EnBW Baltic 1 – Germany's first commercial offshore wind experience

EnBW Erneuerbare Energien GmbH
Dr. Werner Götz
August 2011
EnBW Baltic 1 –
Germanys first commercial offshore wind experience

1. EnBW at a Glance
2. Political Framework & Market
3. EnBW Baltic 1
4. O & M Concept
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## EnBW at a Glance - Business Segments

### Electricity Generation and Trade

#### Generation
- EnBW Kraftwerke AG
- EnBW Kernkraft GmbH
- EnBW Erneuerbare Energien GmbH

#### Trade / Procurement
- EnBW Trading GmbH

### Electricity Grid and Sales

#### Transport
- EnBW Transportnetze AG
- EnBW Regional AG

#### Sales
- EnBW Vertrieb GmbH
- Yello Strom GmbH
- Watt Deutschland GmbH

### Gas

#### Procurement
- EnBW Gas Midstream GmbH

#### Storage
- EnBW Gas Midstream GmbH
- GasVersorgung Süd deutschland GmbH
- EnBW Gas GmbH

#### Trade
- EnBW Gas Midstream GmbH
- EnBW Trading GmbH
- GasVersorgung Süd deutschland GmbH
- EnBW Gas GmbH

#### Transport & Distribution
- GVS Netz GmbH
- EnBW Gasnetz GmbH

#### Sales
- GasVersorgung Süd deutschland GmbH
- EnBW Gas GmbH
- EnBW Vertrieb GmbH
- Yello Strom GmbH

### Energy- and Environmental Services

#### Services
- EnBW Energy Solutions GmbH
- EnBW Systeme Infrastruktur Support GmbH
- EnBW Kraftwerke AG
- Stadtwerke Düsseldorf AG
- EnBW Regional AG
- RBS wave GmbH
- EnBW Operations GmbH
EnBW at a Glance
Generation

› Approx. 4,000 employees
› Installed capacity of 15,500 MW
› Electricity generation: 54 Mrd. kWh

**Generation by source:**

› Nuclear: 5 units (2 in operation)
› Fossil: 22 hard coal units
   - 3 lignite units
   - 2 CCGT units
   - 5 GT units
› Renewable
   - 61 run of river
   - 3 pumped storage
   - 13 biomass
   - 150 wind turbines
   - 13 photovoltaic

Zahlen Stichtag: 31.12.2010
EnBW at a glance
Step by Step Approach

- EnBW Baltic 1 is conceptually based on present international experience
- EnBW Baltic 2 will be inline with gained experience base
- EnBW-North Sea projects will use tomorrows growing experience base

Quelle: www.offshore-wind.de
### EnBW at a glance

#### Offshore Objectives

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Location</th>
<th>Turbines</th>
<th>Generation</th>
</tr>
</thead>
<tbody>
<tr>
<td>EnBW Baltic 1</td>
<td>Baltic Sea</td>
<td>21 Siemens 2,3-93</td>
<td>185</td>
</tr>
<tr>
<td>EnBW Baltic 2</td>
<td>Baltic Sea</td>
<td>80 Siemens 3,6-120</td>
<td>1186</td>
</tr>
<tr>
<td>EnBW He Dreiht</td>
<td>North Sea</td>
<td>80 tendered</td>
<td>4.600 pl.</td>
</tr>
<tr>
<td>EnBW Hohe See</td>
<td></td>
<td>119 not yet tendered</td>
<td></td>
</tr>
</tbody>
</table>

**Total:**

- EnBW Baltic 1: 185 GWh (48,3 MW<sub>el</sub>)
- EnBW Baltic 2: 1186 GWh (288 MW<sub>el</sub>)
- EnBW He Dreiht: 4.600 pl. (1.195 MW<sub>el</sub>)
- EnBW Hohe See: 119 not yet tendered
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Political Framework and Market

.... Strong Political Commitment

German Energy Concept

...there is immediate action required to boost the expansion of Offshore-Wind. In order to increase the capacity by 25 GW until 2030 an investment of 75 Mrd. € will be required .... (page 8)

EEG 2009 / EEG 2011

› min. 30% contribution of renewable electricity generation by 2020

EU-Guideline

› min. 20% contribution of renewable in overall energy consumption by 2020

› Expectation: contribution in electricity generation in EU: 33%

source: Energiekonzept
Political Framework and Market

... Germany’s energy mix is changing dramatically...

- 2010: 16.8%
  - 8% (49 TWh) thereof are wind and pv

- 2010: installed capacity wind 27.200 MW; pv 17.300 MW

- 2010: 26 Billion € invested in renewable energies (19.5 in pv)

- 2011: political decision to shut down 8 nuclear units (8 GW)

- 2011: political decision to phase out nuclear by 2022

Source: AGEB, AGEE-Stat, Energiekonzept 2010
Political Framework and Market
…wind offshore shall develop to be the strongest contributor in Germany's energy mix…

share in electricity generation

<table>
<thead>
<tr>
<th>Year</th>
<th>Others</th>
<th>Geo Thermal</th>
<th>Photovoltaik</th>
<th>Bio-Energy</th>
<th>Wind Offshore</th>
<th>Wind Onshore</th>
<th>Hydro</th>
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<tbody>
<tr>
<td>2008</td>
<td>0.7</td>
<td>4.3</td>
<td>6.3</td>
<td>3.2</td>
<td>6.3</td>
<td>11.6</td>
<td>1.1</td>
</tr>
<tr>
<td>2020</td>
<td>1.1</td>
<td>5.3</td>
<td>5.8</td>
<td>4.3</td>
<td>6.3</td>
<td>11.6</td>
<td>1.1</td>
</tr>
<tr>
<td>2030</td>
<td>1.3</td>
<td>0.6</td>
<td>8.1</td>
<td>5.1</td>
<td>12.9</td>
<td>14.8</td>
<td>1.1</td>
</tr>
<tr>
<td>2040</td>
<td>1.6</td>
<td>1.0</td>
<td>10.2</td>
<td>6.2</td>
<td>18.4</td>
<td>18.4</td>
<td>1.1</td>
</tr>
<tr>
<td>2050</td>
<td>1.8</td>
<td>1.4</td>
<td>11.1</td>
<td>6.9</td>
<td>16.0</td>
<td>16.0</td>
<td>1.1</td>
</tr>
</tbody>
</table>

Quelle: Energieszenarien, Szenario IIa, s. Anlage 2
Political Framework and Market
…. attractive regulatory framework to secure growth

Feed-in tariff per kilowatt hour
› 15 ct for 12 years + x years (“x“ dependent on distance to shore/ water depth)
› Degression after 2018 of 7% per year

EnWG – Grid Connection Settlement
› the costs for grid connection are carried by the grid operator (TSO)
Political Framework and Market
..... massive opportunity expected in Europe

115 Billion € to be invested by 2020

*In operation 2.018 MW*
*Approved/in constr. 12.287 MW*
*Planned 58.162 MW*

+ 35 GW UK Round III

<table>
<thead>
<tr>
<th>Capacity [MW]</th>
<th>DE</th>
<th>BE</th>
<th>UK</th>
<th>DK</th>
<th>Irl.</th>
<th>NL</th>
<th>NO</th>
<th>SE</th>
<th>FR</th>
<th>Estl.</th>
<th>FI</th>
<th>IT</th>
<th>ES</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>in operation</td>
<td>43</td>
<td>30</td>
<td>972</td>
<td>588</td>
<td>25</td>
<td>228</td>
<td>2</td>
<td>130</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.018</td>
</tr>
</tbody>
</table>


considered are only windfarms with concrete ratings
Political Framework and Market
.... growth mainly limited by financial constraints

Findings

- 225 projects/115 GW in planning → 94 projects/36 GW expected to be online by 2020
- 23 GW owned by 8 utilities → € 69 bn required
- utility capex shortfall (€ 35 bn) + IPP debt requir. (€ 30 bn) → € 64 bn debt funding requirement
- high investments require stability, continuity, certainty

Conclusion

- € 115 bn / $ 152 bn
- 25 % ann. growth rate
- € 6,9 bn p. year required
- € 2,2 bn invested 2009
- 114 % increase required
- € 20 bn from presently 14 commercial banks + € 20 bn from EIB/ECA =€ 24,3 bn debt shortfall
- politics and legislation to provide stable support mechanism

* Bloomberg April 2010
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### EnBW Baltic 1 at a glance

**Offshore Windfarm EnBW Baltic 1**

<table>
<thead>
<tr>
<th>Category</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbines:</td>
<td>21</td>
</tr>
<tr>
<td>Capacity:</td>
<td>48.3 MW</td>
</tr>
<tr>
<td>Generation:</td>
<td>185 GWh/a</td>
</tr>
<tr>
<td>Water Depth:</td>
<td>18 m / 50 ft</td>
</tr>
<tr>
<td>Distance to Shore:</td>
<td>16 km / 10 ml</td>
</tr>
<tr>
<td>Project start:</td>
<td>May 2008</td>
</tr>
<tr>
<td>Start Offshore:</td>
<td>March 2010</td>
</tr>
<tr>
<td>Commissioning:</td>
<td>End 2010</td>
</tr>
</tbody>
</table>

![Map of EnBW Baltic 1](image)
EnBW Baltic 1 at a glance

- Height: Mean Sea Level (MSL) +67 m
- Tower Bottom: MSL+12 m
- Rotor-Diameter: 93 m
- Control: pitch controlled
- Power: 2.300 kW
- Weight: Rotor: 60 t | Nacel: 82 t | Tower: 158 t
EnBW Baltic 1 at a glance
Monopile and Transition Piece

Monopile
› Dimension (L x OD): ~ 37 m x 4,3 m
› Weight: ~ 215 t

Transition Piece
› Dimension (L x OD): ~ 27 m x 4,20/4,60 m
› Weight: ~ 250 t
EnBW Baltic 1 at a glance
Foundation and Transition Piece of Topside

Monopile:
› Length: ~ 30 m
› Weight: ~ 250 t

Ice Cone:
› Weight: ~ 530 t

Substructure:
› Weight: ~ 275 t
EnBW Baltic 1 at a Glance
- Statistics

› Number of ships working (total): 60
› Max number of ships at the construction site: 21
› number of ship movements: 1,270
› number of staff engaged: 365 (by CTV)
› Max number of staff at construction site: ~300 (CTV plus ship crew)
› number of staff transports by CTV: 2,594
› monthly break down:

![Graph showing monthly transport data]

<table>
<thead>
<tr>
<th>Month</th>
<th>Personen</th>
<th>CTV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mar</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Apr</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>May</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Jun</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Jul</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Aug</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Sep</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>Oct</td>
<td>12</td>
<td>12</td>
</tr>
</tbody>
</table>

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<td>8</td>
</tr>
<tr>
<td>May</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Jun</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Jul</td>
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<td>8</td>
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<tr>
<td>Aug</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Sep</td>
<td>16</td>
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<td>12</td>
<td>12</td>
</tr>
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## O&M Strategy in General

### Main Drivers for Availability

<table>
<thead>
<tr>
<th>Onshore</th>
<th>Offshore</th>
</tr>
</thead>
<tbody>
<tr>
<td>› Technology failure rates</td>
<td>› Technology failure rates</td>
</tr>
<tr>
<td>› Service concept</td>
<td>› Service concept</td>
</tr>
<tr>
<td>spare part strategy</td>
<td>spare part strategy</td>
</tr>
<tr>
<td>service level</td>
<td>service level</td>
</tr>
<tr>
<td></td>
<td>› Accessibility</td>
</tr>
<tr>
<td></td>
<td>transfer time</td>
</tr>
<tr>
<td></td>
<td>weather window</td>
</tr>
<tr>
<td></td>
<td>day/night access</td>
</tr>
<tr>
<td></td>
<td>› Availability of heavy lifting gear</td>
</tr>
<tr>
<td></td>
<td>crane vessel</td>
</tr>
</tbody>
</table>
Accessibility North Sea
Analysis of wave Conditions and Access

winter month North Sea

workable weather windows
O&M Strategy in General
Main Service Concepts

**Land based service**

› Service station on land for accommodation and material storage
› Staff transfer to assets by Crew Transfer Vessel (CTV) or Helicopter

**Sea based service**

› Offshore Service Vessel provides accommodation and material storage
› Alternatively Operation Platform double utilized as Offshore Sub Station and accommodation
› Staff transfer to assets by Offshore Service Vessel (OSV) / Crew Transfer Vessel / Helicopter

(Source: www.n-o-s.eu)
O&M Strategy in General
Main Service Concepts

Helicopter Service
O&M Strategy in General
Main Service Concepts

Sea based Service – Living Platform

Horns Rev II, DK
Topside and accommodation platform

Bard, Germany
Topside and accommodation platform
O&M Strategy in General
Main Service Concepts

Sea based Service – Offshore service vessel
## O&M Strategy in General
### Analysis of General Concepts

<table>
<thead>
<tr>
<th></th>
<th>Crew Transfer Vessel (CTV)</th>
<th>Offshore Service Vessel (OSV)</th>
<th>Helicopter</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Accessibility</strong></td>
<td>Wave height_{max}=1.5 m</td>
<td>Wave height_{max}=3.5 m</td>
<td>Wave height independent</td>
</tr>
<tr>
<td></td>
<td>Boat landing</td>
<td>Ampelmann</td>
<td>Winch operation</td>
</tr>
<tr>
<td></td>
<td>Daylight operation</td>
<td>24/7 operation</td>
<td>Daylight operation</td>
</tr>
<tr>
<td><strong>Operation time</strong></td>
<td>8.760 h/a x 77% x 50%-840h =</td>
<td>8.760 h/a x 88% -514h=</td>
<td>8.760 h/a x 50%-365h =</td>
</tr>
<tr>
<td></td>
<td>2.533 h/a</td>
<td>7.195 h/a</td>
<td>4.015 h/a</td>
</tr>
<tr>
<td><strong>N° service technician</strong></td>
<td>12 PAX</td>
<td>45 PAX</td>
<td>6 PAX</td>
</tr>
<tr>
<td><strong>Material transfer</strong></td>
<td>400 kg, 15 m board crane</td>
<td>3 t, 20 m board crane</td>
<td>Small transport capacities</td>
</tr>
<tr>
<td><strong>Cost impact</strong></td>
<td>€ 500,-/h</td>
<td>€ 980,-/h</td>
<td>€ 2.400,-/h</td>
</tr>
<tr>
<td><strong>Summary</strong></td>
<td>+ Favorable charter rates</td>
<td>+ Good accessibility</td>
<td>+ Good accessibility</td>
</tr>
<tr>
<td></td>
<td>+ Access to small ports</td>
<td>+ 24/7 operation</td>
<td>+ Fast transfer</td>
</tr>
<tr>
<td></td>
<td>- Non-productive travel time</td>
<td>+ less downtime of WTG</td>
<td>+ No sea sickness</td>
</tr>
<tr>
<td></td>
<td>- Limitation daylight operation</td>
<td>+ Spare parts on board</td>
<td>- High costs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Possible sea sickness</td>
<td>- Limitation daylight operation</td>
</tr>
</tbody>
</table>

### Notes:
- Favorable charter rates
- Access to small ports
- Non-productive travel time
- Limitation daylight operation
- Good accessibility
- 24/7 operation
- Less downtime of WTG
- Spare parts on board
- Possible sea sickness
- Fast transfer
- No sea sickness
- High costs
- Limitation daylight operation
EnBW’s O&M Strategy in General

► Minimisation of operational costs
► < 5 years Service & Availability Contract with turbine OEM
► > 5 years own service with close partnership to turbine OEM
► Know-how transfer, parallel working EnBW service technicians, trained by OEM
► Use of Condition Monitoring Systems (CMS)
► Application of synergies and experience from conventional power plant operation to Offshore Wind Park infrastructure (e.g. OSS, IAG, etc.)
► SAP as O&M planning tool

► Framework contract for Jack-Up Vessel charter
► Long time charter or acquisition of CTV and OSV
► Long time charter for other logistics

► Spare parts lead time contract with OEM
► Minor spare parts ware house
► Storage of strategic spare parts

(Source: www.get-ersatzteile.de)
EnBW’s O&M Concept Baltic 1
Land Based Service Concept

› 21 turbines SWT 2.3-93
› 48.3 MWel
› Distance to shore: 16 km
› Service harbour Barhöft
› Minor spare parts and consumables storage

CTV Specifications:
› Dimension: Length > 18m
› Velocity: > = 20 kn
› Significant wave height (sWH) < 1.5 m
› Transfer time: 75 – 90 min
› Capacity staff: 12 PAX
› Crane: 400 kg / 15 m
› Deck capacity: 7 x 7.5 m
› Staff access by boat landing

(Source: www.n-o-s.eu)
EnBW’s O&M Concept Baltic 2
Sea Based Service Concept

OSV Specifications:
› Dimension: 75 x 17m
› Velocity: >= 15 kn
› Significant wave height (sWH) < 3,5m
› Transfer time: 30 – 40 min
› Capacity staff: 45 PAX
› Crane: 3 t / 20 m
› Deck capacity: 8 x 20’’ container
› Staff access by Ampelmann system

› 80 turbines SWT 3.6 -107
› 288 MWel
› Distance to shore: 32 km
› Service harbour Rostock, Stralsund, Sassnitz, o. e.
› Container area
› Parking area

(Source: www.ampelmann.nl)
Conclusions

### Knowledge

- Almost no experience for far shore operation available
- 2 experts – 3 opinion
- No project is equal to the other
- Regulatory or statutory changes may occur

### Consequence

- Good decision necessary
- Learn as fast as possible
- Site specific analysis and experience essential
- Keep the system flexible
Hi Boss,
... we may need to review our service concept .....