5. Who is responsible for balancing the system?

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In this chapter, we answer four questions. First, how to share responsibility between system operators? Second, how to incentivize market parties to be balanced? Third, how to ensure that reserves are available? And fourth, how to integrate balancing markets across borders?

5.1 HOW TO SHARE RESPONSIBILITY BETWEEN SYSTEM OPERATORS?

In this section, we first explain why primary, secondary and tertiary control have been renamed as the frequency containment, frequency restoration and reserve replacement processes. We then discuss in more detail how the balance responsibility between system operators is shared in each of these three processes. We also refer to a clock incident that illustrates the fragility of the shared responsibility.

5.1.1 Name Change

The ‘primary’, ‘secondary’ and ‘tertiary’ control terminology is included in all power system engineering handbooks. The various synchronous areas in Europe also applied this terminology, but they had their own detailed definitions which did not align. The five synchronous areas in Europe are Continental Europe (CE), the Nordics, the Baltics, Great Britain and Ireland.

We worked as consultants for the European Commission in 2006 and were involved in Babylonian discussions between experts from the Union for the Coordination of the Transmission of Electricity (UCTE) and the Nordic Cooperation of Electricity Utilities (NORDEL), the former bodies for cooperation between transmission system operators (TSOs) in CE and the Nordics respectively. We did not recommend the name change, but we understand why it became part of the solution. Table 5.1 introduces the new terminology and maps it onto the historical concepts of primary, secondary and tertiary control. In the remainder of this chapter, we use the new language of frequency containment, frequency restoration and reserve replacement introduced in 2017 in the System Operation Guideline (SO GL).

Following the Electricity Balancing Guideline (EB GL), also introduced in 2017, a limited number of standard balancing energy products were defined per balancing process. There is one standard automatic frequency restoration reserves (aFRR) product, two standard manual frequency restoration reserves (mFRR) products (direct and scheduled activation), and one standard replacement reserves (RR) product.¹ The Agency for the Cooperation of Energy Regulators (ACER) was in favour of limiting the number of standard balancing energy prod-

Table 5.1 Terminology for reserve products

	Frequency containment process	Frequency restoration process		Reserve replacement process
Operational reserves defined in the SO GL	Frequency containment reserves (FCR)	Automatic frequency restoration reserves (aFRR)	Manual frequency restoration reserves (mFRR)	Replacement reserves (RR)
UCTE	Primary control	Secondary control	Tertiary control	
NORDEL	Frequency-controlled reserves	Fast reserves		

Note: The mapping of names is indicative. Due to different operational practices a perfect one-on-one mapping is not possible.

ucts during the EB GL drafting process, while the European Network of Transmission System Operators for Electricity (ENTSO-E) proposal was to keep several products. The standardized products, however, include standardized and non-standardized characteristics. A standardized characteristic of a standard mFRR product is, for example, its full activation time and an example of a non-standardized characteristic is the minimum duration between deactivation and the following activation. Countries can also choose to introduce so-called specific balancing products, which are balancing services that can be used locally, to complement the standardized European products that will be exchanged across borders. To what extent countries will use specific balancing products and to what extent the non-standardized characteristics of the standard products will diverge is an open issue.

5.1.2 Frequency Containment and the Solidarity Mechanism

The frequency containment process is the first response to a frequency deviation when an imbalance occurs. In each of the synchronous areas in Europe, this first response is an automatic joint reaction by all the control areas in the synchronous area.

As is discussed in Box 5.1, frequency containment reserves (FCR) are dimensioned to handle a so-called reference incident. Traditionally, this was the loss of the largest generation unit. The probability that countries lost their largest unit at the same time was very low, so they benefited from pooling their FCR requirements into a solidarity mechanism. Each synchronous area already had a solidarity mechanism, and the SO GL formalized these mechanisms. Without such a mechanism, each TSO responsible for a control area would have to procure enough FCR to be able to handle the loss of its largest generator. For France, this would imply doubling or even tripling the procured volume of FCR. For a smaller control area like Belgium, it would imply increasing FCR procurement tenfold.

BOX 5.1 PRIMARY FREQUENCY CONTROL IN UCTE AND FREQUENCY-CONTROLLED RESERVES IN NORDEL

In UCTE, dimensioning primary control was based on a reference incident which defined the maximum instantaneous power deviation between generation and demand to be handled by primary control starting from undisturbed operation. This reference incident was defined as 3000 MW, as was the primary control reserve in both the positive and negative directions. This meant that a generation load imbalance of that size could be absorbed without frequency deviations exceeding 200 mHz. The capacity chosen corresponded to the simultaneous loss of two large units of around 1500 MW each. The provision of primary control was a joint action involving generating units and loads spread evenly across the interconnected network. The various countries' contributions to the total primary regulation reserve were determined on an annual basis and distributed in proportion to the share of the energy generated in one year in the entire synchronous area.

In NORDEL, frequency-controlled reserves were split into normal operation reserves and disturbance reserves. At least 600 MW of *normal operation reserves* needed to be available at all times. These reserves were to be fully activated if the frequency deviation from the nominal frequency exceeded 100 mHz. Contributions to the normal operation reserves of the subsystems in the synchronous system were determined based on the annual consumption in the previous year. The division was updated once a year. The volume and composition of the *disturbance reserves* were dimensioned in such a way that a dimensioning fault would not cause a frequency below 49.5 Hz in the synchronous system. The disturbance reserves were distributed among the countries in proportion to their respective dimensioning faults, for example the loss of a large generating station, and the division was updated once a week, or more often if necessary.

Note: Box 5.1 is based on NORDEL (2006) and UCTE (2009). The contribution of each country to the FCR solidarity mechanism can be found in Artelys (2017).

The definition of the reference incident is increasingly being questioned. Following the SO GL, the reference incident for CE was defined as 3000 MW, which is the same as the historical value shown in Box 5.1. The value is also the same for upward and downward FCR. In the decentralizing power system the biggest generation unit has not increased, but we increasingly have incidents involving new interactions between the smaller units, as will be shown in Chapter 6. Whether this will lead to the definition of a new reference incident is an open issue.

5.1.3 Frequency Restoration and Reactive Balancing

The frequency restoration process starts directly after the frequency containment process. This second response to a system imbalance is organized in so-called load frequency control (LFC) areas. The LFC area is generally equal to the TSOs' control area. Following the SO GL, TSOs can decide to jointly operate the frequency restoration process in an LFC block spanning more than one LFC area within a synchronous area. At the time of writing, most TSOs have not yet done this. The restoration of an imbalance is therefore typically done by the relevant TSO in the control area where the imbalance originates.

Frequency restoration reserves (FRR) are used to restore the frequency within a predefined time. First, automatic FRR (aFRR) and later manual FRR (mFRR) are activated to relieve FCR and aFRR respectively. aFRR are automatically activated by a controller operated by the TSO; mFRR are activated upon a specific manual request by the TSO.

Reactive balancing means that the TSO relies on market parties to balance themselves through intraday markets. The TSO does not try to anticipate imbalances by activating reserves before a frequency deviation takes place and the frequency containment and frequency restoration processes kick in. This means that the balancing price can spike in periods in which market parties have not managed to balance themselves in the intraday market. This typically implies that there is much activity in the intraday market and market parties are incentivized to help the system operator to balance the system. Most residual imbalances are handled with aFRR.

5.1.4 Reserve Replacement and Proactive Balancing

The reserve replacement process involves the slowest type of reserves, which can need 30 minutes to be fully activated. The TSOs that have replacement reserves (RR) often rely less on aFRR and apply a proactive balancing approach. They try to anticipate imbalances by activating RR before the frequency containment and restoration processes kick in.

Proponents of proactive balancing argue that it increases system security, which is especially important in more isolated and inflexible power systems. They also argue that the cost of balancing is reduced by using cheaper RR instead of the more expensive FRR. The counter-argument is that a proactive approach does not create enough incentives for market parties to be balanced and invest in assets that can help balance the system. We will come back to this later in this chapter, and also in Chapter 7 when we discuss the missing money problem.

The EB GL and the SO GL do not explicitly rule on proactive versus reactive balancing, but they implicitly favour reactive balancing. A key concept in the codes is the balancing energy gate closure time (GCT), which has been capped at one hour before real time in Europe. Following the codes, market parties can submit balancing energy bids up to the GCT, and TSOs cannot activate balancing energy bids prior to this GCT. This seems to limit TSOs to balancing proactively, but there are exceptions. Several countries have also started to make use of these exceptions to continue with proactive balancing. How this will evolve is very much an open issue.

5.1.5 The Clock Incident

The fragility of the shared balance responsibility between system operators in Europe surfaced in 2018. Many clocks depend on a stable frequency of 50 Hz to run correctly, but the average frequency had been 49.996 Hz for several weeks. Clocks accumulated a delay of about six minutes, which was the first time that electricity balancing reached the mainstream media.

ENTSO-E had to face the media to explain how a dispute in south-eastern Europe could cause clock delays in the whole European continent.² The dispute was between Serbia and Kosovo in the LFC block of Serbia, North Macedonia and Montenegro (SMM block). The system had been short, and had not been fully restored, with a total of 113 GWh missing.

The dispute lasted several weeks. After it was resolved the TSOs decided to catch up by maintaining a frequency of 50.01 Hz for some weeks. This corrected the delayed clocks, except those that had already been restored manually, which were now running several minutes ahead.

5.2 HOW TO INCENTIVIZE MARKET PARTIES TO BE BALANCED?

In this section, we explain balance responsible parties (BRPs) and the imbalance settlement.

5.2.1 Balance Responsible Parties

In principle all market parties have balance responsibility. They can take this responsibility themselves or delegate it to a third party. In what follows, we discuss exceptions and whether this responsibility applies at the unit or portfolio level.

First, exceptions to balance responsibility. Renewable energy projects have often been exempted from balance responsibility. They received feed-in tariffs so that they did not have to worry about wholesale market prices or balancing prices. They just injected whatever they could into the system and got paid for it. Forecasting was a problem for system operators, who had to handle forecasting errors. There were no incentives for these new entrants to help in that process. Following Regulation (EU) 2019/943, this is no longer possible. Only three types of grid users can still receive a derogation: demonstration projects for innovative technologies (limited in time); installations benefiting from support approved by the Commission under Union state aid rules (commissioned before 4 July 2019); and renewable generation with an installed electricity capacity of less than 400 kW (commissioned before 1 January 2026). For renewable generation commissioned after 1 January 2026, the derogation can only apply to installations with an installed electricity capacity of less than 200 kW.

Second, balance responsibility at the unit or portfolio level. The decentralized market model in Europe entails that balance responsibility is defined at the portfolio level, typically within a bidding zone. This gives market parties the possibility of deciding how to dispatch their power plants. Some countries require market parties to balance their generation and consumption portfolios separately, while other countries allow mixed portfolios. There are also exceptions. A few countries still have a more centralized market model, which is often combined with central dispatch and balancing responsibility at the unit level. Note that with smaller bidding zones (see the discussion in Chapter 3), the difference between portfolio bidding and unit bidding becomes smaller. Even if there is portfolio bidding, with nodal pricing a BRP is likely to only have a single unit or a very small portfolio in a certain node. If nodal pricing were only applied to the transmission network, the portfolio would become the resources connected to the distribution grid behind the transmission node.

5.2.2 Imbalance Settlement

In what follows we discuss the main design parameters in the imbalance settlement mechanism: the imbalance settlement period and dual as opposed to single pricing.

First, the imbalance settlement period (ISP). The ISP is the unit of time over which the imbalance of a BRP is calculated. The ISPs in Europe range from 15 minutes (e.g. in the Netherlands) to one hour (e.g. in Poland). This means that a BRP in Poland can be short in some quarters of an hour and long in other quarters of the same hour without paying balancing costs. In the Netherlands, the same BRP will face the costs for both imbalances. The more BRPs face the costs they cause, the more they are incentivized to be balanced. The balancing costs that cannot be allocated to BRPs are socialized by TSOs through their transmission network tariffs. The EB GL states that all EU countries shall apply an ISP of 15 minutes within three years of the entry into force of the regulation, although it leaves some room for exceptions. Regulation (EU) 2019/943 also states that the goal is a 15-minute ISP and adds that ISPs shall not exceed 30 minutes from 1 January 2025, with no exceptions.

Second, dual versus single pricing. Dual pricing implies that BRPs that are unbalanced in the direction of the system imbalance pay the costs of the balancing services that need to be activated, often plus a penalty. The argument for the penalty is that market parties that are unbalanced put the system in danger, so they need an extra incentive to avoid imbalances. Dual pricing also implies that BRPs that are unbalanced in the opposite direction to the system imbalance are not remunerated in the same way as the balancing services that are called upon by the system operator. For instance, if a BRP is helping the system operator to solve a shortage with its imbalance, its remuneration will be capped at the day-ahead price in wholesale markets. Single pricing means no penalties and the same remuneration for activated balancing services and BRPs that are unbalanced in the opposite direction to the system imbalance.

In our research we have long been advocating single pricing. Dual pricing is a legacy from the past in which balancing was a mechanism rather than a market. Dual pricing increases prices in wholesale markets because BRPs are incentivized to buy more than they need to reduce the risk of being short in balancing markets and facing penalties. BRPs will also keep reserves for themselves instead of offering them to the system operator. Dual pricing therefore favours larger players that have reserves over new entrants that rely on the balancing markets. We have also shown that dual pricing in one country can have negative consequences for a neighbouring country because it incentivizes BRPs to move their imbalances across the border to escape penalties.³

The EB GL clearly states that prices should reflect the real-time value of energy and favours single pricing over dual pricing. However, following the EB GL, dual pricing is possible as an exception. At the time of writing, some countries still use penalties, but their number has decreased. Note that in terms of the geographical dimension, the imbalance price or prices are calculated per imbalance price area. In this regard, Regulation (EU) 2019/943 states that each imbalance price area shall be equal to a bidding zone. An exception to this is the case of a central dispatching model, where an imbalance price area may constitute a part of a bidding zone.

5.3 HOW TO ENSURE THAT RESERVES ARE AVAILABLE?

In this section, we first discuss balancing capacity tenders, then balancing energy markets, and lastly the related issue of scarcity pricing in balancing markets.

5.3.1 Balancing Capacity Tenders

In this subsection, we first discuss whether TSOs can own balancing services, and then discuss how they tender for balancing capacity.

First, TSO ownership of balancing services. TSOs have in exceptional cases been allowed to own pumped hydro plants and batteries. However, this creates a conflict of interest between the TSO as the single buyer of balancing services and the TSO as one of the players in this market. Directive (EU) 2019/944 ruled out TSO ownership of energy storage assets, with possible derogations under specific circumstances. TSO ownership of generation assets has already been addressed with the unbundling process, which we referred to in Chapter 1.

Second, TSO tenders for balancing capacity. Market parties that offer balancing services are called balancing service providers (BSPs). They used to mainly be gas-fired power plants, which preferred longer-term contracts and could provide upward and downward services in one contract. This was nicely aligned with the interests of the system operators, who like simplicity and security. Renewable energy players can more easily provide downward than upward balancing services, and for aggregators of demand flexibility the opposite applies. Both prefer separate procurements for upward and downward balancing services. They also prefer tenders closer to real time, when they have a better idea of the services they can provide. Some even prefer to offer balancing energy bids without balancing capacity reservation. In some countries this was not possible; in other countries it was not appealing because whoever won a balancing capacity tender had to provide balancing energy bids at the low price agreed upon in the tender.⁴

To create a level playing field between incumbent and new players in balancing markets, many changes were needed. They increased the complexity of balancing markets but also improved their competitiveness and reduced the costs. This is an ongoing process. Regulation (EU) 2019/943 contains provisions to gradually move away from yearly and monthly contracts towards shorter-term day-ahead tenders. The EB GL states that the balancing energy price should not be predetermined in the balancing capacity contract for standardized products. This rule is reiterated in Regulation (EU) 2019/943. The EB GL also states that upward and downward balancing capacity should be procured separately for FRR and RR. A temporary exception to this rule can be requested. In Chapter 8, we will come back to the specific issues related to flexible generation, demand and storage resources connected to distribution grids and their participation in balancing markets.

5.3.2 Balancing Energy Markets

In what follows, we introduce the main balancing energy market controversies: merit-order activation versus pro-rata activation; and marginal pricing versus pay-as-bid pricing.

First, merit-order activation versus pro-rata activation. As discussed above, many TSOs relied on balancing capacity tenders to secure reserves. They did not always have a balancing energy market to procure aFRR, mFRR or RR closer to real time. The price at which they activated reserves was often agreed upon in a balancing capacity contract. The contracted reserves also contributed to solving an imbalance in proportion to their size without distinguishing between delivery costs, that is, pro-rata activation. Under pro-rata activation, efficient pricing and enabling competition for the provision of balancing energy is an issue. Therefore, the EB

GL prescribes the development of balancing energy markets with merit-order activation of balancing energy bids. Under merit-order activation, the cheapest balancing energy bids are selected one by one up to the required volume. As described in the previous subsection, balancing capacity tenders can still be used to make sure that there are enough balancing energy bids in the market, but not to set their price. Note that this applies to standardized balancing products, but not necessarily to specific products that might still be used at the national level.

Second, marginal pricing versus pay-as-bid pricing. The EB GL makes marginal pricing mandatory for standardized products. Pay-as-bid pricing is a legacy of pro-rata activation, which has been replaced by merit-order activation. However, if all TSOs identify inefficiencies in the application of marginal pricing, they may request an amendment and propose an alternative pricing method. Applying marginal pricing to balancing energy markets is not always straightforward.⁵ Several bids can be activated at different times within a certain settlement period, sometimes even in opposite directions. The EB GL did foresee the development of a methodology for the harmonized implementation of marginal pricing in balancing energy markets.

FCR is the exception. FCR continues to typically be a service that combines upward and downward balancing. These reserves receive as much energy as they give, so that only capacity needs to be remunerated. By its nature, the FCR product is indeed more about capacity than energy.

5.3.3 Scarcity Pricing in Balancing Markets

Here, we first introduce the ‘missing money’ problem related to balancing capacity tenders, and then discuss the scarcity pricing solution that has been proposed.⁶

First, the missing money problem. ACER and CEER’s market monitoring found that in most of Europe balancing capacity is remunerated more than balancing energy, and imbalance settlement prices only recover the balancing energy costs. This means that most balancing costs are socialized through transmission network tariffs. It also means that BRPs are not adequately incentivized to be balanced, and BSPs are not adequately incentivized to invest in flexible assets. We already mentioned that this is an issue when discussing proactive balancing. Balancing capacity tenders are an additional source of missing money in balancing markets.

Second, the solution. In Chapter 7 we will show that capacity mechanisms have been proposed as a solution to compensate investors for the missing money problem. Another solution is to reform balancing markets so that there is no missing money. The reform is referred to as operating reserve demand curves (ORDC). It was proposed by academics and tested for the first time in Texas in 2014. In Europe, the GB regulator Ofgem has applied a similar concept, and the Belgian regulator CREG has started looking into it. The idea is to include an uplift in the imbalance settlement pricing mechanism. When the system is short of reserves, the uplift can increase to a very high value that represents the willingness of customers to avoid being cut off from the system. When there are enough reserves in the system, the uplift goes to zero. Note that the penalties we discussed in the previous section were also a kind of uplift. However, they often disregarded system conditions and were designed to punish BRPs for imbalances rather than to correct the scarcity price signal in balancing markets. The penalties were also often combined with asymmetric incentives to BRPs and BSPs, while the uplift in the ORDC approach applies symmetrically to BRPs and BSPs. The EB GL mentions that an

additional settlement mechanism may be developed to allocate the costs of balancing capacity. To what extent this will be done is an open issue.

5.4 HOW TO INTEGRATE BALANCING MARKETS ACROSS BORDERS?

In this section, we first recall why the integration of balancing markets was started. We then discuss the ongoing integration of balancing markets with imbalance netting, the exchange of balancing energy, the exchange of balancing capacity and sharing of reserves. We end with open issues in congestion management in balancing markets.

5.4.1 Why Was the Integration of Balancing Markets Started?

In the previous section, we discussed how ongoing changes to national balancing markets are helping to bring new players into these markets. In this section, we discuss how the integration of balancing markets across national borders is also helping to reduce balancing costs.

In Chapter 2 we referred to the Sector Inquiry published in 2007. We also discussed how this inquiry helped to accelerate the integration of wholesale markets across borders. Table 5.2 shows why it did the same for balancing markets by revealing the alarming level of concentration in national balancing markets between 2003 and 2005. Even countries that had relatively well-functioning wholesale markets had problematic balancing markets. At the time of the inquiry, TSO unbundling was also limited. The concern was therefore that TSOs were not motivated enough to change the situation because they were in some cases part of the same holding company as the generators profiting from the situation.

The integration process for balancing started after the wholesale process, but it proceeded faster. The Nordics were the first to create a cross-border balancing market in Europe. Other European TSOs followed with several pilots, and the ambition increased further during the drafting process of the EB GL. The drafts referred to coordinated balancing areas (CoBAs). They were going to be regional initiatives that would be slowly merged over time, like the process that had been followed for wholesale markets as described in Chapter 2. ENTSO-E was also proposing a minimalistic approach to balancing market harmonization. ACER argued for harmonized products and integration through European platforms instead of CoBAs, and the final version of the EB GL leans towards ACER's view. Earlier in this chapter, we showed that we have standardized products. In what follows, we introduce the European platforms.⁷

5.4.2 Imbalance Netting

As discussed earlier in this chapter, the first response to a frequency deviation is a shared responsibility (i.e. frequency containment), but the second response (i.e. frequency restoration) is generally the responsibility of the TSO from the control area that caused the frequency deviation. This implies that one TSO might have a positive imbalance to solve while a neighbouring TSO has a negative imbalance at the same time. Until recently, both TSOs would then activate balancing services: one would balance upwards; the other downwards. Imbalance netting simply means they stop doing this and only take action to solve the net imbalance. The TSO with the residual net imbalance then still has to activate balancing services, but it

Table 5.2 Market shares of the largest BSP for FRR between 2003 and 2005

UK	≈19%	DK	≈88%
NL	≈39%	FR	≈91%
ES	≈44%	DE	≈93%
CZ	≈53%	AT	≈100%
IT	≈78%	HU	≈100%
SI	≈86%		

Source: Author's own table based on a graph from the Sector Inquiry (European Commission 2007).

is cheaper than solving the gross imbalance. The other TSO does not have to do anything. Of course, netting can only take place if there is enough transmission capacity available to accommodate the associated flows.

In our research, we found that the potential for Belgium and the Netherlands was significant. The International Grid Control Cooperation (IGCC) project confirmed the benefits. The IGCC is an initiative by the four German TSOs that grew into the biggest balancing pilot for imbalance netting. More specifically, the IGCC avoids the activation of aFRR in opposite directions on different sides of a border in the case that there is interconnector capacity available in the right direction. Between 2012 and 2019, the accumulated benefit from this pilot was €475 million. And this with a cost of only €20 million for setting up the platform and an annual cost of €1 million to run it. There were also smaller pilots running in parallel that confirmed the potential of imbalance netting prior to the EB GL. However, it was later agreed that the IGCC would be used as the starting point for the implementation of a European platform for imbalance netting according to the EB GL. In January 2020, the IGCC was operational in 11 countries (13 TSOs). The initiative is quickly expanding as the EB GL mandates that the platform shall be used to perform the imbalance netting process for at least the CE synchronous area. The EB GL mandates that the platform shall be used to perform the imbalance netting process for at least the CE synchronous area. It is foreseen that TSOs in synchronous areas other than CE performing the automatic frequency restoration process (aFRP) may decide to become member TSOs of the European platform at a later point in time. Netting strongly reduces the need for balancing. As an illustration, in 2017, imbalance netting reduced Latvia's need for aFRR balancing energy by 55 per cent and the Netherlands' need by 83 per cent.⁸

5.4.3 Exchange of Balancing Energy

The Nordics TSOs have been exchanging balancing energy for mFRR since 2002. More recently, balancing pilots have also been set up by the other TSOs. The main aFRR pilot was called EXPLORE (European X-border Project for LOng-term Real-time balancing Electricity market design), and the RR pilot was called TERRE (Trans-European Restoration Reserves Exchange).

Positive experience with these pilots inspired the EB GL drafters to set up European platforms for the exchange of aFRR, mFRR and RR. The EB GL did foresee the development of detailed implementation frameworks for each of these platforms, and TSOs have already started with their establishment. The aFRR platform is called PICASSO (Platform for the International Coordination of Automated Frequency Restoration and Stable System

Operation). It was initiated in July 2017 and involved 16 TSOs (plus 10 observers) by the end of 2019. PICASSO builds further on the work done in the EXPLORE regional project. The mFRR platform is called MARI (Manually Activated Reserves Initiative). The RR platform is called TERRE, which is the same name as the balancing pilot it is based on. TERRE is the only balancing platform that has been launched as of January 2020. At that time, 8 TSOs (plus 6 TSO observers and ENTSO-E) were involved. In January 2020, ACER also adopted decisions regarding the implementation frameworks for the other platforms.

Note that BSPs will continue to submit their balancing energy bids to the TSO of their control area. The TSOs will then submit the bids to the European platforms. This way of working is referred to as the TSO–TSO model. The EB GL states that this is the model for exchanging balancing bids, with possible exceptions where two or more TSOs on their initiative or on request by their relevant regulatory authorities develop a proposal for the application of a TSO–BSP model. The alternative TSO–BSP model means that BSPs can submit their bids to another TSO without passing through their own TSO. This then assumes that the BSPs can purchase and use transmission rights for this purpose. The EB GL only allows alternative proposals applying a TSO–BSP model as temporary solutions, except for certain circumstances related to TSOs operating the replacement reserves process.

5.4.4 Exchange of Balancing Capacity and Sharing of Reserves

The EB GL requires each TSO to publish a balancing report at least every two years. In this report the TSO is asked to analyse the potential for exchange of balancing capacity and sharing of reserves and to put forward explanations and justifications for the procurement of balancing capacity without the exchange of balancing capacity or sharing of reserves. This means that much more information will be available, but the initiatives remain voluntary.

The exception is sharing of reserves for FCR, which is mandatory and already exists for FCR, as was shown in Section 5.1.2. This implies that countries decide together the total amount of FCR to procure and how to share the responsibility between them. In fulfilling this responsibility, they can procure FCR locally or they can decide to exchange balancing capacity across borders. A balancing pilot was set up between the Austrian TSO and the Swiss TSO to exchange FCR capacity in 2013. This pilot was successful and currently the Belgian, Danish, Dutch, French and German TSOs are also part of the FCR cooperation project. In 2019, the project was formalized according to the EB GL.

Note that the SO GL required all the TSOs in a synchronous area to jointly develop a proposal regarding the determination of LFC blocks. In many cases, the LFC block equals the LFC area, which is equal to the control area. Exceptions are the Nordics, Ireland and Great Britain, where the LFC block equals the synchronous area. Germany, Luxembourg and West Denmark are also exceptions. They form an LFC block consisting of several LFC areas. The same applies to Slovenia, Croatia, and Bosnia and Herzegovina and to Serbia, North Macedonia and Montenegro. For these exceptions, the SO GL states that FRR has to be dimensioned per LFC block. The TSOs involved then have to agree on the volume to reserve, the ratio between aFRR and mFRR, and the sharing of responsibility. The SO GL also sets out rules for dimensioning and sharing of RR for LFC blocks in which all the TSOs make use of RR. These rules are similar to those for FCR, which apply to all TSOs. Following Regulation (EU) 2019/943, regional coordination centres (RCCs) will facilitate regional dimensioning

and the procurement of balancing capacity. RCCs were briefly introduced in Chapter 3 and will be discussed in more depth in Chapter 6.

5.4.5 Congestion Management in Balancing Markets

There are three open issues in congestion management in balancing markets: reserving available transmission capacity for balancing markets; filtering balancing bids; and the interaction with redispatching or flexibility markets.

First, the reservation of available transmission capacity for balancing markets. The EB GL requires all TSOs to use available cross-zonal capacity after the cross-zonal intraday gate closure for operating the imbalance netting process or for the exchange of balancing energy. The EB GL also foresees the possibility of reserving available transmission capacity for the exchange of balancing capacity or sharing of reserves for FRR and RR. Nothing is specified regarding imbalance netting or the exchange of balancing energy. Note that available transmission capacity is already reserved for FCR. The so-called reliability margin on transmission lines is to account for FCR. To what extent it is opportune to do additional reservation is very much an open issue.

Second, filtering balancing bids. The SO GL foresees distribution system operators (DSOs) being able to filter balancing bids from BSPs connected to distribution grids. If they fear that certain bids may cause congestion when called upon by TSOs, they can disqualify them. Whether this will result in penalties being paid to the TSO by the BSP and/or paid to the BSP or the TSO by the DSO is an open issue. The SO GL also allows TSOs to filter bids. They do not have to forward all the BSPs' bids to the European platforms. If they fear that certain bids may cause congestion when called upon by neighbouring TSOs, they can also disqualify these bids. Filtering balancing bids is a new issue that has emerged in the ongoing balancing market integration process.

Third, the interaction between balancing markets and redispatching or flexibility markets. Redispatching actions by TSOs were covered in Chapter 3. They imply that fewer resources are available for balancing. Redispatching can be done by activating an upwards balancing bid in one location and a downwards balancing bid in another location. It can also be done by countertrading in the intraday markets. The TSO then procures energy in the intraday market in one location to sell the same amount in another location. Some TSOs also procure redispatching resources in a separate market, possibly in cooperation with DSOs, which have also started to use flexibility to manage congestion in their grids. How congestion management in balancing markets, redispatching markets and flexibility markets will evolve is very much an open issue. We will come back to the topic of TSO–DSO coordination in balancing and congestion management in Chapter 8.⁹

5.5 CONCLUSION

In this fifth chapter on who is responsible for balancing the system, we have answered four questions.

First, how to share responsibility between system operators? The first response to a frequency deviation in Europe is referred to as the frequency containment process with frequency containment reserves. This first response is also a joint response with a solidarity mechanism

in each synchronous zone. The second response is referred to as the frequency restoration process with automatic and manual frequency restoration reserves. This second response is typically per control area and performed by the TSOs in the zone with the imbalance that caused the frequency deviation. TSOs can also choose to share this responsibility by organizing themselves in so-called load frequency control areas and blocks that are bigger than one control area. TSOs can anticipate frequency deviations and resolve imbalances before they occur by activating RR, which is referred to as proactive balancing, as opposed to reactive balancing. The EB GL default is reactive balancing, but proactive balancing is still possible.

Second, how to incentivize market parties to be balanced? All market players either take on the balance responsible party role or delegate this responsibility to a third party. Renewable energy players can no longer avoid this responsibility. The only exceptions are for very small-scale and/or innovation demonstration projects. The imbalance settlement is becoming more cost-reflective with single pricing instead of dual pricing, and with smaller imbalance settlement periods.

Third, how to ensure that reserves are available? Many changes had to be made to balancing markets to create a level playing field between the traditional balancing service providers and new players. Balancing energy markets are becoming more important. At least for standard energy balancing products, these markets will apply marginal pricing and the bids will be activated following a merit order. Shorter-term balancing capacity tenders can continue. To avoid the missing money problem, the costs of these tenders can be included in a scarcity price signal through an uplift on top of the balancing energy price in periods when the system is short of reserves.

Fourth, how to integrate balancing markets across borders? Imbalance netting has proven to be very beneficial and relatively easy to implement. In line with the EB GL, TSOs have started to set up European platforms to exchange balancing energy. Their names are PICASSO (aFRR), MARI (mFRR) and TERRE (RR). Congestion management in balancing markets is also an open issue. This includes reserving available transmission capacity for balancing, filtering of balancing bids and the interaction between balancing markets and redispatching and flexibility markets.

NOTES

1. There is no standard FCR balancing energy product. FCR is paid for reserved capacity rather than activated volume.
2. More details can be found in the ENTSO-E press releases (2018a, 2018b, 2018c).
3. Saguan and Glachant (2007) were pioneers in the study of balancing market design, the negative impact of dual pricing in balancing markets on wholesale prices and the willingness of balancing service providers (BSPs) to pool reserves. In Vandezande et al. (2010) we elaborate on the negative impact of dual pricing with penalties. We argue that the impact is not only discriminatory to new entrant renewable energy players but also counterproductive in terms of the security of the system. In Vandezande et al. (2009a) we illustrate how traders can exploit differences in the imbalance settlement mechanisms of neighbouring countries. ENTSO-E (2019c) is an example of the annual balancing market survey that is conducted by TSOs and includes the penalties that are applied in countries that apply dual pricing.
4. De Vos et al. (2019) present a method for the dimensioning of operating reserves on a daily basis. They show that this dynamic dimensioning approach makes a positive business case for the Belgian system in 2020 as opposed to a static approach in which the capacity required is determined once

- a year. Based on the results of this study, Belgium decided on a gradual implementation towards 2020 of daily procurement of mFRR according to estimations of daily needs.
5. Littlechild (2007, 2015) provides a detailed discussion on the pricing rule for balancing energy. He favours marginal pricing but also recognizes that some characteristics of the balancing energy market make it more difficult to apply this rule in certain situations.
 6. ACER first highlighted this issue in Figure 24 of its 2015 market monitoring report (ACER and CEER 2016). Since 2017 (ACER and CEER 2018, 2019), the share of balancing costs recovered through imbalance settlement has been left out of the report so it is difficult to know how it has evolved. The academic who came up with the operating reserve demand curve (ORDC) concept is William W. Hogan (Hogan 2005, 2013). Papavasiliou and Smeers (2017) study how an ORDC adder would perform in Belgium. An evaluation of the implementation of scarcity pricing in GB can be found in Ofgem (2018).
 7. ENTSO-E (2019a) provides an overview of the nine balancing pilot projects in Europe. ENTSO-E (2014) included the concept of CoBAs in version 3.0 of the EB GL, which was published in 2014. Pentalateral Energy Forum (2016) includes the difference between the views of ACER and ENTSO-E on the level of harmonization required in balancing markets to enable integration during the EB GL drafting process.
 8. In Vandezande et al. (2009b) we calculate the potential for netting between Belgium and the Netherlands using historical imbalance data, balancing prices and available transmission capacity. The quarterly benefits of the IGCC are available in ENTSO-E (2019b), the costs related to the IGCC in Artelys et al. (2016) and the data on Latvia and the Netherlands in ACER and CEER (2018).
 9. The balancing survey in ENTSO-E (2019c) shows that in 2018 mFRR was also used for congestion management in Great Britain and the Nordics. Balancing bids cannot be used for redispatch in the Netherlands and Germany.

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5A.1 ANNEX: REGULATORY GUIDE

Table 5A.1 Regulatory guide

Section of this chapter, topic and relevant regulation	Relevant articles
Section 5.1.1	
<p>The SO GL introduces new names for old concepts: frequency containment, frequency restoration, and reserve replacement.</p> <p>There is one standard automatic frequency restoration reserves product (aFRR), two standard manual frequency restoration reserves (mFRR) products (direct and scheduled activation) and one standard replacement reserves (RR) product.</p>	<p>Art. 2(6–8) provides definitions of the terms ‘frequency containment reserves,’ ‘frequency restoration reserves’ and ‘replacement reserves’.</p> <p>According to the EB GL, implementation frameworks have to be proposed by all TSOs for the European aFRR, mFRR and RR balancing platforms (Arts. 21, 20, 19). One element in these implementation frameworks is proposed standard products (Art. 21(3.i), Art. 20(3.i), Art. 19(3.i)). Only the implementation framework for RR has been approved by the relevant NRAs so far – in December 2018 (All TSOs using RR 2018). This framework specifies that there is one standard RR product. The proposals for the implementation frameworks for aFRR and mFRR were referred to ACER in July 2019. In these proposals, All TSOs (2018a, 2018b) propose one standard product for aFRR and two for mFRR. The mFRR standard products differ in their activation mode, namely direct and scheduled activation. The mFRR implementation framework proposals provide for balancing energy bids to be submitted either only for scheduled activation or for scheduled and direct activation in one common merit-order list. The mFRR implementation framework defines a scheduled activatable bid in Art. 2(2.x) as ‘<i>a standard mFRR balancing energy product bid that can only be activated at one specific point in time, i.e. the point of scheduled activation, with respect to the period of time for which the balancing energy bid is submitted.</i>’ A direct activatable bid is defined in Art. 2(2.e) of the same proposal as ‘<i>a standard mFRR balancing energy product bid that can be activated at any point of time following the point of scheduled activation of the quarter hour for which the bid is submitted and until the point of scheduled activation of the subsequent quarter hour. Every direct activatable bid is a scheduled activatable bid as well, while no scheduled activatable bid is a direct activatable bid.</i>’</p>
<p>According to the EB GL, the standardized products include standardized and non-standardized characteristics.</p>	<p>The standardized and non-standardized characteristics can be found in the implementation frameworks for the respective balancing processes (Arts. 21, 20, 19). The standardized characteristics of a product are defined in the implementation frameworks. The non-standardized characteristics are defined in the terms and conditions for balance service providers (BSPs), which are defined by each TSO individually (Art. 18(1.a)).</p>

Section of this chapter, topic and relevant regulation	Relevant articles
According to the EB GL, countries can also choose to introduce so-called specific balancing products, which are balancing services that can be used locally, to complement the standardized European products that will be exchanged across borders.	Requirements for specific products are described in Art. 26. Art. 26(1.b and f) states that a TSO proposing a specific product has to demonstrate that standard products are not sufficient to ensure operational security and that the specific product does not create significant inefficiencies and distortions in the balancing market. Art. 26(3) states that <i>‘the specific products shall be implemented in parallel to the implementation of the standard products. Following the use of the specific products, the connecting TSO may alternatively: (a) convert the balancing energy bids from specific products into balancing energy bids from standard products; (b) activate the balancing energy bids from specific products locally without exchanging them.’</i> Art. 6(14) of Regulation (EU) 2019/943 reiterates these requirements for specific products.
Section 5.1.2	
Each synchronous area already had a solidarity mechanism and the SO GL formalized these mechanisms.	Art. 153 describes the FCR dimensioning rules. Art. 153(1) states that <i>‘All TSOs of each synchronous area shall determine, at least annually, the reserve capacity for FCR required for the synchronous area ...’</i>
Following the SO GL, the reference incident for CE is defined as 3000 MW. The value is the same for upward and downward FCR.	Art. 153(2.b.i) states that <i>‘All TSOs of each synchronous area shall specify dimensioning rules in the synchronous area operational agreement in accordance with the following criteria: ... (b) the size of the reference incident shall be determined in accordance with the following conditions: (i) for the CE synchronous area, the reference incident shall be 3000 MW in positive direction and 3000 MW in negative direction.’</i> Art. 153(2.c) adds that <i>‘for the CE and Nordic synchronous areas, all TSOs of the synchronous area shall have the right to define a probabilistic dimensioning approach for FCR taking into account the pattern of load, generation and inertia, including synthetic inertia as well as the available means to deploy minimum inertia in real-time ... with the aim of reducing the probability of insufficient FCR to below or equal to once in 20 years.’</i>
Section 5.1.3	
According to the SO GL, the frequency restoration process (FRP) is organized in so-called load frequency control (LFC) areas.	Art. 141(4) states that <i>‘All TSOs of each LFC area shall ... (b) implement and operate a FRP for the LFC area.’</i>
Following the SO GL, TSOs can decide to jointly operate the frequency restoration process (FRP) in an LFC block spanning more than one control area in a synchronous area.	Art. 145(6) states that <i>‘In addition to the aFRP implementation in the LFC areas, all TSOs of an LFC block which consists of more than one LFC area shall have the right to appoint one TSO of the LFC block in the LFC block operational agreement to: (a) calculate and monitor the FRCE of the whole LFC block; and (b) take the FRCE of the whole LFC block into account for the calculation of the setpoint value for aFRR activation in accordance with Article 143(3) in addition to the FRCE of its LFC area.’</i> In addition, an LFC area can consist of more than one control area. If the LFC area is defined over multiple control areas, TSOs can also jointly operate the FRP. An LFC area is defined in the SO GL Art. 3(12) as <i>‘a part of a synchronous area or an entire synchronous area, physically demarcated by points of measurement at interconnectors to other LFC areas, operated by one or more TSOs fulfilling the obligations of load-frequency control.’</i>

Section of this chapter, topic and relevant regulation	Relevant articles
Following the SO GL, frequency restoration reserves (FRR) are used to restore the frequency within a predefined time.	Art. 143(1.a) states that ‘ <i>The control target of the FRP shall be to: (a) regulate the Frequency Restoration Control Error (FRCE) towards zero within the time to restore frequency.</i> ’ The FRCE is defined in Art. 3(43) as ‘ <i>the control error for the FRP which is equal to the area control error of a LFC area or equal to the frequency deviation where the LFC area geographically corresponds to the synchronous area.</i> ’ Table 1 in Annex III of the SO GL indicates that the time to restore frequency is 15 minutes for each synchronous area, except for the Baltic synchronous area, for which no information is listed.
Section 5.1.4	
The replacement reserves process involves the slowest type of reserves, which can need 30 minutes to be fully activated.	The approved implementation framework for the exchange of balancing energy from replacement reserves states that the full activation time of the RR standard product is 30 minutes. Art. 3(30) defines the full activation time as ‘ <i>the period between the activation request by the connecting TSO in case of TSO–TSO model or by the contracting TSO in case of TSO–BSP model and the corresponding full delivery of the concerned product.</i> ’
The EB GL and the SO GL do not explicitly rule on proactive versus reactive balancing, but they implicitly favour reactive balancing. The balancing energy gate closure time is capped at one hour before real time in Europe. Market parties can submit balancing energy bids up to the GCT, and TSOs cannot activate balancing energy bids prior to this GCT. This seems to limit TSOs to balancing proactively, but there are exceptions.	There are several articles of importance with respect to this matter. Most importantly, Art. 29(2–3) of the EB GL states that ‘ <i>2. TSOs shall not activate balancing energy bids before the corresponding balancing energy gate closure time, except in the alert state or the emergency state when such activations help alleviate the severity of these system states and except when the bids serve purposes other than balancing pursuant to paragraph 3. 3. By one year after the entry into force of this Regulation, all TSOs shall develop a proposal for a methodology for classifying the activation purposes of balancing energy bids. This methodology shall: (a) describe all possible purposes for the activation of balancing energy bids; (b) define classification criteria for each possible activation purpose.</i> ’ Regarding the balancing energy gate closure time, two articles imply that the balancing energy GCT for standard products will be at most one hour before real time. First, with regard to the balancing energy GCT for standard products, Art. 24(1–2) of the EB GL states: ‘ <i>1. As part of the proposals [for the European platforms for the exchange of balancing energy], all TSOs shall harmonize the balancing energy gate closure time for standard products at the Union level, at least for each of the following processes: [RR, mFRR, aFRR] 2. Balancing energy gate closure times shall: (a) be as close as possible to real time; (b) not be before the intraday cross-zonal gate closure time; (c) ensure sufficient time for the necessary balancing processes.</i> ’ Second, Art. 59(3) of the CACM GL concerning the intraday cross-zonal GCT states that ‘ <i>One intraday cross-zonal gate closure time shall be established for each market time unit for a given bidding zone border. It shall be at most one hour before the start of the relevant market time unit and shall take into account the relevant balancing processes in relation to operational security.</i> ’ Note that the balancing gate closure time is only capped at one hour for standard products of all reserve types. The timing of the gate closure for specific products is not explicitly restricted.

Section of this chapter, topic and relevant regulation	Relevant articles
Section 5.2.1	
Following Regulation (EU) 2019/943, all market participants are balance responsible with the exception of three types of grid users which can still receive a derogation.	Art. 5(1) of Regulation (EU) 2019/943 states that ‘ <i>All market participants shall be responsible for the imbalances they cause in the system (“balance responsibility”).</i> ’ Art. 5(2) states that ‘ <i>Member States may provide derogations from balance responsibility only for: (a) demonstration projects for innovative technologies, subject to approval by the regulatory authority, provided that those derogations are limited to the time and extent necessary for achieving the demonstration purposes; (b) power-generating facilities using renewable energy sources with an installed electricity capacity of less than 400 kW; (c) installations benefitting from support approved by the Commission under Union State Aid rules pursuant to Articles 107, 108 and 109 TFEU, and commissioned before 4 July 2019.</i> ’ Art. 5(4) states that ‘ <i>For power-generating facilities commissioned from 1 January 2026, point (b) of paragraph 2 shall apply only to generating installations using renewable energy sources with an installed electricity capacity of less than 200 kW.</i> ’
The decentralized market model in Europe entails that balancing responsibility is defined at the portfolio level, typically within a bidding zone. Some countries require market parties to balance their generation and consumption portfolios separately, while other countries allow mixed portfolios. A few countries still have a more centralized market model, which is often combined with central dispatch and balancing responsibility at the unit level.	Art. 54(1) states that ‘ <i>each TSO shall calculate within its scheduling area or scheduling areas when appropriate the final position, the allocated volume, the imbalance adjustment and the imbalance: (a) for each balance responsible party.</i> ’ Art. 110(2) states that ‘ <i>where a bidding zone covers only one control area, the geographical scope of the scheduling area is equal to the bidding zone. Where a control area covers several bidding zones, the geographical scope of the scheduling area is equal to the bidding zone. Where a bidding zone covers several control areas, TSOs within that bidding zone may jointly decide to operate a common scheduling process, otherwise, each control area within that bidding zone is considered a separate scheduling area.</i> ’ Furthermore, Art. 54(3) of the EB GL specifies that ‘ <i>Until the implementation of the [proposal to further specify and harmonize the imbalance settlement], each TSO shall calculate the final position of a balance responsible party using one of the following approaches: (a) [the] balance responsible party has one single final position equal to the sum of its external commercial trade schedules and internal commercial trade schedules; (b) [the] balance responsible party has two final positions: the first is equal to the sum of its external commercial trade schedules and internal commercial trade schedules from generation, and the second is equal to the sum of its external commercial trade schedules and internal commercial trade schedules from consumption; (c) in a central dispatching model, a balance responsible party can have several final positions per imbalance area equal to generation schedules of power generating facilities or consumption schedules of demand facilities.</i> ’ The possibility of keeping a central dispatch model is elaborated upon in the following.

Section of this chapter, topic and relevant regulation	Relevant articles
There are also exceptions. A few countries still have a more centralized market model, which is often combined with central dispatch and balancing responsibility at the unit level.	The self-dispatch model is more in line with the European target model and is seen as the ‘default’ in the EB GL, as can be deduced from Art. 14(2): <i>‘Each TSO shall apply a self-dispatching model for determining generation schedules and consumption schedules. TSOs that apply a central dispatching model at the time of the entry into force of this Regulation shall notify to the relevant regulatory authority ... in order to continue to apply a central dispatching model for determining generation schedules and consumption schedules. The relevant regulatory authority shall verify whether the tasks and responsibilities of the TSO are consistent with the definition [of a central dispatching model] in Article 2(18).’</i> In EB GL Art. 2(18), a central dispatching model is defined as <i>‘a scheduling and dispatching model where the generation schedules and consumption schedules as well as dispatching of power generating facilities and demand facilities, in reference to dispatchable facilities, are determined by a TSO within the integrated scheduling process.’</i>
Section 5.2.2	
Balancing costs that cannot be allocated to BRPs are socialized by TSOs through their transmission network tariffs.	Art. 44(2) of the EB GL states that <i>‘Each relevant regulatory authority in accordance with Article 37 of Directive 2009/72/EC shall ensure that all TSOs under its competence do not incur economic gains or losses with regard to the financial outcome of the settlement pursuant to Chapters 2, 3 and 4 of this Title [Settlement], over the regulatory period as defined by the relevant regulatory authority, and shall ensure that any positive or negative financial outcome as a result of the settlement pursuant to Chapters 2, 3 and 4 of this Title shall be passed on to network users in accordance with the applicable national rules.’</i>
The EB GL states that all EU countries shall apply an ISP of 15 minutes by three years after the entry into force of the regulation, with some room for exceptions. Regulation (EU) 2019/943 states that the goal is a 15-minute ISP and adds that the ISP shall not exceed 30 minutes from 1 January 2025, with no exceptions.	Art. 53 in the EB GL covers the imbalance settlement period. Art. 53(1) states that <i>‘By three years after the entry into force of this Regulation, all TSOs shall apply the imbalance settlement period of 15 minutes in all scheduling areas while ensuring that all boundaries of market time unit[s] shall coincide with boundaries of the imbalance settlement period.’</i> Art. 53(2–3) explains the exemptions. Art. 8(4) of Regulation (EU) 2019/943 states that <i>‘By 1 January 2021, the imbalance settlement period shall be 15 minutes in all scheduling areas, unless regulatory authorities have granted a derogation or an exemption. Derogations may be granted only until 31 December 2024. From 1 January 2025, the imbalance settlement period shall not exceed 30 minutes where an exemption has been granted by all the regulatory authorities within a synchronous area.’</i>

Section of this chapter, topic and relevant regulation	Relevant articles
The EB GL clearly states that prices should reflect the real-time value of energy and favours single pricing over dual pricing. Following the EB GL, dual pricing is possible as an exception.	Art. 52(2) of the EB GL states that ‘ <i>By one year after entry into force of this Regulation, all TSOs shall develop a proposal to further specify and harmonize at least: ... (c) the use of single imbalance pricing for all imbalances ... which defines a single price for positive imbalances and negative imbalances for each imbalance price area within an imbalance settlement period; and (d) the definition of conditions and methodology for applying dual imbalance pricing for all imbalances ... which defines one price for positive imbalances and one price for negative imbalances for each imbalance price area within an imbalance settlement period, encompassing: (i) conditions on when a TSO may propose to its relevant regulatory authority ... the application of dual pricing and which justification must be provided; (ii) the methodology for applying dual pricing.</i> ’ Additionally, Art. 6 of Regulation (EU) 2019/943 states that ‘ <i>The imbalances shall be settled at a price that reflects the real-time value of energy.</i> ’
Section 5.3.1	
Directive (EU) 2019/944 rules out TSO ownership of energy storage assets, with possible derogations under specific circumstances.	Art. 54(1) states that ‘ <i>Transmission system operators shall not own, develop, manage or operate energy storage facilities.</i> ’ Art. 54(2–5) lists the circumstances under which derogations from this rule can be granted by Member States and the specific conditions that apply in such cases.
Regulation (EU) 2019/943 contains provisions to gradually move away from yearly and monthly contracts towards shorter-term day-ahead tenders.	Art. 6(9) states that ‘ <i>... Contracts for balancing capacity shall not be concluded more than one day before the provision of the balancing capacity and the contracting period shall be no longer than one day, unless and to the extent that the regulatory authority has approved the earlier contracting or longer contracting periods to ensure the security of supply or to improve economic efficiency.</i> ’ Art. 6(9–10) specifies the conditions that apply in cases where a derogation is granted. Notwithstanding such derogations, Art. 6(11) states that ‘ <i>from 1 January 2026 contract periods shall not be longer than six months</i> ’ and Art. 6(12) states that ‘ <i>By 1 January 2028, regulatory authorities shall report to the Commission and ACER on the share of the total capacity covered by contracts with a duration or a procurement period of longer than one day.</i> ’
The EB GL states that upward and downward balancing capacity should be procured separately for FRR and RR. A temporary exception to this rule can be requested.	Art. 32(3) states that ‘ <i>The procurement of upward and downward balancing capacity for at least the frequency restoration reserves and the replacement reserves shall be carried out separately. Each TSO may submit a proposal to the relevant regulatory authority ... requesting the exemption to this requirement.</i> ’ The article further lists what the proposal for exemption shall include. Art. 6(9) of Regulation (EU) 2019/943 reiterates ‘ <i>The procurement of upward balancing capacity and downward balancing capacity shall be carried out separately, unless the regulatory authority approves a derogation from this principle on the basis that this would result in higher economic efficiency as demonstrated by an evaluation performed by the transmission system operator ...</i> ’

Section of this chapter, topic and relevant regulation	Relevant articles
<p>The EB GL states that the balancing energy price should not be predetermined in the balancing capacity contract for standardized products. This rule is reiterated in Regulation (EU) 2019/943. A temporary exception to this rule can be requested.</p>	<p>Art. 16(6) of the EB GL states that ‘<i>The price of the balancing energy bids or integrated scheduling process bids from standard and specific products ... shall not be predetermined in a contract for balancing capacity. A TSO may propose an exemption to this rule ... Such an exemption shall only apply to specific products ... and be accompanied with a justification demonstrating higher economic efficiency.</i>’ Art. 6(2) of Regulation (EU) 2019/943 states that ‘<i>The price of balancing energy shall not be pre-determined in contracts for balancing capacity.</i>’</p>
Section 5.3.2	
<p>The EB GL prescribes the development of balancing energy markets with merit-order activation of balancing energy bids.</p>	<p>Arts. 19(2), 20(2) and 21(2) state that the European platforms for RR, mFRR and aFRR respectively shall apply merit-order lists.</p>
<p>The EB GL makes marginal pricing mandatory for standardized products.</p>	<p>Art. 30(1) states that ‘<i>By one year after the entry into force of this Regulation, all TSOs shall develop a proposal for a methodology to determine prices for the balancing energy that results from the activation of balancing energy bids for the frequency restoration process ... and the reserve replacement process ... Such methodology shall: (a) be based on marginal pricing (pay-as-cleared ...</i>’ Art.6(4) of Regulation (EU) 2019/943 states that ‘<i>The settlement of balancing energy for standard balancing products and specific balancing products shall be based on marginal pricing (pay-as-cleared) unless all regulatory authorities approve an alternative pricing method on the basis of a joint proposal by all transmission system operators following an analysis demonstrating that that alternative pricing method is more efficient.</i>’</p>
<p>If all TSOs identify inefficiencies in the application of marginal pricing, they may request an amendment and propose an alternative pricing method.</p>	<p>Art. 30(5) of the EB GL states that ‘<i>Where all TSOs identify inefficiencies in the application of the methodology proposed pursuant to paragraph 1(a), they may request an amendment and propose a pricing method alternative to the pricing method in paragraph 1(a). In such case, all TSOs shall perform a detailed analysis demonstrating that the alternative pricing method is more efficient.</i>’</p>
<p>The EB GL did foresee the development of a methodology for the harmonized implementation of marginal pricing in balancing energy markets.</p>	<p>All TSOs’ (2018c) proposal on methodologies for pricing balancing energy and cross-zonal capacity used for the exchange of balancing energy or operating the imbalance netting process pursuant to Art. 30(1) and Art. 30(3) was referred to ACER in July 2019. In January 2020, ACER (2020a) published its decision, which includes the implementation of a single cross-border marginal price, which ensures that a single marginal price is propagated across all areas among which there is no congestion. At least one price is established for each market time unit, which is defined to be shorter than or equal to the imbalance settlement period. The pricing methodology also differentiates between the different products and processes.</p>
<p>FCR is an exception. It continues to typically be a service that combines upward and downward balancing. These reserves receive as much energy as they give so that only capacity needs to be remunerated. By its nature, the FCR product is indeed more about capacity than energy.</p>	<p>The EB GL states in Art. 32(3) that ‘<i>The procurement of upward and downward balancing capacity for at least the frequency restoration reserves and the replacement reserves shall be carried out separately.</i>’ Hence, this is not a requirement for FCR. Additionally, Art. 46(1) states that ‘<i>each connecting TSO may calculate and settle the activated volume of balancing energy for the frequency containment process with balancing service providers ...</i>’ Hence, paying BSPs for FCR is optional.</p>

Section of this chapter, topic and relevant regulation	Relevant articles
Section 5.3.3	
The EB GL mentions that an additional settlement mechanism may be developed to allocate the costs of balancing capacity.	Art. 44(3) states that <i>‘Each TSO may develop a proposal for an additional settlement mechanism separate from the imbalance settlement, to settle the procurement costs of balancing capacity ... administrative costs and other costs related to balancing.’</i>
Section 5.4.2	
The EB GL requires all TSOs that are performing the automatic frequency restoration process to implement and make operational the European platform for imbalance netting. The platform shall be used to perform the imbalance netting process at least for the Continental Europe synchronous area.	Art. 22(1) states that <i>‘By six months after entry into force of this Regulation, all TSOs shall develop a proposal for the implementation framework for a European platform for the imbalance netting process.’</i> At the time of writing, the proposal by All TSOs (2019) has not yet been approved by all NRAs. All NRAs made a second request for amendment in July 2019. Furthermore, Art. 22(5) states that <i>‘By one year after the approval of the proposal for the implementation framework for a European platform for the imbalance netting process, all TSOs performing the [aFR process] shall implement and make operational the European platform for the imbalance netting process. They shall use the European platform to perform the imbalance netting process, at least for the Continental Europe synchronous area.’</i>
At the time of writing it is foreseen that TSOs of synchronous areas other than CE performing the automatic frequency restoration process may decide to become member TSOs of the European platform at a later point in time.	Art. 5(4) of All TSOs’ revised proposal for the implementation framework for a European platform for the imbalance netting process from September 2019 states that <i>‘TSOs of synchronous areas other than CE performing the [automatic frequency restoration] process may decide to become member TSOs of the [imbalance netting] Platform at a later point in time, after fulfilling the relevant requirements defined in this [implementation framework] and the [imbalance netting] Platform accession roadmap.’</i>
Section 5.4.3	
The EB GL did foresee the development of detailed methodologies for European platforms for the exchange of aFRR, mFRR and RR.	According to the EB GL, implementation frameworks have to be proposed by all TSOs for the European aFRR, mFRR and RR balancing platforms (Arts. 21, 20, 19). The implementation framework for RR was approved by the relevant NRAs – in December 2018 (All TSOs using RR 2018). Proposals for the implementation frameworks for aFRR and mFRR were referred to ACER in July 2019. ACER (2020b, 2020c) adopted decisions on both implementation frameworks in January 2020.

Section of this chapter, topic and relevant regulation	Relevant articles
The EB GL states that the TSO–TSO model is the model for exchanging balancing bids, with possible exceptions under certain circumstances.	Arts. 21, 20, 19 all state that the European balancing platforms shall apply a multilateral TSO–TSO model with common merit-order lists to exchange all balancing energy bids from all standard products. Art. 2(21) defines the TSO–TSO model as ‘ <i>a model for the exchange of balancing services where the balancing service provider provides balancing services to its connecting TSO, which then provides these balancing services to the requesting TSO.</i> ’ Art. 33(2) states that ‘ <i>Except in cases where the TSO–BSP model is applied pursuant to Article 35, the exchange of balancing capacity shall always be performed based on a TSO–TSO model whereby two or more TSOs establish a method for the common procurement of balancing capacity taking into account the available cross-zonal capacity and the operational limits ...</i> ’ Art. 35(1) states that ‘ <i>Two or more TSOs may at their initiative or at the request of their relevant regulatory authorities ... develop a proposal for the application of the TSO–BSP model</i> ’ and lists what such a proposal for the application needs to include.
The EB GL only allows alternative proposals as temporary solutions.	Art. 35(7) states that ‘ <i>By four years after entry into force of this Regulation, all exchanges of balancing capacity shall be based on the TSO–TSO model. This requirement shall not apply to the TSO–BSP model for replacement reserves if one of the two involved TSOs does not operate the reserve replacement process as part of the load-frequency-control structure ...</i> ’
Section 5.4.4	
The EB GL requires each TSO to publish a balancing report at least every two years. The TSO is required to analyse the potential for exchange of balancing capacity and sharing of reserves and to put forward an explanation and justification for the procurement of balancing capacity without exchanging balancing capacity or sharing reserves.	Art. 60(1) states that ‘ <i>At least once every two years, each TSO shall publish a report on balancing covering the previous two calendar years, respecting the confidentiality of information in accordance with Article 11.</i> ’ Art. 60(2) specifies the information to be included in these reports, including ‘ <i>(e) analyse the opportunities for the exchange of balancing capacity and sharing of reserves; (f) provide an explanation and a justification for the procurement of balancing capacity without the exchange of balancing capacity or sharing of reserves.</i> ’
The FCR cooperation project was formalized according to the EB GL in 2019.	In 2019, all relevant NRAs approved the methodology by all TSOs from the Netherlands, Germany, France, Belgium, Austria, Denmark and Switzerland on harmonized rules and processes for the exchange and procurement of balancing capacity for FCR using one standard product according to Art. 33 of the EB GL (50Hertz et al. 2018).
The SO GL requires all TSOs in a synchronous area to jointly develop a proposal regarding the determination of LFC blocks. In many cases, the LFC block equals the LFC area, which equals the control area. The Nordics, Ireland and Great Britain, where the LFC block equals the synchronous area, are exceptions. Germany, Luxembourg and West Denmark, which form an LFC block consisting of several LFC areas, are also exceptions. The same applies to Slovenia, Croatia and Bosnia and Herzegovina and to Serbia, North Macedonia and Montenegro.	Art. 141(2) of the EB GL states that ‘ <i>By 4 months after entry into force of this Regulation, all TSOs of a synchronous area shall jointly develop a common proposal regarding the determination of the LFC blocks, which shall comply with the following requirements.</i> ’ The LFC block proposal by All CE TSOs (2018) was approved in August 2018. The LFC block proposal by All Nordic TSOs (2018) was approved in September 2018 by all the relevant NRAs.

Section of this chapter, topic and relevant regulation	Relevant articles
<p>The SO GL states that FRR has to be dimensioned by LFC blocks. The TSOs involved then have to agree on the volume to reserve, the ratio between aFRR and mFRR, and the sharing of responsibility.</p> <p>The SO GL sets out rules for dimensioning and sharing of RR for LFC blocks in which all TSOs make use of RR.</p> <p>Regulation (EU) 2019/943 tasks the regional coordination centres (RCCs) with facilitating regional dimensioning and procurement of balancing capacity.</p>	<p>Art. 157 states that all TSOs of an LFC block shall set out FRR dimensioning rules in the LFC block operational agreement. The detailed requirements in terms of dimensioning are described in the article.</p> <p>Art. 160 states that all TSOs of an LFC block shall have the right to implement a reserve replacement process. The detailed requirements in terms of dimensioning are set out in the article.</p> <p>Art. 37(1.j and k) lists regional sizing of reserve capacity and facilitating the regional procurement of balancing capacity as tasks of RCCs. Art. 6(7) adds that <i>‘The dimensioning of reserve capacity shall be performed by the transmission system operators and shall be facilitated at regional level.’</i> Art. 6(8) states that <i>‘The procurement of balancing capacity shall be performed by the transmission system operator and may be facilitated at a regional level ...’</i></p>
Section 5.4.5	
<p>The EB GL requires that all TSOs shall use the available cross-zonal capacity after the cross-zonal intraday gate closure for operating the imbalance netting process or for the exchange of balancing energy.</p>	<p>Art. 36(1) states that <i>‘All TSOs shall use the available cross-zonal capacity ... for the exchange of balancing energy or for operating the imbalance netting process.’</i> Art. 37(3) specifies that all the TSOs in a capacity calculation region shall develop a methodology for cross-zonal capacity calculation within the balancing timeframe for the exchange of balancing energy or for operating the imbalance netting process.</p>
<p>The EB GL foresees the possibility of reserving available transmission capacity for the exchange of balancing capacity or sharing of reserves for FRR and RR. Nothing is specified regarding imbalance netting or the exchange of balancing energy.</p>	<p>Art. 36(2.c) states that cross-zonal capacity for the exchange of balancing capacity or sharing of reserves can be allocated. Art. 38(4) adds that cross-zonal capacity allocated for the exchange of balancing capacity or sharing of reserves shall be used exclusively for FRR and RR. Art. 38(1) specifies three approaches allowed to reserve cross-zonal capacity for balancing: a co-optimization approach (Art. 40), a market-based approach (Art. 41) and an approach based on economic efficiency analysis (Art. 42). The capacity reserved shall be limited depending on the way it is calculated (Art. 40(1.d), 41(2) and 42(2)). It should be noted that all TSOs exchanging balancing capacity or sharing reserves shall regularly assess whether the cross-zonal capacity allocated for the exchange of balancing capacity or sharing of reserves is still needed for that purpose as it means that this capacity is no longer offered to wholesale markets (Art. 38(8)).</p>
<p>Available transmission capacity is already reserved for FCR. The so-called reliability margin on transmission lines is to account for FCR.</p>	<p>Art. 38(4) states that <i>‘... The reliability margin calculated pursuant to [the CACM GL] shall be used for operating and exchanging frequency containment reserves, except on Direct Current (DC) interconnectors for which cross-zonal capacity for operating and exchanging frequency containment reserves may also be allocated in accordance with paragraph 1.’</i> Paragraph 1 states that two or more TSOs may at their initiative or at the request of their relevant regulatory authorities make a proposal for reserving capacity for the exchange of balancing capacity according to one of the three possible methods.</p>

Section of this chapter, topic and relevant regulation	Relevant articles
<p>The SO GL foresees that DSOs can filter balancing bids from BSPs connected to distribution grids. If they fear that certain bids may cause congestion when called upon by TSOs, they can disqualify them.</p>	<p>According to Art. 182(5), each reserve-connecting DSO and each intermediate DSO can set temporary limits to the delivery of active power reserves before their activation. Procedures need to be agreed upon with the respective TSO. Furthermore, the SO GL specifies in Art. 182(3) that the prequalification process for balancing resources connected to the distribution level shall rely on rules concerning information exchanges and the delivery of active power reserves between the TSO, the reserve-connecting DSO and the intermediate DSOs. Each reserve-connecting DSO and each intermediate DSO, in cooperation with the TSO, shall have the right to set limits to or exclude the delivery of active power reserves located in the distribution system during the prequalification process. Art. 182(4) specifies that reasons for limitations or exclusion should be technical, such as the geographical location of the reserve-providing units and reserve-providing groups.</p>
<p>Whether filtering bids for balancing by DSOs will result in penalties paid to the TSO by the BSP and/or paid to the BSP or the TSO by the DSO is an open issue.</p>	<p>Art. 15(3) of the EB GL states that each TSO may, together with the reserve-connecting DSOs within the TSO's control area, jointly elaborate a methodology for allocating costs resulting from the exclusion or curtailment of active reserves connected to the distribution level.</p>
<p>The SO GL allows TSOs to filter bids. They do not have to forward all the bids by BSPs to the European platforms. If they fear that certain bids may cause congestion when called upon by neighbouring TSOs, they can also disqualify these bids.</p>	<p>Art. 29(14) on the activation of balancing energy bids from the common merit-order list states that <i>'Each TSO may declare the balancing energy bids submitted to the activation optimization function unavailable for the activation by other TSOs because they are restricted due to internal congestion or due to operational security constraints within the connecting TSO scheduling area.'</i> Additionally, Art. 29(10) states that <i>'Each TSO applying a self-dispatching model and operating within a scheduling area with a local intraday gate closure time after the balancing energy gate closure time pursuant to Article 24 may develop a proposal to limit the amount of bids that is forwarded to the European platforms pursuant to Articles 19 to 21. The bids forwarded to the European platforms shall always be the cheapest bids. This proposal shall include: (a) the definition of the minimum volume that shall be forwarded to the European platforms. The minimum volume of bids submitted by the TSO shall be equal to or higher than the sum of the reserve capacity requirements for its LFC block ... and the obligations arising from the exchange of balancing capacity or sharing of reserves; (b) the rules to release the bids that are not submitted to the European platforms and the definition of the point in time at which the concerned balancing service providers shall be informed of the release of its bids.'</i> Art. 29(11) states that TSOs shall regularly assess the impact of limiting the volume of bids sent to the European platforms and the functioning of the intraday market.</p>