Offshore Wind from a Supply Chain Perspective

- lessons learned from execution of HVDC and Floating WTG projects & thinking ahead

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About Aibel

- Aibel AS is a leading supplier of services related to oil, gas and renewable energy
- Around 4,000 employees
- Offices in Norway, Denmark, Singapore and Thailand
- Yards in Norway and Thailand
- Long term maintenance and modifications contracts
- Deliver new platforms and modules
- Successfully entered into the offshore wind market

WE DELIVER
THE FULL SCOPE OF SERVICES

STUDIES

ENGINEERING

PROCURE-MENT

CON-STRUCTION

INSTALLATION

MC / COMMISIONING

OPERATIONAL SUPPORT

DECOMMIS-SIONING

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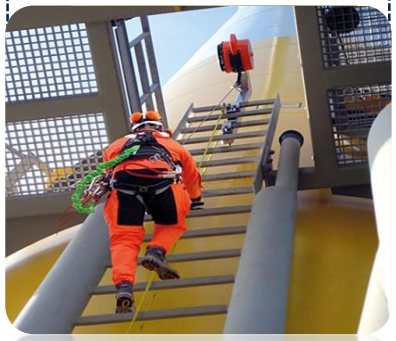
Offshore Wind Business Areas

HVDC

AC Substations

Floating Wind[1)]

O&M



1) Photo: Statoil ASA

DolWin Beta – our first wind platform

- Contract awarded in August 2011 to design and build DolWin beta (ABB)
- Convert alternating current (AC) from wind farms to direct current (DC) – 924 MW, 320kV
- Receive electricity from more than 200 offshore wind turbines
- Size of a football pitch. Accommodation for 24 people
- Construction of the platform in Dubai
- Sail away from Dubai to Haugesund June 2014
- Sail away from Haugesund August 2015
- Installed in the DolWin wind cluster in the German North Sea

Johan Sverdrup Power from Shore

- Contract awarded October 14, 2015
- EPC contract covering engineering, procurement, construction site work, building of a converter station and installation of converter equipment
- The contract also includes trenching and laying of two sets of 300kV alternating-current cables from Kårstø to Haugsneset
- The Johan Sverdrup oil field will be operated by land-based power from production start late in 2019

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Hywind Scotland Pilot Park

- In 2014 Aibel was awarded the contract for FEED and EMA (Engineering and Management Assistance)
- EMA was since expanded to include the design of turbine towers and responsibility of system integration and procurement of equipment
- Aibel was also awarded a contract for installation assistance at Stord Base and in Scotland
- Work was conducted from Aibel's offices in Haugesund and Oslo
- Production started October 2017
- O&G industry now show interest for such floaters

Photo: Øyvind Gravås/Woldcam/Statoil

From Oil & Gas to Renewables and Feedback Renewables to Oil & Gas

What is it that Aibel can do, which is useful competence in developing a sustainable offshore wind industry?

- Experience with large, complex offshore projects
  - With large and challenging wind power projects at sea, there is room and need for large, serious EPC(IC) providers
- Experience transfer from offshore (O&G) environment
  - Design and construction of offshore structures
  - What is required of workers in challenging offshore environment
  - The importance of logistics
  - High quality deliverables
  - Understand the need for study/FEED and well planned T&I
- Well developed HSE culture
- We have also seen a positive Feedback loop, that our now gained Offshore Wind experience is useful back for Oil & Gas Clients and projects
- Concept development with the full chain in mind, design, construction, transport, installation and completion

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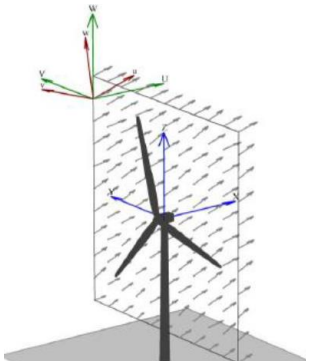
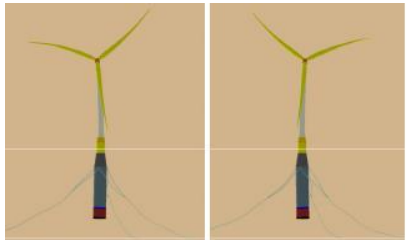
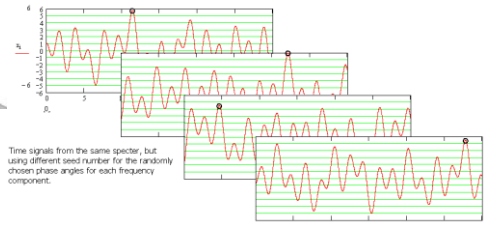
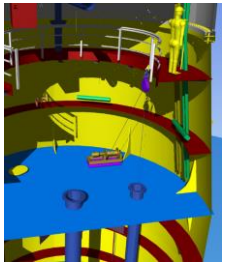
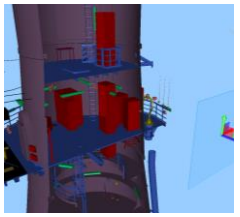
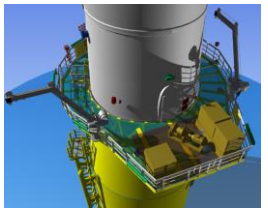
Renewables, differences from O&G

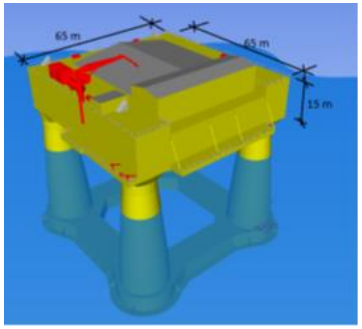
- Differences from O&G
  - Lump sum contracts only
  - Little or no compensation for studies and FEED's
  - Need for Concept development on own cost
  - Clients less experienced in the beginning, seen som trial and error in designs and contract formats
  - Clients more experienced, market is maturing
  - Ship collition, inverted
    - O&G, risk is risers w hydrocarbon, sacrifies vessel
    - OW, risk is oil pollution from vessel, sacrisfies WTG
- Learnings
  - Has learned to be more efficient
  - Has learned design in shallow waters
  - Need to adapt to different thinking
- Simple structures, advanced simulations, really challenging and interesting for engineers
- Still need for multidiscipline design and project execution competence

Further development and ahead

- Following the Dolwin Beta project, we have together with ABB allready improved the HV DC station design significantly
- Next Generation HV DC, Collaboration with Clients and ABB has resulted in significant savings
- For shallow water fixed turbines, still room for improvement e.g. specific offshore turbines prepared for simple marine operations
- More efficient design solutions and execution method
- How to include local content, partners and subcontractors
- Floating WTG's,
  - Construction and assembly logistics and capacity main issue
  - Room for improvement if Turbine suppliers, EPC and installation contractor collaborat
  - truths, innshore assembly? Reaching crane capacities?
  - Still need to develop less costly mooring systems
- Floating Substations, «marinized» HV equipment main issue



Next generation HV DC stations, smaller and no need for AC stations, WTG's directly to HV DC station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