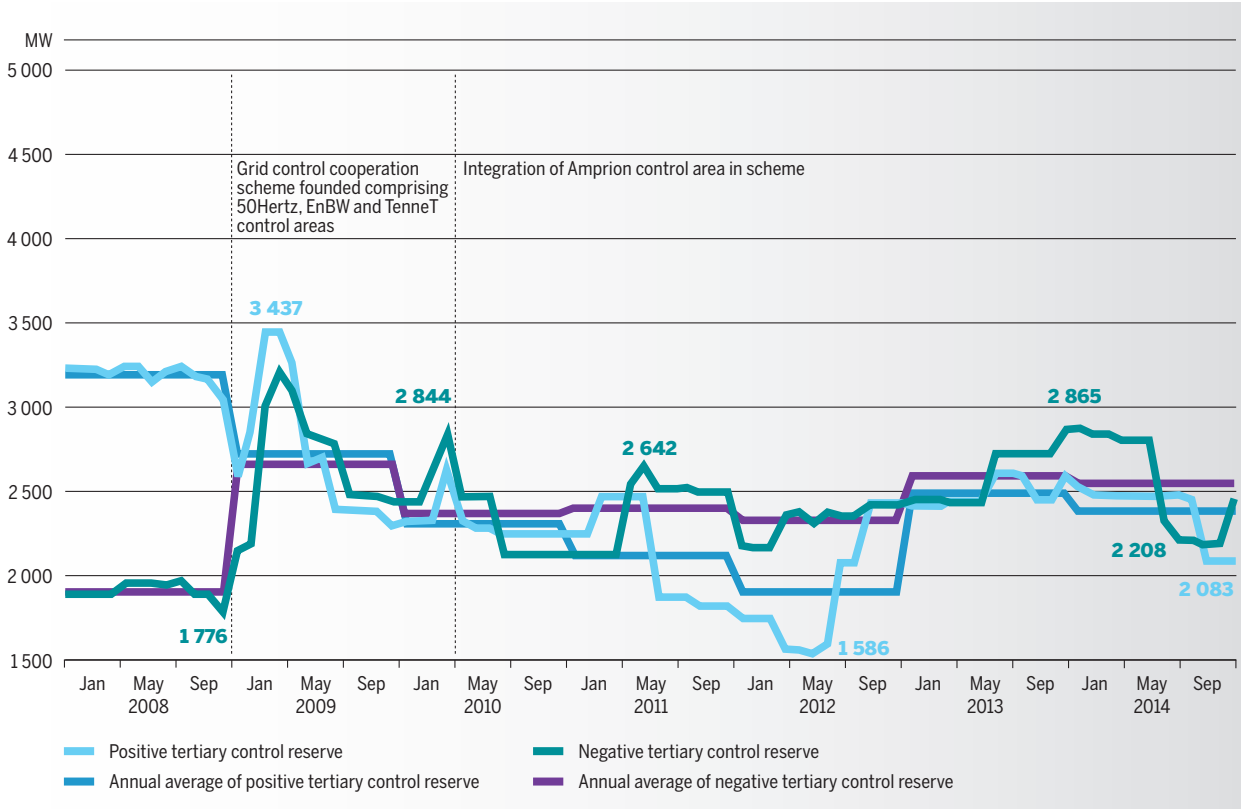


Figure 18: Total volume of tertiary reserve tendered in Germany (MW)
Source: Bundesnetzagentur, Market monitoring report 2015

Therefore, the need for coordination between TSOs with respect to balancing will increase very significantly in the next years.[1)]

Possible additional services

The implementation of the target model for balancing exchanges will follow – as has been the case for market coupling, for instance – a gradual sequence to extend the geographical scope of the common merit order list (CMOL), possibly with a regional approach. More specifically, for the different types of reserves, TSOs will have to set up a CMOL for standardised balancing products, through which they will be able to exchange balancing bids and optimise their activation at the regional or European level,[2)] due to the activation optimisation function (AOF). The Figure 19 schematises the target model for energy balancing exchanges which corresponds to the market coupling model for spot markets.

In this process, the coordination of TSOs will be key and it is possible that RSCs – and/or possibly other entities – could play a role. TSOs will keep the responsibility on balancing and be the contracting entities with the balancing service providers (BSPs) and balance responsible parties (BRPs). This does not question the decentralised organisation of load frequency control, which is seen by TSOs to allow for system duplication and higher robustness.

1) For example, with regard to the European imbalance netting process, the target state should be reached two years after entry into force of the EBGL, which should be reached by continuously enlarging the member TSOs of IGCC.

2) The latest version of network code foresees a gradual regional approach through coordinated balancing areas (CoBAs), but we understand from informal discussions that the regional approach might not be kept as such in the final electricity balancing guideline. According to ENTSO-E's information, a unique platform would be developed and would be gradually joined by TSOs.

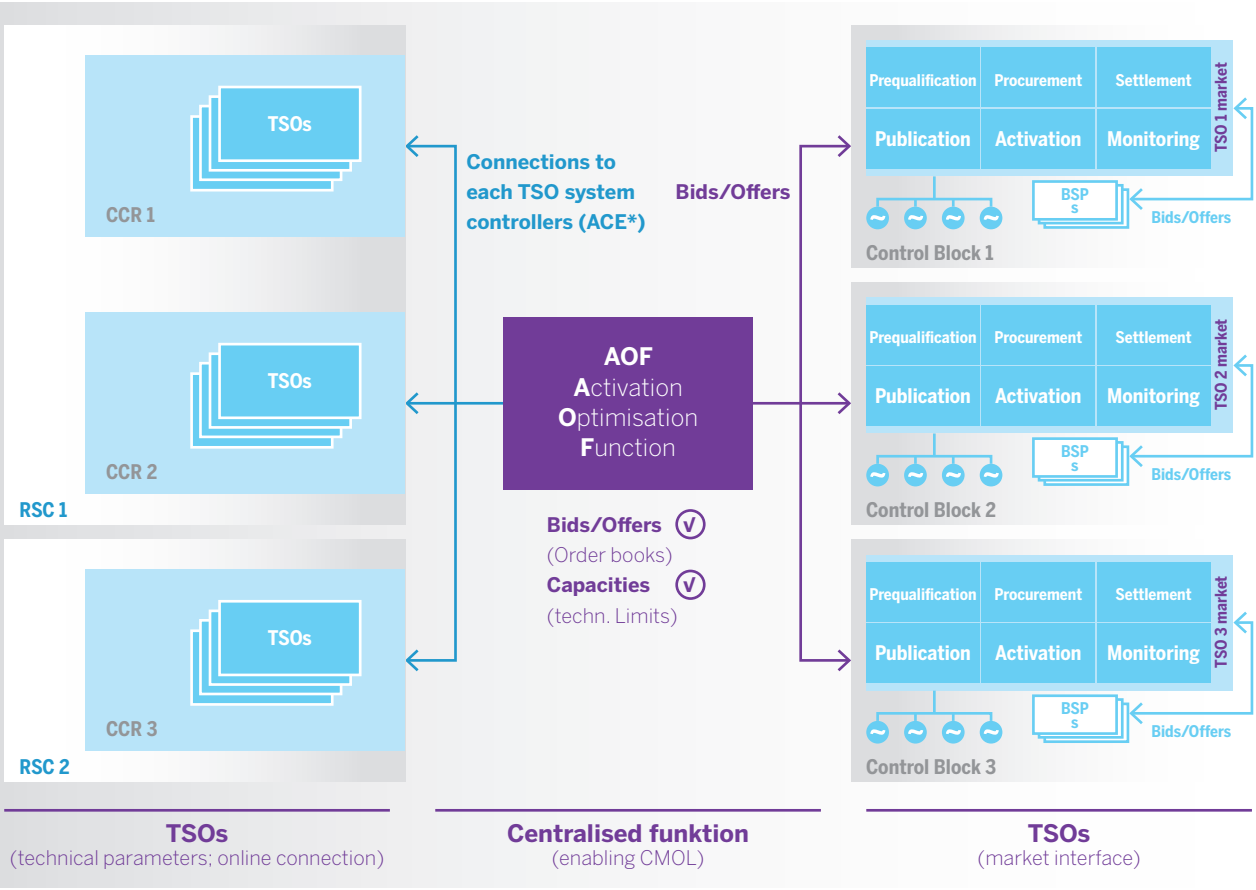


Figure 19: TSO-TSO cooperation model for energy balancing market. Source: ENTSO-E
*Note: * Connection to each TSO necessary. ACE = Area Control Error.*

First, we recommend that TSOs analyse the possible gains of procuring services from RSCs in the context of the implementation of the electricity balancing guideline. RSCs could eventually play a role in the creation and in the coordinated operation of the balancing platforms. For example:

- They could update the common grid model, when this is required, and the capacity calculation for the balancing time frame.
- They could contribute to the merging of the merit order lists into CMOLs and coordinate all inputs into the AOF (and possibly host the algorithm services).
- They could host IT software if it is deemed useful by TSOs.

Secondly, RSCs could provide regional analyses for TSOs in order to investigate possibilities of sharing of reserves and enhanced dimensioning of balancing reserves, and also possibly to analyse the reservation of cross-border capacity for the exchange of balancing reserves, in compliance with the conditions set out in the SOGL. The types of reserves concerned should be identified at regional level on the basis of control area or local specificities. The RSCs' analyses should aim at maximising social welfare. The German experience presented in the text box before illustrates substantial gains that can be expected from such a coordination, even though one has, of course, to bear in mind the specific situation in Germany, where Germany is a single bidding zone and one national legislation encompasses four TSOs. To perform these analyses, RSCs should develop a new set of competences, not yet foreseen in the five services, but they could also use the expertise they gained regarding security analyses. On the basis of these analyses, they could contribute to the opportunity assessment of the TSOs and, if benefits are demonstrated, make recommendations to TSOs with regard to the sizing and the sharing of their reserves. However, the decision on reserve sizing, sharing or exchange will have to be taken by the TSOs, who would if necessary explain to NRAs and ACER the reasons why they deviate from these recommendations.

Lastly, the coordination of the procurement of certain types of balancing reserves could increase its efficiency, especially if there is a possibility of sharing or exchanging these reserves between TSOs. TSOs may coordinate with other TSOs for the exchange and sharing of certain types of reserves if deemed efficient and relevant at regional level and contract with a service provider – such as JAO or power exchanges – for regional procurement of balancing reserves, while TSO would still be the counterparty of domestic BSPs.

Prerequisites

The role of RSCs and/or of other service providers should be carefully assessed during the design and implementation phase of the electricity balancing guideline. TSOs will need to define the process, and clear boundaries for RSCs' tasks and responsibilities should be defined.

To perform such tasks, RSCs should develop adequate knowledge, experience and expertise to support TSOs. They should have their own experts. They should have access to all necessary information and data and have adequate IT equipment, interoperable with TSO systems.

TSOs should be able to monitor RSCs' operational actions and intervene for operational security reasons. They may also consider back-ups.

The implementation of such coordinated procurement schemes, whether for capacity or energy products, requires a sufficient standardisation of balancing products, so that bids put together are fungible and can be compared in the selection process. The implementation of the electricity balancing guideline should a priori address that point.

The activation rules/selection algorithm should be developed/validated by TSOs and approved by NRAs. The regulatory framework should allocate costs efficiently.

Generation adequacy

Motivations

Through interconnections, member states contribute to each other's generation and flexibility adequacy. Generation and flexibility adequacy therefore has a clear and strong European and regional dimension. That is why a strong level of coordination already exists amongst TSOs for performing the generation adequacy forecast[1)] and ENTSO-E has developed and significantly improved coordinated methodologies and cooperation in that field. These improvements may continue, for instance with the integration of a market module to reflect market participants' decisions on mothballs, closures and investments, and therefore to strengthen the robustness of forward-looking scenarios.

However, even if European-wide analyses are a good basis for adequacy assessment, they hardly capture local specificities (sensitivity to temperature, management of hydro systems, RES integration etc.), which vary depending on regions. There is generally – but not always – more homogeneity in neighbouring countries and within regions with regard to the key influential factors for generation adequacy and security of supply. A more detailed modelling can therefore be developed at the regional level, focusing on the impact of these factors and looking in detail at the cross-border contribution that a country might receive from its neighbours in the region. On the other hand, a detailed modelling at European level, considering all influential factors and key issues and constraints, would risk becoming too complex and fail to grasp the interactions that exist between neighbouring countries in such details.

Illustration of the complexity of EU-wide adequacy assessment

ENTSO-E must cover 34 countries at once, and develop every year the methodologies to analyse different aspects of security of supply.

Over the recent period, the level of granularity and complexity has increased significantly as demand for further analyses grows. For instance, the adequacy assessment is no longer based only on deterministic scenarios and timestamps, but ENTSO-E performs now a probabilistic adequacy assessment and computes indicators such as the loss of load expectation (LOLE), which requires Monte-Carlo simulations. More dynamic issues are also considered, such as ramping constraints or inertia.

Consequently, ENTSO-E must limit the investigation to 1 (max 2) scenario(s) per horizon. This is enough to illustrate that the methodologies are appropriate. However, for every member state, 2 or 3 variants of generation set assumptions should be investigated for every horizon (esp. assumptions on decommissioning), as well as recombination with those of neighbouring member states.

This is an example where regional investigations can and must complete the broad – but quite imprecise – picture established at European level.

1) See for instance ENTSO-E scenario outlook and adequacy forecasts and the 2016 mid-term adequacy forecast available at : https://www.entsoe.eu/publications/system-development-reports/adequacy-forecasts/Pages/default.aspx and https://www.entsoe.eu/outlooks/maf/Pages/default.aspx

Furthermore, as capacity mechanisms and other system adequacy mechanisms (SAMs) are being rolled out across the EU, the EC rightly insists on the need to strengthen regional coordination on these aspects – especially to have a more detailed adequacy assessment (a) to justify the need to intervene; and (b) to adequately consider the cross-border contribution of interconnections and capacities located in neighbouring countries. The adapted geographical scope to perform these more detailed analyses is probably the regional level, with ENTSO-E ensuring the consistency and the exchange of information between regions at EU level, for the reasons mentioned in the previous paragraph.

Possible additional services

As RSCs are developing a detailed knowledge of the power system at the regional level and will already be performing shorter term adequacy assessment (e. g. week-ahead), the elaboration of seasonal outlooks at least and possibly the assessment of generation adequacy in the medium term could be a "natural" prolongation of its activities. Thus, RSCs could perform generation adequacy analysis for TSOs at the regional levels, based on inputs from TSOs (evolutions of generation mix, including closures of plants and new build plants and RES scenarios, demand forecasts, grid developments). These regional analyses would specifically focus on the key regional issues (e. g. modelling of hydro power and impact of dry years, high penetration of intermittent RES, sensitivity of inputs and output to weather conditions such as temperatures and cold waves, etc.). The modelling of the system could integrate the aspects which are the most relevant at the regional levels and for which adequate data is available.[1)] It could thus go into more detail than that of ENTSO-E, whereas such detailed modelling at the European level would be too complex because of differences in modelling needs, computational issues or availability of data.

Also, given the changes in system needs, flexibility adequacy assessment could also be integrated in the analysis; not only RSCs would look at generation adequacy at peaks, but they would also look at a number of situations where the system might be at stress due to the lack of downward resources, of inertia sources, or of flexible capacity for instance.

Even though they might not be sufficient as such, these analyses could contribute to analyse the need (or not) to intervene and implement SAMs or for any other possible measures, especially in relation to network development. Additional and more detailed analyses at national level may be necessary, taking into account the regional study results. Policy makers, regulators and TSOs could use these analyses to identify problems and investigate possible solutions in a coordinated way, in the policy regions and at EU level.

More specifically, RSCs could also contribute to TSOs additional analyses to set up some of the parameters of possible system adequacy mechanisms, especially if they are implemented or coordinated at regional level, for example, the evaluation of the possible cross-border contribution at the borders, using detailed inputs and best estimations provided by concerned TSOs: thus, the quality of the data should improve compared to an analysis performed by a single TSO. The TSO (or the NRA or the member state, depending on how responsibilities are defined at the national level) would propose and/or decide on the parameters for the mechanism.

In case of a regional mechanism, the RSC could even make concrete proposals on coordinated technical parameters in order to help TSOs, NRAs and policy makers to set those parameters.

1) To illustrate the issue of data, for instance, in many countries, the impact of temperature on demand is not known in detail while it is a crucial input for countries with high penetration of electrical heating.

Prerequisites

As previously, RSCs should have developed adequate knowledge, experience and expertise (which differ, on certain aspects, to the needs for operational security) to support TSOs. They should have their own experts. They should have access to all necessary information and data, including all relevant scenarios for demand, generation and grid evolutions by concerned TSOs.

In addition, clear guidelines and methodologies should be defined for the RSCs.

Finally, with regard to SAMs, the possibility for the RSCs or TSOs to set parameters in a coordinated way will likely require sufficient cooperation between MSs with regard to SAMs' implementation and design, and possibly a certain degree of harmonisation, or even the agreement on a regional mechanism.[1)]

1) As an example of a political framework to guarantee security of supply, Germany and its eleven neighbours have signed the "Declaration for Regional Cooperation on Security of Electricity Supply in the Framework of the Internal Energy Market" on 8 June 2015. This declaration intends to consider energy security as a European issue, rather than a purely national one and sets out a first set of joint steps to be taken as part of the cooperation (so called "no regret" measures) by Austria, Belgium, the Czech Republic, Denmark, France, Germany, Luxembourg, the Netherlands, Norway, Poland, Sweden and Switzerland. This is, however, only a policy declaration, without a binding legal framework. Available at: http://www.bmwi-energiewende.de/EWD/Redaktion/EN/Newsletter/2015/05/Meldung/topthema-zeitenwende-versorgungssicherheit.html

Network planning

Possible additional services

Building upon the knowledge and expertise gained in operations by RSCs, RSCs could contribute to the process of investment planning for cross-border lines as well as internal lines with significant cross-border impact.

The TSOs (or other responsible bodies where relevant), who have responsibilities to perform network planning and liaise with other TSOs/parties for network investments, could benefit in some projects from a regional approach to their assessment, e. g. though the use of a consistent modelling approach and a richer set of information.

One possible area is where the RSCs could perform a cost-benefit analysis for specific regional projects, supporting proposals.

In addition, the RSCs could support TSOs to perform studies aimed at identifying specific investment needs with a regional perspective, e. g. providing further support to the TYNDP establishment. They could identify corridors of investments in different scenarios and even optimise the conception of projects at the regional level.

Prerequisites

As previously, RSCs should have developed adequate knowledge, experience and expertise (which differ, on certain aspects, to the needs for operational security) to support TSOs. They should have their own experts. They should have access to all necessary information and data, including all relevant scenarios for demand, generation and grid evolutions by concerned TSOs as well as on possible costs of projects. To perform such analyses, a strong coordination with TSOs would be required to integrate local needs and constraints.

If the approach becomes more top-down, the regulatory framework should ensure cost recovery and allocate costs efficiently. In particular, if a TSO has to invest in a project which provides net benefits at the regional/EU level, but no benefit for its grid users, its costs may be shared amongst TSOs, whose grid users actually benefit from the concerned investment. Obviously, such a principle needs to be implemented in a practical way.

In addition to the regional analysis, it has to be acknowledged that a Pan-European view on all grid investments is necessary. Therefore, in addition to close cooperation with the RSCs, the TSOs have to make assessments considering the whole synchronous system as well as the links to the other synchronous systems of the EU, in addition to outside the EU.

Adoption of a gradual and modular process for the implementation of ERC

Our proposal is to follow a gradual and step-by-step approach to improve regional coordination for system operations alongside the coordination of policies and regulations and the harmonisation of market design.

The proposals should be further investigated and fine-tuned on a case-by-case basis with relevant experts. If the benefits do not clearly outweigh the costs and drawbacks, cost-benefit analyses may need to be organised at the European or at the regional levels.

As explained in the previous subsections, these improvements are conditioned by a number of prerequisites, which depend (i) on the development of the capabilities of the RSCs and (ii) on the sufficient harmonisation and coordination of regulations and policies. This regulatory coordination is therefore crucial to enable further developments in system operation. Figure 20 presents this incremental approach, illustrating the need to satisfy some prerequisites before being able to implement new features or improvements.

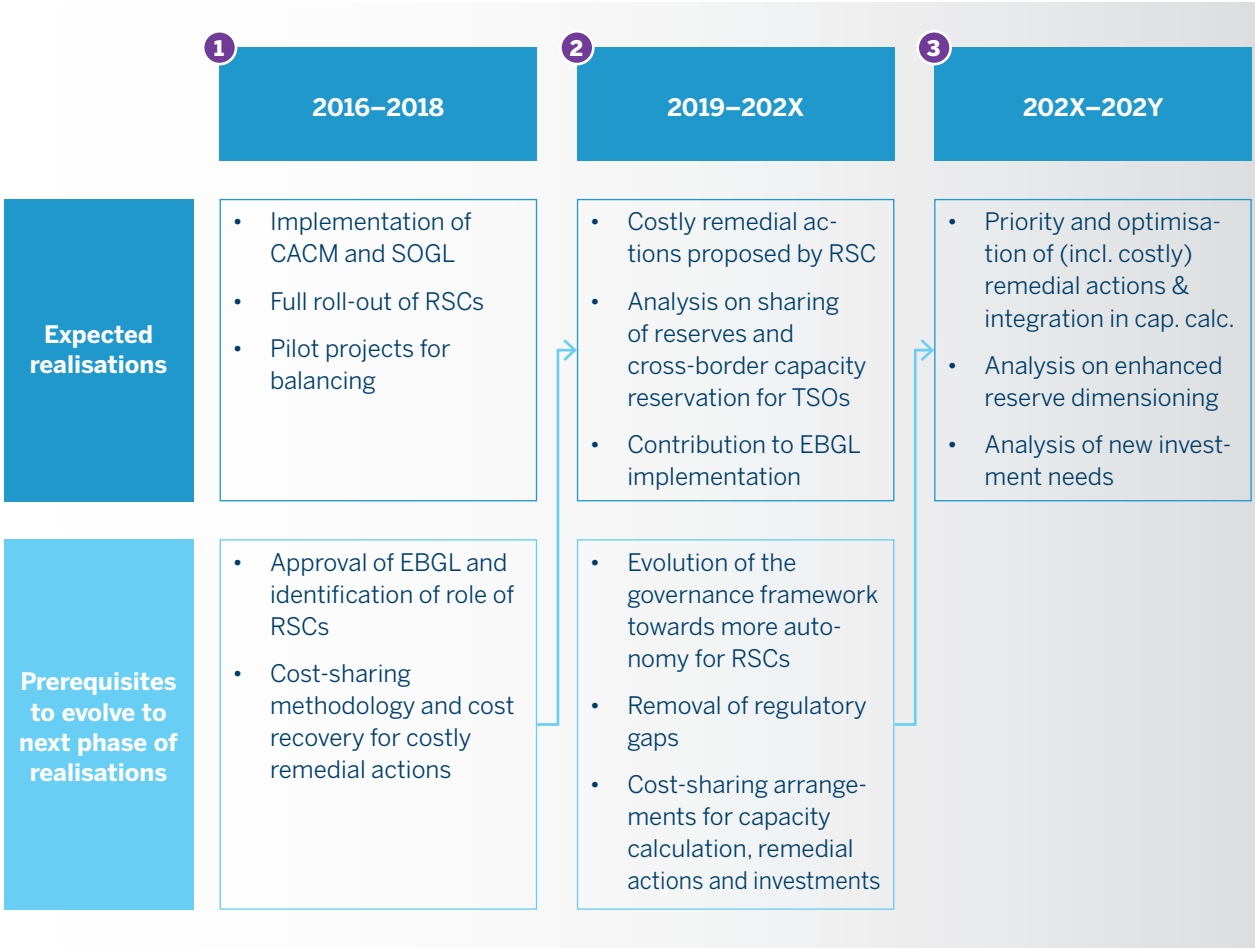


Figure 20: Incremental approach to improve regional coordination for power systems. Source FTI-CL Energy

Section 5

Conclusions

Reminder of the context

The transformation of the electricity industry and the implementation of the Internal Energy Market (IEM) are having a significant impact on the functioning of the European power system and more specifically on system operations.

To address these challenges, TSOs, who have a long history of cooperation, have voluntary coordinated their operational planning processes through Regional Security Coordination Initiatives in areas where this coordination was the most necessary. The system operation guideline now provides for the roll-out of Regional Security Coordinators throughout Europe. RSCs will provide five specific services to TSOs, in relation to operational security analysis and capacity calculation by 2018.

With the growing penetration of intermittent RES and the subsequent changes in the generation mix, market participants optimise their portfolio closer to real time and trade increasingly across borders. Consequently, increased and more volatile power flows leading to significant unscheduled (loop and transit) flows are becoming a problem for system operators and market trading in some parts of Europe.

Given the profound and rapid transformation of the electricity industry and of the IEM, the European Commission is considering the future of system operation, in order to foster cooperation at the regional level.

System operation is intrinsically linked with a wider set of policies, regulations, and governance issues. A range of alternative high level options for regional cooperation of TSOs have been brought forward, which would require radical changes to the current policy and regulatory framework. More specifically, a number of prerequisites to the implementation of further regional coordination have been identified:

- **The harmonisation or the coordination of policies and regulation are necessary steps to improve the overall functioning of the power market and to facilitate the tasks of TSOs and RSCs and allow them to further improve system operations.** In practice, some concerns are mostly due to remaining differences in regulations and market designs, or to the negative impact of certain public policies.
- **The existing synergies and dependencies in terms of decision-making for system operation should be preserved.** These synergies and dependencies guarantee that the close interrelation between TSO tasks is taken into account to maintain security of supply and optimise the operation and the development of the network.
- **A smooth and gradual implementation based on safe evolutionary migration** is necessary in order to allow regulatory and legal frameworks to adapt and TSOs and RSCs to establish a new organisation for system operations.

Departing from a scenario in which the coordination of regulations and policies is ensured, and once ongoing developments of RSCs are achieved, it might also be worth investigating further potential improvement of TSO coordination.

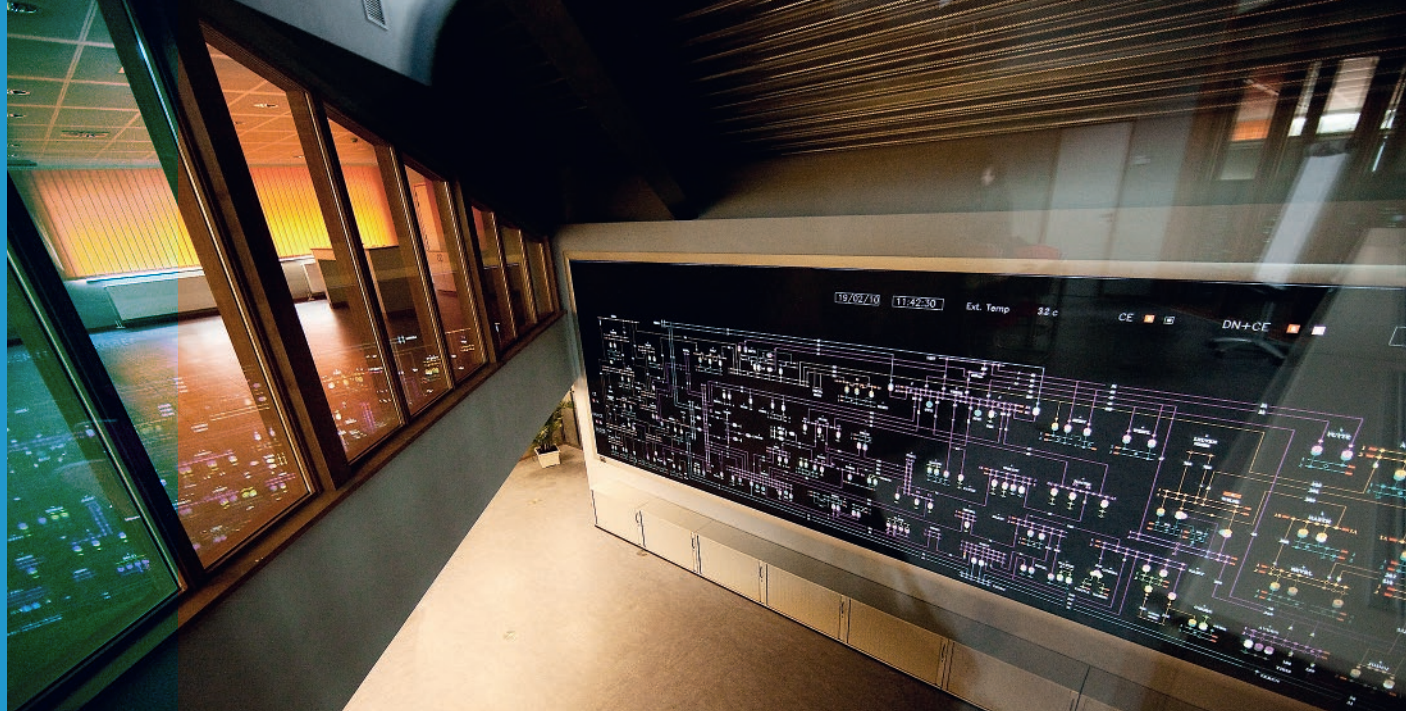
The analysis of high level options for regional coordination of TSOs shows that no options perform better than RSCs in addressing these challenges and concerns in a reasonable time frame. Indeed, the RSC model has the flexibility to evolve both in terms of roles performed but also in terms of the regulatory framework. Options with transfer of liability to entities others than TSOs would likely face acceptability concerns by member states and would induce such in-depth changes in the legal and regulatory frameworks that they could not be implemented in the medium term.

A new legal and regulatory framework would result in a major change in the organisation of operations across Europe, with impacts in terms of human resources, regulations, contractual arrangements with grid users etc., while a too strict separation of activities risks breaking synergies between TSOs' activities and dis-optimising the planning and operation of the power grid. To implement such changes, while maintaining a high level of security of supply, a long transition period would likely be required, during which operational risks may increase as the new responsible entities would face a steep learning curve to acquire the requisite expertise and ability to manage complexity, and would need to develop adequate procedures and IT systems, which TSOs have developed and upgraded continuously.

Our suggested ERC approach

ENTSO-E has therefore asked us to investigate options for the future of system operation that could be **a practical way forward in the medium term and would not require major changes in the institutional and regulatory framework**. We propose an incremental and modular approach, evolving the concept of RSCs. This approach is based on five key pillars:

- **A strong regional cooperation for policy and regulation.** Divergence and gaps in policies and regulations, as well as market design, are either (i) hurdles for further integration or (ii) causes of inefficiencies in operations or market functioning. Moreover, solving these issues is often a prerequisite for strengthening further coordination in system operation and for any form of operational coordination to be efficient.
- **RSCs as regional coordinators for system operation.** RSCs are the natural entities to perform coordinated tasks at regional level for the TSOs. They are gradually increasing their skills and expertise and becoming a trusted counterpart to TSOs for carrying out a sensitive security analysis and various other services.
- **A governance and decision-making process allowing RSCs to efficiently support their tasks pursuing system security and social welfare optimisation at the regional or European level.** The governance of RSCs should be improved to ensure their transparency and allow for an efficient monitoring of their activities by NRAs. Gradual improvements in the governance and evolutions in the scope of interventions could be useful to improve decision processes, create competence to perform trusted analyses and services, which would aim at system security, but also at regional optimisation and social welfare maximisation.
- **RSCs as the natural body to coordinate other services as regionally needed.** As their expertise and experience grow, RSCs will be able to extend their scope of services to TSOs to other tasks related to operational planning, and also to other activities for which coordination would provide added benefits.
- **A geographical modularity focused on efficiency gains.** Situations differ depending on the regions and their specificities. To account for these differences, some modularity could allow geographical differences to coexist efficiently and the extension of the scope of RSCs to certain regions/activities could be motivated by the quantification of costs and benefits.



To foster a stronger cooperation for policy and regulation, we support a concept of policy regions. **Within these policy regions, Member States, NRAs, TSOs, in cooperation with all relevant stakeholders, should build the convergence of policies and regulations and coordinate all the necessary decisions at national and regional levels to allow and facilitate the improvements of the regional cooperation of TSOs.** In particular, they would have to remove all regulatory barriers and agree on necessary methodologies or processes such as cost sharing, etc.

The approach we developed builds upon RSCs and fully integrates the challenge of policy and regulation coordination, while allowing for an incremental and modular, but ambitious, enhancement of regional coordination in SO activities. We consider that it scores well against the predefined criteria. The concept of Enhanced Regional Coordination (ERC) does not preclude any further evolution beyond 2030 towards other long-term solutions. Our proposed ERC approach is a no-regret solution, which is compatible with any option and which would in any case be a useful step, should one decide in the future to opt for one of these options.

In this concept, the allocation of responsibility is clear and the **TSOs remain fully responsible for operational security**. Thus, provided that coordination of regulations and policies is also improved, the proposed concept allows for RSCs to gradually enhance TSOs' coordination, to provide complementary analyses and to perform new coordinated tasks, but the allocation of responsibility and the governance ensure that the TSOs could perform analyses and remain in a position to prevent any action which could jeopardise operational security.

Moreover, considering economic efficiency and social welfare at the wider regional or European scope is the driver for this approach. The proposed framework for policy regions with effective regulatory coordination and the proposed framework for RSCs, with the evolution of governance and the decision-making process, specifically aim to foster more efficient decisions and limit national preferences at the detriment of regional optimisation. This ERC approach should therefore improve economic efficiency. Moreover, the extension of RSCs' scope of activity, motivated by Cost Benefit Analysis (CBAs) where relevant, also contributes to higher economic efficiency.

Our ERC approach does not require major changes in the institutional and regulatory framework as it is based on the approach set in the new regulation. However, its evolution intrinsically integrates the necessary evolutions in policies, regulations and market design.

ANNEXES

Annex A

Critical review of the proposal for Regional Centres for Before Real-Time operations

A report commissioned by the European Commission on the "Options for future European electricity model" was published in December 2015. Its apparent objective is to develop a target model for transmission system operations that would be implementable in 2020 and that would be able to meet the challenges that can be expected up to at least 2025.

This appendix summarises the approach as we understand it from the description in the study, and highlights open questions and potential issues raised by the approach.

Identification of the objectives pursued to design the coordination approach

The formal objective of the BRT-RC study is to develop a target model for transmission system operations in order to accommodate and deal with the changes in the European system. In particular, the study is supposed to identify and describe options for an alternative organisation of system operations and planning functions that are key for the effective, secure and cost-efficient operation of Europe's transmission networks.[1)]

While the study "focuses upon the options", it does not identify the underlying reasons of the need for those options. Furthermore, the formulation of the objectives is not quite clear and mixes the notions: the changes in the system are defined as something to accommodate with on the one hand and something to achieve on the other. The changes expected from the suggested options refer to the three main objectives of the EC energy policy:

- Sustainability and integration of RES,
- Competitiveness and market facilitation,
- Security of supply.

1) BRT-RC study, p.10.

Presentation of the BRT-RC model

The BRT-RC study proposes centralisation of TSO network planning functions by a pan-European body and centralisation of the System operations performed before real time through Regional operation centres (BRT-RCs), while keeping a national TSO focus on real-time operations.

Repartition of activities

The BRT-RC study delimits the activities and the responsibilities of the corresponding entities by the time-frames of the system planning:

- Long-term network planning which happens several years before delivery,
- System operation before real time which corresponds to a time-frame of several months before delivery but can be as close as the gate closure, and
- Real-time system operation which corresponds to the 15 minutes before delivery of electricity.

Long-term planning activities such as long-term scenario development, adequacy assessment and network development planning are expected to be centralised by a pan-European body like ENTSO-E. At the same time, the same functions are expected to be performed at the national level by TSOs. An iterative process between national and centralised level aims to optimise the system planning at the European level as is already the case with respect to the network scenario planning within the TYNDP.

Real-time system operation activities are also to be performed at both regional and national level. Whereas regional entities will correspond to an additional layer in charge of monitoring, coordination and alert, TSOs would in practice keep the original activities of manual and automatic real-time control and operational security monitoring.

Finally, the remaining activities are expected to be centralised at the regional level only. In particular, the activities explicitly defined to be centralised include balancing, capacity calculation, adequacy assessment, outage coordination, congestion management and remedial actions.

Governance and responsibilities

The BRT-RC study suggests that the regional entities would bear responsibilities comparable to those of TSOs. It is explicitly written that "centralisation means moving functions that are executed by national TSOs to a regional level, including the decision power related to those functions".[1] In particular, the full centralisation of the system operation before real time intends to transfer the authority to the ROCs. In practice, the definition of the limit between real-time and before real-time system operation suggests that the authority of ROCs stops and goes back to the TSO 15 minutes before the gate closure.

There is no clear governance mechanism assigned to this centralisation and transfer of decision-making power. The study stresses the need of updating the governance of the system operation in order to be in line with the new model.

1) BRT-RC study, p.5.

The potential governance model supposes three distinct bodies:

- European regulatory body which would have judicial power. This would correspond to the current ACER which would need to be given a stronger mandate and therefore this would imply shifting powers from the NRAs to ACER.
- European entity which would be responsible for the development and implementation of methods and tools and more generally for the framework of the tasks executed by regional centres. This would correspond to ENTSO-E acting in consultation with the regulatory body.
- Regional centres which would be responsible for the execution of tasks. This would correspond to the RSCs which would gain decision-making power. There is no clear indication as to how this would be implemented in practice.

In general, the governance model highlighted in the BRT-RC study is more of an alternative hypothetical suggestion than a clear framework, in particular with regards to the BRT-RCs.

Identification of open issues and challenges of the BRT-RC model

Open questions

The creation of BRT-RCs would raise the issue of the responsibility and liability for security of supply: TSOs would need a tighter control on BRT-RC actions if they continue to ultimately shoulder the responsibility of these actions. Governance of BRT-RCs is a key issue as decisions and actions by BRT-RCs might interfere with local actions.

The transfer of responsibility of system operations' key tasks raises fundamental legal, institutional and political questions which need to be addressed as a pre-requisite to the creation of BRT-RCs.

Besides legal challenges raised by the transfer of decision power to the regional level, regional coordination may be hindered by governance issues:

- In most if not all European countries, TSO is liable for the operation of the grid,
- Regional coordination with partial responsibilities will dilute the liability between the TSO and the regional entity.

Lack of justification of structuring proposals

Artificial boundaries between before real-time and real-time operations (15min before gate closure) ignore SO realities, synergies and interrelation. On the contrary, they raise questions on security and efficiency of the system operation.

These boundaries omit the synergies that exist between the different TSOs activities, and especially the "feed-back" loops between long-term, operational planning and real-time activities. Defining strategies for operational planning and security management requires inputs from both longer-term time-frames and real-time operations.

Therefore, BRT-RCs would not be able to act independently because they would need inputs from TSOs.

Furthermore, this discontinuity of activities may bring security issues. For instance, the security analysis would be entirely performed by the BRT-RCs, while the implementation of this analysis would be under the responsibility of the TSO. If the BRT-RC suggests a remedial action which is not optimal for the TSO, there would clearly be a conflict of interest which would moreover occur at a critical moment (too late for interaction between the TSO and the BRT-RCs).

Review of the ability of the approach to meet its objectives

The aim of the BRT-RC study is to define a model which would help with addressing a number of issues observed in the European system operation. Our understanding is that implementing BRT-RCs will not obviously allow for the addressing of those issues.

Implementing BRT-RCs will not help foster market integration at the European level. The main obstacle for the market integration is not the coordination among TSOs but the lack of coordination of national policies. For instance, coordinating and harmonising RES support policy such as adequacy standards, renewable connection rules, etc. and bespoke national systems would be more beneficial. It will probably not be implemented by BRT-RCs.

Moreover, infrastructure differences such as local network structures and system specificities are also sources of national differences to be tackled. BRT-RCs would not be in a position to implement this kind of harmonisation.

Finally, the harmonisation of legal and regulatory aspects might not happen in the most efficient way. Because it is a prerequisite for BRT-RCs implementation, the process of harmonisation would be accelerated. Implementing this in too much of a hurry might be less efficient than in a more pragmatic and gradual evolution which can take into account the dynamic nature of the power system.

Annex B

Results of interviews and questionnaire from TSOs on the BRT-RC proposal

We issued a questionnaire to each of the TSOs to understand each national System Operator's views with regards to the BRT-RCs and related issues. The questionnaire sought to obtain facts and opinions from each TSO on three key topics:

- Review the current system operation organisation by understanding how system operations are currently organised within each entity and establishing how key SO activities are performed;
- Understand the potential for regional cooperation in system operations by identifying what would be beneficial from each TSO's view regarding regional cooperation; and
- Assess the proposal of Regional Centres for Before Real-Time operations in the EC study by asking for opinions on the pros and cons of the BRT-RC proposal of the EC study vs. regional service provider concept currently pursued by ENTSO-E initiatives.

The core conclusions from the 19 documents received are summarised into four key categories below:

Operational issues

In order for BRT-RCs to complete its tasks as outlined in the draft model, the BRT-RCs would need to hold full local knowledge. This would obviously result in the duplication of many functions. For example, the communications to local generators. It would be likely that the BRT-RCs would need the transfer of expertise from the national TSOs into the regional centre.

It is not feasible to break the link between real time and long term planning because of more granular information discovery in real time. The information learnt from real-time operations is a key input into the longer term planning process. It is best if a single entity performs both roles.

Furthermore, a split by time period is unsuitable because it will lead to responsibility confusion. TSOs need to act before real time to secure supply. Instead, a better approach would be to split by function to avoid duplication and a lack of clarity over responsibility.

Accountability for Security of Supply

The entity with final decision rights must be the entity with liability for Security of Supply. Should the final decision rights be transferred to the regional level, the liability of Security of Supply should transfer from National to the regional entity. This transfer of risk is likely to be politically unacceptable for several EU countries.

Further, some TSOs expressed that Security of Supply accountability should be held by a single entity across the end to end process, from development to operation. This would provide transparency, efficiency and liability benefits to decision making.

The transition to BRT-RCs would therefore dilute security responsibility away from countries and across the process steps.

In addition, concerns were raised about how the BRT-RCs would trade off global against local constraints. For example, how should the BRT-RC select between actions that have a positive result for one nation and a negative result for another?

Regional synergies

Many TSOs questioned whether the BRT-RCs would deliver synergies. A small number did consider that synergies could be achieved but only if the BRT-RC had sufficient local knowledge, accountability for its actions and a common IT solution.

Some TSOs considered that the BRT-RCs would lead to a number of redundancies. In particular, redundancies in relation to load frequency control and restoration.

Using RSCs to deliver regional change

Several TSOs stated that the RSC would be better placed to deliver synergies by separating functions rather than a time based split. They considered the RSC approach to be more practical because it is already in the process of making small step-by-step transfer of specific functions.

The RSCs' current plans to deliver the "5 steps" were considered by the TSOs to be already challenging enough. There was therefore, no further need for legislation. Instead, better regional integration would be achieved by ensuring all RSCs and TSOs delivered a common high standard across EU in these areas first

In practical terms, the TSOs do not consider it feasible that the BRT-RCs could be operational by 2020. The BRT-RCs are yet to be well defined with significantly more detail required on implementation, responsibilities, and expertise. The current experience with RSCs reform suggests that it will take a considerable amount of time to implement.

Annex C

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