Potential cross-border balancing cooperation between the Belgian, Dutch and German electricity Transmission System Operators

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E-Bridge competence in energy

POTENTIAL CROSS-BORDER BALANCING COOPERATION BETWEEN THE BELGIAN, DUTCH AND GERMAN ELECTRICITY TRANSMISSION SYSTEM OPERATORS

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Executive Summary

In September 2012, ACER issued the Framework Guidelines on Electricity Balancing that provide the framework on the integration of national balancing markets towards one single European electricity balancing market. In December 2012, ENTSO-E was requested to deliver a Network Code that is in line with the principles as set out by the Framework Guidelines on Electricity Balancing. The draft Network Code on Electricity Balancing was consulted during summer 2013 and delivered to ACER in December 2013. The Network Code on Electricity Balancing is not expected to enter into force earlier than September 2015.

The Belgian, Dutch and German TSOs have taken already first steps with regard to cross-border cooperation in balancing. Together with the Danish, Czech and Swiss TSOs they form the international grid control cooperation. The purpose of the international grid control cooperation is to avoid counteracting activation of balancing energy by netting of imbalances. The cooperation was initially established between the German TSOs and stepwise enlarged to neighbouring TSOs. Besides this, TenneT NL joined in January 2014 the existing common procurement for frequency containment reserves between Germany and Switzerland. Furthermore, TenneT NL and Elia share a part of their manual frequency restoration reserves. In order to test the feasibility of the balancing target model, to evaluate the implementation impact and to gather and report on the experience gained, ENTSO-E launched a call for pilot projects. In response to this call, Elia and TenneT NL applied for a cross-border balancing pilot project called "*Design and evaluation of a harmonised reactive balancing market with XB optimisation of Frequency Restoration while keeping control areas, bid zones, and Regulatory oversight intact*" that was accepted by ENTSO-E.

As the Belgian, Dutch and German TSOs are open for new initiatives for cross-border cooperation in balancing, they jointly initiated a feasibility study as a first step for possible further cooperation in balancing. The study takes into account the requirements of the relevant draft European Network Codes and Framework Guidelines. E-Bridge and IAEW assisted these TSOs with analysing potential options for cross-border cooperation in balancing between the TSOs.

This study was conducted in two steps. First, the existing balancing market designs of all three countries were compared in detail. Even though all countries procure a set of similar products, the detailed comparison reveals important differences of the technical product definitions, the procurement procedure, the bid selection and bid activation, the settlement, the imbalance pricing and the overall balancing approach.

In a second step of this study, the potential cooperation options and their impact on the existing market design have been evaluated. In principle the cross-zonal cooperation possibilities can be distinguished into options that require product harmonisation by the TSOs and options that do not require any harmonisation of the product. Further there are options to cooperate for balancing capacity and options to cooperate for balancing energy. The figure below lists all the potential options for cooperation that are discussed in the scope of this feasibility study.

	HARMONISATION not necessary	HARMONISATION necessary
ENERGY	**Imbalance Netting** **Definition**: avoidance of counteracting activation of balancing energy **Expected benefit**: lower activation energy volumes **Challenge**: available cross zonal capacity **Application**: FRR	**Common Merit Order (CMO)** **Definition**: Integration of individual Merit Orders for activation energy bids into one CMO **Expected benefit**: selection and activation of most efficient balancing energy bids **Challenge**: available cross zonal capacity **Application**: FRR
RESERVE CAPACITY[1]	**Reserve Sharing** **Definition**: mutual provision of FRR reserve capacity among TSOs **Expected benefit**: lower amounts of procured reserve capacity **Challenge**: available cross zonal capacity **Application**: FRR	**Exchange of Reserve Capacity/ Consideration of additional energy bids** **Definition**: reserve capacity is procured in a coordinated way (TSO-TSO, TSO-BSP) **Expected benefit**: lower combined expenditures for procurement of reserve capacity **Challenge**: reservation of cross zonal capacity required & exchange of balancing energy for FRR **Application**: FCR, FRR

[1] Further investigation is needed if "common dimensioning" as an option to cooperate for reserves requires harmonisation.

The reasons to cooperate are twofold: on one hand countries may benefit from more efficient balancing of demand and generation resulting in lower costs and/or higher quality. On the other hand the Framework Guidelines on Electricity Balancing require TSOs to apply imbalance netting, standardise the balancing energy and capacity products, to harmonise the main features for imbalance settlement and to facilitate the cross-zonal exchange of balancing energy from manual frequency restoration reserves and replacement reserves. Besides, cooperation may be restricted by operational security constraints. Alongside with maintaining defined quality targets[1] for load-frequency control each TSO must be able in the event of European-wide disturbances to manage the system balance with the balancing resources located in its control area.

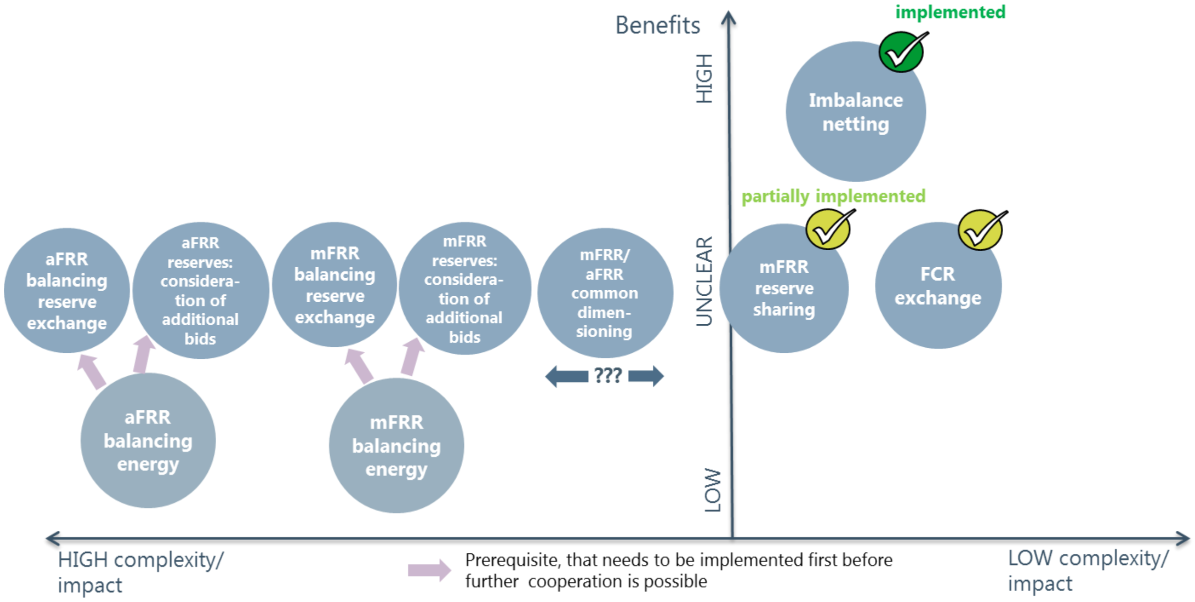
Both, the required harmonisation and the potential cooperation result in benefits and challenges. By harmonising the balancing market design, the three countries potentially may reap the benefits from creating a regional level playing field, reducing the administrative cost for international BSPs, fulfilling future legal requirements and by implementing 'best practice' increase socio-economic welfare. This requires that challenges associated with the harmonisation are overcome: the TSOs will have to agree on standard product definitions, bid selection, activation and settlement procedures whilst any change may impact regulation quality, prices and incentives on BRP.

Besides, other cooperation initiatives, regulatory and technical developments may also affect benefits and challenges. For example close alignment is required if one TSO is part of two coordinated balancing areas activating balancing energy bids from one common merit order list. This might be an issue in case Germany forms one coordinated balancing area with Belgium and the Netherlands and one with other neighbouring TSOs, such as with Austria and Switzerland. The

[1] Currently the quality targets are laid down in the UCTE Operation Handbook. In the future the requirements from the Network Code Load Frequency Control and Reserves will be applicable.

introduction of flow-based capacity calculation is an example for regulatory developments that will impact cross-zonal cooperation in balancing. Changes to generation portfolios due to either political (for example nuclear phase out, renewable subsidy schemes) or technical developments (batteries, renewables becoming capable of providing system services, smart technologies) will impact the benefits for cooperation as well as the design of the product and procedures to allow participation thereof.

In the figure below all options for cooperation are sorted in a coordinate system reflecting their estimated complexity for introduction and the expected benefit. The estimated complexity is based on the TSOs' experience: for example TenneT NL and Germany cooperate on FCR and all TSOs have implemented imbalance netting. The benefits of the cooperation are qualitatively assessed and divided into the three categories 'high', 'unclear' and 'low'.



The figure depicts that the less complex cooperation options are already fully or partially established. The more complex options for cooperation are also the options where the potential benefit is difficult to calculate and therefore unclear: the currently applicable FRR market designs diverge considerable between the three countries making any quantitative comparison and benefit calculation rather impossible.

As an outcome of this feasibility study we recommend to follow two paths:

1. Fully implement the "less complex" options for cooperation:

- Analyse the prerequisites for Belgium joining the existing common procurement for frequency containment reserves between Germany, the Netherlands and Switzerland
- Increase the amount of frequency containment reserve exchange for the Netherlands and Germany (within the security limits set by the draft Network Code Load Frequency Control & Reserves)
- Analyse further potential in sharing manually activated frequency restoration reserves (within the security limits set by the draft Network Code Load Frequency Control & Reserves)

2. Start the discussion on harmonisation of the "more complex" products for cooperation:

- Start the discussion on the harmonisation of the automatic and manual frequency restoration reserves products for cooperation with the aim of establishing a common merit order list
- Investigate the cooperation possibilities for frequency restoration reserves capacity by common dimensioning, the consideration of additional balancing energy bids and the exchange of reserves

This report contains the outcome of the work undertaken in both steps of this project. It is expected that the project will be continued in a next phase.

CONTENTS

1. Introduction

The efforts to achieve one European internal electricity market have mainly focused on harmonising and integrating spot and forward markets. Harmonised procedures for cross-zonal capacity allocation were introduced for long and short term time frames such as day-ahead market coupling. Contrary to this, balancing markets were predominantly developed on a national basis resulting in diverging current market designs across Europe. In September 2012, ACER issued the Framework Guidelines on Electricity Balancing (FG EB) that provide the framework on the integration of national balancing markets towards one single European electricity balancing market. The FG EB concentrate on Frequency Restoration Reserves and Replacement Reserves and require the standardisation of balancing products, balancing energy pricing and imbalance pricing as to ensure a level playing field before a full integration of the markets. One main objective of the framework guidelines is the step-wise implementation of cross-border exchanges of balancing energy from Replacement Reserves and Frequency Restoration Reserves that should first emerge in different areas and gradually be integrated into one European platform.

In December 2012, ENTSO-E was requested to deliver a Network Code that is in line with the principles as set out by the FG EB. The draft Network Code on Electricity Balancing (NC EB) was consulted during summer 2013 and delivered to ACER in December 2013. ACER provided its reasoned opinion in March 2014 and requested ENTSO-E to adjust the NC EB accordingly before it can be recommended for adoption. The NC EB is not expected to enter into force earlier than September 2015.

In order to test the feasibility of the balancing target model as explained in the FG EB, to evaluate the implementation impact and to gather and report on the experience gained, ENTSO-E launched a call for pilot projects on balancing in February 2013. In response to this call, Elia and TenneT NL applied for a cross-border balancing pilot project called "*Design and evaluation of a harmonised reactive balancing market with XB optimisation of Frequency Restoration while keeping control areas, bid zones, and Regulatory oversight intact*" that was accepted by ENTSO-E. The final report of the initial study was published in August 2013 and is to be considered the first deliverable of this pilot project.

Likewise, the German TSOs applied for a cross-border balancing pilot project called "*Common Merit Orders for manual and automatic Frequency Restoration Reserves with real Time Flow Based congestion management*". Since December 2008, the German TSOs purchase the required reserve via a joint auction. This process facilitated the development of the German Grid Control Cooperation (GCC) which nowadays comprises four different modules:

- Module 1: Prevention of counteracting balancing energy activation
- Module 2: Common dimensioning of control reserve
- Module 3: Common procurement of automatic frequency restoration reserves
- Module 4: Cost-optimised activation of balancing energy

TenneT NL and Elia joined Module 1 of the GCC in February and October 2012 respectively thereby extending the GCC into the International Grid Control Cooperation (IGCC). Besides this, the Belgian, Dutch and German TSOs have taken further steps with regard to cross-border cooperation in balancing. TenneT NL joined in January 2014 the existing common procurement for Frequency Containment Reserves (FCR) between Germany and Switzerland for a share of its FCR obligations. Furthermore, TenneT NL and Elia share their manual Frequency Restoration Reserves (mFRR). Finally Elia procures parts of its FCR obligations from French Balance Service Providers (BSP).

As the German, Belgian and Dutch TSOs are open for new initiatives for cross-border cooperation in balancing, they have decided to initiate a common study as a first step of a possible further cooperation between both pilot projects in December 2013. E-Bridge and IAEW assisted these TSOs with analysing potential options for cross-border cooperation in balancing between all TSOs taking into account the requirements of the relevant draft European Network Codes and Framework Guidelines. The study was conducted jointly by the consultants and all involved TSOs in two steps. First, the existing balancing market designs of all three countries were compared. Secondly, potential cooperation models and their impact on the existing markets were evaluated.

2. Current practices and arrangements for the procurement and use of balancing services

2.1. Overview of products

The Network Code on Load Frequency Control and Reserves[2] (NC LFC&R) and the Supporting Document define three processes for load-frequency control for the entire European Union:

- The Frequency Containment Process: *"stabilizes the frequency after the disturbance at a steady-state value (...) by a joint action of Frequency Containment Reserves within the whole Synchronous Area".*
- The Frequency Restoration Process: *"controls the frequency towards its Setpoint value by activation of Frequency Restoration Reserves and replaces the activated Frequency Containment Reserves."*
- Reserve Replacement Process: *"replaces the activated Frequency Restoration Reserves and/or supports the Frequency Restoration Reserves activation by activation of Replacement Reserves."*

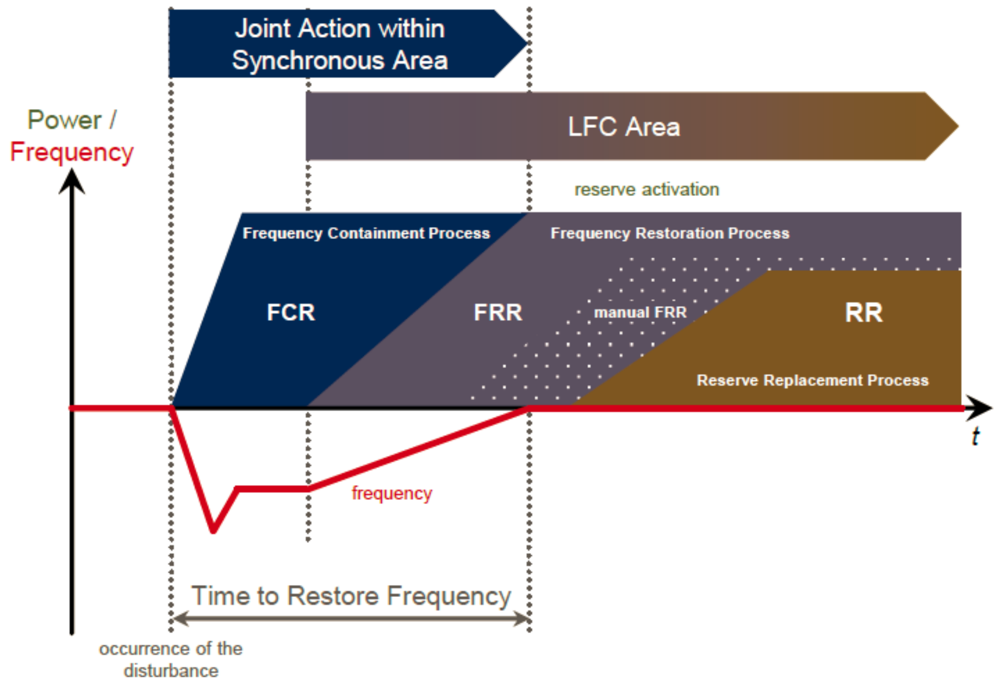


Figure 1: Dynamic hierarchy of load-frequency control processes (under assumption that FCR is fully replaced by FRR)[3]

Each load-frequency control process is supported by a dedicated set of operational reserves. The by the NC LFC&R defined operational reserves and their national equivalent are listed in Table 1.

[2] Published under www.entsoe.eu, finalized by ENTSO-E and recommended for adoption by ACER in September 2013
[3] Source: Supporting Document for the Network Code on Load-Frequency Control and Reserves (www.entsoe.eu).

Process for load-frequency control	Operational reserves defined by NC LFC&R	ENTSO-E Central Europe Operation handbook	Operational reserves equivalent in Belgium	Operational reserves equivalent in the Netherlands	Operational reserves equivalent in Germany
Frequency Containment Process	Frequency Containment Reserves (FCR)	Primary Control	R1	Primaire Regeling	Primärregel-leistung
Frequency Restoration Process	Automatic Frequency Restoration Reserves (aFRR)	Secondary Control	R2	Regelvermogen	Sekundärregel-leistung
	Manual Frequency Restoration Reserves (mFRR)	Tertiary Control	▪ Non-contracted CIPU bids ▪ R3 production ▪ R3 dynamic profile ▪ ICH (*interruptible loads*)	▪ Reserve-vermogen ▪ Noodver-mogen	Minutenreserve-leistung
Reserve Replacement Process	Replacement Reserves (RR)	Tertiary Control	-	-	-

Table 1: Operational reserves according to the NC LFC&R, the Operation Handbook definition and their equivalent in Belgium, the Netherlands and Germany

As illustrated in Table 1, all countries have equivalent operational reserves to those defined by the NC LFC&R in place except for replacement reserves that are not procured in any of the three countries. The philosophy of the involved TSOs is that the replacement reserve process should be performed by the market parties in the intraday market as much as possible. For the Frequency Restoration Process two different products are used, the automatically-activated and the manually-activated Frequency Restoration Reserves. Replacement reserves (RR) are not used by the Belgian, Dutch and German TSOs and thus are not contracted. In its letter of 21.03.2014 ACER[4] clarified that "*all TSOs which are using RR (...) processes for balancing purposes should implement the regional and European integration models for the exchanges of the respective balancing energy*". This statement can be construed as a conditional obligation. If replacement reserves are currently not used by TSOs then they are not obliged to introduce them. Thus the cooperation for replacement reserves is not in scope of this study.

Hereafter the existing balancing market design in Belgium, the Netherlands and Germany will be described concentrating on the main features and highlight the key similarities and differences. Appendix A provides an exhaustive comparison of the current balancing market design in the three countries.

[4] Opinion of the Agency for the Cooperation of Energy Regulators No 07/2014 on ENTSO-E Network Code on Electricity Balancing (www.acer.europa.eu)

2.2. Frequency Containment Reserves (FCR)

2.2.1. Product specification

Due to the fact that key principles for FCR – previously denominated on the European continent as primary reserves – were defined by the UCTE Operation Handbook, the current FCR products of the three countries share most technical requirements.

Furthermore the commercial characteristics of the FCR product procured by TenneT NL and the German TSOs are almost the same. This is due to the fact that only since 2014 TenneT NL needs to procure FCR. For this, TenneT NL joined the common German and Swiss procurement platform to procure its required FCR quantity partly in the joint Dutch, German and Swiss auction. Thus TenneT NL basically took over the existing FCR product specifications and procurement arrangements. Before 2014 the provision of FCR was mandatory for all running generation units with an installed capacity of more than 60MW in the Netherlands.

All TSOs procure a symmetrical FCR product that is activated as a linear function of the frequency deviation up to ±200mHz. Whereas this is the only product used in Germany and the Netherlands, Elia procures additional FCR products that cover certain parts of the frequency ±200mHz band[5]. This allows more parties (including load) to offer FCR to Elia and provides a necessary increase in competition in the Belgian market for FCR.

Furthermore, Elia distinguishes between base, peak and long-off-peak[6] products, whereas the Dutch and the German TSOs only procure a base product. The rational, why Elia uses quite a range of FCR products, is not historical, but rather cost driven. By procuring a range of asymmetric and symmetric products and allowing for a deadband, the technical capabilities of varying sources for FCR are better taken into account, the participation of load is facilitated and the overall costs are reduced.

2.2.2. Procurement of balancing capacity, bid selection, and remuneration

Elia procures the R1 symmetrical 100mHz product since 2014 via a monthly tender whereas all other FCR products are procured via annual tenders. From 2015 on all FCR products will be procured via a monthly tender. Unlike Elia, TenneT NL and the German TSOs procure FCR through weekly auctions.

During procurement the Dutch and German TSOs select bids from a common merit order starting with the lowest bid price. In contrary, Elia selects bids by co-optimising the price with aFRR that are procured at the same time in order to minimise FCR and aFRR balancing capacity costs. Currently generation units often operate in must-run to be able to offer the required balancing services. The possibility to link FCR bids to other FCR and aFRR bids allows BSP to provide both, FCR and aFRR with the same unit under must-run and thereby lower the overall costs. Furthermore, the prices are subject to final approval by the Belgian regulatory authority.

In all three countries the remuneration of the contracted balancing capacity is based on the pay-as-bid principle and there is no remuneration of the activated energy.

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[5] Additionally Elia procures R1 symmetrical 100mHz, R1 upwards (-200mHz, -100mHz) and R1 downwards (+100mHz, +200mHz). The sum of these three products corresponds to the symmetrical 200mHz product.

[6] Peak product: Monday to Friday from 08:00-20:00h. The long off-peak product: remaining time

2.3. Automatic Frequency Restoration Reserves (aFRR)

2.3.1. Product specification

All TSOs use one basic product for upward and for downward regulation. Whereas TenneT NL uses only a base product, the German TSOs distinguish between peak and long off-peak[7] and Elia between base, peak and long off-peak products. All countries pre-contract balancing capacity. On top of that Elia and TenneT NL regard additional balancing energy bids that are contracted close to real time (in Belgium at D-1 and in the Netherlands at H-1).

In all three countries response shall start within 30 seconds after the aFRR request was sent by the TSO. Beyond this, the product definitions for aFRR differ significantly between the three countries:

- Belgium: BSPs have to guarantee a ramp rate of 13,3% per minute of the balancing capacity offered. Elia activates all D-1 selected bids in parallel on a pro-rata basis;
- The Netherlands: TenneT NL requires only a minimum[8] ramp rate of 7% per minute of the balancing bid offered. Unlike Elia, TenneT NL activates aFRR bids sequentially according to a balancing energy merit order starting with the bid with the lowest price. If circumstances so require, TenneT NL may also activate more bids in parallel;

Germany: Contrary to the Belgian and Dutch TSO, the German TSOs do not require BSPs to guarantee a fixed ramp rate of the balancing capacity respectively bid offered. Once a bid is activated, the German TSOs require the provider of aFRR to provide the full offered bid volume at the latest 5 min after its activation. Additionally to this, a minimum ramp rate of at least 2% of the nominal output of a unit (or alternatively of an aFRR pool, per pool) is required and tested during the prequalification phase. Practically, this means that BSPs offering aFRR to German TSOs have to take into account the ramp rates of their unit or pool when determining the volume of their bid in order to ensure that they can offer the full bid volume 5 minutes after its activation.

Figure 2 highlights these differences.

[7] Long off-peak includes besides the off-peak hours during the week (20:00-08:00h) all weekend hours. In Germany additionally federal holidays are included.

[8] BSP may offer higher ramp rates to TenneT NL. This is rather a theoretical option, as in practice this rarely happens.

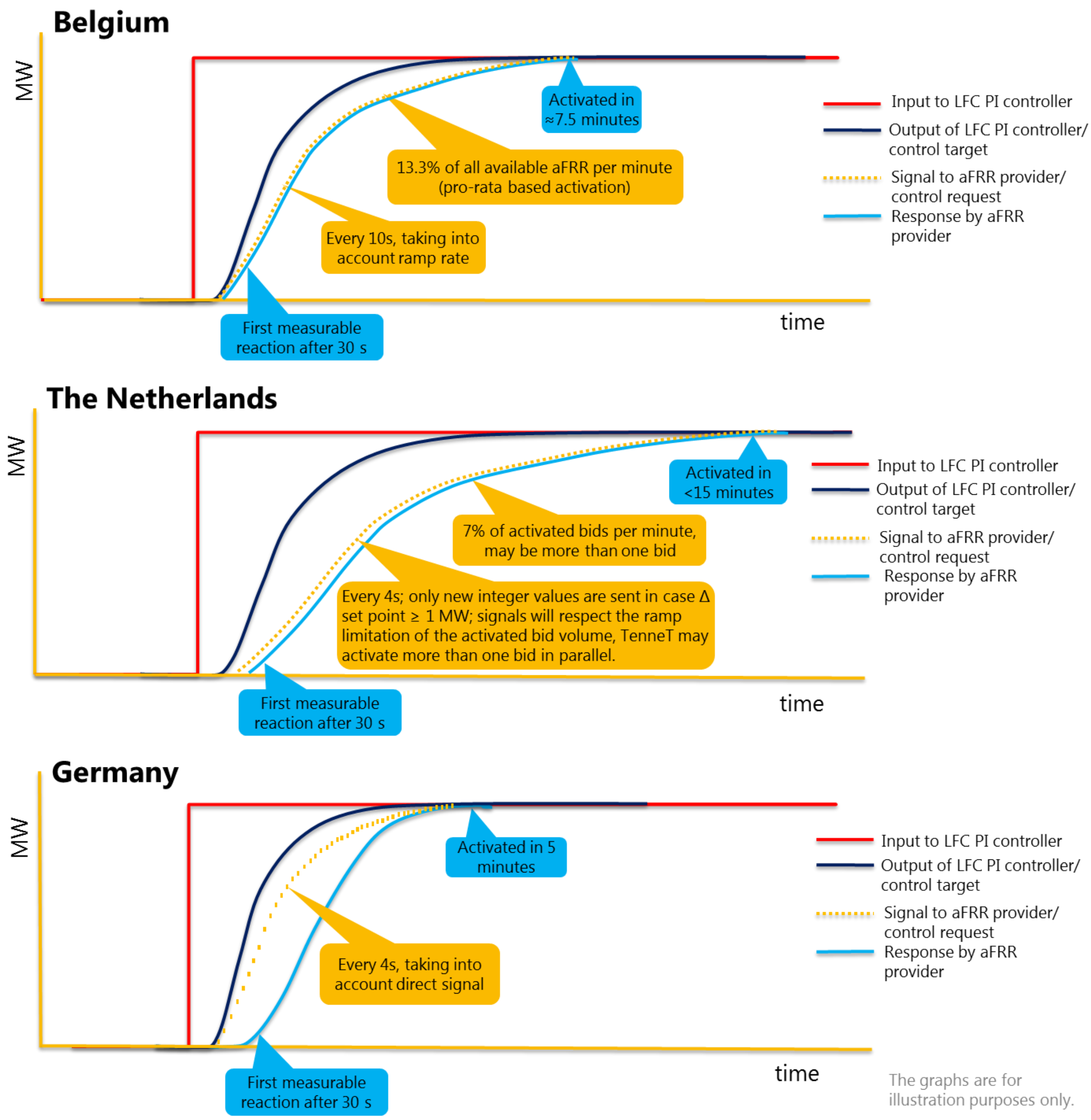

Figure 2: Schematic comparison of aFRR activation and response

2.3.2. Procurement of balancing capacity

The procurement process for aFRR balancing capacity and balancing energy represents another fundamental difference between the Belgian and Dutch market design on one hand and the German market design for aFRR on the other hand.

In Belgium and the Netherlands the procurement of aFRR balancing capacity takes place independently of the procurement of balancing energy. Both TSOs procure balancing capacity via an annual tender. Additionally, Elia procures a share of the total aFRR balancing capacity via a monthly tender (since 2014). From 2015 on the total amount of aFRR balancing capacity will be procured via a monthly tender in Belgium. As already described in section 2.2.2, Elia selects bids by co-optimising the price of FCR and aFRR as to minimise the overall procurement costs due to must-run of units. Therefore BSP may link aFRR bids to other aFRR (upwards and downwards) and FCR bids. Dutch BSP offer several packages linking the price to a certain volume of balancing capacity. TenneT NL selects bids by performing an economic optimisation taking into account the smallest overshoot (if any) whilst aiming for the lowest average price for all procured capacity. Thus, TenneT NL does not necessarily always select the lowest bid first. The BSP are remunerated at the offered price (pay-as-bid) in both countries. However, as for FCR, in Belgium the prices for aFRR balancing capacity are subject to final approval by the Belgian regulatory authority.

aFRR is jointly procured by all German TSOs. However, each TSO may define a technically required minimum share of aFRR that has to be procured exclusively from technical units connected in its control area *(Kernanteil*[9]*)*. However, this has to be justified by the TSO and requires approval by the Federal Network Agency *(Bundesnetzagentur)*. Yet, the main difference with Belgium and the Netherlands is that in Germany aFRR balancing capacity and balancing energy are jointly procured. Besides the offered aFRR volume the bid contains both a price for the balancing capacity and a price for the balancing energy. During the tender procedure the bids are only selected according to the balancing capacity price starting with the lowest price. The balancing energy price is not considered. After the selection of the successful balancing capacity bids, their activation is based on a merit order of their offered balancing energy price. The remuneration of the balancing capacity takes place according to the pay-as-bid principle.

The availability requirement is 100% in all three countries. In order to avoid any unavailability, BSP may transfer a contract to another BSP until day-ahead in Belgium. In Germany, BSP may transfer their contract for any imbalance settlement period (ISP) to other prequalified units of another BSP, but only within one control area.

2.3.3. Bids for balancing energy

As indicated in the previous chapter there are fundamental differences in the procurement of aFRR balancing energy between the Belgian and Dutch market on the one hand and the German market on the other hand.

Elia and TenneT NL operate an open daily balancing mechanism for the final selection and activation of aFRR balancing energy bids having a product resolution in time of 15 minutes. Pre-contracted BSPs selected during the tenders for balancing capacity are obliged to place mandatory bids for balancing energy corresponding to the pre-contracted volume. In addition to this, pre-contracted BSPs and any other interested parties may place additional bids[10] (also known as voluntary or free bids) for balancing energy. All bids are combined in one merit order. A difference between the Dutch and the Belgian market is that Belgian BSPs need to provide their aFRR balancing energy bids day-ahead before 18:00h while the Dutch BSPs are allowed to provide their bids until one hour ahead of operation.

As explained in chapter 2.3.2, the German TSOs do not explicitly select balancing energy bids as the balancing energy price is provided together with the balancing capacity price during the combined tender. The German TSOs do not regard any additional bids for balancing energy as done by the TSOs in Belgium and the Netherlands. Furthermore, in Germany the balancing energy volume and price is provided for a whole week during the weekly auction for the peak and the off-peak product.

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[9] This requirement is stipulated in §6 (2) of the *Strom-Netzzugangsverordnung* (StromNZV). Currently, no exclusive procurement is conducted.

[10] Due to the pro-rata activation of aFRR, Elia in practice hardly receives additional bids.

2.3.4. Selection, activation and remuneration of balancing energy

The selection, activation and remuneration of balancing energy bids for aFRR differ between all three countries:

- Belgium: The selection of the balancing energy bids takes place D-1 at 18:00. Elia selects up to 150MW of aFRR (both upward and downward) according to their price starting with the lowest one. Elia activates all bids that have been selected day-ahead in parallel according to their participation factors for pro-rata activation. The remuneration is based on the pay-as-bid principle; however BSPs have to regard the price caps applied by Elia.
- The Netherlands: All bids provided up to H-1 are sorted in a common merit order, and depending on the system needs sequentially activated in real time respecting the merit order. In case of larger system imbalances TenneT NL may activate more than one bid in parallel (with the result that the activated volume is higher than the real time need for aFRR). The activated energy is remunerated at the marginal price[11] of the combined automatic and manual FRR activation for each ISP.
- Germany: Balancing energy bids are selected by the TSOs according to their price for balancing capacity during the tender approximately one week ahead. All selected bids are sorted afterwards according to their balancing energy price in a common (German-wide) balancing merit order list starting with the cheapest one. Depending on the system needs the German TSOs activate the bids sequentially in real time starting with the lowest bid. The activated balancing energy is remunerated at the offered price.

Table 2 compares how the TSOs activate aFRR in real time and how the settlement volume and price towards the BSP is determined.

[11] The marginal price is set by the most expensive bid which has been activated during the ISP, even if activated only for a very short period of time (i.e. a couple of seconds).

	Question	Answer Belgium	Answer the Netherlands	Answer Germany
1	What is requested by the TSO?	Successive discrete control requests in MW are sent to the BSP (the ramp rate limitation in MW/min as implied by the actual volume of bids activated from that BSP is not exceeded).	Successive discrete control requests in MW are sent to the BSP (the ramp rate limitation in MW/min as implied by the actual volume of bids activated from that BSP is not exceeded).	Successive discrete control requests in MW are sent to the BSP (BSPs are requested to provide the full amount and take into account the ramp restrictions themselves).
2	How does the TSO request it?	Every 10s a signal is sent to the BSP how to change the set point to be followed by BSP.	Every 4s a signal is sent to the BSP how to change the set point to be followed by BSP.	Every 4s a signal is sent to the BSP how to change the set point to be followed by BSP.
3	How is the volume for settlement towards the BSP determined?	The requested volume (integral of the signal send to BSP, per kWh) is settled.	The requested volume (integral of the signal send to BSP, per kWh) is settled.	The delivered volume (integral of the measurement of the BSP) is settled.
4	How is the price for settlement determined?	The weighted average price of the selected bids per provider.	Marginal price cross-product aFRR and mFRR.	Pay as bid – "best-accounting-method[12]".

Table 2: Comparison of aFRR activation and settlement methods

The comparison reveals important differences how the TSOs request and settle aFRR: whilst Elia and TenneT NL consider the ramp rates when requesting aFRR the German TSOs don't. As a consequence in Belgium and the Netherlands the requested volumes can be used for the settlement whereas the German TSOs have to use the delivered volume for settlement. Moreover, each country applies a different method to determine the settlement price towards the BSP. In combination with the price caps applicable in Belgium and to certain extend in the Netherlands and the combined balancing capacity and balancing energy procurement in Germany, these settlement methods trigger in each country a certain pricing behaviour of BSP.

2.4. Manual Frequency Restoration Reserves (mFRR)

2.4.1. Product specification

mFRR balancing capacity is contracted in Belgium, Germany and the Netherlands. However, mFRR balancing energy is only used intensively in Belgium, far less in Germany and hardly in the Netherlands. All three countries facilitate the participation of both generation and load for mFRR. All TSOs activate mFRR only after almost all aFRR is activated, hence there is no economic optimisation between aFFR and mFRR performed. Same as for aFRR Elia and TenneT NL facilitate the participation of additional balancing energy bids. Whereas TenneT NL only pre-contracts upwards balancing capacity for emergency purposes, Elia uses additional bids alongside with balancing energy bids from pre-contracted reserves. The German TSOs do not allow for additional

[12] If within an ISP several bids with different prices from one BSP are activated, the TSO starts accumulating the delivered volume in the cheapest (usually first) bid multiplied by the price, afterwards in the next more expensive bid and so on.

bids and similar to aFRR procure balancing capacity and balancing energy in a combined auction selecting the successful bids according to their balancing capacity price only. On top of these differences, the product definitions for mFRR differ significantly between the three countries:

- Belgium: Elia relies on non-contracted and pre-contracted mFRR products. The mainly activated mFRR products are the non-contracted CIPU bids that are provided for upward and downward regulation. Elia only contracts reserves for upward regulation and there are different types of pre-contracted mFRR products: besides the "R3 production" there is a set of mFRR products with some particularities with regard to the number of activations and the maximum duration during a certain time period (R3 dynamic profile and interruptible loads). The latter are typically provided by load and are only activated at the very end of the merit order (after all additional bids and contracted R3 production were activated) and therefore in practice are hardly ever activated. All R3 products, non-contracted and pre-contracted are directly activated. When activated, Elia asks in principle for power (MW), but due to the direct activation the BSP shall ramp up/down in accordance with the specification of the activated unit, which are known by Elia;
- The Netherlands: TenneT NL uses two different mFRR products; a standard balancing energy product per ISP (upwards/downwards) and a standard balancing capacity product "emergency power" (*Noodvermogen*). Emergency power is only procured for upward regulation purposes and designed to be used only in case of a sudden large generation outage or an outage of an importing HVDC interconnector. Consequently, it is rarely activated. Emergency power can be provided by load and generation and is the only product that TenneT NL contracts balancing capacity for. Emergency power can be directly activated whereas the balancing energy product is scheduled activated per ISP. When activated, TenneT NL requests for energy (kWh, MWh) to be delivered within an ISP. There is no power profile attached to this and the BSP fulfilled its obligation if the delivered energy (MWh) summed up during the ISP corresponds to the energy offered in the activated bid.
- Germany: The German TSOs use one mFRR standard product per 4-hour interval and direction (upwards/downwards) called *"Minutenreserve"*. The mFRR product is scheduled activated for the next ISP. In case the mFRR call was send less than 7.5 minutes before the next ISP, the BSP has to provide mFRR only in the next but one ISP. When activated, the German TSOs ask for power (MW) to be delivered from the first to the last second of an ISP, thus, the BSP has to ramp up/down before the ISP and ramp back within the consecutive ISP. Besides this standard product the German TSOs may use interruptible loads *(Abschaltbare Lasten)* that are procured in a separate market and are only activated when almost all aFRR and mFRR is utilized. Since interruptible loads are not part of the dimensioning of operational reserves and are hardly ever activated, they will not be further detailed in this study.

The differences described afore are graphically displayed in Figure 3.

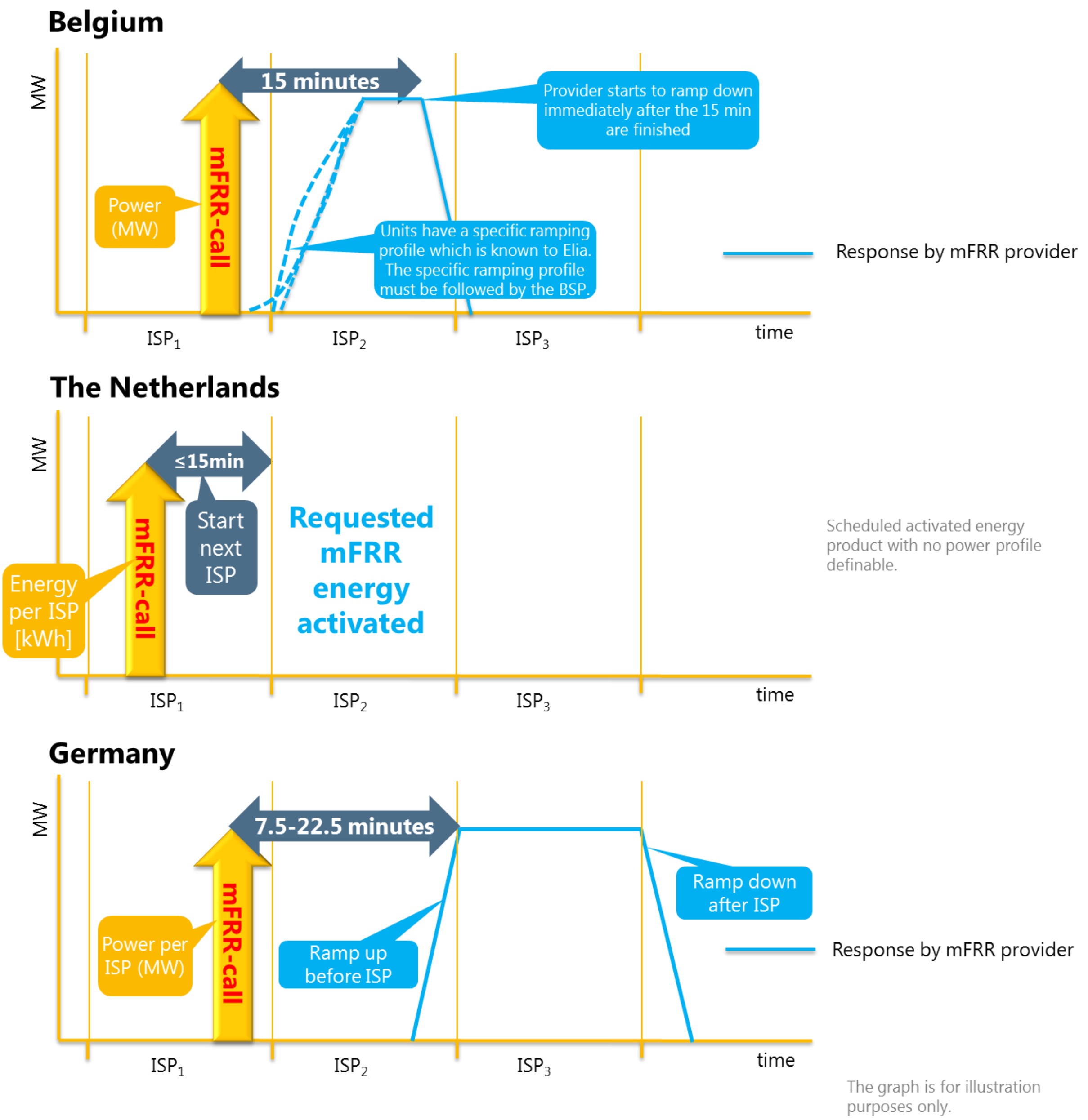

Figure 3: Schematic comparison of mFRR activation and response

2.4.2. Procurement of balancing capacity

As indicated earlier there are some fundamental differences in the way balancing capacity is contracted.

- **Belgium**: Elia only contracts mFRR balancing capacity for upward regulation. The annual tender for R3 production takes usually place in June. The annual tender for the remaining mFRR products takes place in October. Balancing capacity is contracted for three different resolutions in time: base, peak and long off-peak[13]. The availability requirement for R3 production and R3 dynamic profile is 100% whereas there are different rules applicable for interruptible loads. Only providers of R3 production may transfer their contract to another BSP up to day-ahead. Further for R3 production and R3 dynamic profile, the BSP may link bids or add conditions.

[13] Long off-peak includes besides the off-peak hours during the week (20:00-08:00h) all weekend hours.

The guiding principle for the balancing capacity bid selection by Elia is overall cost minimisation. On top of that some special rules for the R3 dynamic profile are applied[14].

- The Netherlands: TenneT NL only contracts upward balancing capacity ('emergency power') which should cover the imbalance caused by a sudden large outage. The product resolution is one year. This 'emergency power' is procured via an annual tender and the availability must be defined by the provider in its offer. When selecting bids the overall cost minimisation is the guiding principle, however TenneT prioritises bids with at least 97% availability and with a preferred start-up time of up to 10 minutes (maximum is 15 minutes). Emergency power is remunerated pay-as-bid.
- Germany: The German TSOs procure mFRR balancing capacity for upward and downward regulation. The auctions take place usually day-ahead at 10:00h; except for Sundays and Mondays for which balancing capacity is always procured on Fridays. The product resolution in time is four hours starting with the time period 00:00-04:00h and ending with 20:00-24:00h. The availability requirement is 100% and to guarantee this, BSP may transfer their contract to other prequalified units of another BSP within the control area (BSP may add/delete units to/from mFRR pool for every 15 minutes). The bid selection takes place according to the price for balancing capacity, starting with the cheapest bid. The BSP are remunerated according to the offered price (pay-as-bid).

2.4.3. Bids for balancing energy

As indicated in section 2.4.1 fundamental differences exist in the procurement of mFRR balancing energy between the Belgian and Dutch market on the one hand and the German market on the other hand. Both, Elia and TenneT NL operate a balancing mechanism for the final selection and activation of mFRR balancing energy bids having a product resolution in time of 15 minutes. The differences are:

- Belgium: Pre-contracted BSPs selected during the tenders for balancing capacity (only for R3 production) are obliged to place mandatory bids for balancing energy corresponding to the pre-contracted volume at D-1 18:00h. The price shall be equal to the 'free price' as offered in the CIPU contract and hence can be updated until H-1. Further generation units with an installed capacity of more than 75MW have to bid all their "available capacity" (mandatory requirement). On top of this pre-contracted BSPs and any other interested parties (generators <75MW, consumption) may place additional bids for mFRR balancing energy. For the latter and the mandatory bids from generators >75 MW a gate closure of H-1 is applicable. All bids contain a starting price and an activation price. Furthermore, so called implicit bidding is applicable: this means that BSP only place price bids, whereas the volumes are determined by Elia based on the current production schedule of each generator.
- The Netherlands: Generation units with an installed capacity >60MW have to provide mandatory bids for "available capacity" (providers have to declare availability, in practice these bids are seen as voluntary bids). Additionally any other interested parties (generators <60MW, consumption) may place bids for mFRR balancing energy.
- Germany: The German TSOs do not explicitly procure balancing energy bids as the balancing energy price is provided together with the balancing capacity price during the combined tender. Currently, the German TSOs do not regard any additional bids for balancing energy as

[14] Elia does not accept more than 40MW from one single BSP, more than 45MW from two BSPs and more than 50MW from three BSPs. mFRR balancing capacity is remunerated pay-as-bid.

this is the case in Belgium and the Netherlands. Further, the balancing energy volume and price is provided for a time period of four hours (six daily four hour windows)[15].

2.4.4. Selection, activation and remuneration of balancing energy

The selection, activation and remuneration of balancing energy bids for mFRR differ between all three countries:

- Belgium: BSP may bid or adjust their bids for balancing energy (non-contracted bids and R3 production[16]) up to one hour before real time (gate closure at H-1). Elia activates first all non-contracted bids according to the price merit order followed by the contracted bids (also price merit order). R3 dynamic profile and interruptible loads are only activated at the very end of the merit order. For non-contracted bids portfolio activation is applicable (even though the offers are unit-based). The pre-contracted reserves are activated unit-based. The remuneration is based on the pay-as-bid principle. For R3 dynamic profile there is no payment for energy applicable.
- The Netherlands: BSP may bid or adjust their bids for balancing energy up to one hour before real time (gate closure at H-1). All bids are sorted in a common merit order and depending on the system needs, are sequentially activated in real time respecting the merit order. TenneT NL only activates full bids. The activated balancing energy is remunerated at the marginal price of the combined automatic and manual FRR activation for each ISP.
- Germany: All balancing energy bids are sorted in a common (German-wide) merit order list. Depending on the utilisation of aFRR the German TSOs activate mFRR balancing energy bids sequentially in real time starting with the cheapest bid. The activated balancing energy is remunerated at the offered price. There are no pricing restrictions applicable, neither to the balancing capacity nor to the balancing energy price.

Table 3 compares how the TSOs request mFRR in real time and how the settlement volume and price towards the BSP is determined. The comparison shows that there are differences between the methods applied by the TSOs.

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[15] For the German TSOs implementing additional mFRR balancing energy bids is an interesting option for developing the mFRR market. Any decision must be approved by the regulatory authority.

[16] For pre-contracted R3 production only prices can be adjusted up to H-1; the corresponding volumes have to be provided at D-1 18:00h.

	Question	Answer Belgium	Answer The Netherlands	Answer Germany
1	What is requested by the TSO?	Direct activated power profile product	Scheduled activated energy product, without a power profile attached	Scheduled activated power profile product
2	How does the TSO request it?	Manual activation by dispatcher	Manual activation by dispatcher	Semi-automatic activation by dispatcher (Merit Order List server)
3	How is the volume for settlement towards the BSP determined?	Requested energy derived from requested power profile (incl. ramp rates)	Requested energy amount[17]	Delivered volume within a ISP (ramps are not included)
4	How is the price for settlement determined?	Pay-as-bid	Marginal price cross-product aFRR/mFRR	Pay-as-bid

Table 3: Comparison of mFRR activation and settlement methods

2.5. Imbalance Settlement

Appendix A provides an overview of the detailed arrangements for imbalance settlement. Regarding similarities, all three countries have implemented a reactive balancing philosophy with arrangements that aim at providing clear and effective incentives for BRPs to keep their balance. However, comparing the balancing philosophy more in detail reveals bigger differences, especially between the Belgian and Dutch imbalance settlement arrangements on one side and the German on the other side.

Besides providing incentives for self-balancing, the arrangements in Belgium and the Netherlands also aim at delivering system support: Balance Responsible Parties (BRP) are incentivised to reduce the system imbalance of the TSO's control area within an ISP. This is common practice in the Netherlands since many years. In Belgium BRPs are legally allowed to actively respond to system imbalance since 2014[18], however, the BRP always need to have the physical capacity available that would allow them to keep their own BRP balance.

In order to incentivise BRPs, the imbalance prices in Belgium and the Netherlands are equal to the marginal price for the activation of both, aFRR and mFRR. Therefore in both countries the imbalance prices reflect the system status. However, there are differences in the detailed pricing method.

As shown in Appendix A, Elia applies a single price system with additional components that are added in case the system imbalance exceeds 140MW (both directions). IGCC imbalance netting volume is considered as aFRR activation and therefore included in the imbalance price calculation

[17] As marginal pricing is applicable TenneT does not measure what is provided by the BSP as any deviation from the requested volume will cause imbalances in the balance group of the BSP. Thus a non-delivery of mFRR will not be profitable.

[18] In practice most BRPs already actively responded to system imbalance before this date.

as an automatic FRR activation. IGCC netting adds to the aFRR volume and is priced at the capacity weighted average price that is paid for aFRR balancing energy.

In the Netherlands, there are two basic imbalance pricing schemes: single and a dual pricing. Their application depends on whether TenneT NL took balancing actions only into one direction or into both directions within the ISP. Different to Belgium, in the Netherlands the effect of the IGCC imbalance netting is directly applied to the ACE and consequently reduces the ACE, the activation of aFRR and thus the marginal control energy price and the imbalance price.

Both TSOs, Elia and TenneT allow BRP to adjust their schedules D+1 (ex-post scheduling). This aims at minimizing the imbalance of two BRPs where one BRP trades its negative against another BRP' positive deviation.

As indicated, the German TSOs have also a reactive balancing philosophy, yet the execution differs from the Belgian and the Dutch one. The contractual obligation on the German BRP is to be in balance for every ISP and any predictable deviation is seen as an infringement of duties *(Prognosepflichtverletzung)*. In case of unplanned outages of generation units, BRP are legally obliged to be in balance at the latest at the end of the consecutive three ISPs (after 45-60 minutes)[19].

BRP have the possibility to trade intraday and adjust their schedules 15 minutes prior to every quarter of an hour. Furthermore, ex-post scheduling is currently still[20] allowed within a control area until 16:00h of the next working day. By doing so, the BRPs may minimize their exposure to the imbalance price that is only known 20 days after the delivery month.

The imbalance price does not seem to provide the equally high incentives to the BRP as does the Dutch or the Belgian one. On the one hand, the publication of the imbalance price only 20 working days after the delivery month as opposed to shortly after the actual delivery, should incentivise BRP to make the best prognosis possible in order to minimize deviations thereby mitigating their risk of being exposed to unfavourable imbalance prices. On the other hand, the calculation method of the imbalance price, which determines an average balancing energy price leads in principle to lower imbalance prices compared to a marginal pricing system, where the most expensive bid activated sets the imbalance price. Like in the Netherlands, the IGCC imbalance netting reduces the net imbalance and thus the average balancing energy price.

The imbalance settlement period is 15 minutes in all three countries. Further the costs for balancing capacity are not taken into account for imbalance settlement but are recovered through use of system charges.

2.6. On-going developments and potential changes

In addition to the ongoing investigations in the framework of the ENTSO-E pilot projects, Elia and the German TSOs investigate the following changes to their national balancing market design:

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[19] The BRP is allowed to (and should) be in balance earlier than legally required.

[20] The Federal Network Agency (Bundesnetzagentur) is running at the moment a public consultation (number BK6-14-044) that aims at abolishing this possibility for ex-post scheduling. Background is that some BRP have abused this rule and thereby created a risk for the system as well as financial losses for the TSOs.

- Belgium: Elia decided to move to a monthly procurement period for FCR and aFRR balancing capacity from 2015 onwards. Shorter procurement periods and procurement closer to real time reduces the price and availability risk for BSP. This would decrease barriers to entry for new BSP thereby fostering competition which would ultimately lead to lower prices.
- Belgium: An analysis is ongoing whether to implement a merit order based activation for aFRR instead of the currently applied parallel pro-rata activation. The implementation of a merit order based activation of aFRR may be one step towards a potential cooperation in cross-zonal activation of aFRR balancing energy. On the other hand, abolishing the system of pro-rata activation of aFRR may result in a lower regulation quality in Belgium.
- Belgium: An analysis is ongoing to move from implicit unit bidding to explicit portfolio bidding for mFRR.
- Germany: The TSOs currently investigate to extend the existing procurement mechanism by allowing for additional bids for aFRR and mFRR.

2.7. Quantitative Analysis

All TSOs pre-contract balancing capacity. The volume of FCR to be procured by the TSOs is determined on ENTSO-E level and depends on the total production volume of each control area. The production volume in Germany is around 5.5 times higher than in the Netherlands and about 7 times higher than in Belgium. The Belgian and the Dutch market have a more comparable size and the amount of FCR procured by both TSOs is shown in Figure 4. TenneT NL procures twice as much aFRR balancing capacity as does Elia. In contrary, Elia procures twice as much upward mFRR capacity as TenneT NL. Furthermore, both TSOs have access to additional bids. Figure 4 shows that both TSOs receive on average a quite significant amount of additional bids, especially for mFRR. Whereas TenneT NL receives also additional bids for aFRR, Elia in practice does receive only occasional amounts.

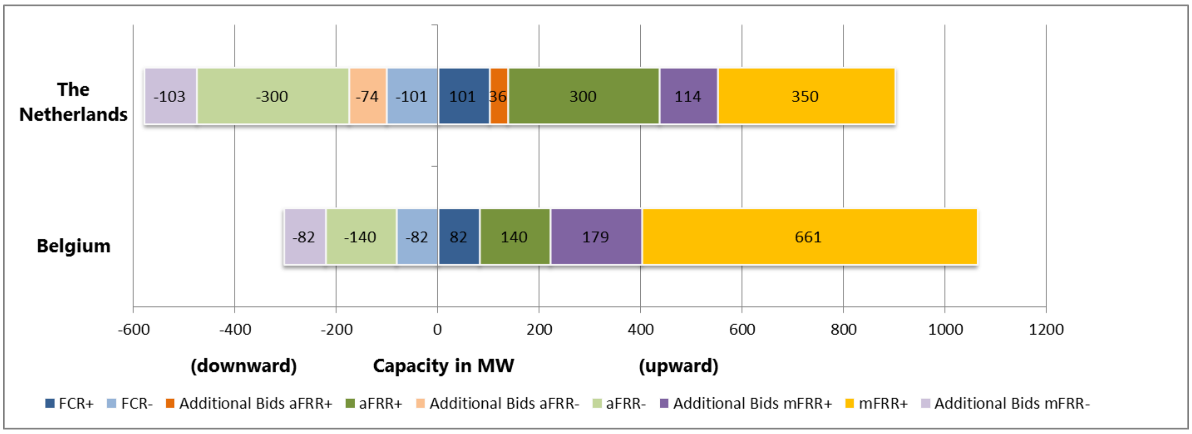


Figure 4: Average volume of operational reserves in Belgium and the Netherlands[21]

Figure 5 shows that the German TSOs make only use of pre-contracted balancing capacity and do not use additional bids. When comparing the procured volumes to the production volume, the German TSOs procure overall more balancing capacity than TenneT NL. The same holds when

[21] E-Bridge, based on data provided by Elia and TenneT NL. All figures are given for the year 2014. Whereas the procured FCR and FRR capacities are the same for the whole year, the figures given for the additional bids in BE and NL are the average figures for the period January to April 2014.

comparing the procured German volume for upward balancing capacity to the Belgian volumes. Whilst the Belgian and the Dutch TSO do not procure any downward mFRR balancing capacity, the German TSOs procure a rather significant amount of 2,831MW.

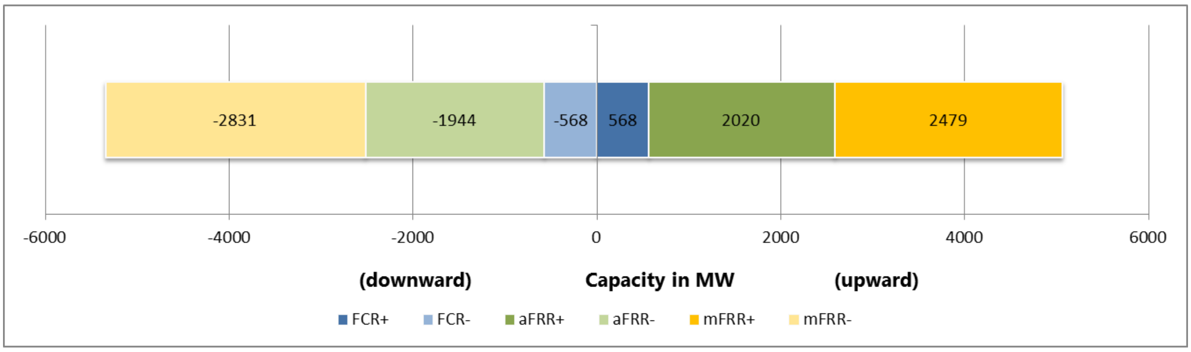


Figure 5: Average volume of contracted operational reserves in Germany[22]

Figure 6, Figure 7 and Figure 8 display the monthly aggregated volumes of activated balancing energy per ISP. The diagrams highlight very well the contribution of the IGCC imbalance netting by avoiding the counter-activation of aFRR between different TSOs and thereby significantly reducing the activation of balancing energy from aFRR.

Figure 6 shows that during 2013 and the first month of 2014 Elia activated slightly more downward than upward balancing energy on average. Thus the BRP were in total rather long. In comparison with TenneT NL and the German TSOs, Elia activates a considerable amount of mFRR in relation to aFRR. Furthermore, the diagram shows that Elia usually activates additional mFRR bids. Upward mFRR from pre-contracted balancing capacity is hardly activated: during the considered time period, these only played a significant role during January and October 2013.

[22] E-Bridge, based on data published under www.regelleistung.net. All figures are given for the year 2014. The procured FCR volume is the same for the whole year, whereas the procured FRR volumes change approximately every quarter. The displayed values are the average values of Q1 (starting with 06.01.14) and Q2 2014.

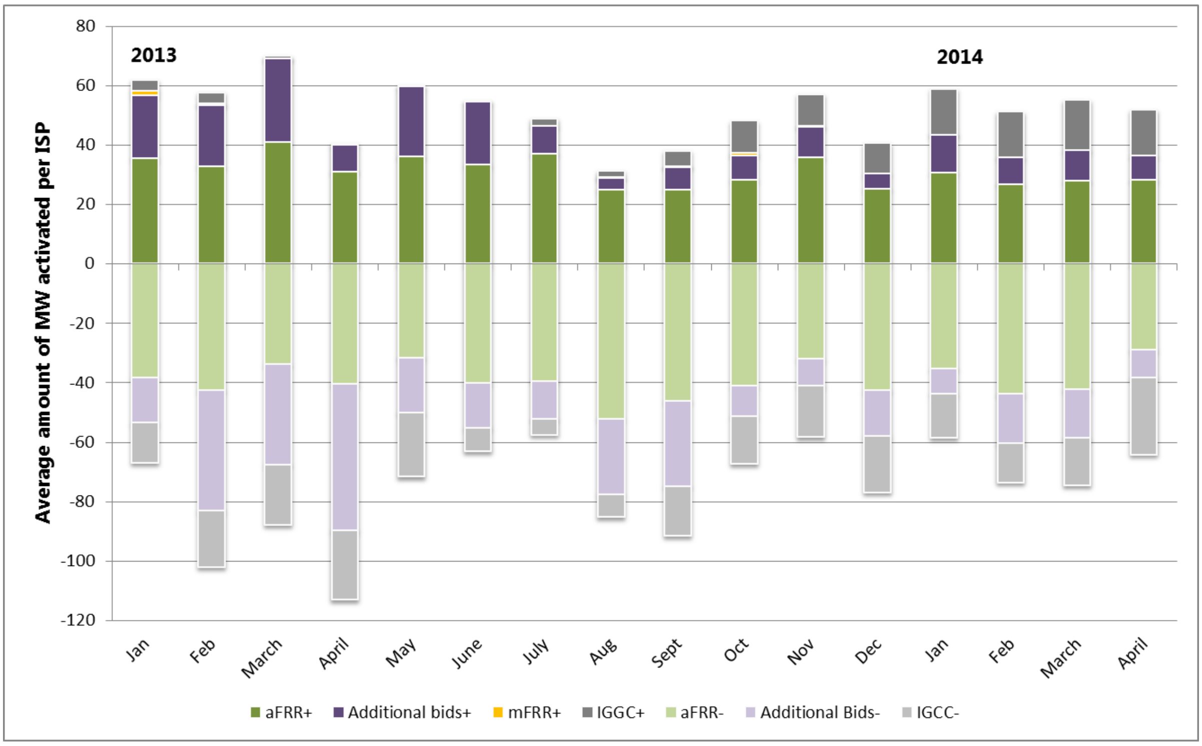


Figure 6: Belgium: monthly aggregated volumes of activated balancing energy per ISP (01/2013 – 04/2014, by type of service)[23]

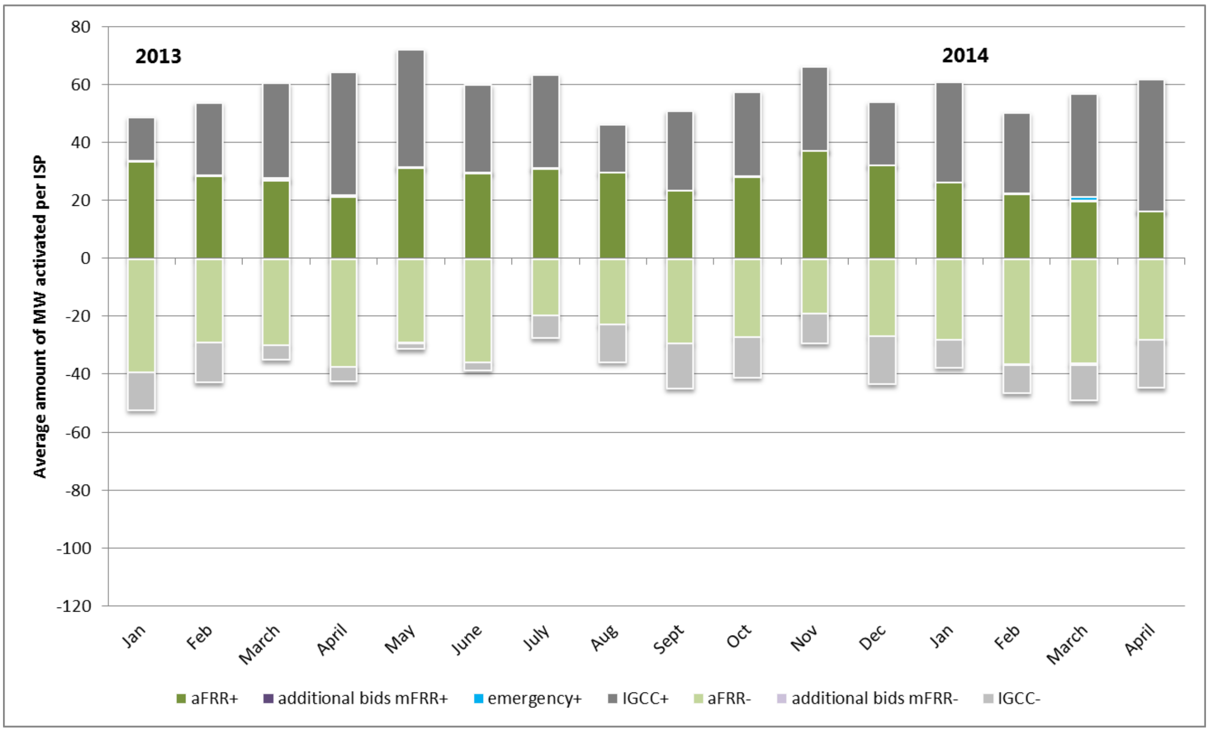


Figure 7: The Netherlands: monthly aggregated volumes of activated balancing energy per ISP (01/2013 – 04/2014, by type of service)[24]

[23] E-Bridge, based on data published by Elia (www.elia.be)
[24] E-Bridge, based on data published by TenneT NL (www.tennet.eu)

TenneT NL mainly relies on aFRR to balance its control area. Additional bids from mFRR are hardly activated and their volume is too small to be seen in Figure 7. In contrary to Belgium, the BRP were in total rather short during 2013 and the first month of 2014. Thus TenneT activated on average slightly more upward than downward balancing energy.

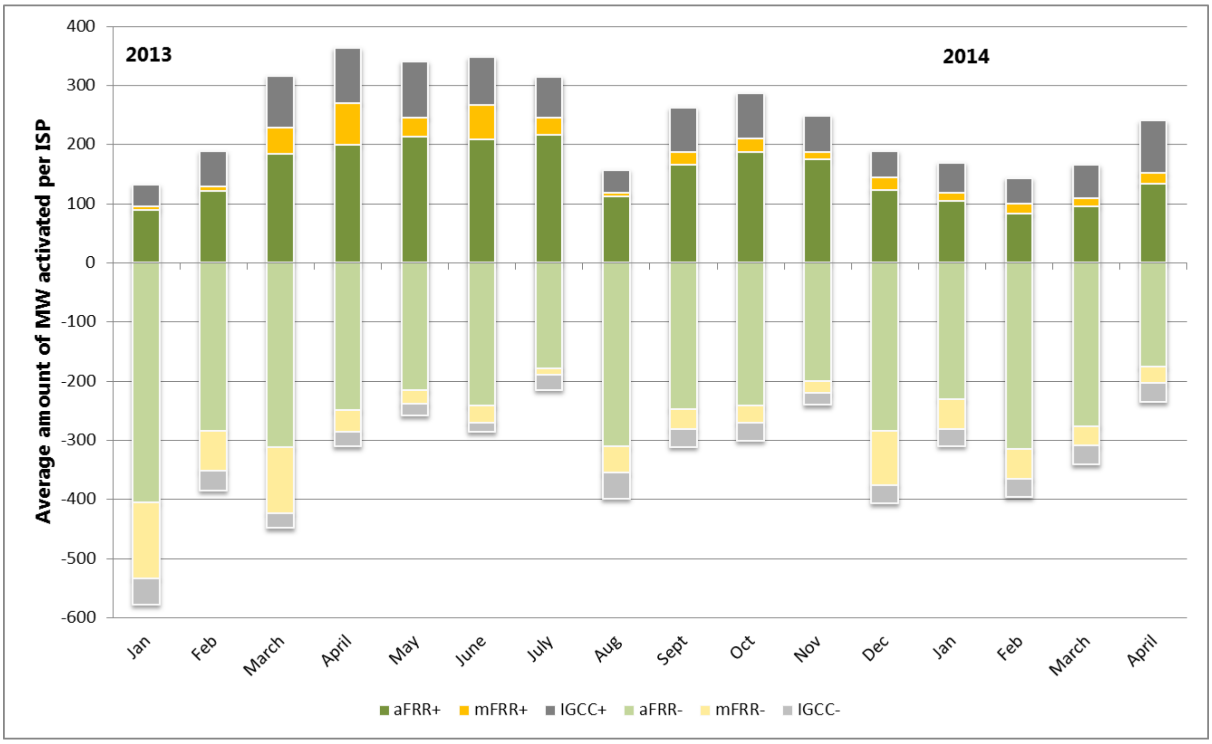


Figure 8: Germany: monthly aggregated volumes of activated balancing energy per ISP (01/2013 – 04/2014, by type of service)[25]

Figure 8 shows that during 2013 and the first month of 2014 the German TSOs activated on average slightly more downward than upward balancing energy, thus the BRP were in total rather long. Further the German TSOs activate to the biggest extend aFRR and much less mFRR.

Figure 9 displays the distribution of balancing energy prices, which BSPs received for activated balancing energy during 2013. As these prices are not published in Germany the distribution of the balancing energy price[26] (reBAP) is displayed instead. Except for the extreme ends of the duration curves there is especially for downward regulation not much difference between the Belgian and Dutch marginal price. The extreme ends of the curves indicate that Dutch BSP earn a higher margin from providing balancing energy than Belgian BSPs.

[25] E-Bridge, based on data published under www.regelleistung.net

[26] The reBAP is the coefficient of the sum of what was paid to the BSP for activation energy (costs-revenues) and the overall activation energy volume (for all German control areas).

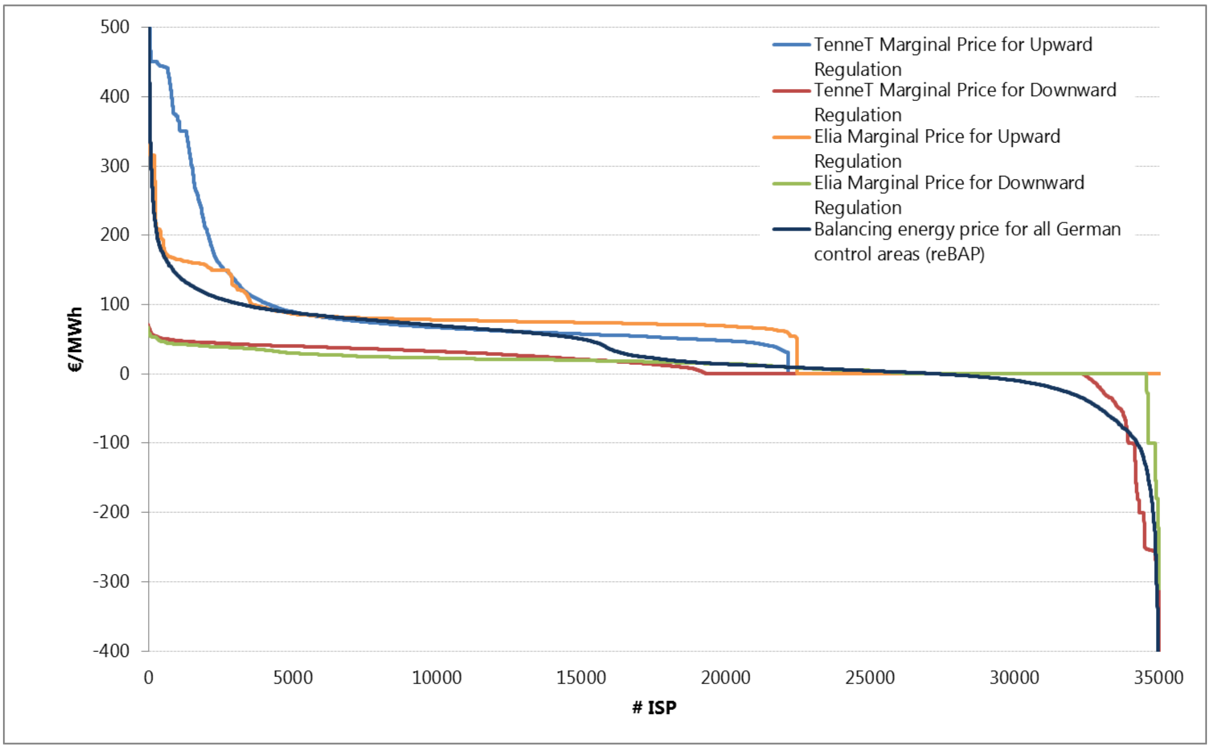


Figure 9: Duration curve of balancing energy prices in Belgium, the Netherlands and Germany in 2013[27]

[27] E-Bridge, based on data published under www.elia.be, www.tennet.eu and www.transnetbw.de.

3. Options for Potential Cross-Border Cooperation

3.1. Introduction

This chapter discusses potential options for cross-border cooperation in balancing. The reasons to cooperate are twofold: on one hand countries may benefit from more efficient balancing of demand and generation resulting in lower costs and/or higher quality. On the other hand the FG EB require TSOs to apply imbalance netting, to standardise the balancing energy and balancing capacity products, to harmonise the main features for imbalance settlement and to facilitate the cross-zonal exchange of balancing energy from mFRR and RR.

Cooperation may be restricted by operational security constraints. Besides maintaining defined quality targets[28] for load-frequency control each TSO must be able in the event of European-wide disturbances to manage the system balance with the balancing resources located in its control area.

Consecutively potential options for cooperation in balancing will be discussed more in detail starting with the requirements deriving from the FG EB.

3.2. Relevant Requirements of the Framework Guideline on Electricity Balancing

The FG EB concentrates on aFRR, mFRR and RR. FCR are not in the scope of the FG EB. In December 2012, ACER requested ENTSO-E to deliver a Network Code that is in line with the principles as set out by the FG EB. The draft NC EB was delivered to ACER in December 2013 after public consultation in summer 2013. ACER provided its reasoned opinion in March 2014 and requested ENTSO-E to adjust the NC EB accordingly before it can be recommended for adoption. ACER expects the NC EB not to enter into force before September 2015.

Within 1 year after entry into force of the NC EB TSOs have to present:

- A proposal for standard balancing energy and balancing capacity products, and
- A proposal for the pricing method based on marginal pricing ('pay-as-cleared')[29]

Within 2 years after entry into force of the NC EB:

- TSOs have to minimise counteractive activation of balancing energy by applying imbalance netting, and
- A multilateral TSO-TSO model with a common merit order list with margins for balancing energy from RR must be established.

[28] Currently the quality targets are laid down in the UCTE Operation Handbook. In the future the requirements from the NC LFC&R will be applicable.
[29] Unless TSOs provide all NRAs with a detailed analysis demonstrating that a different pricing method is more efficient for EU-wide implementation.

Within 3 years after entry into force of the NC EB:

- The harmonisation of the main features for imbalance settlement is required,
- TSOs have to present a proposal for the target model for the exchanges of balancing energy from aFRR, and
- TSO have to present a proposal for the modifications of the multilateral TSO-TSO model with a common merit order list with margins[30] for balancing energy from RR and mFRR that shall enter into force only 1 year later.

Within 4 years after entry into force of the NC EB

- A multilateral TSO-TSO model with a common merit order list with margins for balancing energy from RR and mFRR must be established,
- TSOs shall 'coordinate' the activation of balancing energy from aFRR[31] including the coordination with mFRR and RR.

Within 6 years after entry into force of the NC EB:

- A multilateral TSO-TSO exchange model with a common merit order list for balancing energy from mFRR and RR must be implemented, and
- TSOs shall implement the target model for aFRR.

Further the FG EB require the implementation of a balancing energy market that allows for the participation of additional balancing energy bids (also called voluntary bids or free bids that are provided in addition to the balancing energy bids from pre- contracted balancing capacity). Furthermore, the gate closure for balancing energy bids shall not be before H-1. BRPs shall be incentivised to balance themselves or to help balancing the electricity system. TSOs shall facilitate this by publishing volumes and prices of activated balancing energy in the previous ISP and the system imbalance shortly after real time.

FG EB allows the TSOs to use cross-zonal capacity (CZC) that remains unused after the intraday market gate closure for exchanging balancing energy. Any ex-ante reservation of cross-border capacity for exchanging or sharing of reserves must be proven by a solid cost-benefit analysis. Alternative the FG EB recommend the application of a probabilistic approach.

The FG EB put a lot of emphasis on harmonisation and TSOs only have limited possibilities to define specific national products. Moreover, any proposal for specific national products must be complemented with thorough justifications and with a proper cost-benefit analysis.

With regard to the common merit order of balancing energy bids TSOs have to justify the application of any unshared bids when submitting such proposal to the national regulatory authorities for approval:

- The volume of unshared bids shall not be higher than the amount of procured balancing capacity;

[30] A certain amount of the most expensive balancing energy bids can be not shared.
[31] The FG EB does not strictly require the use of a common merit order list for aFRR.

- For the purpose of transparency, all balancing energy bids shall be shared in one common merit order list, whereas unshared bids can be marked unavailable for activation by other TSOs;
- The volume of unshared bids should take into account the availability (e.g. using a statistical or probabilistic approach) of the balancing energy bids from the common merit order list.

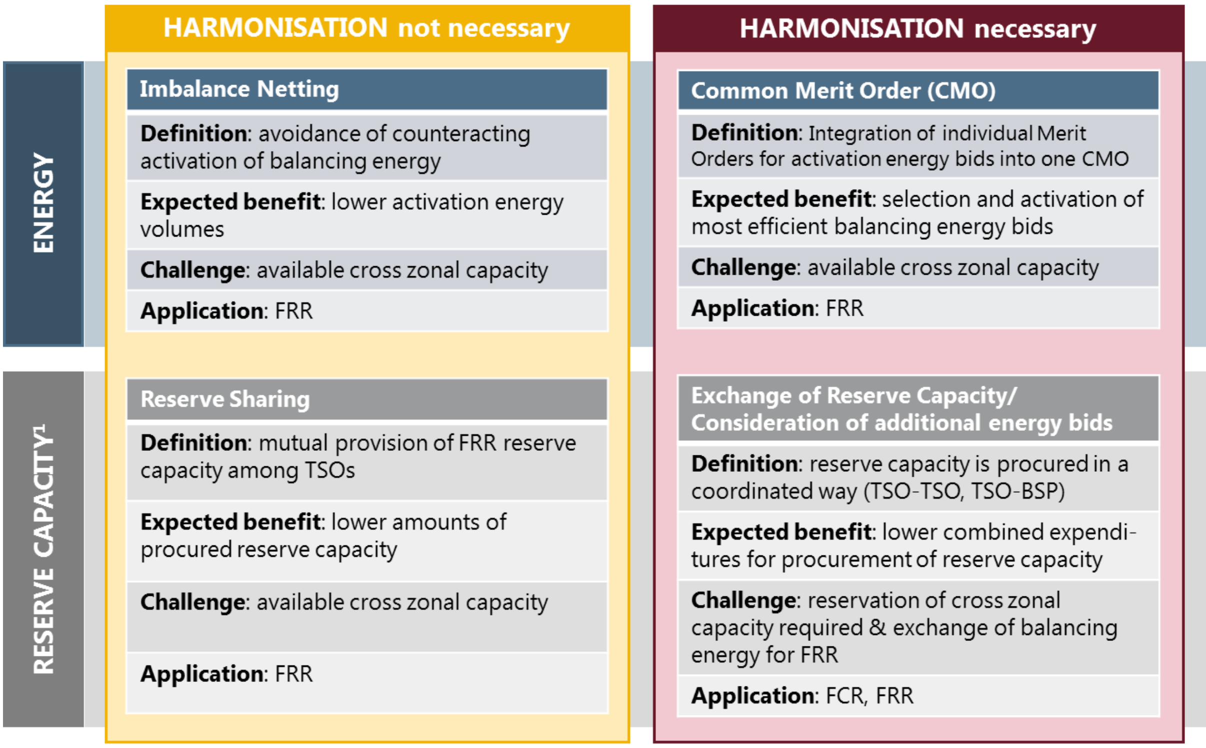
3.3. Principal options for cross-zonal cooperation in balancing

In principle the TSOs of the three countries could cooperate for all balancing products that they use today.

For almost all cooperation options CZC must be available. Appendix B provides diagrams showing the available CZC after intraday trading for the Dutch-German and the Dutch-Belgium border for the years 2009 and 2013. We note that at the moment there are no direct physical interconnectors between Belgium and Germany[32]. The diagrams show that for all borders and directions there are longer time periods where substantial amount of CZC is available. However, the diagrams also show that availability of CZC is different between hours, days and years and that therefore TSOs cannot completely rely on the availability of CZC for exchanging balancing services. There are always hours of the year that all CZC is used by the spot and forward markets.

In principle the cross-zonal cooperation possibilities can be distinguished into options that require harmonisation by the TSOs and options that do not require any harmonisation. Further there are options to cooperate for balancing capacity and options to cooperate for balancing energy. All these options are displayed in Figure 10.

[32] However, there are two interconnections under implementation: an AC connection between Luxemburg (part of the German control block) and Belgium planned to become operational in 2016 and a DC link between Germany and Belgium ("ALEGrO") planned to become operational in 2019.



[1] Further investigation is needed if "common dimensioning" as an option to cooperate for reserves requires harmonisation.

Figure 10: Options for cross-zonal cooperation for balancing capacity and balancing energy

In the consecutive sections these options for cooperation will be described more in detail.

3.3.1. Options for FCR

The FCR volume is determined for the whole synchronous area and each TSO must ensure its initial FCR obligation. Sharing of FCR is not allowed as this would reduce the overall available FCR for the synchronous area. Thus the only option for cross-zonal cooperation in FCR is exchanging FCR balancing capacity. Doing so, TSOs do not physically exchange FCR between countries but take over initial obligations from other TSOs. Therefore the harmonisation of specific product quality is not required. Yet, in order to create a level playing field the alignment of the procurement time frames and the applicable penalty scheme in case of non-delivery is recommended.

Further the exchange limits for FCR as laid down in the draft NC LFC&R must be obtained:

- *"The TSOs of a LFC Block shall ensure that at least 30 % of their total combined Initial FCR Obligations, (…) is physically provided inside their LFC Block; and*
- *the amount of FCR Capacity, physically located in an LFC Block as a result of the Exchange of FCR with other LFC Blocks, shall be limited to the maximum of:*
  - *30 % of the total combined Initial FCR Obligations (…) of the TSOs of the LFC Block to which the FCR Capacity is physically connected; and*
  - *100 MW of FCR Capacity."*

For exchanging FCR no CZC reservation is required as long as this does not lead to an increase of the transmission reliability margin.

Neither the FG EB nor other European regulation requires cooperation for FCR. The existing cooperation of the German, Swiss and Dutch TSOs for the procurement of FCR is founded on a merely voluntary basis and the motivation was that TSOs saw benefits in a common procurement procedure and allocation. As FCR must be procured by all TSOs further potential of this cooperation option will be analysed more in detail in chapter 4.

3.3.2. Options for aFRR and mFRR

There are several potential options to cooperate for aFRR and mFRR: TSOs may minimise counteracting activation of balancing energy by applying imbalance netting, integrate individual merit order lists for balancing energy into one common merit order list and cooperate for balancing capacity.

3.3.2.1. Netting of Imbalances

Imbalance netting – the avoidance of counteracting activation of balancing energy constitutes the easiest option for FRR cooperation with the lowest technical complexity with regard to its implementation. As noted earlier the implementation of imbalance netting is also required by the FG EB.

Imbalance netting was first implemented between the four German control areas as the first module of their GCC. In October 2011 it was extended to the IGCC when the Danish TSO Energinet.dk joined the cooperation. TenneT NL and Elia joined the IGCC in February and October 2012 respectively. By automatic netting of active power imbalances across control area borders cross-border counteracting activation of balancing energy is avoided. This enables all participating TSOs to reduce their utilisation of balancing energy.

As the potential of imbalance netting is fully utilized between the three countries this option will not be regarded further in this study.

3.3.2.2. Common Merit Order Lists for balancing energy

The FG EB require a multilateral TSO-TSO model with a common merit order list with margins[33] of balancing energy from mFRR and RR four years after entry into force of the NC EB at the latest. Even though the FG EB does not strictly require the use of a common merit order list for aFRR the TSOs shall 'coordinate' activation of aFRR with mFRR and RR[34].

Establishing a common merit order list for balancing energy (aFRR and mFRR) requires a fair amount of harmonisation: the procurement procedures and time frames need to be harmonised as well as the products. Further the TSOs have to align on activation and settlement principles. To mention only one example, in order to establish a common merit order list of balancing energy from aFRR the response requirements need to be harmonised which could mean that either Belgium and Germany have to accept a slower aFRR product or Belgium and the Netherlands need to introduce a faster aFRR. Changing this has an impact on other aspects of the balancing market design. Introducing a slower product in Belgium and Germany will lead to a lower balancing quality while the introduction of higher ramp rates in the Netherlands may reduce available aFRR and will consequently increase costs and reduce possibilities for BRPs to contribute to the system balance. This example shows that by changing one aspect of the market design the impact on other aspects needs to be carefully analysed and considered. For cross-zonal activation

[33] A certain amount of the most expensive balancing energy bids can be not shared.
[34] In case RR is introduced in the market area.

of aFRR and mFRR remaining CZC after the intraday gate closure can be used that should be always available in at least one direction.

While cooperation is not trivial also the potential benefits are difficult to estimate. The reason for this is that potential benefits result from both, the required harmonisation of the considerably different markets designs and the cooperation. This requires so many assumptions making any quantitative comparison and benefit calculation rather impossible.

However, there are several reasons why a further investigation of the establishment of a common merit order list for both, aFRR and mFRR should be further investigated. First of all, the 'cooperation on mFRR balancing energy' and the coordination with aFRR activation are required by the FG EB after the entry into force of the NC EB. Further all TSOs make extensive use of aFRR activation why all countries could potentially benefit from cooperation. On top of this, Elia and to a lesser extend the German TSOs make frequent use of mFRR activation. The implementation of a common merit order list for balancing energy is a precondition for exchanging of FRR balancing capacity and the consideration of additional bids for procurement of balancing capacity. Considering both, the 'cooperation on FRR balancing energy' and the 'cooperation on balancing capacity' may make the business case more positive. For all these reasons, the analysis of a common merit order list for both, aFRR and mFRR activation will be further regarded as recommended options for cooperation in chapter 4.

3.3.2.3. Cooperation for balancing capacity

With regard to aFRR and mFRR balancing capacity the following cooperation options were identified:

- Sharing of balancing reserve
- Exchanging of balancing reserve
- Common dimensioning of balancing reserve
- Consideration of additional balancing energy bids for procurement of balancing capacity

All these options require the availability of CZC that can be either guaranteed by ex-ante reservation after proving socio-economic welfare or the application of a probabilistic approach as suggested in the FG EB.

By **sharing balancing reserve** the total regional balancing reserve volume is reduced. Sharing of balancing reserve is only possible if the balancing reserve is used in exceptional cases. Since aFRR is used continuously, sharing of aFRR balancing reserve is no option. Considering these big hurdles sharing of aFRR balancing reserve will not be considered further in the scope of this study. Therefore, we will focus on sharing mFRR balancing reserve only.

According to the NC LFC&R the reduction of the positive/negative FRR balancing reserve of a LFC block by concluding a sharing agreement is limited to the difference, if positive, between the size of the positive dimensioning incident and the FRR balancing reserve required to cover the positive/negative LFC block imbalances in 99 % of time based on historical records and 30% of the N-1 limit.

An ex-ante reservation of CZC for mFRR reserve sharing may not be required if each TSO shares mFRR balancing reserve redundantly with more than one neighbouring TSO. However, there might be a risk that CZC is completely used in importing direction if the country has the highest electricity wholesale market price of all countries in the region. Redundancy works in the

Netherlands since the Dutch wholesale market price for electricity is usually in between the German and Belgian price. Based on this, TenneT NL shares already 300MW of mFRR balancing reserve with Elia and TenneT Germany.

Sharing of mFRR balancing reserve does not require the harmonisation of the mFRR product. In the very rare cases - usually the unplanned outage of a large generation unit – that one TSO requires the balancing energy from the shared balancing reserve the exchanged is based on a TSO to TSO contract.

As all TSOs in the scope of this study procure (at least upward) mFRR balancing reserve further potential of this option will be analysed more in detail in chapter 4.

The remaining three options for cooperation on balancing reserve, **the common dimensioning, the exchanging of balancing reserve** and **the consideration of additional balancing energy bids for procurement of balancing capacity** were only touched upon in the scope of this feasibility study. Especially the methods of common dimensioning and the consideration of additional balancing energy bids for procurement of balancing capacity (i.e. to procure less balancing capacity by taking local and cross border additional bids into account) require more time for discussion among the TSOs to allow any conclusion to be made. Whereas common dimensioning reduces the overall balancing reserve volume in the system of the TSOs cooperating exchanging of balancing reserve and the consideration of additional balancing energy bids ensures efficient procurement to ensure the availability of the required balancing capacity. Further the latter two options require the prior implementation of 'cooperation on FRR balancing energy' (i.e. the establishment of a common merit order list). Thus, exchanging balancing reserve will not be the first step for cooperation, but may help making the business case for implementing the 'cooperation on FRR balancing energy' positive.

3.4. Summary

Figure 11 lists all the potential options for cooperation discussed in this chapter. The options are sorted in a coordinate system reflecting their estimated complexity for introduction and the expected benefit. The estimated complexity is based on the TSOs' experience: for example TenneT NL and Germany cooperate on FCR and all TSOs have implemented imbalance netting. The benefits of the cooperation are qualitatively assessed and divided into the three categories 'high', 'unclear' and 'low'.

Figure 11 depicts that the less complex cooperation options are already fully or partially established. The more complex options for cooperation are also the options where the potential benefit is difficult to calculate and therefore unclear: the currently applicable FRR market designs diverge considerable between the three countries making any reliable quantitative comparison and benefit calculation highly complex.

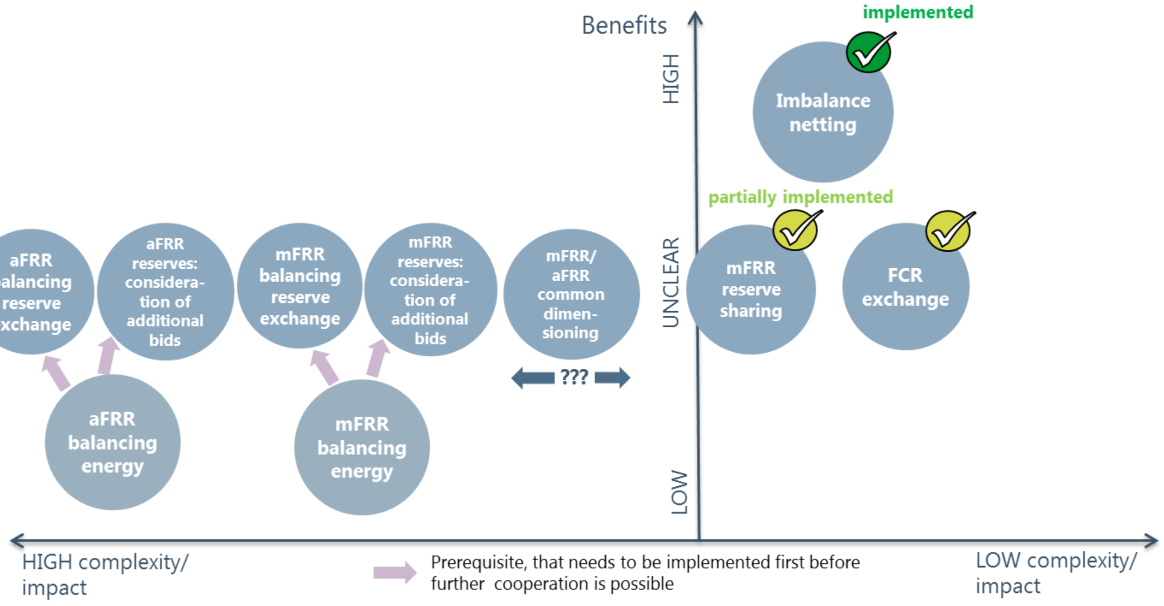


Figure 11: Options for cross-zonal cooperation for balancing capacity and balancing energy sorted by the level of complexity

4. Recommended options for integration

4.1. Introduction

The following options for cooperation are recommended for further analysis:

- FCR cooperation:
  - Analyse the prerequisites and consequences for Belgium joining the existing common procurement for FCR between Germany, the Netherlands and Switzerland.
  - Increase the amount of FCR exchange for TenneT NL and Germany (within the security limits set by the draft NC LFC&R);
- mFRR reserve sharing: Analyse further potential for mFRR reserve sharing (within the security limits set by the draft NC LFC&R);
- Activation of FRR balancing energy bids from a common merit order list: Start the discussion on the harmonisation of the aFRR and mFRR products with the aim of establishing a common merit order list for balancing energy as a first step and as prerequisite for cooperating on aFRR and mFRR balancing capacity;
- Further the investigation of the cooperation possibilities for FRR balancing capacity is recommended: the common dimensioning, the consideration of additional balancing energy bids for procurement of balancing capacity and the exchange of balancing reserves.

Except for the last one, all recommendations for cross-border integration will be discussed subsequently more in detail, explaining for each option the rational, showing the benefits and discussing drawbacks and risks.

4.2. Extending the existing FCR cooperation

4.2.1. Rational

FCR must be procured by all six TSOs. Since the total volume of FCR cannot be reduced (see section 3.3.1), the only possibility to increase overall efficiency is to procure FCR in countries with the lowest costs for FCR.

Since 2014, the German TSOs, Swissgrid and TenneT NL procure FCR in a common procedure using one common merit order list. BSP from all three countries may take part. Swissgrid procures in total 25MW and TenneT NL procures in total 35MW in the common procurement procedure.

We recommend Elia analysing the prerequisites for Belgium to join this existing common Dutch/German/Swiss FCR procurement. Additionally we recommend for the Dutch and the German TSOs to increase the amount of FCR for exchange respecting the limits set in the NC LFC&R. Table 4 shows for each country the required quantity of FCR in 2014 and the exchanged potential that can be still utilised. With "import" the quantity of FCR is meant that the TSO may procure maximum from foreign BSP. With "export" the quantity is meant that national BSP may provide in total to foreign TSOs.

	Belgium	The Netherlands	Germany
Required quantity for 2014	±82MW	±101MW	±568MW
Minimum FCR required in country	25MW	30MW	170MW
Maximum import potential	57MW	71MW	398MW
Currently procured in common procedure	0MW	35MW	60MW
FCR that can still be procured in common procedure/other countries	57MW	36MW	338MW
Maximum allowed FCR that can be exported to other countries	100MW	100MW	170MW
Maximum FCR that is currently exported to other countries	0MW	35MW	60MW
FCR that can still be exported to other countries	100MW	65MW	110MW

Table 4: Required FCR quantity and exchange potential respecting NC LFC&R

As already indicated exchanging FCR may generate concrete financial benefits. The prices paid by TenneT NL for FCR procured in the common procedure with Germany and Switzerland were in all weeks in the first half of this year on average lower than the prices for FCR procured in the national tender procedure. In some weeks the prices paid for FCR procured in the common tender procedure were up to 5 times lower than those from the national tender. However, the value of this comparison should not be overestimated as TenneT NL procures FCR only since 2014 and any new process has some "learning curve" with high prices at the beginning that settle after some time at the correct market value. Thus the prices achieved during May and June indicate that the prices for FCR procured in the national tender further converged to about 30 % higher level than the prices obtained in the common procedure. It should be noted that prices may further converge or even get lower than the German prices.

Besides, we have made a qualitative analysis based on the assumption that there will only be benefits of coupling FCR reserve markets if price differences between markets exist for specific periods in time. Price differences between FCR reserve markets may result from different market rules, laws, taxes and subsidies or from physical differences between reserve providing portfolios. Since there is no need for coupling markets if the benefits can be realised by only changing the rules, we focus on physical differences between reserve providing portfolios. Different portfolios may provide reserves with different efficiency/cost which may change over time by (continuously) changing fuel and activation costs. This includes both generation (including renewables) and interruptible load. For FCR we see the following potential benefits from differences in generation portfolio:

- **2014**: Only Germany has big share of prequalified hydro, nuclear and lignite units. At times when one or more of these type of units are a cheaper source of FCR than gas fired units in Belgium, Germany and the Netherlands, Germany may be a large provider of FCR. A similar effect may apply to hard coal units, which are available in Germany and the Netherlands;
- **Future:** A decreasing potential is expected due to the nuclear phase out in Germany and the phase out of old hard coal units in the Netherlands. There might be a potential benefits in exchanging FCR from renewables if there is a difference in the feed-in tariff and the feed-in pattern.

4.2.2. Preconditions and Constraints for Elia joining the procurement

Since for exchanging FCR cross-zonal capacity reservation and the harmonisation of the specific product quality is not required this cooperation option is one of the less complex ones from an implementation point of view.

Table 5 shows that Elia currently procures four different FCR products. Only the 'R1 symmetrical 200mHz' product is comparable with the FCR products that are procured in the other two countries. If Elia will join the common Dutch/German/Swiss procurement procedure, this product could be easily exchanged. However, also a combination of the other three products in fact results in the 'R1 symmetrical 200mHz' product and could therefore be exchanged in the common procurement procedure. Hence, there is no need to remove these products from the Belgian market.

The required changes and issues that need to be analysed and potentially harmonised if Elia joins the common Dutch/German/Swiss procurement procedure are shown in Table 5. An issue that needs to be analysed is how to deal with the currently applied co-optimization with aFRR. This bears the risk of a significant cost increase for Elia as today there is a combined procurement for FCR and aFRR in order to minimize the costs for must-runs.

Even though the procedure for imbalance adjustment for activation and the penalty scheme differ between Belgium on one side and the Netherlands and Germany on the other side, aligning this is not a precondition for cooperation. However, it needs to be noted that this does not provide a level playing field for BSP and the latter should be harmonised in case the NC EB will require the establishment of a cross-zonal secondary market for FCR.

	Belgium	The Netherlands	Germany
Capacity product	▪ **R1 symmetrical 200mHz** ▪ **R1 symmetrical 100mHz** ▪ **R1 upwards** [-200mHz, -100mHz] ▪ **R1 downwards** [+100mHz, +200mHz]	1 standard product, *similar to Belgian* **R1 symmetrical 200mHz** product: FCR shall be activated as a linear function of frequency deviation between -200mHz (+100%) and +200mHz (-100%)	1 standard product, *similar to Belgian* **R1 symmetrical 200mHz** product: FCR shall be activated as a linear function of frequency deviation between -200mHz (+100%) and +200mHz (-100%)
Product resolution	Yearly and monthly peak/long off-peak/base, from 2015 onwards only monthly	Weekly base	Weekly base
Bid selection	Co-optimization with aFRR, objective is to minimize FCR and aFRR costs	Lowest possible total costs: CMO starting with the lowest bid price	Lowest possible total costs: CMO starting with the lowest bid price
Min. bid	1MW	1MW	1MW
Max. bid	Prequalified volume	Prequalified volume	Prequalified volume
Partial bid acceptance	Elia may accept partial bids in steps of 0.1MW	TenneT NL may accept partial bids in steps of 1MW	TSOs may accept partial bids in steps of 1MW
Imbalance adjustment for activation	Yes, for symmetrical 200mHz product	No	No
Capacity re-muneration	Pay-as-bid	Pay-as-bid	Pay-as-bid
Energy re-muneration	No energy remuneration	No energy remuneration	No energy remuneration
Penalty in case of non-availability	In case CSS<0: 5*CSS[35] In case CSS>0: 1.3*CSS Min. penalty of 10 €/MWh (*penalty capped for year to annual income and for month to 2*monthly income*)	10 times bid price (corresponding to the time and capacity of non-availability)	10 times bid price (corresponding to the time and capacity of non-availability)

Table 5: Overview of the FCR product definitions to be harmonised

Further the approval of the national regulatory authority is required to implement the changes needed for the Belgian market design to allow Elia to join the common procurement platform. This includes the approval of going from yearly respectively monthly to weekly tenders and a letter of comfort that any price obtained for FCR in the common procurement will be accepted by the regulator[36].

The experience of TenneT NL that little effort was needed when joining the common procurement platform is not completely applicable to Belgium since the starting situation for Belgium is a situation in which FCR is already procured. TenneT NL did not procure FCR before 2014 and introduced the German/Swiss products and procedures when joining the common procurement platform.

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[35] Clean Spark Spread

[36] Belgian regulation requires the Belgian regulator to approve the price paid for reserve capacity.

4.2.3. Preconditions and Constraints for increasing the volume for TenneT NL and the German TSOs

TenneT NL and the German TSOs already procure FCR via a common procedure. We did not identify any preconditions to increase the amount of FCR for exchange. The only constraint to be respected is the exchange limit defined in the NC LFC&R.

4.2.4. Risk Assessment

Table 6 the risks for Elia joining the common procurement of FCR are listed and assessed. For the second recommendation, the Dutch and German TSO increasing the volume of FCR procured today via the common tender we did not identify any risk or additional costs.

Risk	**Assessment**	**Explanation**	**Mitigation**
Regulation quality/ reliability	(0)	No issues expected	
Costs	(-)	Risk of significant cost increase for Belgium as today there is a combined procurement for FCR and aFRR in order to minimize the costs for must-runs.	Weekly tender should lower the need to create must-runs. German BSP may provide FCR at much lower costs than Belgian BSPs. Coordinate the local aFRR procurement with the cross-zonal FCR procurement aiming at minimising the risk of an increase of must-runs.
Implementation Technical complexity (i.e. harmonisation effort, process and IT changes)	(-) (0)	Elia will have to change existing processes and IT systems (i.e. for settlement) if joining the common procurement platform. Belgian BSPs will have to change their processes and IT system.	
Implementation Legal/regulatory/ contractual framework	(-) (0)	Today the prices for FCR have to be approved by the Belgian NRA. Keeping this procedure will be difficult when procuring FCR in a common weekly tendering procedure. Approval needed by Belgian NRA to change to a weekly FCR procurement procedure.	Official confirmation from Belgium NRA needed, that costs will be accepted whatever the outcome of the weekly procurement is.

Table 6: Overview of potential risks and measures for mitigation for Eli joining the common procurement of FCR

If the current draft version of the NC EB enters into force, the implementation of a secondary market for FCR when forming a coordinate balancing area (CoBA) will be required. The German, Dutch and Swiss TSOs form already a CoBA for FCR and therefore this may be a fact to be regarded in future. For Elia this can be seen as an additional risk when joining the common Dutch/German/Swiss procurement procedure.

4.3. Sharing of manual Frequency Restoration Reserves (mFRR)

4.3.1. Rational

mFRR balancing capacity is procured by all TSOs, whereas Elia and TenneT NL only procure upwards mFRR balancing capacity. The draft NC LFC&R[37] obliges all TSOs of a LFC block:

- to determine the positive/negative FRR capacity such that it is not smaller than the positive/negative dimensioning incident of the LFC Block, and
- to ensure that the positive/negative FRR Capacity (or a combination of FRR and RR capacity) is sufficient to cover the positive/negative LFC block imbalances in at least 99 % of the time based on the historical record.

These dimensioning rules result in the fact that the total procured FRR capacity is only activated very few hours a year. As it is very unlikely that two LFC blocks would need to activate their full amount balancing capacity at the same time, there is a potential to reduce the amount of balancing capacity to be procured by both TSOs and share a part of the reserves and thereby reduce costs.

Reserve sharing is less complex to implement than exchanging of reserves as it does not require the harmonisation of the mFRR product.

TenneT NL shares all procured mFRR balancing capacity ("emergency reserves") already with Elia and the German TSOs. There is currently no additional potential left.

Elia only pre-contracts upward mFRR balancing capacity. Same as TenneT NL Elia shares also reserves. It needs to be investigated if some further potential for upward reserves (incremental) is left.

Both, TenneT NL and Elia do not pre-contract downward mFRR balancing capacity. In case the draft NC LFC&R is not interpreted in a way that "sufficient FRR capacity" can be also ensured by regarding additional bids at H-1, TenneT NL and Elia may have to procure more mFRR balancing capacity for both, upward and downward. To reduce the therewith associated costs TSOs may make further use of reserve sharing, however, only if Elia and the German TSOs are able to decrease the amount.[38]

The rules in the NC LFC&R do not allow the German TSOs to share mFRR reserves as the FRR balancing capacity for the dimensioning incident is much lower than the 99%-percentile of the historical imbalances. Currently the German TSOs procure FRR balancing capacity that covers the historical imbalances for 99.975% of time.

4.3.2. Constraints and Preconditions

As described in section 3.3.2.3 reserve sharing is limited by the rules laid down in the draft NC LFC&R: reserve sharing is allowed if FRR balancing capacity to cover the dimensioning incident

[37] Article 46 2.

[38] Besides reserve sharing, exchanging of reserves will be another option to facilitate efficient procurement in case Elia and TenneT NL have to pre-contract also decremental (downward) reserves. Having a common merit order for mFRR (and aFRR) balancing energy bids in place is a prerequisite for exchanging reserves (see also recommended options for integration, chapter 4.4.1 and 4.5.1).

exceeds the amount of FRR balancing capacity required to cover the historical imbalances for 99% of time. Further the maximum FRR reduction is limited to 30% of the dimensioning incident.

Reserve sharing does not require any harmonisation of the mFRR product. However, for the activation of the shared balancing capacity cross-zonal capacity is needed.

4.3.3. Risk Assessment

In Table 7 the risks identified are listed and assessed.

Risk	Assessment	Explanation	Mitigation
Regulation quality/ reliability	(0)	Risk if cross-zonal capacity is not reserved ex-ante	Sharing agreement with all neighbouring TSOs may make it likely that at least at one border cross-zonal capacity is available.
Costs	(+)	Potential to reduce mFRR balancing capacity costs	
Implementation Technical complexity (i.e. harmonisation effort, process and IT changes)	(0)	No real risks: the procurement procedure for mFRR reserve needs to be adjusted in Germany and a process established with TenneT NL to activate the shared reserve	
Implementation Legal/regulatory/ contractual framework	(0)	For Germany the acceptance of the NRA is needed	
Impact on BRP/BSP (i.e. self-balancing incentives)	(0)	Less income for BSP because TSOs procure less mFRR balancing capacity: on one hand risk for reducing the number of BSPs, on the other hand potential benefit due to increased competition	

Table 7: Overview of potential risks and measures for mitigation when sharing mFRR balancing capacity

4.4. Activation of aFRR balancing energy bids from a common merit order list

4.4.1. Rational

aFRR balancing energy is the main source for balancing in all three countries. Our qualitative analysis (approach was explained in section 4.2.1) came to the same results for aFRR as for FCR. There might be potential benefits for the cooperation due to the large German hydro, nuclear and lignite portfolio. In case price differences persist the potential benefit might be higher than for mFRR since the activated aFRR volume is larger and is expected to increase in future. However, harmonisation is challenging and required for any cooperation.

There is further a legal rational for cooperation. Within one year after entry into force of the NC EB TSOs have to present a proposal for the standard balancing energy and balancing capacity products. Even though the FG EB does not require the implementation of cross-zonal exchange of aFRR, further investigation is useful as this allows Elia, TenneT NL and the German TSOs to strongly influence the development of the standard product.

Having a common merit order for aFRR balancing energy bids in place opens the possibility for cross-zonal cooperation for aFRR reserves (common dimensioning, consideration of additional balancing energy bids for procurement of balancing capacity and exchange of reserves) and may make the business case more positive.

4.4.2. Constraints and Preconditions

The main issues are organisational and technical issues that need to be harmonised. The ongoing investigation between Elia and TenneT NL revealed that the devil is in the details and finding solutions to overcome national market design differences is crucial for success. Table 8 highlights which issues need to be at least analysed and potentially harmonised.

	Belgium	The Netherlands	Germany
Ramp rate	13.3% of offered bid volume	≥ 7% of offered bid volume	Full provision after 5min
Procure-ment procedure	▪ Mandatory bids for contracted reserves ▪ Additional bids by other generators Gate closure: D-1 at 18:00	▪ Mandatory bids for contracted reserves ▪ Mandatory bids for "available capacity" of generators >60MW Gate closure: H-1	Additional bids not available, balancing energy is procured in combination with balancing capacity W-1
Product resolution	15min	15min	Week (peak/long off-peak)
Activation	Pro-Rata based on selected bids in D-1, consequently parallel activation	Sequential by energy CMO (parallel activation in case of larger system deviations)	Sequential by energy CMO, TSOs do not activate bids in parallel with the aim to increase the ramp rate
Remunera-tion energy	▪ Pay-as-bid ▪ Requested is paid	▪ Marginal pricing (cross-products aFRR/mFRR) ▪ Requested is paid	▪ Pay-as-bid ▪ Metered is paid
Pricing restrictions	Price caps: ▪ Downward: 0€/MWh ▪ Upward: Fuel cost of CCGT with 50% efficiency + 40€/MWh	Price caps for contracted capacity only: ▪ Downward: D-1 spot price - 1,000€/MWh ▪ Upward: D-1 spot price +1,000€/MWh	none

Table 8: Overview of the aFRR product definitions to be harmonised

The most crucial point will be the harmonisation of the response requirements. It needs to be investigated whether Belgium and Germany may accept a slower aFRR product, Belgium and the Netherlands need to introduce a faster aFRR or Germany and the Netherlands introduce the Belgium ramp rate. Changing this has an impact on other aspects of the balancing market design. Introducing a slower product in Belgium and Germany will lead to a lower balancing quality while the introduction of higher ramp rates in the Netherlands may reduce available aFRR and will consequently increase costs and reduce possibilities for BRPs to contribute.

By all means, the German TSOs will have to implement a balancing market design that allows for the participation of additional balancing energy bids. It needs to be carefully investigated if the introduction of additional bids will be sufficient to start the cooperation, or if the whole procurement regime must be changed by procuring aFRR balancing energy separately from aFRR balancing capacity as foreseen in the NC EB. In conjunction with this the question must be answered whether additional balancing energy bids and pre-contracted balancing bids can be merged to one common merit order.

Another crucial point is the harmonisation of the activation procedures for aFRR. The working assumption is that all TSOs introduce sequential activation by merit order list. Refraining from pro-rata parallel activation may impact the regulation quality in Belgium and the impact and possible mitigation measures need to be carefully analysed.

The remuneration of balancing energy is another point that requires thoughtful analysis. In theory TSOs may establish a common merit order list while keeping different pricing schemes in the countries and accepting the absence of a level playing field for BSPs. However, the combination of the pay-as-bid and the marginal pricing scheme will have an impact on the transparency and traceability of balancing energy prices for BSPs and in the end on the prices for balancing energy and balancing capacity bid by the BSP in the different countries. Last but not least also the effect of different remuneration schemes on the imbalance prices needs to be carefully regarded. However, to start the cooperation the harmonisation of the imbalance settlement is not a precondition.

To allow TSOs to activate a bid from the common merit order list, cross-zonal capacity must be available.

4.4.3. Risk Assessment

As highlighted in the previous section the introduction of a common merit order list for aFRR balancing energy is not trivial and the effects and potential risks by changing the existing market design requires careful consideration. Table 9 shows an overview of the risk assessment and suggests potential measures for mitigation.

Risk	Assessment	Explanation	Mitigation
Regulation quality/ reliability	(-) (-)	Lower regulation quality when introducing a slower aFRR product in BE and DE Lower availability of reserve providing units when introducing a faster aFRR product in NL and BE	Investigate possible options for dealing with a slower aFRR product Investigate possible options for dealing with a faster aFRR product
Costs	(-) (-) (0)	Risk of increasing cost in case of a faster aFRR product in NL and BE Risk of increasing cost due to larger contracted volumes in BE Costs for changing current systems (automatic aFRR selection etc.)	Investigate possible options for dealing with a faster aFRR product and related cost effects
Implementation Technical complexity (i.e. harmonisation effort, process and IT changes	(-)	Technically very challenging details need to be harmonised. The devil is in the details that need to be harmonised: even slight differences can cause problems	Allow for time needed to make a thoughtful analysis and consult with BSPs and regulators
Implementation Legal/regulatory/ contractual framework	(-)	NRAs of all three countries have to agree on pricing method (pay-as-bid/marginal[per product, cross products, per country, cross country]) Standard products still need to be proposed by ENTSO-E and approved by ACER. Risk for not being compliant	Allow for time needed to make a thoughtful analysis and consult with all market participants
Impact on BRP (i.e. self-balancing incentives)	(-) (-)	Reduced costs for balancing may decrease incentives for BRPs Higher ramping requirements will reduce potential of BRP to deliver system support in NL and BE	Analyse adjustment of imbalance pricing scheme

Table 9: Overview of potential risks and measures for mitigation when establishing a CMO for aFRR balancing energy bids

4.5. Activation of mFRR balancing energy bids from a common merit order list

4.5.1. Rational

mFRR balancing energy is used intensively in Belgium, far less in Germany and hardly in the Netherlands. All countries have access to significant volumes of mFRR.

If the decision needs to be taken whether to start cooperating for mFRR or aFRR balancing energy it is clearly recommend to start with aFRR as it is used more intensively. However, the FG EB puts a lot of emphasis on the implementation of cross-zonal exchange of mFRR. Thus there will be a legal requirement to cooperate as soon as the NC EB enters into force. Same as for aFRR, the TSOs have to present within one year after entry into force of the NC EB a proposal for the standard balancing energy and balancing capacity products. The development of this could be strongly influenced by the TSOs of the three countries, if continuing with the investigation on how to implement cross-zonal exchange of mFRR. Experience from the BE-NL pilot project revealed a lot of market design interactions between aFRR & mFRR. Hence any decision to start to exchange only mFRR and not aFRR needs to be carefully investigated.

Besides, having a common merit order for mFRR balancing energy bids in place opens the possibility for cross-zonal cooperation for mFRR reserves (common dimensioning, consideration of additional balancing energy bids for procurement of balancing capacity and exchange of reserves) and may make the business case more positive.

Our qualitative analysis (approach was explained in section 4.2.1) came to the same results for mFRR as for FCR and aFRR. There might be potential benefits for the cooperation due to the large German hydro, nuclear and lignite portfolio.

4.5.2. Constraints and Preconditions

Same as for aFRR, the main issues are organisational and technical issues that need to be harmonised. With regard to the technical complexity, agreeing on common principles to implement a common merit order for mFRR balancing energy bids should be easier compared to aFRR. Table 10 highlights the issues that need to be at least analysed and potentially harmonised.

	Belgium	The Netherlands	Germany
Basic product	**Power/Energy** ▪ In principle Elia asks for power, but BSP can ramp up/down within ISP and ramp back next ISP. ▪ Direct activation	**Energy** ▪ BSP has to deliver the offered energy (transactional minimum) within the ISP when its bid is activated. ▪ Scheduled activation per ISP, no power profile definable	**Power** ▪ BSP is requested to ramp before ISP, keep the requested position within the ISP (and for subsequent ISPs if requested by TSO), ramp to initial position afterwards. ▪ Scheduled activation per ISP
Procure-ment procedure	▪ Gate closure H-1: ▪ Mandatory bids for other 'available capacity' from generators >75MW ▪ Additional bids for generators <75MW and consumers	▪ Gate closure H-1 ▪ Mandatory bids for "available capacity" of generators >60MW ▪ Additional bids for generators <60MW and consumers	Additional bids not available, balancing energy is procured in combination with balancing capacity D-1 at 10:00h
Provision	Unit-based bids, but portfolio activation for additional bids	Portfolio-based (bids and activation)	Portfolio-based (bids and activation)
Bidding	Implicit bidding	Explicit bidding: bids contain price and volume information	Explicit bidding: bids contain price and volume information
Bid selection and activation	▪ Sequential activation of all additional bids based on merit order ▪ Afterwards contracted bids based on merit order	▪ Sequential activation of all additional bids based on merit order ▪ Afterwards contracted bids based on merit order	▪ No additional bids ▪ Contracted bids initially chosen by capacity price CMO are sequentially activated according to an energy price CMO
Activation time	≤ 15 minutes	≤ 15 minutes	22.5 – 7.5 minutes (between 15-7.5 minutes compulsive)
Remunera-tion energy	Pay-as-bid	Marginal pricing (cross-product aFRR/mFRR)	Pay-as-bid

Table 10: Overview of the mFRR product definitions to be harmonised

First of all the TSOs will have to agree on a standard product to be exchanged using the common merit order. Further analysis is necessary if limiting the scope to additional bids is a feasible way forward. On the one hand this allows the German TSOs to implement such product with a timely resolution of 15 minutes additionally to the existing mFRR product with a timely resolution of 4 hours. When putting a common merit order in place this approach may require that the German TSOs activate first all additional bids and only afterwards the pre-contracted bids, to be in line with the Belgian & Dutch approach. This could lead to situations where the German TSOs have to activate more expensive additional balancing energy while balancing energy bids from pre-contracted reserves would be available at a lower price. The alternative could be that the pre-contracted bids are part of the common merit order but marked as non-available for Elia and TenneT NL. Yet, as soon as the NC EB enters into force both approaches will have to be reassessed as the NC EB only allows the TSOs to keep the most expensive bids locally.

To allow TSOs to activate mFRR bids from the common merit order list, similar issues need to be investigated and potentially harmonised as for aFRR (section 4.4.2): the remuneration of balancing energy, the impact on the imbalance prices and the availability of cross-zonal capacity. Depending on settlement method, prices for mFRR balancing energy can increase significantly (for cross product aFRR/mFRR and cross-zonal marginal pricing) compared to the prices paid today in a pay-as-bid regime for mFRR balancing energy in Belgium and Germany. The activation of an mFRR balancing energy bid will not only affect the availability of CZC for IGCC but also for aFRR given a common merit order list is established.

4.5.3. Risk Assessment

The introduction of a common merit order list for mFRR balancing energy is technically not as challenging as for aFRR, yet there are potential risks when changing the existing market design.

Table 11 shows an overview of the risk assessment and suggests potential measures for mitigation.

Risk	Assessment	Explanation	Mitigation
Regulation quality/ reliability	(-) (0)	In Belgium risk for lower quality if mFFR product is standardised (currently Elia exactly knows the power schedule of each mFRR providing unit) For Elia move from implicit unit to explicit portfolio bidding is a substantial change with an important impact on existing tools	Investigate possible options for dealing with this issue
Costs	(-) (0)	If applying the Dutch approach for settlement (i.e. cross-product marginal pricing with aFRR energy), mFRR prices can increase significantly in Belgium and Germany. Risk for increased mFRR balancing capacity prices if the German TSOs decide besides the introduction of additional bids for separate procurement of balancing capacity and energy. Costs for changing current systems (automatic aFRR selection etc.)	The FG EB does not explicitly require separate procurement for balancing energy and reserves, but the consideration of additional bids up to H-1. To maintain a level playing field this could imply the allowance for pre-contracted mFRR reserves to adjust the balancing energy price up to H-1.
Implementation Technical complexity (i.e. harmonisation effort, process and IT changes	(-)	Harmonisation towards a standard product with same activation and settlement principles is challenging and will require a thorough analysis and time. For example the interaction between contracted and non-contracted bids needs to be assessed (how to build the CMO?)	Allow for time needed to make a thoughtful analysis and consult with all market participants and regulators
Implementation Legal/regulatory/ contractual framework	(-) (0) (-)	NRAs of all three countries have to agree on pricing method (pay-as-bid/marginal[per product, cross products, per country, cross country]) The Belgian Grid Code imposes to activate first the non-contracted reserves before the contracted ones Standard products still need to be proposed by ENTSO-E and approved by ACER. Risk for not being compliant	Allow for time needed to make a thoughtful analysis and consult with all market participants
Impact on BRP (i.e. self-balancing incentives)	(0)	Depending on the pricing method imbalance prices could increase in Belgium and Germany and provide strong balancing incentives. On the other hand activating the most efficient balancing energy bids from a CMO could also lead to lower imbalance prices.	

Table 11: Overview of potential risks and measures for mitigation when establishing a CMO for mFRR balancing energy bids

APPENDIX

A. Detailed Comparison of the existing Balancing Markets

B. Available cross-zonal capacity

C. List of Abbreviations

D. List of Figures

E. List of Tables

A. Detailed Comparison of the existing Balancing Products

Content

FCR - technical characteristics 1/2

	Belgium	The Netherlands	Germany
Basic product	Symmetric or asymmetric band	Symmetric band	Symmetric band
Capacity product	▪ **R1 symmetrical 200mHz** [-200mHz, +200mHz] ▪ **R1 symmetrical 100mHz** [-100mHz, +100mHz] ▪ **R1 upwards** [-200mHz, -100mHz] → typically load ▪ **R1 downwards** [+100mHz, +200mHz] → typically nuclear *(see definitions on slide 5)*	1 standard product[1], similar to Belgian **R1 symmetrical 200mHz** product: FCR shall be activated as a linear function of frequency deviation between -200mHz (+100%) and +200mHz (-100%)	1 standard product, similar to Belgian **R1 symmetrical 200mHz** product: FCR shall be activated as a linear function of frequency deviation between -200mHz (+100%) and +200mHz (-100%)
Response time	▪ 100% within 30s ▪ 50-100% within 15-30s ▪ ≤50% within 15s	▪ 100% within 30s ▪ 50-100% within 15-30s ▪ ≤50% within 15s	▪ 100% within 30s ▪ 50-100% within 15-30s ▪ ≤50% within 15s *(currently faster in DE)*
Available for	15 minutes	15 minutes	15 minutes
Deadband	▪ R1 symmetrical: Not allowed ▪ R1 upward/downwards: ±100mHz	Not allowed	-10mHz to +10mHz (around 50Hz)

[1] Units >60MW without contract obligations, still need to keep FCR on with a deadband of 500mHz and droop of 8%. Since this is an emergency measure, this 'product' will not be further discussed in the scope of this study.

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FCR - technical characteristics 2/2

	Belgium	The Netherlands	Germany
Insensitivity of controller	±10mHz	±10mHz	±10mHz
Required quantity[1]	±82MW (2014)	±101MW (2014)	±568MW (2014)[2]

[1] Based on Operations Handbook policy 1 A-G3
[2] Commonly procured by all German TSOs. Yet, according to §6 (2) of the StromNZV each TSO may procure a technically necessary share of FCR only from technical units connected in it's control area („*Kernanteil*"). This has to be justified by the TSO and approval of the regulatory authority is required.

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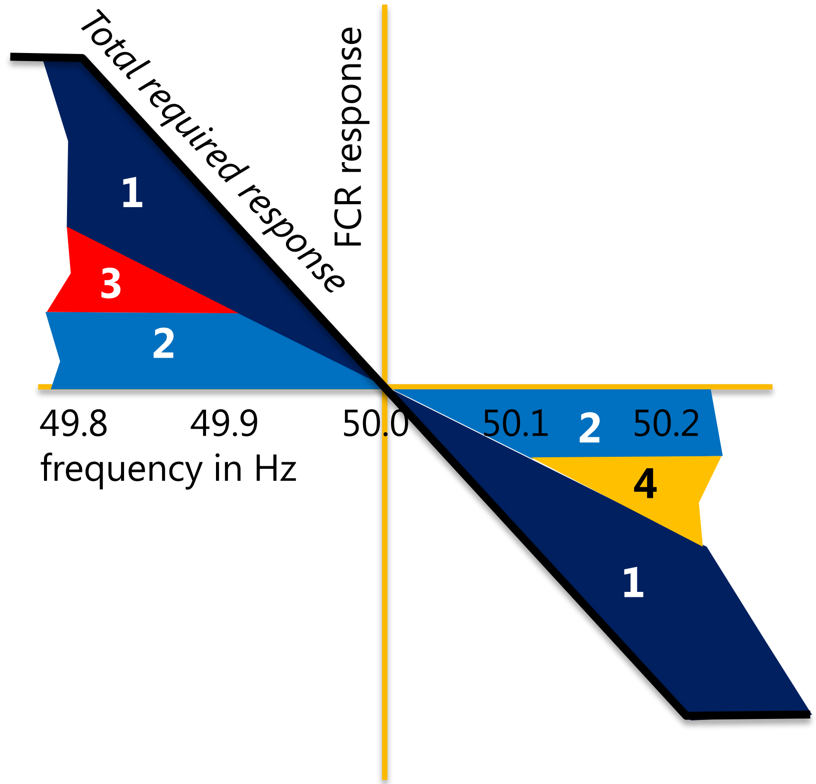
FCR products at Elia

1. **R1 symmetrical 200mHz**: this product is activated between -200mHz and + 200mHz, whereas the total contracted volume must be activated at the most extreme bands of the frequency interval indicated here above.
2. **R1 symmetrical 100mHz**: this product is activated between -100mHz and +100mHz, whereas the total contracted volume must be activated at the most extreme bands of the frequency interval indicated above. This maximum contracted volume must however also remain activated for frequency deviations between [-200mHz,-100mHz] and [100mHz, 200mHz].
3. **R1 upwards**: this product is activated between [-200mHz, -100mHz], whereas the total contracted volume must be activated at -200mHz. This product is mainly supplied by industrial clients (load).
4. **R1 downwards**: this product is activated between [100mHz, 200mHz], whereas the total contracted volume must be activated at 200mHz. This product is only supplied by base-load Elia-connected generation.



FCR – balancing capacity procurement 1/3

	Belgium	The Netherlands	Germany
Participation of BSPs requires	For generators: CIPU contract As from 2014: Framework agreement *(being drafted for 2015 procurement)*	Valid FCR framework contract (including legal, organizational, technical, IT and prequalification details)	Valid FCR framework contract (signed after successful prequalification with a capacity higher or equal to the minimum bid size)
Procurement period	▪ ±55MW (2014): Annual tender in June (28MW for *R1 symmetrical 200mHz*, 27MW for *R1 downwards*, 27MW for *R1 upwards* ▪ ±27MW (2014): Short term (monthly) tender for *R1 symmetrical 100mHz* ▪ From 2015 all products will be procured via monthly tenders.	▪ ±66MW: weekly auction, every Tuesday at 09:00 for the next week starting with Monday (separate auction for NL) ▪ ±35MW: weekly auction, every Tuesday at 15:00 for the next week starting with Monday (common procurement with DE and CH TSOs)	Weekly auction, every Tuesday at 15:00 for the next week starting with Monday (common procurement with NL and CH TSOs)
Product resolution in time	• ±55MW (2014): one year (split peak/long off-peak/base)[1] • ±27MW (2014): one month (split peak/long off-peak/base)	One week	One week
Minimum bid size	1MW	1MW	1MW
Maximum bid size	Prequalified volume	Prequalified volume	Prequalified volume

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[1] Peak: Mo-Fr from 08:00 to 20:00, long off-peak: remaining time

FCR – balancing capacity procurement 2/3

	Belgium	The Netherlands	Germany
Bid increment	1MW	1MW	1MW
Linking bids	The BSP may link bids to other aFRR and FCR bids[1]	No	No
Bid selection	Co-optimization with aFRR, objective is to minimize FCR+aFRR costs[2]	Lowest possible total costs for procuring FCR: CMO starting with the lowest bid price	Lowest possible total costs for procuring FCR: CMO starting with the lowest bid price
Partial bid acceptance	Elia may accept partial bids in steps of 0.1 MW	TenneT may accept partial bids in steps of 1MW	TSOs may accept partial bids in steps of 1MW
Pooling allowed	yes	yes	yes
Remuneration	Pay-as-bid	Pay-as-bid	Pay-as-bid
Availability requirement	100%	100%	100%
Penalty in case of non-availability	▪ In case CSS<0: 5*CSS[3] ▪ In case CSS>0: 1.3*CSS ▪ Min. penalty of 10 €/MW.h (*penalty capped for year to annual income and for month to 2*monthly income*)	10 times bid price (corresponding to the time and capacity of non-availability)	10 times bid price (corresponding to the time and capacity of non-availability)

[1] Currently only gas-fired units provide FCR in Belgium (often in must-run)
[2] Both, FCR and aFRR are procured at the same time
[3] Clean Spark Spread

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FCR – balancing capacity procurement 3/3

	Belgium	The Netherlands	Germany
Nomination	Day ahead nomination (before 17:00-18:00) of units and MW per unit, per 15 minutes period	Day ahead (before 17:00) nomination of units and MW per unit	Day ahead (before 17:00) nomination of units and MW per unit per TSO *Additionally possibility to add/delete units to/from pool for every 15 minutes and switching within the pool anytime possible within one control area*
Transfer of obligation / secondary market	FCR provider is allowed to transfer obligation to other provider connected to the TSO if he informs Elia; only on day ahead; non-organised market	FCR provider is allowed to transfer obligation to other unit of provider or other provider connected to the TSO if he informs TenneT NL	FCR provider is allowed to transfer obligation to other provider situated in the same control area (i.e. connected to the same TSO)
Yearly average price[1]	R1 200mHz: Yearly 40-50 €/MW.h R1 100mHz: Monthly 85 €/MW.h[2]	30.13 €/MW.h[3]	17.65 €/MW.h
Cost recovery	100% Grid Users	100% Grid Users	100% Grid Users

[1] Calculated as the total annual costs for FCR capacity divided by the procured quantity and the hours of a year. *Figures of 2013 when not marked differently.*
[2] Average of Jan-Apr 2014
[3] Average of Jan-March 2014

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FCR - activation

	Belgium	The Netherlands	Germany
Energy remuneration	No energy remuneration	No energy remuneration	No energy remuneration
Imbalance adjustment for activation	Yes, except for R1 upwards product	No imbalance correction for activation	No imbalance correction for activation

FCR – cross-zonal collaborations

	Belgium	The Netherlands	Germany
Existing collaboration with other TSOs	Agreement with RTE that Elia may procure FCR from French BSP (TSO-BSP model). *30MW were procured in 2013. Elia may procure in 2015 as well from French BSP.*	FCR is procured by the German, Dutch and Swiss TSOs in one common tender procedure using one MOL (TSO-TSO model). BSP from all three countries may take part. Swissgrid procures in total 25MW and up to this value bids from non-Swiss BSP are regarded. TenneT procures in total 35MW and up to this value bids from non-Dutch BSP are regarded.	

FCR – prequalification 1/2

<table>
<tr><th></th><th>Belgium</th><th>The Netherlands</th><th>Germany</th></tr>
<tr><td>Required pre-qualification tests</td><td>In order to attest a production unit to participate in a specific service it must successfully pass a simulation test:
Immediate frequency change leading to a maximum activation of primary control
Is 50% of the maximum R1 activated at t=15s
Is minimum 100% of the maximum R1 activated at t=30s
Does minimum 100% of the maximum R1 remain activated from t=30s to t=120s
Does the generation unit/off-take return to its original set point after t=121s</td><td>Frequency response tests (at a single setpoint, agreed by TSO and BSP and droop of 8%):
Frequency step of +200mHz: response shall be minus 5% of maximal nominal power of unit (Pnom) within 30s
Frequency step of -200mHz: response shall be plus 5% of Pnom within 30s
Frequency ramp 0 to+200mHz in 2 minutes: response shall linearly decrease to -5% of Pnom (30s lagging to frequency)
Frequency ramp 0 to -200mHz in 2 minutes: response shall linearly increase to +5% of Pnom (30s lagging to frequency)
(new Systeemcode bijlage 4, TenneT's pre-qualification documents describe also 1. and 2. with 100mHz steps)</td><td>TSO reserves the right to perform tests.

This can happen in the context of specially arranged functional tests (e.g. by the switching on of tolerable test signals on the primary controller) or during ongoing operation of the technical unit under primary control.

The BSP has to prequalify each unit (and the pool) at his connecting TSO. A successful prequalification is recognized by the other German TSOs.</td></tr>
<tr><td>When are tests required?</td><td>Before offering FCR
If already offered in the past and no problem with activation control not required</td><td>Before offering FCR
In case of structural changes to unit
In case of repetitively insufficient response</td><td>Before offering FCR</td></tr>
</table>

FCR – prequalification 2/2

	Belgium	The Netherlands	Germany
Prequalification	Per unit, for specified capacity upward and downward	Per unit, for specified capacity upward and downward units that are too small (size-wise or cannot deliver symmetrically) to individually prequalify, need to provide the same information and test results. In addition, these units need to indicate with which other units they are pooled.	Per unit, for specified capacity upward and downward Units that cannot deliver the minimum capacity can be pooled for prequalification (only within a control area).
Minimum balancing capacity per unit	Minimum bid size per unit is 1 MW	≥2% of nominal power of unit (with absolute minimum of 100kW for pooled units)	±2% of nominal power of unit (with absolute minimum of ±2MW per unit)
Tests/monitoring after prequalification?	No periodical tests Response being monitored *Elia checks the availability of the balancing capacity (also those who do not actually offer) systematically every 15 minutes. If there is a big outage, Elia makes extra checks.*	No periodical tests Response being monitored	No periodical tests Response being monitored
Independent test report required?	No	TenneT NL requires KEMA test report	No, if requested by TSO, BSP has to provide operations log.
Required real time measurements	Yes	SCADA measurements per unit, maximum 4s resolution	Yes

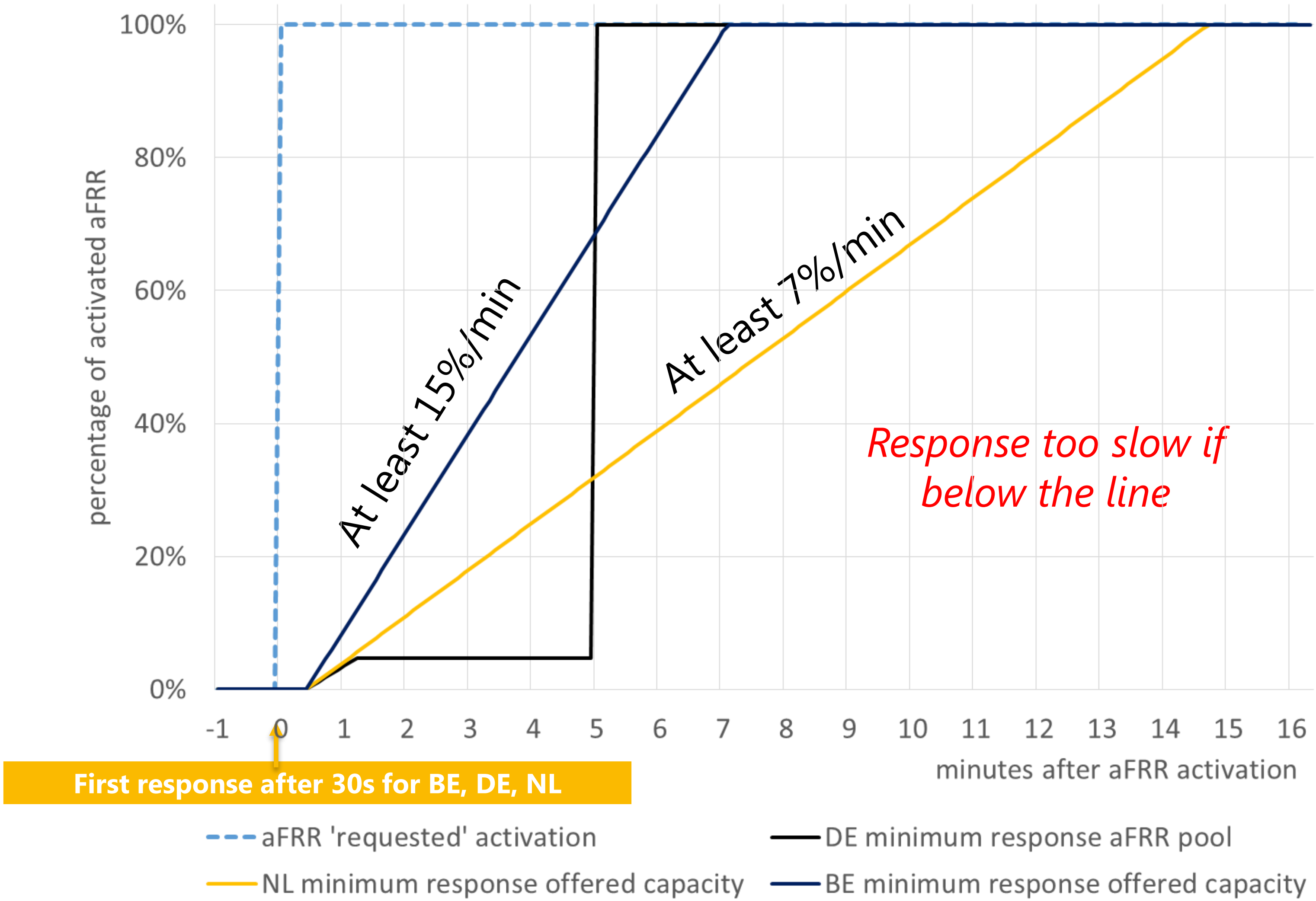
Content

aFRR - technical characteristics

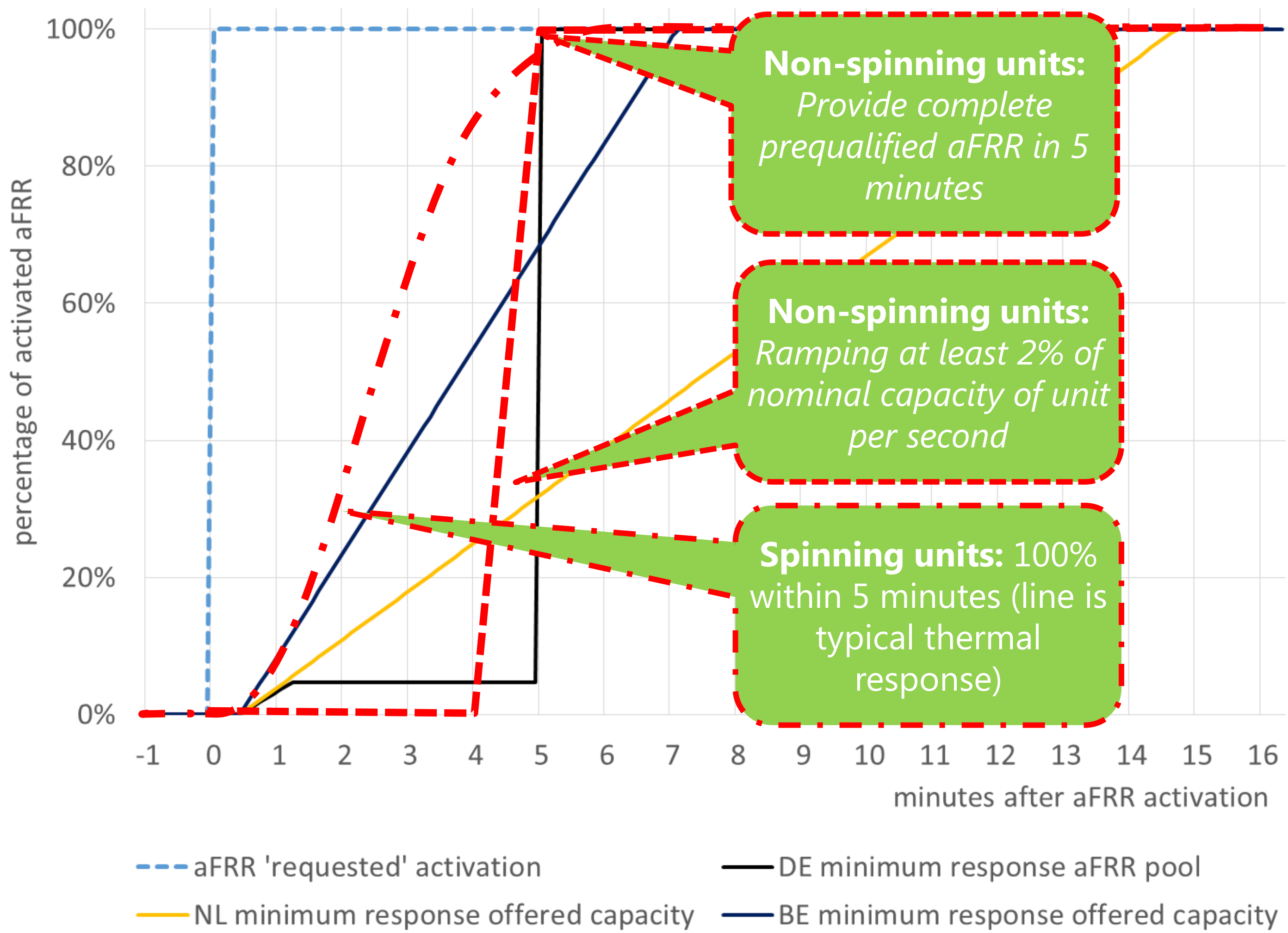
	Belgium	The Netherlands	Germany
Basic product	1 product, separate for upward/downward (procured for three different time resolutions, see next slide)	1 product, separate for upward/downward	1 product, separate for upward/downward (procured for two different time resolutions, see next slide)
Response time	30s	30s	30s
Ramp rate	13,3% of offered bid volume	≥ 7% of offered bid volume	Full provision after 5 min *(A minimum ramp rate depending on the nominal output of a unit needs to be fulfilled by the provider: ≥2% per single unit or if offered via a pool per pool [if pooling of slower with faster ramping units, however non-spinning units need to fulfil the 2% in any case])*
Quantity contracted	±140MW (2014)	±300MW (2014) *Minimum values secured by contract; additional bids aFRR balancing energy allowed and obtained.*	-1,969MW/+2,042MW (Q1/2014)[1] -1,919MW/+1,998MW (Q2/2014)[1] -1,906MW/+1,992MW (Q3/2014)[1]

[1] Commonly procured by all German TSOs. Yet, according to §6 (2) of the StromNZV each TSO may procure a technically necessary share of aFRR only from technical units connected in it's control area („*Kernanteil*"). This has to be justified by the TSO and approval of the regulatory authority is required.
The contracted quantities change approximately every quarter – the value for Q1 was procured for the time period starting with 06.01. and for Q3 starting with 07.07. 2014.

Minimum response requirements for aFRR for 'bid capacity'



Separate prequalification requirements for 'spinning' (thermal) and 'non-spinning' units in Germany, ***on unit basis***



Units that cannot deliver the minimum capacity can be pooled for prequalification (cross-control area pooling only allowed for reaching the required minimum size ["facilitate market entry"], afterwards disregard of this privilege)

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[1] When aFRR is offered via an aFRR control pool this requirement is valid for the pool (pooling of slower with faster ramping units)

aFRR - balancing capacity procurement 1/3

	Belgium	The Netherlands	Germany
Procurement period	▪ ±120MW (2014): *Annual tender* in June ▪ ±20MW (2014): *Short term (monthly) tender* From 2015 on only a monthly tendering	Annual tender	Weekly auction, every Wednesday at 15:00 for the next week starting with Monday
Product resolution in time	*Annual tender:* ▪ Year for peak hours (08:00 -20:00 on Monday - Friday) ▪ Year for off-Peak (20:00 - 08:00 + weekends) ▪ Base *Short term (monthly) tender:* ▪ Month (split peak/ long off-peak/base)	Year	▪ Week peak product (08:00 -20:00 on Monday - Friday) ▪ Week off-peak product (20:00 - 08:00 + weekends +federal holidays)
Availability requirement	100%	100%	100%
Penalty	▪ In case CSS<0: 5*CSS[1] ▪ In case CSS>0: 1.3*CSS ▪ Min. penalty of 10 €/MW.h (penalty capped for year to annual income and for month to 2*monthly income)	Per ISP with limited response: monthly fee/2880 If more than 12 ISPs or more than 8 consecutive ISPs with limited response: monthly fee/30 *(not instead of BSP's liability)*	10 times bid price (corresponding to the time and capacity of non-availability)
Provision	Portfolio-based	Portfolio-based	Portfolio-based

[1] Clean Spark Spread

aFRR - balancing capacity procurement 2/3

	Belgium	The Netherlands	Germany
Minimum bid size	1MW	4MW	5MW
Maximum bid size	Not more than 50MW (up or down) of a single unit (unless the BSP can recover this aFRR via other units)	100MW	Prequalified volume
Partial bid acceptance	TSO may accept partial bids in steps of 1MW except they are marked as indivisible	No partial acceptance	TSOs may accept partial bids in steps of 1MW
Linking bids	The BSP may link bids to other aFRR and FCR bids	No	No
Bid selection	Co-optimization with FCR, objective is to minimize FCR+aFRR costs	Economic optimization (not necessarily cheapest bids) Changes in tendering procedure under investigation	Lowest possible total costs for procuring aFFR capacity: CMO starting with the lowest bid price
Remuneration	Pay-as-bid	Pay-as-bid	Pay-as-bid
Secondary market[1]	Yes, BSP may transfer contract to other BSP until day ahead; Both BSPs need to inform Elia	BSP is contractually not allowed to transfer obligations	Yes, BSP may transfer contract to other prequalified units of another BSP within the control area (add/delete units to/from pool for every 15 minutes)

[1] No organised market, used to avoid unavailability

aFRR - balancing capacity procurement 3/3

	Belgium	The Netherlands	Germany
Cost Recovery	100% Grid Users	100% Grid Users	100% Grid Users
Yearly average price[1] *upward*	Yearly: 20-25 €/MW.h Monthly: 28 €/MW.h[2]	Combined upward and downward 16.50 €/MW.h 14.78 €/MW.h[3]	7.63 €/MW.h
Yearly average price[1] *downward*	Yearly: 20-25 €/MW.h Monthly: 28 €/MW.h[2]		11.54 €/MW.h

[1] Calculated as the total annual costs for aFRR capacity divided by the procured quantity and the hours of a year. *Figures of 2013 when not marked differently.*
[2] Average of Jan-Apr 2014
[3] Average for year 2014

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aFRR - balancing energy procurement 1/3

	Belgium	The Netherlands	Germany
Procurement mechanism	▪ Mandatory bids for contracted balancing capacity ▪ Additional bids by other generators[1] ▪ Gate closure D-1 at 18:00	▪ Mandatory bids for contracted balancing capacity ▪ Mandatory bids for "available capacity" of generators >60MW *(providers to declare availability, in practice voluntary bids)* ▪ Additional bids ▪ Gate closure H-1	▪ Weekly, every Wednesday 15:00 for the next week starting with Monday ▪ Energy price is provided together with capacity price, bids are selected per capacity price
Product resolution in time	15 minutes	15 minutes	One week
Provision	Unit-based bids, but portfolio based activation	Portfolio-based (bids and activation)	Portfolio-based (bids and activation)
Pricing restrictions	Price caps: ▪ Downward: 0€/MWh ▪ Upward: Fuel cost of CCGT with 50% efficiency + 40€/MWh	Bid price range around day-ahead market prices (*for contracted capacity only*) [2] Price caps: ▪ Downward: D-1 spot price minus 1,000€/MWh ▪ Upward: D-1 APX spot plus 1,000€/MWh	none

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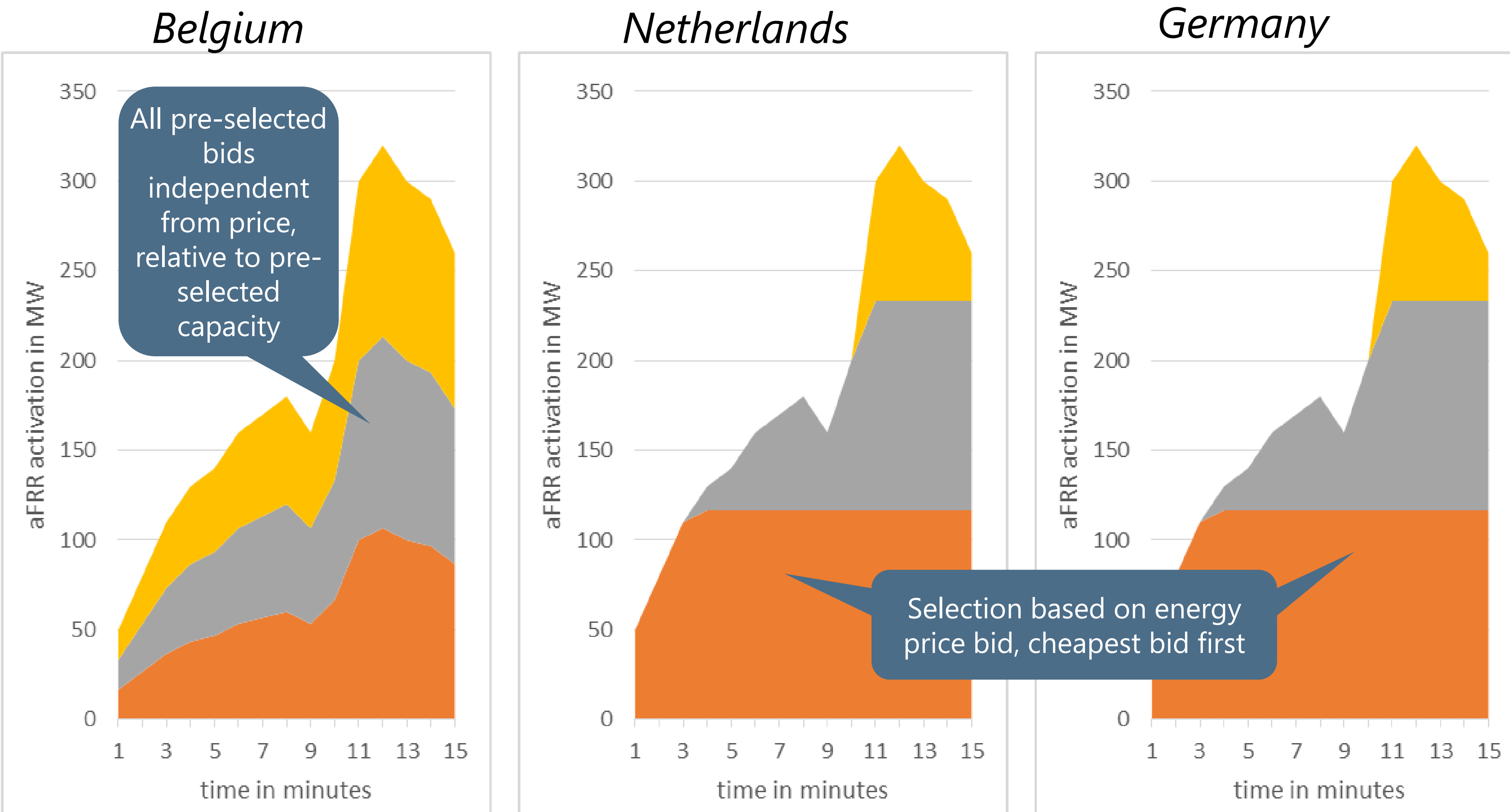
[1] In practice hardly used due to pro-rata activation scheme
[2] Source: *Modelovereenkomst Regelvermogen 2011* (aFRR contract template)

aFRR - balancing energy procurement 2/3

	Belgium	The Netherlands	Germany
Minimum bid size	1MW	4MW	5MW
Maximum bid size	Prequalified volume	999MW	Prequalified volume
Remuneration energy	▪ Pay-as-bid ▪ Requested is paid	▪ Marginal pricing (cross-products aFRR and mFRR) ▪ Requested is paid	▪ Pay-as-bid ▪ Metered is paid
Bid selection	Participation factors for pro-rata based activation selected day ahead	*See activation*	Bids were selected by the capacity price CMO
Activation	Pro-Rata based on selected bids in D-1, consequently parallel activation Analysis ongoing to go to MO activation	Sequential by energy CMO (*parallel activation only in case of larger system deviations*), re-optimization each ISP	Sequential by energy CMO *(TSOs do not activate bids in parallel with the aim to increase the ramp rate)*
Bid divisibility – step size for activation	Partial activation in 0.1MW steps possible	Partial activation in 1MW steps possible	Partial activation in 1MW steps possible
Min. activation period to be price setting bid	Not applicable	Not applicable (*min. balancing energy volume to be settled: 1kWh*)	Not applicable
Activation cycle time[1]	10s	4s	4s

[1] Time between two activations of aFRR, i.e. cycle time of the TSO's load frequency controller (*How often calculates the load frequency controller a new aFRR set point and therefore sends new aFRR instructions to the BSPs.)*

Merit order based vs pro-rata activation



Pro-rata | **Merit order** | **Merit order**

→ merit-order under analysis

(but TenneT NL may use more bids in parallel to meet required ramp rate)

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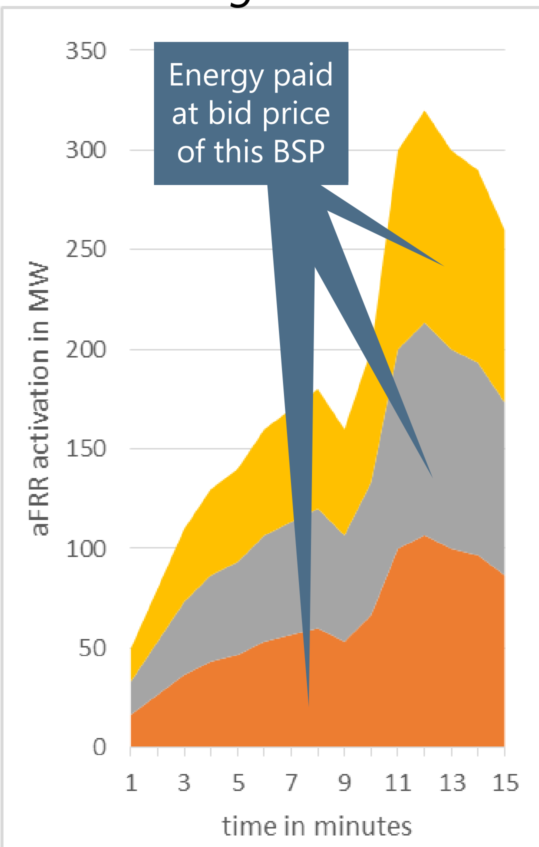
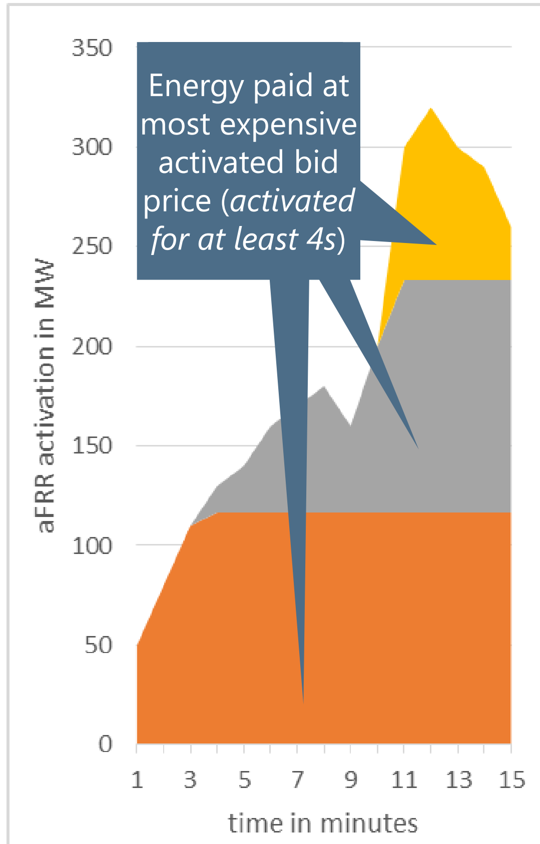
Energy remuneration of aFRR activation

Belgium

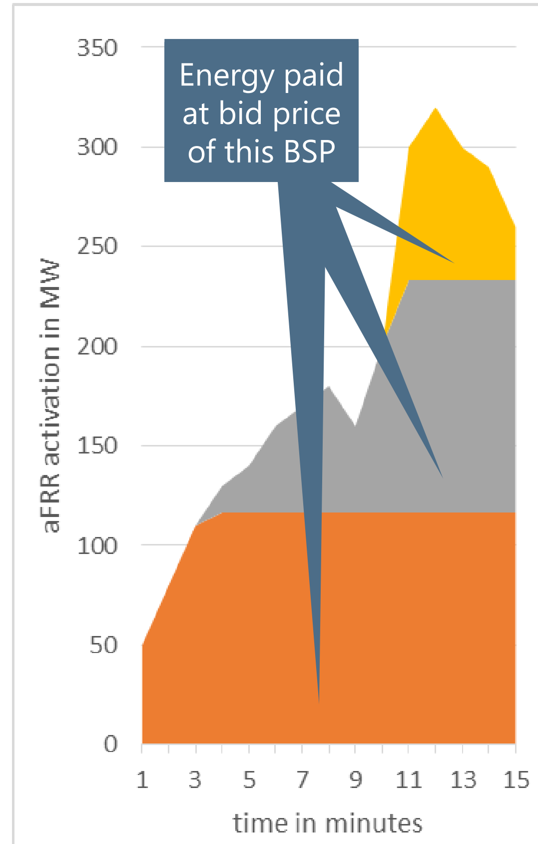


Pay-as-bid price paid

Netherlands



Marginal price paid
(highest price of both, aFRR and mFRR activation)



Pay-as-bid price paid

aFRR - balancing energy procurement 3/3

	Belgium	The Netherlands	Germany
Yearly average price[1]	Upwards: 65€/MWh Downwards: 18.60€/MWh	Upwards: 143.39€/MWh Downwards: -11.31€/MWh	Upwards: 90.21€/MWh Downwards: -3.82€/MWh
Cost recovery	100% BRP	100% BRP	100% BRP

aFRR – cross-zonal collaboration

	Belgium	The Netherlands	Germany
Existing collaboration with other TSOs	Imbalance netting – International Grid Control Cooperation (IGCC)		
Collaboration under investigation	Implementation of aFRR assistance (each TSO helps, if other TSO s are short, module 2 of IGCC)		
Collaboration under investigation	Implementing a common merit order list without unshared bids		-

[1] Sum of yearly costs (paid by the TSOs to the BSP) divided by the total yearly amount of activated energy in MW *(figures from 2013)*. Upwards positive price means TSO pays BSP, downwards positive price means BSP pays TSO.

aFRR – prequalification 1/2

	Belgium	The Netherlands	Germany[1]
Required pre-qualification tests	Technical capability to be tested and certified	Ability to exchange required signals and messages	Technical capability of each unit to be tested and certified
When are tests required?	Before offering aFRR	Limited to before offering aFRR due to an installed daily response quality monitoring process	▪ Before offering aFRR ▪ When adding additional units/off-take to aFRR pool
Prequalification	In order to attest a production unit to participate in a specific service it must successfully pass a simulation test of 100 minutes: ▪ to follow a variable signal with a deviation smaller than 7.5% of the maximum value ▪ For this test a sample will be taken every 10 seconds	Supplier portfolio prequalification is done based on relevant documentation and agreements. See also the previous answer. Contracted suppliers have demonstrated their regulating capability for at least 2 months.	The prequalification procedure comprises: ▪ Technical requirements for every single technical unit ▪ Technical requirements for the aFRR pool of the BSP ▪ Requirements for the control system connection ▪ Organisational requirements *Units that cannot deliver the minimum capacity can be pooled for prequalification (cross-control area pooling only allowed for reaching the required minimum size ["facilitate market entry"], afterwards disregard of this privilege)*

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[1] The BSP has to prequalify each unit (and the pool) at his connecting TSO. A successful prequalification is recognized by the other German TSOs.

aFRR – prequalification 2/2

	Belgium	The Netherlands	Germany
Tests/monitoring after prequalification?	Response monitored by Elia, aggregate response must not deviate more than 15% from dynamic set point	Response monitored by TenneT NL based on reference signal and measurements	TSO can request tests in case of reasonable doubt to the proper functioning of the control connections
Independent test report required?	No	No, but the complete supplier process from bidding to responding including education is audited by an independent specialist/consultant assigned by the TSO.	No
Required real time measurements	Yes, 10s measurements	Yes, 4s measurements	Yes, ≤4s measurements

Content

mFRR - technical characteristics 1/2

	Belgium	The Netherlands	Germany
Basic product	▪ *CIPU bids* (upward/downward, bids from non-contracted capacity) ▪ *R3 production:* mFRR provided by generation (only upward) ▪ *R3 dynamic profile:* - only completely activated - per contract: limited number and duration of activations - energy remuneration € 0/MWh, no imbalance correction → implicitly imbalance price is paid ▪ *Interruptible loads (ICH)*[1]: ▪ A2: max. duration 2h total duration over contract 24h ▪ *A4:* max. duration 4h, total duration over contract: 16h ▪ *A8:* max. duration 8h, total duration over contract: 24h ▪ *All products:* Directly activated	▪ *Balancing bids:* Standard energy product per ISP, per direction ▪ Scheduled activation per ISP ▪ *Emergency*[1]: Directly activated, supplementary to merit order list	▪ 1 product, separate for upward/downward, can be provided by generation and load ▪ Scheduled activation per ISP (procured for six different time resolutions, see next slide) *Additional balancing capacity products, which are not part of mFRR dimensioning are interruptible loads:* ▪ *SOL: immediately interruptible loads* ▪ *SNL: quickly interruptible loads* *(see slide 29)*

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[1] *ICH* in BE and *Emergency* in NL are part of the mFRR dimensioning and therefore regarded as mFRR reserves. In Belgium they are activated at the very end of the MO: after additional bids and contracted aFRR and mFRR bids have been activated. Thus in practice they are hardly ever activated as BRP react faster.

mFRR - technical characteristics 2/2

	Belgium	The Netherlands	Germany
Activation	Semi-automatic activation	Manual activation	Semi-automatic activation (MOLS)
Activation Time	▪ *R3 production* and *R3 dynamic profile:* ≤15min ▪ *Interruptible loads:* ≤3min	▪ *Balancing bids:* Next ISP (≤15min) ▪ *Emergency:* ≤15min	Next ISP: 22.5 – 7.5min (between 15-7.5min compulsive) *Activation for full delivery between ISPs in exceptional cases possible.*
What is activated?	**Power/Energy** In principle Elia asks for power, but BSP can ramp up/down within ISP and ramp back next ISP.	**Energy** BSP has to deliver the offered energy (*transactional minimum*) within the ISP when its bid is activated (*physical delivery can be deactivated earlier*).	**Power** BSP is requested to ramp before ISP, keep the requested position within the ISP (and for subsequent ISPs if requested by TSO), ramp back to initial position afterwards.

Germany – interruptible loads

End 2012 a regulation (AbLaV) was put in place that obliges TSOs to tender 3,000MW of interruptible loads connected to the 110 kV grid or higher. This regulation will expire end of 2015.

The regulation defines two types of interruptible loads:

- 1,500MW SOL: immediately (within 1sec) interruptible loads (*currently*[1] *prequalified: 251MW*)
- 1,500MW SNL: quickly (within 15 min) interruptible loads (*currently*[1] *prequalified: 916MW*)

Products to be procured during monthly tenders (bid size: min. 50MW, max. 200MW):

- Interruption of at least 15min at any given time, several times a day at different intervals for a duration of up to one hour per day, max. four times a week
- continuously for at least four hours at any given time, once every seven days
- continuously for at least eight hours at any given time, once every 14 days

Prices are regulated:

- Capacity price: 2,500€/MW per month
- Balancing energy price: set by provider in range of 100-400€/MWh (*in practice at the upper end*)

There are exemptions for when the contracted loads do not have to be available (if contracted in the regular mFRR or aFRR tender and if they were sold at the exchange at a price that is at least in one ISP higher than the bid's balancing energy price)

→ Interruptible loads are not part of the aFRR and mFRR dimensioning and in practice are hardly used.

[1] Status as of 06.10.2014

mFRR - balancing capacity procurement 1/3

	Belgium	The Netherlands	Germany
Contracted volume	**Only upward:** 661MW (2014) ▪ *R3 production:* 350MW ▪ *R3 dynamic profile:* 50MW ▪ *Interruptible loads:* 261MW	***Only upward "Emergency"*:** 350MW (2014), product can only be delivered by load and generation <60MW, capacity shall be available for 60 minutes	**Upwards and downwards contracted:** -2,838MW/+2,472MW (Q1/2014)[1] -2,801MW/+2,464MW (Q2/2014)[1] -2,208MW/+2,476MW (Q3/2014)[1]
Procurement period	▪ *R3 production:* annual in June ▪ *R3 dynamic profile:* annual in October ▪ *Interruptible loads:* annual in October	Annual tender	▪ D-1 auction at 10:00 for delivery on Tuesday-Saturday ▪ D-2 auction at 10:00 for delivery on Sunday ▪ D-3 auction for delivery on Monday *Further adjustment of auction due to a federal public holiday to the last working day (Monday-Friday).*
Product resolution in time	*All products:* year (split peak/long off-peak/base)	Year	Six daily 4h-products: 00:00-04:00, 04:00-08:00, 08:00-12:00, 12:00-16:00, 16:00-20:00 and 20:00-24:00
Availability requirement	*R3 production/R3 dynamic profile:* 100% *Interruptible loads:* average availability on yearly basis no penalties for first 3% that has not been made available	To be defined in the offer, TenneT prioritises bids with at least 97% availability in its selection.	100%

[1] Commonly procured by all German TSOs. Yet, according to §6 (2) of the StromNZV each TSO may procure a technically necessary share of mFRR only from technical units connected in it's control area („*Kernanteil*"). This has to be justified by the TSO and approval of regulatory authority is required.
The contracted quantities change approximately every quarter – the value for Q1 was procured for the time period starting with 06.01. and for Q3 starting with 07.07. 2014.

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mFRR - balancing capacity procurement 2/3

	Belgium	The Netherlands	Germany
Penalty	*R3 production:* Per missing ISP and MW, penalty related to Belpex Day Ahead*1,3 with a Floor (penalty capped for year to annual income and for month to 2*monthly income) *R3 dynamic profile:* Per missing ISP and MW, penalty is balancing capacity price + 30% (penalty capped for year to annual income) *Interruptible loads:* balancing capacity price + 20% (penalty capped for year to annual income)	Yes, specified in individual contracts	Three times D-1 EPEX-Spot price of the relevant hour(s) multiplied by the not-available capacity and the respective time slice (i.e. 4h)
Provision	Portfolio-based	Portfolio-based	Portfolio-based
Minimum bid size	*R3 production/R3 dynamic profile:* 5MW	20MW	5MW
Maximum bid size	Prequalified volume	100MW	Prequalified volume
Partial bid acceptance	TSOs may accept partial bids in steps of 1MW	No partial bid acceptance	TSOs may accept partial bids in steps of 1MW except BSP has mark them as indivisible (*possible for bids up to 25MW*)
Linking bids / bid criteria	*R3 production/R3 dynamic profile:* The BSP may link bids or add conditions	No	No

mFRR - balancing capacity procurement 3/3

	Belgium	The Netherlands	Germany
Bid selection	Cost minimisation over *R3 production* and *R3 dynamic profile,* but not more than 40MW *R3 dynamic profile* from one single BSP, not more than 45MW from two BSPs and not more than 50MW from three BSPs *Interruptible loads (ICH):* cost minimisation	Based on: • Availability: at least 97% availability is prioritized • Start-up time: preferably 10 minutes, not more than 15 minutes but with the overall aim to minimize costs	Lowest possible total costs for procuring mFFR capacity: CMO starting with the lowest bid price
Remuneration capacity	Pay-as-bid	Pay-as-bid	Pay-as-bid
Yearly average price[1] *upward*	R3 production: 5-6€/MW.h R3 dynamic profile: 3.38€/MW.h Interruptible loads: 1.41€/MW.h	3.34€/MW.h 2.36€/MW.h[2] (*'emergency', in practice interruptible loads*)	0.95€/MW.h
Yearly average price[1] *downward*	No downward mFRR contracted	No downward mFRR contracted	5.71€/MW.h
Cost Recovery	100% Grid Users	100% Grid Users	100% Grid Users
Secondary market[3]	*R3 production:* BSP may transfer contract to other BSP on day ahead. Both BSPs need to inform Elia *R3 dynamic profile/Interruptible loads (ICH):* No	No	Yes, BSP may transfer contract to other prequalified units of another BSP within the control area (add/delete units to/from pool for every 15 minutes)

[1] Calculated as the total annual costs for mFRR capacity divided by the procured quantity and the hours of a year. *Figures of 2013 when not marked differently.*
[2] Average for year 2014
[3] No organised market, used to avoid unavailability

mFRR - balancing energy procurement 1/3

	Belgium	The Netherlands	Germany
Procurement mechanism	Gate closure H-1: ▪ Mandatory bids for contracted balancing capacity *R3 production* ▪ Mandatory bids for other 'available capacity' from generators >75MW ▪ additional bids for generators <75MW and consumers	Gate closure H-1 ▪ Mandatory bids for "available capacity" of generators >60MW *(providers to declare availability, in practice voluntary bids)* ▪ additional bids for generators <60MW and consumers	Procured together with capacity – same gate closure and same product resolution: ▪ D-1 auction at 10:00 for delivery on Tuesday-Saturday ▪ D-2 auction at 10:00 for delivery on Sunday ▪ D-3 auction for delivery on Monday
Product resolution in time	15min (units bid start price and activation price)	15min	Six daily 4h-products: 00:00-04:00, 04:00-08:00, 08:00-12:00, 12:00-16:00, 16:00-20:00 and 20:00-24:00
Provision	▪ Unit-based bids, but portfolio activation for additional bids ▪ Unit-based activation for pre-contracted balancing capacity	Portfolio-based (bids and activation)	Portfolio-based (bids and activation)

mFRR - balancing energy procurement 2/3

	Belgium	The Netherlands	Germany
Pricing restrictions	Mandatory bids for contracted balancing capacity *R3 production*: price shall be equal to 'free price' as offered in CIPU contract	Price caps: ▪ Downward: D-1 spot price minus 1,000€/MWh ▪ Upward: D-1 APX spot plus 1,000€/MWh	None
Minimum bid size	1MW	4MW	5MW
Maximum bid size	Prequalified volume	999MW	Prequalified volume
Bidding	Implicit bidding (price bids placed by BSPs, volumes determined by TSO based on current production schedule of each generator)	Explicit bidding: bids contain price and volume information	Explicit bidding: bids contain price and volume information
Bid selection and activation	▪ Sequential activation of all additional bids based on merit order ▪ Afterwards contracted bids based on merit order	▪ Sequential activation of all additional bids based on merit order ▪ Afterwards contracted bids based on merit order	▪ No additional bids ▪ Contracted bids initially chosen by capacity price CMO sequentially activated according to a energy price CMO

mFRR – balancing energy procurement 3/3

	Belgium	The Netherlands	Germany
Bid divisibility – step size for activation	Partial activation in 0.1MW steps possible	Activation of full bids only	Partial activation in 1MW steps possible; except the bid was marked as indivisible (*possible for bid sizes up to 25MW*)
Remuneration energy	*Additional bids and R3 production*: Pay-as-bid *R3 dynamic profile:* no energy payment *Interruptible loads:* Highest of 108% of Belpex and 75€/MWh	Marginal pricing (cross-product aFRR mFRR) For activated 'emergency power': highest of 1) marginal control price (cross-product aFRR mFRR), 2) and APX price + 200€/MWh, 3) 200€/MWh	Pay-as-bid
Yearly average price[1]	Upwards: 116€/MWh Downwards: 7.36€/MWh	Upwards: 365.10€/MWh Downwards: -310.67€/MWh 'emergency': 288.78€/MWh	Upwards: 169.18€/MWh Downwards: -95.11€/MWh
Cost recovery	100% BRP	100% BRP	100% BRP

[1] Sum of yearly costs (paid by the TSOs to the BSP) divided by the total yearly amount of activated energy in MW *(figures from 2013)*. Upwards positive price means TSO pays BSP, downwards positive price means BSP pays TSO.

mFRR – cross-zonal collaboration

	Belgium	The Netherlands	Germany
Existing collaboration with other TSOs	Reserve sharing with TenneT NL	Reserve sharing with Elia and German TSOs	Reserve sharing with TenneT NL (emergency contract)
Collaboration under investigation	Common merit order for non-contracted bids		-

mFRR – prequalification

	Belgium	The Netherlands	Germany[1]
Required prequalification tests	Technical capability to be tested and certified only for contracted balancing capacity	▪ Scheduled activated mFRR: No ▪ Direct activated mFRR: Ability to fulfil contractual obligations	For the to be prequalified mFRR volume an operational test with two provision cycles is required. The proof has to be provided by the BSP.
Prequalification	For each reserve providing unit an activation test is performed without prior notification in which the unit must be able to attain its contracted power within 15min	Scheduled activated mFRR: No	The prequalification procedure comprises for each technical unit (generation/load): ▪ Technical requirements for every single technical unit ▪ Organisational requirements
When are tests required?	Before offering mFRR or after two consecutive failed deliveries.	▪ Scheduled activated mFRR: No ▪ Direct activated mFRR: Contractual stipulation	Before offering mFRR
Tests/monitoring after prequalification?	Monthly check whether delivery was sufficient	▪ Scheduled activated mFRR: No ▪ Direct activated mFRR: Yes	If requested by TSO, BSP has to provide within 10 working days operations log per technical unit.
Independent test report required?	No	No	No
Required real time measurements	No	No	No

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[1] The BSP has to prequalify each unit (and the pool) at his connecting TSO. A successful prequalification is recognized by the other German TSOs.

Content

Imbalance settlement 1/3

	Belgium	The Netherlands	Germany
Settlement per	ISP of 15min	ISP of 15min	ISP of 15min
BRPs	One type	One type	One type
Legal context balance responsibility	Contractual obligation in BRP contract and Grid code. Since 2014 BRPs are legally allowed to actively respond to system imbalance[2]. However, the BRP always needs to have the physical capacity available that would allow them to keep their balance.	Legal obligation to act according to programs; BRP contract; Mandatory Collateral	▪ Contractual obligation on BRP to be in balance for every ISP ▪ In case of unplanned loss of production legal obligation on BRP to be in balance latest at the end of the following third ISP (after 45-60min)[1].
Balancing philosophy	Reactive, arrangements aim at providing clear and effective incentives for self-balancing or deliver system support → **BRP to react into the right direction within ISP**	Reactive, arrangements aim at providing clear and effective incentives for self-balancing or deliver system support → **BRP to react into the right direction within ISP**	Reactive, arrangements aim at providing clear and effective incentives for self-balancing → **BRP to be always in balance within a ISP**
Horizon of balancing (TSO perspective)	In principle current and next consecutive ISP	In principle current and next consecutive ISP	In principle current and **next three** consecutive ISPs

[1] BRP is allowed to (and should) be in balance earlier than legally required.
[2] In practice most BRPs already actively responded to system imbalance before this date.

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Imbalance settlement 2/3

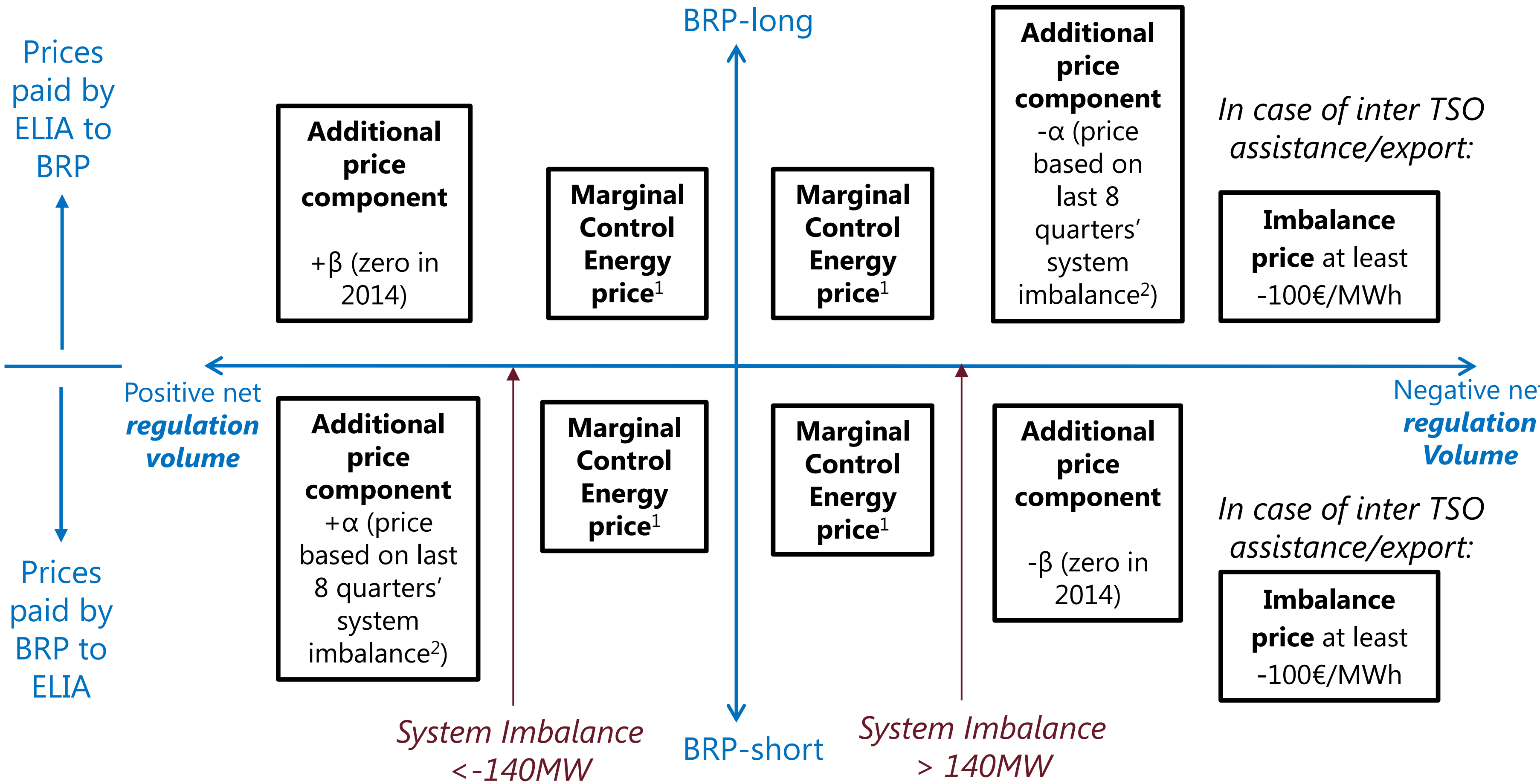
	Belgium	The Netherlands	Germany
Exemptions for	▪ Off-shore wind generation[1] ▪ New generation plants in commissioning phase[1]	-	Renewables under the feed-in tariff are balanced by the TSO who in his role as BRP is subject to the same balancing rules and imbalance prices.
Basic scheme	Single price, with additional components in case of large imbalances	▪ *Single price* if balancing action in one direction in that ISP ▪ *Dual price* if balancing actions in both directions in that ISP	Single price, with additional incentives
TSO's position in imbalance pricing scheme based on:	Activated net regulation volume *See slide 43*	Activated net regulation volume *See slide 44*	System Imbalance *See slide 45*
Imbalance pricing for imbalances that *aggravate* system imbalance	Marginal and alpha (*see next slide "Additional or minimum incentives"*) Marginal is most expensive of: ▪ Capacity weighted average price that is paid for aFRR control energy ▪ Highest price that is paid for activating mFRR control energy)	Marginal control energy price	Average control energy price (AEP)[2] *In cases where more than 80% of the contracted positive/negative FRR were activated, the AEP is increased/reduced by 50%, in any case no less than by 100€.*

[1] Imposed by Belgian law
[2] Calculated as: (costs-revenues)/activated net volume
To avoid extreme imbalance prices caused by an activated net volume close to zero (difference of negative and positive activation within one ISP), the imbalance price is limited by the highest activated bid price in one ISP.

Imbalance settlement 3/3

	Belgium	The Netherlands	Germany
Imbalance pricing for imbalances that *reduce* system imbalance	Marginal and Beta (see below)	Marginal control energy price	Average control energy price
Additional or minimum incentives	1. *Alpha (only for aggravating):* If absolute value of the System Imbalance is bigger than 140MW: additional price based on last 8 quarters' system imbalance 2. *Beta (only for reducing):* at this moment zero 3. In case of system surplus and inter TSO assistance/export price at least -100€/MWh	In practice: no *(In case of insufficient system performance in the previous week an incentive component (normally 0 €/MWh) may be increased for next week's imbalance prices. This happens rarely.)*	Imbalance price is coupled to the average volume weighted EPEX Spot intraday market price of the respective hour (EPEX ID): ▪ Control area long: AEP≤EPEX ID ▪ Control area short: AEP≥EPEX ID
How is the IGCC considered in the imbalance price	IGCC netting is considered as aFRR activation. IGCC netting adds to the aFRR volume and is priced at *weighted average* aFRR price. The reason is to keep correct incentives for BRP.	IGCC reduces the ACE/net imbalance and therefore the marginal control energy price.	IGCC reduces the net imbalance and therefore the AEP.

Imbalance pricing - Belgium



[1] Marginal Control Energy price is highest price of aFRR and mFRR. aFRR prices capped.

[2] $\alpha = \frac{\frac{1}{8}\sum_{i=t-7}^{t}(System\ Imbalance\ per\ PTUi)^2}{15{,}000}$

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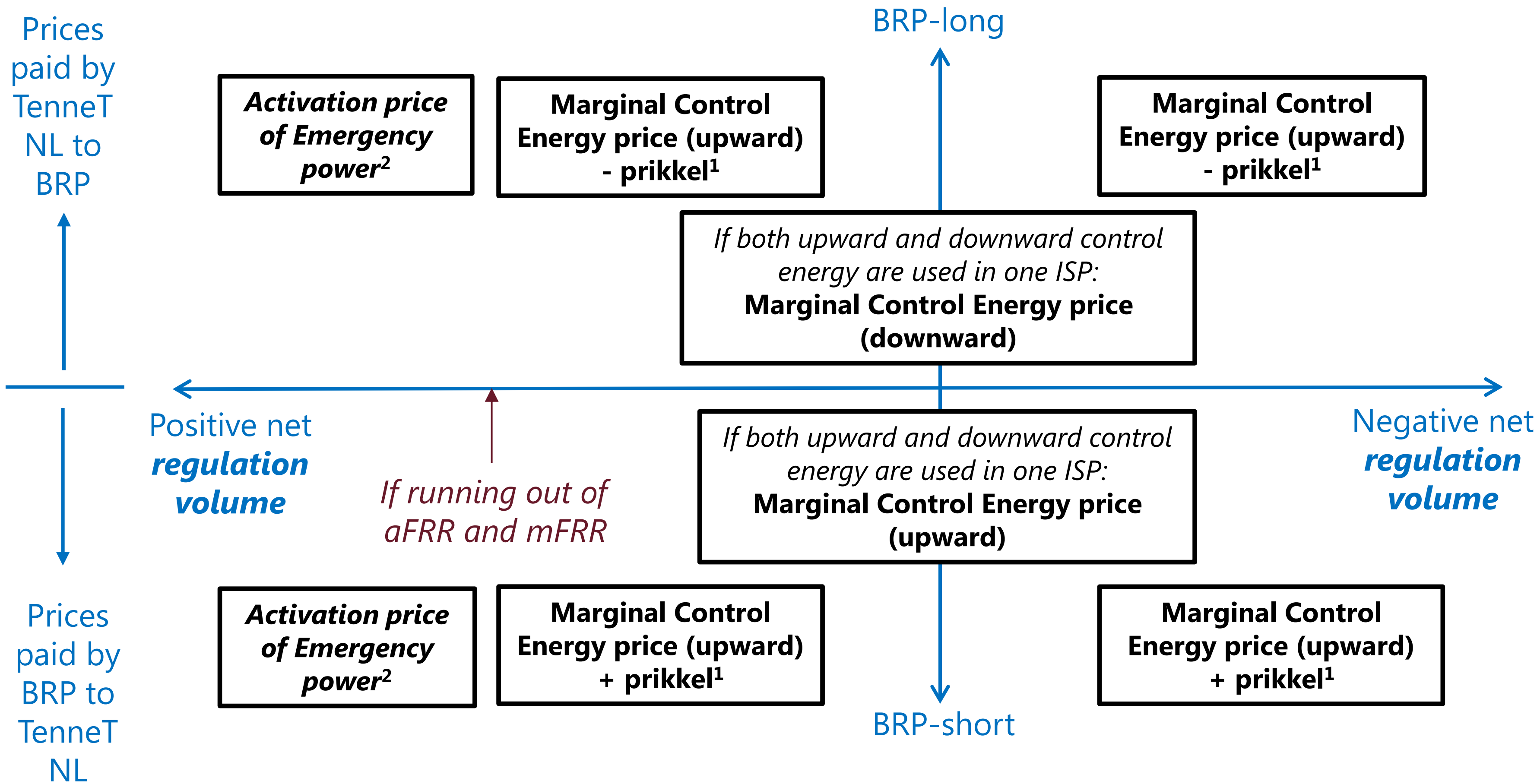
Imbalance pricing – The Netherlands



[1]**prikkel:** In practice zero (In case of insufficient system performance in the previous week an incentive component may be increased for next week's imbalance prices. This happens rarely.)

[2] Highest of (Marginal Control Energy price (upward) + 10%, day ahead APX price for applicable hour + 200€/MWh, 200€/MWh).

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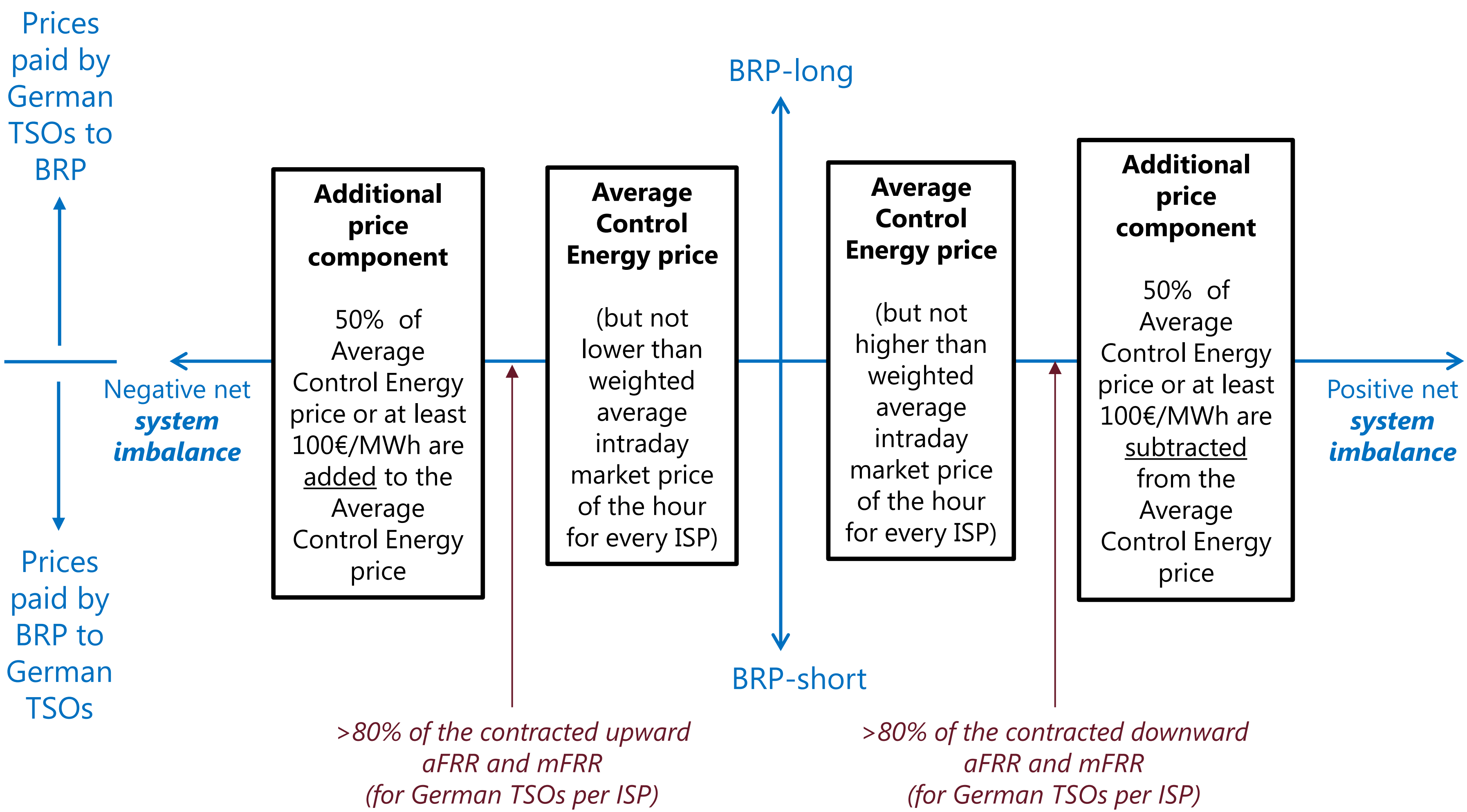
Imbalance pricing - Germany



Content

Publication of imbalances 1/2

	Belgium	**The Netherlands**	**Germany**
Imbalances (in MW)	2-3min after the fact	Not published	<15min after ISP *per control area and per GCC*
Activated FRR (in MW)	2-3min after the fact	2-3min after the fact (1min resolution), separately for aFRR and mFRR, indication for activation of "emergency power"	<15min after ISP *(according to rules - in real time often faster*)
Imbalance price (in €/MW.h)	2-3min after 15 min ISP	Day after (preliminary)	<20 working days after the delivery month[1]
FRR activation prices (in €/MW.h)	2-3min after 15min ISP	2-3min after the fact (1min resolution): price setting bids	Not published[2]

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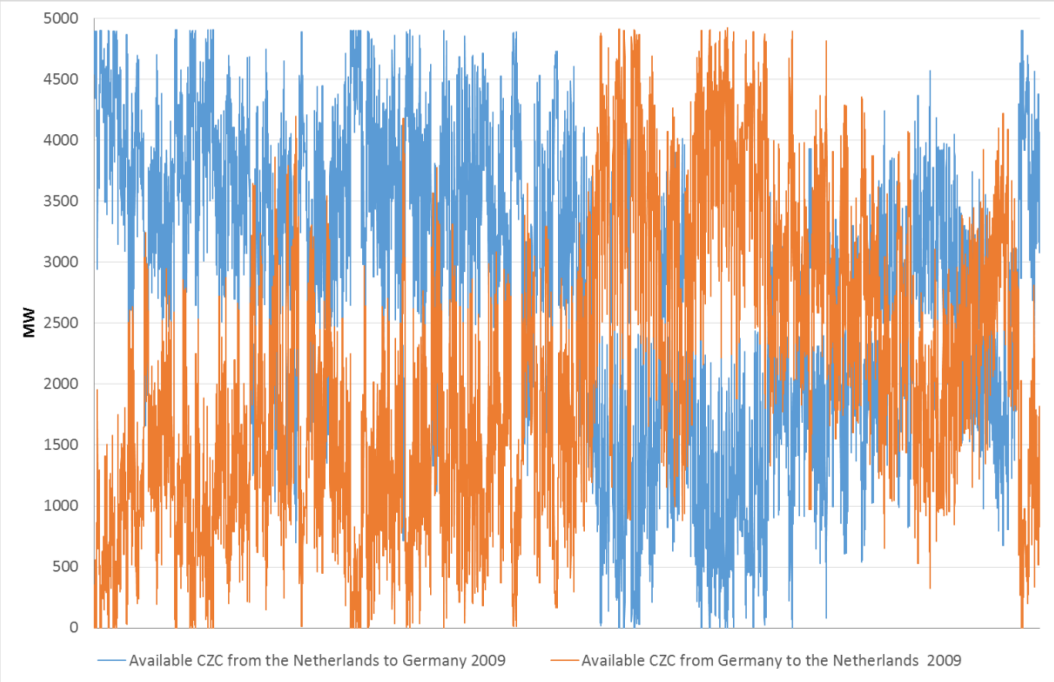
[1] Publication would be faster if marginal pricing was applicable.
[2] BNA decided that TSOs are not allowed to publish this to avoid exercise of market power.

Publication of imbalances 2/2

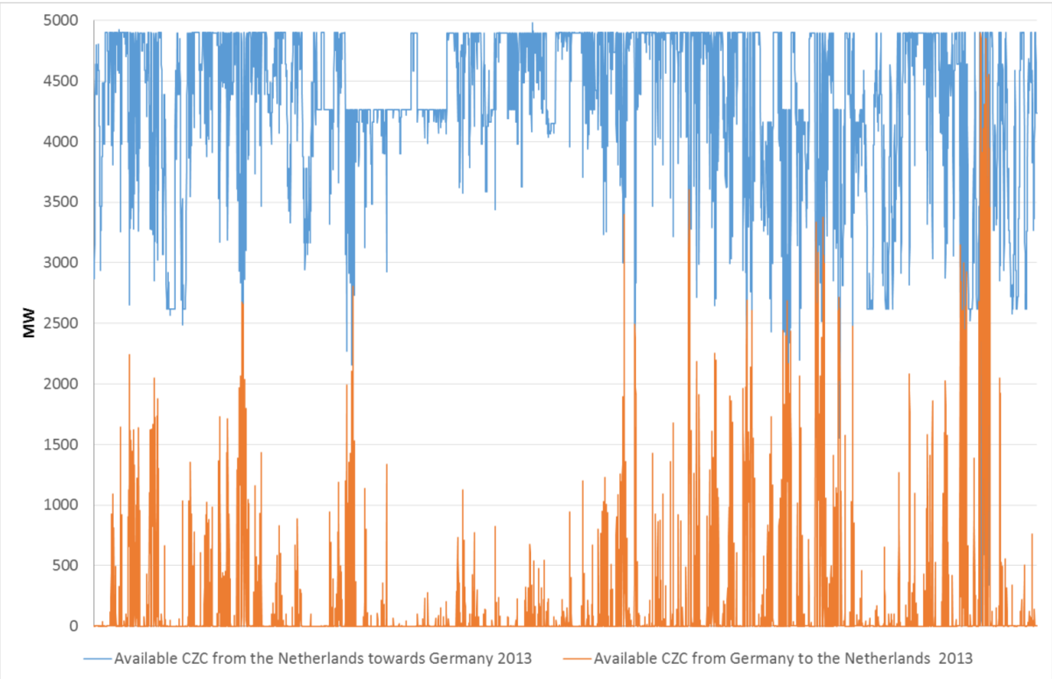
	Belgium	The Netherlands	Germany
Other publications	Per ISP and for the entire day: ▪ Available regulation capacity, separately for each product Per ISP, 2-3min after ISP: ▪ Measurements and forecasts for wind (separate for off/on-shore) and solar generation (incl. geographical information) ▪ Net Regulation Volume: difference between the sum of the volumes of all upward and downward regulations ▪ Indication whether IGCC is used ▪ Exchange to distribution networks per Elia substation ▪ Inter-TSO activation warning: Indication that special imbalance price of at least -100€/MWh (in case of system surplus and inter-TSO assistance/export) is active. Incidentally, Elia provides warnings: ▪ D-1/ID Balancing warnings if lack of reserves is expected. BRPs are requested to provide additional reserves – upward or downward.	Per ISP, 2-3min after ISP: ▪ Indication whether IGCC is used Per ISP for the entire day: ▪ Available regulation capacity ▪ Aggregated merit order of regulation capacity Ex-post: ▪ Aggregated balancing energy volumes and prices for settlement ▪ Aggregated Imbalance volumes and prices	Per ISP for the entire day: ▪ Available regulation capacity, separately for each product ▪ Merit order list (price, volume) of regulation energy, separately for each product

B. Available cross-zonal capacity

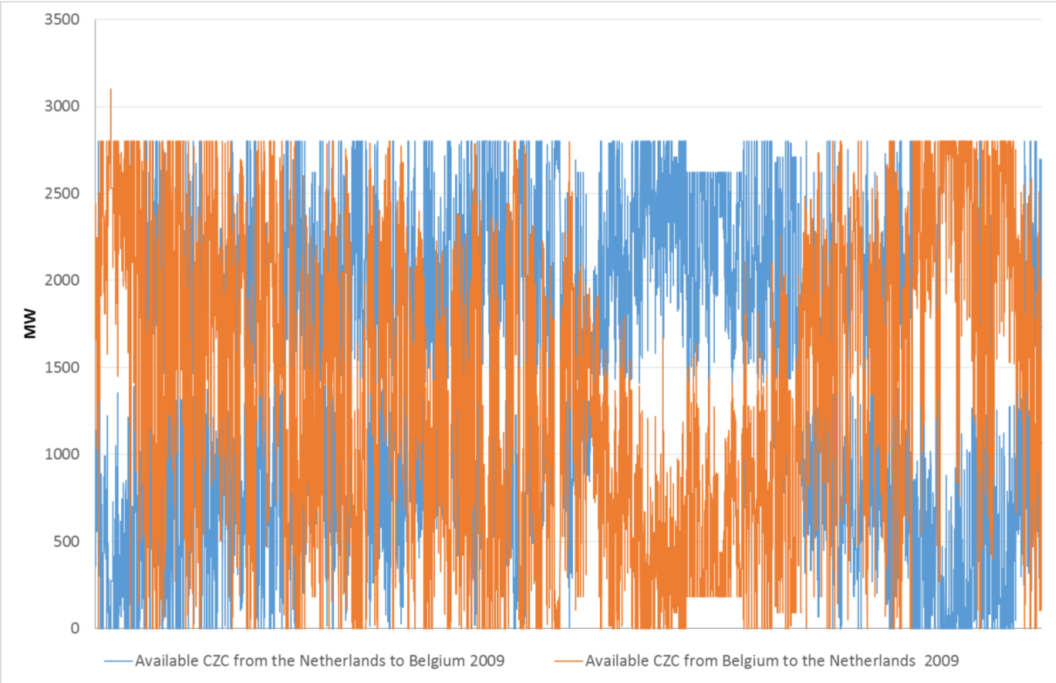
Available cross-zonal capacity after intraday trading for the Dutch-German and the Dutch-Belgium border for the years 2009 and 2013 (quarter-hourly-values).



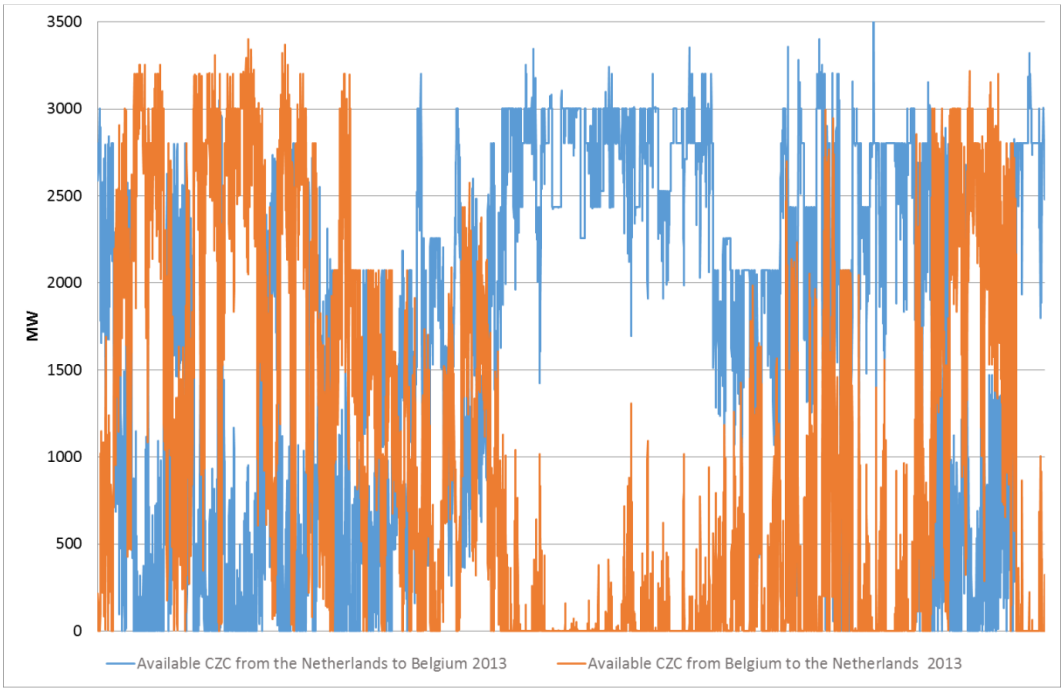
Available CZC after intraday trading for the Dutch-German border for 2009



Available CZC after intraday trading for the Dutch-German border for 2013



Available CZC after intraday trading for the Dutch-Belgium border for 2009



Available CZC after intraday trading for the Dutch- Belgium border for 2013

C. List of Abbreviations

ACER	Agency for the Cooperation of Energy Regulators
aFRR	Automatic Frequency Restoration Reserves
BRP	Balance Responsible Party
BSP	Balance Service Provider
CIPU	Coordination of the Injection of the Production Units
CSS	Clean Spark Spread
CMO	Common Merit Order
CoBA	Coordinated Balancing Area
CZC	Cross-Zonal Capacity
Elia	Elia System Operator NV
ENTSO-E	European Network of Transmission System Operators for Electricity
FCR	Frequency Containment Reserves
FG EB	Framework Guidelines on Electricity Balancing
GCC	Grid Control Cooperation
IGCC	International Grid Control Cooperation
ISP	Imbalance Settlement Period
LFC	Load-frequency control
MO	Merit Order
MOL	Merit Order List
mFRR	Manual Frequency Restoration Reserves
NC EB	Network Code on Electricity Balancing
NC LFC&R	Network Code Load Frequency Control and Reserves
NRA	National Regulatory Authority
ReBAP	regelzonenübergreifender einheitlicher Bilanzausgleichs-energiepreis (common balancing energy price)
RR	Replacement Reserves
TenneT NL	TenneT TSO B.V.
TSO	Transmission System Operator

D. List of Figures

E. List of Tables

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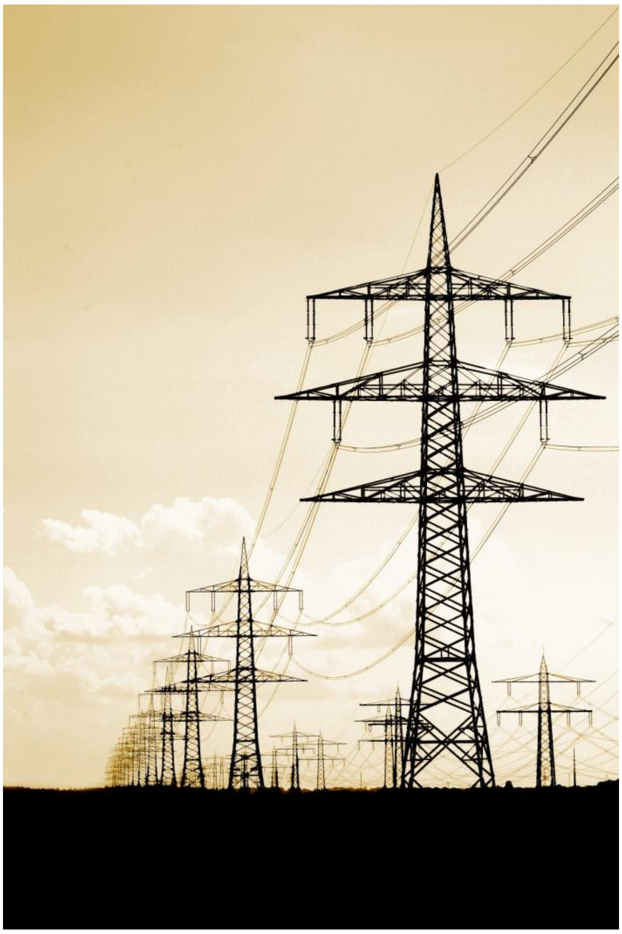

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