

DR.TECHN. OLAV OLSEN AS

DESIGN OF CONCRETE FOUNDATION FOR WAVE POWER PLANT

Marin Byggeteknikkdagen 10. april 2025

Martin Rypestøl

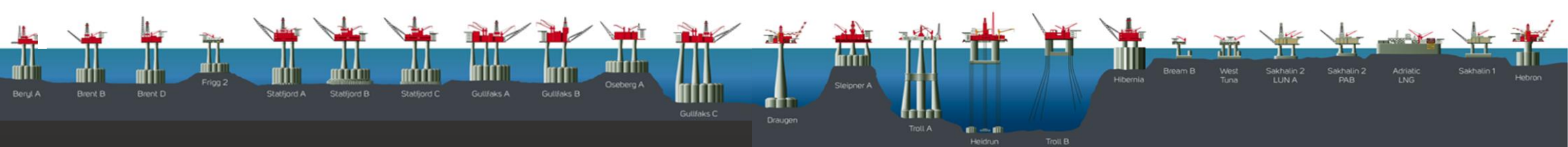
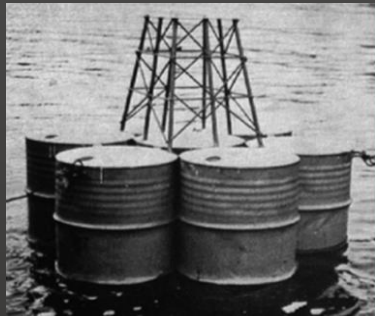
Dr.techn. Olav Olsen AS

OUR HISTORY

- Founded 1962 by Dr.techn. Olav Olsen
- From October 2020 part of Artelia Group
- 160 employees (Artelia Group 9800 employees worldwide)
- Main office at Lysaker
- Regional office in Trondheim, Bergen and Ålesund
- Consultancy services spanning Structural Engineering, Maritime engineering, Geotechnics, Environmental studies, Hydrology, and HVAC/Utilities
- Actively engaged in R&D projects

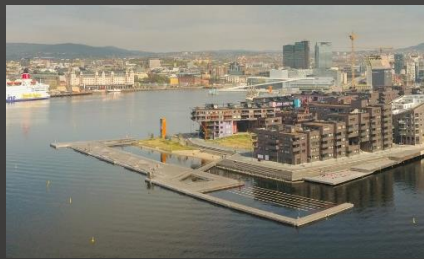
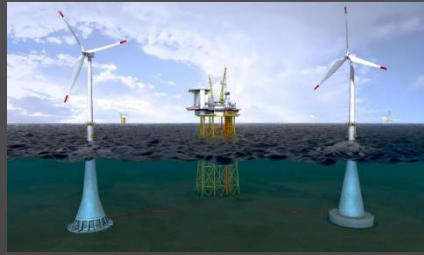


Marine Structures for Oil & Gas during 50 years



World-leading competence in design of marine concrete structures

New focus - Marine structures in concrete and steel



- Foundations for offshore wind
 - OO-Star Wind Floater (concept acquired by Bouygues TP)
 - Hywind (concept by Equinor)
 - GBS structures
 - Jacket structures
- Wave power foundations
- Quays and coastal structures
- Aquaculture
- Bridges

CONTENTS

Wave Energy

- Theory and energy mix
- Wave energy converters (WECs)

About WaveRoller

- How the Wave Energy Converter (WEC) works
- Surge Phenomenon
- Environment
- Project History

ONDEP

- Project specifics
- Dr.techn. Olav Olsen involvement
- Levelized cost of energy (LCOE)



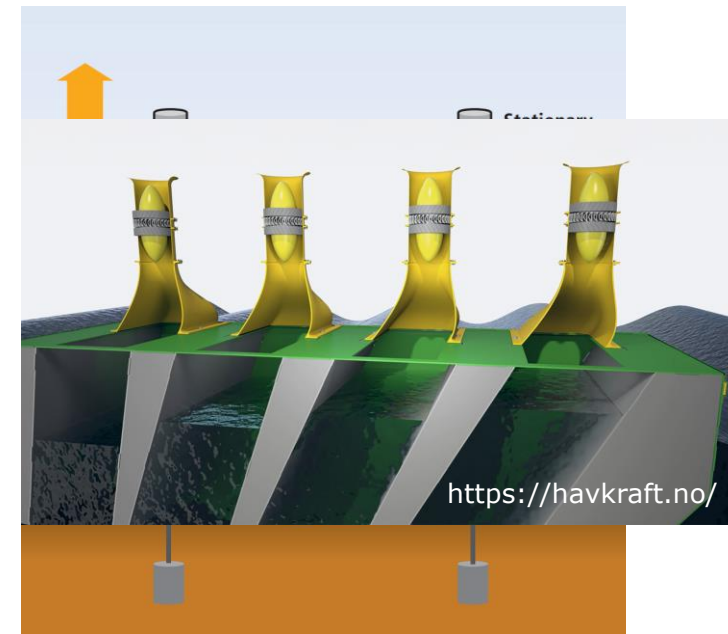
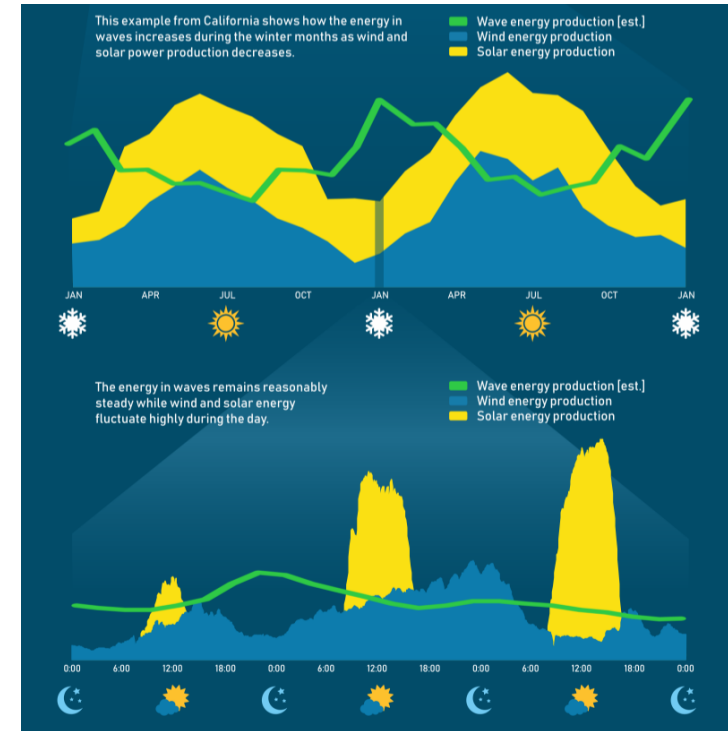
WAVE ENERGY

> Theory and energy mix

- Wave energy – the largest untapped energy source in the world
- Wave energy has positive correlation
 - Larger waves during winter
 - Electricity prices often higher during winter
- No clear day-night pattern
 - Compared to solar energy
- Energy in ocean waves accumulated from wind blowing across surface over large distances
 - Energy content more concentrated
 - Changes slowly and less variations compared to wind and solar
 - Provides more predictable production

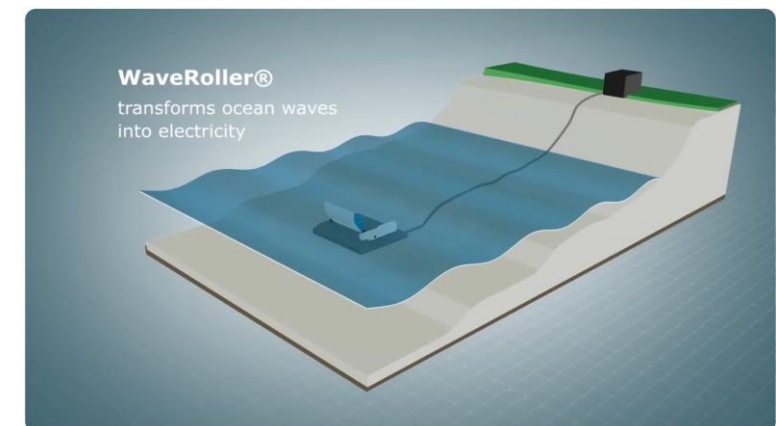
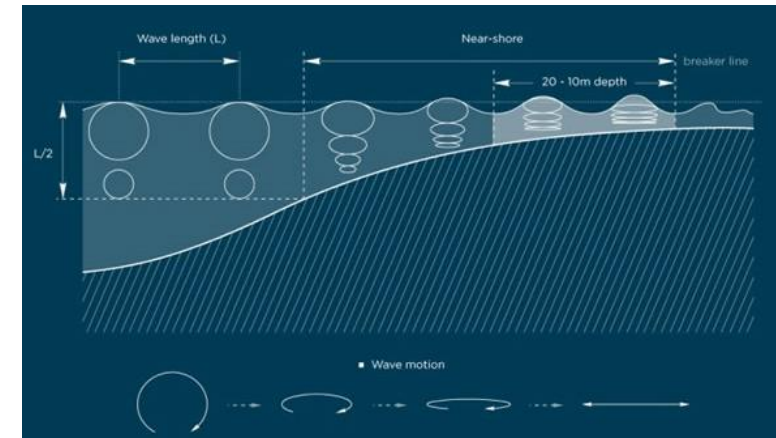
> Wave energy converters

- Point absorber
- Oscillating wave surge converter
- Oscillating water column



WAVEROLLER

- > Technology developed by AW-Energy (AWE)
 - Convert ocean wave energy to electricity
 - Deployed in near-shore areas (0.3-2km from the shore)
 - Water depths 8-20m
 - Rated capacity 350-1000kW for a single unit
- > Surge phenomenon
 - Circular motion of water particles in deep water
 - “Shoaling” as they approach shore and interfere with seabed
 - Particle motion elongates to horizontal elliptic motion
 - Amplify horizontal movement in near-shore areas
 - Strong surge zone optimal for WaveRoller
- > Oscillating flap absorbing energy from waves
 - Hydraulic piston pumps
 - High-pressure fluid connected to hydraulic motor
 - Hydraulic motor drives electricity generator
 - Connected to electrical grid by subsea cable



WAVEROLLER

> Project history

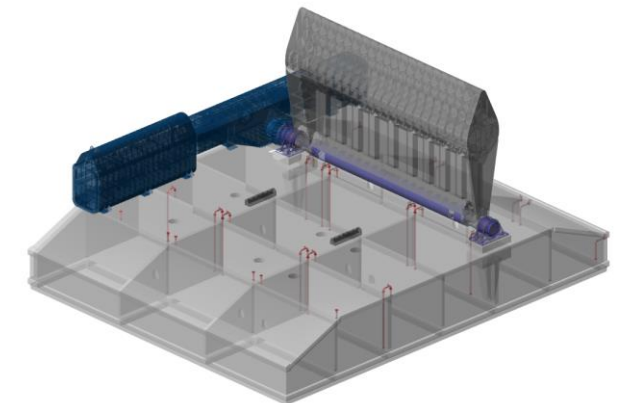
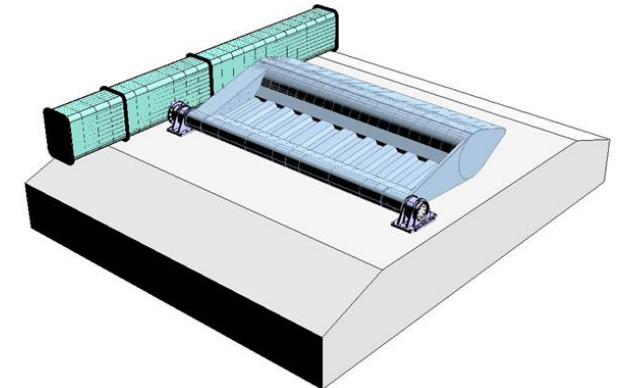
- Steel foundation – Prototype Peniche 2012 (Surge)
- Concrete Barge Foundation (Surge 2)
 - Olav Olsen designed concrete foundation for WaveRoller
 - Concept to detail design (2015-2017)

> Advantages of concrete against steel:

- Longer design life (>50 years possible for concrete barge)
- Simple construction technique
- Local fabrication – also in developing countries
- Simple installation, air compression and valves only
- Robustness related to geotechnical stability
- Robustness related to loads



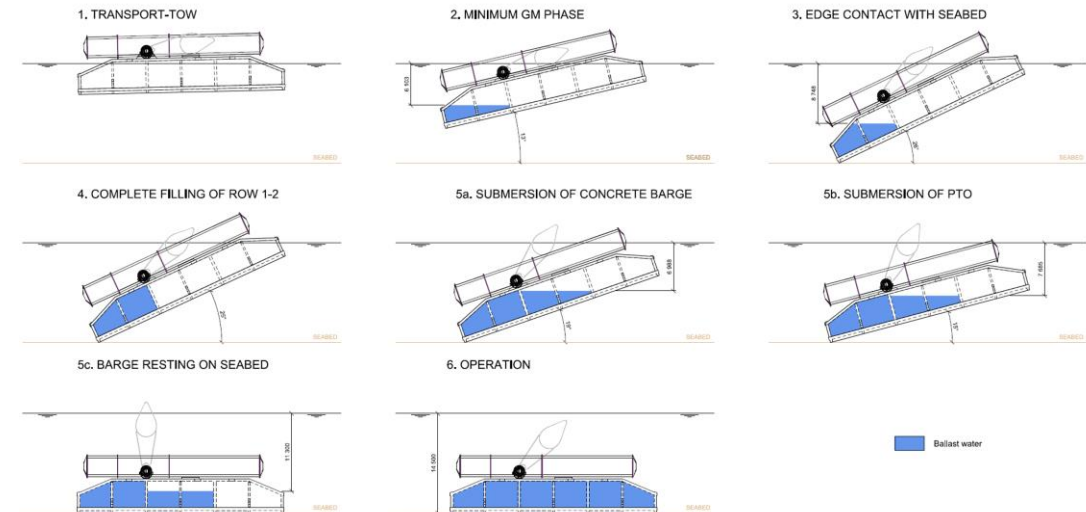
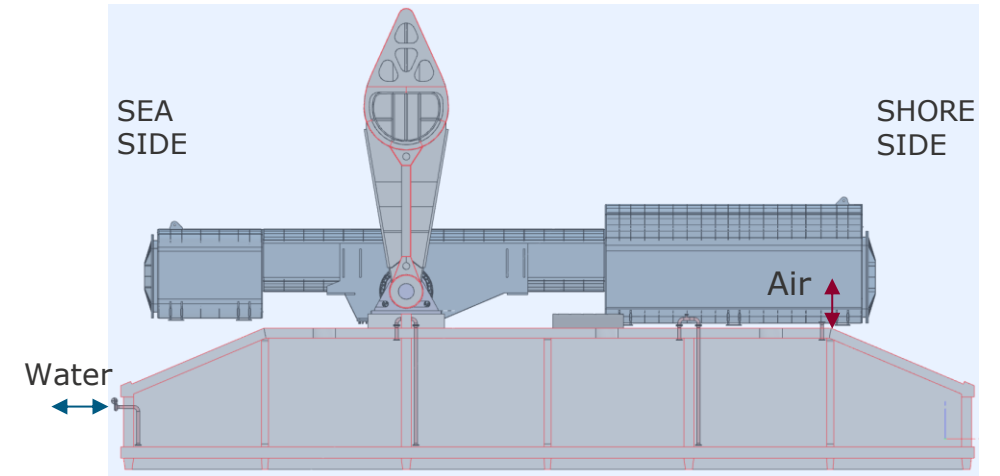
Steel Prototype 2012



Concrete Concept 2015

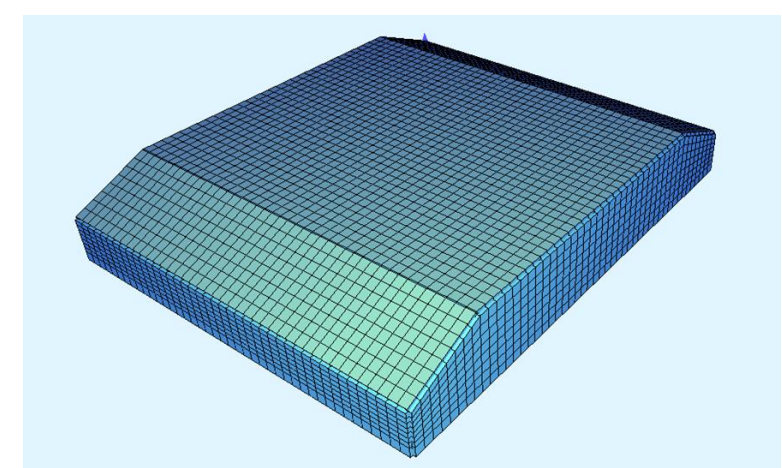
WAVEROLLER

- > Self-floating unit
 - Simple mechanical system for installation and removal
- > Ballast system
 - Built up by compartments
 - Each compartment consisting of 2 cells with large openings in dividing wall
- > Installation phases
 - Temporary phases governing for the concrete foundation
 - Maximum hydrostatic pressure during installation and empty tanks
 - Internal overpressure during removal
 - Moments in walls and slabs with opposite signs
 - Sequence reversed for removal by use of air and internal overpressure in compartments

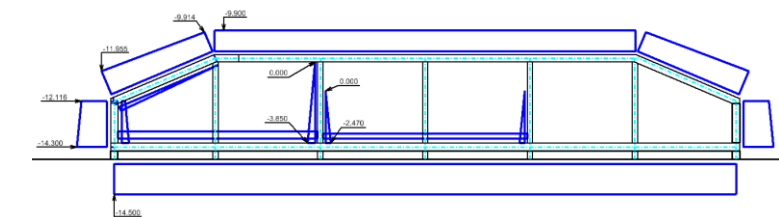


WAVEROLLER CONCRETE DESIGN

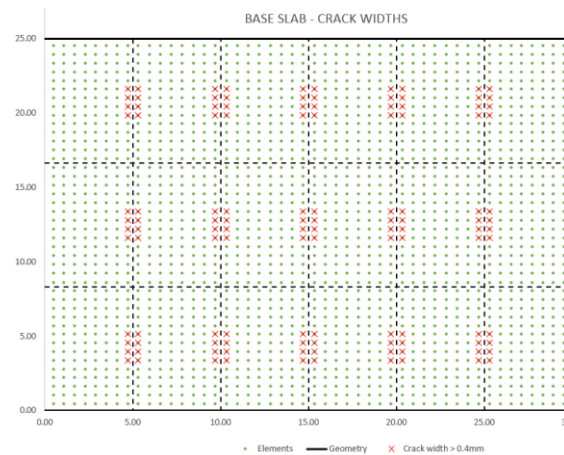
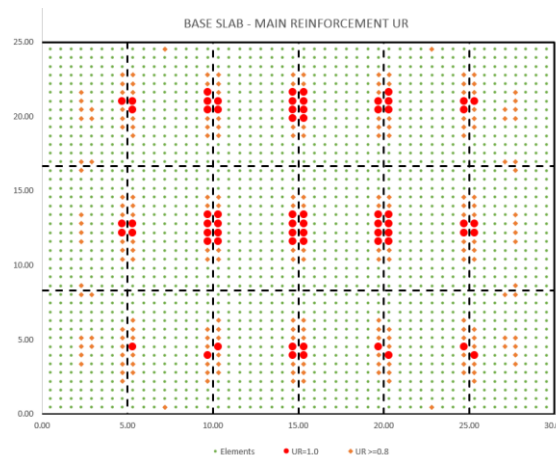
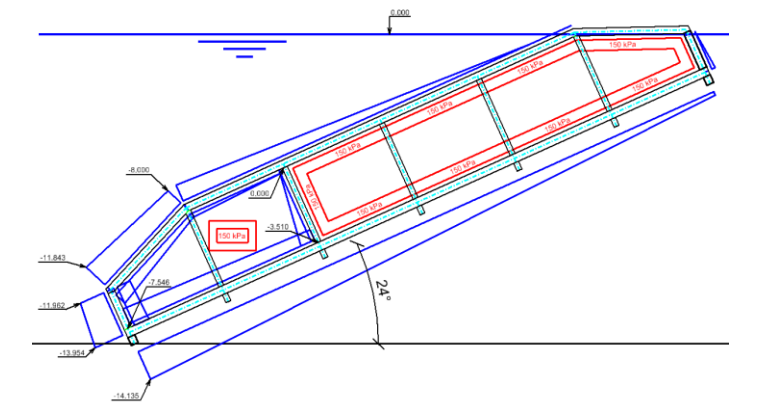
- > Wave loads on concrete foundation
 - Based on wave input from AWE
 - Consider different depths, wave heights and periods
 - Total wave loads = wave load on foundation + wave load on panel
- > Floating stability for all installation phases
 - Including intermediate positions of the submersion phase
- > FE-Analysis
 - Created in Sofistik
- > Design calculations for ULS, SLS and FLS in ShellDesign
 - Crack widths and utilization of reinforcement



Phase 5c



Phase 4 Removal

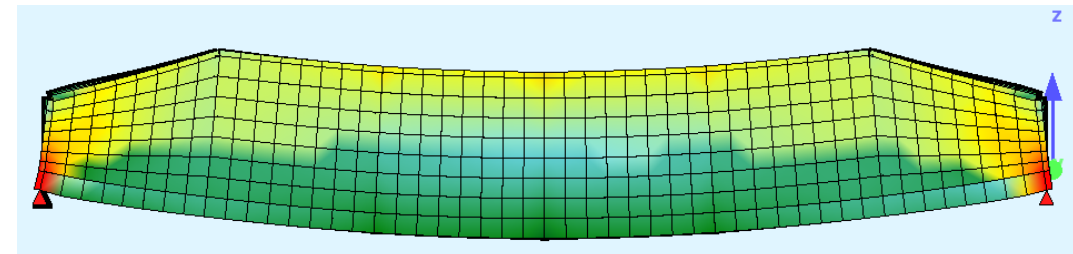
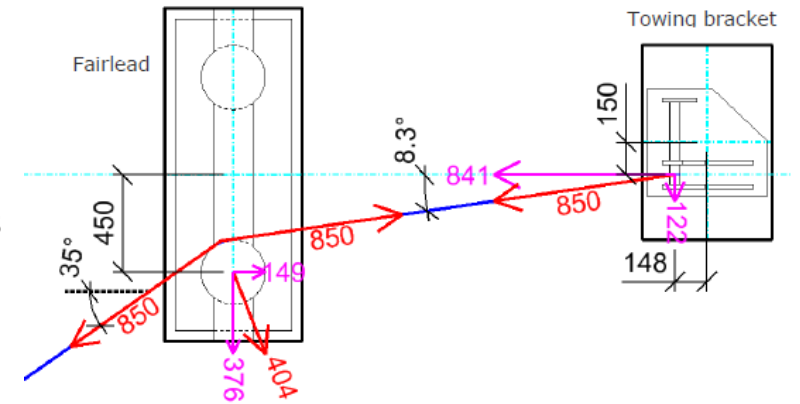
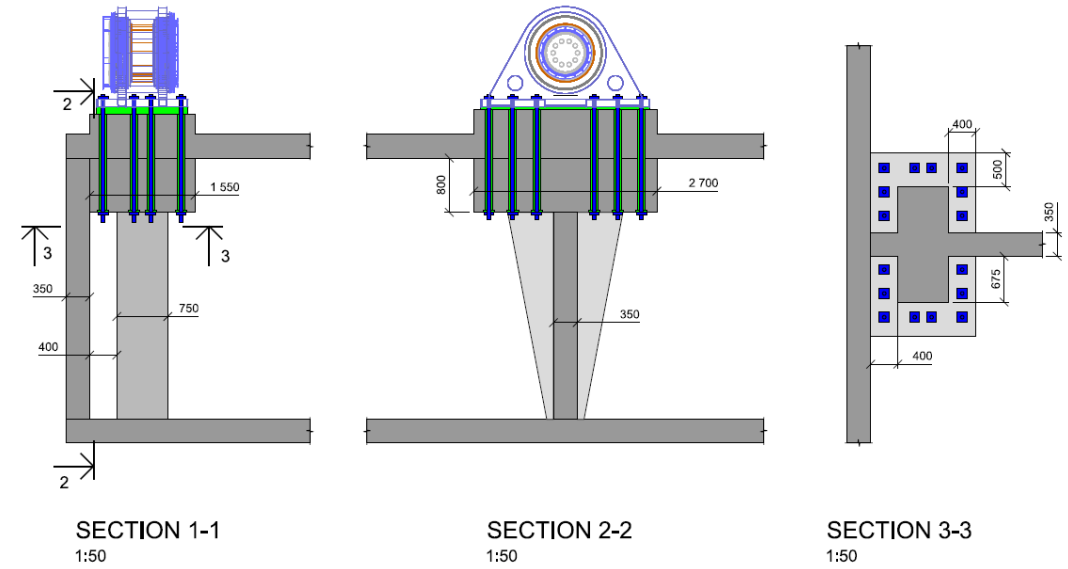


WAVEROLLER CONCRETE DESIGN

- > Design of panel bearing brackets
 - Panel forces transferred to concrete foundation
 - Local design of bracket above top slab

- > Design of embedment plates
 - Fatigue life of welds between base plate and bolt sleeves
 - Towing/mooring brackets embedment plates

- > Robustness for uneven soil
 - Provoke highest mid-span moment by support on outermost walls
 - 40cm ribs applied under the base plate to avoid vertical peak-loads

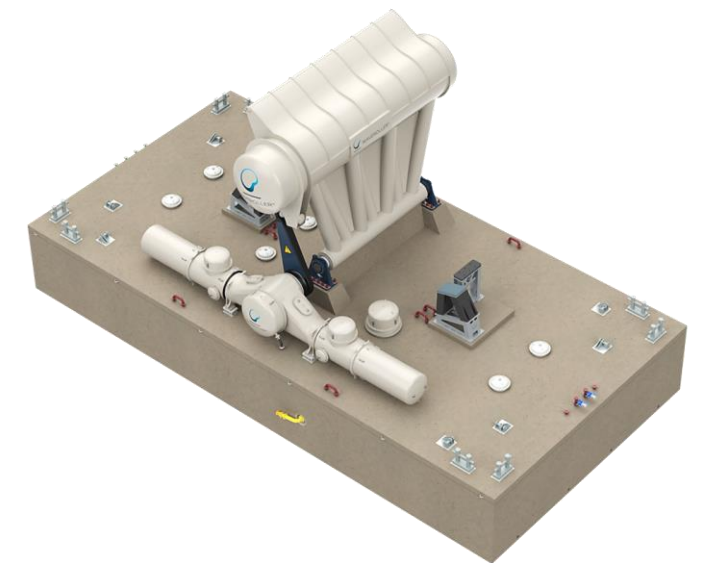
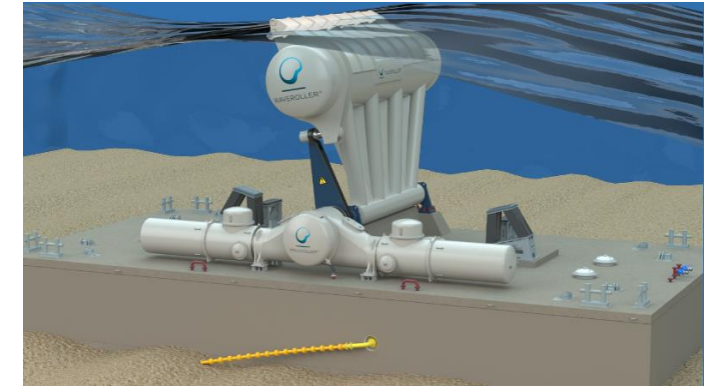


DEPLOYMENT SURGE 2



ONDEP

- > Project funded by EU
 - 14 partners from 9 countries
- > Establish a 2MW wave energy farm in Peniche, Portugal
 - 4 units of 500kW
- > OO involvement in project
 - Responsible for validation of the Concrete Base Foundation
 - Sizing and global design
 - Foundation dimensions and number of compartments
 - Stability
 - Concrete design
 - Global and local structural design
 - Mechanical outfitting
 - Ballast system
 - Compressed air and distribution system
 - Contribute to
 - Onshore assembly and offshore installation
 - Manufacturing of the concrete foundations



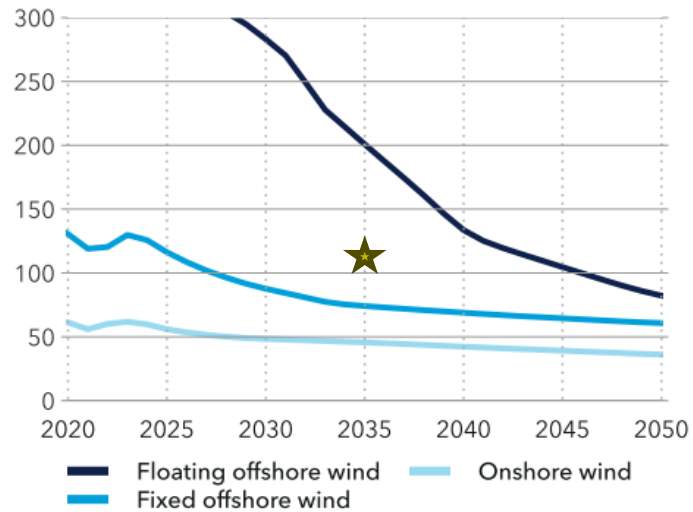
ONDEP

> Projected levelized cost of energy (LCOE) below 100Euro/MWh by 2035

FIGURE 4.12

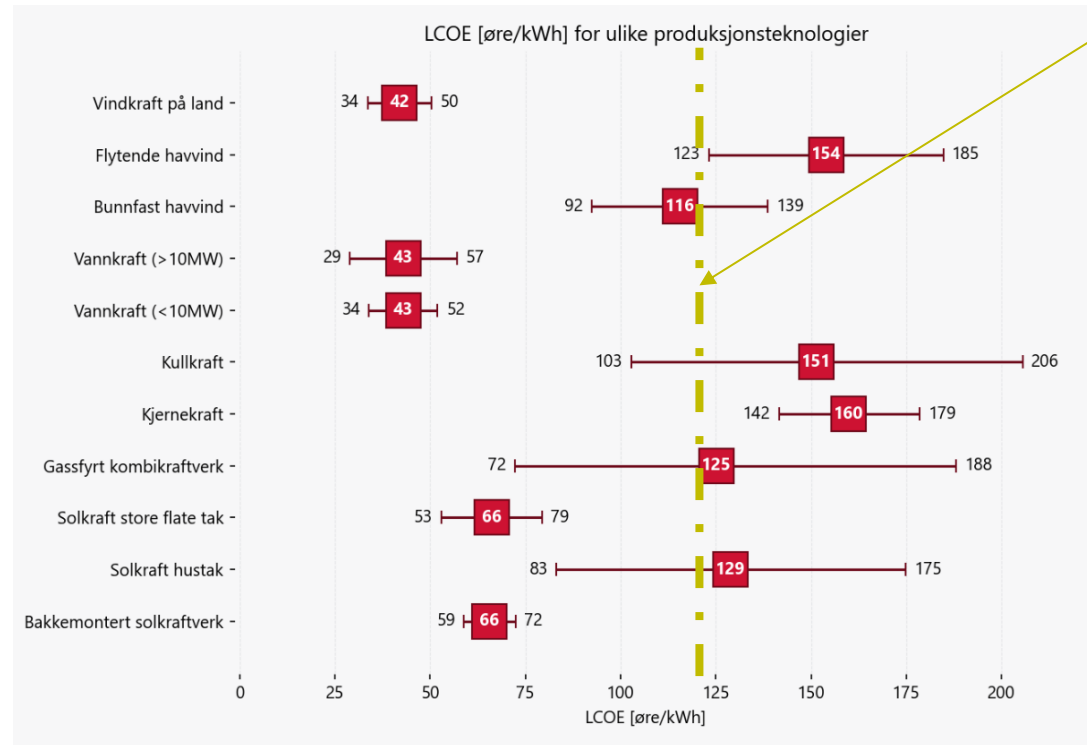
Norway levelized cost of wind electricity

Units: USD/MWh



Historical data source: GlobalData (2024), DNV analysis

Energy Transition Outlook Norway 2024
DNV AS



ONDEP

The Norwegian Water Resources and Energy Directorate (NVE)
<https://www.nve.no/energi/analyser-og-statistikk/kostnader-for-kraftproduksjon/>

QUESTIONS?

DISCLAIMER & COPYRIGHT

Disclaimer

Dr.techn. Olav Olsen provides no warranty, expressed or implied, as to the accuracy, reliability or completeness of the presentation. and neither Dr.techn. Olav Olsen nor any of its directors or employees will have any liability to you or any other persons resulting from your use.

Copyright

Copyright of all published material including photographs, drawings and images in this presentation remains vested in Dr.techn. Olav Olsen and third party contributors as appropriate. Accordingly, neither the whole nor any part of this document shall be reproduced in any form nor used in any manner without prior permission and applicable acknowledgements. No trademark, copyright or other notice shall be altered or removed from any reproduction.