Universal Foundation


# Modular Suction Buckets

## Experiences from Trial Installation Campaign

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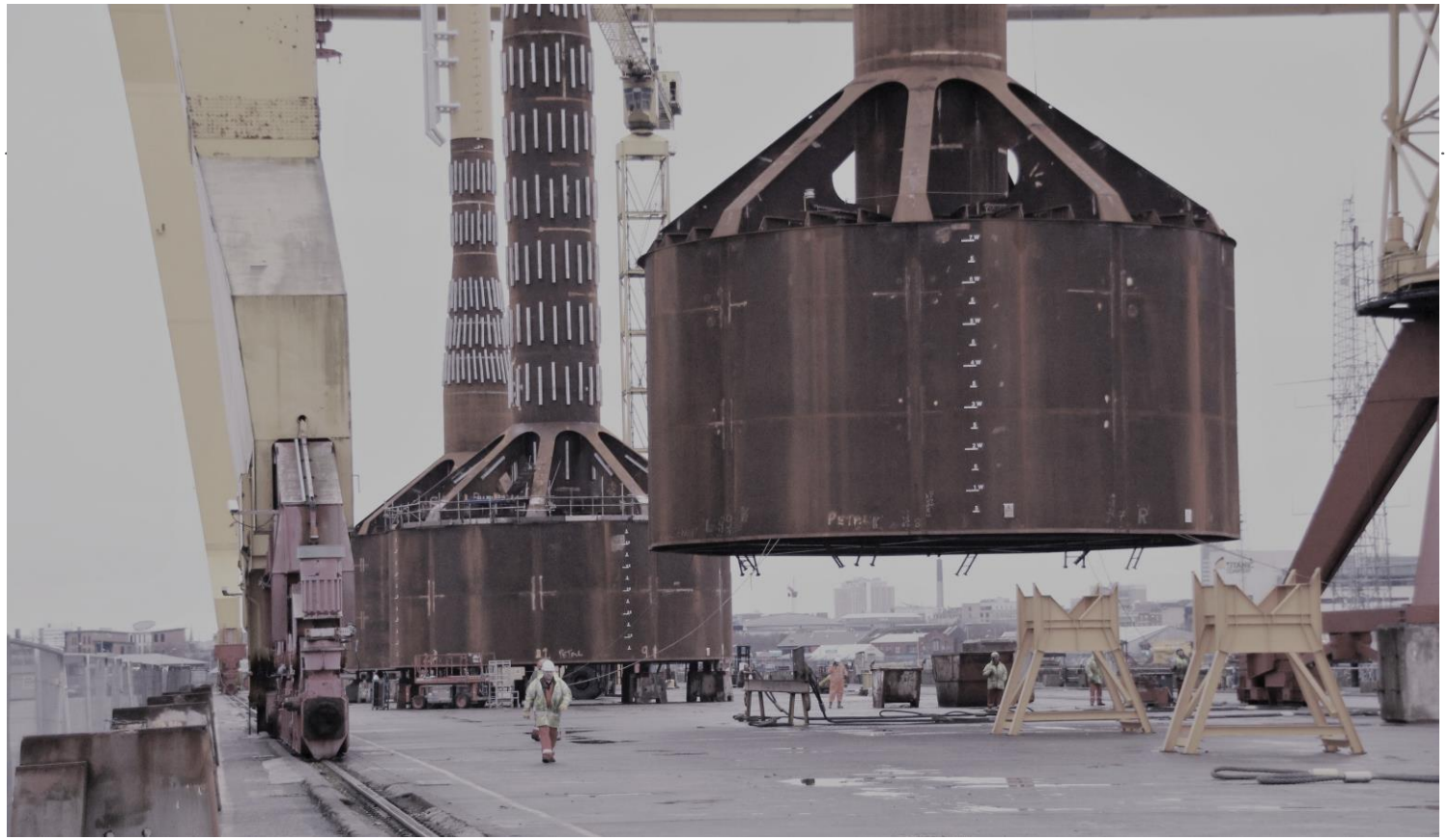
# Reducing the cost of offshore wind through bankable innovation



# On a clear MISSION

Support our partners in winning development bids and the rapid deployment of the Mono Bucket foundation for offshore wind parks to be built from 2020-2030

# Track Record

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| PROJECT NAME | YEAR | KEY ACHIEVEMENTS |
|---|---|---|
| **FREDERIKSHAVN (DK)**<br>▪ Mono Bucket supporting a Vestas V90 3MW WTG | *2002 – still operational* | WTG load testing and monitoring |
| **HORNS REV 2 (DK)**<br>▪ Mono Bucket supporting a met mast | *2009 – 2015* | Floating installation concept proven<br>Integrated scour protection system validated<br>2015 - proved full decommissioning capability |
| **DOGGER BANK (UK)**<br>▪ Mono Buckets supporting two met masts | *2013 – 2017* | Installation at a UK R3 “true offshore site”<br>Foundation hit by 50-year design wave (20 m)<br>2017 - 100% removal of two Mono Buckets |
| **TRIAL INSTALLATION (UK)**<br>▪ Mono Bucket installations to test soil sensitivity | *2014* | Tests at Dudgeon, Dogger Bank and Hornsea<br>29 installations in 24 days |
| **EUDP PROJECT – Part 2**<br>▪ Trial installations of new generation bucket | *2019* | 13 successful installations and retrievals |

***MANY MORE TO COME…..***

# Industrialization Suction Bucket Roadmap

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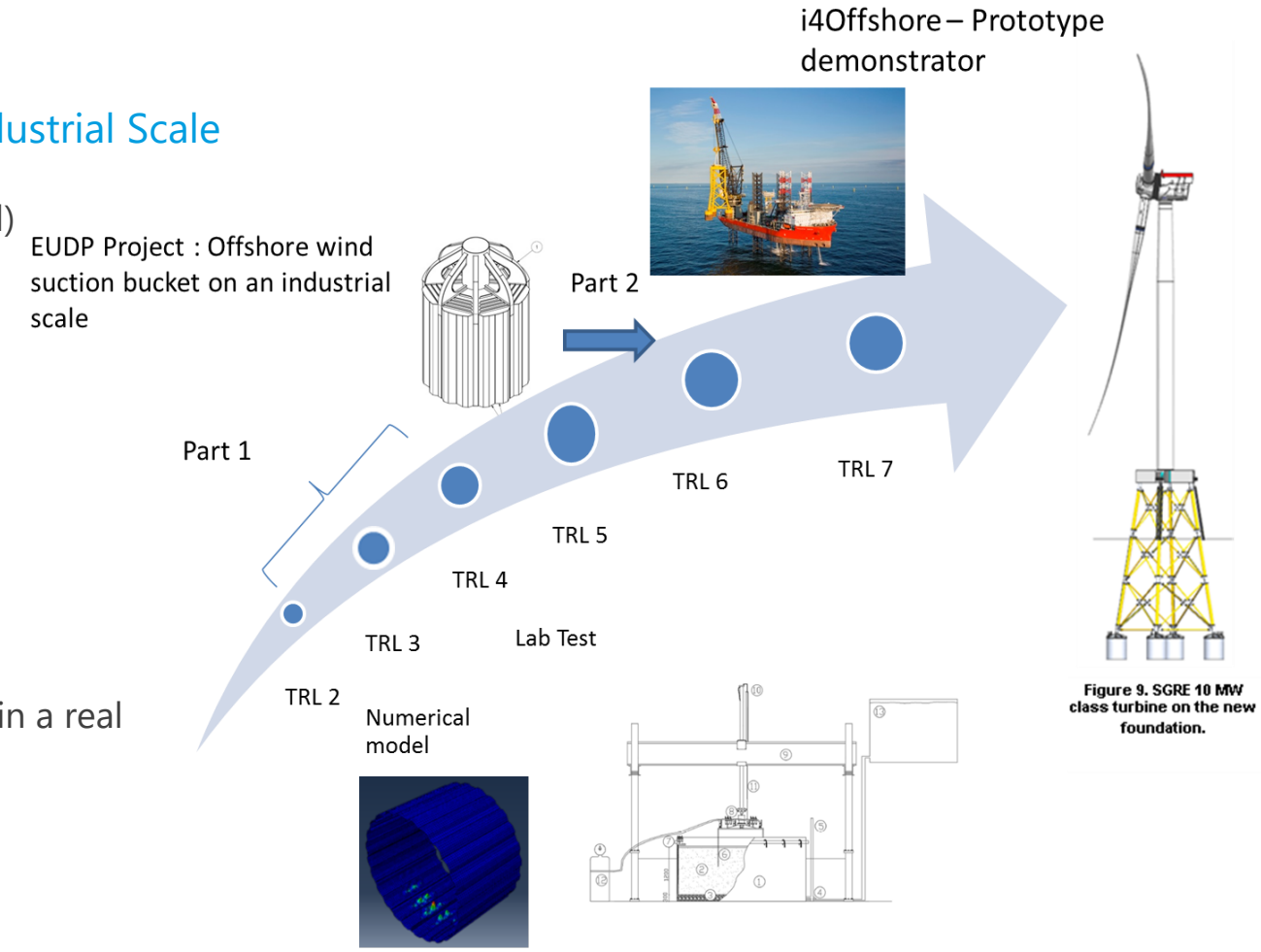
## Reduction of LCoE of Offshore Wind

### Offshore Wind Suction Bucket on an Industrial Scale

- Suction bucket suitable for mass production (i.e. industrialized)
- 30% to 40% cost reduction
- Part 1 2016-2018 – Design and Fabrication (~€ 2 Million)
- **Part 2 2019 – Trial Installation (~€ 4 Million)**

- Reduce LCoE by 43% relative to 2014
- Cost-effective innovative 10 MW class offshore wind solution in a real offshore environment
- ~€ 20 Million funding from EU Horizon 2020 Project



# Industrialization Suction Bucket Background

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A joint industry project focused on reducing LCoE by combining competencies

AALBORG UNIVERSITY
DENMARK

SIEMENS Gamesa
RENEWABLE ENERGY

IB ANDRESEN INDUSTRI
Specialists in processing and shaping of steel

Universal Foundation
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On a **40% cost out mission** wrapped in a **gravity jacket** + specialist in **coil steel bolted towers** + above state of the art **suction bucket technology**

# EUDP Project – Step 1 (Design and Fabrication)

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## Light-weight Modular Suction Bucket

- Pressed coil steel (>15% cheaper than plate steel)
- Assembly with bolted connections
- Diameter of 8 m, skirt height of 8 m
- 17 mm skirt thickness (30 - 45 mm for 'traditional' buckets)
- Suitable for road transportation of pre-fab elements
- Can be assembled at quay side in horizontal position
- **~30-40% cost-reduction**

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# EUDP Project – Step 1 (Design and Fabrication)

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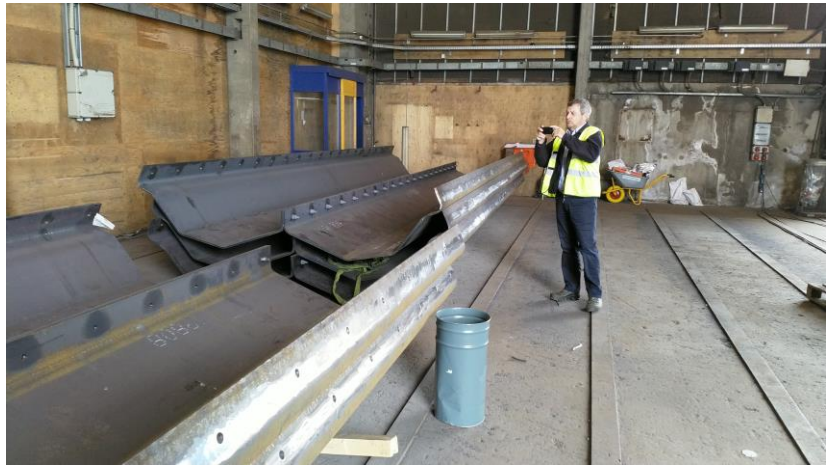

# EUDP Project – Step 2 (Trial Installation)

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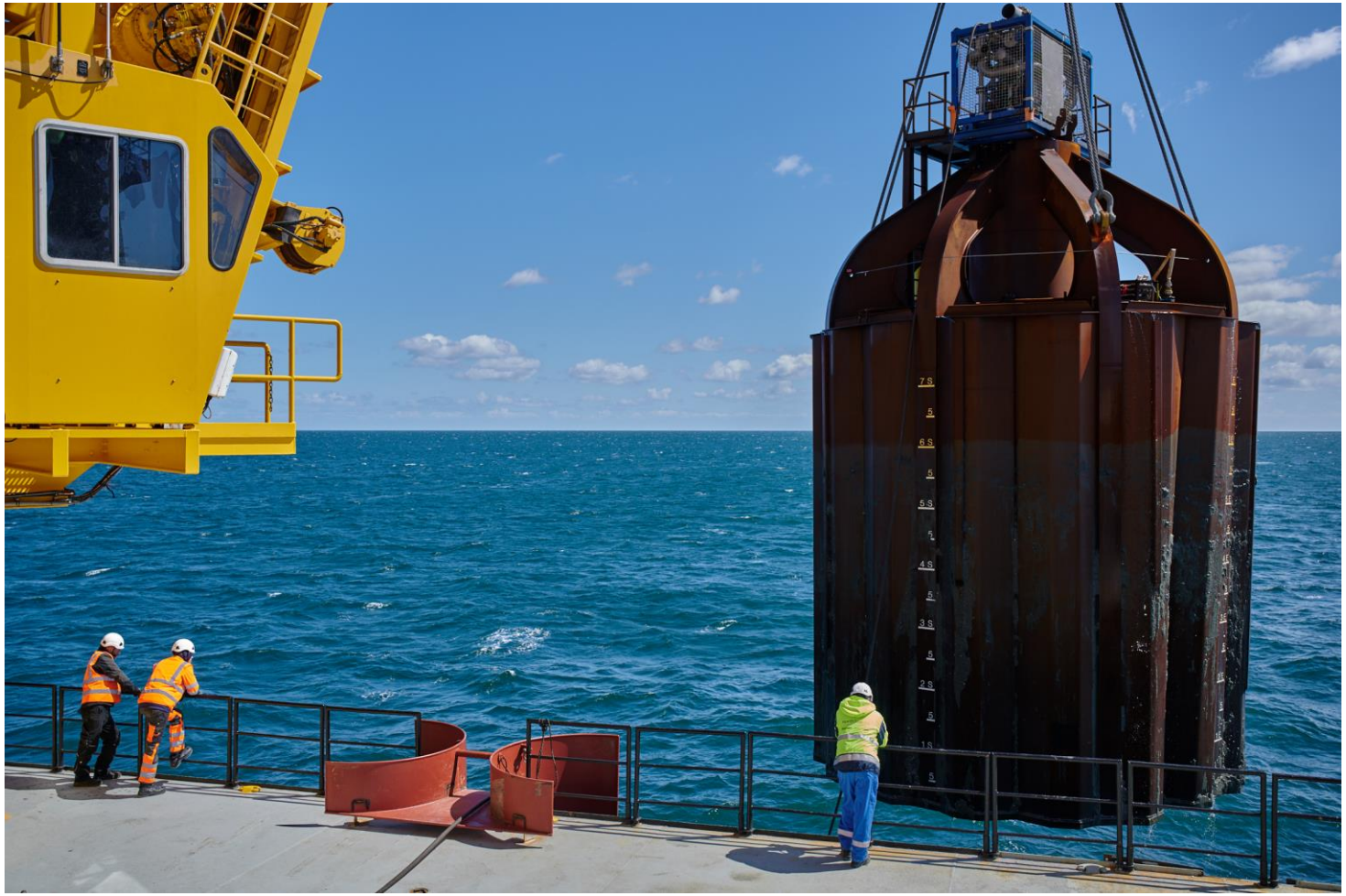

## Trial Installation Objectives

- Proof robustness of light weight modular bucket
- Proof install-ability in varying soil conditions
- Collect data to verify/improve installation predictions
- Learn from experiences to reduce concept risks

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Fred. Olsen Windcarrier

# EUDP Project – Step 2 (Trial Installation)

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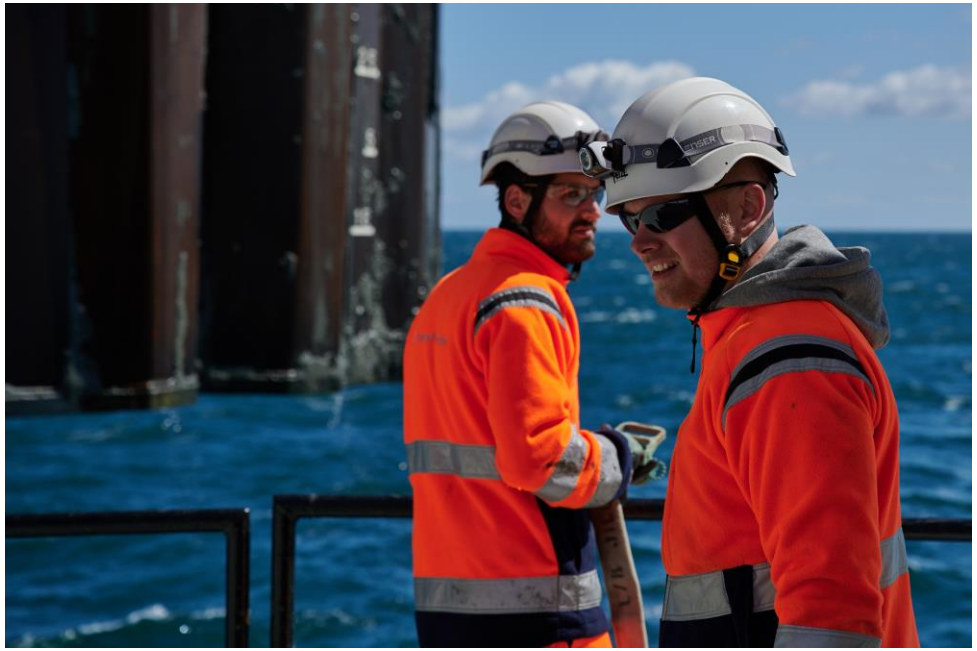
## Trial Installation Test Site (1)

- Frederikshaven Havmøllepark (DK)
- About 4.5 km from shore
- Possibility to perform trial installations at 15 positions
- Water depth approximately between 15 m and 20 m
- Variable ground conditions consisting generally of silty sand underlain by clay and sand layers



# EUDP Project – Step 2 (Trial Installation)

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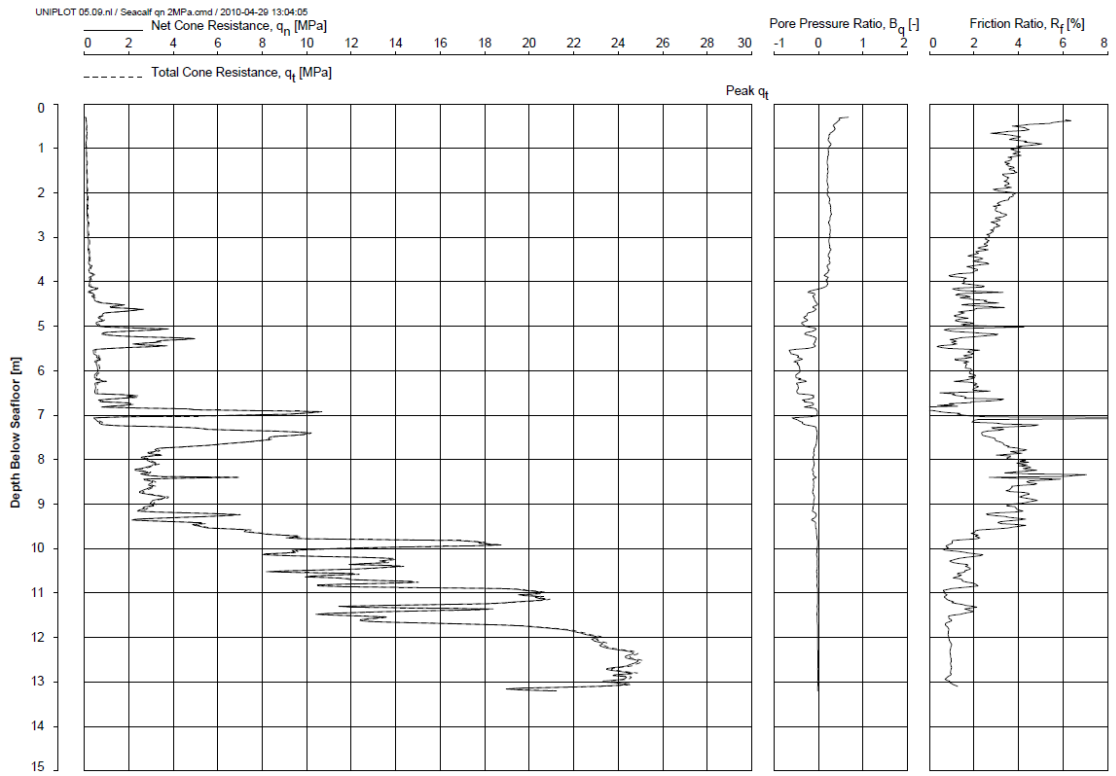
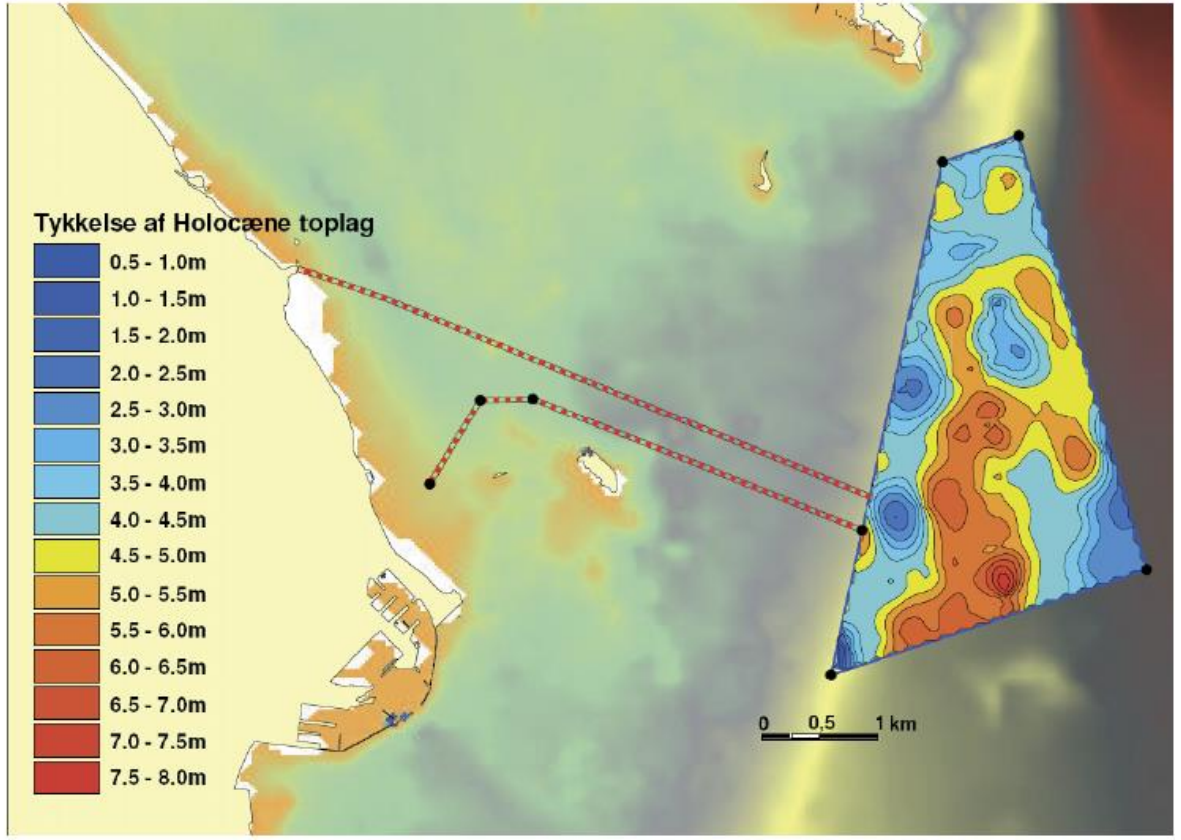
## Trial Installation Test Site (2)

- Variable ground conditions consisting generally of silty sand underlain by clay and sand layers



# EUDP Project – Step 2 (Trial Installation)

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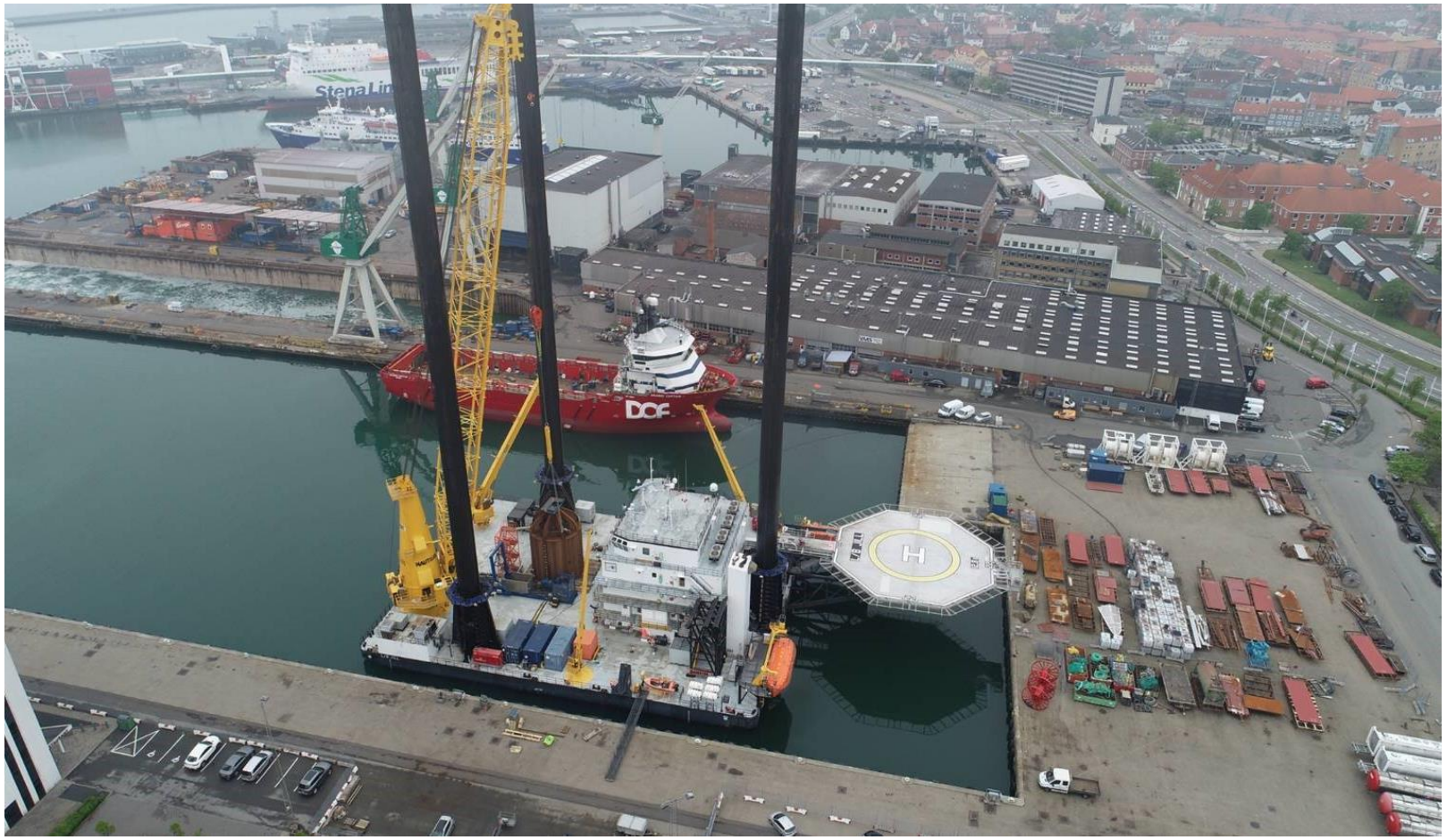
## Lift Boat Jill

- 3-legged self elevating platform, with DP2 positioning system
- 120 m long legs
- 250 t crane at 17 m outreach
- Aiming for the 3-5 MW offshore wind turbine market, mainly doing operations and maintenance (O&M) work
- Recently taken into Fred. Olsen Windcarrier fleet (long-term charter)



# EUDP Project – Step 2 (Trial Installation)

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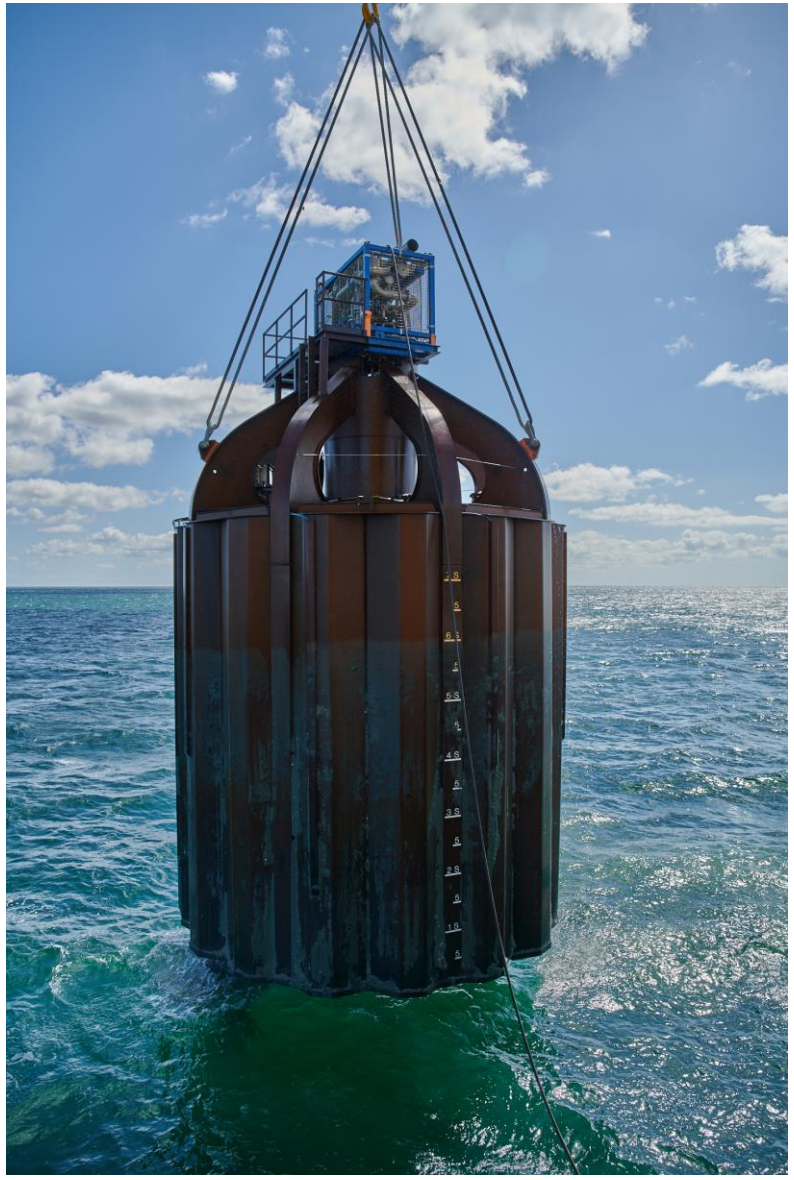

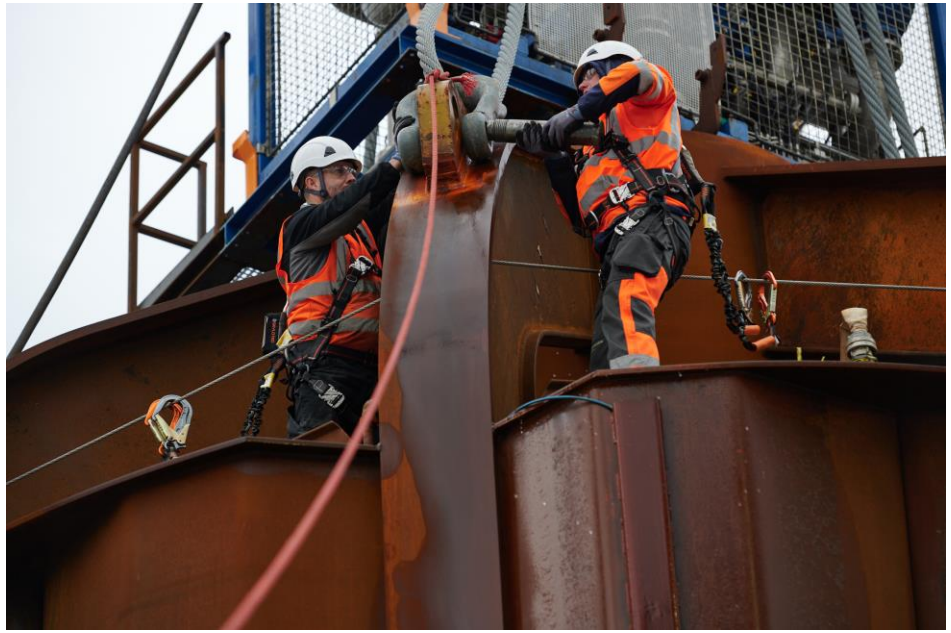

## Bucket Layout and Instrumentation

- Diameter of 8 m, skirt height of 8 m
- Weight of approximately 65 t, including pump unit
- Nozzles on skirt rim in 3 sectors
- 12 strain gauges (5 on lid, 7 on skirt)
- Pore pressure measurements in 3 levels on 2 locations
- Inclination measurements
- Measurement of installation/retrieval pressures

# EUDP Project – Step 2 (Trial Installation)

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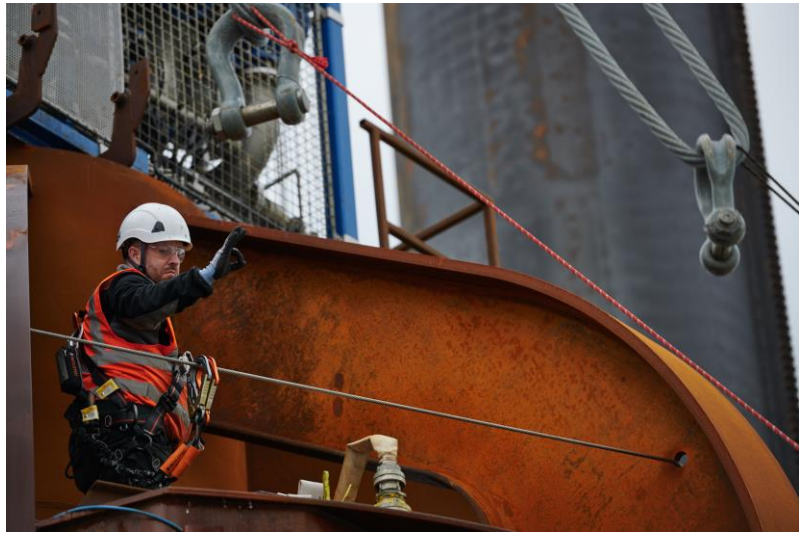
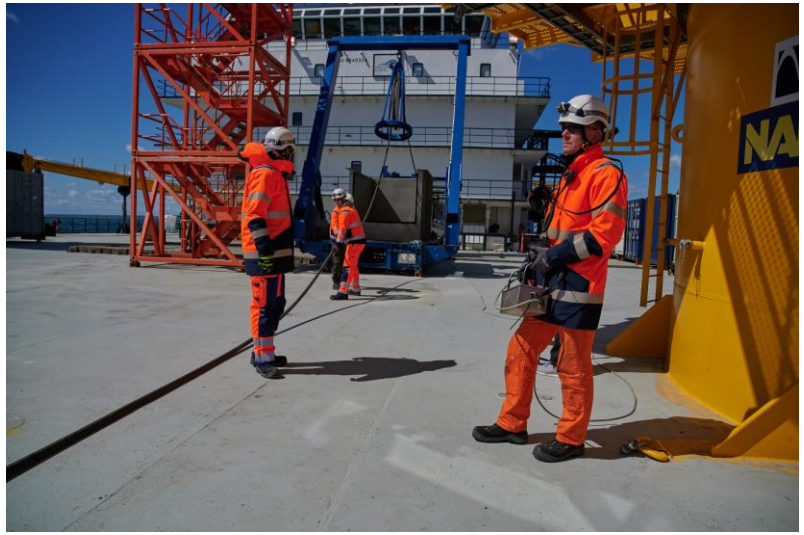
## Installation and Retrieval Operations

- 10 UF project managers/installation experts
- 1 University of Aalborg Professor
- 1 ROV operator
- 2 Crane operators
- 6 Rigging/lifting professionals
- Marine crew





# EUDP Project – Step 2 (Trial Installation)

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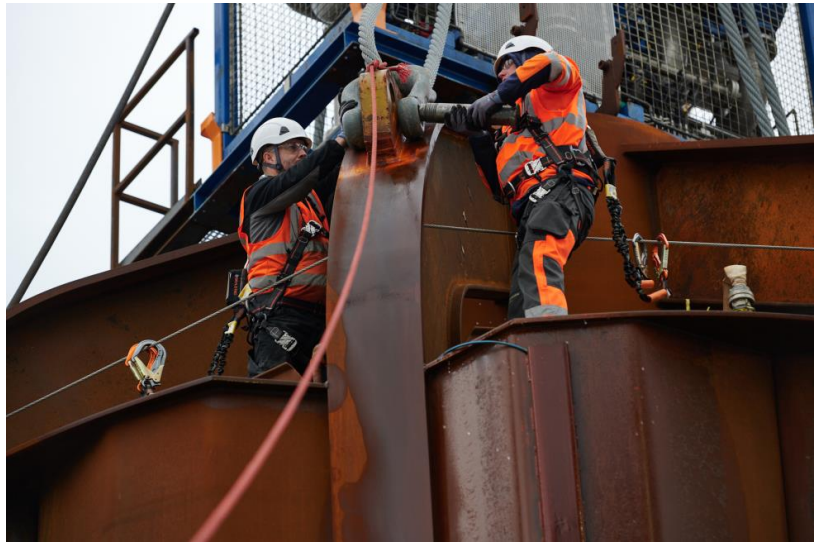

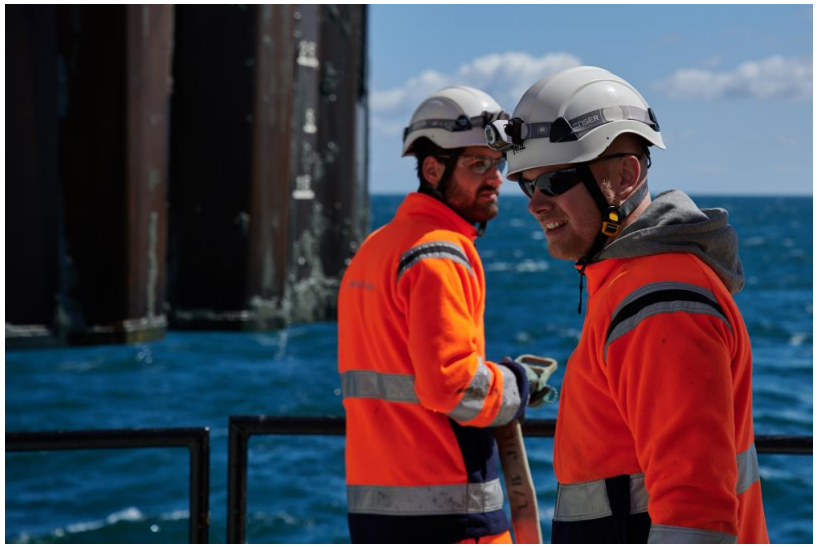

# EUDP Project – Step 2 (Trial Installation)

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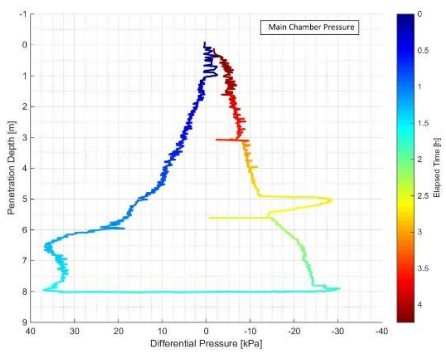
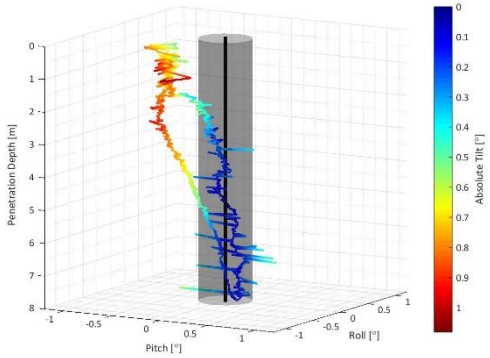
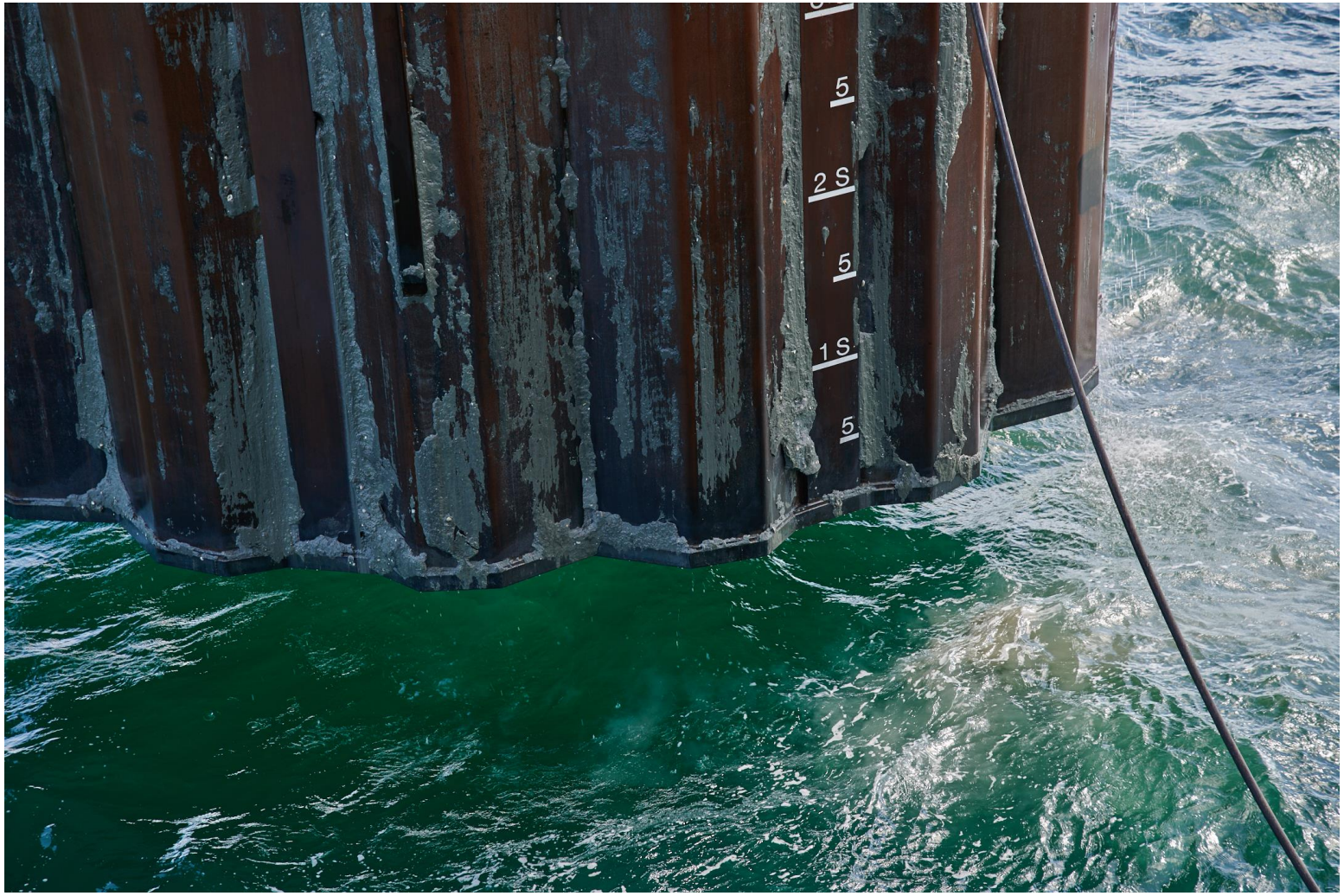
## Installation and Retrieval Results

- 13 successful installations and retrievals in 2 weeks, including WoW
- Reached maximum installation depth of 8 m
- Managed to correct initial bucket inclination



# EUDP Project – Step 2 (Trial Installation)

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## Trial Installation Objectives

- Proof robustness ✓
- Proof install-ability ✓
- Collect data ✓
- Train & Learn ✓

# Next Step – i4Offshore

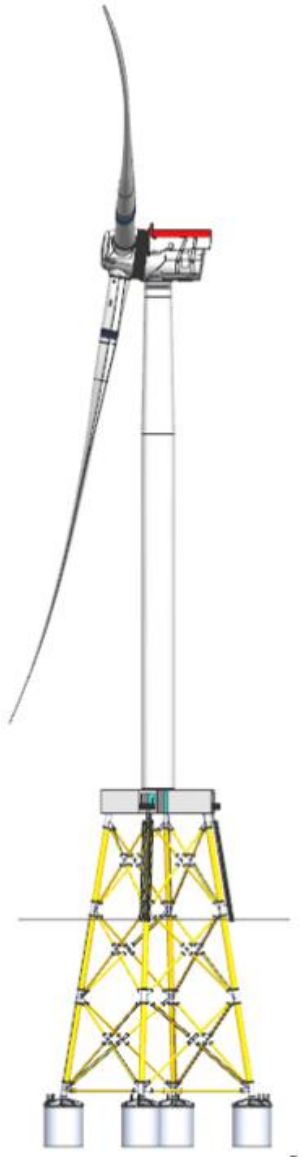
Universal Foundation

**Reduce LCoE by at least 43% relative to a 2014 baseline from 140 €/MWh to below 80 €/MWh, at challenging sites**

Demonstrate and validate:

- 10MW-class next generation direct drive turbine offshore
- Gravity jacket foundation, **supported by suction buckets**, in real offshore environment
- Innovative cable-in-pipe system
- Fast assembly of jackets in a non-yard facility
- Mass-produced nodes optimized by robotic welding

One integrated at-sea, full-scale demonstrator at Kriegers Flak (Vattenfall owned)



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