Marine operations and logistics lessons learned from Hywind Tampen

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Navigating the Future

Leveraging on existing knowledge & assets from the O&G industry

High synergies between floating wind turbine installation and traditional O&G mooring projects

Same installation methodology: ROVs, DP operations, Offshore crane, chain deployment and rigging

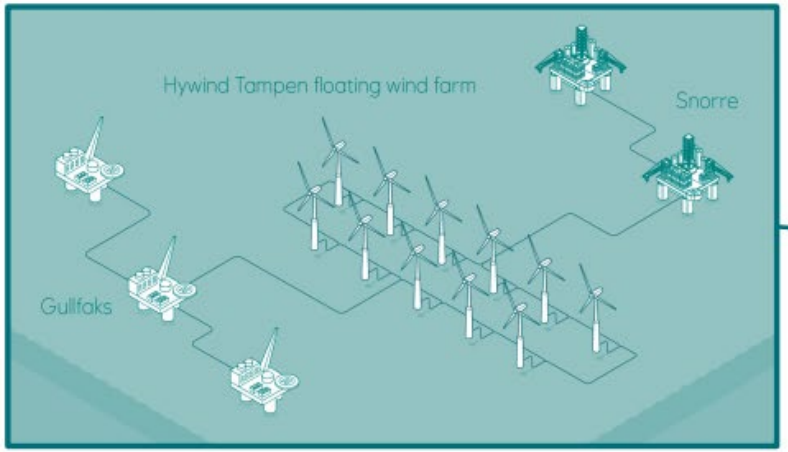
4500 people globally

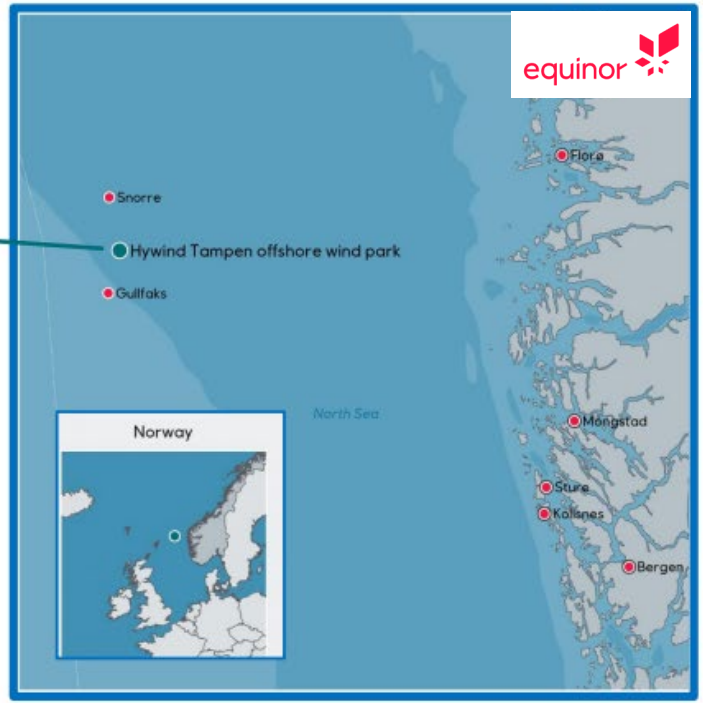
Fleet of 70 specialized vessels

Offices on 6 continents

Main office is in Bergen

Hywind Tampen – offshore wind farm in the North Sea





- 11 wind turbines between Snorre and Gullfaks
- Combined capacity of 88MW
- Concrete substructures and shared anchors
- Considerable CO2 emission reductions

DOF established a JV with Aker Solution for the Assembly and installation of the 11 turbines. Aker Solution acted as the building contractor and Dof as the turbine installation contractor

Management and coordination of Floating wind turbine assembly operations.

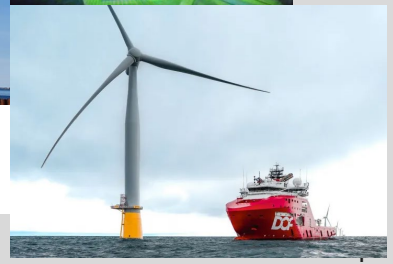
Mooring system, receipt, storage and installation.

Floating wind turbine tow out and hook-up.

<u>WHEN</u>
Tendering 2018-2019
Contract Execution 2019 (Oct) – 2023 Q3





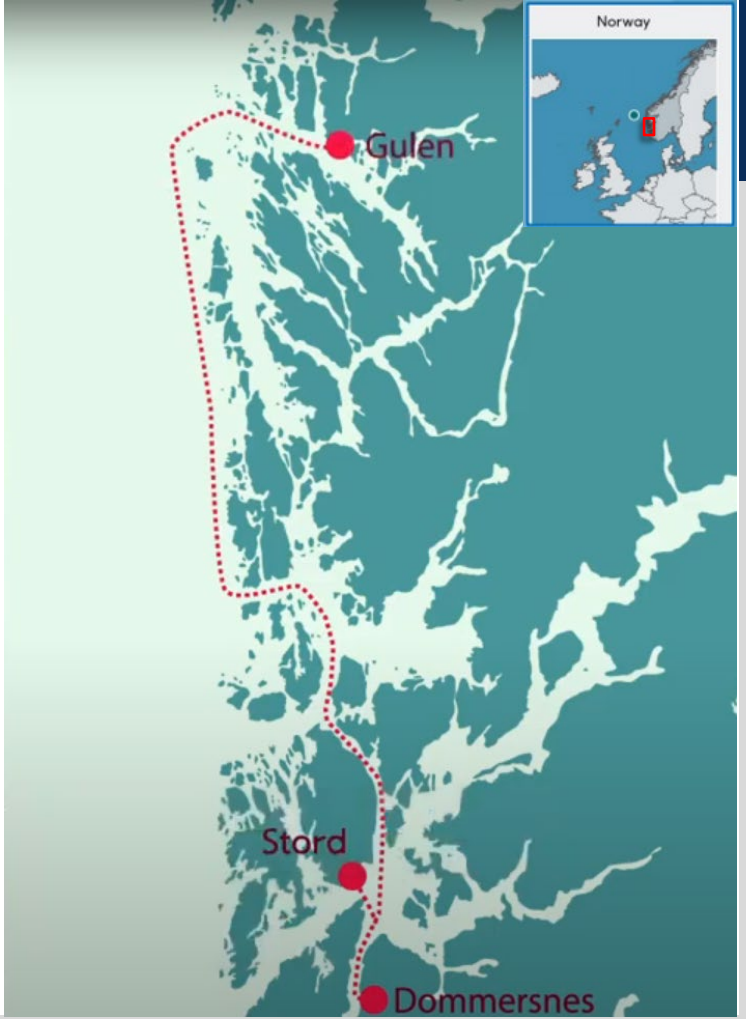



On and Near shore Construction Sites:

1) Stord yard (start of slip forming)

2) Dommersnes (completion of slip forming

3) Gulen (assembly & commissiong site)

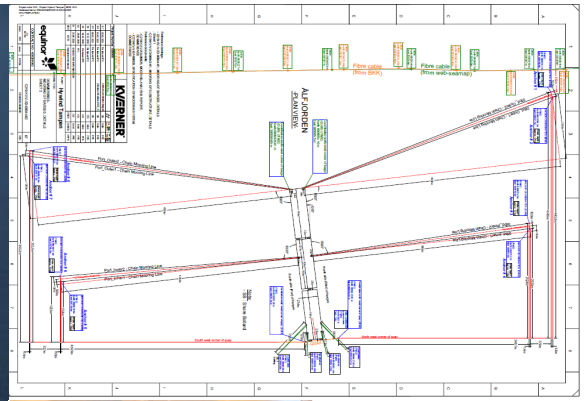


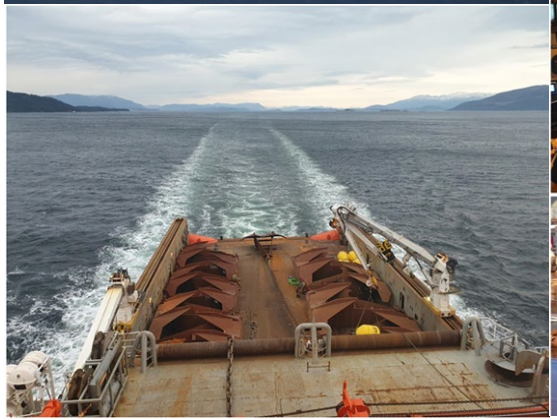
Marine Operation’s during Construction - Preparatory work at Dommersnes

Mooring for 250 000 ton of substructures.

11 times the weight of all cars at Lagunen parking (2222 P- plasser).

3 North Sea barges to create the “floating quay”

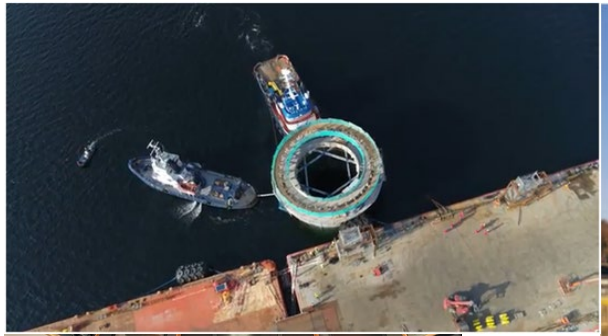


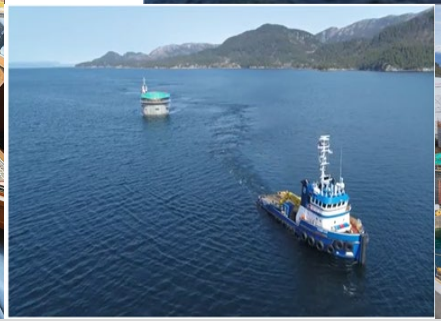


Marine Operation's during Construction – Out of dock and tow to Dommersnes

Out of dock operation

- Crane capacity.
- Stability w ballast
- Release of hooks

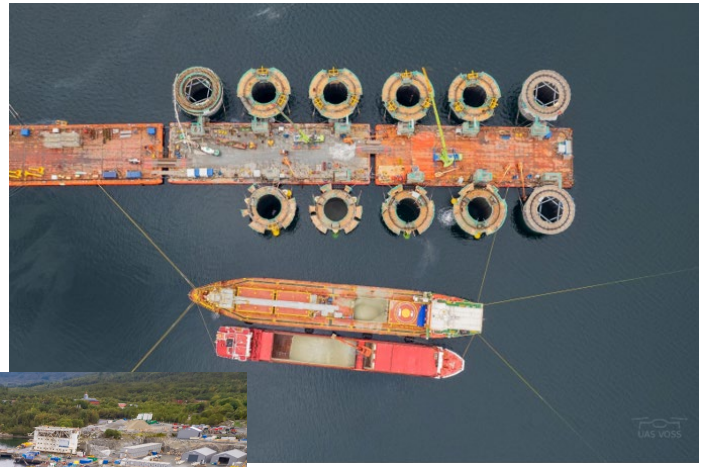




Marine Operation’s during Construction

Concre Substructure fabrication at Dommersnes:

Each structure is 22.000 Te & 108m «tall & deep» when completed !

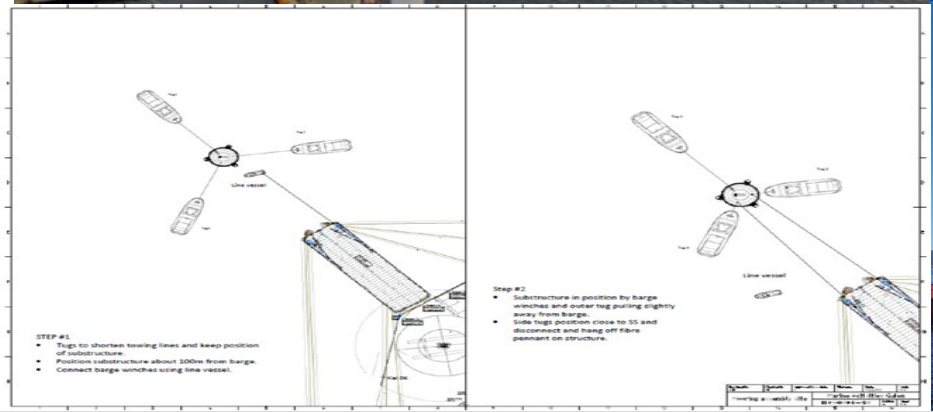


Marine Operations During Construction

Top deck installation

- Tight tolerances and guiding
- Overview/access limited during landing
- Wind sensitive
- Temperature sensitive

Towing inshore: Dommersnes - Sløvåg



Assembly Site at Wergeland base Sløvåg

Assembly of Turbines and Floating Substructure.

Commissioning testing and storage inshore.

DCF Subsea

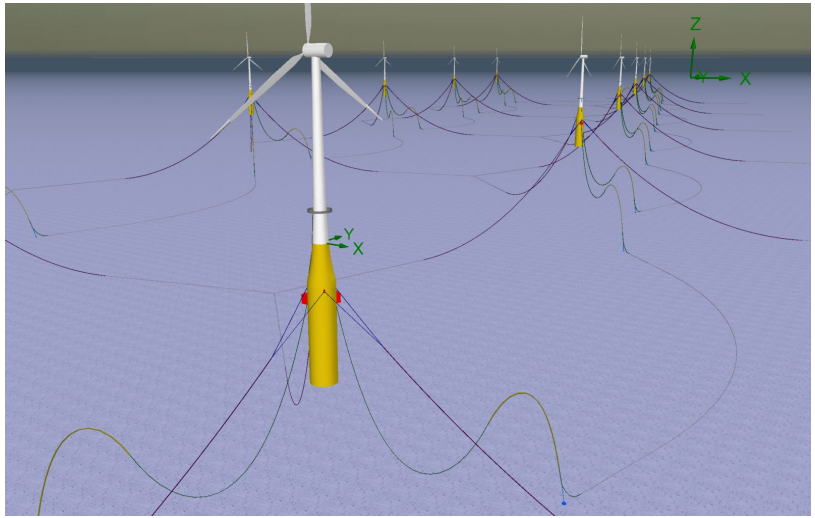
Marine Operations Offshore

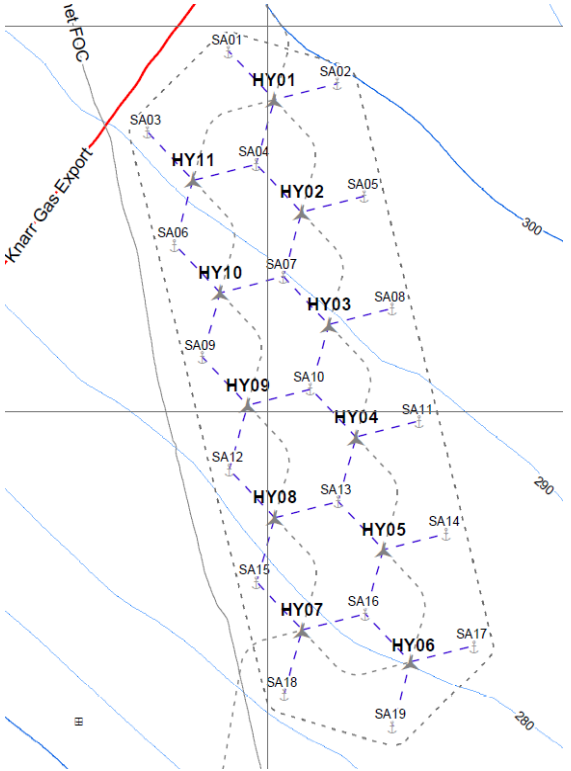
Install anchors and bottom part of mooring lines.

Tow-out and connect floating wind turbines.

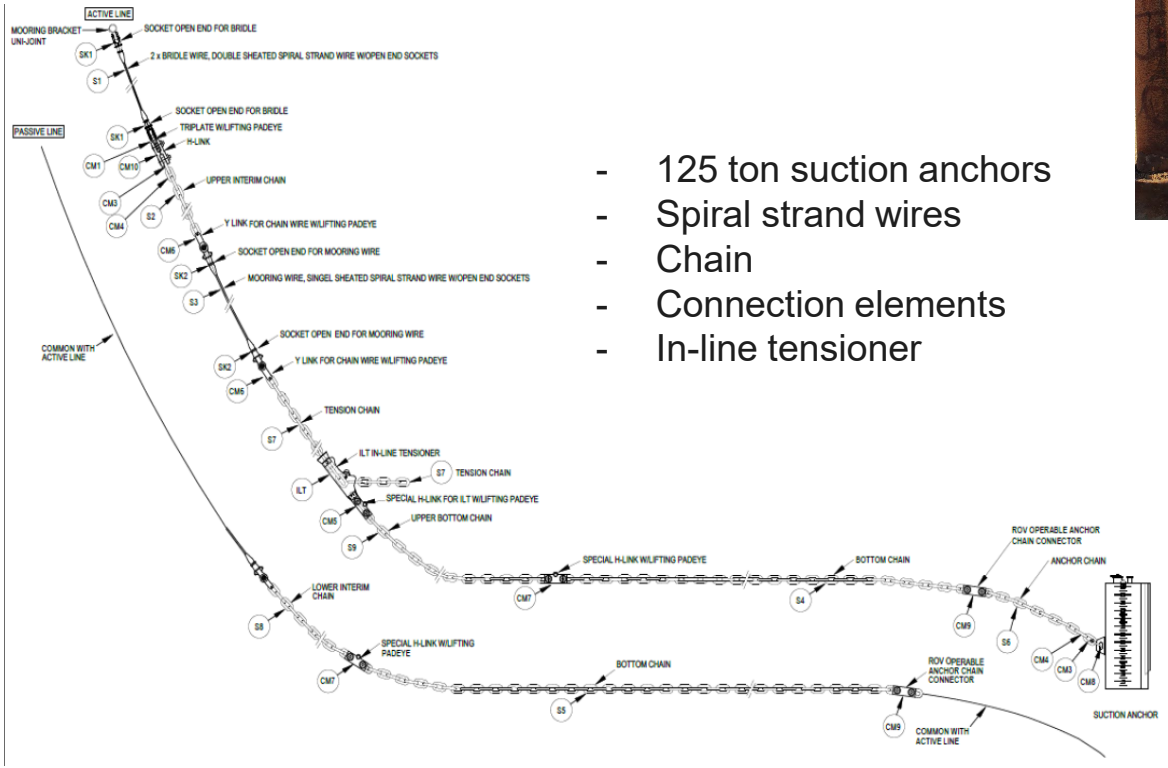
The Anchor System Field Layout

<u>Optimised mooring system</u>
19 anchors
1.7 pr turbine (ie sharing)
33 anchor lines

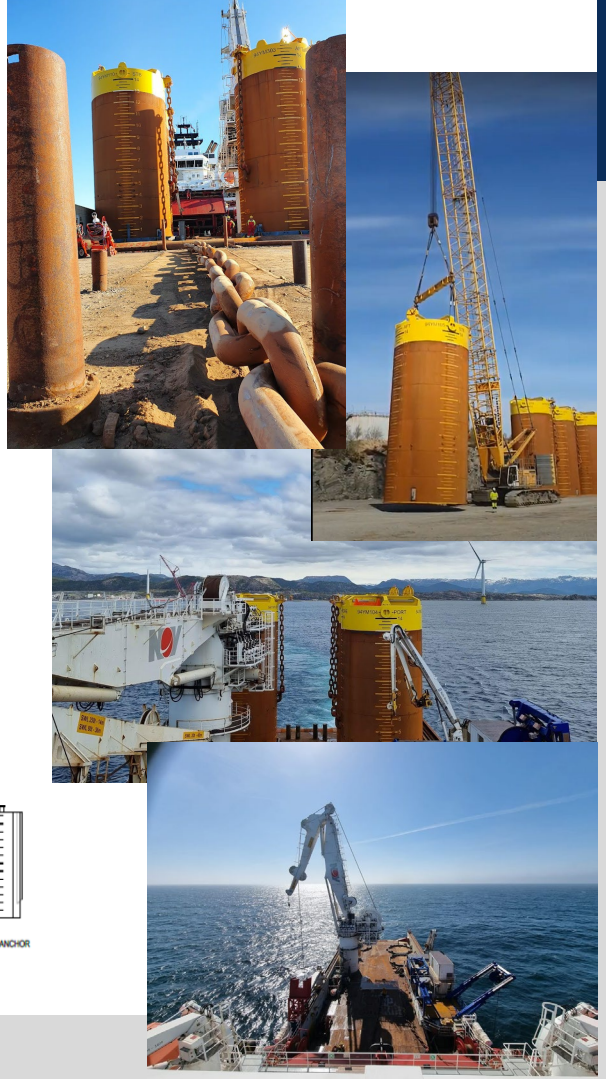




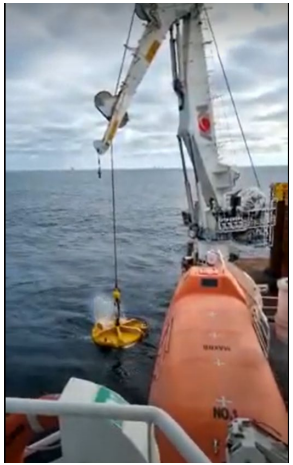
The mooring line configuration

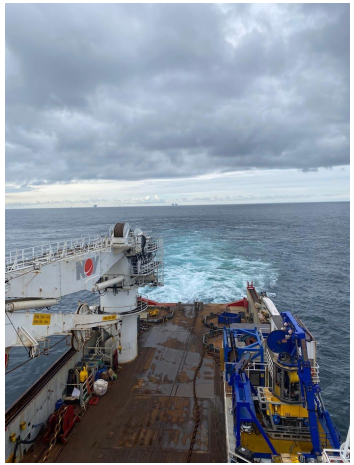


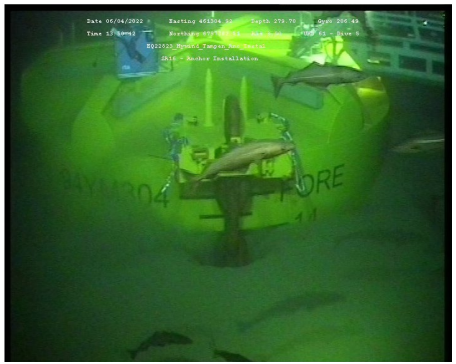
- 125 ton suction anchors
- Spiral strand wires
- Chain
- Connection elements
- In-line tensioner



Mooring Installation

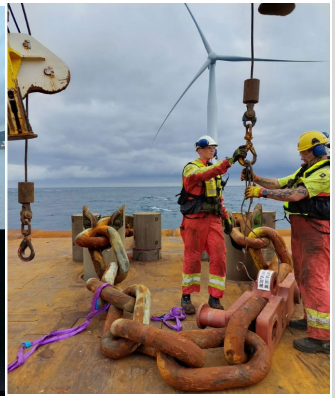


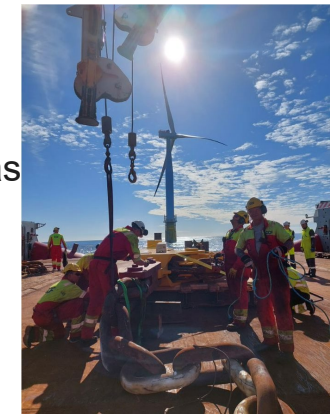


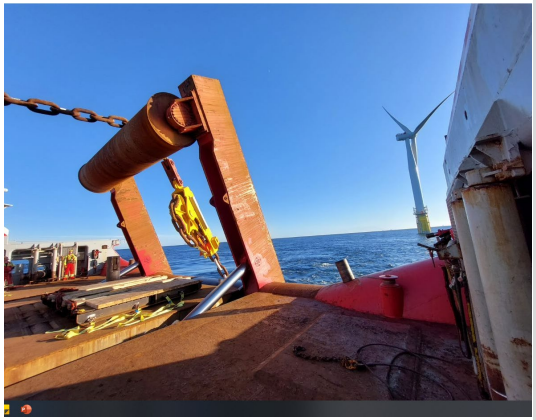


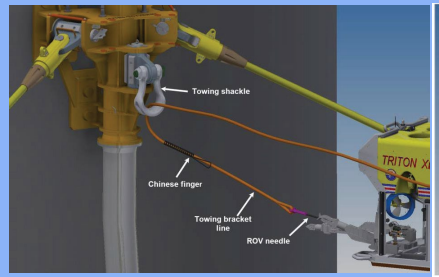
Tow out and hook-up

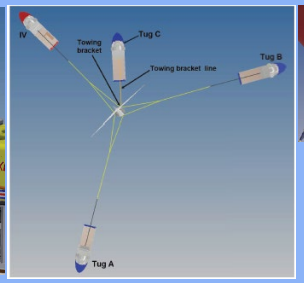
- Spread. 3 towing and 1 installation vessel.
- Skandi Iceman «a-frame» used for In-Line Tensioner installation. ILT launch. working well
- Hook-up operations combining several vessels with system under tension. Not ideal, time consuming and fragile method. Substructure fabrication, installation, operation and maintenance should get more focus when designing the mooring system
- Soil and water depth will vary but within some areas there should be optimalisations. Oil&Gas are one off, robust but expensive
- Hook-up and installation time has to come down. 60 days for 7 turbines. (logistics, weather and method)

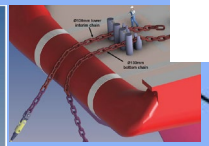


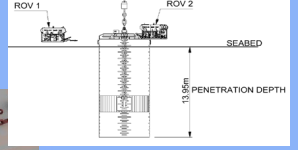


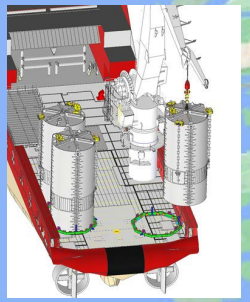


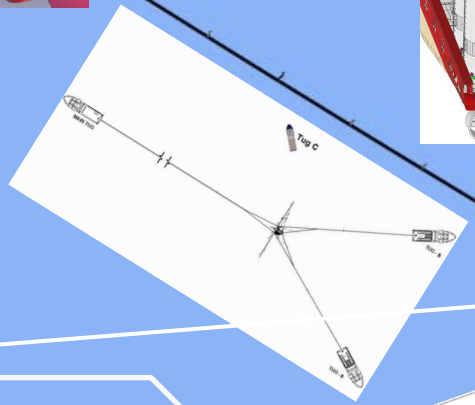


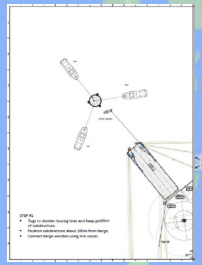


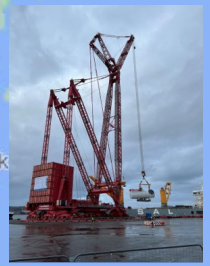


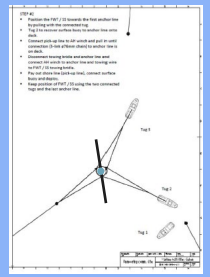


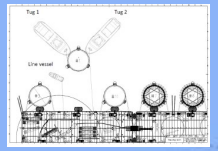












Baltasound
Mid Yell
Sumburgh
Sandane
Førde
Bergen
Straume
Radal
200,00 kr

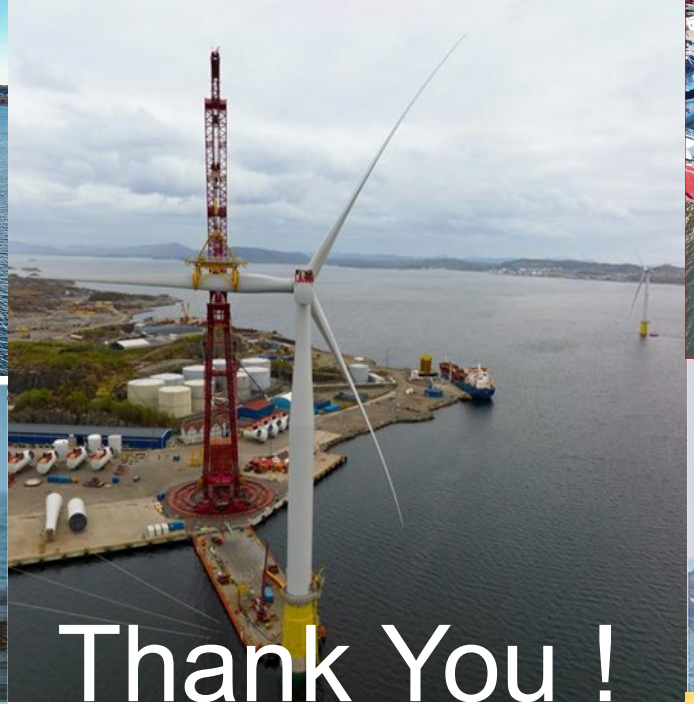
Some of the key lessons learnt

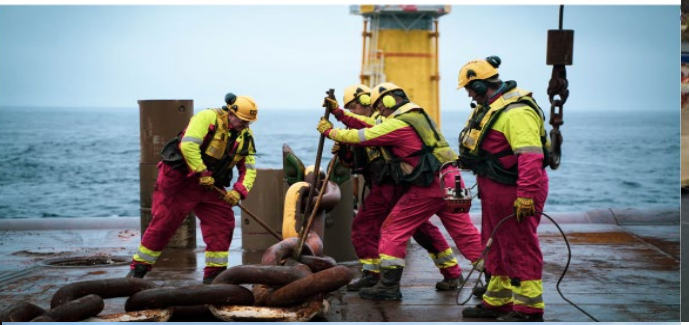
- **Industrial Partnerships** built on complementary competence, capability & capacities
- **Early engagement** of key suppliers. Studies and FEED agreements to mature the solution(s) with the key suppliers is a good investment.
- **Factory mind set**. An offshore floating wind farm is not a “one off tailor made production unit” for O&G. Make sure that the contractors understand the dependency of each other. A delay in the factory process one place could have large consequences further down in the production cycle. Build robustness/slack and independencies between activities in your execution plan
- **Contracting execution models** to promote **collaboration spirit** focused on joint productivity, but also need to ensure robustness and slack in dependencies between key activities
- **OIM vs foundation** & mooring system **in-place analysis**. Took long time to agree “**one system model**”. This delayed design and procurement activities for the mooring system
- **People & Competence** are key for success.
- **Oil & Gas Experiences is very useful especially HSE culture,** but focus on simplification, cost reduction, efficiencies and reliable solutions are key due to the project scale & complexity

Some of the key lessons learnt

- **The number & type of AHTs** was under-estimated for offshore tow-out & hook up. If you have 35 turbines to install (~500MW) and tow out 1 turbine/week you need more than 8 months to complete. In addition, you need to install the mooring system & the inter-array cables. Therefore, you need a year to complete (or 2 annual seasons). When selecting your marine spread make sure this is carefully considered
- **Mooring line system was complex**. Future solutions should be based on use of less chain and wire and more fiber lines. In-line tensioner for 3rd mooring line should be best practice
- **More specialized vessels**, have to be developed once we have sufficient experience. Long term contracts for vessels will be and advantage for all
- **Unforeseen changes** will come and make a major impact on projects. Examples from Hywind fuel price, tax regime, Covid and the Ukraine war created supply chain constraints
- **With mooring campaigns** over 4 months, we had vessel breakdowns 3 times requiring replacement vessels at a time when the market was very busy
- **We need more predictability on future project** to preserve and develop the competence required to deal with the massive increase of projects that is indicated to be ahead of us
- **For a 500MW wind farm** (30+ turbines) an estimated 1000 AHT & 300 CSV days will be required

Collaboration & competent people were the most critical success factors





Thank You !