Integrating RES-E in Balancing Markets by harmonising procurement of FRR in selected Central European Countries

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To achieve the so-called "European Internal Energy Market", the Agency for the Cooperation of Energy Regulators (ACER) and the European Network of Transmission System Operators for Electricity (ENTSO-E) play a key role. Among others, the task of ACER is to propose framework guidelines, providing the basis for the so-called "Network Codes" - developed by ENTSO-E - for a European cross-border electricity market and the corresponding integration of large-scale renewable electricity generation (RES-E). High shares of RES-E generation require also robust balancing measures and procedures in the electricity system. In this context, the "Framework Guidelines on Electricity Balancing" build the basis for the "Network Code on Electricity Balancing" (NC EB), [1, 2]. The main purpose of the NC EB is to achieve a well-functioning, integrated balancing electricity market in Europe. The main cornerstones of future cross-border balancing market design are well defined in the NC EB. However, there are still many open questions in terms of fine-tuning of balancing market design options in its practical implementation.

There are several electricity balancing pilot projects having already been started or will start in the near future. The work presented in this paper focuses on projects with the geographic scope of Central Europe. This includes the common activation of automatic Frequency Restoration Reserve (aFRR) in Austria and Germany (started in July 2016) as well as the common procurement of aFRR in the above-mentioned area, which is planned to start mid-2017. The start for common procurement and activation of mFRR has not yet been published, but will also be analysed within this work. In addition, the impact of a further extension of the common balancing area to Belgium and the Netherlands is analysed.

In a first step the analysis considers the currently existing installed electricity generation capacities in the respective countries to evaluate the influences of different balancing market designs on the current electricity markets. The "ENTSO-E Vision 3" scenario (see [3]) will be used to evaluate the challenges of future electricity systems with high shares of RES-E.

The used model is called EDisOn (**E**lectricity **Dis**patch **O**ptimizatio**n**) and it is a fundamental market model and has been developed in MATLAB (see [4]). The model computes the optimal (cost minimal) dispatch of thermal power plants in the electricity system and considers also RES-

E generation of wind, PV and run-of-river. It is designed as a linear programming problem (binary on-/off-conditions are linearized) and is deterministic in nature, assumes a perfect competitive market with perfect foresight, and uses an hourly resolution of a full year. In addition, a detailed transmission and (Pumped-) Hydro Energy Storage (PHES) representation is implemented.

In order to enable the consideration of balancing energy markets, a model extension recently has been developed [5]. In two additional steps the balancing energy market mechanisms are considered in the model EDisOn+Balancing. Firstly, the procurement of the balancing capacity, which is also based on an hourly resolution, is simulated and, subsequently, the activation of balancing energy for balancing the control areas' imbalances on a ¼ hourly resolution.

The geographical scope comprises Central Europe, meaning that the control areas of Austria, Germany, Belgium and the Netherlands are considered in detail. For these countries different designs of balancing markets are analysed. The remaining neighbouring countries like Poland, Czech Republic, Hungary, Slovakia (currently no direct interconnection to Austria), Slovenia, Italy, Switzerland and France are considered for Day-ahead market clearings only.

At the conference first quantitative results will be presented. The expected quantitative results should confirm that common procurement and activation of balancing energy (aFRR and mFRR) in the whole simulated region has significant advantages in terms of cost reduction and increasing flexibility in the electricity system. In addition, the integration of windfarms, batteries and interruptable loads into balancing markets will be modelled and quantified.

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