# INTEGRATION OF VIRTUAL POWER PLANTS IN CROSS-BORDER BALANCING MARKETS CONSIDERING DIFFERENT MARKET ARCHITECTURES

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## ABSTRACT

*The subject addressed in this paper is the integration of Virtual Power Plants (VPPs) in balancing markets under consideration of current developments to improve cross-border balancing market architectures. The aggregation of small units (pooling) can be a significant step towards the integration of fluctuating Renewable Electricity Generation (RES-E) and Demand Response (DR) in electricity balancing markets. Hence, implications of VPPs on different national balancing markets and cross-border balancing market architectures according to the results of the EU project eBADGE are analysed. In the Project eBADGE an optimal pan-European intelligent balancing mechanism is proposed that enables VPPs participation and corresponding demo projects will be piloted on the borders of Austria, Italy and Slovenia.*

## INTRODUCTION

For the integration of the European electricity market the Internal Energy Market (IEM) shall be developed by 2014 and electrically isolated member states from the rest of the EU be incorporated by 2015 [1]. Furthermore, the integration of fluctuating renewable energies will be fostered and the security of supply be assured.

To ensure the implementation of these goals the European Network of Transmission System Operators (ENTSO-E) currently develops Network Codes based on the framework guidelines of the Agency for the Cooperation of Energy Regulators (ACER). One of these is the Network Code on Electricity Balancing (NC EB) [2] that boosts the development of an Integrated European balancing mechanism, based on ACER's Framework Guideline [3]. The NC EB aims at creating a level playing field for all potential providers of Balancing Services, including demand side response, energy storage and intermittent resources. Harmonized processes and the use of Standard Products should form a framework for providers to offer Balancing Services to regional or pan-European Balancing Markets based on TSO-TSO cooperation.

The way towards a harmonized regulatory framework is difficult, as shown by an in-depth study carried out within the project eBADGE [4]. Additionally, different "intermediate" market architectures for Cross-Border procurement and activation of balancing capacity and balancing energy are highlighted in chapter 3 in this paper [5]. Moreover, the result of a study of ENTSO-E [6] highlights "the great diversity of arrangements that exist for ancillary services and imbalance charges across Europe - which will be one of the biggest challenges when designing Balancing schemes". The balancing market designs are highly diverse in the different countries and have to be harmonised in order to implement cross-border balancing architectures across Europe and to develop a fully integrated IEM.

This context motivates the FP7 research project eBADGE [7], led by Telekom Slovenije and encompassing 13 partners including the Austrian and Slovenian Transmission System Operators APG and ELES, the Slovenian market operator Borzen, the German ICT provider SAP and several research institutions. The aim of eBADGE is to propose an optimal pan-European Intelligent Balancing mechanism also able to integrate Virtual Power Plants (VPPs) Systems. Furthermore, demand response, yet being one of the most promising providers of ancillary services, is in many European countries prevented from competing on an equal ground with conventional power generation. In order to achieve its objectives, the eBADGE project develops a simulation tool for studying the integrated balancing market and a unified data-exchange standard using a high performance message bus between balancing and capacity entities. These components are being integrated into a single pilot eBADGE Energy Cloud that will, along with the other components, be validated through tests in the laboratory and a field trial.

In this paper an overview about possible market architectures for cross-border exchange of balancing energy is given and the conditions for VPPs to participate in the balancing markets in Austrian, Italy and Slovenia (AIS) are analysed.

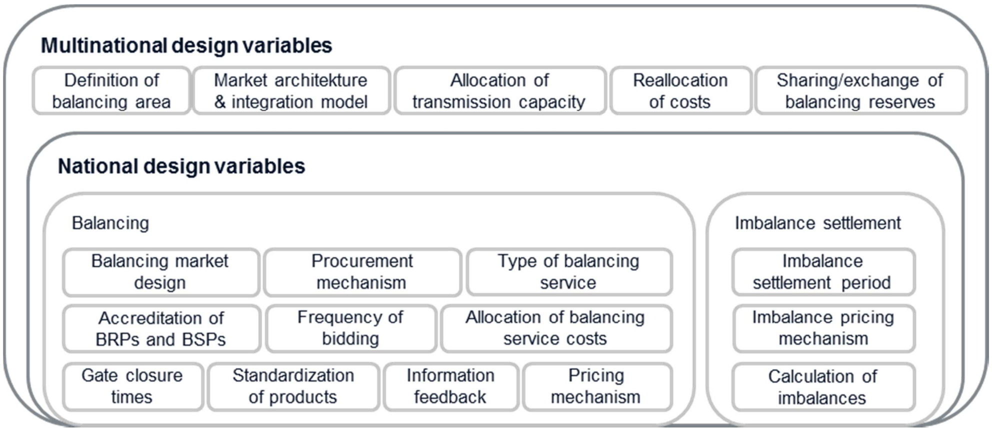


**Figure 1: Selected design variables for analysis of national balancing markets [4]**

## DESIGN VARIABLES FOR BALANCING ENERGY MARKETS

The diversity of procurement schemes for ancillary services across Europe has to be taken into account when developing cross-border balancing schemes and to further integrate VPPs. According to selected design parameters, balancing markets can be analyzed as shown in Figure 1.

While the multinational design variables have yet to be designed, the national balancing market design parameters need to be harmonized for successful implementation of cross border balancing in a way to ensure secure balancing and to enhance global welfare. The challenge of defining these parameters and of defining the degree of harmonization is to specify them in an intelligible way, but to let room for national technical requirements and specifications.

One parameter is the selected market architecture for the cross-border exchange of balancing. These different market architectures for the integration of European balancing market and thus, for cross-border procurement of balancing energy will be explained in the following.

## MARKET ARCHITECTURES FOR CROSS-BORDER EXCHANGE OF BALANCING ENERGY

### Overview about several balancing market architectures

Different market architectures for the integration of European balancing market and thus, for cross-border procurement of balancing energy exist, as can be seen in Table 1 they have different pros (+/++) and cons (-/--). The starting point is a national balancing market without any exchange of balancing energy bids.

The cross-border BSP (Balancing Service Provider) – TSO (Transmission System Operator) concept is followed by two gradually enhanced cross-border TSO-TSO balancing market architectures (considering different principles of bid exchange). The most advanced market architecture coincides with the so-called *'Target Model'* being consistent with the overall framework defined in the ACER and ENTSO-E documents [2][3][8].

The balancing market within the control zone of a single TSO (national model) is organised based on the following subsequent steps for procuring and – in case of activation – balancing services from different Balancing Service Providers (BSPs) fulfilling the prequalification criteria: (i) Procurement of balancing capacity, (ii) Procurement of balancing energy and (iii) Activation of balancing energy of selected BSPs. For the first two mentioned steps above ((i) & (ii)) separate tenders exist and the corresponding bids are split for upward and downward regulation. Well defined standard products can be offered by BSPs to the TSO that clears the market in the corresponding national market place for procurement of balancing energy.

In the cross-border BSP-TSO concept it is foreseen that Balancing Service Providers (BSPs) can offer balancing energy bids not only to the Transmission System Operator (TSO) in their own control area, but also to other TSOs in neighboring control areas. This offer of balancing energy bids by a BSP to a TSO has to be accepted by the 'own' TSO in the control area where the BSP is located. In case of activation of these kinds of balancing energy bids a cross-border balancing energy exchange takes place as long as there is sufficient cross-border transmission capacity available at the point in time when it is actually needed.

**Table 1 : Comparison of the different cross-border balancing market concepts [5]**

| | Cross-border BSP-TSO model | Bilateral / multilateral TSO-TSO model without common merit order | Multilateral TSO-TSO model with common merit order - lower degree of harmonization | Multilateral TSO-TSO model with common merit order - high degree of harmonization |
|---|---|---|---|---|
| Economic allocation efficiency | -- | - | + | ++ |
| Short/medium term applicability in practise | ++ | + | - | -- |
| Support of VPPs as BSPs | -- | -- | - | + |
| Harmonisation needs of neighbouring balancing markets | -- | - | + | ++ |
| Market compatibility / competition / transparency | -- | - | + | + |
| Social welfare / system cost (global optimum) | -- | - | + | ++ |

The bilateral/multilateral market-based TSO-TSO balancing model with surplus exchange is a further development of the previously described national approach. The aim of such a balancing market model is that the involved TSOs exchange some surplus balancing energy bids based on predefined criteria. It is important to note that the exchange is restricted to surplus balancing energy bids only. The determination and procurement of balancing capacity is carried out separately by each of the TSOs. Hence, no exchange of balancing capacity among the TSOs exists and also no reservation of cross-border transfer capacity is needed to enable the exchange of balancing capacity. However, a cross-border exchange of surplus balancing energy bids is only feasible if sufficient cross-border transfer capacity is available in case of activation.

The bilateral/multilateral market-based TSO-TSO balancing model with common merit-order list with unshared bids can be interpreted as an intermediate step next to the so-called 'target model'. Moreover, this approach can deliver valuable experience before implementing the target model. The challenge of the TSO-TSO balancing model with common merit-order with unshared bids, however, is to find criteria or a set of criteria determining both balancing energy bids need and need not to be shared among the different TSOs (= unshared bids). Exchanging balancing energy bids on a common function and, in case, activation of some of these balancing energy bids finally results in cross-border balancing energy exchange. This balancing energy exchange, however, is feasible only if there are sufficient cross-border transmission capacities available.

The target model is a fully integrated TSO-TSO balancing model with common merit order, where all bids of the Balancing Service Providers (BSPs) are shared on common function. The procurement of balancing capacity bids and balancing energy bids is conducted by the connecting-TSO. Then, each TSO will forward the procured balancing energy bids to the common function, cross-border exchange among the TSOs balancing capacity is only optional hence, the procured balancing capacity bids remain on national TSO level. Therefore, a reservation of cross-border transmission capacity is not obligatory. However, a cross-border exchange of balancing energy is feasible only if sufficient cross-border transmission capacity is available.

## The way towards the target model architecture for cross-border exchange of balancing energy

The NC EB proposes a phased approach to fostering cooperation amongst balancing areas; the key concept is the one of "coordinated Balancing Areas", seen as cooperation with respect to the Exchange of Balancing Services between two or more Transmission System Operators". As time passes, the level of cooperation within a Coordinated Balancing Area and between neighbouring ones will increase, neighbouring Coordinated Balancing Areas will merge in order to reach the final target of a single pan-European Common Merit Order list. To reach this goal a certain degree of harmonisation is necessary.

**Table 2: Relevant parameters for participation of VPPs in AIS for FRRman [4][9][10][11]**

| | Austria | Slovenia | Italy |
|---|---|---|---|
| **Participation of Demand Response (DR)** | Not defined | Not defined | Excluded |
| **Participation of Renewable Energies (RES-E)** | Not defined | Not defined | Excluded |
| **Minimum bid size** | ≥10 MW | ≥1MW | ≥10 MW |
| **Possibility for pooling of units** | Yes | Yes | No |
| **Minimal prequalified technical unit** | ≥0.5 MW | ≥1 MW | ≥10 MW |
| **Timeframe of Balancing Capacity** | Week ahead | Year ahead | Day ahead/Intraday |
| **Timeframe of balancing products** | 4 hour block on five weekdays or two weekend days) | ≥16 hours | 6 hour blocks |

The balancing markets in Austria, Slovenia and Italy (AIS) and the need for harmonization between them were analysed according to the design variables in Figure 1. The first dissimilarity between the three countries is the balancing market design. The dispatching system is the same in Austria and Slovenia (self-dispatch system on portfolio basis), but different in Italy (central dispatch system). Many details in the Network Code on Electricity Balancing implicitly assume a self-dispatch balancing market design. For central dispatch markets an exceptional regulation is in place. The optimization algorithm of the central-dispatch model takes simultaneously the balancing requirement as well as the internal congestions into account. The balancing resources have to be mandatory offered in Italy, whereas in Slovenia the balancing capacity is procured by bilateral contracts. In Austria the market-based mechanism of a tendering process is used. The manual Frequency Restoration Reserve (FRRman) balancing service of the three countries is indeed according to the operation handbook of the ENTSO-E, but the FRRman differs in some parameters as for instance regarding the time to full activation (10 minutes in Austria, 15 minutes in Slovenia and Italy). At least some of these differences have to be harmonized for the cross-border market opening of balancing energy. A start of these harmonisations would be an adaptation of the gate closure times – day-ahead, intraday, balancing energy, capacity allocation and favourable the (imbalance) settlement time unit – as different gate closure times make the cross-border provision of balancing energy nearly impossible.

## CONDITIONS FOR VPPS TO PARTICIPATE IN BALANCING MARKETS

### Conditions for VPPs in the target model

ENTSO-E stresses that the participation of VPPs should not only be considered, but especially facilitated in order to avoid the rise of short-term balancing cost in the current scenario of increasing penetration of RES-E and DR [2][8]. Results show (see Table 2) that currently the balancing markets are not perfectly designed to allow the integration of VPPs in the balancing markets. Therefore, it is highly recommended to explicitly consider VPPs, DR and RES-E when defining the rules of coordinated balancing areas. A huge step in this direction would be the possibility of aggregation of small units (pooling), which would transfer most of the technical and bureaucratical aspects to the aggregator's level, giving to a large amount of small units the chance to participate in the Balancing Market [12]. According to the NC EB aggregation and the single participation of DR and RES-E shall be allowed. Furthermore, the timing of the markets is critical as DR and RES-E can only participate if the balancing markets are close to real-time. This is regulated in the NC EB by limiting the contracts of balancing capacity to one month (longer contract periods have to be approved by the Energy Regulator).

### Requirements for the integration of VPPs in the balancing market architectures

To include more participants and smaller units in the balancing market architectures for cross-border exchange of balancing energy the term BSP has to be extended and the standard products have to be chosen accordingly in the sense that also distributed generators, small sized energy storage and load response can contribute in this segment as a market participant. Furthermore, for the integration of VPPs it is important to implement a balancing energy market that is closer to real time (e.g. one hour before real-time). Additionally, the approach in case of congestions in the distribution grid has to be handled by the local DSOs in order to solve local grid problems that may arise by the participation of generators or loads in the balancing scheme.

## Conditions for VPPs in AIS

The current product specifications in AIS countries and the lack of a verification methodology currently hinder the participation of VPPs, RES-E and DR in the national balancing markets as shown in Table 2. The exclusion, but also the non-definition, of DR and RES-E hinder the participation. The higher the minimum bid size the more small units have to be pooled and, of course, the permission of pooling is necessary condition for VPPs. Pooling is allowed in Austria and Slovenia, but not in Italy. The minimum bid size is quite high in Italy and Austria; however, the Austrian TSO APG plans to reduce it from 10 MW to 5 MW [13]. In case of a low limit for the minimal prequalified technical unit smaller units are excluded. In all three AIS countries a minimal limit for the technical units is provided, but it is questionable if a limit is necessary. In case no limit is set the aggregator bears the risk and the costs of connecting small units. Furthermore, the timing of the balancing markets and the coordination timing of the balancing market with the electricity markets is important to integrate VPPs, DR and RES-E [14-16]. The forecast of renewables and demand is more accurate close to real-time; hence the participation in balancing markets can be estimated more precisely in case the procurement balancing capacity is closer to real-time. The flexibility of DR and RES-E differs depending on time of the day, season, and weather conditions. Therefore, short timeframes of balancing products (e.g. one hour) offer the needed flexibility to schedule the application of VPPs.

## CONCLUSION

Different balancing market architectures allow the cross-border exchange of balancing energy. The introduction of a TSO-TSO model with common merit order (target model) requires the harmonization of several balancing market design variables; hereof the balancing markets in the three countries AIS were compared. As shown the markets differ in relevant aspects and at least some of the balancing parameters have to be harmonized to enable the introduction of cross-border exchange of balancing energy. A starting point would be an adjustment of the gate closure times. The NC EB delivers the regulatory basis for the harmonisation and the configuration of the coordinated balancing area. Furthermore, the NC EB facilitates the integration of VPPs, RES-E and DR. Currently the in all three AIS countries the balancing market design should be adjusted to allow the participation of VPPs, RES-E and DR (see Table 2). Therefore, the eligibility requirements should be particularly defined for them. Furthermore, pooling should be allowed and the minimum bid size as well as the minimal prequalified technical unit should be low enough to reduce the entry barriers for new market participants.

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