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Successes and challenges of renewables deployment in the EU power sector

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Successes and Challenges at Renewables Deployment in the EU Power Sector

Keynote at the CO₂ Summit II: Technologies and Opportunities
Santa Ana Pueblo, 12 April 2016
## Renewables: high-impact for every region Global 2016

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>EU-28</th>
<th>USA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>1,000 km²</td>
<td>4,383</td>
<td>9,832</td>
</tr>
<tr>
<td>Population</td>
<td>million</td>
<td>511</td>
<td>321</td>
</tr>
<tr>
<td>Energy consumption</td>
<td>Mtoe</td>
<td>1,610</td>
<td>2,290</td>
</tr>
<tr>
<td>Power generation (net)</td>
<td>TWh</td>
<td>3,100</td>
<td>4,100</td>
</tr>
<tr>
<td>there of renewables</td>
<td>TWh</td>
<td>900</td>
<td>562</td>
</tr>
<tr>
<td>Share of renewables in power generation</td>
<td>%</td>
<td>29.0</td>
<td>13.7</td>
</tr>
<tr>
<td>Energy consumption per capita</td>
<td>toe</td>
<td>3.2</td>
<td>7.1</td>
</tr>
<tr>
<td>Power generation per capita</td>
<td>kWh</td>
<td>6,067</td>
<td>12,773</td>
</tr>
</tbody>
</table>

Source: German Member Committee of the World Energy Council and U.S. Energy Information Administration
Share of renewable energies in total electricity generation

- EU-28
- World
- USA
Energy mix in 2015 power production

**EU-28**
- Coal: 26%
- Gas: 17%
- Oil: 2%
- Nuclear: 26%
- Hydro: 11%
- Wind: 10%
- Solar: 5%
- Other RES*: 3%

**USA**
- Coal: 33%
- Gas: 33%
- Oil: 19%
- Nuclear: 1%
- Hydro: 6%
- Wind: 5%
- Solar: 1%
- Other RES*: 2%

* such as biomass and geothermal energy

Source: German Member Committee of the World Energy Council and U.S. Energy Information Administration
CO₂ emissions in the USA, in the EU-28 and in Germany

Change rates in %:

<table>
<thead>
<tr>
<th>Time Period</th>
<th>USA</th>
<th>EU-28</th>
<th>Germany</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990 - 2015</td>
<td>+ 7%</td>
<td>- 18%</td>
<td>- 23%</td>
</tr>
<tr>
<td>2005 - 2015</td>
<td>- 10%</td>
<td>- 18%</td>
<td>- 9%</td>
</tr>
</tbody>
</table>

Renewables policy scheme overview for the EU

- **FIT/tender**
- **Premium**
- **CFD**
- **Quota – GC mechanism**
- **Combination of multiple schemes**
- **Suspended/expired**
- **New legislation pending/under consultation**

Source: EU-Commission and other sources
Share of renewable energies in total electricity supply in the EU countries in %

- **2004**
- **2014**
Energy transition – Energiewende

► In 2010 the German government decided on a lifetime extension of nuclear power plants to build a bridge to a low-carbon economy.

► Fukushima was a turning point.

► Consequences:
  - Phase-out of nuclear energy in parallel with a
  - conversion from a fossil-based to a renewables-based energy supply and a
  - concurrent reduction in energy consumption via increased energy efficiency

► Three motives:
  - Climate mitigation
  - Finiteness and external effects of fossil resources
  - Risks of nuclear energy
Central elements of the German Energiewende

- **Reduction in GHG emissions**: by 40% by 2020 and 80 to 95% by 2050 – compared with 1990 level (2015: reduction of 27% compared to 1990)

- Increase in the **share of renewable energy in total energy consumption** to 30% in 2030 and 60% in 2050 (share in 2015: 13%)

- Increase in the **share of renewable energy in total power consumption** to 50% in 2030 and 80% in 2050 (share in 2015: 33%)

- Complete **nuclear phase-out** by the end of 2022

- Improved **energy efficiency**: Halving the primary energy consumption by 2050 compared with 2008 level

The project is based on the assumption that a highly industrialized society can be securely and competitively supplied by a generation system based predominantly on RES.
Promotion of green electricity by Renewable Energy Sources Act (EEG)

Guaranteed feed-in payments for green electricity for 20 years after commissioning the plant concerned.

Grid operators are obliged to immediately and as a priority purchase the entire quantity of green electricity offered.

The plant operator is paid the EEG feed-in tariff by the local grid company; the four German transmission system operators are in charge of selling this electricity at the (usually lower) market price via the power exchange.

The trading companies pass on the deficit (feed-in tariff minus market price) to consumers by imposing an EEG reallocation charge.
Installed capacity for power generation in Germany on the basis of renewables

Average annual increase: 15%
Average Price for PV Rooftop Systems in Germany (10kWp – 100 kWp)

Data: BSW-Solar, Graph: PSE AG 2015

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Share of renewables in meeting electricity demand and total volume of EEG support charge

Promotional charge in €bn

- EEG support charge in €bn
- Share of renewables in %

27%-point increase over 1999 – funding provided to this end by electricity consumers between 2000 and 2015: approx. €125bn
Development of wholesale prices for electricity in Germany and EEG reallocation charge

Wholesale electricity prices (base load)

EEG reallocation charge

Position: January 2016

Source: Transmission system operators' transparency platform
France’s „pragmatic“ energy transition

The law (adopted in July 2015) has six main objectives

1. To reduce greenhouse gas emissions by 40% in 2030 compared to 1990
2. To decrease fossil fuel consumption by 30% in 2030 compared to 2012
3. To increase the share of renewable energy in final energy consumption to 32% and in electricity generation to 40% in 2030
4. To reduce final energy consumption by 50% in 2050 compared to 2012
5. To diversify electricity generation, including reducing the share of nuclear energy to 50%, in 2025
6. To decrease waste in landfills by 50% in 2050

The law enjoys broad acceptance throughout society.
The dilemma of European energy policy
Legal basis: Article 194, Treaty on the Functioning of the EU

Aims of the Union policy on energy:

a) Ensure the **functioning of the energy market**;
b) Ensure **security of energy supply** in the Union;
c) Promote **energy efficiency** and **energy saving**, and the **development of new and renewable forms of energy**;
d) Promote the **interconnection of energy networks**

European Parliament and Council shall establish the measures necessary to achieve these objectives.

However: „Such measures shall not affect a Member State‘s right to determine the conditions for exploiting its energy resources, its choice between different energy sources and the general structure of its energy supply (…)“

EU RES target of 20% until 2020 and 27% until 2030

Structural tension between national and EU level

Energy Mix is Member States‘ choice
## Energy mix in ten of the 28 EU member states 2014 in %

<table>
<thead>
<tr>
<th>Country</th>
<th>Lignite</th>
<th>Hard coal</th>
<th>Nuclear energy</th>
<th>Gas</th>
<th>Renewables</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>25</td>
<td>19</td>
<td>15</td>
<td>10</td>
<td>26</td>
<td>5</td>
</tr>
<tr>
<td>Poland</td>
<td>34</td>
<td></td>
<td>48</td>
<td></td>
<td>3</td>
<td>13</td>
</tr>
<tr>
<td>Czech Rep.</td>
<td>42</td>
<td>6</td>
<td>35</td>
<td></td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>Greece</td>
<td>46</td>
<td></td>
<td>19</td>
<td>26</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Denmark</td>
<td>34</td>
<td>7</td>
<td>58</td>
<td></td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Austria</td>
<td>5</td>
<td>8</td>
<td>83</td>
<td></td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td>1</td>
<td>42</td>
<td>1</td>
<td>55</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>2</td>
<td></td>
<td>78</td>
<td>2</td>
<td>17</td>
<td>1</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>29</td>
<td>19</td>
<td>30</td>
<td></td>
<td>21</td>
<td>1</td>
</tr>
<tr>
<td>Netherlands</td>
<td>29</td>
<td>4</td>
<td>49</td>
<td></td>
<td>13</td>
<td>5</td>
</tr>
</tbody>
</table>

Source: IEA, Electricity Information 2015
Overview: EU Climate and Energy Policy
New targets for 2030 were set in October 2014

<table>
<thead>
<tr>
<th></th>
<th>Greenhouse gas emissions</th>
<th>Renewable energy</th>
<th>Energy efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>until 2020</td>
<td>-20 %</td>
<td>20 %</td>
<td>-20 %</td>
</tr>
<tr>
<td></td>
<td>reference year 1990</td>
<td>of energy consumption</td>
<td>Absolute reduction compared to business-as-usual scenarios</td>
</tr>
<tr>
<td>until 2030</td>
<td>-40 %</td>
<td>27 %</td>
<td>-27 %</td>
</tr>
<tr>
<td></td>
<td>(mandatory, national targets)</td>
<td>(mandatory, no national targets)</td>
<td>(indicative, no national targets)</td>
</tr>
<tr>
<td></td>
<td>reference year 1990</td>
<td>of energy consumption</td>
<td>Absolute reduction compared to business-as-usual scenarios</td>
</tr>
</tbody>
</table>

Interconnectivity
- 10 %

- 15 % (indicative, no national targets) from national capacity

- Only GHG reduction target will be translated into national binding targets
- Renewables and efficiency targets are EU-level targets
- Energy efficiency target is only indicative
- New governance structure to coordinate EU and national policies
  → transparency, predictability, regional cooperation
2030 framework for the European power sector

Climate target

GHG emission reduction by 40% compared with 1990 emission levels

Emission reduction of 43% by 2030 compared with 2005 emission levels for sectors which are part of the ETS (power sector and industry)

Emission reduction of 30% by 2030 compared with 2005 emission levels for sectors which are not part of the ETS (households, traffic)

ETS = Emission Trading Scheme

Expectation for the power sector

Increase in the share of renewable energy in power generation from 21% in 2012 to 45% in 2030
Impact of COP21 on EU climate policy

The EU as frontrunner!?
► EU and its Member States submitted its Nationally Determined Contribution of an at least 40 % domestic reduction in greenhouse gas emissions by 2030 compared to 1990, to be fulfilled jointly
► but also wants a mechanism for all UN parties to review and possibly increase targets in 2025

What will come after COP21??
► The climate agreement, deposited at the UN in New York, will be opened for one year for signature on 22 April 2016 – High Level signing ceremony on Mother Earth Day in New York
► Debate on ETS reform will gear up – fundamentals could be questioned
► The so-called effort sharing has to be decided
  - contribution of each Member State for the non-ETS sectors in the form of national binding targets
  - 2030 framework foresees variation from 0 - 40 % emission reduction
Price setting for electricity on the wholesale market – principle in central Europe

Market price $p^{old}$
Natural gas was the price setting fuel

Market price $p^{new}$ with extended use of renewables
Hard coal sets the price

- Renewable energy
- Nuclear energy
- Lignite
- Hard coal
- Natural gas
- Oil
Forward wholesale power prices in Germany for the year that follows

€/MWh

- Offpeak
- Baseload
- Peakload

Ø-price reduction in % from 2010 to 2015

- 40%
- 38%
- 37%

Clean Dark and Clean Spark Spread
(Margins of gas- and hard coal-fired power plants)
Based on prices for the year that follows

CSS = clean spark spread (peak load electricity price minus cost of natural gas and CO₂ determined for the year that follows)
CDS = clean dark spread (base load electricity price minus cost of hard coal and CO₂ determined for the year that follows)
Electricity Consumption and Generation in Germany on 23 August 2015

Electricity Consumption and Generation in Germany on 3 November 2015

The biggest drawback of renewables: Their availability is not in our hands

At times, wind and solar power meet more than three-quarters of electricity demand …

… while at others they all but vanish from the scene

Conventional power plants are needed to ensure security of supply

But the expansion of renewables leads to conventional power plants becoming increasingly unprofitable
Requirements for conventional power plants regarding flexibility/operation will change seriously

Previously

► Baseload power plants
► Intermediate load plants
► Peakload power plants
► High efficiency at maximum load

In Future

► Similar requirements for all fuels/plant types
► Design for many load changes
► High ramp-rates
► Low minimum load
► Economic operation even at low number of operating hours

Security of supply
Power generation capacity in Germany GW (net)

<table>
<thead>
<tr>
<th>Year</th>
<th>Renewable energy</th>
<th>Conventional power plants</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>93.9</td>
<td>105.3</td>
</tr>
<tr>
<td>2025</td>
<td>141.4</td>
<td>77.3</td>
</tr>
<tr>
<td>2035</td>
<td>181.0</td>
<td>77.5</td>
</tr>
</tbody>
</table>

Source: Bundesnetzagentur, January 2016 (Status 10/11/2015) and 2015 Electricity Grid Development Plan, scenario B
Interconnection capacities compared to the total capacity installed within the EU-28

Breakdown of total household price in 2014

€/MWh

Source: Eurelectric, February 2016
Evolution of Policy Support Costs (PSCs) elements in the EU-28 power prices for households

Source: Eurelectric, February 2016
Electricity prices for industry and households 2015

Figures in USD/MWh

<table>
<thead>
<tr>
<th>Industry</th>
<th>Private households</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>146</td>
</tr>
<tr>
<td>Japan</td>
<td>169</td>
</tr>
<tr>
<td>Norway*</td>
<td>36</td>
</tr>
<tr>
<td>USA</td>
<td>67</td>
</tr>
<tr>
<td>OECD total</td>
<td>108</td>
</tr>
<tr>
<td>Germany</td>
<td>326</td>
</tr>
<tr>
<td>Japan</td>
<td>227</td>
</tr>
<tr>
<td>Norway</td>
<td>97</td>
</tr>
<tr>
<td>USA</td>
<td>128</td>
</tr>
<tr>
<td>OECD total</td>
<td>165</td>
</tr>
</tbody>
</table>

* Prices for the second quarter 2015

Conclusion – Lessons Learnt (1)

General aspects including impacts for conventional energies

- The energy transition should not be limited to the power sector but also include the cooling/heating market, industry and transportation.
- Further electrification is the key for a successful reshaping of the energy supply.
- A diversified energy mix should be given preference over one-sided arrangements.
- As far as conventional energy sources are concerned, one should rely on least-cost solutions.
- Whether preference is given to coal, gas or nuclear energy should be a rational decision – taking into account the central targets of energy policy such as security of supply, competitiveness and environmental protection.
- With respect to climate change mitigation, CC(U)S should be seen as an important option besides energy efficiency and renewable energies.
Governance of the penetration of renewable energies

► In providing incentives for investment in renewable energies one should avoid impairing the market system.

► The fast penetration of renewable-based power generation in Germany has produced a strong learning curve effect, especially in the case of solar PV.

► The effects on employment as regards the construction of solar panels are concentrated in China but the share of domestic service providers in total installation costs has increased.

► A renewable-energy promotion system which is based on "produce and forget" with long-term guaranteed margins for investors is not a sustainable solution in the long run. It is only appropriate at the very starting point.

► The system has led to a skyrocketed increase in particular in PV installation which exceeded the expectations and targets.
Infrastructure aspects

► The renewable-energy promotion system applied in Germany has caused disparities between the locations of generation and the demand centres – wind is one example.

► The necessary extension of the grid system should go hand in hand with the expansion of renewables-based generation plants.

► Another Lesson Learnt: It can be appropriate to adjust the promotion system in a way that generation takes place where the power is needed.

► Tender systems can be seen as an adequate instrument in order to ensure that the dimension and the location of the investment are in line with policy targets and power system requirements.

► Checking the option of the installation of storage in the distribution grid versus an investment in the extension of the grid system
Conclusion – Lessons Learnt (4)

Adaptation of the Market Design

► Despite the massive increase in renewable-based power generation, conventional power plants are still needed on nearly the same scale as before in order to cover demand when the wind does not blow sufficiently and the sun does not shine.

► The necessary operational flexibility of coal- and gas-fired power plants can be achieved, but conventional plant operators face considerably reduced revenues as a result of the expansion of intermittent renewables.

► Experience in the EU: The existing "energy-only-market" is not sufficient any more to guarantee security of supply. An additional capacity market is necessary in order to ensure security of supply in the long run.

► Using the instrument of market prices (setting the right price signals) in order to achieve load adjustments.