Integration of power balancing markets in Europe – Transparency as a design variable

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Abstract

The European integration is proceeding fast in the electricity sector. Recently, a set of commission regulations, the so called "EU winter package", attracted attention. In particular, the harmonisation of balancing regulations is enforced by the Guideline on Electricity Balancing (GLEB). In this context, this paper compares power balancing in the Netherlands and Germany. The approach of passive balancing through transparency about imbalance volumes and prices in real-time is in the spotlight. As a result BRPs provide passive balancing services (at no costs) and the activation of reserve capacity by the TSO is reduced or even avoided. This scheme is practiced in the Dutch control area. But would an approach like this also work in the German set-up? Analysing the two market designs shows a lot of similarities, but we identified some significant differences as well.

1. Introduction

The integration of power balancing markets aims for more competition and therefore cheaper prices for balancing power. Guidance comes from the EU commission regulation "Guideline on Electricity Balancing" (GLEB) [1]. It entered into force on 18. December 2017 and schedules the consultation process for the creation of common European balancing rules. The GLEB being a formal EU Commission regulation (2017/2195) is legally binding for EU member states, relevant regulatory authorities and system operators. The aim of the regulation is to harmonize balancing arrangements in Europe over the next years. Its fundamental scope is the "optimisation between the highest overall efficiency and lowest total costs for all parties involved" ([1] Article 3.2).

The harmonization of national balancing mechanisms and market based procurement processes is a challenging task. Röben (2018) found that especially the high variability of the existing national balancing approaches and secondary controller set-ups could put a barrier to the European balancing market harmonization approach [2].

The most important aspects are the integration of markets, common power balancing products, common prequalification requirements for service providers and common rules for cross-border balancing. Once a common European balancing regulation is implemented, the situation for transmission system operators (TSO), balancing service provider (BSP) and balancing responsible parties (BRP) in Europe will have changed.

The GLEB is also intending to "support the achievement of the European Union target for the penetration of renewable generation" and at fostering transparency in balancing markets ([1] Article 3.1). These additional scopes make the regulation highly relevant for the project Norddeutsche Energiewende[1] (NEW 4.0). NEW 4.0 is addressing a range of research questions on future energy systems and markets. One aspect of NEW 4.0 is a feasibility study aiming to analyse the strengths and weaknesses of transferring the Dutch approach of a highly transparent balancing market to Germany. This includes the approach of passive balancing for more efficiency in power balancing.

The Dutch TSO publishes real-time data about the activated reserve capacity on its homepage, including the price and volume of the activated bids. Figure 1 shows a screenshot of the webpage. With the information displayed, BRPs can check whether their own imbalances are currently contributing to the systems imbalance or acting against it and therefore stabilizing the system. This can serve a basis for the decision on whether or not flexibility in the BRP's portfolio should be used for changes in the scheduled energy exchange. In the Netherlands these BRP decisions lead to a strong additional power balancing effect, which is called "passive balancing" since it is not actively triggered by the system operator but "passively induced" by the published information on imbalance direction, volumes and prices. Introducing such a publication of real-time balancing data in Germany and therefore enabling passive balancing by BRPs could lead to a reduction in balancing costs which in Germany are transferred to the public (grid users) as part of the grid usage fees. Reduced grid usage fees and/or the possibility to achieve revenues from passive balancing measures might lead to new market opportunities and could reduce operational

[1] NEW 4.0 "North-German transition towards renewable energy", several partners from industry and public institutions work on IT pilot schemes in the federal states Hamburg and Schleswig-Holstein. NEW 4.0 started in December 2016. See www.new4-0.de for details. (Sponsor)

costs for the resident industry. For the TSO passive balancing comes for free and helps to reduce the necessary amounts of reserve capacity.

On the other hand, passive balancing might bear some disadvantages. For one, security of supply of sufficient reserve capacity at all times lies within the responsibility of the TSO. Effects from passive balancing are not fully foreseeable. Furthermore, publishing sensitive data on the current imbalance situation could involve risks, e.g. unforeseen speculation on profits or overreactions of market participants. This could potentially destabilize the grid. Another challenge is to tune the control scheme of the secondary reserve controller and the full activation time of secondary reserves to the reaction time of the assets activated by the BRP's through passive balancing. If these time dependencies are not considered the secondary reserve controller might start oscillating.

Balance delta plus prices

The 'Balance delta' table shows the quantities of regulating and reserve capacity TenneT has requested for its operations. It shows these quantities, approximately halfway each minute, for the most recent half hour, together with the prices of the pricesetting bids.

Table | Table 2-hours | XML | Explanation | Export data

Time indication			Activated power					Price development	
			Regulating		Reserve		Emerg. (0/1)	Highest price	Lowest price
Number	Seq. nr.	Time	Up	Down	Up	Down	Up	Up	Down
1	1167	19:26	99	0	0	0	0	46,22	
2	1166	19:25	97	0	0	0	0	46,22	
3	1165	19:24	96	0	0	0	0	46,22	
4	1164	19:23	98	0	0	0	0	46,22	
5	1163	19:22	99	0	0	0	0	46,22	
6	1162	19:21	97	0	0	0	0	46,22	
7	1161	19:20	99	0	0	0	0	46,22	
8	1160	19:19	98	0	0	0	0	47,12	
9	1159	19:18	98	0	0	0	0	47,12	
10	1158	19:17	94	0	0	0	0	46,22	
11	1157	19:16	91	0	0	0	0	46,22	
12	1156	19:15	96	0	0	0	0	46,22	
13	1155	19:14	103	0	0	0	0	59,80	
14	1154	19:13	110	0	0	0	0	63,04	
15	1153	19:12	94	0	0	0	0	59,80	
16	1152	19:11	77	0	0	0	0	59,80	
17	1151	19:10	63	0	0	0	0	53,79	
18	1150	19:09	48	0	0	0	0	52,15	
19	1149	19:08	37	0	0	0	0	52,15	
20	1148	19:07	23	0	0	0	0	46,22	

Figure 1: Publication of real-time data in the Netherlands [3]

In order to evaluate these risks, a model of the power system is required. Frunt (2011) presents a simplified model of the power system that simulates the frequency deviation as a function of a power disturbance [4]. The model accounts the influence of mass inertia, self-regulating loads, primary control and secondary control.

Frunts model was developed further by de Haan (2016) [5]. He exanimates the benefits of cross-border balancing and models the exchange of imbalances between two synchronous areas. Furthermore, he distinguishes TSOs by their reactive or pro-active behaviour [5]. Reactive TSOs perform mainly automatically activated reserves and BRPs are responsible to keep their scheduled energy interchange. The TSOs in Germany and the Netherlands are classified as reactive, but the Dutch TSO applies passive balancing as a supporting measure.

Nobel (2016) describes a comprehensive decomposition of power systems in a conceptual model and analyses design choices and market efficiency of the Netherlands and Germany [6]. He expresses general conclusions about the objectives of TSOs and key features of ideal balancing markets:

"Provision of balancing energy by the system operator is a result, and not the objective of power balancing. This choice allows, invites, and basically incentivizes active participation and competition between imbalance and balancing energy. This choice requires a consistent set of design features:

- An imbalance settlement period not longer than time to restore frequency,
- Imbalance prices equal to balancing energy prices (not more, not less),
- Balancing energy price to reveal scarcity,
- Real-time system balancing information feedback to all users." ([6], p.109)

Ocker and Ehrhart (2017) performed related research about a cost benefit estimation of recent market reformations in Germany [7]. The authors show, that costs for balancing energy could be reduced while the share of fluctuating renewable energy was increased at the same time. The cost benefits were achieved through the reformation of balancing markets allowing more competition. Ocker, Braun and Will (2016) present a comparison of balancing market set-ups of 24 ENTSO-E countries to identify the main drivers for the configuration of European balancing power markets [8]. Finally, Ocker (2017) conducted a performance comparison of seven auction methods for frequency restoration reserves (FRR), including the Netherlands and Germany [9]. The interrelation of day-ahead, intra-day and real-time balancing markets for flexibility providers is examined by Brijs, et. al. (2017) [10].

Literature review on load-frequency-control (LFC) shows that the design of balancing markets does not play a major role in the field of applied research on power balancing systems. Shankar et. al. (2017) review 574 scientific publications on LFC mechanisms and do not cover market design frames [11]. Pappachen et. al. (2017) review 245 scientific publications on LFC issues and classify frequency regulation as an ancillary service, focusing on the area control error (ACE) and the implemented IEEE-39 bus for methods of primary and secondary control [12].

The current national balancing markets have major differences in design and minor interactions like imbalance netting. Imbalance netting avoids the activation of frequency restoration reserves by summing up imbalance of all involved countries. Thus, opposing imbalance is counterbalanced. It requires no change of national procurement processes and is the first step towards the integration of balancing markets. Eight European countries joined the pilot project "International Grid Control Cooperation" (IGCC) over the last years and perform imbalance netting since [13].

The literature give a detailed introduction into the related field of balancing market design, but scientific research focusing on transparency as design variable is on rare occasions.

An exception can be found with van der Veen and Hakvoort (2016) [14]. They developed a structured design space in which market conditions, system developments and market incentives are examined. The authors identified 23 balancing market design variables and mirror these against the design of the Dutch balancing market [14].

Section 2 presents the goal and scope definition of this investigation. Section 3 outlines the GLEB and the current regulation for balancing markets in Germany and the Netherlands. Section 4 concludes and reasons what kinds of barriers exist for passive balancing in Germany. Section 5 outlines the research questions for future investigations and presents a draft action chart for a potential simulation of the effects of passive balancing in Germany.

2. Goal and Scope Definition

The intention of this paper is to deliver a contribution to the discussion about transparency measures in an integrated European power balancing market. The current consultation process is open for input from all concerned ENTSO-E member companies and national regulators. Thus, a variety of stakeholders are involved. Additional conclusions from the academic sector can help to evaluate and prioritize different design options.

At a first glance, transparency as a design variable for balancing markets seems a promising approach. The closer evaluation of its overall suitability for a more efficient provision of reserve capacities through passive balancing though requires methods of interdisciplinary research combining the fields of legislation, economics and engineering. For the German situation the two most apparent questions are:

Which other balancing market design variables interact (how strong?) with transparency and/or passive balancing measures? What potential downsides/problems can occur if passive balancing was introduced to the German control areas?

With regard to the findings of [2], we extend the design space of [14] by the full activation time (FAT) of automatic Frequency Restoration Reserves (aFRR) for the examination. Thus, our design space has 24 design variables. On the background of these 24 design variables this paper lists and compares the according regulations of the Dutch and German balancing markets as well as the predefined settlement issues of the upcoming European legislation [1] in the GLEB.

In a first step, the similarities and differences between the national market set-ups are described and potential conflicts with the GLEB are identified. The German power balancing market design is analysed by reviewing the legal texts of regulators and operational handbooks. The Dutch balancing market design regulation was analysed by [14] and is taken from there.

In a second step, potential conflicts regarding transparency for market participants and passive balancing are identified. In this context, the Dutch approach of passive balancing is investigated and compared to the German balancing strategy. A special focus is laid on the parameter "publication of national data" with regard to transparency on system imbalance in real-time. Related design parameters from the design space are identified and interrelations are examined. In addition, potential conflicts with transmission system (and/or reserve controller) set-ups are discussed.

3. Results

This section compares the Dutch to the German balancing mechanisms in relation to the GLEB. With regard to the 24 design variables the following displays a list of the regulation rules and documents comparing intended GLEB regulations to current national regulations in the Netherlands and Germany. In Germany, the Federal Grid Agency (German: "Bundesnetzagentur") is the regulator and its decision board 6 (in German: "Beschlusskammer 6" (BK6)) covers the regulation of electricity grids including the balancing mechanism.

Besides looking at regulations coming from legislation, it is important to put the international agreements of transmission system operators into the context. The system operators act as profit-oriented stakeholders with the special responsibility for securing the supply of electricity. The European Network of Transmission System Operators for Electricity (ENTSO-E) represents the system operators self regulation and its handbook is commonly applied in Europe. It describes the technical framework of the interconnected European electricity grid but does not intent to introduce common (reserve capacity) markets. In order to unify the balancing mechanisms and markets in the EU, the commission opened a consultation process about common balancing markets for concerns from the system operators. After a consultation phase, a new handbook is intended to clarify technical details and cover rules for common balancing markets.

The design variables for balancing markets can be assigned to following categories [14]

1. General variables
2. Balancing planning variables
3. Balancing service provision
4. Balance settlement variables

The following paragraphs list the results of our comparison of the variables in each category.

1. General variables

1.1. Schedule time unites

The imbalance settlement period in Germany as well as in the Netherlands is 15 minutes according to the ENTSO-E network code [15]. The GLEB states "all TSOs shall apply the imbalance settlement period of 15 minutes in all scheduling areas" within three years after entry into force ([1] Article 53.1). Thus, the GLEB is already fulfilled by both countries.

1.2. Publication of national data

The publication of data about balancing market design and results is the most important design choice when it comes to transparency. In the Netherlands, the activated balance energy bid (price and dispatched energy volume) is published on a website (see Figure 1) with a resolution of 1 minute. In Germany, data about activated reserves and costs is published 15 minutes after the end of an imbalance settlement period under the following internet address: www.regellesitung.net (BK6-12-024 decision 5). The resolution is the settlement period only (15 minutes). The course of the imbalance over the 15 minute interval is not published.

1.3. Full activation time (FAT)

This parameter is added to the design space of van der Veen, because it is likely to play an important role in the context of passive balancing. The interrelation of FAT of reserves and the activation time of resulting passive balancing by BRPs might be crucial for a well working aFRR controller set up. The Netherlands apply 15 minutes, whereas Germany applies 5 minutes for aFRR [16]. This is important because the short activation times in Germany lead to high amounts of settlement periods with both positive and negative reserves being activated (zero line crossings, see [6], p. 90). In a system like this the published imbalance would be an uncertain indicator for BRPs additional passive balancing measures through real time schedule adjustments. On the other hand additional passive balancing contributions would act as a disturbance (transient) to the aFRR controller causing oscillations.

The consultation process for common fixation of the FAT is ongoing in the GLEB ([1] Article 25.4) and could result in a compromise between the German and the Dutch approach. Such a compromise could be potentially harmful for at least one or even both national aFRR controller set-ups and as a result the efficiency of the connected balancing markets. This risk should be evaluated before the settlement of a common parameter for aFFR. As a result aFRR controller designs might have to be adjusted.

2. Balance planning variables

2.1. Zonal versus nodal responsibility

This design parameter addresses the geographical aggregation level of energy schedules. BRPs submit their schedules for each network node or for geographically defined subsystems within a control area. The Netherlands and Germany both apply a scheme of zonal responsibility (for balancing responsible parties) in control areas ([14], p.190; BK6-07-002 annex 1 - 4.1.2).

2.2. Responsibility for renewable energy generation

In the Netherlands, the BRPs with renewable energy generation in their portfolio have the same responsibility for their balance as any other BRP ([14], p.190). In Germany, renewables covered by the Renewable Energies Act (German: Erneuerbare Energien Gesetz (EEG)) receive a fixed feed-in tariff and the system operator is responsible for balancing fluctuating production ("Evaluierungsbericht der BNetzA zur Ausgleichsmechanismusverordnung" 1.1). The GLEB does not cover this issue, but it clearly states to aim at achieving the EU target of renewable energy penetration ([1] Article 3.1 g). In this context, responsibility for imbalance could be taken away from renewable energy producers to support the required grows.

2.3. Net versus separate positions

This design parameter defines weather a BRP has to submit two separate schedules for energy consumption and energy production or if a net position including the two positions is applied. The Netherlands and Germany both apply net balance positions within control areas ([14], p.190; BK6-06-013 annex "Bilanzkreisvertrag" annex 3 - 1.1).

The GLEB states, "each TSO shall apply a self-dispatching model for determining generation schedules and consumption schedules" ([1] Article 14.2). Nevertheless, there are three approaches suggested for the final position of BRPs, leaving the decision about net or separate final positions open to the consultation process ([1] Article 54.3).

2.4. Final gate closure time

The final gate closure time is the last point in time for a BRP to update the scheduled energy exchange. In the Netherlands, BRPs can submit their final schedule until 10 pm of the day after the imbalance settlement period ([14], p.190). In Germany, BRPs can change their schedule until 4 pm of the next day ("BK6-14-044 (4.4) referring to StromNZV [4] §5 Abs. 3"). Both countries apply a "day after settlement" scheme for BRPs. In Germany the final price of the balancing energy is not known at the moment of the resulting imbalance of a period is published.

The GLEB states, the common final gate closure time should be no earlier than 8 hours before (!) the imbalance settlement period ([1] Article 24.5).

2.5. Initial gate closure time

The initial gate closure time is the last point in time for BRPs to submit an initial energy schedule. The initial energy schedule of each BRP has to be submitted no later than 2 pm in the Netherlands ([14], p.190) and no later than 2.30 pm in Germany of the day before the imbalance settlement period (BK6-06-013 annex "Bilanzkreisvertrag" annex 3 - 1.2). The GLEB does not address the initial gate closure time.

2.6. BRP accreditation requirements

Both countries apply technical, organisational and administrative requirements ([14], p.190; BK6-06-013 annex "Bilanzkreisvertrag" - 3). The GLEB demands a proposal for common requirements within 6 months. Therefore, drafts can be expected in July 2018 ([1] Article 18.1).

3. Balance service provision

3.1. Balance service classes

Balance classes are individually defined by system operators in the EU, but a set of classes is the common design. Table 1 shows the acronyms of these classes according to the ENTSO-E Operational Handbook and the GLEB as well as the wording used in the Netherlands and Germany. The GLEB does not use the wording of the ENTSO-E handbook, but introduces new terms ([1] Articles 0.13, 19, 20 and 21).

Table 1: Balance service classes in the ENTSO-E operational handbook [15], the GLEB [1], the Netherlands [14] and Germany [17]

ENTSO-E operational handbook	GLEB	The Netherlands	Germany
Primary Control Reserves (PCR), as a function of system frequency	Frequency Containment Reserves (FCR)	Primary Power (PP)	Primary Reserves (PRL)
Secondary Control Reserves (SCR), as a function of area imbalance	automatic Frequency Restoration Reserves (aFRR)	Regulating Power (RgP)	Secondary Reserves (SRL)
Tertiary Reserves (TR), to replace activated reserves	manual Frequency Restoration Reserves (mFRR)	Reserve Power (RsP)	Minute (or tertiary) Reserves (MRL)
	Replacement Reserves (RR)	Emergency Power (EP)	“Abschaltbare Lasten” (AL)

The Dutch and the German products are based on national regulations ([14], p. 190; [17]). The different national reserve types might not be transferable directly to the upcoming standard products resulting from the GLEB ([1] Article 5), depending on the results of the consultation process.

3.2. Reserve requirements

The technical characteristics of reserve classes are based on the ENTSO-E handbook and national markets. The handbook defines the size of PCR for the interconnected European grid to be 3 GW and clarifies how the responsibility is distributed between the TSOs. The required PCR for each control area is defined annually [15]. The sizing of other reserve classes is up to national conditions and regulations. Historic data of volumes show, the Netherlands had 101 MW PP, 215 MW RgP and 350 MW EP in 2015 ([14], p. 190). Germany had 583 MW PRL, 1846 MW SRL and 1072 MW MRL (BK6-15-158).

GLEB requests a proposal for common product requirements within two years. Therefore, results can be expected in December 2019 ([1] Articles 25.2 and 25.4).

3.3. Control system

The Netherlands and Germany apply the load-frequency-control system of ENTSO-E regarding the Central European synchronous area ([15] Policy 1 Load-Frequency Control A-S2.3 and B-S2.1).

GLEB requests a common activation optimisation function of all reserve types from a common merit order list, which is under negotiation ([1] Article 31 and 58). The common activation optimisation function is not described in detail, but might be crucial for passive balancing. See 3.7 for the discussion of the function.

3.4. Methods of procurement

Both countries apply bilateral contracts for balancing capacities. Balancing Service Providers (BSP) offer their capacity to the TSO via capacity bids (power) and energy bids. In the Netherlands, plants with more than 60 MW are obligated to provide primary power and offer all available up- and down-regulation capacity to the market ([14], p.190). In Germany, plants with more than 100 MW have to provide primary reserves (https://www.regelleistung.net/ext/static/prequalification).

GLEB describes the procurement process for BSPs. They shall submit capacity bids and, if the capacity is contracted, energy bids to their connecting TSO ([1] Article 16.2 and 16.4). A new approach is enabling the submission of voluntary "free" energy bids from any prequalified BSP, if the reserve capacity was not contracted ([1] Article 16.5).

3.5. Timing of balancing service markets

In the Netherlands, primary control capacity is contracted on a weekly basis. Gate closure for regulating power is a day before delivery at 2.45 pm. Bids can be adapted up to 1 h before the period of delivery ([14], p. 191).

In Germany, PRL capacity is contracted on a weekly basis, until Tuesday 3 pm for the following week. SRL and MRL is contracted a day before delivery. Until 8 am for SRL and until 10 pm for MRL. Publication of bid results is done 1 hour after end of bidding period at the latest (BK6-10-097 (2), BK6-15-158 (2), BK6-15-159(2)). An adaptation of the bids is not possible.

GLEB requests a consultation process. TSOs shall harmonise all gate closure times for standard products ([1] Article 24.1).

3.6. Balancing service pricing mechanisms

This parameter is another interesting factor when considering transparency in balancing processes, as the Dutch price signal consists of data from the pricing mechanism. In the Netherlands this can be easily done since the pricing follows a "pay as cleared" scheme, where the last reserve called sets the price for the whole activated reserve capacity. In Germany the pricing follows as pay as bid scheme and therefore the resulting imbalance price can not so easily be published in real time.

Figure 2 visualises the Dutch and the German balancing service pricing mechanisms. Only pre-qualified BSPs are allowed to bid on the balancing markets. BSP offer their balancing reserves as products with different ramp-up times on three different balancing markets. The FCR bids simply contain a price in € per reserve capacity power in MW. The aFRR and mFRR bids contain a second component, which is the price for the activated reserve energy in € per MWh. FRR are not symmetrical, thus, up- and downward reserves are procured separately in separated bidding auctions.

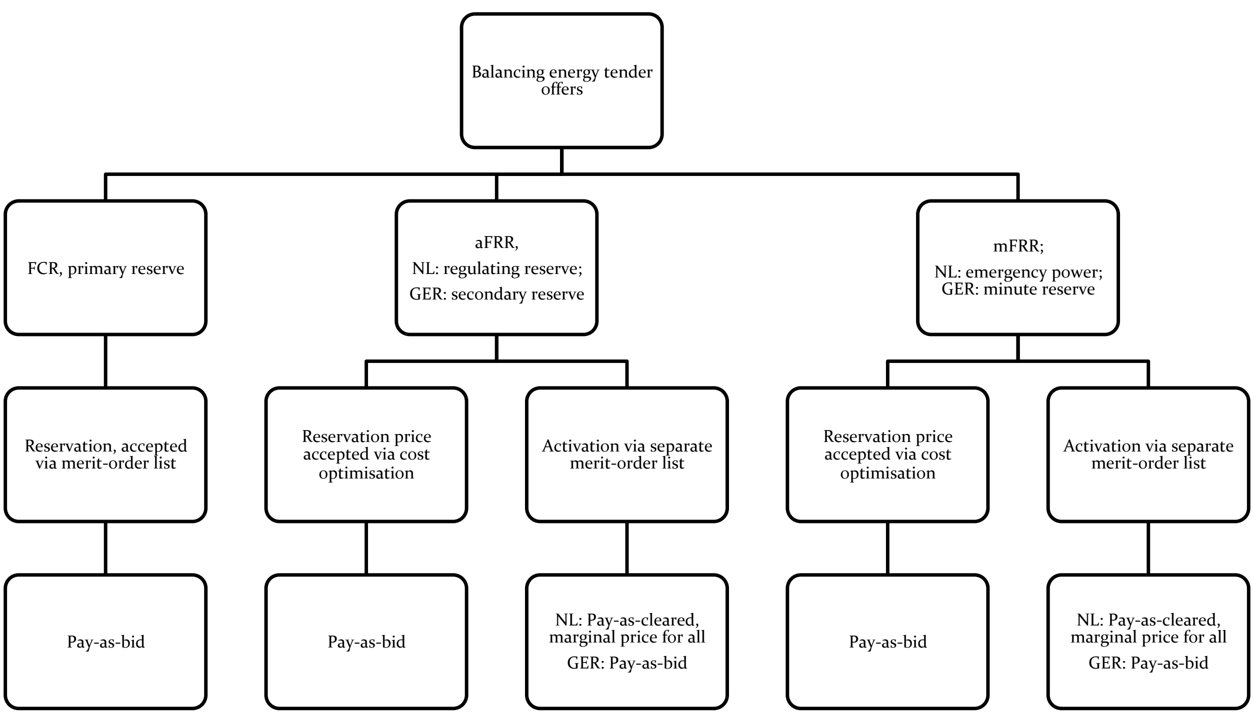

Figure 2: Balancing energy procurement and settlement in the Netherlands ([14]) and Germany (BK6-10-097 (5), BK-15-158 (9), BK6-15-159 (19))

Both countries apply pay-as-bid for capacity reservation of all reserve classes, but the clearing of activated FRR differs as mentioned above. While Germany applies pay-as-bid for the activated reserves, the Netherlands apply a marginal price. Figure 2 illustrates the procurement and clearing mechanism of the reserve classes in the Netherlands and Germany. Besides the clearing of activated energy bids, the design is similar in both countries ([14], p. 191; BK6-10-097 (5), BK-15-158 (9), BK6-15-159 (19)).

GLEB requests a common merit order list for the procurement mechanism, but does not specify the clearing principle ([1] Articles 0.11 and 29).

3.7. Activation strategy

Primary reserves, expressively FCR, respond to the system frequency according to ENTSO-E requirements in both countries ([15] Policy 1 Load-Frequency Control A-S2.3 and B-S2.1). Furthermore, in both countries the aFRR and mFRR bids are activated following a merit order with the amount of activated energy being a function of the area control error (ACE) and therefore the real imbalance of the control area. Multiple bids can be activated in parallel ([14], p. 191; BK6-15-158 (9), BK6-15-159 (10)).

GLEB requests a common activation optimisation function, which is under negotiation ([1] Article 31 and 58). The function shall take into account activation of different balancing energy products, operational security, all balancing energy bids and activation requests of all TSOs. If passive balancing is applied, the function has to be adjusted accordingly.

Germany with its four control areas has such a common activation optimisation in use since 2010. It contains four modules: (1) avoidance of activation of reserve capacities of opposing directions in interconnected control areas, (2) common dimensioning of reserve capacities, (3) common procurement of FRR and (4) cost optimized activation of FRR. Currently the first module is in active use between Germany and Denmark since 2011. In 2012 Switzerland, Belgium, the Czech Republic and the Netherlands joined this group, followed by Austria in 2015 and France in 2016 [13].

3.8. Bid requirements

Both countries apply different bid requirements, according to their portfolio and balancing market set-ups.

In the Netherlands, regulating power ramps up with 7% per minute. A bid must be in the range between 4 and 999 MW. The price may range to 100,000€/MWh, respectively -100,000€/MWh ([14], p. 191).

In Germany, bids of primary, secondary and minute reserves require an increment of 1 MW. Primary control is contracted for the period of a whole week. Secondary and minute reserves are contracted for periods of 4 hours (6 slots per day) (BK6-10-097 (2,7), BK-15-158 (2,5), BK6-15-159 (2,5)). The maximum price is limited to 9.999 €/MWh.

GLEB requests a proposal for common product requirements within two years. Thus, they are under negotiation and drafts can be expected by December 2019 ([1] Articles 25.2 and 25.4).

3.9. BSP accreditation

Both countries apply the ENTSO-E operational handbook for the synchronous area of central Europe. Primary reserves are required to reach a full activation after 30 s with linear development and without overshooting ([15] Policy 1 Load-Frequency Control A-S2.3). Secondary reserves start latest 30 s after receiving new set point frequency and are required to be fully operational after 15 minutes ([15] Policy 1 Load-Frequency Control B-S2.1).

GLEB requires the successful completion of the prequalification pursuant to Article 159 and Article 162 of Regulation (EU) 2017/1485. A proposal for requirements is requested within 6 month and is under negotiation. Therefore, drafts can be expected in July 2018 ([1] Articles 16.1 and 18.1).

4. Balance settlement variables

4.1. Allocation of balancing capacity costs

Both countries include the costs for capacity reservation in their system service tariffs according to the national regulations. Thus, the costs are allocated to all system users ([14], p. 191).

In principle, the GLEB also allows an additional settlement mechanism separate from the imbalance settlement ([1] Articles 5.3 g and 44.3). The approach of allocating costs for capacity reservation to all system users could remain.

4.2. Allocation of balancing energy costs

Both countries allocate balancing energy costs through imbalance settlement mechanisms. The BRPs pay for the costs in proportion to their energy imbalance ([14], p.191; BK6-06-013 annex "Bilanzkreisvertrag" (10.2)).

GLEB requests the same approach of cost settlement based on metered activation for each settlement period and each imbalance area ([1] Article 45).

4.3. Imbalance pricing mechanism

The imbalance pricing mechanism is another parameter, which interrelates with the transparency issue. The pricing mechanism defines potential revenues and costs for BRPs; thus, it is an important aspect for incentivising passive balancing behaviour. Both countries accumulate the costs for balancing energy over the settlement period of 15 minutes, but the details of how the costs are settled differ due to the different approaches in the balancing service pricing mechanisms (see 3.6). IN both cases the direction of the net imbalance of the control area and the activated reserves are considered when settling the imbalance costs.

Figure 3 visualises the Dutch imbalance pricing mechanism. Figure 4 visualises the German imbalance pricing mechanism.

The GLEB does not predefine this design variable and even allows national regulations to differ in this design choice ([1] Article 55.1).

The Netherlands apply single and dual pricing, depending on the activated reserves ([14], p.191). Single imbalance prices are applied for settlement periods, if only up- or only downward reserves have been activated. In these cases BRPS that have a corresponding imbalance pay for the balancing energy. BRPs that have an opposing imbalance receive revenue. A dual pricing scheme is applied, in cases of periods with the activation of up- as well as downwards reserves. In such periods BRPs pay for any imbalance since a resulting direction cannot be determined. Therefore BRPs can only earn revenues in periods with single imbalance prices.

The Dutch imbalance settlement summarised (see Figure 3):

- Comparison of scheduled power exchanges with measured data. All costs for balancing energy are accumulated for each settlement period (15 minutes).
- Dual prising is applied only if both up- and downward reserves have been activated.
- If no up- and no downward reserves have been activated no costs or revenues are cleared.
- The power exchanges within each BRP portfolio are aggregated and compared to the scheduled energy exchanges. The BRP imbalance is compared with the net system imbalance.
- Clearing: BRP either pay for costs, if their imbalance was in accordance with net system balance or receive revenues, if their imbalance was opposite the net system balance.

Germany applies a single price mechanism, but increases the cost in case of a negative net imbalance and decreases the costs in case of positive net imbalance before clearing ([10], p.45). German imbalance settlement summarised (see Figure 4):

- Comparison of scheduled power exchanges with measured data. All activated reserves and costs for balancing energy are accumulated for each settlement period (15 minutes).
- Negative (short) system balance caused by less generation and/or more consumption in control area than scheduled. Positive (long) system balance caused by more generation and/or less consumption in control area than scheduled.
- An additional component of the single-price is incentivising positive (long) system balance.
- The power exchanges within each BRP portfolio are aggregated and compared to the scheduled energy exchanges. The BRP imbalance is compared with the net system imbalance.
- Clearing: BRP either pay for costs, if their imbalance was in accordance with net system balance or receive revenues, if their imbalance was opposite the net system balance.

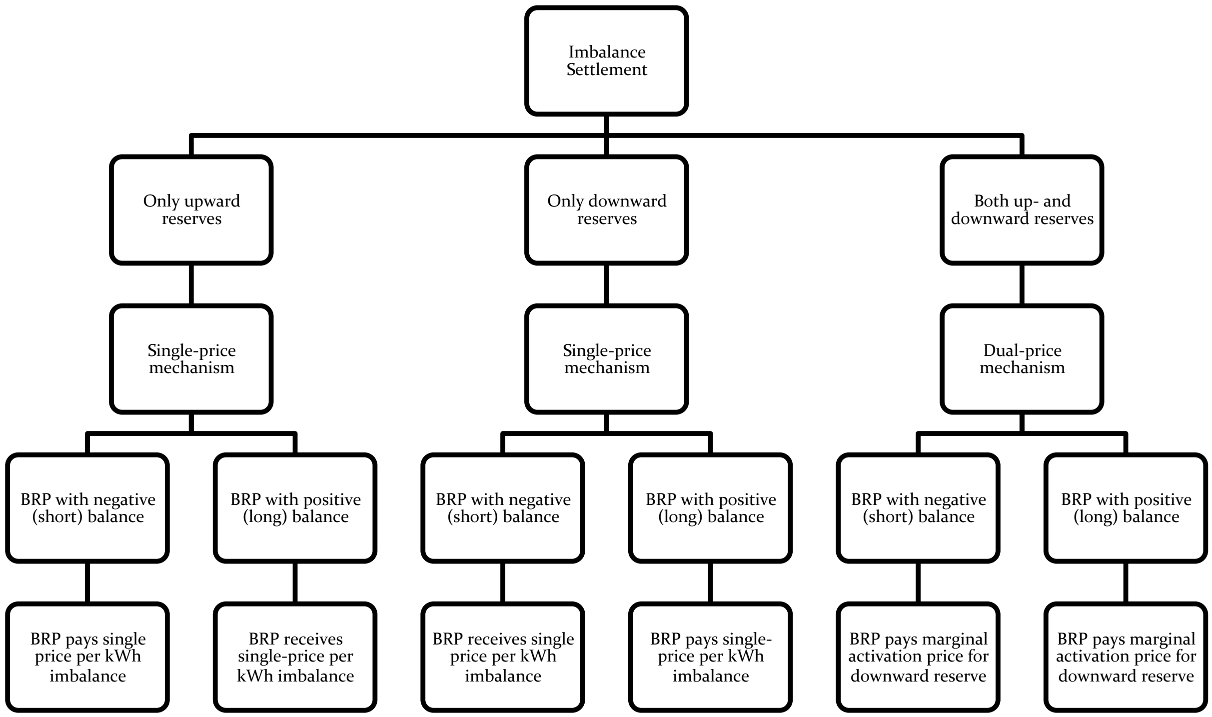

Figure 3: Imbalance settlement in the Netherlands, combination of single and dual pricing ([14], p.191)

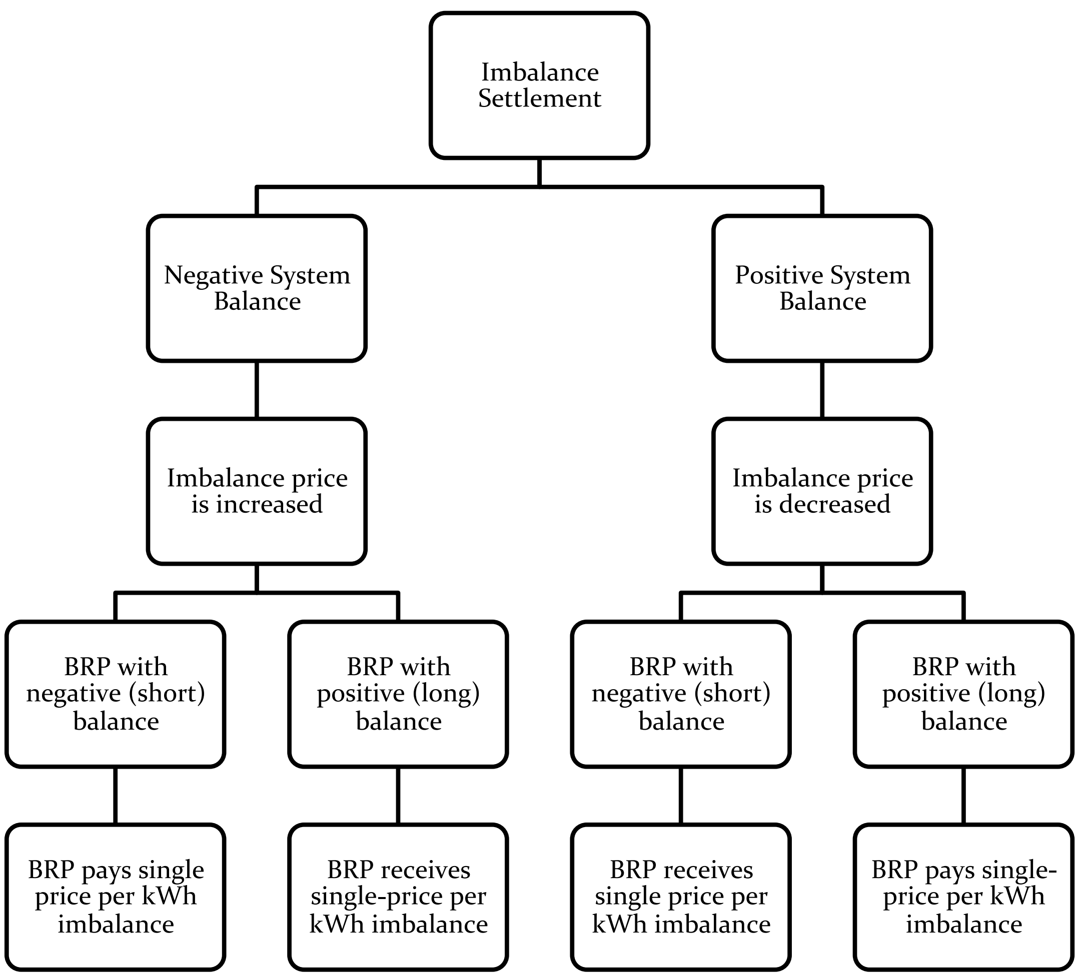

Figure 4: Imbalance settlement in Germany, single-pricing ([10], p. 45)

4.4. Penalty for non-delivery

The Netherlands does not apply a penalty for non-delivery of balance energy. Nevertheless, the missing energy creates an imbalance and therefore costs for the BRP, which is in this case also a BSP ([14], p.191). The German legislation allows penalties.

4.5. Allocation of net settlement sum

Both countries adapt the system service tariff in order to deal with remaining money after clearing. Therefore, the national legislations do not allow extra income for the TSO from overcharging BRPs ([14], p. 191; BK6-06-013 annex "Bilanzkreisvertrag" (10.2)).

4.6. Timing of settlement

The Netherlands apply a weekly settlement and the clearing takes place ten days after the end of the settlement week ([14], p.191).

Germany applies a monthly settlement and the clearing takes place 20 days after the end of the settlement month. The clearing results in Germany are published in the “reBap” time-cost dataset (BK6-06-013 annex "Bilanzkreisvertrag" (10.2) and (11.2)).

4. Conclusions

The two countries pursue similar strategies of reactive balancing. Nevertheless, they apply opposed strategies when it comes to transparency and passive balancing. This complicates the European integration and harmonisation process, since a well functioning passive balancing is depending on a number of design variables.

If passive balancing is supposed to play a role in a harmonized European balancing market lay out, the variables 1.1, 1.2, 1.3, 3.6, 3.7 and 4.3 can be defined as the most relevant design variables for incentivising BRPs.

The designs of the Dutch and German balancing markets represent two different design strategies, especially in terms of the publication of data.

- The Dutch approach represents the more transparent option. The publication of data on imbalance volumes and prices happens immediately and is visible online to the general public. Any BRP can react to the price signal and act in favour of system stability. Thus, the balancing service of the TSO acts complementary to the passive balancing of the BRP and only accounts for the remaining rest of the imbalance. Balance services are still required for security of supply, but the amount of activated balancing energy by the TSO is reduced significantly. This approach works for the Netherlands quite well because the aFRR is activated slower (with a longer response time) compared to the German system [16].

- The German balancing market design does not include incentives for BRPs other than keeping to their submitted schedule. Information on imbalance volumes and prices is only published ex post. The German strategy is to minimise imbalances by promoting good scheduling (accurate load and generation prediction) and to compensate any imbalances by the activation of reserve capacity through the TSOs. The advantage of passive balancing of the BRPs is lacking. But passive balancing by BRPs could more easily lead to resonance oscillations in Germany since the aFRR full activation time is comparatively short [16].

The GLEB does not specify the design of this issue for the future harmonized European balancing system, but it schedules a consultation procedure and requests all EU member states to reach an agreement within two years. In order to give solid recommendations, different market set-ups should be evaluated.

As the different national approaches both work reliably, a set of possible common market design parameters are under negotiation. The common European regulation has to guarantee security of supply, but for efficiency purposes should also minimize the activation of balancing energy to a technically and financially necessary limit.

Transparency on prices and volumes in power balancing is controversial. Even though the transparent approach has been working well for the Dutch market, it is not as such ad hoc transferable to any other transmission system due to the different secondary reserve controller set-ups and aFRR activation times. Additionally different relations of time-critical processes, energy intensity of needed reserves, prices per unit and trading strategies should be taken into consideration. These variables might cause different reactions of BRPs to price signals and therefore cause different effects to the electricity system. Therefore, investigating the effects of transparency measures on TSO imbalances is important for the consultation procedure on establishing a common European markets for electricity balancing.

5. Future research

Future research in NEW 4.0 is trying to further analyse the impacts and effects passive balancing could have in the German control area. Market design parameters, which might influence the efficiency of passive balancing, are the settlement period (see section 3 - 1.1), the publication of data (1.2), FAT of aFRR (1.3), the balancing service pricing mechanism (3.6), activation strategy (3.7) and the imbalance pricing mechanism (4.3). In order to examine the influence and interrelations of these parameters in the German balancing market set up more closely a computer model is going to be built. Simulations on passive balancing strategies of different BRPs are going to be carried out.

As a next step, interviews about possible passive balancing strategies will be conducted with BRPs in Germany. The interviewees are chosen to represent different industrial sectors. The likely BRP balancing strategies in a more transparent German balancing market set up will be analysed. The aim is to estimate how different BRPs in Germany would react to an imbalance price signal within the imbalance settlement period. Simulation runs are to examine suitable secondary reserve controller set ups for passive balancing in Germany as well as possible reductions in the activation of balancing reserves for Germany. Figure 5 shows a draft of the indented control loop design for the simulation runs, based on [4] and [5].

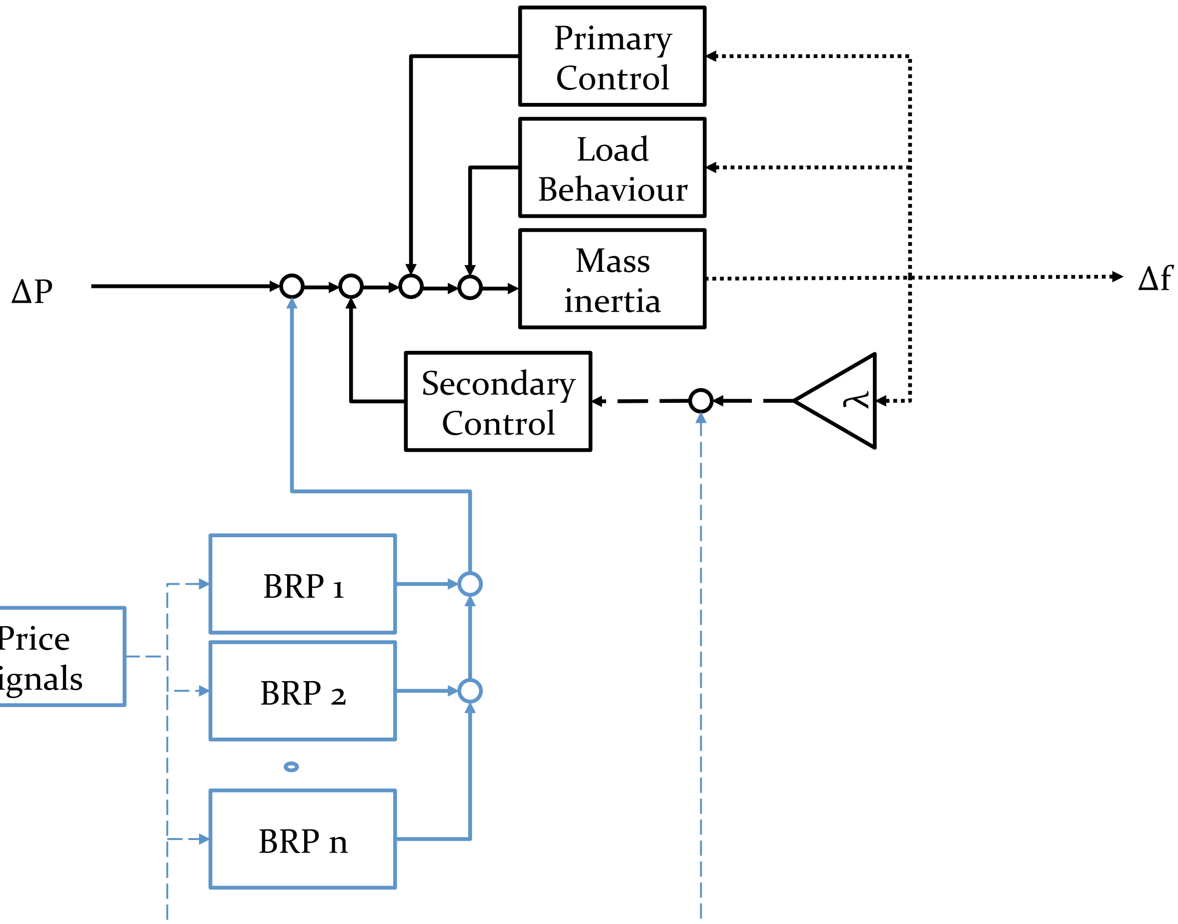

Figure 5: Draft action chart for future research

This research is conducted in the project NEW 4.0, NEW 4.0 is part of framework programme "Show Case Intelligent Energy – Digital Agenda for the Energy Turnaround (SINTEG)" founded by the German Ministry for Economics and Energy (BMWi). Within this programme five model regions are going to demonstrate solutions for an energy future based on very high shares of renewable energy. One such model region formed in Hamburg and Schleswig Holstein under the title "Northern German Energy Turnaround NEW 4.0". This innovation alliance consists of a consortium of 60 partners from politics, science and economy. In more than 100 single projects it aims at realising 25 large demonstrators in six use cases. NEW 4.0 started in December 2016 runs until November 2020. The approach of passive balancing is investigated in this context. See www.new4-0.de for details.

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