MARIN BYGGTEKNIKKDAGEN APRIL 2018

# OFFSHORE FLOATING WIND TURBINES

OO Star Wind Floater

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**Dr. techn. Olav Olsen AS**

# OFFSHORE FLOATING WIND TURBINES

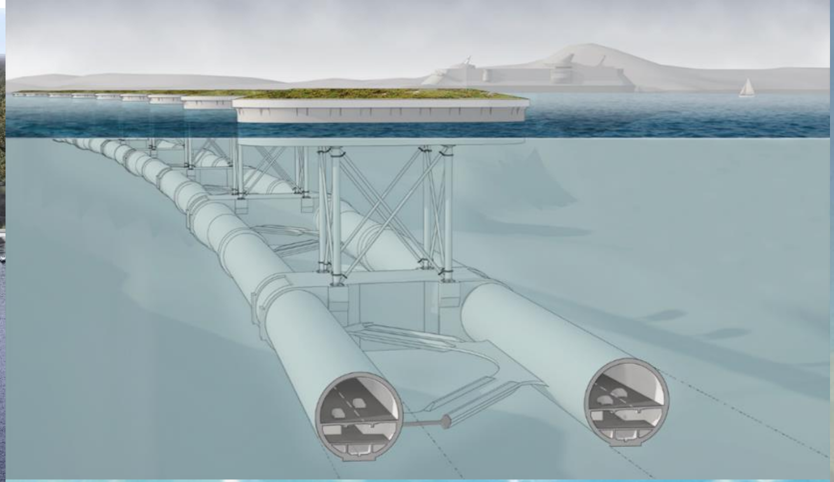


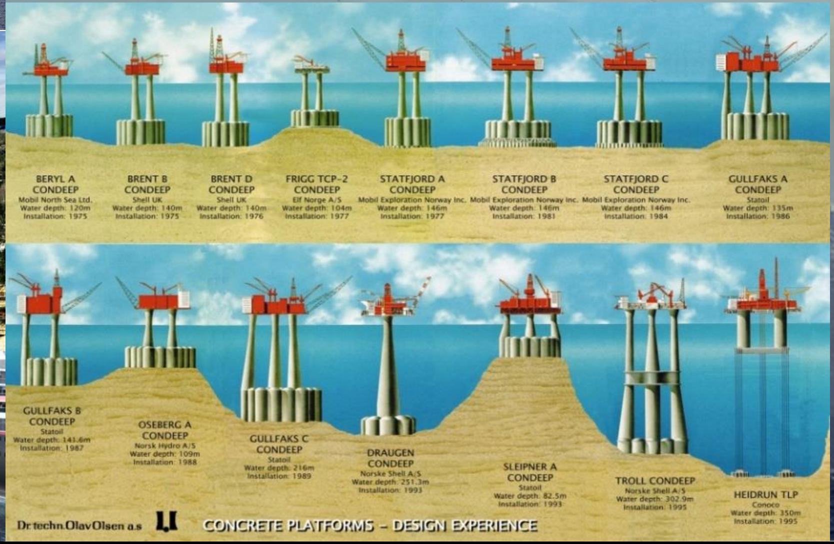
Contents:

# COMPANY PRESENTATION

# DR.TECHN. OLAV OLSEN – COMPANY PROFILE

- Independent structural and marine consulting company founded in 1962
- Offices in Oslo and Trondheim
- Approximately 90 employees
- Contributes in all project phases, from concept development to decommissioning
- Active in research and development projects

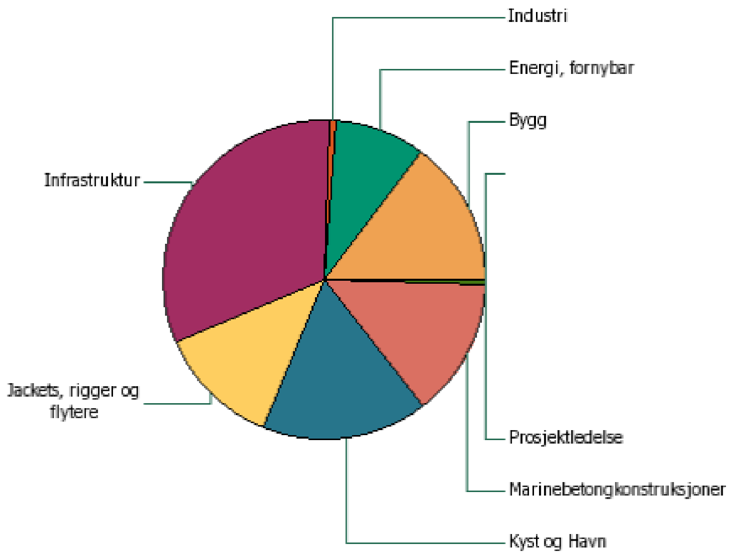



BERYL A CONDEEP
Mobil North Sea Ltd.
Water depth: 120m
Installation: 1975
BRENT B CONDEEP
Shell UK
Water depth: 140m
Installation: 1975
BRENT D CONDEEP
Shell UK
Water depth: 140m
Installation: 1976
FRIGG TCP-2 CONDEEP
Elf Norge A/S
Water depth: 104m
Installation: 1977
STATFJORD A CONDEEP
Mobil Exploration Norway Inc.
Water depth: 146m
Installation: 1977
STATFJORD B CONDEEP
Mobil Exploration Norway Inc.
Water depth: 146m
Installation: 1981
STATFJORD C CONDEEP
Mobil Exploration Norway Inc.
Water depth: 146m
Installation: 1984
GULLFAKS A CONDEEP
Statoil
Water depth: 135m
Installation: 1986
GULLFAKS B CONDEEP
Statoil
Water depth: 141.6m
Installation: 1987
OSEBERG A CONDEEP
Norsk Hydro A/S
Water depth: 109m
Installation: 1988
GULLFAKS C CONDEEP
Statoil
Water depth: 216m
Installation: 1989
DRAUGEN CONDEEP
Norske Shell A/S
Water depth: 251.3m
Installation: 1993
SLEIPNER A CONDEEP
Statoil
Water depth: 82.5m
Installation: 1993
TROLL CONDEEP
Norske Shell A/S
Water depth: 302.9m
Installation: 1995
HEIDRUN TLP
Conoco
Water depth: 350m
Installation: 1995
Dr.techn.Olav Olsen a.s
CONCRETE PLATFORMS – DESIGN EXPERIENCE

# BUSINESS AREAS

- > Buildings
- > Offshore Oil & Gas
- > **Renewable energy**
- > Infrastructures
- > Harbours and Industry
- > OO «Futurum»

Core business: Structural & Marine engineering




Adding value to company and clients

# OLAV OLSEN – CAPABILITIES OFFSHORE WIND

> Substructures
- Bottom fixed and floating
- Steel and concrete
- Design and analysis (ShellDesign)
- Geotechnics

> Mooring and anchors
- System configuration
- System design
- Geotechnics

> Installation
- Method development
- Installation concepts

> Fully coupled simulations
- SIMA
- 3DFloat
- Deeplines
- (Orcaflex, Ashes, FEDEM Windpower)

> Cost models
- Fabrication and installation
  - Substructure
  - Mooring
  - Anchors

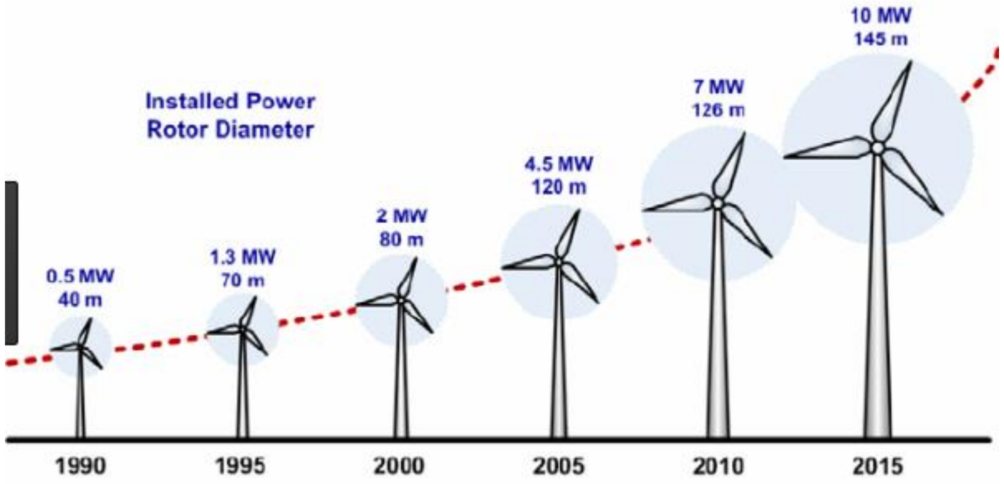
> Third party verification

# OFFSHORE WIND TURBINES

DR. TECHN.
OLAV OLSEN

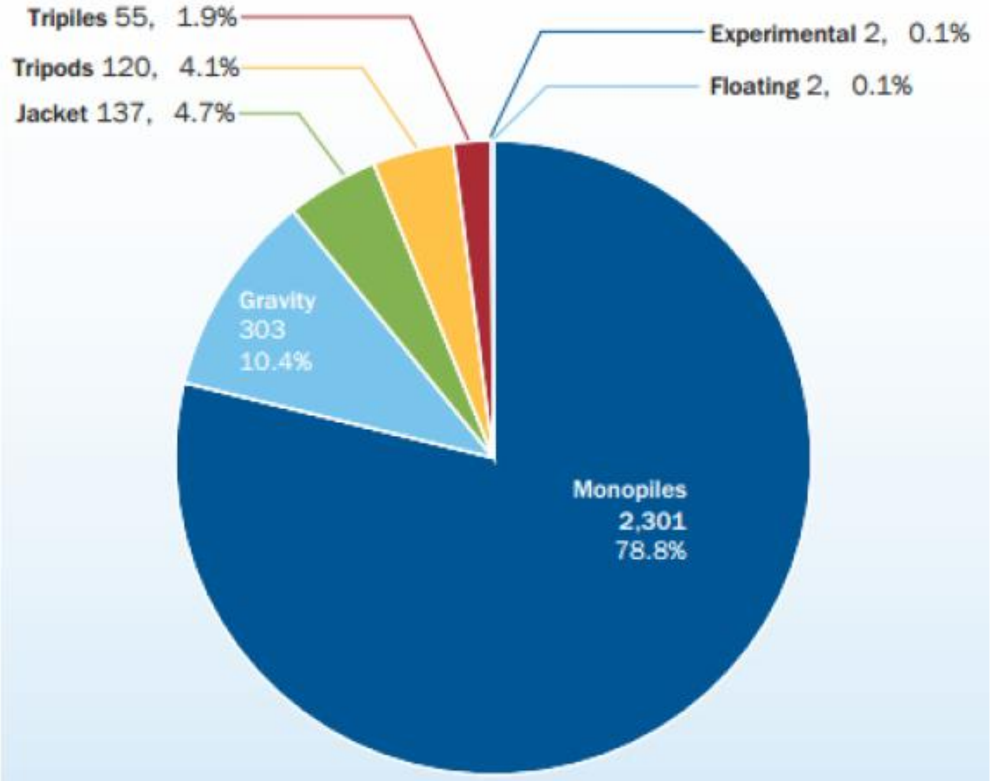
# OFFSHORE WIND – HISTORY AND STATUS

- First offshore wind farm – Vindeby 1991 (closed in 2016)
  - Waterdepth 4 m, 11 WTG 450 kW, concrete substructure (GBS)
- Todays wind turbine sizes about 6-8 MW, hub height 100-120 m
- Mostly monopiles, steel piles drived into seabed
- Todays monopiles – up to 8 m diameter and 1300 ton
- Competing bottom fixed substructures – jackets, tripods and GBS
- Bottom fixed wind farms is about to get industrialized and cost effective



# OFFSHORE WIND – HISTORY AND STATUS

- Special cases where monopiles are avoided:
  - Water depth > 50 m
  - Wind turbines > 10 MW
  - Bedrocks
  - Ice

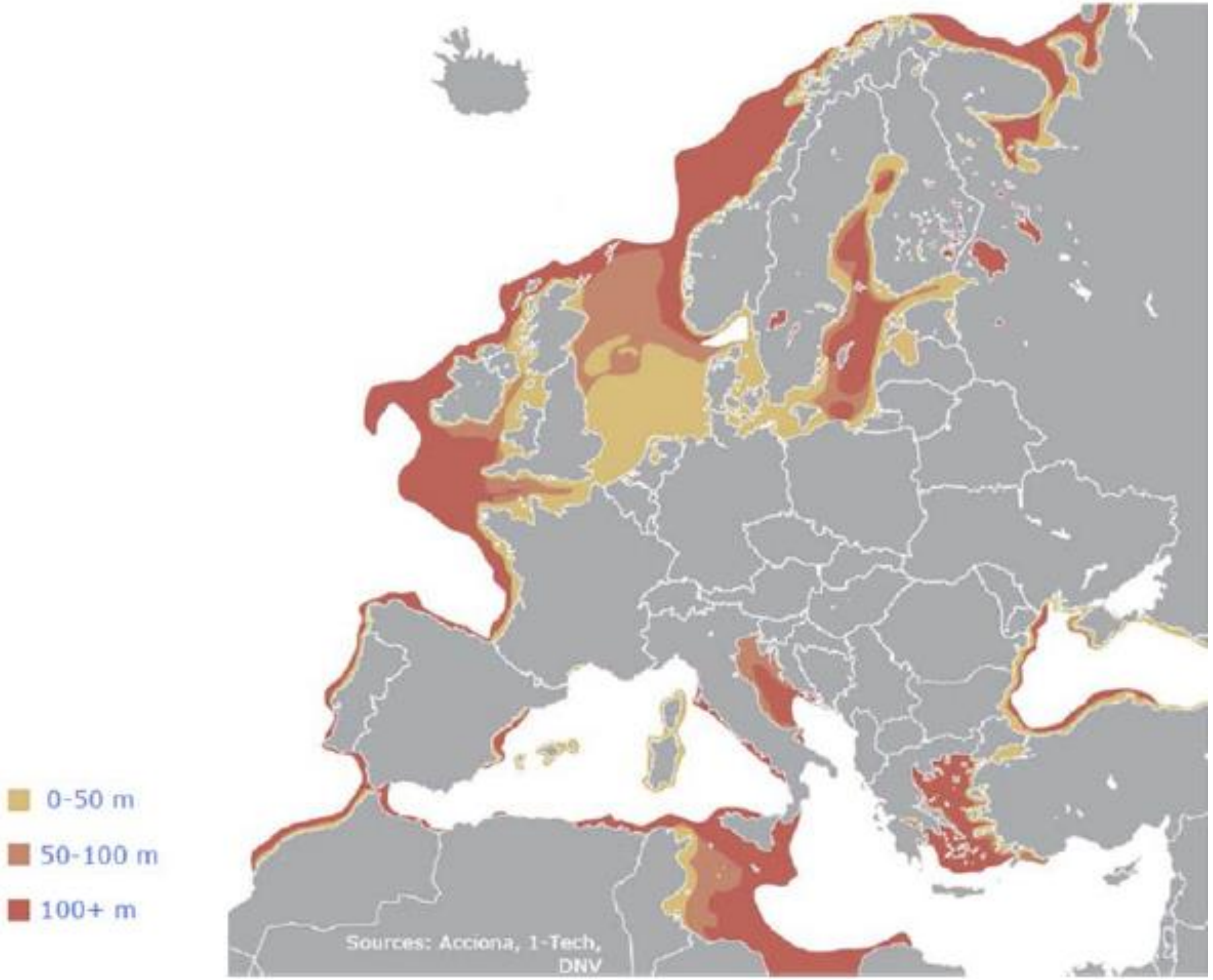



Source Carbon Trust 2015

# OFFSHORE WIND – HISTORY AND STATUS

- Floating solutions will eventually compete with bottom fixed
- First full scale floating wind turbine – Hywind Demo 2009 (2,3 MW)
- Full scale demos also installed in Portugal and Japan
- First floating demo wind farm – Hywind Scotland 2017
- Floating wind is entering the market, but is still at demo level

Figure 1.1.1.Sea depth around Europe (DNV-GL, 2014)

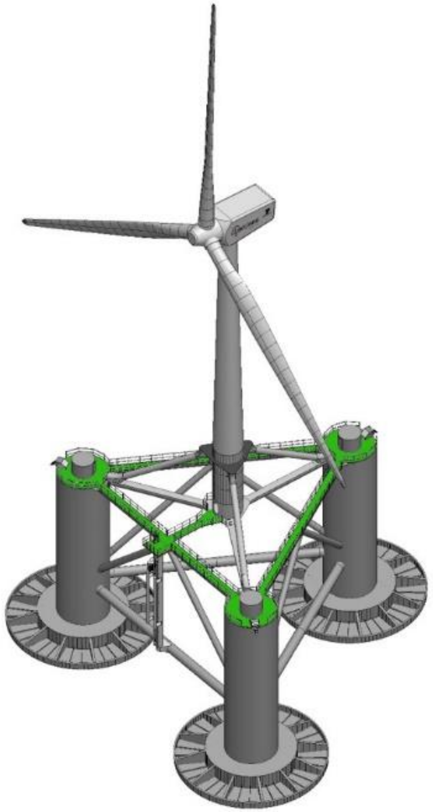


# OUTLOOK

- We believe that floating wind will beat onshore wind as well as bottom fixed offshore wind in the future
- We believe that in the future there will be three different segments within the wind industry:
  - **Onshore wind**; WTGs limited to typically **5 MW** due to transport and installation limitations on land
  - **Offshore wind, bottom fixed**; WTGs limited to typically **10 MW** due to installation cost
  - **Offshore wind, floating**; WTGs possibly **20 MW**, no size limitations related to assembly and installation

# FLOATING OFFSHORE WIND TURBINES

Hywind
Hydro/Statoil

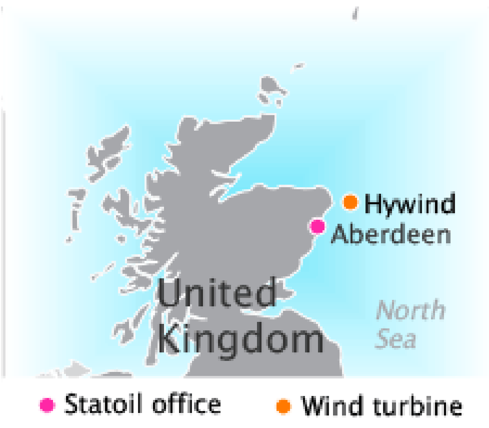


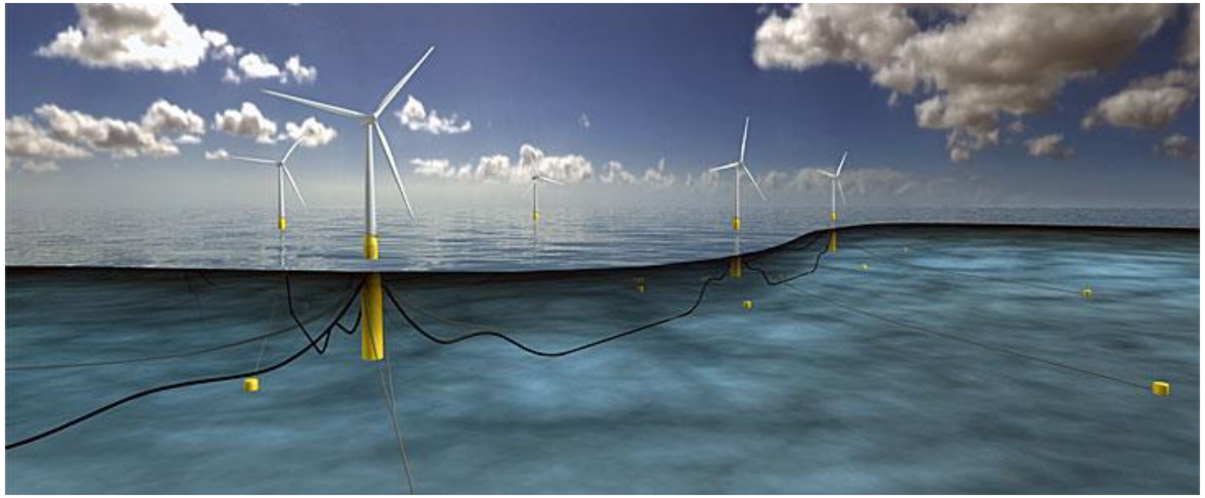
HiPRWind
EU project

OO Star Wind Floater
Patented concept

# HYWIND SCOTLAND PROJECT

- Demo park on the east coast of Scotland.
- Progression from Hywind DEMO.
- 5 units.
- 6 MW turbines.
- Construction start-up: Fall 2015
- Installed: Summer/Fall 2017
- Production started: October 2017



4C Offshore



HOME CONSULTANCY SUBSCRIPTIONS REPORTS OFFSHORE WIND TIDAL TRANSMISSION VES

News

# Hywind exceeds expectations

Thursday, 15 February 2018 · 0 comments · Windfarms · Statoil · Tom Russell

Image source: Øyvind Gravås / Woldcam - Statoil ASA

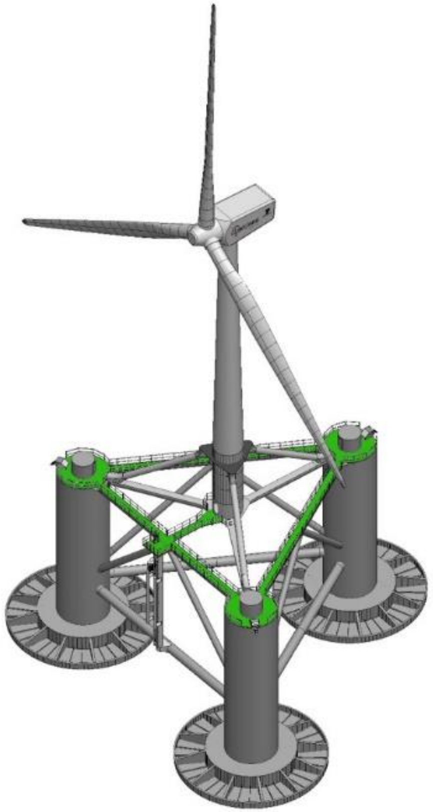
Despite one hurricane, one winter storm and wave heights of up to 8.2m, Hywind Scotland pilot park performed better than expected in its first three full months in production, according to project operators Statoil.

The 30MW wind farm is the world's first commercial floating wind farm and was commissioned last Autumn. It is located 25km offshore Peterhead in Aberdeenshire, Scotland.

During the winter, when the wind is at its strongest, the typical capacity factor for an bottom fixed offshore wind farm is 45-60%. A capacity factor of 100 % means all wind turbines have generated at maximum output every second of the day. Statoil stated that, Hywind Scotland achieved an average of approximately 65% during November, December and January.

# FLOATING OFFSHORE WIND TURBINES

Hywind
Hydro/Statoil



HiPRWind
EU project

OO Star Wind Floater
Patented concept

# OO STAR WIND FLOATER

# OO-STAR OFFSHORE WIND FLOATER (Patent)

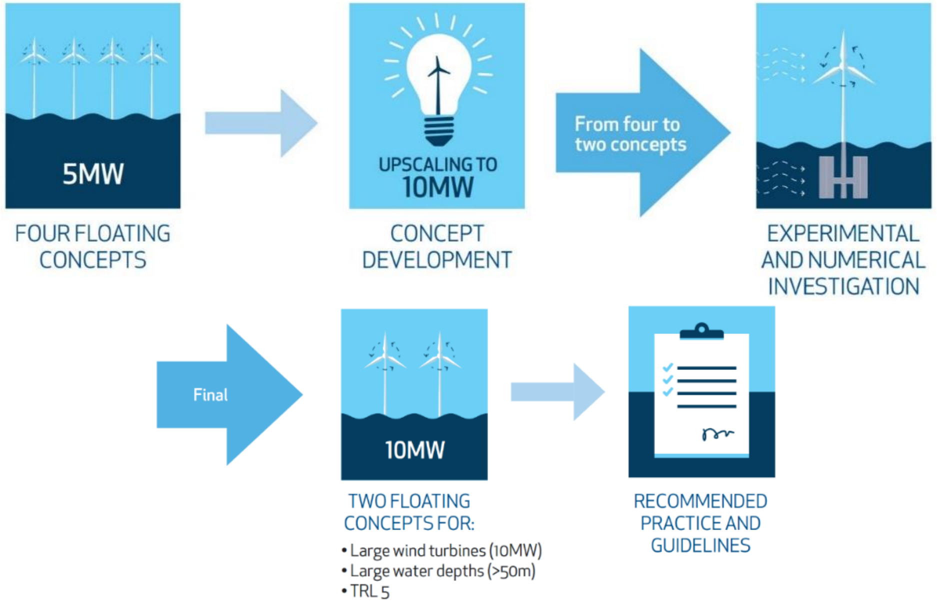
DR. TECHN. OLAV OLSEN

# OO-STAR WIND FLOATER – GENERAL DESCRIPTION

- The OO Star is a robust, stable and very simple semisubmersible floater
- Water depth potential from 50 m
- Concrete, steel or a combination (hybrid). Material selection according to optimal design, cost, fabrication facilities etc.
- The OO Star consists of a central shaft supporting the WTG, and a tri-star shaped pontoon supporting 3 buoyancy cylinders for optimal stability.
- The OO Star can be fabricated in a dock, on a barge or on a quay. The structure is well suited for modular fabrication.
- The full substructure can float with very small draft and the unit can be fully assembled at quay-side before tow to site. No requirements for deep waters.
- Transport to site by towing. No requirements for expensive heavy lifting offshore.

# HORIZON 2020 - LIFES 50+

- Horizon 2020 project, total budget 7.3 MEuro
- Project lead by SINTEF Ocean
- OO Star Wind Floater selected as one of two concepts for Phase 2 (model testing and further development)
- Project web page: [http://lifes50plus.eu/](http://lifes50plus.eu/)



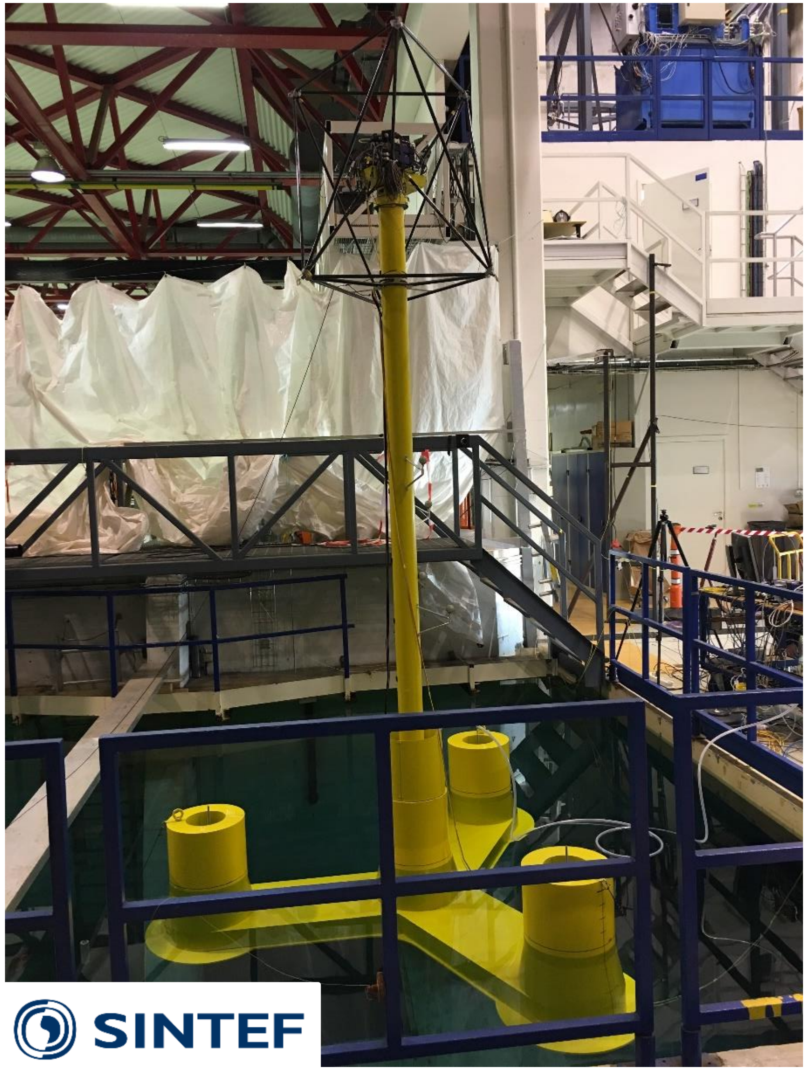


DR. TECHN. OLAV OLSEN

This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 640741

# LIFES 50+ MODEL TESTS

- Model tests in Phase 2:
  - Ocean Basin at SINTEF Ocean, November 2017 (Scale 1:36)
  - Wind tunnel at Polimi, Spring 2018 (Scale 1:75)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This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 640741

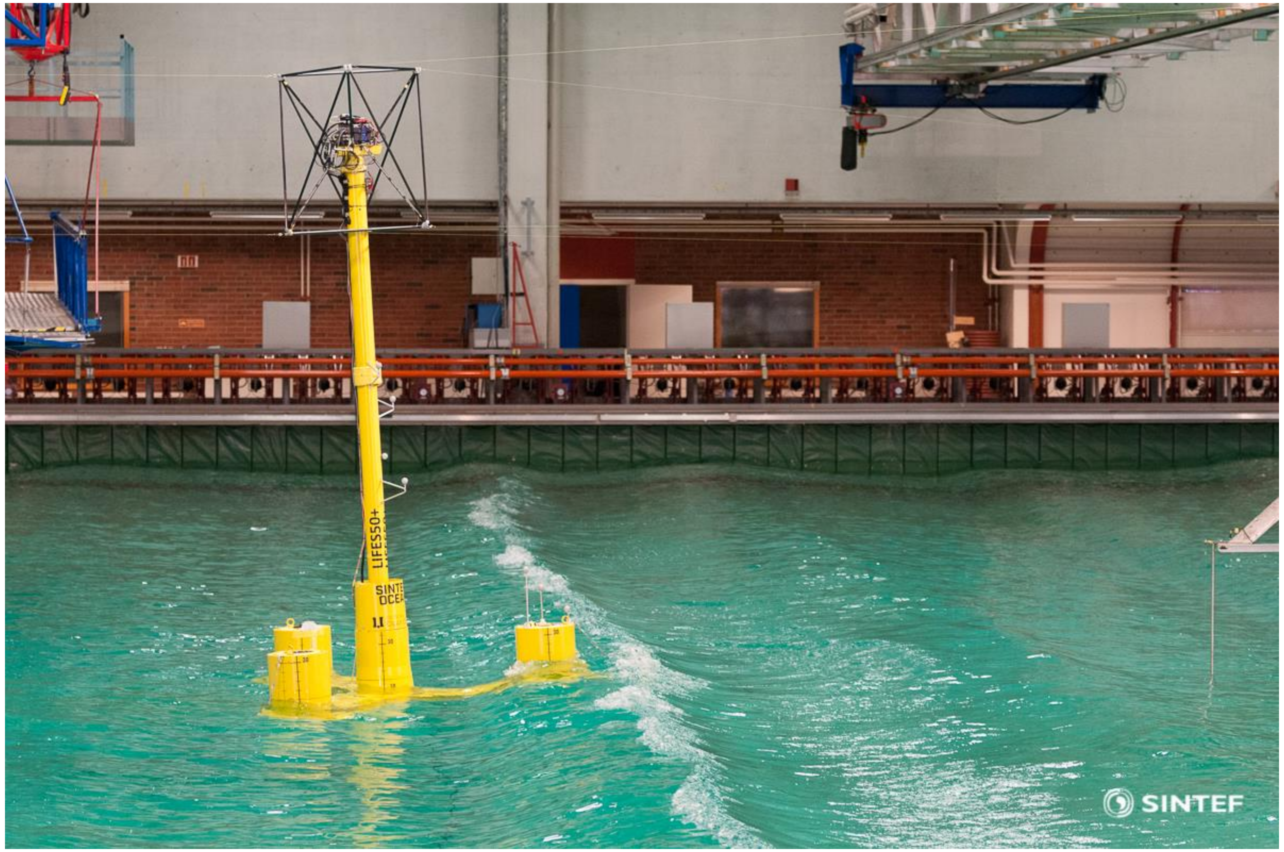
# OCEAN BASIN AT SINTEF OCEAN

> Real-time hybrid model testing

> Physical waves and current

> Rotor loads are included by real-time aero simulation

> Communication between physical model and aero simulation in real-time

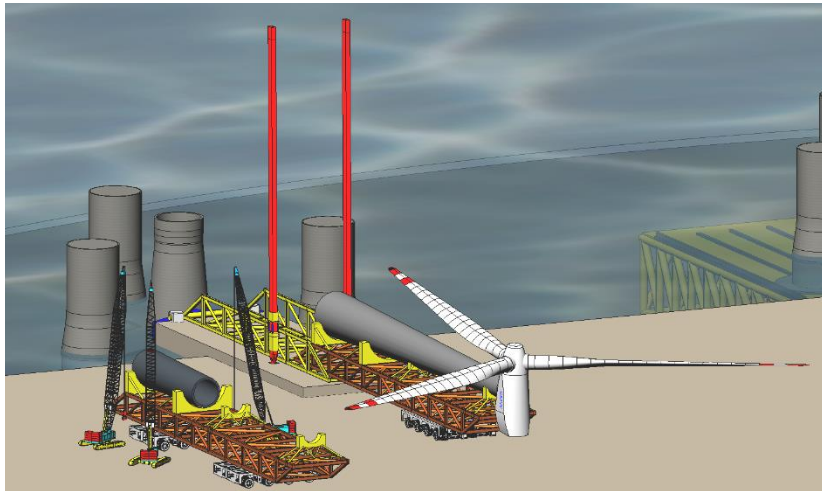


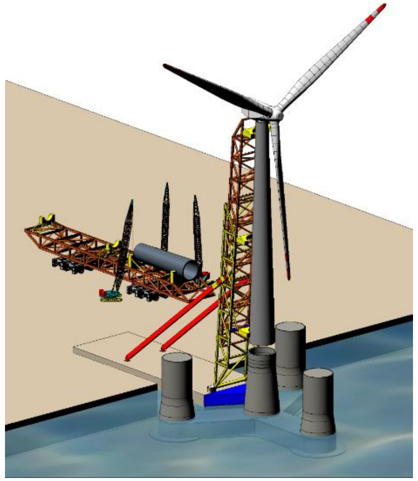
# VIDEO – MODEL TEST

- https://www.youtube.com/watch?v=l3gQeD_rVe8

# FLOATING WIND – KEY ADVANTAGES

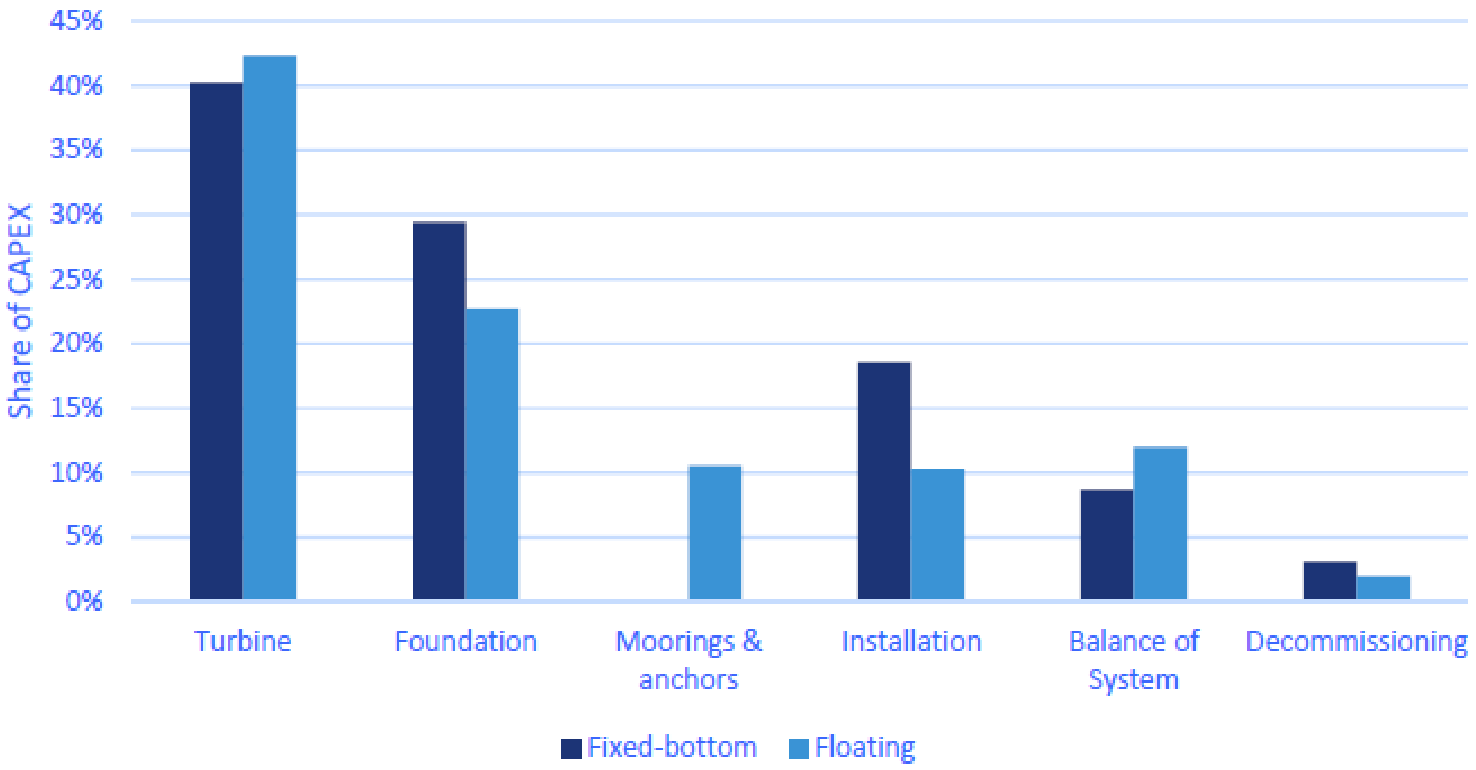
- Floating wind has larger energy potential than bottom fixed.
- In some areas floating wind is the only way to go. This will ensure development of a floating market.
- Floating substructures have higher potential for standardization than bottom fixed (not very sensitive to water depth and soil conditions). Efficient and cost effective mass fabrication of substructures
- Shallow draft floaters - Quayside assembly and testing prior to tow out
- Installations without offshore heavy lift – tow to site
- Simple removal – reverse installation
- Potential for efficient supply chain and significant cost reductions
- Potential for reuse – 2nd hand value of floater will reduce energy cost





# FLOATING WIND – CHALLANGES

- The main and overall challange is to reduce cost of energy – cannot rely on subsidies in the future




Source Carbon Trust 2015

# RESEARCH PROJECT – INNOVATIVE MOORING SYSTEMS

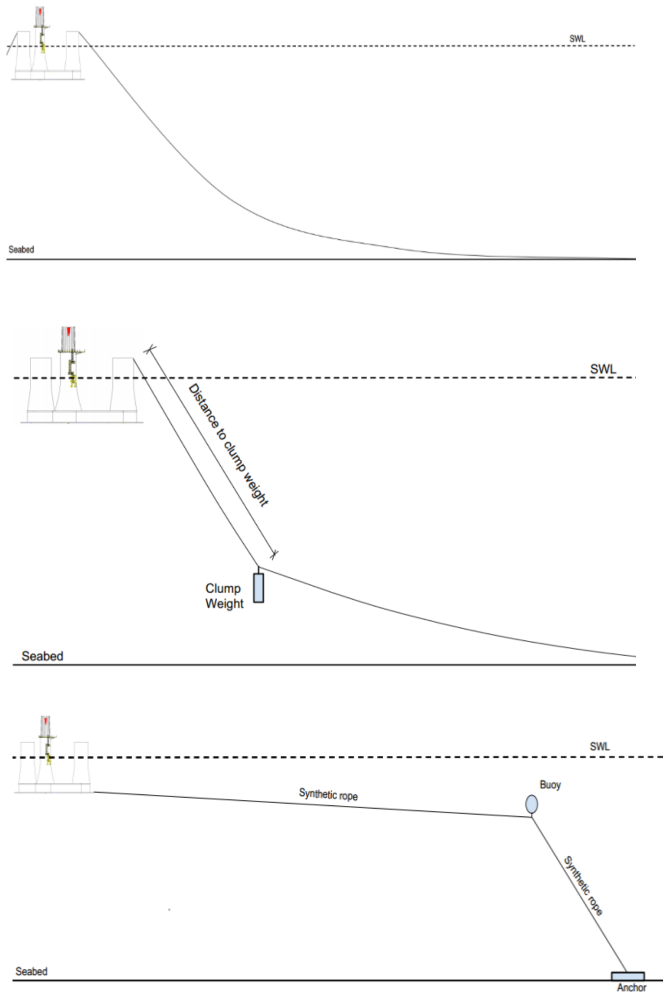
> Based on OO Star Wind Floater

> Scope: Shallow Water Mooring Systems

> Duration 1.5 years

> Partners: Olav Olsen, IFE, Statoil, Rolls Royce, Vicinay, OTS, Aibel, Servi

> External advisors: DNV-GL, NGI, FMGC



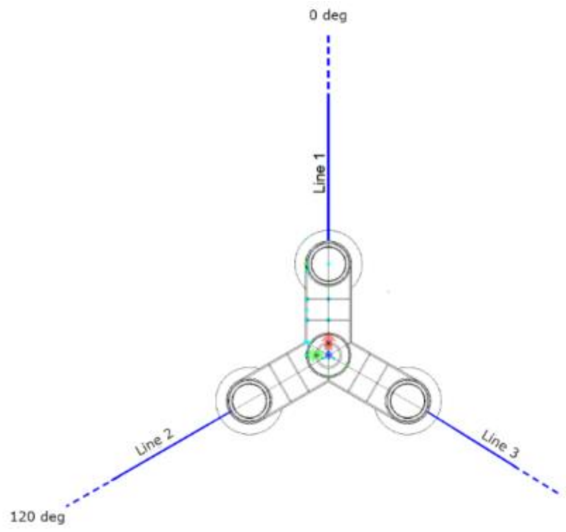
# INNOVATIVE MOORING SYSTEMS

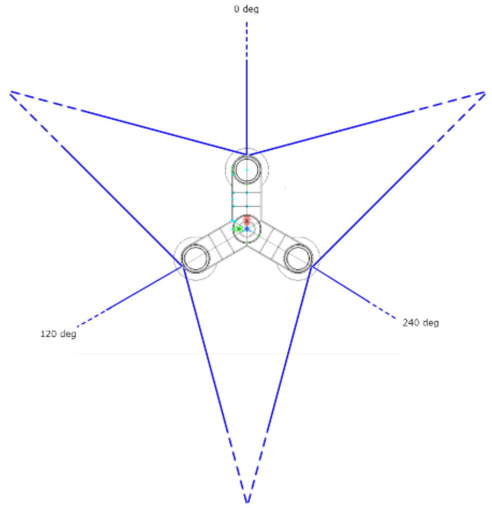
## CHALLENGES

> Shallow water systems – ULS and FLS loads, high stiffness
> Interaction with cables – allowable offsets

## VARIABLES

> Mooring line types – Chain, steel wire, fibre ropes
> Configurations, buoyancy, clump weights
> Redundancy – no. of mooring lines
> Anchor types and possible sharing of anchors



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