The German Experience
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The Transmission System Operator 50Hertz

- Part of the ELIA Group
- Ensures the supply of electricity to over 18 million people in Germany
- System operator for Berlin, Hamburg, Brandenburg, Mecklenburg-Western Pomerania, Saxony, Saxony-Anhalt and Thuringia
- Responsible for the operation, maintenance and expansion of the "Electricity Highways" (220 kV and 380 kV)
The German Experience / Oxford, 5.10.2015 / Dr. Niels Ehlers

50Hertz' responsibility for the society includes secure system operation, RES integration and market development

Transmission grid operator

- Responsible for the operation, maintenance and expansion of **ultra-high voltage lines** and **connection of offshore wind farms**

System operator

- Responsible for the **control and balancing** of the transmission system, 24/7: frequency and voltage control, congestion management

Market facilitator

- Catalyst of the **electricity market development**, esp. in northern and central-eastern Europe

Trustee for RES processes

- Responsible for the **financial management** of the **renewable energy processes**

Source: 50Hertz
### 50Hertz at a glance

**Surface area**
- 2014: 109,360 km² (~31%)
- 2010: 109,360 km² (~31%)

**Total length of lines**
- 2014: 9,855 km (~30%)
- 2010: 9,800 km (~28%)

**Maximum load**
- 2014: ca. 16 GW (~21%)
- 2010: ca. 17 GW (~20%)

**Energy consumption**  
(based on electricity supplied to final consumers in acc. with the EEG)
- 2014: ca. 95 TWh (~20%)
- 2010: ca. 98 TWh (~20%)

**Installed capacity:**
- of which RES: 24,938 MW (~29%)
- of which Wind: 14,637 MW (~40%)

**Workforce**
- 2014: 893
- 2010: 650

**Turnover**
- Grid: 8.569 billion €
- 2010: 5.6 billion €

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 Provisional data, approved values will be available on August 2015; In brackets: share of total value. Source: 50Hertz as of 31/12/2014; Stand: June 2015
German Energy Transition „Energiewende“

What are the core elements of German „Energiewende“?

Policy-driven structural changes in the German energy system:

- Phase out of nuclear energy production by 2022 ✔
- Dynamic RES development (EEG 2.0) ✔
  Targets: 40-45% by 2025, 80% by 2050
- Greenhouse gas reduction: Future of coal generation questioned
  Target: 40% CO₂ reduction by 2020, 80-95% by 2050
- Energy efficiency: electricity efficiency up by 50% by 2050
- Grid extension to transport RES energy to demand centres in Southern Germany
Development of Renewable Energy Sources (RES) in Germany

- Wind
- Photovoltaics
- Biomass

Area proportional to installed capacity

Source: 50Hertz, TenneT, Amprion, TransnetBW, Google Earth
Forecast: expansion of renewable energy in Germany

Reference area corresponds to 100 MW

*) Scenario B of the 2025 GDP
We encountered overlapping infeed of wind and PV of up to 45 GW
RES in the 50Hertz control area - Forecast

Installed capacity in MW

<table>
<thead>
<tr>
<th>Year</th>
<th>Wind (MW)</th>
<th>Photovoltaics (MW)</th>
<th>Biomass (MW)</th>
<th>Others (MW)</th>
<th>Total (MW)</th>
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</thead>
<tbody>
<tr>
<td>2000</td>
<td>2100</td>
<td>0</td>
<td>0</td>
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<tr>
<td>2005</td>
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<td>2020</td>
<td>32650</td>
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<td>32650</td>
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<tr>
<td>2025</td>
<td>37380</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>37380</td>
</tr>
</tbody>
</table>

*As at July 2014, Source: 50Hertz

As at 31/12/2014
2014 EEG forecast scenario „trend“
Rising share of RES leads to new requirements and challenges

- Develop forecasting instruments to improve their accuracy
- Develop grid infrastructure to meet new transport demands (due to new areas of generation) and as source of flexibility
- Investigate ways to reduce “must-run” capacities – RES to deliver ancillary services (integration into control power markets…)
- Implementation of real-time data exchange and direct steering of RES
- Harmonised European approach to RES policy

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- Develop new market design bringing together RES and complementary conventional power plants and storage
- Full steering of conventional plants and RES in emergency situations
- Substantially develop demand-side response
- Enhance real-time cooperation between TSOs and DSOs: data exchange, review roles and responsibilities
- Develop new business models cross-linking electricity and other energy sectors
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Current grid situation in Europe

Trade balances in Europe (Jul-Oct ‘15)

- **High exports from Germany** and Scandinavia and high imports in South-Eastern parts of Europe
- **High unscheduled power flows** via Poland and Czechia
- In order to keep the system stable, the **German TSOs need to redispatch** in the scale of up to **10 GW**.
- The problem cannot be solved by Germany alone, international redispatch cooperation is necessary.
- Germany contracted **reserve power plants** in Austria, Switzerland, France and Italy of more than 4 GW.

Data source: transparency.entsoe.eu
Operational challenges from wind

- High exports from Northern Germany in times of high wind infeed
- Grid congestion on German North-South lines and at the Polish border
- Insufficient redispatch potential within Germany
- Redispatch costs in 2015 could reach **500 mio. €**

Conclusion: grid development is the key to the success of the energy transition
Stress on European neighbouring grids due to unplanned load flows – 50Hertz counter-measures

**Redispatch („virtual PST“)**
- reduces system-security-relevant flows
- ensuring efficiency and cost effectiveness = challenge

**Phase shifters (physical PST)**
- reduces system-security-relevant flows
- investment required

**Grid expansion**
- ensures system-security in entire system
- enables integrated European market

**Operational Challenges of RES**

**Short-term**
- **Redispatch**
- **Phase shifters**
- **Grid expansion**

**Middle-term**
- **Redispatch**
- **Phase shifters**
- **Grid expansion**

**Long-term**
- **Redispatch**
- **Phase shifters**
- **Grid expansion**
Federal Requirement Plan for 2012 as legal basis for grid development need

Federal Requirement Plan Act adopted by German Bundestag in June 2013

- Basis: 2012 Grid Development Plan of the TSOs
- 36 projects confirmed
- 3 HVDC corridors
- Current Grid Development Plan confirms Federal Requirement Plan
- The Federal Requirement Plan Act is amended at least every three years

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Operational challenges from PV
Solar eclipse 2015 March 20

Installed capacity in Europe:
80,000 MW PV – thereof in Germany 40,000 MW
Operational challenges from PV

Solar eclipse 2015 March 20
simulated PV in-feed (worst case analysis)

German TSO counted on market mechanisms for basic balancing
System operation on March 20th 2015
Power plant operation

Pumped storage and hard coal power plants in Germany, Switzerland and Austria supplied the backup capacity.
Nuclear and lignite units could remain in baseload operation.
The 15-min market performed very well to balance the system.
For better integration of RES into the system, must-run generation must be reduced. Ancillary services must be provided by RES to run the system stable. (balancing, reactive power, black-start, fault-detection....)
Balancing from RES

- Wind power plants are technically capable to provide balancing energy. **50Hertz is currently involved in pilot projects in Germany** to test this within the German market framework.

- Current challenges are the definition of the baseline and the design of the balancing market (daily tendering, hourly products....)
Special challenge: own generation to avoid surcharges

Average electricity price for households (3.500 kWh/a)

Own generation can have positive effects on innovation, but negative distributive impacts on socialized costs must be avoided.
**Evaluation of „Energiewende“**

<table>
<thead>
<tr>
<th>Key successes</th>
<th>Key failures</th>
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<tbody>
<tr>
<td>Significant roll-out of RES</td>
<td>Focus mainly on installed capacity rather than on used energy</td>
</tr>
<tr>
<td>Significant contributions to cost reductions for solar and wind globally</td>
<td>High costs for consumers since feed-in tariffs were not reduced with same speed as solar panel prices dropped</td>
</tr>
<tr>
<td>Broad economic participation</td>
<td>Limited success of Combined Heat and Power (CHP)</td>
</tr>
<tr>
<td>Sustained high level of system security</td>
<td>Slow development of transmission and distribution network</td>
</tr>
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|                                                                           | No policy framework yet for the next phase (RES share > 25%): energy market reform needed that takes into account dominance of wind and solar |
Challenges of „Energiewende“

- **European energy policy**: How to coordinate the „Energiewende“ with neighbouring countries?
- **Grid development**: How to speed up and raise acceptance?
- **Costs**: How to share costs (>30 bln. €/a) within society?
- **Market design**: How to find an appropriate balance between price-based coordination and investment certainty?
- **Combined Heat and Power (CHP)**: How much is needed/useful?
- **Conventional power plants**: How to accompany restructuring in power industry?
- **RES integration**: How to increase flexibility of producers and consumers?

**Conclusion**: A long road ahead…
Many thanks for your attention

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