Ratcheting up renewables - wind energy use in Europe

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• Wind energy use worldwide: Status and research needs
• Driving forces: politics and financial incentives
• Integration of wind energy: experiences in Germany
• Ratcheting up wind energy use: expansion of grid
• System analysis research: cumulated energy balances
Development of wind energy use on different continents

Source: DEWI-Magazin, Nr. 33, 2008
<table>
<thead>
<tr>
<th>Country</th>
<th>Power 31.12.07 [ MW ]</th>
<th>Share %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>22.200</td>
<td>24</td>
</tr>
<tr>
<td>USA</td>
<td>16.800</td>
<td>18</td>
</tr>
<tr>
<td>Spain</td>
<td>15.100</td>
<td>16</td>
</tr>
<tr>
<td>India</td>
<td>8.000</td>
<td>8</td>
</tr>
<tr>
<td>China</td>
<td>6.000</td>
<td>6</td>
</tr>
<tr>
<td>Danmark</td>
<td>3.100</td>
<td>3</td>
</tr>
<tr>
<td>Italy</td>
<td>2.700</td>
<td>3</td>
</tr>
<tr>
<td>Other</td>
<td>20.100</td>
<td>22</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>94.000</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Source: Global Wind Energy Council www.gwec.net

Installed wind energy capacities on different countries
Shares of the suppliers in the world market

Basis: New erected capacity 2007: about 22 000 MW
1. Environmental & Social Impacts:
   Integration into the landscape, noise impacts, birds flight paths, Life Cycle Analysis, sustainability

2. Wind Turbine & Component Design Issues:
   Basic research in aerodynamics, structural dynamics, dynamic forces, new materials, feasibility studies of new systems, generators using permanent magnets, gear boxes

3. Testing, Standardisation, & Certification:
   Common accepted certification procedures

4. Grid Integration:
   Forecast of wind resource, power quality, use of energy storage

5. Operation & Maintenance:
   Condition monitoring, early failure detection, maintenance of offshore turbines, corrosion

6. Offshore Wind Technology:
   Foundation structures, meteorology, grid connection, transport and erection
New devices need testing: Problems with gear boxes
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How to finance wind energy?

- Different support systems in European Union countries: Feed-in tariff, tax incentives, quota
- Most of them are feed-in tariff systems, “imported” from Germany
- In Germany: fixed feed-in regulation for electricity from renewable energies over 20 years operation time, ensured by federal law
- On-shore wind millers get about 8 – 12 US Cent / kWh from their grid operator, recording location and operating time
- Off-shore wind millers get about 17 US Cent / kWh from their grid operator, until 2015 installed windmills get 21 US Cent/kWh (Bonus)
- Grid operators are refinanced by all electricity consumers
- Consumers pay an add on off about 1.4 US Cent/kWh, including 19% VAT-tax
- Additionally: CO₂-certiﬁcates increase conventional fuels in price
Different systems of support for wind power in EU
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About Germany:

- Area: 350,000 km²
  - = 2.7 x Louisiana
- 82 Million people
  - = 18 x Louisiana
- Population density:
  - 230 cap / km²
- Reunification: 1990
- GDP: 28,000 US $ / cap
- Mobility: 52 cars / cap
- Capacity power stations: 100 GW
- Policy until yet:
  Enforcement of renewable, facing out nuclear, facing out German coal mining
Political influences:

- Ecotax
- Renewable energy legislation
- CHP legislation
- Facing out nuclear
- CO$_2$- Certificates
- Closing German hardcoal mining
- Unbundling of production and grid

Electricity production in Germany 2007 (about 630 TWh)

Other: Waste, Pumping water electricity
Source: BMWI Energiedaten
Wind replaces coal – but no coal power stations

Calm week

Stormy week (Kyrill storm)
from 12.-18. January 2007

Source: EnBW, EON, RWE, Vattenfall.
The red projects are already licenced by the authorities

Graphic: Eilers-Media
Different constraints for offshore wind energy in Europe

<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Location</td>
<td>near Copenhagen</td>
<td>Nordsea</td>
</tr>
<tr>
<td>Distance to coast</td>
<td>3.5 km</td>
<td>100 km</td>
</tr>
<tr>
<td>Deep of water</td>
<td>2 – 6 m</td>
<td>30 – 40 m</td>
</tr>
<tr>
<td>Average wind velocity</td>
<td>7.2 m/s</td>
<td>9.2 m/s</td>
</tr>
<tr>
<td>Number of units</td>
<td>20 x 2 MW</td>
<td>12 x 5 MW</td>
</tr>
<tr>
<td>Foundation</td>
<td>Monopile</td>
<td>Tripod</td>
</tr>
</tbody>
</table>
Possible foundations of offshore wind converters

**Monopile**
- until 20 m deep of water
- Steel- or concrete construction

**Gravity foundation**
- until 10 m deep of water
- Steel- or concrete construction

**Tripod, Jacket**
- more than 20 m deep of water
- Steel construction
Fundaments for windmills for the windward Alpha Ventus
Enforced market introduction of renewables increased electricity cost over two decades in Germany
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Operation offshore in Western Europe
Windenergy and liberalisation of markets require bulk transmission capacity
## Extension of wind power capacities and grid in Europe

<table>
<thead>
<tr>
<th>Country</th>
<th>Status 2007</th>
<th>Future capacity</th>
<th>Grid improvement and expansion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>22 GW</td>
<td>30 to 45 GW until 2030</td>
<td>Grid improvement and at minimum additional 800 km new high voltage transmission lines necessary until 2020</td>
</tr>
<tr>
<td>Austria</td>
<td>1 GW</td>
<td>3 GW to 2020</td>
<td>Grid extension already necessary without wind power extension necessary</td>
</tr>
<tr>
<td>France</td>
<td>2.5 GW</td>
<td>27 to 40 GW until 2020</td>
<td>Beyond 7 GW grid improvement and additional new high voltage transmission lines necessary</td>
</tr>
<tr>
<td>Netherlands</td>
<td>1.7 GW</td>
<td>2.2 to 6 GW until 2020/30</td>
<td>Beyond 3 GW grid improvement necessary</td>
</tr>
<tr>
<td>Spain</td>
<td>15 GW</td>
<td>40 GW Potential</td>
<td>Beyond 13 GW grid improvement necessary</td>
</tr>
<tr>
<td>Poland</td>
<td>0.3 GW</td>
<td>2 to 5 GW until 2030</td>
<td>Beyond 2.5 GW grid improvement necessary Beyond 5 GW additional new high voltage transmission lines necessary</td>
</tr>
</tbody>
</table>
Solar power stations in USA and Spain

Source: Schlaich Bergermann and partner
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Example of Process-Chain-Analysis
Gained or substituted Primary energy equivalent

Primary energy demand (CED) for Production, Operation, Disposal

Start of construction

Start-up

End of operating

Time of earning

Operational phase

Disposal

Energy Payback Time (EPT):

Substituted fossil energy

Energy supply for construction, operating and disposal

Energy Payback Time (EPT)
<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
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<tbody>
<tr>
<td>Rotor blade</td>
<td>3%</td>
</tr>
<tr>
<td>Housing without generator</td>
<td>15%</td>
</tr>
<tr>
<td>Generator</td>
<td>23%</td>
</tr>
<tr>
<td>Steeltower</td>
<td>30%</td>
</tr>
<tr>
<td>Fundament</td>
<td>11%</td>
</tr>
<tr>
<td>Monitoring system and network access</td>
<td>12%</td>
</tr>
</tbody>
</table>

Structure of cumulative energy demand of an onshore-plant (1.5 MW)
Structure of cumulative energy demand of an offshore-plant (5 MW)

3 %
Rotor blade

22 %
Housing without gearbox

5 %
Gearbox

21 %
Steeltower

1 %
Network access

42 %
Fundament

Source:
Picture: REPOWER;
Data: LEE
Comparison of cumulative energy demand (CED) and yearly primary energy output
Thank you for your attention

www.lee.rub.de