Cooperation as a key to cost reductions for offshore wind

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Outline

• Norwegian oil and gas industry
  – Cooperation
  – Govermental regulations
  – Support schemes for Norwegian research
• Examples from NORCOWE
  – OBLEX-F1
  – Improved understanding of turbulence
  – NORCOWE Reference Wind Farm
• 1+1=5!
Ownership of oil and gas licences
Statfjord as an example
Norwegian oil and gas industry

- Business sensitive information
  - Geological information
  - Interpretation of geological information

- Common interests in developing the oil&gas vendor industry
  - Close cooperation on development of the technical solutions, transparency between the vendor and the customer
  - Detailed technical information available to the oil&gas companies from the vendors
  - Use of JIP to mature the vendor industry
  - A development project is considered successful when implemented in the vendor industry
Strong governmental involvement

- Oljedirektoratet founded in 1972 (first oil detected in August 1969)
- Petroleumstilsynet founded in 2004 (demerged from Oljedirektoratet)
Investment in Norwegian research

- Strong incentives to invest in Norwegian research by governmental regulations
- Norwegian authorities told the oil companies to install instruments on their offshore installations
- Norwegian Petroleum Directorate (OD) collected the data, and set up R&D programs to analyze the data. The analyses were paid by the oil companies
- OD still collects data from the Norwegian continental shelf
- Investment in R&D in Norway was important to get licences on the Norwegian continental shelf
Cooperation in the Norwegian oil and gas industry

- The Norwegian Oil and Gas association (Norsk olje og gass) consists of 54 oil/gas companies and 55 supplier companies. The companies represent about 35 000 employees.
- Founded in 1965 as Norsk Industriforening for Oljeselskapene
- Have organized joint projects to meet regulatory requirements
- An example of commercial cooperation: Turbinpool, a joint maintenance contract for 97 gas turbines from Norsk Hydro, Statoil and Exxcon Norge towards GE.
Why is scientific cooperation needed?

<table>
<thead>
<tr>
<th>Scale</th>
<th>Relevant Length (m)</th>
<th>Relevant Time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mesoscale</td>
<td>10,000 - 10 km</td>
<td>Days - Hours</td>
</tr>
<tr>
<td>Park scale</td>
<td>10 - 1 km</td>
<td>20 min - 20 s</td>
</tr>
<tr>
<td>Rotor scale</td>
<td>200 - 50 m</td>
<td>10 - 2 s</td>
</tr>
<tr>
<td>Blade scale</td>
<td>5 - 0.5 m</td>
<td>0.5 - 0.01 s</td>
</tr>
</tbody>
</table>

Factor of $10^6$ in relevant length and time scales

*By courtesy of Finn-Gunnar Nielsen*
Examples from NORCOWE

- OBLEX-F1 – measurement campaign at FINO1
- LIMECS – Lidar measurement campaign at Sola (Stavanger)
- Improved understanding of turbulence and loads on offshore wind turbines
- NORCOWE Reference Wind Farm
- Validation of models with data from Sheringham Shoal
- Lysefjord bridge (UiS, NPRA, UiB, CMR, DTU)
FINO 1

- Research platform
- Commissioned 2003
- Owner: Federal Ministry (BMWi)
- Administration: Projektträger Jülich
- Public available data
Measurement concept

- LIDAR - Vertical profile
- MW Radiometer - Temp. profile
- LIDAR - Inflow scan
- LIDAR - Wake scan
- SailBuoy - wave, surface temp.
- Submerged buoy
- Floating Lidar
- Wave Camera
- DCF - Turbulence
- Bottom Frame
- ADCP/ADV
- Wave buoy
- Wave statistics, surface currents and turbulence
Scanning lidar #1
Windcube 100s

Microwave radiometer
RPG-HATPRO G4

Scanning lidar #2
Windcube 100s

Wave camera

2x DCF
turbulence sensors

Slide 14/20 – Jan 16
Scanning lidars

- Online instrument control and webcam monitoring
- Real-time access to wind profiles for inflow and wake
Workshop on OBLEX-F1 data
Validation of turbulence models

- Industrial motivation: accurate estimation of loads
- Validation of turbulence models, with a particular focus on applications to loads is a main focus area in NORCOWE in 2016-2017
- Coherence investigations of atmospheric turbulence as collaboration between UiB, UiS, UiA, CMR and Statoil
- Utilizing the OBLEX-F1 data to see if waves, atmospheric stability, wind and wave field influence the turbulence characteristics
Norcowe reference wind farm

Thomas Bak, Angus Graham, Alla Sapronova, Zhen Chen, Torben Knudsen, John D Sørensen, Mihai Florian, Peng Hou, Masoud Asgarpour
Key parameters

- Reference zone: FINO3
- Installed capacity: 800 MW
- Number of turbines: 80
- Turbine: DTU 10 MW turbine, rotor* 178m, hub height 119m
- Water depth / foundations is not in the initial focus – 22 meter, monopile

Developmental work on Norcowe’s reference wind farm (RWF) has taken place at Aalborg University and Uni Research. The RWF comprises a fictitious 800 MW wind farm at the location of the FINO3 met mast, 80 km west of the island of Sylt at the Danish-German border.

- The farm involves a set of 80 reference wind turbines and two substations.
- DTU’s 10 MW reference wind turbine is the chosen turbine type, a variable-speed rotor of diameter 178 m and hub height 119 m.
- Foundations are monopiles: mean water depth at FINO3 is 22.5 m, soil type comprises medium dense to very dense sand deposits with gravel and silt constituents.
- There is a real wind farm at FINO3, DanTysk, owned by Vattenfall.
How can 1+1=5?

- Common goals, joint effort
- Skilled people
- Clusters (industry, academia, education and public sector)
- Good management systems in the industry
- Governmental regulations
- Industrialization and standardization

It’s all about people!
Thank you for your attention!