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**Research Report**

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# Intraday- and real time activity of TSOs: Germany

Christian Nabe<sup>1</sup> and Karsten Neuhoff<sup>2</sup>

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## 1. The elements of Intraday and Real-time Markets in Germany

This section characterizes the essential elements of intraday and real-time (balancing) markets and summarizes information on the performance of these elements. It shows how do the processes work in practice from the perspective of generation, TSO, and consumers.

### 1.1. System forecast and Redispatch

#### Two Day Ahead Congestion Forecast (D2CF Process)<sup>3</sup>

The 2-Days Ahead Congestion Forecast files (D2CF files), provided by the participating TSOs for their grid two-days ahead, are a best estimate of the state of the CWE electric system for day D. Each CWE TSO produces for its zone a D2CF file which contains:

- best estimation of the Net exchange program(e.g. from an agreed reference day)
- best estimation of the exchange program on DC cables( e.g. from a reference day)
- best estimation for the planned grid outages, including tie-lines and the topology of the grid as foreseen until D-2
- best estimation for the forecasted load and its pattern
- if applicable best estimation for the forecasted renewable energy generation, e.g. wind and solar generation
- best estimation for the outages of generating units, based on the latest info of availability of generators
- best estimation of the production of generating units, in line with outage planning, forecasted load and best estimated Net exchange program (e.g. from an agreed reference day)

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<sup>3</sup> Process description taken from CWE FB MC approval Document (June 2014)

The D2CF is used for the ATC (and later Flow-Based parameter) determination. Redispatch measures based on D2CF calculations are communicated at 8:00 am Day-ahead. Redispatch based on “worst case” D-2 calculations necessary to determine the operation of old, inflexible capacities procured via annually contracted redispatch reserves in Southern Germany (according to the “Reservenetzverordnung”). Although some of these reserves are located outside Germany (Austria, Italy), they do not require the allocation of network capacity as they help to relieve congestion.

#### **Day Ahead Congestion Forecast (DAC-F Process)<sup>4</sup>**

TSOs create hourly load flow projection after day-ahead market clearing based on (i) hourly nominations at installation level (>100 MW) submitted by 14.30 (ii) wind- and solar forecasts bought from several providers (iii) estimates of demand based announced schedules.

The picture of individual German TSOs is aggregated by the TSO Amprion for Germany and then submitted to the TSO Swissgrid to integrate in European wide congestion forecast. In telco(s) between 18.00 and 21.00 (worst case 23.00) response measures to anticipated over-load are agreed (primarily topological but also re-dispatch usually within countries) and in iterative approach tested for their impact.

Within Germany for obvious violations of constraints within Germany / or unacceptable loop flows re-dispatch measures are already incorporated in planning prior to submission of plans to Swissgrid.

Currently the day- ahead forecast is not consistently updated at intraday stage. Instead based on real-time monitoring of flows corrective measures are implemented. This would imply need to retain increasing security margins and spinning reserve (increasing with level of change to dispatch at intraday level due to e.g. deviations from day ahead generation / load forecast/ nomination). Market actors state that if the intraday-market and its liquidity was further increased, more redispatch measures would be required

Generation units called for re-dispatch measures are not allowed to subsequently engage in intraday trading activities the flow impact (e. g. the generation production volume resulting from an incremental measure cannot be undercut subsequently, nor can the production volume resulting from a decremental measure be increased subsequently).

In order to avoid excessive cost and too many interventions, TSOs do only implement re-dispatch measures at day-ahead stage to the extent that concerns with flow pattern remaining after re-dispatch can be corrected with the flexibility accessible with real-time measures.

#### **Impact of Flow-based Market Coupling**

The implementation of the flow-based market coupling, now scheduled for April 2015 will make the congestion forecast process more transparent. The coordinated determination of the ATC which in operation as of November 2010 was already based on the assessment of critical branches.<sup>5</sup> The

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<sup>4</sup> More detailed Process descriptions for the D2CF most TSO can be found in the CWE FB-MC approval documents (June 2014) :

<http://www.casc.eu/media/140801%20CWE%20FB%20MC%20Approval%20document.pdf>

<sup>5</sup> See chapter 4.1.1. of the FB-MC approval document.

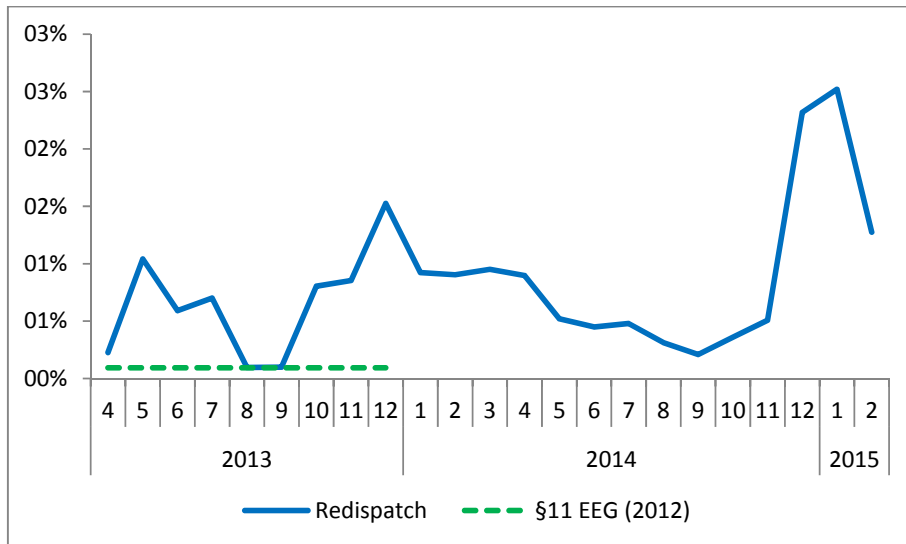
determination of the required parameters such as critical branches, the remaining capacity of the critical branches as well as the PTDF in the FB-MC is based on the D2CF model.<sup>6</sup>

The daily determination of ATC was based on a worst-case assessment of the network situation. Hence, in theory the hourly resolution of the FB-MC parameters improves accuracy of the network representation. The calculation of the required parameters needs to be finalized at 8:00 am Day-ahead. These parameters need to be calculated with high security margins as D-2 forecast errors of variable renewable power generation are substantial. This accounts especially for the prediction of the hour of arrival of a wind front.

Secondly, the applied generation shift keys are only an approximation of the market result. In fact, the determination of the FB parameters and the market results can be seen as a chicken-and-egg problem.

Remedial actions aim to increase the Flow-based domain e.g. by topology changes or tap-settings of phase-shifting transformers. These actions are taken into account in a second D2CF calculation. Results are incorporated in the FB parameters. Given these restrictions the resulting risk level of the FB-system is not clear.

The security margins incorporated in the FB parameter setting results in restrictive transmission capacity allocation day-ahead and can thus result in significant volumes of transmission capacity made available for commercial transactions at the intraday stage. The use of these capacities may be an advantage for larger market participants who can use them more effectively than smaller players. Figure 1 below displays the redispatch volumes in Germany, along with volumes of grid management according to §11 Renewable Energy Act (this is curtailment of renewables and combined heat and power units).



**Figure1:** Monthly redispatch volumes in Germany as % of gross electricity consumption.

<sup>6</sup> A detailed description of the process of determining the remaining available capacity on the critical branches can be found here: [http://www.casc.eu/media/pdf/FB/Annex%202016\\_2%20Example%20How%20does%20FB%20capacity%20calculation%20work.pdf](http://www.casc.eu/media/pdf/FB/Annex%202016_2%20Example%20How%20does%20FB%20capacity%20calculation%20work.pdf)

### **ERRP Data collection Process**

In 2014 German TSOs established a new data collection process for all generation > 10 MW, connected to a voltage level of  $\geq 110$  kV (no renewables). Generation is obliged to deliver data to the respective TSO after Day-ahead gate closure<sup>7</sup> as well as whenever schedules are updated based on intraday trade. This includes ramp rates, minimum run conditions as well as cost for start-up and operation. So far responsiveness of generators varies both among the large generation companies (with respect to value quality of information), and most generation below 100 MW is not providing data. The objective of the data is to provide TSOs information to identify least cost generation for re-dispatch measures. The process has not yet been coordinated at European level. So far, there is no connection of the ERRP process to the DACF process and the timeline is not clearly specified.

### **Semi-market based redispatch: Sicherheitsinduzierte Verkäufe (SiV Process “security-based sales”)**

The SiV process is a special redispatch process which is only applied in the 50Hertz regulation area and this process will very likely cease to exist. However, it is interesting to describe as it is based on the use of intraday-market.

Most re-dispatch measures involved localized plants that had to reduce production (e.g. largely coal units in 50Hertz regulation area) and the need to increase production outside of the 50Hertz regulation area to ensure energy balance.<sup>8</sup> This production increase often turned out to be expensive, as few suitable plants were available, implying that high variable cost units might be called upon. Security based sales offered an alternative approach. TSOs acquired in the intraday trading platform generation outside of their own territory. While this might reduce the efficiency of the re-dispatch measure it apparently largely reduced costs of the measure. Regarding this process it appears intriguing how little precision is necessary for grid operation, if bids can be selected irrespective of (electric) efficiency and any remaining impact on grid can be resolved in real time.

#### **1.2. Control reserve procurement**

Primary (control) reserves (Primärregelleistung), secondary reserve (Sekundärregelleistung) and tertiary reserves (Minutenreserveleistung) are procured ahead of real-time.<sup>9</sup> These reserve types are specifically acquired for system balancing, not for congestion management. The other reserve types are discussed in designated sections.

For primary and secondary reserves the required volume is calculated based on Graff Haubrich approach. Currently Germany is contracting a multiple of reserve volumes compared to neighbours like Belgium or Netherlands.

Primary and secondary reserves are contracted on a weekly basis, tertiary reserve on a daily basis (4h products). Auctions take place before the day ahead market at the power exchange. German TSOs have been discussing shorter contracting periods to allow different generation technologies to participate (e. g. wind if contracting at daily basis), but neighbours just succeeded in following the monthly pattern. However, TSOs are also reluctant to move to shorter time periods, as they are concerned then they might struggle in periods of generation shortage to contract for their reserve requirements (in first auction). German TSO have some reservations against a dynamic, daily

<sup>7</sup> See decision of the German Energy Regulator (“Bundesnetzagentur”) Nr. BK06-13-200: Data exchange processes in the framework of an energy information network for electricity (translation by author).

<sup>8</sup> 50Hertz sells in their own regulation area to ramp down lignite plants and buys in the adjacent Tennet regulation area.

<sup>9</sup> According to the new terminology introduced in the EU network code the reserve categories are named frequency containment, frequency restoration and replacement reserves

adjusted procurement volume since it requires an additional probabilistic assessment of the forecast errors and ramps of the next day. TSO have the incentive to be “on the very safe side” since they do not benefit from lower prices of reserves but would be accounted for insufficient reserve procurement.

The bids with the lowest capacity price are accepted while energy prices do not need to be cost reflected. Dispatch is based according to energy price submitted.

For pre-qualification suppliers of control reserve products have to provide evidence that they are able to fulfil the technical requirements concerning the provision of different control-reserve qualities.<sup>10</sup> As access conditions for the corresponding markets potential providers of control reserve have therefore to undergo a technical pre-qualification (separately for each control reserve quality). Beside technical qualifications proper provision of control reserve under operational conditions and economic efficiency of the potential supplier have to be guaranteed. All control reserve qualities are exclusively pre-qualified by the TSO in which control area the Technical Units concerned are connected, independently of the voltage level (reserve connecting TSO). The pre-qualification follows the minimum requirements differentiated according to control reserve quality and documented in the German Transmission Code (appendix D)<sup>11</sup>. A deployment of control reserve for testing purposes is absolutely required for the pre-qualification (normally two times in a row). The corresponding activation patterns for each control reserve qualification are published on the tender platform [www.regelleistung.net](http://www.regelleistung.net).”

Backup of reserve is required to reach a reliability of 100% of reserve provision and use. As this is not possible in practice, in the same control area and backup can be provided by third parties with capacities which have not been contracted by the TSO. No clear definition of the security level is provided. To secure the availability of reserves, providers may fall back on prequalified technical units of third parties’ installations in the same control area. If providers cannot provide reserve when it is called, they are likely to lose their reserve contracts. A specific penalty is not defined. However, up to now, no such cases became public.

Regional differentiation (Kernanteile) is in principle possible for contracting of secondary reserve, however no constraints are currently imposed (TSOs are concerned that this could increase costs for imbalances they are exposed to for the RE they market).

Both units that are providing reserve and units that are nominated to secure the provision of reserve cannot be called for re-dispatch measures by the TSO. This creates an opportunity for generators to deliberately exclude units from re-dispatch. As re-dispatch (i) is already implemented early in the day (ii) inhibits units that are called from participating at intraday market (iii) is only remunerated cost based and does not remunerate opportunity costs generators also have an incentive to exclude units from re-dispatch (subject to lawsuit to be decided 21? Jan. 2015?).

The possibility of reserve pooling has been successfully implemented. Reserve pools demonstrate a great accuracy when following the control commands of TSO. They would prefer to pre-qualify pools rather than small units.

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<sup>10</sup> This and the following description is taken from Consentec (2014): “Description of load-frequency control concept and market for control reserves”

<sup>11</sup> [https://www.bdew.de/internet.nsf/id/A2A0475F2FAE8F44C12578300047C92F/\\$file/TransmissionCode.pdf](https://www.bdew.de/internet.nsf/id/A2A0475F2FAE8F44C12578300047C92F/$file/TransmissionCode.pdf)

### 1.3. Balancing responsible parties and imbalance pricing

Each market participant needs to establish at least one balancing group per regulation area (4 regulation areas in Germany). Market participants have submit schedules for their own balancing groups.

Price formation in balancing market gives incentives for balanced schedules. The imbalance prices are single prices for every 15 min. period. It is derived from average costs of secondary and tertiary reserve energy employed by the TSO. Reserves are dispatched according to their energy bids. As additional incentive to keep schedules, the imbalance price is increased if more than 80% of the contracted control reserve is deployed: In these situations it is raised to 100 €/MWh or 1.5 times the original amount.

Schedule deviations have not only financial consequences. In case of intended (not random) deviations (“Prognosepflichtverletzung”), TSOs may cancel the balancing contract with traders and make their trading activity impossible. So far, no case of contract cancellation is known in public.

Market parties need to restore a balanced schedule after 1 h and 15 min.

Market participants make re-nominations after real time to avoid imbalance charges in the so-called after market, in case they find a matching partner with the reverse imbalance.

With increasing incentives against imbalances in balance groups, the use of reserves has been declining. This was also achieved due to the integration of the formerly four Balancing areas into one (Netzregelverbund).

## 2. Common groups of elements / interactions across elements

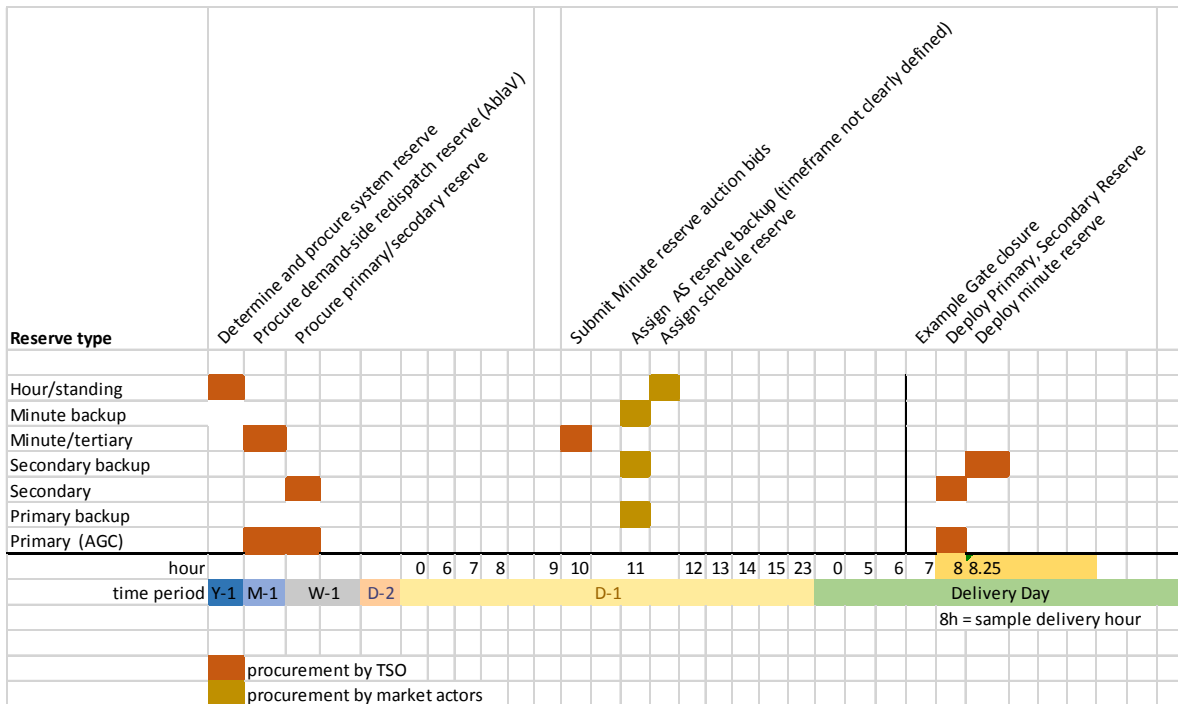
### 2.1. Fragmentation of reserve products

Secure power system operation always required a set of reserve products to ensure supply matches demand for power at all times. Given the different response modes of generation assets, most power systems thus had defined different qualities of reserves that were good complements both at generation side (supply of reserve) and from the system perspective (demand for reserves).

In the meantime additional reserve categories have been added to the German power system. (i) To accommodate transmission constraints that emerged to the nuclear phase-out, a special network reserve exclusively for redispatch purposes is contracted. (ii) As the reliability of privately provided reserve products is difficult to evaluate for the TSO, reserve providers have to nominate back-up for their own reserve provision. (iii) Because of limited depth of intraday market, balancing groups typically contract reserves for the failure of the largest generation asset. (iv) Because the format of traditional reserve products does not match the characteristics of some demand response, a new reserve category addresses their special properties.

While each of these new reserve categories appears to provide a suitable response to a specific question, together they create a situation where flexibility options that from a technical perspective substitute for each other are only accessible for specific purposes or users. This has the following implications:

- Uncertain remuneration of flexibility: The remuneration for reserve products is heavily influenced by the regulatory determined reserve product definition and the competition within the product group rather than on the real value of flexibility for the system.
- Uncertainty for remuneration of generation investment: In principle a separate procurement of different reserve categories will imply a higher reserve pool than would otherwise we acquired, and with increasing demand overall higher prices. However, any future adjustment to the regulation could alter the situation and reduce artificially created scarcity. This is why the revenue stream of reserve products is not regarded as reliable for generation investments.
- Difficulty to reflect scarcity in reserve prices: In theory, prices charged for reserve provision should reflect the increased probability of lost load events in the case of deployment of contracted reserves. This is however difficult to implement if different reserve products can offer substitute services to the system and thus would need to be jointly priced.
- Decreased level of security of reliability: The system might have sufficient technical flexibility, but because of the different categorization it is not accessible to the local TSO, let alone shared with neighbors (because part of private balancing groups, or because classified as reserve to resolve transmission constraints not to secure generation adequacy).



### 2.2. Spatial diversity

For secure system operation the transmission system operator has to account for the spatial distribution of generation and load so as to avoid violation of thermal and voltage constraints. In power market designs with uniform pricing zones, in our case covering both Germany and Austria, this creates two basic sets of challenges for TSO: The chicken and egg problem of transmission allocation and gaming of re-dispatch measures.



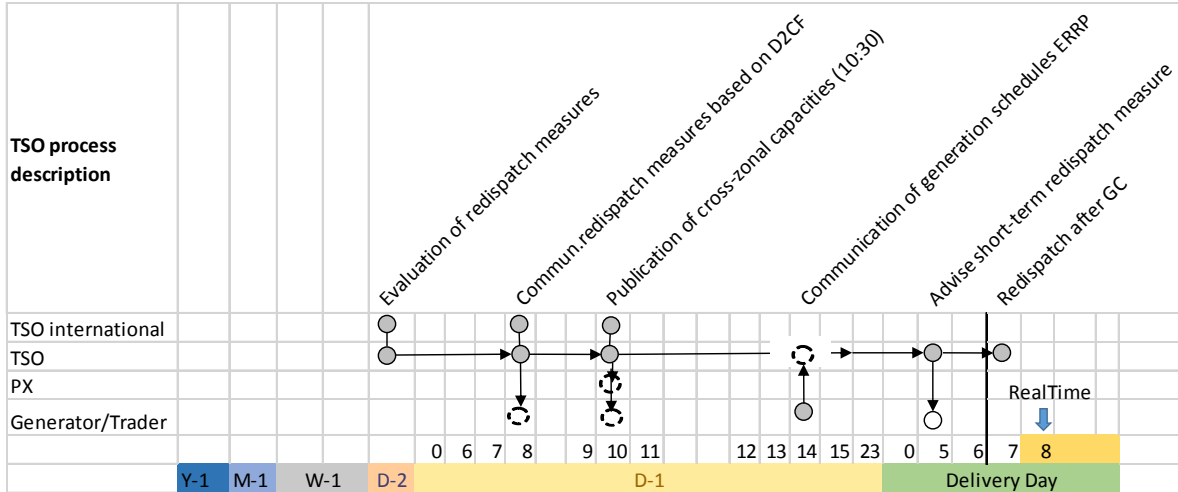
**Resolve the chicken and egg issue of transmission allocation and use:** The transmission capacity available for commercial transactions between pricing zones depends on the generation and load pattern within a pricing zone (technical term: generation shift keys). However, the generation and load pattern within a pricing zone is a function of the market outcome and as such is influenced by the volume of transmission capacity made available by TSOs for international transfers.

The German TSOs use an iterative approach in response to the chicken and egg issue. They use historic generation patterns (day minus 2) for initial calculations of transmission capacity for commercial transfers, and then update this information based on schedules nominated by market participants after day-ahead power exchange closure. Based on the updated flow-patterns, redispatch measures are coordinated with neighboring TSOs.

At intraday stage it is anticipated (but so far not implemented) that additional transmission capacity may be made available to market participants. Given the large uncertainties on generation patterns, and hence reserve margins for day-ahead transmission allocation, it is to be anticipated that significant volumes of transmission capacity will only be made available to the market at intraday stage. This new available capacity combined with updated wind/solar predictions might lead to significant changes of generation patterns compared to day-ahead predictions. These dynamics of system operation will be an increasing challenge for TSO and might imply a re-consideration of gate closure times.

**Avoid gaming of re-dispatch measures:** At times the predicted or nominated generation pattern will result in violation of network constraints, and thus requires the TSO to implement re-dispatch measures, e.g. ask generation at some location to increase and at other location to decrease power production. The anticipation of such re-dispatch measures may already influence the action of market participants, and has in other systems offered gaming opportunities that put system security at risk.

The German TSOs have contracted in Southern Germany and adjacent countries generation assets that are exclusively used to increase generation and precluded from participating in the market (the “Netzreserve”). For all generation assets, remuneration for re-dispatch is merely cost based, to avoid profit opportunities from gaming. However, with increasing volumes of re-dispatch measures this implies increasing volumes of generation is contracted and remunerated outside of the market. Furthermore it creates incentive to nominate generation assets for reserve provision or as back-up for reserve provision so as to preclude the use for re-dispatch measures, thus limiting the pool of available capacity for redispatch measures.



**2.3. III. Incentive compatible versus administrative requirements**

Power market regulation needs to balance the use of administrative requirements and financial incentives. Neither is it suitable to impose merely administrative requirements for all actions if a market is to be retained, nor is it practical to link all requirements of the complex interactions of power system operation to financial mechanisms.

In Germany market participants are both legally required to submit at gate closure a schedule that is in balance for each region of a TSO, and can be subject to investigation and legal consequences (they will lose their contract) if failing to do so. In addition, imbalances that are increasing system imbalance are charged at least at the more costly of the latest price of intraday market and cost of reserve to adjust for imbalance.

This approach creates a challenge for the reliability of schedules available for TSOs in their system planning. Once redundant reserves are procured, instances during which overall reserves level is scarce are rare and therefore market participants will face very limited market based incentives for balanced schedules. Such incentives are further moderated as long as ex-post nominations allow correcting for imbalances.

Table: Type and spatial resolution of nomination

		Spatial resolution		
		Plant level	TSO region	Country
Mechanism for accuracy	Administrative Requirement	Non binding nomination	Legal requirement of balanced submission	
	Incentive from market signal		Imbalance charge	

In response, administrative requirements for information provision and balanced schedules have been formulated, but they are difficult to enforce in particular among small actors and distribution system operators. This is an inherent challenge of an administrative requirement at the center of a market based mechanism. If the administrative requirement is formulated too stringent, then it results in many instances of excessive administrative costs and operational risk for market

participants. If it is formulated to lenient, then it puts system at risk, because of low quality of information available to the TSO. This in particular a challenge because of the diversity of actors and situations. In most hours some deviations are of no concerns, but in hours of tight system situations, precision is necessary. In contrast, financial incentives that are linked directly to real time prices increase the incentive for balances schedules at critical times and for large transactions through the volatility in situations of system stress that can be hedged with balanced schedules.

A second challenge of the approach is linked to the spatial resolution of reliable information available to TSOs. The congestion forecast process is currently not based on market information, due to both the previously described timing problems (chicken-egg, current approach see above) and the focus on balanced schedules that are provide information on TSO level only, but do not offer information on the locations of generation and load to the TSO. A new process requiring the timely reporting by market participants on location specific schedules to the TSO during the intraday time frame is being introduced. However, to date the quality of data provided seems unsatisfactory, and it seems difficult to enforce high quality data provision. Furthermore, market participants retain the flexibility for continued re-nominations, hence also the reliability of the information for system operation decisions is limited. Also not included is information on DSM and renewables deployment. As TSOs consider their own forecasts on renewable production more reliable and suitable than the market nominated information this seems of less concern. For Congestion forecast on DSO level would require higher spatial resolution schedule information. Overall for an efficient and secure management of transmission congestion on the system, a closer alignment between market and non-market areas will be necessary.

### 3. Envisaged developments

This section describes main options for adjustments of overall design or individual elements/introduction of new elements currently discussed in national context, the motivation for the proposed change and if available evaluations.

#### 3.1. Additional Reserve product

A new reserve product is currently in discussion, the “TSO-Auffangnetz”. It is motivated by the long-term requirement for redispatch potential especially if the if the networks are not dimensioned for transmission “of the last kWh” (3%-rule). This reserve type may address the problem, that the volume of contracted redispatch reserve (Netzreserve) is relatively large due to the large distance to the congested line.

This product can be characterized as replacement reserve. Unlike minute reserve this reserve type should not be used for system balancing but to provide redispatch capacity. Hence it can partly replace the “Netzreserve”. A large share of this capacity would be required in Southern Germany.

The design of the “Auffangnetz”-reserve is not clear yet. While some TSO would prefer to contract designated assets, other prefer to procure them in a market-based, technology neutral way. The procurement could be for a two-year period with an auction 6 months ahead. It is not clear yet at which markets the assets can participate (day-ahead, intraday).

#### 3.2. Regelenergiearbeitsmarkt (Reserve energy energy market) vs. secondary reserve market

The ENTSO-E Draft Network Code on Electricity Balancing (EB, Version 3.0, 6. Aug. 2014) requires the implementation of a market for balancing energy, which according to the code is only allowed to

open after the gate closer of intraday market.<sup>12</sup> This also coincides with two domestic motivations for the implementation of such a new market:

- The use of control reserve can be expensive because (i) the energy bid component has been increased as competition for acceptance of contracting purely on capacity price (ii) primarily units with high variable cost are participating
- There is an interest to allow for wind power to deliver flexibility even so wind is not able to participate in auctions for provision of reserve week ahead (as wind forecasts are not good enough at that point). One driver in this regard is the motivation to reduce the must-run volume of conventional generation.
- The market may help to replace the ordinance on interruptible loads (AbLaV)

However, there are also concerns associated with the implementation of a reserve energy market in Germany.

- How will a reduction of imbalance costs impact the incentives for market participants to avoid imbalances in balancing groups ?
- Will it result in fewer calls for day-ahead contracted reserves, and thus – according to the observed bit pattern – an increased price in bids either for (energy or) capacity provided by reserves?
- Would it help to implement a bid-evaluation scheme based on both energy and capacity bids for the day-ahead reserve market?
- How would the implementation of the reserve energy-energy market impact the volumes of reserve contracted ahead? If it will not reduce contracted reserve volumes, then it is difficult to see how it is to reduce the must run share of fossil generation.
- Would it be necessary to switch from PaB to MCP?

As an alternative implementation, the trading of reserve products in a secondary market is under discussion. However, this concept may not be compatible with the MIFID (Markets in Financial Instruments Directive).

### 3.3. Discussion of merged reserve and redispatch products

So far, the purpose of control reserve products (system balance) and redispatch products (congestion management) has been strictly separated in German market design. However, shrinking available generation capacity raises the question whether it would be efficient to use reserves for both purposes.

This discussion touches a second paradigm of a single German price zone. As soon as multi-purpose reserves are defined and procured in the market, a regional component will be introduced in the market sphere. The question arises at which point regional components should be introduced.<sup>13</sup>

A possible entry point could be the Regelenergiearbeitsmarkt. An introduction at this point might imply a regional price differentiation in the real time market (Ausgleichsenergiepreis) as well as regional cost differences of reserves. Hence the question arises, whether it would be appropriate and possible to re-balance distribution effects between North and South.

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<sup>12</sup> „Article 32.4: A Balancing Energy Gate Closure Time shall be after the ID Cross Zonal Gate Closure Time for manually activated Balancing Energy bids and avoid cross zonal Intraday Market and Balancing Market taking place at the same time“.

<sup>13</sup> NB: It can be argued, the Intraday market has a regional component, as it is possible to bid in a single control area (e.g. Tennet DE). However, borders of control zones are not necessarily matching network congestion. This is especially true for the TenneT DE control zone which contains congested transmission lines between north and south.

**Literature sources for the ERRP process:**

Festlegung:

[http://www.amprion.net/sites/default/files/BK6-13-200\\_Beschluss\\_2014\\_04\\_16.pdf](http://www.amprion.net/sites/default/files/BK6-13-200_Beschluss_2014_04_16.pdf)

Implementation guideline:, detailed data description:

[http://www.amprion.net/sites/default/files/BK6-13-200\\_Beschluss\\_2014\\_04\\_16\\_Anlage\\_2.pdf](http://www.amprion.net/sites/default/files/BK6-13-200_Beschluss_2014_04_16_Anlage_2.pdf)