Situation Depending Dimensioning of Balancing Reserves in Interconnected Transmission Networks

- Background and Motivation
- Analysis
- Methodology
- Exemplary Results
- Conclusion

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Background and Motivation

Load Frequency Control and Operating Reserves

Stable and reliable grid state requires balanced load and power generation at any time

- Transmission System Operators take the overall responsibility for the electricity system
  
  - obliged to maintain a secure network operation
  
  - striving to compensate imbalances in case of disturbances

- Obliged to dimension and procure an efficient and adequate amount of reserves to balance possible imbalances

Actual Dimensioning Method

- Individual dimensioning of Frequency Restoration Reserve (FRR) per Load Frequency Control (LFC) Block

- Today, probabilistic and static dimensioning process
  
  - based on historical data (e.g. last year)
  
  - constant dimensioned amount of FRR for a period e.g. of 3 month – day, night, etc.

- Static and isolated dimensioning procedure for each LFC Block does not consider the changing requirements for balancing reserves and should be evaluated or adapted

- How can potential synergy effects of an European cooperation and the underlying transmission grid be included in a dynamic dimensioning process of balancing reserves?
Imbalances caused by Different Events

- Different types: Outages, Load, deterministic imbalances, etc.
- Each Imbalance has a defined geographical allocation or is distributed over a certain area
- Expected feed-in from Renewable Energy Sources (RES) bases and relies on weather forecasts

### General Weather Situation

Stochastic dependencies of the feed-in and forecasts errors due to same weather situations to be assumed

### Correlation of Forecast Errors

- Forecast errors of the feed-in from wind energy plants show geographical correlation
- Forecast errors of the feed-in from wind energy plant show temporal correlation

- Situational and stochastically dependent (geographical and temporal) modelling of each imbalance necessary
International Grid Control Cooperation (IGCC)

- Compensation of imbalances in two (or more) adjacent LFC Blocks over cross-border lines within the IGCC: DE, NL, CH, BE, AT, etc.
- Imbalance Netting Process is limited by the free transmission capacities between LFC Blocks
- Activation of balancing reserve only for remaining imbalances
- Reduction of the activated balancing reserve in total
  - E.g. in Germany about 30% per year
- So far INP is not considered in the dimensioning process of balancing reserve
  - No impact on procured amount of reserve
  - Lower probability of activation of balancing reserve

- Considering the INP in the dimensioning process could reduce the necessary amount and costs for reserve, but requires
  - Modelling of network restrictions (i.e. to determine the INP potential) within the dimensioning process

 Activation of aFRR in Germany 2015
Situation Depending Dimensioning of Balancing Reserve

Requirements for applied Methodology

- Modelling of volatile and interdependent (chronological and geographical) imbalances in short time intervals
- Dimensioning process has to be performed for multiple LFC Blocks simultaneously in order to consider cross-border synergies and respect restriction from the grid

Schematic Methodology Overview

<table>
<thead>
<tr>
<th>Input</th>
<th>Methodology</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Historical forecast errors, outages, weather data</td>
<td>step-1: Generation of imbalance scenarios with a Monte-Carlo Simulation per grid node</td>
<td>Regional Minimum Reserve</td>
</tr>
<tr>
<td>Expected Feed-In Situation</td>
<td>Evaluation of reserve qualities and products per LFC Block</td>
<td>Static vs. dynamic dimensioning process</td>
</tr>
</tbody>
</table>

Since transmission capacity is limited, especially between LFC Blocks the possibility of activation has to be guaranteed, therefore minimal regional reserves in specific areas have to be defined.
Methodology

Generation of Imbalance Scenarios

- Determination of a time dependent time series for each imbalance type and per transmission grid node
- Consideration of geographical dependencies in case of RES forecast errors
- Balance deviation per transmission grid is represented by the sum of the time series of each type of imbalance
- Generation of balance deviations for a large number of scenarios (>1000) to obtain a representative sample of possible occurring imbalances

Scenario reduction by clustering and as input for step-2
Simulation of INP by using a variation of a Security- Constrained Optimal-Power-Flow
Evaluation of Reserve Qualities and Products

- Load flow calculation of all selected scenarios in the respected area
  - Possible congestions of operating assets (transformers or lines) due to imbalances
  - Imbalance netting based on real available transfer capacity between LFC Blocks
- Compensation of the imbalances by means of available (cross border) reserves (i.e. activation of +/- reserves)
  - Compliance with technology-specific restrictions (performance, gradient, etc.)
  - Specification of a rule-block-specific Merit-Order-List of activation prices for reserves

Possible potential of INP by optimizing a SCOPF

- Determination of necessary procurement by a closed optimization of all respected scenarios
Exemplary Investigations

Scenario Context and respected area of investigation

- Exemplary investigations for a future generation system 2025: Belgium, France, The Netherlands and Germany
- The dynamic dimensioning process is performed for 4-h reserve products an 2,000 scenarios (minutes sharp)

Further results which can be evaluated

- Geographical and chronological dependent distribution of different imbalances types and areas
- Impacts of the possible Imbalance Netting Process on the dimensioning and comparison with static methods
- Consequences of cross zonal reserve provision and activation (Reserve Exchange/Sharing)
Summary

Background and Motivation

- Future generation systems are highly penetrated by renewable energies and are facing challenging tasks regarding operating reserves and balancing the system.
- European wide ambitions to harmonize and integrate balancing power markets to use synergy effects like imbalance netting or cross zonal reserves.
- Dynamic and situation depending dimensioning of balancing reserves could be solution to meet the demand for reserves in future adequately.

Objective of the paper

- How can potential synergy effects of an European cooperation and the underlying transmission grid be included in a dynamic dimensioning process of balancing reserves?

Essential findings

- Methodology allows to evaluate possible envisaged changes in the balancing markets.
  - Pan-European provision of balancing reserves.
  - Definition of standard products and qualities.
  - Impact of further harmonization on congestions in the transmission grid in future generation systems.
DISCUSSION

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