Industry Solution - FRP Monopile Technology

Cost efficient offshore wind

in deeper

waters

Jon Høvik Entriom Wind



Fully Restrained Platform (FRP) Monopile

SOLUTION

Opens vast acreage for opportunities

Depth down to 120 meters

Market Opportunity - FRP Monopile Comparison – Available today

Foundation EFCI CAPEX – 25 – 50 % reduction Compared to existing foundations







• Levelized Cost Of Energy

\$106

\$98

FRP

Monopile



\$130

\$107

Jackets

XXL Monopile Theoretical - technology in concept stage

\$115

\$99

Semi submersible

LCOE Assessments from feasibility studies 60-80m water depth

FRP Relative Comparison

- Based 4 feasibility studies in Europe and in the US for water depths 60–80 meters
- Use of comprehensive bottoms up EPCI model
- Higher metal prices increases FRP advantage
- Including cable to grid on land

Available through existing suppliers and plants

Partner with Supplies

Diminish risk and accelerate commercialization





Vessel Owners and Installers



Engineering Companies









Mooring Systems

Mooring Lines



Qualif . & Certification Technology



Client Driven Development

through feasibility studies and testing

Project	Ket Takeaway
Vineyard 1	FRP feasibility down to 80m WD, Improvement in LCOE, Des further matured in 2022
Third-party certification	Gained independent system certification for DNV in 2023
ScotWind Offshore WF	Feasible in 80m WD, substantial savings vs. alternatives. 202
Top Mooring Assembly development and testing	FRP matured to TRL 6. Installation validated. DNV certification 2024
EDF France Project	Feasible with 22MW turbine in 75m WD. Significant Capex and LCOE (\$19/MWh) savings vs. alternatives. 2024
Simply Blue Celtic Sea	Feasible down to 75m WD. Sustainable LCOE savings (\$8.90/MWh). 2025
OXAN Feasibility	Optimizing system for shallow embedment. Ongoing
New concept	Technical feasible down to 90m WD. Existing T&I. 50% capex reduction vs. jacket alternatives. Ongoing
Orsted	Technical feasibility assessment. Startup phase





Demonstration Project in 2025

Demonstration Project

- Validate design methods and numerical models
- Demonstrate supply chain, fabrication, transportation and EPCI
- Verify technical and commercial performance
- Develop lessons learned to further de -risk the technology
- Certify DNV TQ to reach TRL 9 or equivalent



-2027





DNV issues "Statement of Feasibility" for Entrion Wind's new FRP Monopile Concept

Oslo, March 27, 2023

DNV has issued a "Statement of Feasibility", affirming that the Fully Restrained Platform (FRP) Monopile is considered conceptually feasible and a promising candidate for further development and qualification. The technical review used the industry -recognized service specification DNV-SE-0190 to detail and clarify the certification activities and facilitate achieving compliance for the new concept...

The FRP monopile concept combines fixed and floating platform technologies, and can be used in water depths up to 100 meters. This is the first milestone in the design process, affirming that the FRP Monopile is considered conceptually feasible and a promising candidate for further development and qualification. The DNV feasibility study will allow Entrion Wind to demonstrate that they are taking a responsible approach to managing risk and putting in place the basis for a successful project.





Minimized Risk

Combine proven components with reliable new technology DNV Component Level Certification in Progress

Top Mooring Assembly

- Tested and Qualified 2023 & 2024.
- Testing facilities at university.
- Specially designed test stand for mooring equipment.
- First used in 1975



Fig. 5. ODECO Super Rig winch-windlass under full static and dynamic test. Gear and disc brake covers removed.



TMA functional scale test



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Orcaflex simulations



Full dynamic simulation





Pull-in analysis

Mooring Line Installation

AIN

- Tool oriented for pull-in
- Pulling in

ENTRION

• Rod entering guide funnel

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FRP monopile installation – <u>Existing vessel fleet</u>

- Vessel 1 Install anchor piles with SOV / AH
 - Big crane and good deck space
- Vessel 2 Install monopile (MP)
 - Large MP inst. vessel
 - As usual, but MP's lighter and smaller diam.
 - More MP per voyage
 - (Installed MP can withstand a 1 year storm) lacksquare
- **Vessel 2 Install transission piece (TP)**
 - Readily rigged with TMA and messenger ropes for mooring installation
- Vessel 3 Install mooring lines w. small
 - SOV with 3D gangway and small heave comp crane
 - Connect to anchor with H-link
 - Connect to MP by TMA
 - Pull in and pre-tension moorings





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Think Deeper - Think Greener - Think Future.

FRP monopiles are available NOW

- infrastructure needed.
- Fabrication in existing monopile plants No investments in fabrication and

- Less diameter
 - Larger installation weather window
 - More piles per voyage
- Less length
- Less weight

Installation by existing heavy lift fleet



The EW Team

Management Team



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