INTEGRATION OF RENEWABLES - CHALLENGES FOR TSOs

Collective Nonlinear Dynamics of Complex Electricity Grids
Frankfurt Institute for Advanced Studies, 22.11.2016

DR. JOCHEN BAMMERT, TRANSNETBW, PRODUCTS & PRINCIPLES
Our company TransnetBW GmbH

TRANSMISSION SYSTEM OPERATOR IN BADEN-WÜRTTEMBERG

/ Headcount 576 (as of 31 December 2015)
/ Revenues 6.1 billion EUR (fiscal 2015)
/ Business model wholly-owned subsidiary of Energie Baden-Württemberg AG certified Independent Transmission Operator (ITO)
/ Locations Headquarters Stuttgart
System Control Center Wendlingen
several operating sites
Our company

THE TRANSMISSION GRID IS IN OUR FOCUS

380/220kV Transmission grid

Supra-regional distribution grid (predominantly 110kV)

Regional distribution grid (predominantly 20kV)

Local grid (predominantly 0.4kV)
Our company

THE TRANSMISSION GRID IS IN OUR FOCUS

...a European network

(* compare ENTSO-E Map)
Our company

OUR GRID IS A MAJOR LIFELINE FOR RESIDENTS AND BUSINESSES

Area served by TransnetBW: 34.600km²
Total line length (220 and 380kV): 3.170 km
49 substations
Peak load in Baden-Württemberg: 12.5GW
Electricity demand in Baden-Württemberg: 62TWh
Our company

OUR MAIN TASKS

- provide customers free access to the grid
- maintain the infrastructure and invest in it
- commercialization of RES energy
- security of supply
Challenges

OUR MAIN CHALLENGES

- Reduction of conventional generations units / shut down
- Shut-down of nuclear power plants (phase out)
- Delayed expansion of the grid
- Increase need for transport capacity from North to South
- No incentive to build power plants in the South
- Addition of RES
Challenges

A SOCIOPOLITICAL CHALLENGE

<table>
<thead>
<tr>
<th>Approval procedure grid invests</th>
<th>Regulatory framework</th>
</tr>
</thead>
<tbody>
<tr>
<td>duration and complexity must be reduced</td>
<td>stable and reliable regulatory framework needed</td>
</tr>
<tr>
<td>to create acceptance by the population</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Funding for investments</th>
<th>New technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>intelligent use of financial instruments and financial structures for grid invests</td>
<td>addition of RES requires innovations</td>
</tr>
<tr>
<td></td>
<td>regulatory funding required</td>
</tr>
</tbody>
</table>

TransnetBW is a Designer of the Energy Revolution
Challenges

DEVELOPMENT: MORE REDISPATCH

Days with measures (§13 (1), §13(2) EnWG) at TransnetBW

<table>
<thead>
<tr>
<th>Year</th>
<th>Netzbezogen gem. §13.1</th>
<th>Marktbezogen gem. §13.1</th>
<th>Marktbezogen fü Partner-ÜNB</th>
<th>Summe gem. §13.1, §13.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>37</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>73</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>147</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>199</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>261</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>290</td>
<td></td>
<td></td>
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</tbody>
</table>

Neg. Redispach: decrease infeed
Increase infeed
Decrease North-South flows
Network reserves outside Germany
**Challenges**

**RES > TRANSIT FLOWS > REDISPATCH**

- New generation-load pattern leads to transit and loop flows across other grids
- Lack of coordinated capacity calculation in CEE & weak grids
- Transit/Loop flows can cause overloads in other grids > redispatch
- Sometimes overloads cannot be handled by one or two TSOs anymore
Challenges

SOLUTION: MULTILATERAL REMEDIAL ACTION

- Most TSC TSOs* concluded a contract for multilateral redispatch measures (MRA)
- e.g. redispatch between APG (up) and 50HzT (down) to relieve congestion in PL
- MRA is used after bilateral redispatch is exhausted
- 65 MRAs since 1.9.2015 till now (45 Mio. €)

* http://www.tscnet.eu/
Challenges

**CAUSATION PRINCIPLE**

/ Who should pay for MRAs? TSOs & NRAs decided 50% requester & 50% causer

/ TSOs analysed several cost sharing keys (PFD, uTK, STD,...) for causer part

/ TSOs decided to start with the **Simple tie-line decomposition key** (STD)

/ STD treads control areas as „black boxes“, considers cross-border flows only and identifies sources and sinks of transit flows

/ MRA contract will be elaborated further

*P. Hoffmann, S. Almeida de Graaff, J. Bammert, *The simple tie-line decomposition method - a new approach for a causation based cost-sharing key*, Cigre No. 5 (June 2015)*
Conclusion

SUMMARY

/ At the moment, integration of RES is a challenge for TSOs. Grid modernization is too slow.
/ The grid is key to integration of RES
/ RES changed flow patterns in the grid
/ RES addition is a driver for Redispatch & transit/loop flows
/ Complex Redispatch solutions necessary to keep Security of Supply
/ RES integration affects other topic as well
/ TSOs are designers of RES integration

THANK YOU FOR YOUR ATTENTION!
Backup
Challenges

TRANSMISSION GRID IS KEY TO ENERGY REVOLUTION

/ The Energy Revolution impacts the transmission grid
/ Addition and action of RES set requirements for the grid. The volatile power infeed must be handled any time.
/ In order to ensure the Security of Supply, a modernization of grid is needed.
/ The actual grid was not build for such an energy system.
/ In BW we need 90km new 380kV lines and 240km of HVDC lines.
**PRODUCTS FOR SYSTEM SERVICES**

<table>
<thead>
<tr>
<th>Frequency control</th>
<th>Voltage maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>primary control</td>
<td>Reactive power control</td>
</tr>
<tr>
<td>secondary control</td>
<td>control of compensation devices</td>
</tr>
<tr>
<td>tertiary control</td>
<td>short-circuit capacity</td>
</tr>
<tr>
<td>automated frequency-based shedding</td>
<td>transformer control / tap-changer</td>
</tr>
<tr>
<td>spinning reserves (system inertia)</td>
<td></td>
</tr>
<tr>
<td>load shedding and connection</td>
<td></td>
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<tr>
<td>demand response</td>
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<table>
<thead>
<tr>
<th>Power system operation</th>
<th>Restoration of supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>operational planning</td>
<td>black start und island operation capability</td>
</tr>
<tr>
<td>congestion management</td>
<td>comprehensive network coordination (concepts)</td>
</tr>
<tr>
<td>Redispatch (from market-based power till load shedding)</td>
<td>initiation with/without voltage pre-counter</td>
</tr>
<tr>
<td>Reserve power (inter-/national)</td>
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