Challenges and Solutions for TSOs with high share of RE

German Experience

Delhi, September 2017
Dr. Johannes Henkel, Head of Energy Market Development, 50Hertz
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Market development and regulatory framework

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Agenda

1. Introduction 50Hertz and the German „Energiewende“
2. Challenges and solutions in high RE systems
3. Conclusion
50Hertz as part of the European Electricity System

1. 50Hertz
2. TenneT TSO
3. Amprion
4. TransnetBW
## 50Hertz at a glance

<table>
<thead>
<tr>
<th></th>
<th>2016</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grid area</strong></td>
<td>109.589 km² (~31 %)</td>
<td>109.360 km² (~31 %)</td>
</tr>
<tr>
<td><strong>Length of lines</strong></td>
<td>10.215 km (~30 %)</td>
<td>9.800 km (~30 %)</td>
</tr>
<tr>
<td><strong>Max. Load</strong></td>
<td>ca. 16 GW (~20%)</td>
<td>ca. 17 GW (~20 %)</td>
</tr>
<tr>
<td><strong>Power consumption</strong></td>
<td>~ 96 TWh (~20 %)</td>
<td>ca. 98 TWh (~20 %)</td>
</tr>
<tr>
<td><strong>Installed capacity:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- of which Renewables</td>
<td>51.686 MW (~26%)*</td>
<td>38.354 MW (~35%)</td>
</tr>
<tr>
<td>- of which Wind</td>
<td>28.435 MW (~30%)*</td>
<td>15.491 MW (~30%)</td>
</tr>
<tr>
<td>- of which Renewables</td>
<td>17.129 MW (~37%)*</td>
<td>11.318 MW (~40%)</td>
</tr>
<tr>
<td><strong>RES share in power consumption</strong></td>
<td>47.8%</td>
<td>ca. 25%</td>
</tr>
<tr>
<td><strong>Turnover</strong></td>
<td>9.5 bln. €</td>
<td>5.6 bln. €</td>
</tr>
<tr>
<td>- of which grid</td>
<td>1.3 bln. €</td>
<td>0.6 bln. €</td>
</tr>
</tbody>
</table>

Source: 50Hertz; As of 2016/12/31 - *preliminary figures – final figures will be available on 2017/08/31
Greenhouse Gas Emissions in Germany

- **Current status**: Few emission reductions in household and traffic sector
- **2050**: High emission reductions in energy sector necessary due to high CO₂ reduction costs

Source: Umweltbundesamt 2016; Climate protection plan 2050 of the German Government November 2016
RES development in Germany

Massive RES growth in Germany since the introduction of the Renewables Energy Law (EEG) in 2000 – with Wind and PV as the main growth drivers

2000
- ~ 30,000 plants
- 1.665* MW installed wind in Germany

2006
- ~ 221,000 plants
- 2.233* MW installed wind in Germany

2016
- ~ 1,600,000 plants
- 45.910* MW inst. wind

RES development in Germany

Wind
PV
Biomass
* BWE Figures
Source: 50Hertz, TenneT, Amprion, TransnetBW, Google Earth

Challenges and solutions for TSOs in high RE systems – Dr. Johannes Henkel
On April 30th 2017 13-15h, **85%** of the load in Germany were covered by RES (and the lights stayed on)
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Challenges in a transition to a high RE system

1. Synchronization of RE generation growth with necessary grid extension
2. Responsibilities (and rights) for RES
3. Balancing (in different timeframes)
4. Congestion management
Volume control

- After a learning curve with feed-in tariffs, RES support costs for new installations could be drastically reduced.
- In a recent auction for offshore wind farms, some bids were awarded at 0 €/MWh support.
Renewables growth requires an adaptation of the transmission grid infrastructure – Synchronization necessary

Till 2025:

- ~ 25 GW
- ~ 20 GW

Increasing power transport capacities to connect consumption centers with RES generation

Targets

Increasing European connectivity to improve RES and market integration – the key element of EU energy policy

A strategic grid development in a regional context is the key for a successful energy transition
Challenges and solutions for TSOs in high RE systems – Dr. Johannes Henkel

Challenges in a transition to a high RE system

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Grid connection codes

- In Germany, a major of RES installations had to be retrofitted in order to avoid sudden curtailment at a fixed over- or underfrequency (49.5 Hz or 50.2 Hz).
- Other important grid connection requirements include reactive power behaviour.
- Grid connection codes are necessary for all generators and loads, not just RES and are needed to reflect physical realities!

By designing grid connection codes right and in time for all market participants, large follow-up costs can be saved.
Ancillary services from RES

- Current challenges are the definition of the baseline and the design of the balancing market (daily tendering, hourly products….)

- Other pilot tests have shown that RES can contribute effectively to stabilize the voltage if faults occur in the system.

- Further pilot projects will even include black-starting a system with RES installations.
Challenges in a transition to a high RE system

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Balancing the grid in different timeframes

**RES volatility**

- Days to Hours
- Hours to Minutes
- Minutes to Seconds

**Implemented solutions**

- New auctions for **strategic reserves** (=backup power plants)
  - *Capacity market if necessary*
- Introduction of a **liquid intraday market**
  - Usage of **15-min products**
  - International **market coupling**
- **International imbalance netting** (*IGCC*):
  - Allow new market participants in the balancing market (battery storages, loads, wind turbines)
  - Dynamic allocation of balancing capacity

*International Grid Control Cooperation*
Ultra-short term volatility
Grid Situation Sunday, 2016/08/28

- The system must be able to react fast to changing forecasts
- **Solution:** Enhanced forecasts, short term trading
Grid control cooperation – avoiding counteractive balancing

The grid control cooperation helped to reduce the balancing demand significantly and saved already > 330 Mio. USD of balancing activations

Module 1 - IGCC: Avoid Counteractivation
Module 2: Common Dimensioning
Module 3: Common Procurement of capacity
Module 4 – National GCC: Activation based on common Merit Order List
Challenges in a transition to a high RE system

1. Synchronization of RE generation growth with necessary grid extension

2. Responsibilities (and rights) for RES

3. Balancing (in different timeframes)

4. Congestion management
### Congestion management

- **Right market design depends on structural congestions in the grid**
- **There is no general best solution**

**Status quo:** Large bidding zones and/or central dispatch

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Efficient (re-)dispatch

- In Germany, all generators must submit their planned schedules in 15-min resolution to the TSO
- 50Hertz mitigates grid congestion by redispatching power plants and RES generators
- Redispatch costs in Germany can range between 500-1.000 Mio. USD.

- Independent of the market design schedules of generators should be transparent to the system operator
## Redispatch: Action Options in Time

<table>
<thead>
<tr>
<th>Load and RES feed-in forecast</th>
<th>→ Forecast error decreases</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Option</strong></td>
<td>Morning D-1</td>
</tr>
<tr>
<td>Slow Reserve PP</td>
<td>Green</td>
</tr>
<tr>
<td>Start/Stop of PP</td>
<td>Green</td>
</tr>
<tr>
<td>Shift of Control Power</td>
<td>Green</td>
</tr>
<tr>
<td>Change in PP output („working point“)</td>
<td>Green</td>
</tr>
<tr>
<td>Start/Stop of PP (as emergency measure)</td>
<td>Red</td>
</tr>
<tr>
<td>Curtailment of RES</td>
<td>Red</td>
</tr>
</tbody>
</table>
4 TSO process for congestion management

**Day-Ahead 08-11h**
- **WAPP**
  - Week-Ahead-Planning Process
  - Use of reserve power plants, planning of forced start-up of market power plants

**Day-Ahead 16-18h**
- **pRD (New!)**
  - 4-TSO Planning of preventive Redispatch measures
  - Includes starting/stopping blocks and large shifts in power plant part

**Day-Ahead 20-22h**
- **DACF**
  - Day-Ahead Congestion Forecast
  - Only singular measures, no global optimisation possible
  - Insufficient lead time for changes > 1 GW

**t-4h**
- **IDCF**
  - Intraday Congestion Forecast (international, TSC Transmission Security Cooperation)

**approx. t-2h**
- **Curative**
  - Curative Redispatch
  - RES curtailment
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Conclusions

- **RES support should follow a transparent volume path** (regarding capacity), otherwise there will be a too high investment uncertainty in the market.
  - Regarding investments in backup generation AND regarding infrastructure.
- The **TSO needs sufficient transparency and online data** about the renewable infeed. All RES installations should be controllable.
- **RES should participate actively in the market** (energy and ancillary services).
- **Some major design choices** need to be taken based on market situation. There is no general first best solution!
  - Desired level of security of supply
  - Congestion Management
  - System Balancing
  - TSO/DSO cooperation
Thank you for your attention!

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