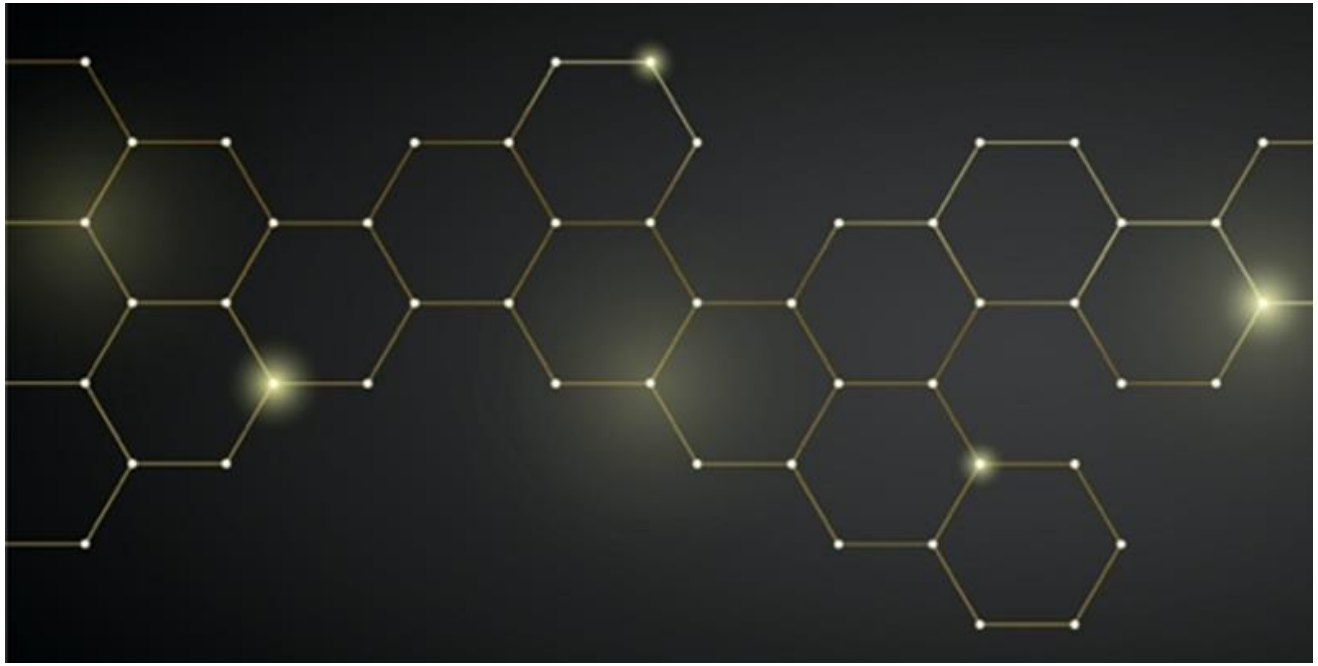
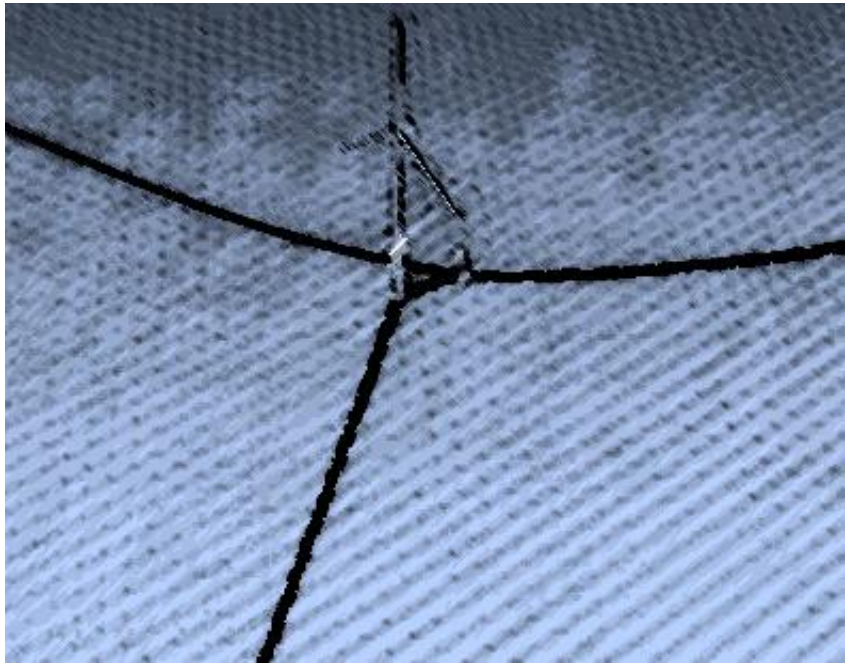




Analysis of Honeymooring™ as a cost-reducing concept for Floating Offshore Wind Turbines

EERA DeepWind Conference, 19-21 January, 2022

Finn-Christian Wickmann Hanssen, Mohd Atif Siddiqui, Niklas Norman, Arnt Fredriksen, Thor Valsø-Jørgensen

SE MAR

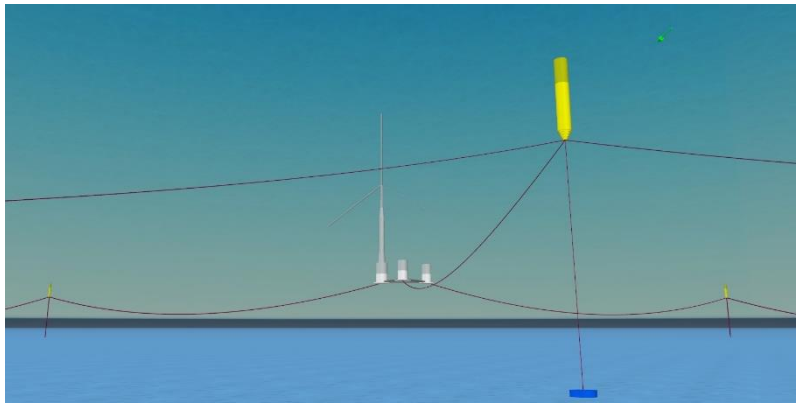
Introducing the Honeymooring™ concept

Honeymooring™ is:

- Sharing of anchors in a floating wind farm using buoys and synthetic fibre ropes
- Applicable for most FOWTs
- Can also be applied for other types of array-moored floaters (such as floating solar parks)

Key benefits compared to traditional system:

- Reduced cost
- Reduced mooring line loads
- Reduced environmental impact
- Easier marine operations
- Scalable for a wide range of water depths

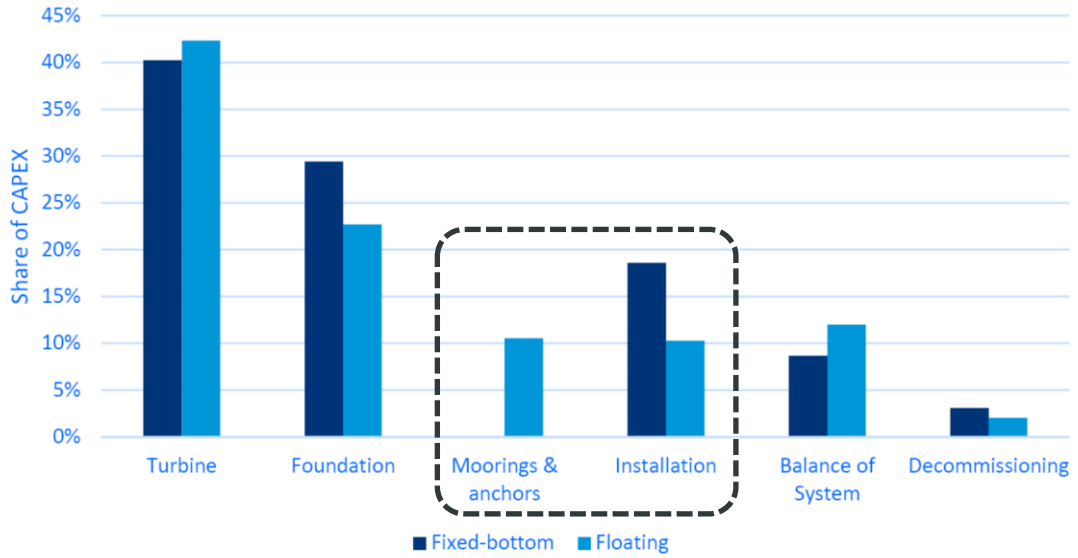


Cost and environment considerations

Cost contributors for floating wind turbines*:

- **CAPEX** – 70-80% of total cost
  - Mooring & installation ~20%**
- **OPEX** – 20-30% of total cost
- **Decommissioning** – 1-3% of total cost

*Maienza, C., et al. "A life cycle cost model for floating offshore wind farms." Applied Energy (2020)



**Carbon Trust - Floating Offshore Wind: Market and Technology Review Prepared for the Scottish Government (2015)

Honeymooring™ reduces CAPEX*:**

- Cheaper, lighter mooring lines
- Low pretension levels = Less costly installation vessels

Honeymooring™ likely reduces OPEX*:**

- Low mooring tensions reduce structural component loads
- Simple disconnection/reconnection of single FWT for inshore repair/maintenance

***Compared to traditional catenary or hybrid-type mooring systems

Honeymooring™ reduces LCOE for floating wind farms

Better environmental footprint for fibre ropes than for chains

No mooring lines interacting with the seabed

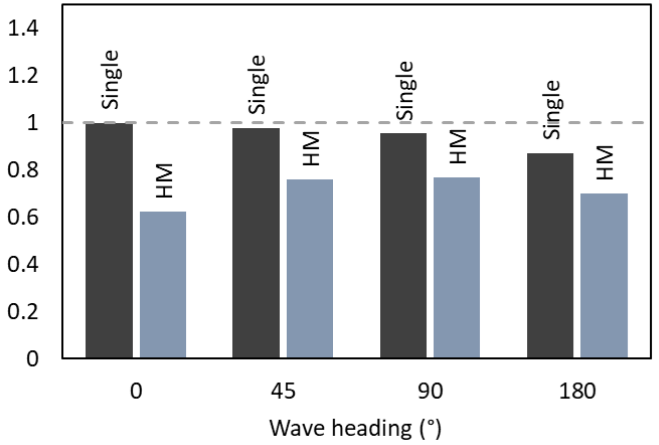
Honeymooring™ is an environment-friendly mooring solution

SE MAR

Preliminary analysis results for simplified model

- Water depth 300 m
- H_s = 8.5 m, T_p = 12 s, wind speed of 12 m/s
- Collinear wind and waves
- Simplified wind turbine modelling

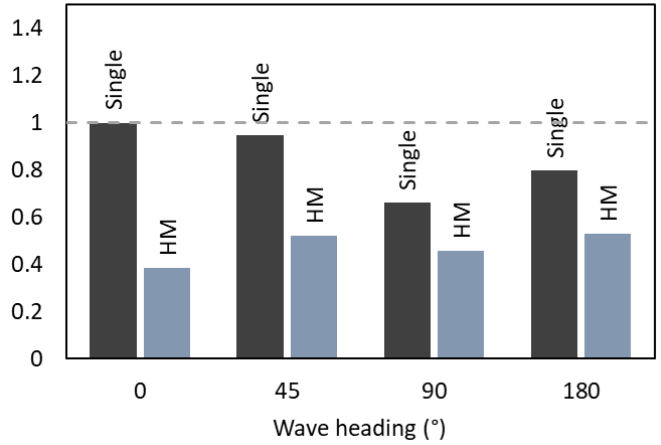
Maximum line tensions*



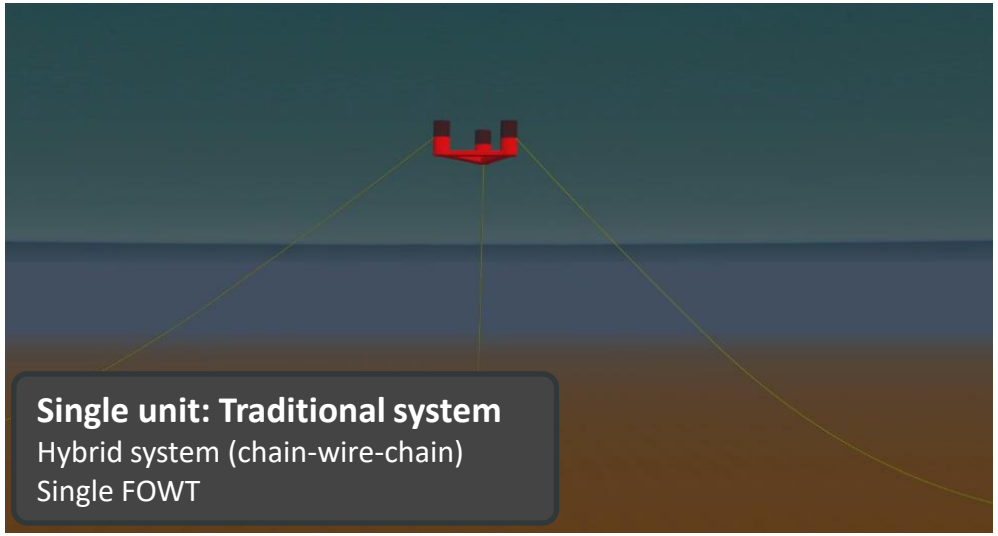
Reduced maximum tensions experienced by floater

* HM: Loads in horizontal lines

St. dev. line tensions



Significantly reduced fatigue loads



Challenges in design of shared moorings

Examples of applicable standards:

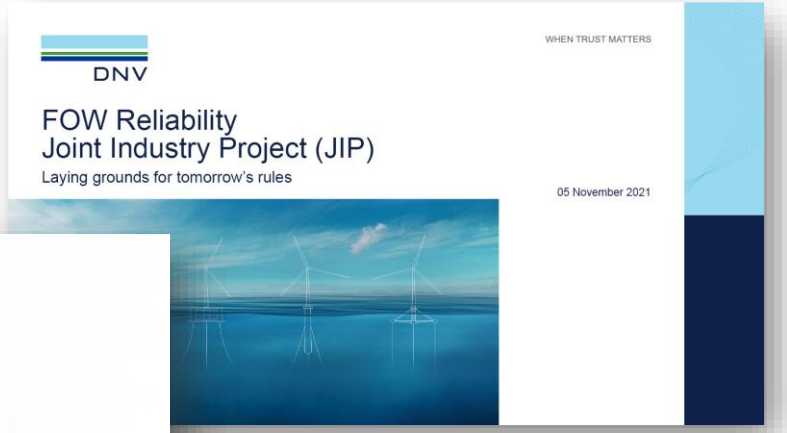
- IEC61400-3-2 Design requirements for floating offshore wind turbines
- DNVGL-ST-0119 Floating wind turbine structures
- DNVGL-OS-E301 Position mooring

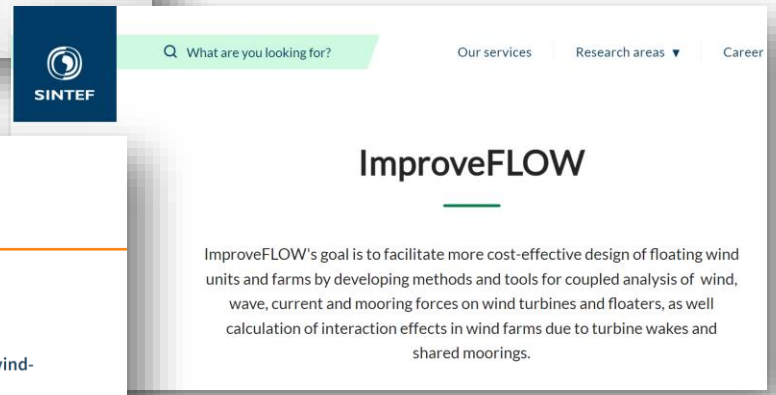
Challenges in existing standards:

- Mainly made considering single units
- Redundancy requirements & consequence class for shared moorings
- Interaction effects between turbines missing
- Calibrated safety factors for shared moorings

Challenges in numerical analysis:

- Interaction effects between turbines
  - How to model?
  - How important are they for mooring loads?
- Relevant failure scenarios (ALS cases)
- How to simplify computationally heavy models?
  - Representing wind field over large area
  - Modelling turbine controller





SE MAR

Ongoing activity and way forward

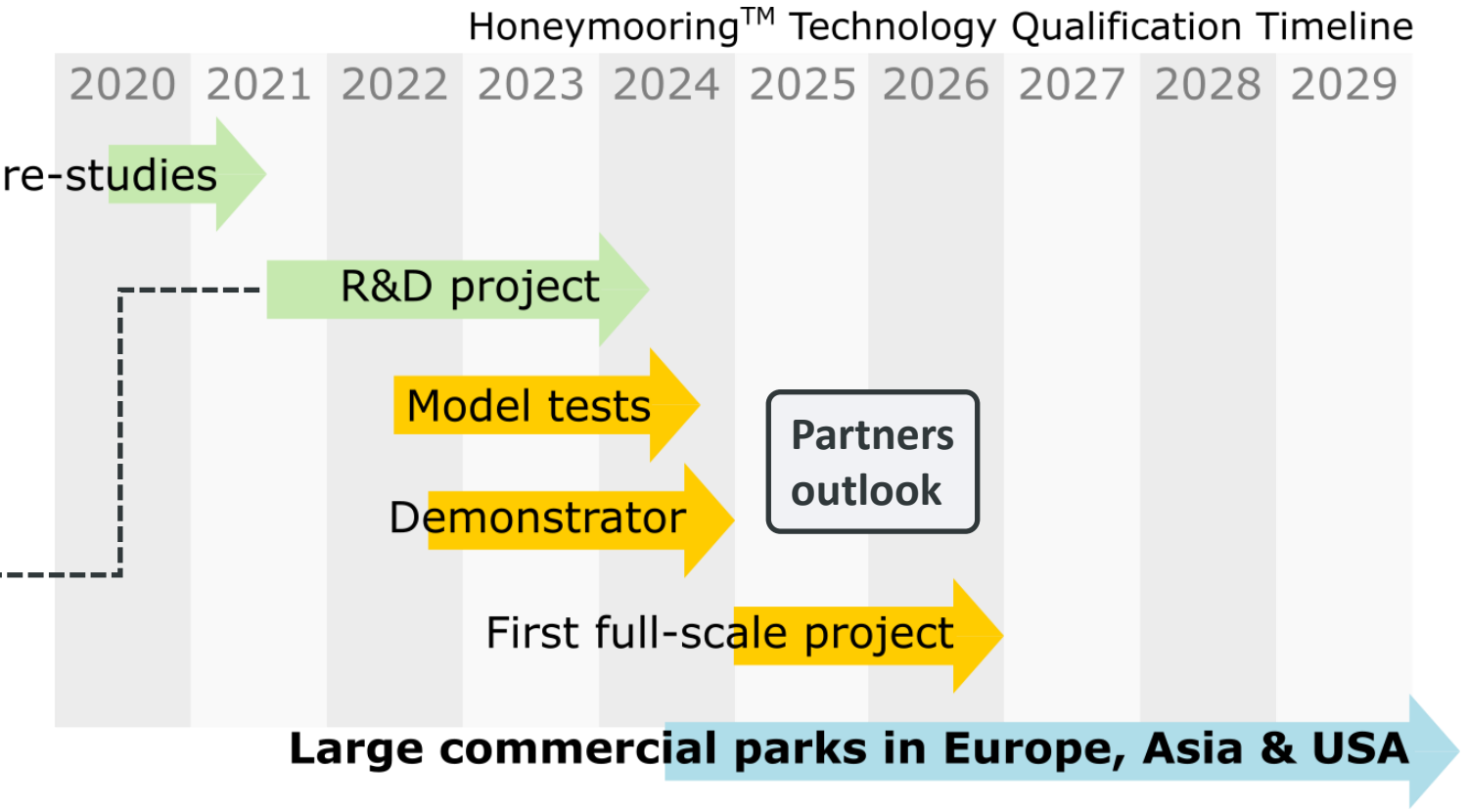
Pre-studies (2020 - 21):
- Validated substantial cost-reduction potential
- Demonstrated high-level technical feasibility

TotalEnergies equinor Innovasjon Norge

R&D project (2021 - 24):
- Research Council of Norway IPN scheme
- Developing coupled analysis methodology
- Design optimization
- Investigation of suitable power-cable solution

TotalEnergies equinor SINTEF

Norcable Forskningsrådet



Goal: **Have Honeymooring™ qualified and ready for use in commercial projects in 2025**

SE MAR

Thank you for the attention!

Contact: finn.hanssen@semar.no