German Energiewende

Experiences and Challenges from a TSO Perspective

Tokyo, 17. September 2014
Dr. Klaus von Sengbusch
Agenda

- 50Hertz
- Energiewende in Germany - Aims & current Status
- Key Challenge 1: Minimize Costs for new RES
- Key Challenge 2: Balancing of volatile Generation and Load
- Key Challenge 3: Dealing with uncertain forecasts
The Transmission System Operator 50Hertz

- Ensures the supply of electricity to over 18 million people in Germany

- System operator for Berlin, Brandenburg, Hamburg, Mecklenburg-Western Pomerania, Saxony, Saxony-Anhalt and Thuringia

- Responsible for the operation, maintenance and expansion of the "Electricity Highways" (220 kV and 380 kV)
### 50Hertz at a Glance

<table>
<thead>
<tr>
<th><strong>Value (Share in DE)</strong></th>
<th></th>
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<tbody>
<tr>
<td><strong>Surface area</strong></td>
<td>109,360 km² (31%)</td>
</tr>
<tr>
<td><strong>Total length of lines</strong></td>
<td>9,995 km (29%)</td>
</tr>
<tr>
<td><strong>Maximum load</strong></td>
<td>~ 16 GW (21%)</td>
</tr>
<tr>
<td><strong>Energy consumption</strong></td>
<td>~ 98 TWh (20%)</td>
</tr>
<tr>
<td>(based on electricity supplied to final consumers in acc. with the EEG)</td>
<td></td>
</tr>
<tr>
<td><strong>Installed capacity:</strong></td>
<td>~ 44,539 MW (~24%)*</td>
</tr>
<tr>
<td>- Renewables</td>
<td>22,727 MW (~28%)*</td>
</tr>
<tr>
<td>- Wind</td>
<td>13,408 MW (~40%)*</td>
</tr>
<tr>
<td><strong>Workforce</strong></td>
<td>821</td>
</tr>
<tr>
<td><strong>Turnover</strong></td>
<td>8.6 billion €</td>
</tr>
<tr>
<td>- Grid</td>
<td>0.9 billion €</td>
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* provisional data, approved values will be available on June 2014

Source: 50Hertz, as at 31/12/13
TSOs are the Backbone for the Energy Supply

The four Core Activities:

- Transmission Grid Operator (On- and Offshore)
- System Operator
- Market Facilitator
- "Trustee" for RES- and CHP-Processes

Responsibility for Society

RES: Renewable Energy Sources
CHP: Combined Heat and Power

The TSOs play a key role for the German Society
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Aims and current Status
**Aims of German Energiewende**

<table>
<thead>
<tr>
<th>Category</th>
<th>2020</th>
<th>2050</th>
</tr>
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<tbody>
<tr>
<td>Greenhouse gas emissions (reference 1990)</td>
<td>-40%</td>
<td>&lt;80%</td>
</tr>
<tr>
<td>Primary energy (reference 2008)</td>
<td>-20%</td>
<td>-50%</td>
</tr>
<tr>
<td>Primary energy: share of RES</td>
<td>18%</td>
<td>60%</td>
</tr>
<tr>
<td>Consumption of electricity (reference 2008)</td>
<td>-10%</td>
<td>-25%</td>
</tr>
<tr>
<td>Electricity generation: share of RES</td>
<td>&gt;35%</td>
<td>80%</td>
</tr>
<tr>
<td>Energy consumption heating (reference 2008)</td>
<td>-20%</td>
<td>-80%</td>
</tr>
<tr>
<td>Energy consumption traffic (reference 2005)</td>
<td>-10%</td>
<td>-40%</td>
</tr>
<tr>
<td>Electric cars</td>
<td>&gt;1 Mio.</td>
<td></td>
</tr>
<tr>
<td>Nuclear phase out</td>
<td>until 2022</td>
<td></td>
</tr>
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High relevance for TSOs
Electricity Production in Germany

Current expectation: The 2020 aims in the areas “share or RES” and “nuclear phase out” will be reached

Source: 2. Monitoring-Bericht BMWi
Wind and photovoltaics remain dominant players in RES development.

**Forecasted RES Capacity in Germany**

![Bar chart showing forecasted RES capacity in Germany from 2013 to 2018.](chart.png)

Source: r2b
Gross Costs of RES in Germany

Source: TU Berlin, Prof. Erdmann
Gross and Net Costs of RES in Germany

Source: TU Berlin, Prof. Erdmann
RES-Process in Germany

Electricity market

Power exchange

Marketing expenses / earnings

Horizontal load equalisation

Financial compensation

TSO marketing

Physical compensation

Vertical load equalisation

Marketing expenses / earnings

Earnings from direct marketing

Direct marketing

TSO

RES account

RES surcharge

Power supply

Minimum remuneration (minus saved grid fees)

Earnings from direct marketing

RES

Power supply

Compensation pursuant to EEG

Uniform nationwide RES surcharge on electricity price

Upon request: reduced RES surcharge on electricity price

Supplier

Final customer

Privileged final customer

RES surcharge

Source: based on the implementation aid for the EEG of 2009 published BDEW
Changes resulting from the new legislation (1/2)

**Onshore Wind:**
- target corridor for new installations incl. repowering: 2,500 MW/year
- base tariff: 89 €/MWh
  - reduction of base tariff for new installations based on corridor
  - cuts in payments for locations with good wind conditions

**Photovoltaics:**
- target corridor: ~2,500 MW/year
- stop of support scheme when reaching 52 GW (installed capacity Q1 2014: ~36 GW)

**Offshore Wind:**
- target corridor: ~850 MW/year
- base remuneration: 154 €/MWh for maximum of 20 years (-5 €/MWh/a starting 2018) or 194 €/MWh for maximum of 8 years

**Biomass:**
- target corridor of 100 MW/year (!) ... ongoing discussions

RES-mix still defined by politics as further “learning curves” are expected
Direct marketing (DM):
- DM based on floating market premium mandatory for new RES above 500 kW in 2015 and above 100 kW in 2017

Introduction of tendering:
- First auctions in 2017 for large PV systems

RES-surcharge on self-produced electricity:
- Full RES-surcharge for new non-RES and non-CHP generation units
- 40% RES-surcharge for new RES or CHP generation units > 10 kW or > 10MWh
- No RES-surcharge for new RES or CHP generation units <= 10 kW and <= 10 MWh

Small-scale decentralized generation (e.g. residential PV systems including storages) is further subsidized by new legislation
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Key Challenge 1:
Minimize Costs for new RES
Floating Market Premium

Assumption:
Target remuneration for wind is 89 €/MWh

Market premium is calculated monthly ex-post based on the in-feed from reference wind-parks and day-ahead spot market prices.

<table>
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<tr>
<th>Example</th>
<th>Single Wind Farm</th>
<th>Reference wind parks</th>
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<tbody>
<tr>
<td>Feed-In</td>
<td>100 MWh</td>
<td>1100 MWh</td>
</tr>
<tr>
<td>Feed-In multiplied with spot price</td>
<td>3,397 € (33.97 €/MWh)</td>
<td>37,576 € (34.16 €/MWh)</td>
</tr>
<tr>
<td>Market premium</td>
<td></td>
<td>89.00 – 34.16 = 54.84 €/MWh</td>
</tr>
<tr>
<td>Payment (excl. management premiums etc.)</td>
<td>33.97 + 54.84 = 88.81 €/MWh</td>
<td>34.16 + 54.84 = 89.00 €/MWh</td>
</tr>
</tbody>
</table>

No long- or mid-term price risk for investors
Experiences with floating market premium exist; costs of direct marketing similar compared to marketing costs of TSOs for large RES (e.g. wind farms)

- For small RES (e.g. residential PV systems) marketing by TSOs is more efficient
- New legislation: Mandatory direct marketing for large RES gives better incentives for investments in controllability
Lessons Learned

- In case of large RES the costs for marketing of TSOs and other market participants are similar.
- Mandatory direct marketing is beneficial e.g. for driving the process of sourcing control power from RES and for market base curtailing of RES.
- To minimize subsidies of new RES, risks for investors have to be minimized; this can be reached by the floating market premium as well as the fixed feed-in tariff.
- The main potential for further reduction of subsidies (if the RES-mix is defined by politics) is the process of negotiating the needed remuneration for special projects; Therefore a tendering process will be tested now.

Future Challenges

- How can the impact of the RES surcharge on industry can be minimized?
- How can market distortions due to the RES surcharge (e.g. by self production) be minimized?
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Key Challenge 2: Balancing of volatile Generation and Load
Expansion of Renewable Energy Sources in Germany

2000 | 2006 | 2012

- wind
- photovoltaics
- biomass

Area proportional to installed capacity

Source: 50Hertz, TenneT, Amprion, TransnetBW, Google Earth
Increasing Distance between Consumption and Production

Source: GDP 2012, German TSO 31.01.2012
Grid load in the 50Hertz area

Asynchronous line load > 5h/a

Grid load increases dramatically due to the changes in energy production.
System Security: Interventions in Grid and Market

Redispatch volumes and costs

Quantity in GWh

Costs in Mio. €

TenneT Redispatch in direction 50Hertz
Redispatch international
Redispatch national grid area 50Hertz

Situation as at 31/05/2014*
*provisional data

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The Federal Requirement Plan as Foundation for the Grid Expansion

2012 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 FRP
- Law of FRP about to be updated in 2015 and 2018
Grid Extension Projects at 50Hertz

1. Interconnector Vierraden – Krajnik
2. Northerin line Hamburg – Schwerin
3. Southwest-interconnector 1 Lauchstädt – Vieselbach
4. High-temperature line Remptendorf – Redwitz
5. Baltic 1
6. Grid connection substation Altentreptow Nord
7. Capacity expansion substation Perleberg
8. Transition 220-kV to 380-kV Ragow – Thyrow and Ragow – Wustermark
9. Rebuilding Eula – Großdalzig for Mining Schlehnhain
10. Grid connection substation Stendal West
11. Southwest-interconnector 2 Vieselbach – Altenfeld
12. Grid connection substation Förderstedt
13. 380-kV-line Bärwalde-Schmölln
14. Substation Wolmirstedt
15. Baltic 2
16. 3. Interconnector to Poland
17. 380-kV-Ring Berlin
18. Uckermark-Line Neuenhagen – Bertikow
20. Wolmirstedt – Perleberg
21. Offshore connections Baltic Sea
22. Combined Grid Solution

Projekte seit 2009
## Role of Storages
### General Types

#### Short-term Storages (STS)
- **Technologies:**
  - Pumped Storage
  - Batteries
  - Compressed Air
- **Efficiency factor:** ~ 80%
- **Capacity / Power:** ~5 Wh/W

#### Long-term Storages (LTS)
- **Technology:**
  - Power to Gas
- **Efficiency factor:** ~ 40%
- **Capacity / Power:** Unlimited
Role of Storages
Influence on Generation

- No short term needs for storages in the energy only market
- Storages are mainly needed for provision of ancillary services
Lessons Learned

- In Germany grid extension is the cheapest way to balance consumption and RES production efficiently
- To realize grid extensions new processes with intensive involvement of the public are needed; these processes have been set up now
- Large storages are not needed at least until 2020 for integration of RES and are currently economically unviable; with the large share of lignite in the German energy mix they would even increase CO2-emissions in the next years

Future Challenges

- Ensure security of supply and give incentives for sufficient new conventional generation at the right places
- Optimize redispatch process
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Key Challenge 3:
Dealing with inaccurate Forecasts
Operational Challenges due to Forecast Inaccuracy

PV forecasts for Germany, April 2013
- Dramatic forecast errors of up to 8800 MW in the day-ahead forecast
- Intraday forecasts clearly better in comparison, closer match with actual feed-in

Need for large amount of flexible generation in special situations
Intraday (ID) Market in Germany

- h-ID products since 25.09.2006
- h-ID products since 29.03.2011
- ¼-h-ID products since 14.12.2011

Gate Closure  t - 75 min  T - 45 min  t - 15 min

OTC ¼-h-Produkte
Dealing with inaccurate Forecasts
Conclusions

Lessons Learned
- Liquid intraday markets are key success factor for dealing with inaccurate forecasts of RES

Future Challenges
- Source control power also from volatile RES
- Provide market design that gives sufficient incentives for investments in flexibility
Many thanks for your attention!

Dr. Klaus von Sengbusch

50Hertz Transmission GmbH
Eichenstraße 3A
12435 Berlin

+49 30 5150 2610
klaus.vonsengbusch@50hertz.com

www.50Hertz.com

Tokyo, 17. September 2014
An Elia Group company