Offshore Grid Connections as a Pillar of the *Energiewende*

Tim Dawidowsky,
CEO Business Unit Transmission Solutions,
Power Transmission Division, Energy Sector
Wismar, July 5, 2012
### Siemens Energy Sector – Clean electricity for the world

<table>
<thead>
<tr>
<th>Top performance in six Divisions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fossil Power Generation</strong> (E F)</td>
</tr>
<tr>
<td><strong>Wind Power</strong> (E W)</td>
</tr>
<tr>
<td><strong>Solar &amp; Hydro</strong> (E X)</td>
</tr>
<tr>
<td><strong>Oil &amp; Gas</strong> (E O)</td>
</tr>
<tr>
<td><strong>Energy Service</strong> (E S)</td>
</tr>
<tr>
<td><strong>Power Transmission</strong> (E T)</td>
</tr>
</tbody>
</table>

- **World record**: 60.75% efficiency for combined cycle power plants
- **New dimensions**: 6 MW for wind turbines
- **World record**: 33.9% efficiency for PV with concentrated photovoltaic module
- **Deep-sea capable**: 36 kV seabed power distribution at depths of up to 3,000 m
- **Additional**: 200 MW through modernization in 2011
- **World record**: 800 kV for direct current transmission (HVDC)

Additional 200 MW through modernization in 2011
### Siemens Energy Sector – Organizational structure and portfolio

#### Energy Sector
CEO: Michael Suess

<table>
<thead>
<tr>
<th>Sector</th>
<th>Divisions</th>
<th>CEO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fossil Power Generation (E F)</td>
<td>Roland Fischer</td>
<td></td>
</tr>
<tr>
<td>Wind Power (E W)</td>
<td>Felix Ferlemann</td>
<td></td>
</tr>
<tr>
<td>Solar &amp; Hydro (E X)</td>
<td>Ted Scheidegger</td>
<td></td>
</tr>
<tr>
<td>Oil &amp; Gas (E O)</td>
<td>Adil Toubia</td>
<td></td>
</tr>
<tr>
<td>Energy Service (E S)</td>
<td>Randy Zwirn</td>
<td></td>
</tr>
<tr>
<td>Power Transmission (E T)</td>
<td>Karlheinz Springer</td>
<td></td>
</tr>
</tbody>
</table>

#### Portfolio
- **Fossil Power Generation (E F)**
  - Roland Fischer
  - Products (e.g. large combined cycle gas & steam turbines, generators), energy solutions
  - Power plant solutions (e.g. turnkey power plants)
  - Instrumentation & controls
  - Fuel gasification systems, dismantling projects

- **Wind Power (E W)**
  - Felix Ferlemann
  - Wind turbines (on- and offshore)

- **Solar & Hydro (E X)**
  - Ted Scheidegger
  - Large photovoltaic (PV) plants
  - Solar-thermal power plants
  - Hydro power plants (small hydro power plants, tidal power plants)
  - Energy storage

- **Oil & Gas (E O)**
  - Adil Toubia
  - Gas turbines (<50 MW)
  - Steam turbines (≤250 MW)
  - Compressors
  - Oil & gas solutions (up-, mid- and downstream, power supply systems for the oil and gas industry)
  - Solutions for urban utilities and industrial power supplies

- **Energy Service (E S)**
  - Randy Zwirn
  - Service for oil & gas and industrial applications
  - Service for large power plants, e.g. spare parts, longterm service contracts, maintenance & repair, modernization and upgrades, air filter systems and services
  - Services for wind power plants

- **Power Transmission (E T)**
  - Karlheinz Springer
  - Equipment and systems for AC and DC high voltage transmission (substations, gas- and air-insulated switch-gear, gas-insulated power lines, circuit breakers, components)
  - Power transformers
  - Distribution transformers
Siemens Energy Sector – Organizational structure

CEO Michael Suess 1)

Energy Sector

Fossil Power Generation (E F)
Roland Fischer

Wind Power (E W)
Felix Ferlemann

Solar & Hydro (E X)
Ted Scheidegger

Oil & Gas (E O)
Adil Toubia

Energy Service (E S)
Randy Zwirn

Power Transmission (E T)
Karlheinz Springer

Business segments
- Conventional Island (E F CI)
- New Technologies (E F NT)

- Products (E F PR)
- Energy Solutions (E F ES)
- Instrumentation & Electrical (E F IE)

- Americas (E W AM)
- APAC (E W APAC)
- EMEA (E W EMEA)

- Solar Thermal Energy (E X STE)
- Photovoltaic (E X PV)

- Industrial Power (E O IP)
- Compression & Solutions (E O C&S)

- Oil & Gas and Industrial Applications Services (E S SO)
- Service Fossil (E S SF)
- TurboCare (E S TC)
- Service Renewables (E S SR)

- Transmission Solutions (E T TS)
- High Voltage Products (E T HP)
- Transformers (E T TR)

1) Member of the Managing Board of Siemens AG
Ambitious Offshore Objectives in Europe

The largest offshore markets are Great Britain and Germany. Both countries are planning rapid and sharp expansion of offshore wind power.

<table>
<thead>
<tr>
<th>Germany</th>
<th>Great Britain</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 gigawatts (GW) planned by 2020</td>
<td>1.2 gigawatts (Round 1 completed)</td>
</tr>
<tr>
<td>15 gigawatts by 2030</td>
<td>7.2 gigawatts (Round 2 ongoing)</td>
</tr>
<tr>
<td>25 gigawatts by 2030</td>
<td>2.0 gigawatts (Expans. 1&amp;2 ongoing)</td>
</tr>
<tr>
<td></td>
<td>32 gigawatts (Round 3 planned)</td>
</tr>
<tr>
<td></td>
<td>6 gigawatts (Scotland planned)</td>
</tr>
<tr>
<td></td>
<td>48.6 gigawatts</td>
</tr>
</tbody>
</table>

15% Offshore share of energy mix by 2025

25% Offshore share of energy mix by 2020
## European offshore plans
(in megawatts)

<table>
<thead>
<tr>
<th>Country</th>
<th>Online</th>
<th>Under construction</th>
<th>Consented</th>
<th>Planned</th>
<th>Total</th>
<th>Size of government concession zones or foreseen future tender zones</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>195</td>
<td>462</td>
<td>750</td>
<td>450</td>
<td>1,857</td>
<td>2,000</td>
</tr>
<tr>
<td>Denmark</td>
<td>854</td>
<td>0</td>
<td>418</td>
<td>1,200</td>
<td>2,471</td>
<td>4,600</td>
</tr>
<tr>
<td>Estonia</td>
<td>0</td>
<td>0</td>
<td>1,000</td>
<td>0</td>
<td>1,000</td>
<td>n/a</td>
</tr>
<tr>
<td>Finland</td>
<td>26</td>
<td>0</td>
<td>765</td>
<td>3,502</td>
<td>4,294</td>
<td>n/a</td>
</tr>
<tr>
<td>France</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6,000</td>
<td>6,000</td>
<td>6,000</td>
</tr>
<tr>
<td>Germany</td>
<td>195</td>
<td>833</td>
<td>8,725</td>
<td>21,493</td>
<td>31,247</td>
<td>8,000</td>
</tr>
<tr>
<td>Greece</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4,889</td>
<td>4,889</td>
<td>n/a</td>
</tr>
<tr>
<td>Ireland</td>
<td>25</td>
<td>0</td>
<td>1,600</td>
<td>2,155</td>
<td>3,780</td>
<td>n/a</td>
</tr>
<tr>
<td>Italy</td>
<td>0</td>
<td>0</td>
<td>162</td>
<td>2,538</td>
<td>2,700</td>
<td>n/a</td>
</tr>
<tr>
<td>Latvia</td>
<td>0</td>
<td>0</td>
<td>200</td>
<td>0</td>
<td>200</td>
<td>n/a</td>
</tr>
<tr>
<td>Malta</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>95</td>
<td>95</td>
<td>95</td>
</tr>
<tr>
<td>Netherlands</td>
<td>247</td>
<td>0</td>
<td>1,792</td>
<td>3,953</td>
<td>5,992</td>
<td>6,000</td>
</tr>
<tr>
<td>Norway</td>
<td>2</td>
<td>0</td>
<td>350</td>
<td>11,042</td>
<td>11,394</td>
<td>n/a</td>
</tr>
<tr>
<td>Poland</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>900</td>
<td>900</td>
<td>n/a</td>
</tr>
<tr>
<td>Portugal</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>478</td>
<td>478</td>
<td>n/a</td>
</tr>
<tr>
<td>Spain</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6,804</td>
<td>6,804</td>
<td>n/a</td>
</tr>
<tr>
<td>Sweden</td>
<td>164</td>
<td>0</td>
<td>991</td>
<td>7,124</td>
<td>8,279</td>
<td>n/a</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>1,586</td>
<td>4,308</td>
<td>588</td>
<td>42,114</td>
<td>48,596</td>
<td>47,000</td>
</tr>
<tr>
<td>Total Europe</td>
<td>3,294</td>
<td>5,603</td>
<td>17,341</td>
<td>114,737</td>
<td>140,976</td>
<td>73,695</td>
</tr>
</tbody>
</table>

Source: EWEA - European Wind Energy Association
**Benefits of Offshore Wind Power**

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**...sustainability**

*7 months* until positive energy balance

(on average an offshore wind farm redeems the energy input for fabrication, transport and installation after this period)

**100% CO₂-free power generation**

(even taking into account fabrication, transport, installation and maintenance, CO₂ emissions are only 7-12g CO₂/kWh)

**...high level of reliability**

97% availability

and better

More than 20 years of operation have already been proved by Siemens offshore wind turbine plants

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**...wide acceptance**

Markedly higher yield per turbine

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**...higher yield**

Typical annual yields

<table>
<thead>
<tr>
<th>Turbine Type</th>
<th>Inland</th>
<th>Coastal (onshore)</th>
<th>Offshore</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.3 MW turbine</td>
<td>7 GWh</td>
<td>9 GWh</td>
<td>–</td>
</tr>
<tr>
<td>3.6 MW turbine</td>
<td>–</td>
<td>12 GWh</td>
<td>18 GWh</td>
</tr>
<tr>
<td>6.0 MW turbine</td>
<td>–</td>
<td>23 GWh</td>
<td>31 GWh</td>
</tr>
</tbody>
</table>

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**...more steady yields**

100% more full-load hours

(Offshore, with more than 4,000 operating hours annually at full load possible)

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**...reasonably priced electricity**

**EEC tariff**

For 12 years at 15 cts/kWh or for 8 years at 19 cts/kWh and then: 3.5 cts/kWh

(=price level electricity exchange)

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**...enormous potential**

80% more capacity

(wind turbines with a total output of 30 gigawatts (GW) currently installed in Germany, further 25 gigawatts offshore planned by 2030)
Siemens is global market leader for offshore wind turbines (1/2)

Siemens Renewable Energy

Wind Power Division and Solar & Hydro Division
- 6.9 billion euros in new orders received (FY 2011)
- 3.9 billion euros in revenues (FY 2011)
- 11 billion euros in order backlog (Q2 2012, Wind Power Division, onshore & offshore)

The Wind Power Division has already commissioned 800 offshore wind turbines with a total output of 2.5 gigawatts (GW)

A further 1,200 offshore wind turbines with an output of more than 4.4 gigawatts are planned
Siemens is global market leader for offshore wind turbines (2/2)

<table>
<thead>
<tr>
<th>Completed projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991 – Vindeby, DK (11 x 0.45 MW)</td>
</tr>
<tr>
<td>2000 – Middelgrunden, DK (20 x SWT-2.0-76)</td>
</tr>
<tr>
<td>2002 – Samsø, DK (10 x SWT-2.3-82)</td>
</tr>
<tr>
<td>2002 – Rønland, DK (4 x SWT-2.3-93)</td>
</tr>
<tr>
<td>2003 – Rødsand/Nysted, DK (72 x SWT-2.3-82)</td>
</tr>
<tr>
<td>2003 – Frederikshavn, DK (1 x SWT-2.3-82)</td>
</tr>
<tr>
<td>2007 – Lillgrund, SE (48 x SWT-2.3-93)</td>
</tr>
<tr>
<td>2007 – Burbo Banks, UK (25 x SWT-3.6-107)</td>
</tr>
<tr>
<td>2008 – Lynn/Inner Dowsing, UK (54 x SWT-3.6-107)</td>
</tr>
<tr>
<td>2009 – Horns Rev II, DK (91 x SWT-2.3-92)</td>
</tr>
<tr>
<td>2009 – Hywind, NO (1 x SWT-2.3-82)</td>
</tr>
<tr>
<td>2009 – Gunfleet Sands, UK (48 x SWT-3.6-107)</td>
</tr>
<tr>
<td>2009 – Rhyl Flats, UK (25 x SWT-3.6-107)</td>
</tr>
<tr>
<td>2010 – Rødsand II, DK (90 x SWT-2.3-93)</td>
</tr>
<tr>
<td>2010 – Pori, FI (1 x SWT-2.3-101)</td>
</tr>
<tr>
<td>2011 – Baltic I, DE (21 x SWT-2.3-93)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ongoing projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greater Gabbard, UK (140 x SWT-3.6-107)</td>
</tr>
<tr>
<td>Sheringham Shoal, UK (88 x SWT-3.6-107)</td>
</tr>
<tr>
<td>London Array, UK (175 SWT-3.6-120)</td>
</tr>
<tr>
<td>Walney, UK (51 x SWT-3.6-107 / 51 x SWT-3.6-120)</td>
</tr>
<tr>
<td>Lincs, UK (69 x SWT-3.6-120)</td>
</tr>
<tr>
<td>Gwynt Y Mor, UK (160 x SWT-3.6-107)</td>
</tr>
<tr>
<td>West of Duddon Sands, UK (108 x SWT-3.6-120)</td>
</tr>
<tr>
<td>Teesside, UK (27 x SWT-2.3-93)</td>
</tr>
<tr>
<td>Anholt, DK (111 x SWT-3.6-120)</td>
</tr>
<tr>
<td>Baltic 2, DE (80 x SWT-3.6-120)</td>
</tr>
<tr>
<td>Borkum Riffgat, DE (30 x SWT-3.6-107)</td>
</tr>
<tr>
<td>DanTysk, DE (80 x SWT-3.6-120)</td>
</tr>
<tr>
<td>Borkum Riffgrund 1, DE (77 x SWT-3.6-120)</td>
</tr>
<tr>
<td>Meerwind Süd Ost, DE (80 x SWT-3.6-120)</td>
</tr>
<tr>
<td>Amrumbank West, DE (80 x SWT-3.6-120)</td>
</tr>
<tr>
<td>Rudong Intertidal, CN (21 x SWT-2.3-101)</td>
</tr>
</tbody>
</table>
Siemens is global market leader for offshore grid access (1/2)

Siemens Power Transmission Division

- 7.3 billion euros in new orders received (FY 2011)
- 6.3 billion euros in revenues (FY 2011)

The Power Transmission Division has already commissioned 6 offshore grid connections with a total output of 1.6 gigawatts (GW)

A further 8 offshore grid connections for a total of 4.7 gigawatts have been ordered
Siemens is global market leader for offshore grid access (2/2)

### Completed projects

- **2007** – Lillgrund, SE (110 MW)
- **2008** – Lynn & Inner Dowsing, UK (194 MW)
- **2010** – Thanet, UK (300 MW)
- **2010** – Greater Gabbard, UK (500 MW)
- **2010** – Bard 1, DE (400 MW)
- **2011** – Galloper, UK (140 MW)

### Ongoing projects

- **Gwynt y Mor**, UK (576 MW)
- **Lincs**, UK (270 MW)
- **London Array**, UK (630 MW)
- **Nordsee Ost**, DE (288 MW)

### 10 grid connections with 3.4 gigawatts capacity in AC technology

#### Cable links longer than about 80 km are only possible with HVDC

### 4 grid connections with 2.9 gigawatts capacity in high voltage direct current technology (HVDC)

- **Borwin 2**, DE (800 MW)
- **HelWin1**, DE (576 MW)
- **HelWin2**, DE (690 MW)
- **Sylwin 1**, DE (864 MW)
Pioneer Projects in the North Sea

**AC links in Great Britain**
- Normally 20-25 km from the coast
- Average output of 350 megawatts
- Water depth of 20-35 meters
- Platform with 2,000-2,500 tons

**HVDC grid connections in Germany**
- More than 100 km from the coast
- Average output of 730 megawatts
- Water depth up to 70 meters
- Platform with 10,000-15,000 tons

- Five times further out at sea
- Double the output
- Twice the water depth
- Five times as heavy

**Siemens is the global market leader in HVDC links**
- More than 40 connections implemented around the globe
- Converter substations for subsea cables on land up to now
Pioneer Projects with HVDC Converter Substations

Siemens
- HelWin 1 (576MW)
- HelWin 2 (690MW)
- BorWin 2 (800MW)
- SylWin 1 (864MW)

Competition
- BorWin 1 (400MW)
- DolWin 1 (800MW)
- DolWin 2 (900MW)

To be awarded
- DolWin 3 (900MW)
Challenges posed by initial HVDC grid connections

- Pioneer work
- Complexity
- Definition of processes (Engineering, Approval/Licensing, Lead Time)
- Meshing of processes
- Short lead times
- Networking of those involved

One-off production

- **BorWin2** (800 MW – 300 kV)
- **SylWin1** (864 MW – 320 kV)
- **HelWin1** (576 MW – 250 kV)
- **HelWin2** (690 MW – 320 kV)

Long delivery times
On the way to smooth HVDC grid connections

Experience gained

Improved risk management

Augmented project management

Bolstering of resources

Optimized resource management

Acquired experts

Strong partners

Norming

Standardization

Industrialization

Close intermeshing of processes

Improved coordination between the parties

Shorter delivery periods

Greater demand for HVDC grid links over the medium term

- At present, 5 GW of HVDC grid links ordered in Germany
- 25 GW planned for Germany for offshore wind power by 2030
- In Great Britain in Round 3, several wind farms planned at more than 80 km from the coast