System Integration of Variable Renewable Energies

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Asia Clean Energy Forum 2015
Manila, 17.06.15
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Asia Clean Energy Forum 2015, Technical and Market Integration of Variable Renewable Energies
1. Direct marketing of RE

1.1 The facts

Direct marketing of RE in Germany

- Predominantly onshore wind (32 GW) and solar PV (5.4 GW)
- 70 specialized direct marketing electricity trading companies
- Part of a balancing group and incentivizes demand response

From 2015: > 500 kW (e.g. On/offshore wind and PV utility scale, biogas)
From 2016: > 250 kW (e.g. PV factory rooftops)
From 2017: > 100 kW (e.g. PV medium rooftops)
Not included: Small hydro and small PV
1.1 The facts

Direct marketed capacity in percent of installed capacity

- 90% of wind is directly marketed
- More than 60% of biomass
- For PV < 20%

Fraunhofer (2014)
1.2 The market premium

- No payment of the FIT to participants
- The higher the market price, the lower the premium
- Responsibility of RE operators to sell electricity at the market
- Full integration of RE in current market questionable
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Agora Energiewende (2015)

8.90 ct/kWh as initial feed-in tariff for wind onshore

3.9

market price

5.0

market premium

8.79

net feed-in tariff
2. The balancing market

Participation in the balancing market requires:

• Direct marketing

• Minimum capacity of 5 MW, resp. 1 MW

Pooling to form virtual power plants

Alt Daber PV plant in Germany

• 67.8 MW capacity

• 2 MW battery storage

• Participation in the balancing market at the high voltage level
2.1 Contribution of RE

Participation of controllable RE in the German balancing market

- Mainly biomass (820 MW) and hydro (230 MW)
2.2 Operating reserve and RE

Rule of thumb: 1 GW of RE

30-70 MW of additional operating reserve
2.2 Operating reserve and RE

- Deployment of reserve capacity decreased since 2008
- Negative secondary reserve > Positive secondary reserve reserve

![Graph showing average deployment of secondary reserve (MW) for 2012 and 2013.]

BNetzAg (2014)
3. Feed-in management

- Less than 1% of entire EEG – remunerated electricity
- Compensation payment in 2013: 43.7 Million Euro

Greenbook Electricity Market Reform (BMWi):

“The grids must be expanded at the transmission and distribution level”

“It makes economic sense not to extend the networks for the “last kilowatt hour generated”
4. Technical prerequisites/requirements

Remote Control:
Prerequisite for direct marketing and participation in balancing market:

VDE application guides

- Generators in the low voltage distribution network (VDE-AR-N 4105)
  - Phase balancing
  - Frequency-based power reduction
  - Reactive power control (through inverters)
  - Inverter reconnection conditions
  - Output power control

- Generators in the high voltage network (VDE-AR-N 4210)
  - Extended requirements for reactive power feed-in
  - Extended requirements for static voltage stability (up to several minutes)
### 5. Outlook

#### 5.1 The electricity market reform

**Debate in Germany**

“Energy-only market” (Electricity market 2.0) vs. Capacity market

Features of the EOM and the capacity market

<table>
<thead>
<tr>
<th>EOM</th>
<th>Capacity market</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity market provides incentives for capacity (high price of electricity during some times)</td>
<td>Maintenance of capacity is refinanced through an additional capacity market</td>
</tr>
<tr>
<td>No price cap from the regulator’s side</td>
<td>Explicit payment for capacity (apportioned to customers)</td>
</tr>
<tr>
<td>Measures needed: Faster, shorter and more flexible day-ahead, intra-day and balancing markets</td>
<td>Measures needed: State introduces a capacity market and regulates it</td>
</tr>
</tbody>
</table>

**German government favors the EOM**
5.2 Smart metering

Current rollout scenarios for Germany are economically not viable

Overview of different rollout scenarios

<table>
<thead>
<tr>
<th>Results for 2014-2022</th>
<th>EU scenario</th>
<th>Continuity scenario</th>
<th>Rollout scenario Plus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net benefit in bl. Euro</td>
<td>-0.1*</td>
<td>-0.6*</td>
<td>1.5*</td>
</tr>
<tr>
<td>Rollout rate in %</td>
<td>80</td>
<td>23</td>
<td>68</td>
</tr>
<tr>
<td>Cost per final customer in Euro/year</td>
<td>29</td>
<td>14</td>
<td>21</td>
</tr>
</tbody>
</table>

* 2012-2032

Key points of Rollout Scenario Plus:

- Differentiate between intelligent measurements system and intelligent meter
- Equip decentralized RE from 0.25 kW (not from 7 kW)

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1) Ernst & Young, 2013, “Kosten-Nutzen-Analyse für einen flächendeckenden Einsatz intelligenter Zähler“
Dominant position of Wind and Solar PV in the future

German Electricity Mix in 2014

- Lignite: 25.6%
- Nuclear: 15.9%
- Hard coal: 9.6%
- Gas: 9.6%
- Oil: 0.8%
- Others: 4.3%
- Wind: 8.6%
- Hydro: 3.4%
- Biomass: 8.0%
- Solar: 5.8%

Envisaged future development of RES

Electricity Import and Export

German Import/Export balance 2003-2014 (GWh, physical flows)

- Germany is a net electricity exporter
- Biggest export markets: The Netherlands and Austria
- 21 GW of interconnecting capacity
- Closer links to neighboring markets in recent years

Agora Energiewende (2015)