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<th>STRABAG OFFSHORE WIND</th>
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<td>- DESIGN PHILOSOPHY</td>
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<td>- FULL SCALE TEST</td>
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<td>SUMMARY AND OUTLOOK</td>
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</table>
STRABAG OFFSHORE WIND
STRABAG SE GROUP

- Leading European Contractor
- **76,866** employees
- **13,713 € Mio** (2011)
  - 36% Building Construction / Civil Engineering
  - 46% Transportation Infrastructures
  - 16% Special Divisions and Concessions

- **Corporate Social Responsibility**
  - Renewables part of our Sustainability Philosophy: Energy efficiency and reduction, CO₂ reduction, CDP top score

- More than 100 years of experience
- Strong and solid financial background

Activities EU markets
STRABAG OFFSHORE WIND
STRABAG OFFSHORE WIND AS PART OF THE STRABAG GROUP

**STRABAG** Offshore Wind
Cuxhaven/Hamburg/Stuttgart/Dublin

- 80 In House Offshore Engineers
  - Structural Design
  - Mechanical & Electrical
  - Geo-technical Design
  - Hydraulic & Soil Mechanics
  - Ship & Vessel Design
  - Logistics
  - Wind Tide and Wave Analysis
  - Etc.

**STRABAG** Inhouse

- Zentrale Technik (In-house engineers)
  - 650 Engineers
  - “Brain Pool” to support STRABAG Projects worldwide.

- Strong Research, Development and Innovation

Broad knowledge
Interface competence
Reliable, experienced and long-term partner
LIVING KNOW-HOW
CO-OPERATIONS STRABAG OFFSHORE WIND

Mott MacDonald

Co-operations with Research and Development Institutions
- Universities Braunschweig, Trinity & Bolton Street Dublin, Hamburg, Hannover, Karlsruhe, Stuttgart, Vienna
- Fraunhofer Gesellschaft

Networks UK and Ireland
- Crown Estate London Cost Reduction Program
- Concrete Centre London Promoting Concrete Gravity Base Foundations
- DECC London Offshore Accelerator Program
- NOW National Offshore Wind Association of Ireland

Networks Germany and EU
- WAB Windenergie Agentur Bremerhaven / Bremen e.V.
- Stiftung Offshore Windenergie
- ENCORD - European Network of Construction Companies for Research and Development

Approx. £150 per MW/hr

To below £100 per MW/hr
Global Tech I
North Sea Project (confidential)
Project Albatros I
FINO
Arkona
Anholt Substation
e tc.
Onshore Foundations

- Gravity as standard for good soil conditions
- Simple and proven
- Robust concrete construction technology
- Decades of experiences within STRABAG Group
TECHNICAL DESIGN PHILOSOPHY

STRABAG GBF Offshore Foundation

- Foundation system for industrial mass production
- Water depths up to 55 m
- Minimal environmental impact
  - no pile driving noise
  - low operating noise
  - minimal blockage effect
- Designed for ~ 90% of North Sea / Irish Sea
- Serial production, Onshore assembly, Transport and Installation pre-assembled unit
- Minimise time between Invest and ROI
- Up to 10MW
- Life Cycle Design: Lower maintenance, Longer operation designed for 25 years ++ to 50 years Repowering capacity, 100% removable
TECHNICAL
DESIGN PHILOSOPHY - 360° ENGINEERING

STRABAG GBF Offshore Foundation

- Integral load calculation
- Holistic understanding of specific offshore requirements
- Engineering Know How
- Interface Competence
- Optimisation of the entire system
- Minimising risk
TECHNICAL DESIGN PHILOSOPHY

STRABAG GBF designed for large OWT

- In-House global load calculation program Garrard Hansons “Bladed”
- Existing basic design for turbine types of 5-8 MW
- Feasibility study successful up to 10 MW
- Easy to adapt GBF design to all tower diameters
- Design Frequencies comply with requirements of established 5-8 MW turbine types
- Design co-ordination with 8 of the leading turbine manufacturers
Monopiles, Jackets and Gravity Base Foundations: personalised solution for your project

- We cover 100%
- For UK & Ireland we focus on Gravity Base, >3MW >25m
TECHNICAL
OPTIMIZED LEAN DESIGN 2012 FOR SERIAL PRODUCTION & INSTALLATION
**Example 45 m water depth**

<table>
<thead>
<tr>
<th>Component</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ø shaft</td>
<td>Base: 8.50m, LAT: 5.80m</td>
</tr>
<tr>
<td>Base plates</td>
<td>3 x ~128m² = 384m²</td>
</tr>
<tr>
<td>Concrete</td>
<td>~ 7000 t</td>
</tr>
<tr>
<td>Reinforcement steel</td>
<td>~ 620 t</td>
</tr>
<tr>
<td>Pre-stressed reinforcement steel</td>
<td>~ 80 t</td>
</tr>
<tr>
<td>Secondary Steel</td>
<td>~ 62 t</td>
</tr>
<tr>
<td>Volume Ballasting, sandbags (or stones)</td>
<td>~ 2800 m³</td>
</tr>
</tbody>
</table>
TECHNICAL ANALYSIS

- Numeric simulations and predictions
- Scale model wave tank testing
- Full size testing wave loadings

This project has been co-funded by the European Union under the European Energy Programme for Recovery
TRIAL STRABAG GRAVITY FOUNDATION
ANALYSIS – LIVE 1:1 FULL SCALE TEST

- First systematic full scale test of offshore load cases
- R&D program Geotechnical Aspects with cyclic impacts
- Subsoil like North Sea conditions
- Over 300 sensors
- Simulation of
  - Real load assumptions
  - Realistic severe North Sea storms
  - Cyclic wave loads (≠ Oil and Gas)
  - Loads up to 1100 to every 12 seconds
  - 1.2 million cycles

Proof of function and viability under real conditions
- No soil liquefaction
- Foundation well suited for all sea states
TRIAL STRABAG GRAVITY FOUNDATION
PROCESS
**PROCESS**

**FABRICATION – PORTS AND PLANT**

- **Ports**
  - Cuxhaven for German North Sea
  - Negotiations & Pre-Agreements with ports in England, Scotland, & Ireland

- **Requirements for fabrication yards**
  - Production Area with sea access
  - Area required ~ 30 ha.
  - Local labor (engineering and production)
  - Storage areas for blades, turbines, towers

- **Industrial plant for large-scale production**
  - High automation
  - Flexible capacity
  - Complete pre-installation onshore
  - Safeguarding the coastal regions – creating jobs at the UK & Ireland locations
PROCESS
SERIAL FABRICATION FOUNDATION

- Serial Production
  - Foundation
  - Concrete shaft
- Weather-independent production
- Quality assurance
- Reduced H&S risks
PROCESS
ONSHORE INSTALLATION TOWER, TURBINE AND BLADES

Full onshore assembly
- 80++ completed foundations per year
- Duration production 9 weeks
- Onshore pre-installation of tower, turbine and rotor blades
- Onshore Turbine testing and trial operation

Local supply chain
- Concrete delivered or mixed on site
- Standard reinforcement
- Secondary Steel
PROCESS
SEA BED PREPARATION AND TEST SITES

Process
- Excavation 2 m to 8 m
- Levelling

Test Excavation Pits
- Numerical simulation completed
- Full scale demonstration pits 05/2013
  - Optimising excavation method
  - Tool optimisation
  - Verification of best inclination angle
  - Sedimentation issues in pit
  - Current & tidal effects
**Offshore-transport & installation vessel**

- Self propelled (high capacity)
- Proven semi-submersible technology - like Gas-Platforms (low motion and acceleration)
- Dynamic Positioning DP2
- Up to 2.5m significant wave height
- Heave compensation
- Transport & Installation ~ 2 days

- Foundation is designed for offshore wind use - not for floating out to install.
PROCESS
TRANSPORT AND INSTALLATION

- Pickup at plant from finger pier
- Transport with semi-submersible installation vessel
- Set down process by ballasting the vessel
- Lowering with winch-system
PROCESS
TRANSPORT AND INSTALLATION

- Set down into the prepared pit
- Disconnect the load handling device
- Vessel departs
PROCESS
BALLASTING AND SCOUR PROTECTION

Ballasting and Scour Protection

- Ballasting of concrete boxes (open top)
- Sand bags (rock armor) as scour protection
- Refilling construction pit
COMMERCIAL
INVEST TO OPERATION

Cost for Wind Farm
Construction Costs
Interest

First Revenue
Start Return on Invest

Start Construction
Start Operation

time
COMMERCIAL IMPACT ON COST OF ENERGY

Reducing costs: Short project duration STRABAG Gravity Base

- short construction cycles
- one season installation
- serial production
- quality control
- smart engineering
- reduced risks
- reliable logistics
- low health, safety and environmental risks
COMMERCIAL IMPACT ON COST OF ENERGY

- **Reduced costs**
  - original construction

- **Lower maintenance costs**

**Repowering / longer operation**
- no demolition
- no new construction
- no downtime

**Construction**

**Operation**

**'Normal' End of Life**
## COMMERCIAL
### CHALLENGES AND OPPORTUNITIES

<table>
<thead>
<tr>
<th>Challenges</th>
<th>Opportunities</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Global</strong></td>
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</tr>
<tr>
<td>- Climate Change</td>
<td>- Renewables</td>
</tr>
<tr>
<td>- EU CO₂ reduction targets</td>
<td>- New Jobs &amp; Skills,</td>
</tr>
<tr>
<td>- Rethinking Energy Mix</td>
<td>- Competetiveness EU</td>
</tr>
<tr>
<td>- Grids</td>
<td>- New Markets</td>
</tr>
<tr>
<td>- Legislation</td>
<td></td>
</tr>
<tr>
<td>- Most significant challenge since Industrial Revolution</td>
<td></td>
</tr>
<tr>
<td><strong>STRABAG</strong></td>
<td><strong>STRABAG</strong></td>
</tr>
<tr>
<td>- Technical uncharted territory</td>
<td>- ‘Frontier Spirit’</td>
</tr>
<tr>
<td>- New ways of thinking</td>
<td>- Industrial Production &amp; Processes</td>
</tr>
<tr>
<td>- Amazing dimensions of market and solutions</td>
<td>- Living our responsibility</td>
</tr>
<tr>
<td></td>
<td>- Use of proven, solid technology in a new and smart combination</td>
</tr>
<tr>
<td><strong>Technical Risks</strong></td>
<td><strong>Derisking</strong></td>
</tr>
<tr>
<td>----------------------</td>
<td>----------------</td>
</tr>
<tr>
<td>High cyclic loads</td>
<td>Robust construction materials</td>
</tr>
<tr>
<td>- Material behaviour</td>
<td>- Proven technology</td>
</tr>
<tr>
<td>- Structural soil interaction</td>
<td>- Numeric simulation and</td>
</tr>
<tr>
<td>Construction and material quality</td>
<td>- Scale tests and</td>
</tr>
<tr>
<td>New technologies and new approaches</td>
<td>- Real life 1:1 tests</td>
</tr>
<tr>
<td>Environmental Risks</td>
<td><strong>Derisking</strong></td>
</tr>
<tr>
<td>Construction / Operating noise</td>
<td>- Use of environmental friendly technology</td>
</tr>
<tr>
<td>Poisonous coatings</td>
<td>- Close cooperation with authorities and research institutions</td>
</tr>
<tr>
<td>High volume construction vessels traffic</td>
<td></td>
</tr>
<tr>
<td>Commercial Risks</td>
<td><strong>Derisking</strong></td>
</tr>
<tr>
<td>Interface risks in multi-contracting</td>
<td>- EPCI contractor</td>
</tr>
<tr>
<td>Risks of delays</td>
<td>- Predictable construction processes</td>
</tr>
<tr>
<td>Production capacity</td>
<td>- Industrial serial production</td>
</tr>
<tr>
<td>Complex logistics</td>
<td>- Use of proven technology</td>
</tr>
<tr>
<td>Completion risk</td>
<td>- Experienced and powerful builder</td>
</tr>
<tr>
<td>Price of materials</td>
<td>- Use of local materials, eg concrete</td>
</tr>
<tr>
<td></td>
<td>- Reinforcement made of recycled steel</td>
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</tbody>
</table>
[...] SUMMARY AND OUTLOOK
STRABAG Offshore Wind offers:

- Industrial local production
- Optimal technical and commercial EPCI solution packages
- Cost, scheduling and quality certainty
OUTLOOK

THE MARKET

Department of Energy and Climate Change

Targets for UK:
The central range indicates that up to **18 GW** could be deployed Offshore by **2020**. Beyond 2020 there is a very high potential for deployment Offshore with over **50 GW** possible **by 2030**” That’s potentially **10,000 Turbines!!**

‘Irish must spend extra €5bn to meet 2020 targets’ 21st August 2012

Irish wind-farm operators will need to spend another €5bn or so in capital investment and construct an additional 3-3.5GW of onshore wind power if Ireland is to meet its 2020 EU climate change targets, according to a new report by Davy Stockbrokers.

In Ireland the Government has to implement the OREDP which has been “on hold” for the past 3 years and give Offshore Planning Consents. Industry and Investors will then look after the rest and start creating opportunities and jobs for offshore wind energy sector in Ireland.
OUTLOOK
TIME TO MARKET

2.5 years
STRABAG OFFSHORE WIND IS READY TO GO …

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