On Efficient Transmission Balancing Operation

Capturing the Normal State Frequency and Active Power Dynamics

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Abstract

In an electric power system, there will always be an electric balance. Nevertheless, System Operators (SOs) often uses the term imbalance. Here, the term imbalance refers to the difference between trades and real-time measurements. This thesis defines the term imbalance and develops a framework helping SOs in finding better decisions controlling these imbalances.

Imbalances are controlled by many decisions made at various stages before real-time. A decision can be to increase the flexibility in production and consumption. However, this is not the only decision affecting real-time balancing operation. Other decisions are grid code requirements, such as ramp rates of HVDC and generation; balancing market structure, such as imbalance fees and trading period lengths; and the strategies used in the system-operational dispatch.

The purpose of this thesis is to create a new possibility for SO to find decisions improving the balancing operation.

In order to find and compare decisions, the thesis develops a framework that evaluates many different decisions made at various stages before real-time. The framework consists of the following. First, it develops an intra-hour model using multi-bidding zone data from a historical time-period; able to capture the normal state frequency and active power dynamics. The model creates high-resolution data from low-resolution measurements using several data-processing methods. The uncertainty from the historical time-period is re-created using many sub-models with different input data, time-scales and activation times of reserves. Secondly, the framework validates the model and identifies system parameters based on simulated frequencies and frequency measurements in the normal state operation. Finally; new decisions’ are modelled, tested, and evaluated on their impact on selected targets supporting corporate missions of the SOs.

The goal of the framework is that it should be able to find better decisions for balancing operation but also that it should be applicable for real and large power systems. To verify this, the framework is tested on a synchronous area containing 11 bidding zones in northern Europe. Results show that the framework can be validated and trusted.

Three new decisions, made at various stages before real time, have been modelled, tested and evaluated. The modelled decisions were (i) lower ramp rates for generation, (ii) increased capacities for automatic reserves, and (iii) a new strategy for the system-operational dispatch. One implication of applying the balancing evaluation framework on data from July 2015 is that all tested decisions improve several selected targets supporting the corporate missions of the SOs.
The conclusion is that the balancing framework is useful as a simulation tool in helping SOs in finding more efficient decisions for transmission system balancing operation.

**Keywords**
Active Power Dynamics, Frequency Control, Normal State, Power System Balancing, Transmission System Operator