The challenges of being innovative in a mature market 2016-04-20

Niels Emsholm, E.ON Climate & Renewables,
E.ON Climate & Renewables operates a capacity of 5.1 GW across Europe and North America¹

1. Includes Amrumbank West upgraded to 301 MW in 2016.
Global Unit Renewables

We bring a wealth of experience and industrial scale know-how to further build out our Renewables business.

**Investments (bn€)**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CAGR</td>
<td>2.3</td>
<td>1.5</td>
<td>1.0</td>
<td>1.2</td>
<td>1.2</td>
<td>1.7</td>
<td>0.9</td>
<td>1.5</td>
<td>0.9</td>
</tr>
</tbody>
</table>

**EBIT development (bn€)**

<table>
<thead>
<tr>
<th>Year</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAGR</td>
<td>0.1</td>
<td>0.1</td>
<td>0.2</td>
<td>0.3</td>
<td>0.3</td>
<td>0.4</td>
<td>0.5</td>
<td>0.4</td>
</tr>
</tbody>
</table>

**Capacity installed (GW cumulated)**

- **Solar**
- **Offshore wind**
- **Onshore wind**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity installed</td>
<td>1.1</td>
<td>2.8</td>
<td>4.2</td>
<td>5.2</td>
<td>5.9</td>
<td>4.4</td>
</tr>
</tbody>
</table>

**Key take away**

- **Total investments of €10bn** in new capacity since inception of E.ON Climate & Renewables.
- **Over 50 projects** delivered with vast majority completed on time and on budget.

---

1. CAGR = Compound Annual Growth Rate
We have a strong track-record in Onshore Wind

Operated Capacity (GW)

2.9 GW

1.2 GW

Operated capacity countries

Key facts

- 4.1 GW operated capacity
- Portfolio spread across Europe and the US

Project examples

**Camster**, onshore wind farm in the north of Scotland
COD: 2013
E.ON share: 100%
Capacity: 50 MW

**Grandview I**, onshore wind farm in Texas Panhandle
COD: 2014
E.ON share: 50%
Capacity: 211 MW

**Roscoe**, onshore wind farm in West Texas
COD: 2008
E.ON share: 100%
Capacity: 209 MW
Global Unit Renewables

We rank among the top tier in Offshore Wind experience

**Operated Capacity (GW)**

1.0 GW

- Operated capacity countries

**Key facts**

- 1.0 GW operated capacity, global #2\(^1\)
- Portfolio across Germany, Nordic and UK

**Project examples**

- **London Array**, the world’s largest offshore wind farm
  - COD: 2013
  - E.ON share: 30%
  - Capacity: 630 MW

- **Humber Gateway**, offshore windfarm UK North Sea
  - COD: 2015
  - E.ON share: 100%
  - Capacity: 219 MW

- **Amrumbank West**, offshore windfarm German North Sea
  - COD: 2015
  - E.ON share: 100%
  - Capacity: 301 MW

---

1. The European offshore wind industry – key trends and statistics 2015, European Wind Energy Association
Niels Emsholm

Asset Management E.ON EC&R (OEM WTG’s of SWP, Nordex & Senvion)

Professional experience
• Power and wind industry since 1992
• Offshore technical management at Dong Energy (2003-2009)
• E.on Climate and Renewables since 2011

Current tasks
• Asset management (Technical Support)
• WTG package manager
• Upgrades
• Operations Committee London Array
• Project reviews
• Technical Due Diligence + 5 MW machines
• Global technical support + governance
• Life-time extension assessment process
Agenda

• Is the wind industry mature and Innovative

• Challenges and examples of being innovative in a maturing industry

• Conclusions
The challenges of being innovative in a mature market

- Mining: First machinery used 130 years ago, Cars: First car serial production units started 100 years ago.
- Aviation: First commercial flight dates from 70 years ago.
- Wind turbines: First serial production units started 30 years ago but Standards are emerging: but we are not mature enough nor innovative enough !!!!

Focus

- Supply chain in Europe + Asia (little experts in US)
- Direct drive vs geared
- Offshore (auctions) vs onshore (market price)
- Grid connection offshore still immature and singular
- Economy of scale - offshore ?
- Standardization of blades, towers, drive train and other components ?
- Global vs proximity to manufacturing & assembly and local content
Global Unit Renewables

The challenges of being innovative in a mature market

Status

- Life-time extension to 25 years on portfolio (new and old flets) is emerging
- Yield optimization with large potential to increase or avoid reduction/losses
- Owner’s or small suppliers cannot sufficiently optimize independently of OEM’s
- Durability beyond normal tests for material

Focus

Doing yield optimization and life-time extension is a challenge

- Optimized/correct yaw + pitch
- Optimized blade repair (1-7% loss in AEP to be optimized) (LEP)
- Additional vortex generators
- Dino tails
- Power boost/uprate within permit, type certificate + load envelope
Global Unit Renewables

The challenges of being innovative in a mature market

- Innovative and building on synergies with offshore transformer platform
- Rules built on exemptions from oil and gas
- One of a kind (60 km offshore, lower maintenance, boats still competitive + time of transfer to and from hotel not insignificant)
- So far exceeded by hotel vessel, Ampelmann style and better CTV’s (industrial)
The challenges of being innovative in a mature market

Floating foundations

- Little appetite from OEM on component warranty and HSSE issues (lift + access)
- New support in France for demo
- Maybe difficult to perform large replacement and blade maintenance

Lessons learnt
The challenges of being innovative in a mature market

**Drones for blade inspection of wind generators – YouTube:**
https://www.youtube.com/watch?v=jHGFJdIQF0o

- Offers less down-time
- Weather sensitive
- Cannot repair - yet
- Not yet approved by BSH
Life cycle cost and inventiveness

HTS impact.
- The direct drive seems to work fine except some issues with bearing cost and full scale testing issues.
- The superconductor is sensitive to the functionality of the cooling system – which is often an area of cost cutting and then causing down-time.

Advise
- Demonstrate offshore readiness (corrosion and protection when no grid and extended outage of unit including simplicity in maintaining the cooling unit).
- Be more mindful to repair scenarios – long lead time to repair large parts.
- Pls proceed and give us cheaper and more reliable wind.
Considerations

1. Development
   - Innovative is fun but not cheap (risk free) nor mature

2. Construction
   - Industrial in nature – reduce all risk and offshore work

3. Operations
   - Testing is expensive, no tradition for plan and little flexibility and often no opportunity for scale