SITUATION DEPENDING DIMENSIONIG OF BALANCING RESERVES IN INTERCONNECTED TRANSMISSION NETWORKS

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Overview

As frequency is a key indicator for the operating security of the entire interconnected network, each Load Frequency Control Block has to dimension and procure a sufficient amount of balancing reserves in line with [1, 2]. Nevertheless, the current development and structural changes in the electrical power system in Europe lead to new challenging tasks in terms of balancing the system while using the interconnected system and resources in an efficient way. Therefore, the European Agency of Energy Regulators (ACER) and the European Network of Transmission System Operators for Electricity (ENTSO-E) aim to harmonize structure and operational rules, control process and product definitions on an European level [3].
Besides these harmonisation efforts and envisaged cooperations, the increasing volatile feed-in of renewable energy sources rises the questions of the validity of static methods to dimension reserves. Therefore, this paper presents a method to determine the demand of balancing reserve with a dynamic approach, allowing to take the effects of the Imbalance Netting Process into account. Furthermore, the necessity of regional procurement of reserves due to network and operational issues is adressed and will be evaluated.

Methods

In order to adress the aforementioned questions, different methods are used to determine the necessary amount of region- and time- specific balancing reserves. As the dimensioning is situation depending, an expected feedin situation for Europe as a result of [4] is used as base scenario.

To determine the situation depending balancing reserve, a Monte-Carlo-Simulation (MCS) is performed. Therefore, the occuring imbalances (outages, forecast errors, etc.) are drawn stochastically (geographical and chronological) dependent for a large number of scenarios, based on the forecast feedin situation [5]. The imbalances are modeled with a detailed geographical resolution (e.g. network nodes) so that netting effects through European cooperation, such as the imbalance netting process, can be modelled and adjusted to determine their potential of reducing the dimensioned control power [6]. Developed methods are based on copulae and Markov Chains.

These scenarios of imbalances are used as input data for a reserve activation (network) simulation. Based on a Security-Constrained-Optimal-Power-Flow (SCOPF) [7] an optimization problem is solved for each imbalance scenario simultaneously. This allows to evaluate the impact of the imbalance netting process (INP) on network congestions considering all relevant contingencies (n-1 secure) in the European transmission grid. Furthermore, a modified optimization based on the SCOPF allows to determine minimal regional reserves (MRR).

Theoretically, due to the interconnected system and the envisaged harmonized markets within the Synchronous Area (SA), the necessary amount of reserves could be procured within a limited geographical area. However, since the transmission capacity is limited, especially between the Load Frequency Control Blocks (LFC Blocks), a cross-border activation could lead to network congestions on interconnection lines. In order to prevent congestions and to be able to gurantee the possibility of activation, minimal regional reserves in specific areas have to be defined.

Results

For exemplary investigations, the presented approach is evaluated for a scenario 2024 based on [8]. The European transmission grid is based on publicly available data [9] and adjusted according to the Network Development Plan [10]. The following presented exemplary investigation focuses on the situation depending reserves and the asscociated regional restrictions for the provision of reserves.
The left side of figure 1 shows the examplary progression of dynamic Frequency Restoration Reserve (FRR) for Germany for the period of two weeks. The depicted progression shows periodic variations, which are mainly driven by possible forecast errors of Photovoltaik feedin,. The same evaluation can be done for all other LFC Blocks with corresponding results, as the imbalance scenarios are drawn and evaluated for the SA. The yearly evaluation shows, that the necessary amount of reserves can be reduced.

As stated in the methodology, the operating reserves partly have to be provided by the respected LFC Block. The focus area of these further evaluations is defined by Germany, the Netherlands, Belgium and France - the results are shown exemplary for Germany.
The MRR for Germany is depicted on the right side of figure 1. The cumulative distribution function shows that in the chosen time period the reserve provision could be at least in 50% guaranteed by other LFC Blocks.

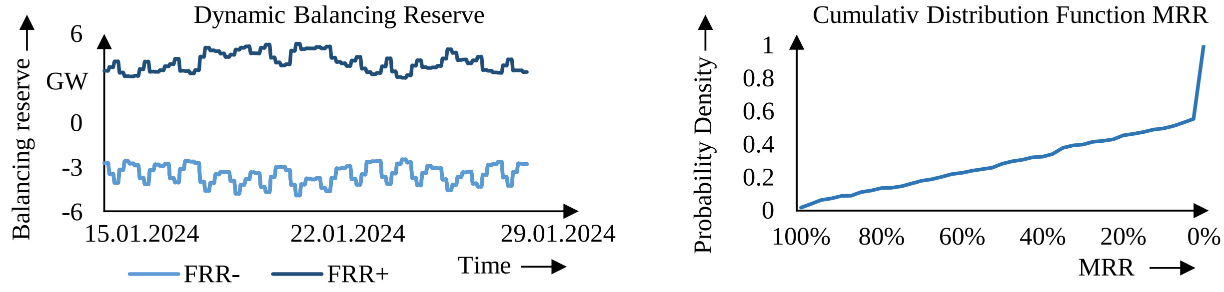

Figure 1: Exemplary progression of dynamic balancing reserve and the associated cumulativ distribution function of the minimal regional reserve in Germany

Further results which can be evaluated:

- Geographical and chronological dependent distribution of imbalances
- Situation dependent balancing reserve demand for the European LFC Blocks
- Impacts of the possible Imbalance Netting Process on the dimensioning
- Congestions caused by balancing energy and therefore the necessary regional procurement of reserves
- Consequences of cross zonal reserve provision and activation (Reserve Exchange/Sharing)

The results make quantitative findings available concerning the expected changes in the balancing markets, i.e. the pan-European provision of balancing reserves, the standard products and the impact of further harmonisation on congestions in the transmission grid in future generation systems.

Conclusions

The dynamic and situation depending dimensioning of balancing reserves lead to significant reduction of reserve procurement for future generation systems which are highly penetrated by renewable energies. In addition, cross-border cooperations, such as the Imbalance Netting Process, lead to a reduction of reserve utilization by netting of imbalances. An extension of this process is the cross-border activation and provision of balancing reserve. However, regional restrictions for reserve provision have to be considered in both cases due to limitations of the underlying transmission network.

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