Cranes and Heavy Lift Solutions

May 2023

DeepWind

Floating Offshore Wind Subgroup

Image source – WindSpider

Image credit – First Subsea

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Programme

10.00am – Introduction and housekeeping – Jeya Calder, HIE

10.05am – Introduction to webinar theme – Lucy Green, Genesis Energies

10.10am – Overview of Crane/Heavy Lift technology development – DeepWind

10.25am

Innovation Technology Showcase

1) Quayside lifting tool - **Steve Binney, Osbit**
2) Heavy lift options for FOW – **Arjan Keuzenkamp, Van Oord**
3) Self-Erecting Nacelle and Service System - **Sandra Eager, SENSEwind**
4) Solar electric air crane - **David Taylor, Skylifter**

11.25am – Q&A session

11.35am – End of webinar

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Cranes and Heavy Lift Systems Overview

Heavy Lift Challenges for FOW

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- Onshore
  - lift at quayside increasing in height
  - Nacelle weight also increasing
  - Very few cranes available that can handle 16MW plus turbines

- Offshore
  - Floating cranes require heave and motion compensation which is expensive
  - Very few floating systems currently available, leading to significant day rates
  - No jack-ups, as yet, capable of operating in 80m plus water depth. Would also be an expensive solution

Turbine assembly in Rotterdam (9.5MW)

Image – Principle Power


2019
GE 12MW Turbine
780 tonnes
150m height
Tandem lift
Sif
Image - Liebherr


2023
18MW Turbine
1200 tonnes
225m height
BMS
BMS
Image - Huisman

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Reach

Substructure design has implications for the reach required for the crane system

TOP – Rotterdam, floater with turbine mounted on one of the tri-columns – approximately 20m

Image – WindFloat, Principle Power

BOTTOM – Port of Grenaa, Denmark, centrally mounted turbine floater design – approximately 40m

Image – TetraSpar, Stiesdal Offshore

To port or not to port …that is the question

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- No clear industry consensus as yet on O&M strategies for floating wind
- If you build it….will they come?
  Port operators do not want to commit to investing in crane and heavy lift systems that may not be required if return-to-port is not the direction that the industry goes
- Project based leasing is the option at the moment but this is not cost effective if you have consecutive construction projects or long term O&M contracts

Modular self-erecting crane system

Image – WindSpider

Image- Fred Olsen 1848

Vessel based systems

Image - DEME Offshore

- Vessel based system currently being developed by DEME Offshore and self hoisting crane specialist, Liftra
- Aimed at next gen offshore wind turbines for both fixed and floating wind

Summary

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- No one-size-fits-all answer to the requirement for crane systems on and offshore but investment risk still a major hurdle.
- Land based turbine assembly still appears to be the lowest cost approach for floating offshore wind and is still the technology's major advantage compared to fixed when considering construction methodologies
- O&M solutions may need to be decided very early in the process i.e. alongside substructure selection if some innovations are to be included
- Cranes and heavy lift systems require significant innovation to be applied to deliver future fit for purpose systems in floating offshore wind

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Technology Showcase

Van Oord
Marine ingenuity

SENSEwind

SBIT

SKYLIFTER®

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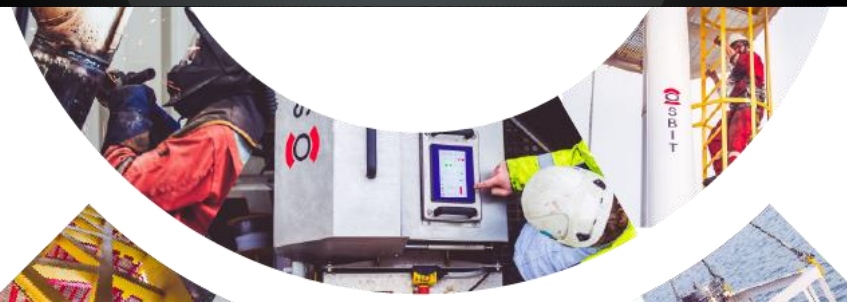
Steve Binney

Floating Wind Installation Methods



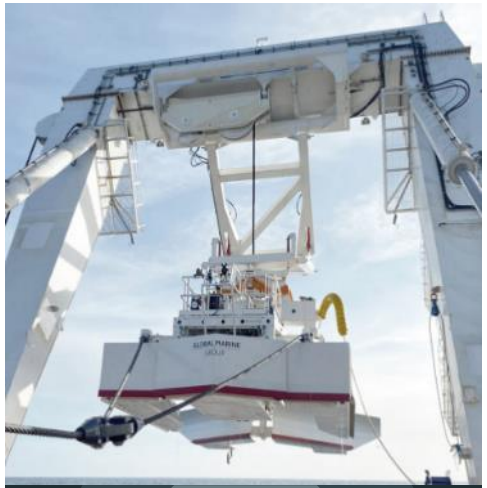
Steve Binney
Director


SBIT

With our technology, more is possible

Well Intervention

Access Systems



Subsea Trenching

Pipe and Cable Lay

Subsea Harvesting

Offshore Handling

Wind Farm Installation

Test Equipment

Control and Data

Working across the established and renewable offshore energy sectors, we develop equipment to enable energy transition and support a wide range of operations.

Osbit:

- Head office in **Riding Mill UK**
- Dedicated Assembly facility in **Port of Blyth UK**
- Satellite offices – **USA** *(Providence)* & **Netherlands** *(Rotterdam)*

Manufacture:

- To suit customer requirements

Osbit WTG Crane Concept

Concept Goals

- Future Proof Design
  - Remove restriction on WTG height
  - Remove restriction on WTG weight
- Improve Mobilisation
  - Reduce ground bearing pressure
  - Simplify to quicken to reduce costs
- Improve Uptime
  - Significantly improve operating wind speed

Design Parameters

Nacelle mass (including rigging)	1300t
Tower mass – Total	1200t
Tower mass – max individual	350t
Blade mass - each	165t
Floater Type	Edge Mounted Semi-Submersible Spar

*Above numbers include rigging & specialist lift tools and 5% mass factors as per DNV

Osbit WTG Quay System

Significantly reduced height Vs Ring Crane

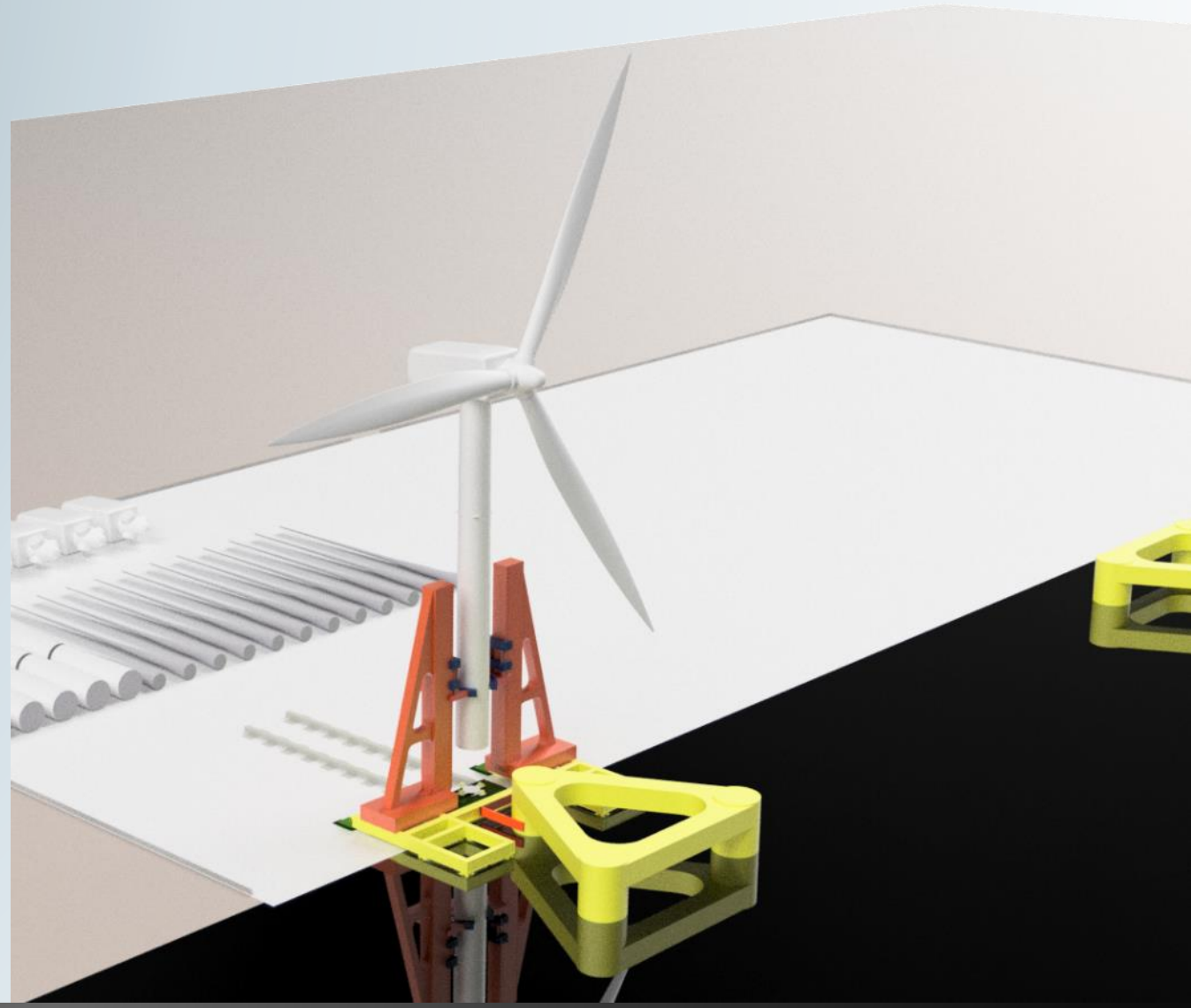
Handling tools enable

- Guided lifts
- Bolt alignment
- Safer lifts
- Operating in higher winds

WTG modifications required

- 2 Tower sections require external features
- No modification to standard internal bolt pattern
- No modification to Nacelle or Blades

Enables smaller, cost effective, more widely available crawler cranes to operate normal lifts



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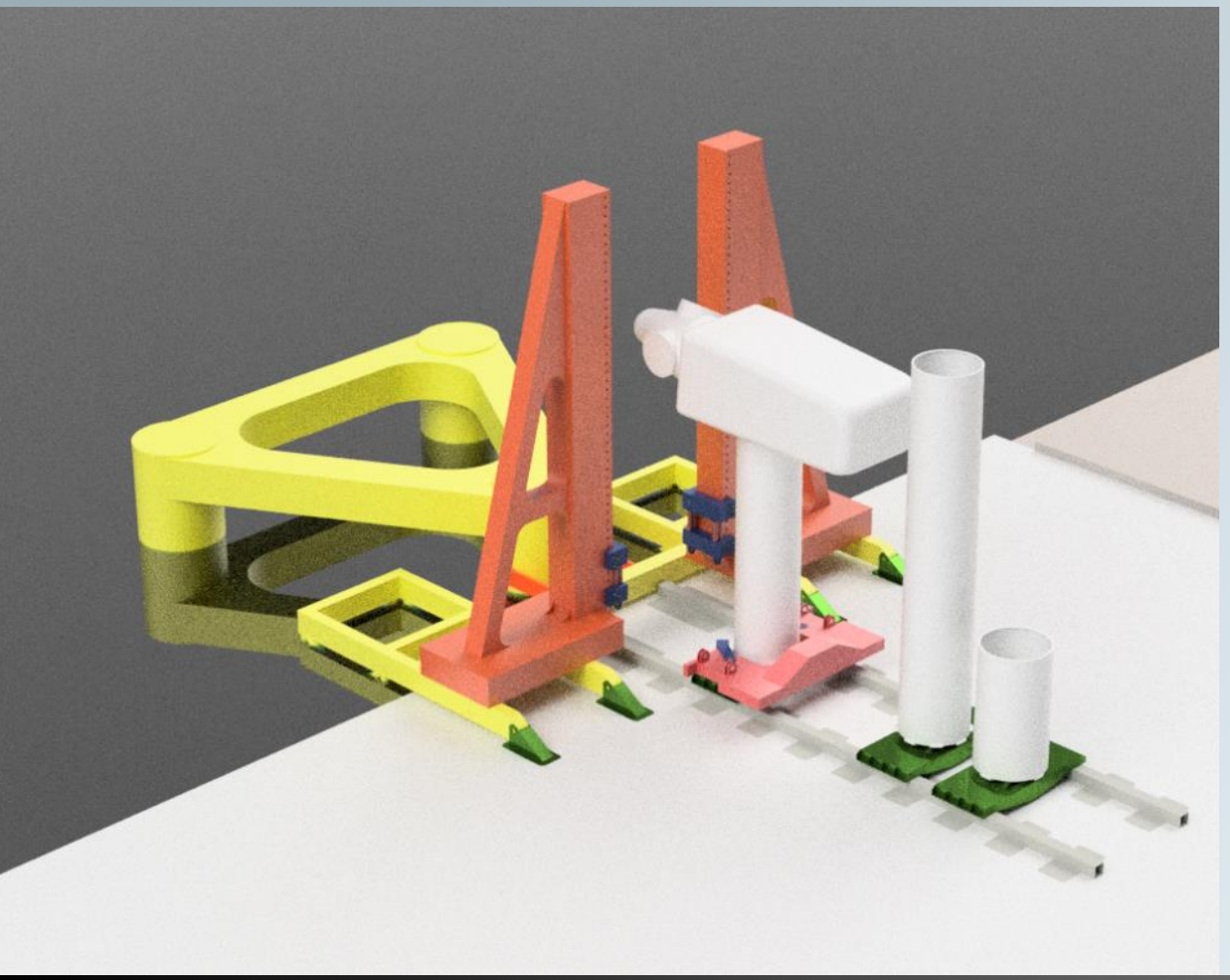
Osbit WTG Quay System – Build Storyboard



Tower parts pre-loaded into site configurable skid rails. X & Y translation possible

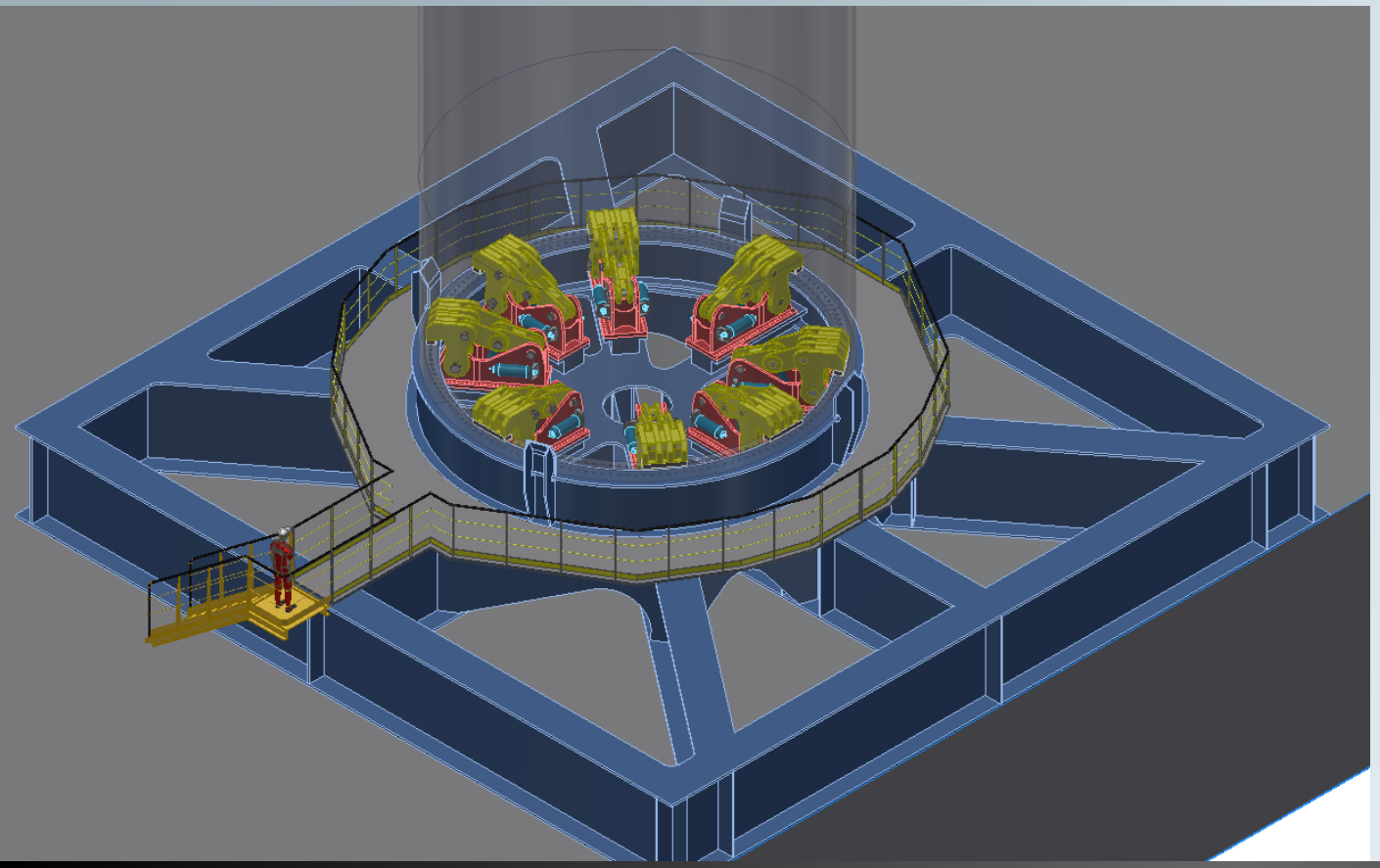
Nacelle & Top Tower section pre-commissioned – off critical path

2 Middle Tower Sections pre-commissioned

Moments carried by skid frames

Floater – Quay Edge is configurable

Osbit WTG Quay System – Tower Interfaces



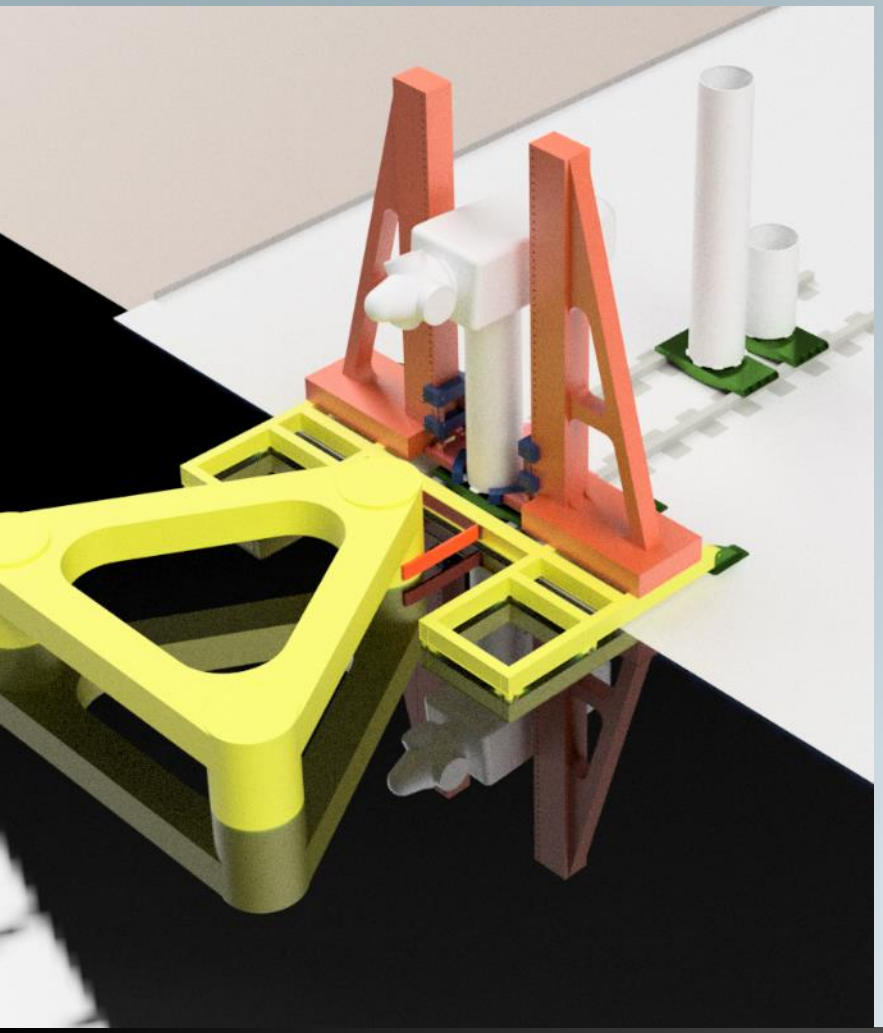
Osbit's Flange Clamp - Engages on unmodified internal flanges

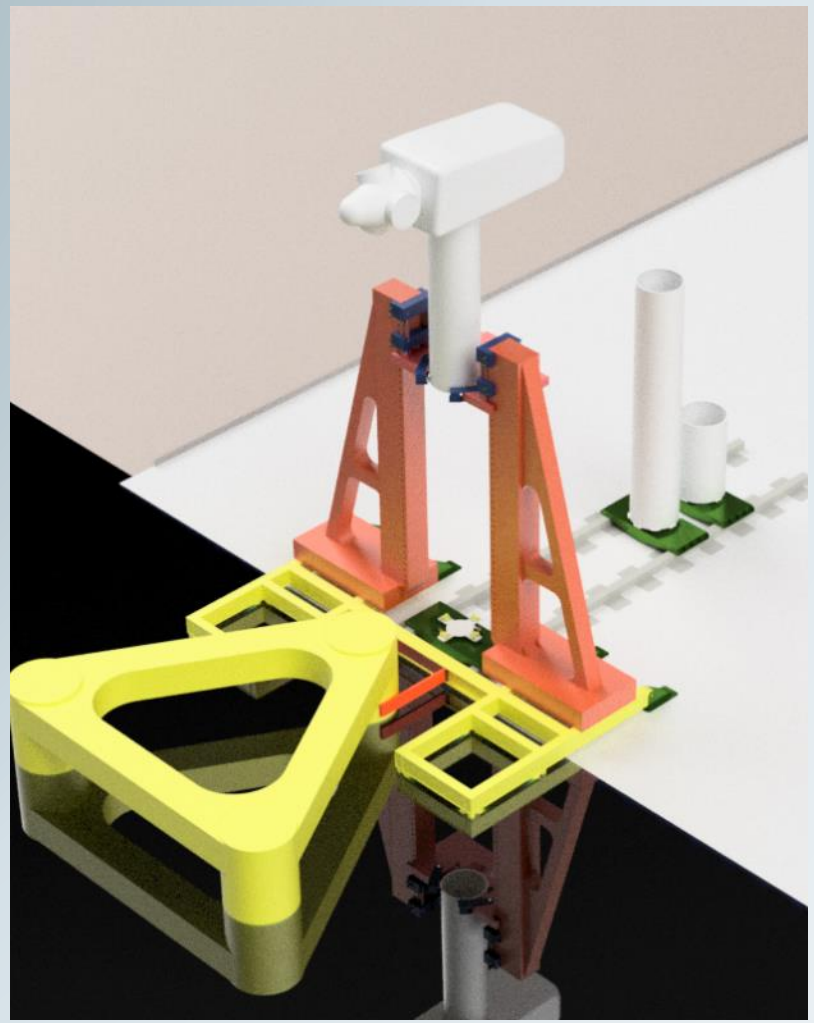
Can be applied to a similar but smaller new external feature

Quick engage & removal

Pretensioned connection for immediate load & moment holding

Osbit WTG Quay System – Build Storyboard





Nacelle and Upper Tower skidded into Jacking System on main Lift Beam

- Clamped to external tower features

Climber System engaged onto Lift Beam

Upper section raised

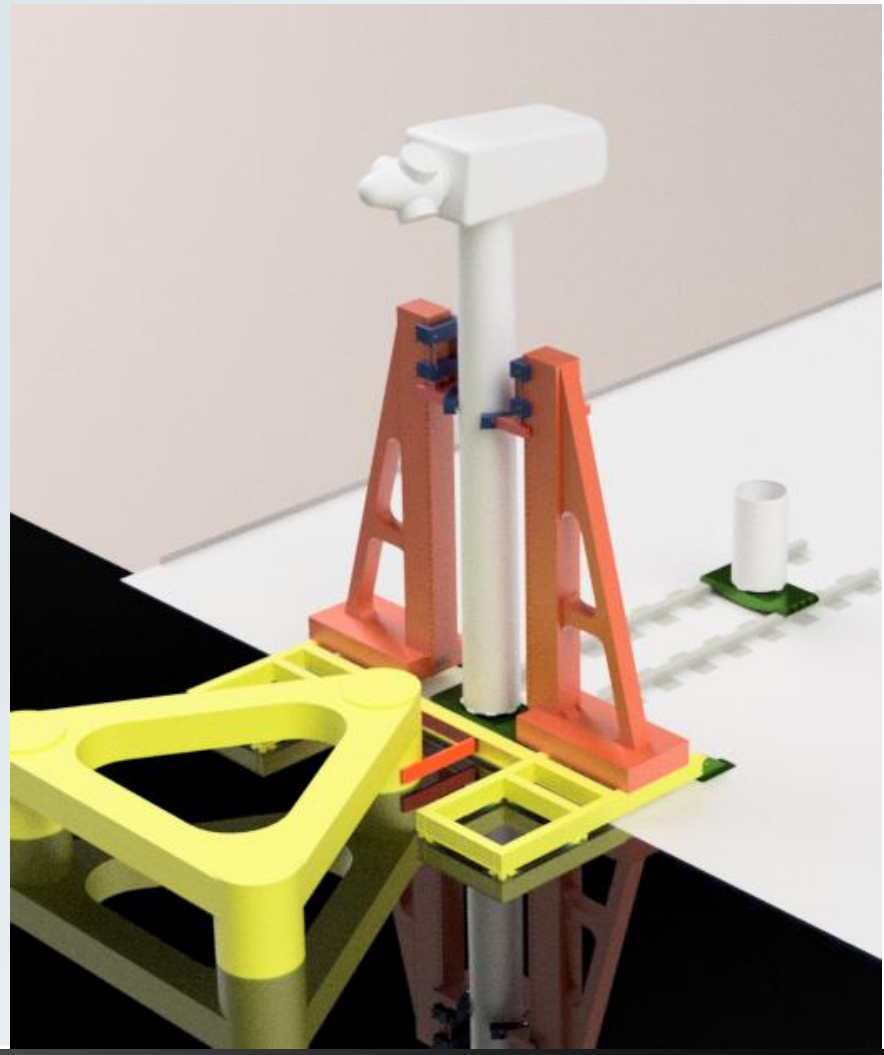
Osbit WTG Quay System – Build Storyboard

Middle Tower Section skidded into Jacking system

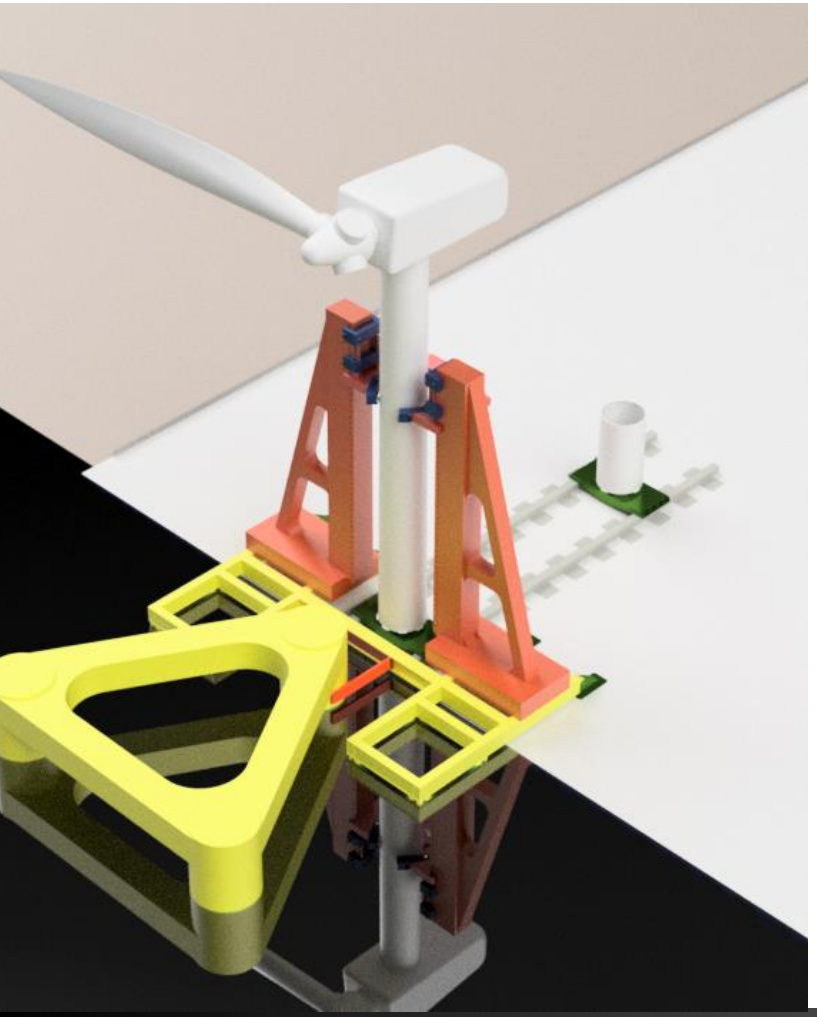
Upper Tower lowered onto Middle Section – connection made

WTG held on both Lift Beam & Skidding Frame

- Stable hold point created
- Wind loading capabilities dramatically improved



Osbit WTG Quay System – Build Storyboard



Prior to final build & lift – Blades are installed

- Install at reduced height
- Double Tower supports remain engaged
- Crawler crane with fly jib, or integrated handling tool

Osbit WTG Quay System – Tower configurations

All combinations of Tower sections supported

- 4 piece – equal & varying length
- 3 piece – equal & varying length

Double Tower support remains

Osbit WTG Quay System – Build Storyboard

Lifting Beam Lowered – engages bottom of Middle Section

Tower Lifted

Osbit WTG Quay System – Build Storyboard

Lower Tower Section skidded in

Upper Tower assembly lowered

Connection Made

Double Supports remain until final assembly onto Floater

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Osbit WTG Quay System – Build Storyboard

Jacking System lifts Assembled WTG

Translates over Floater

Lowers Tower onto Floater

Connection made & Lift Beam disengaged

Tower translated onto quay

Floater towed away

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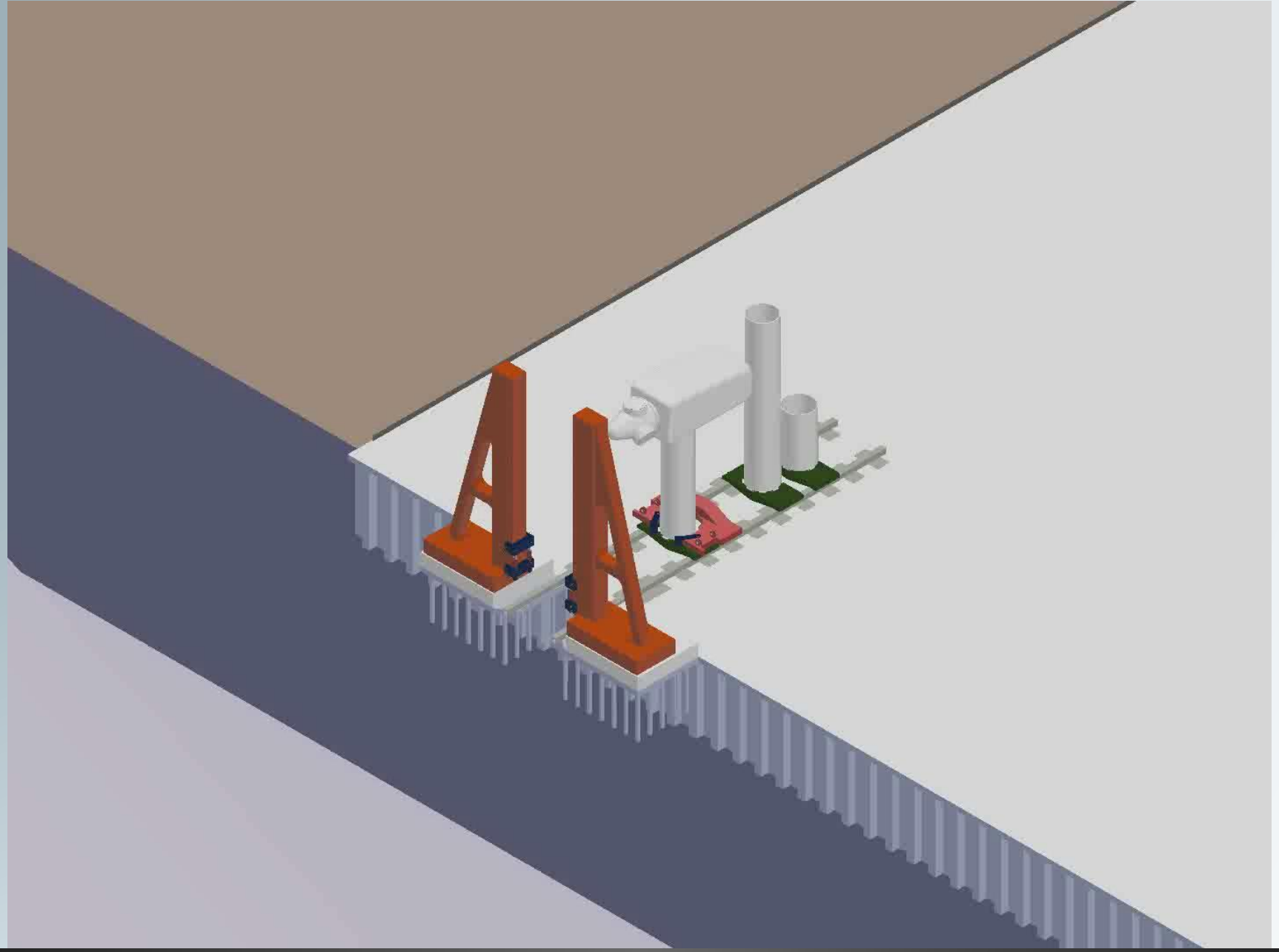
Osbit WTG Quay System – Quay arrangements

Site specific Quay arrangements

Translating Tower or Non-translating



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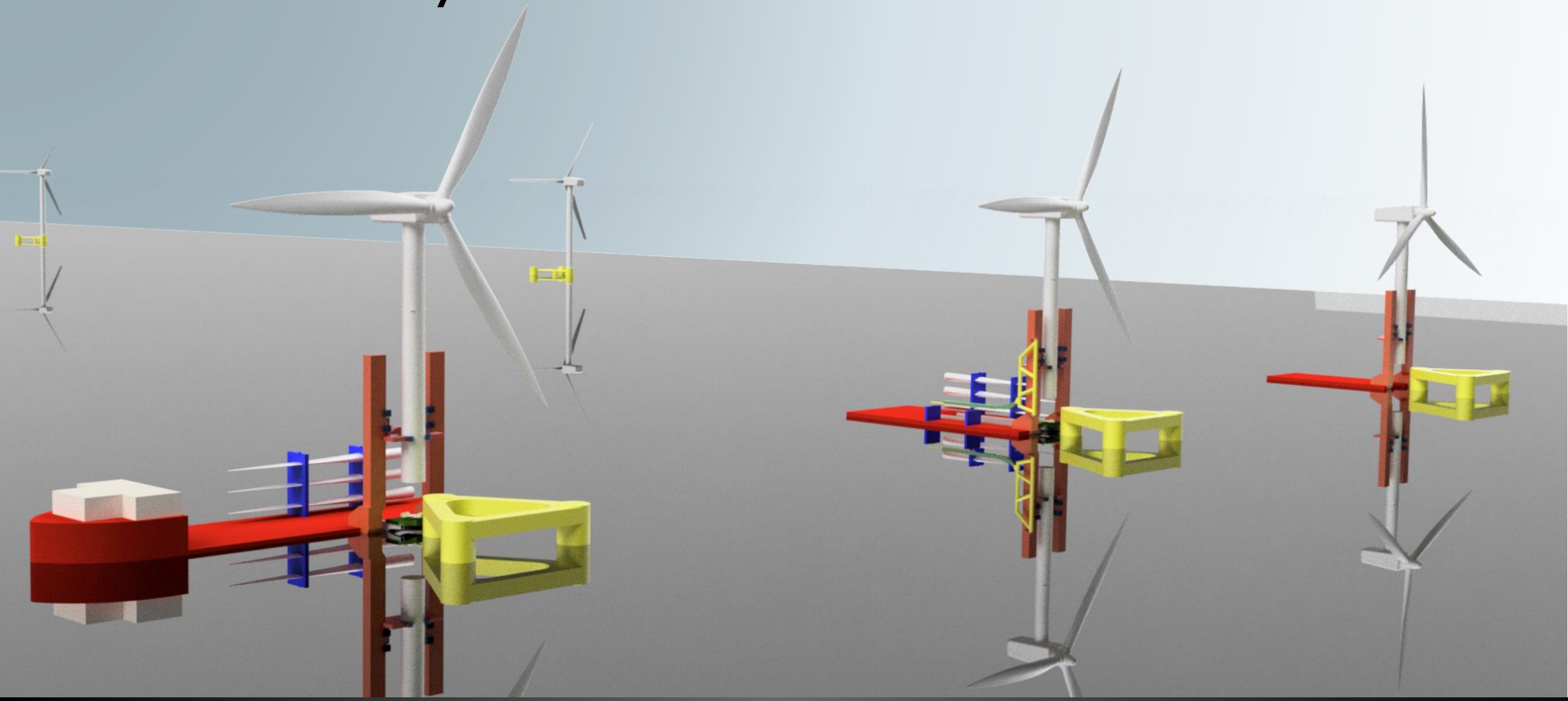
Osbit WTG Vessel System – Installation and Maintenance



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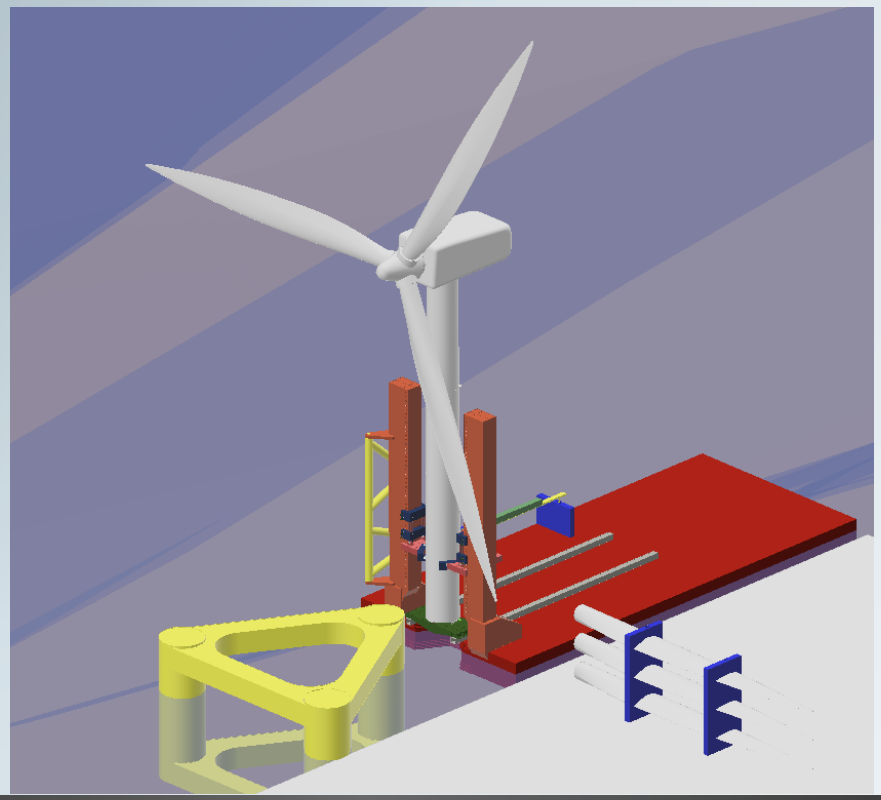
Osbit WTG Vessel System – Installation and Maintenance

Technology can be applied to lift barges & monohulls

Options to moor barge alongside smaller marshaling yards to enable otherwise restricted locations



Questions & Answers

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North of Scotland Offshore Wind Cluster

Arjan Keuzenkamp

Van Oord
Marine ingenuity

DeepWind
North of Scotland Offshore Wind Cluster

Sandra Eager

SENSEwind

SENSEwind

Installing and servicing turbines

higher... deeper... safer... cheaper... anywhere.

FOW Subgroup webinar

Wednesday 17 May 2023

JOHNSTON CARMICHAEL

www.sensewind.com

SENSE system: Self Erecting Nacelle and Service

Lower cost of energy
Eliminates need for expensive specialised vessels

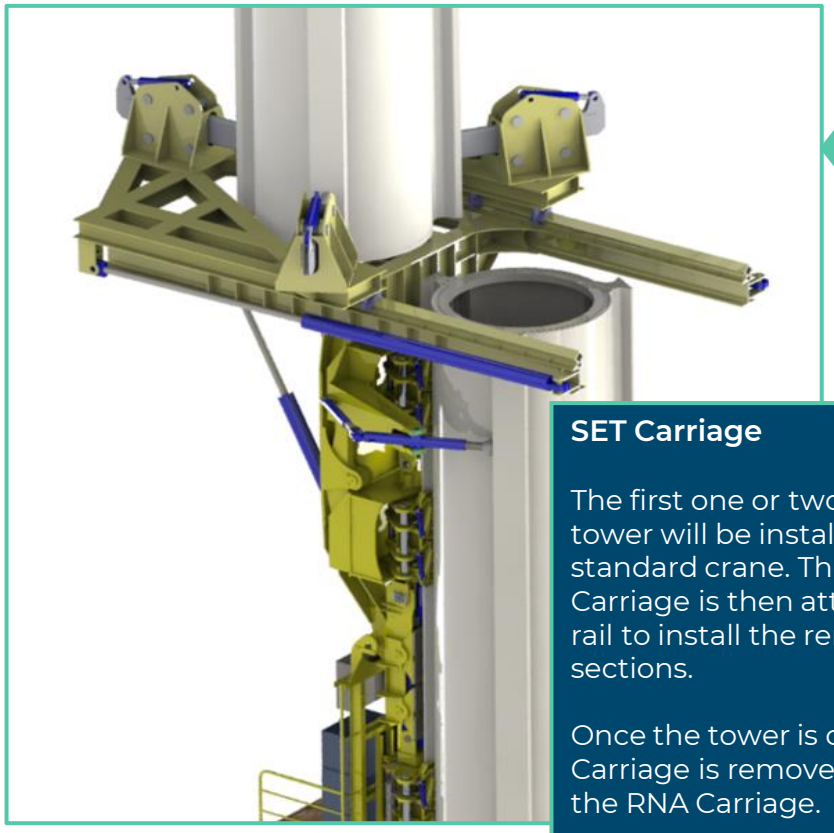
Safer and quicker
Automated heavy lifts, rapid installation

Higher availability
Quicker and easier exchange of major components

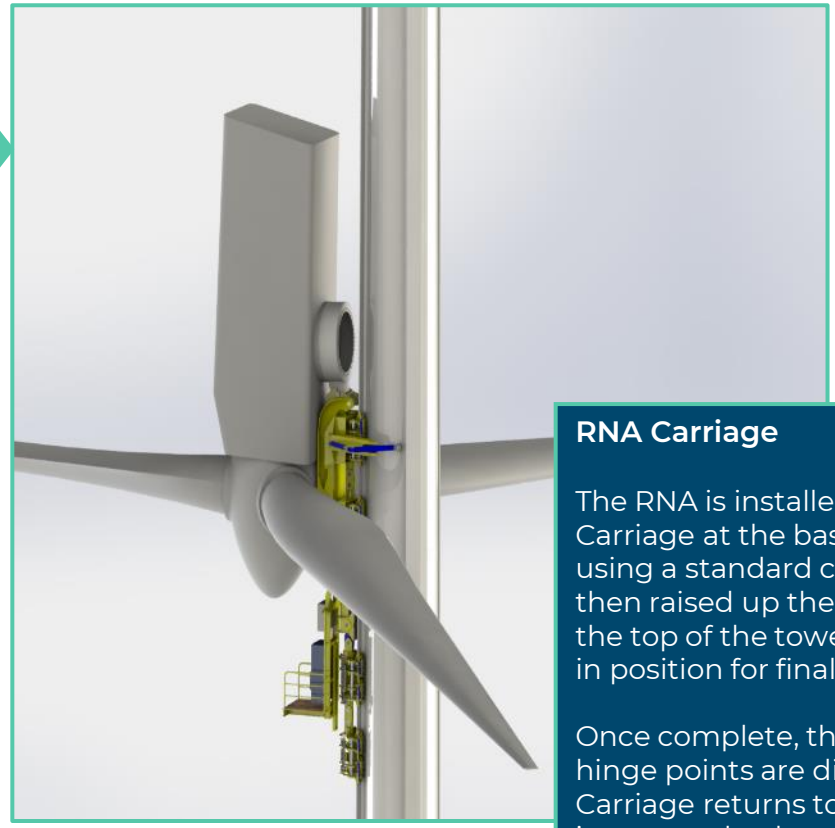
Explosion of new sites
Thought to be economically unviable

SENSE technology – installation

SENSE is designed to install and service large wind turbines without specialist large cranes. It can be used across onshore and offshore, fixed and floating wind projects, and is scalable to be compatible with any size of turbine.



The same SENSE lifting system is used in both SET and RNA Carriage configurations to install the complete turbine.



SET Carriage

The first one or two sections of a tower will be installed using a standard crane. The SENSE SET Carriage is then attached to the tower rail to install the remaining tower sections.

Once the tower is complete the SET Carriage is removed and replaced by the RNA Carriage.

RNA Carriage

The RNA is installed on the RNA Carriage at the base of the tower using a standard crane. The RNA is then raised up the tower, rotated at the top of the tower, and held safely in position for final bolting.

Once complete, the RNA Carriage hinge points are disconnected, the Carriage returns to ground level and is removed to be used on the next turbine.

Watch the animation: sensewind.com

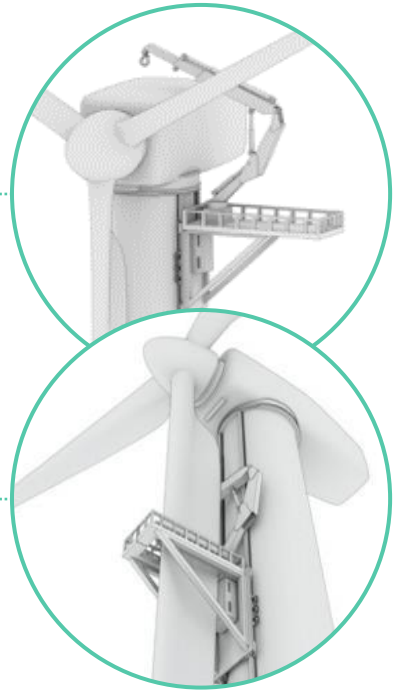
SENSE technology – operations and maintenance

The SENSE system is used throughout the life of the wind farm, providing a cost-effective service and safe access for rapid response and high availability.

Service Platforms

Service platforms utilise the tower rail system and provide a stable platform for undertaking in-situ repairs and inspections works.

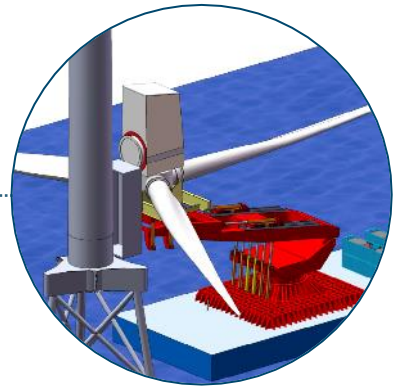
The blade inspection platform also allows for fast and efficient individual blade replacement.



Vessel to Tower ("V2T") Transfer System (under development)

The V2T is a mechanism to transport fully assembled RNAs on the carriage using commonly available construction vessels. The carriage is then transferred to the tower for installation.

The V2T can also be used for installation and for maintenance as part of a service exchange strategy.



SENSE value proposition

SENSE allows for easier, safer and more cost-effective installation, maintenance, and major component replacement. SENSE can significantly reduce the LCoE for offshore and onshore wind projects: Lower CapEx, lower OpEx and reduced construction risk.

Undertake inspections and maintenance without tall cranes

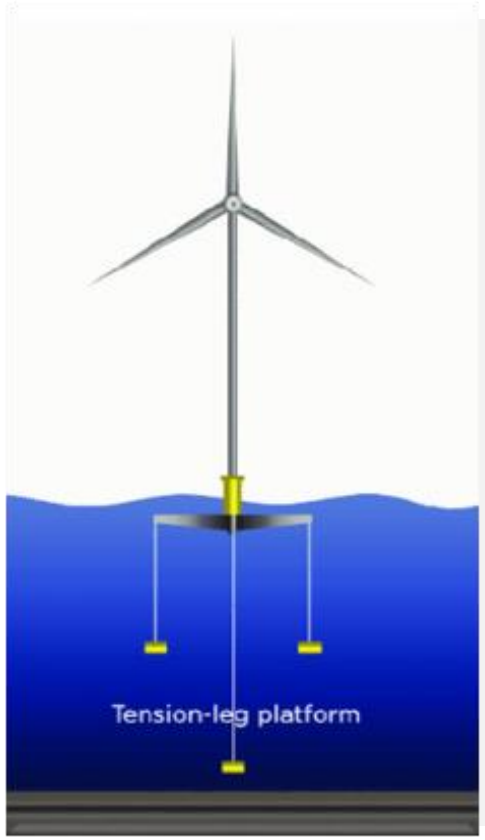
No large, expensive cranes or crane vessels for RNA installation

Reduces the number of lifting operations during installation

Eliminates the requirement for handling systems to repair/replace major components

Indicative cost savings – offshore floating wind

SENSE has the potential to reduce costs for different floating foundations, with the most obvious benefits observed in TLP and semi-submersible solutions.



Tension-Leg Platform ("TLP")

Without SENSE

- Complex offshore installation due to foundation being unstable prior to anchoring.
- Challenge of completing O&M in-situ – float back is not practical so a floating vessel is required.

With SENSE

+ Tower self-erects at quayside.
+ Foundation tow-out with nacelle at tower base lowers the centre of gravity.
+ Nacelle lift performed on site following anchoring.
+ Significant cost and risk reduction compared to maintenance by a floating exchange vessel.
+ Maintenance platform aids external repairs and inspection.

Saving	£740m
LCoE	-9%
Opex NPV	-18%

"Results are based on the current specifications of the SENSE technology and existing supply chain and vessels and are consequently considered highly conservative.

XODUS

Modelling methodology: based on a ScotWind project with NE7 characteristics. 500MW installed capacity, grid connection at Peterhead, installation port at Nigg and 25 years of operations.

Indicative cost savings – offshore floating wind

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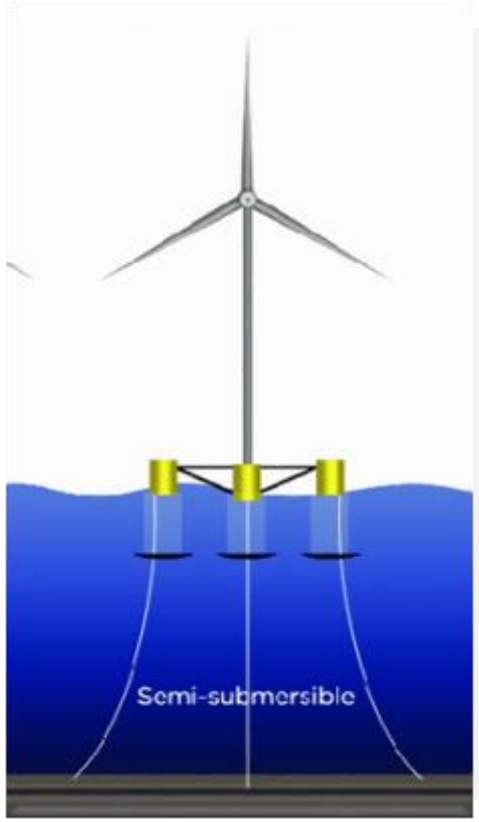


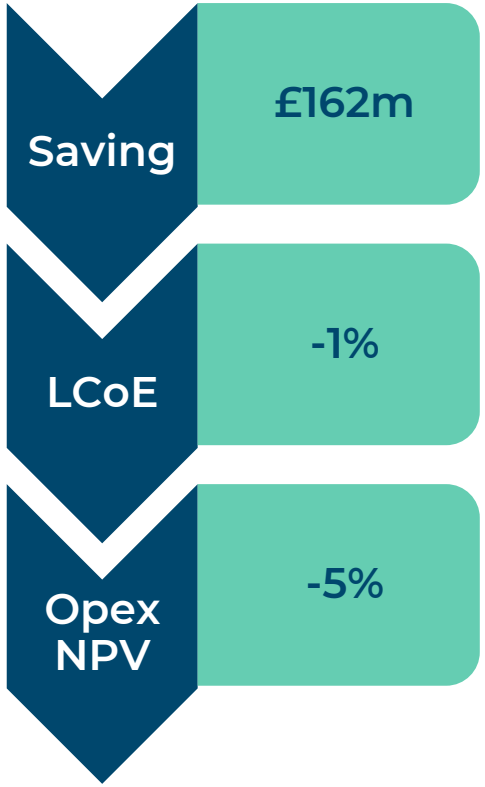
Semi-submersible

Without SENSE

- Requires a very large onshore crane to install the turbine prior to float out.
- Floater tow-to-port or in-situ component exchange are costly and time consuming.

With SENSE

+ Reduction in installation complexity.
+ Tower self-installs.
+ Nacelle lifted onto SENSE carriage at the base of the tower section.
+ A smaller crane is required at the quayside.
+ Significant cost reduction using a floating exchange vessel rather than tow-to-port for maintenance.
+ Maintenance platform aids external repairs and inspection.

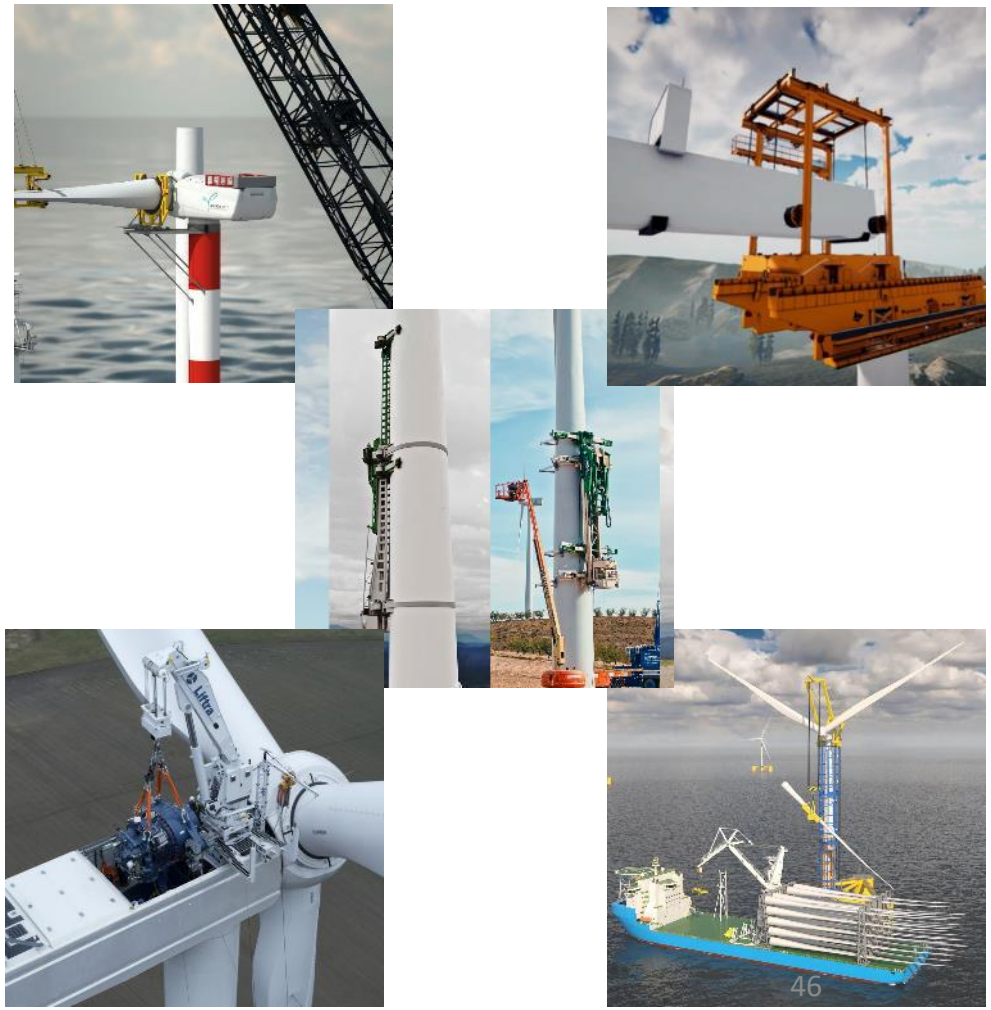


Modelling methodology: based on a ScotWind project with NE7 characteristics. 500MW installed capacity, grid connection at Peterhead, installation port at Nigg and 25 years of operations.

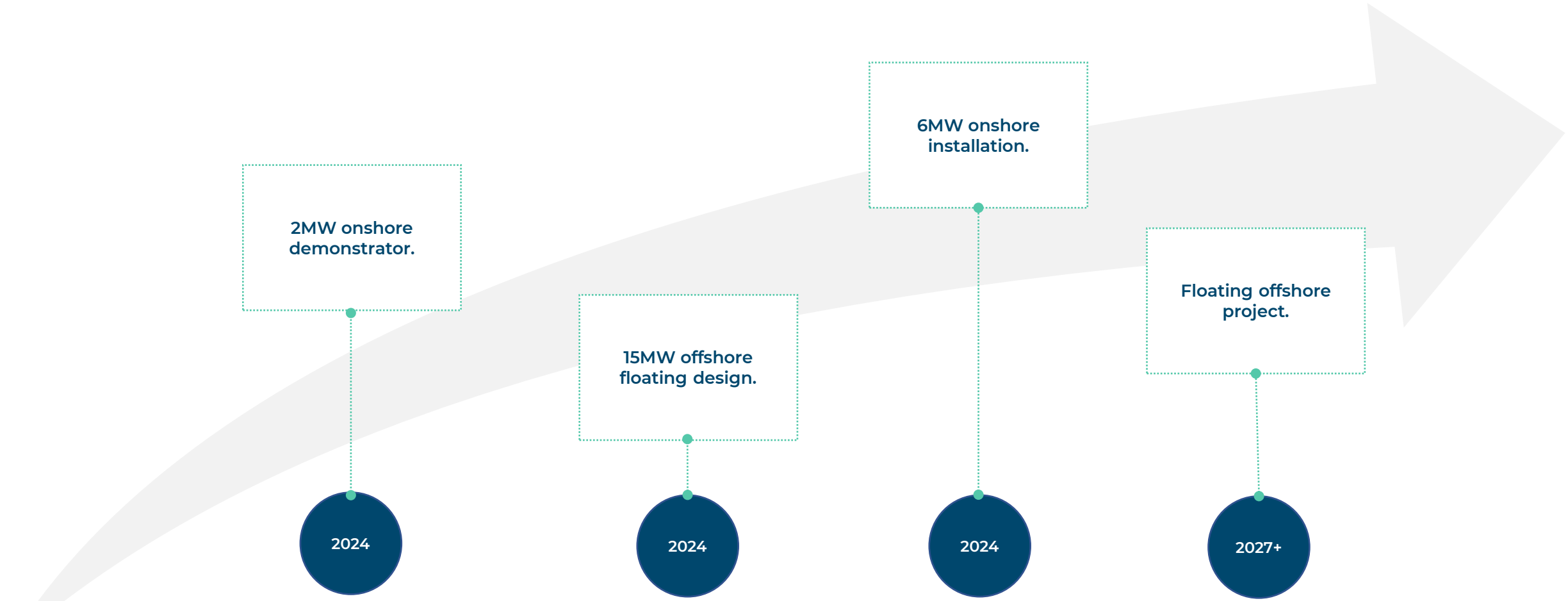
SENSE is differentiated from the competition

Some proposed solutions resolve some of the problems the market faces. SENSE is the only solution which resolves all the problems – cradle to grave.

- ✓ Small, lightweight, and cost effective
- ✓ Single carriage system for both tower and RNA installation
- ✓ Suitable for onshore and offshore
- ✓ Rapid installation time
- ✓ Critical components assembled at low level
- ✓ No jack up vessel requirement
- ✓ Optimised weather window utilisation
- ✓ Avoids components dangling from a wire at height
- ✓ Stable service platforms for safer maintenance



Next steps


2MW onshore demonstrator.
2024
15MW offshore floating design.
2024
6MW onshore installation.
2024
Floating offshore project.
2027+

Partners and collaborators

Technology partners

Glosten
PELASTAR

SENSEwind

SUBSEA MICROPILES

Delivery partners

GREEN MARINE
ENERGY SUPPORT SERVICES

GEODIS

GMC

CREADIS

HOULDER

CATAPULT
Offshore Renewable Energy

XODUS

Collaborators

Duncan Plant

aerotrope

industrial systems and control

Funding and incubation support

JOHNSTON CARMICHAEL

Department for Business, Energy & Industrial Strategy

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North of Scotland Offshore Wind Cluster

David Taylor

SKYLIFTER®

A Game Changer

SkyLifter Air-Crane:

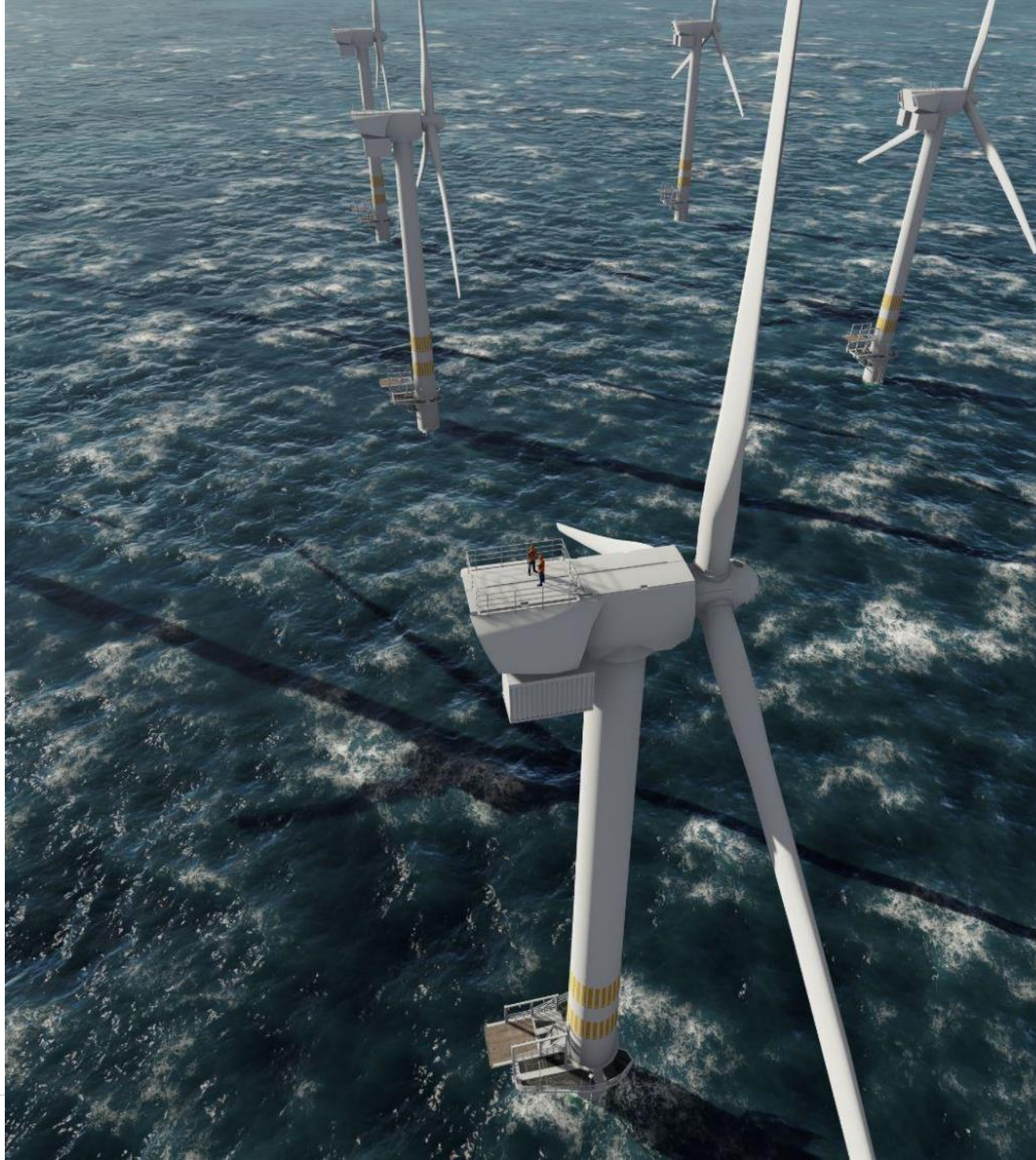
DeepWind Offshore Cluster FOW Subgroup

offshore wind Scotland

The Problem

Main Component Exchange

- Floating Cranes
  - Expensive
  - Slow
  - Susceptible to sea conditions
  - Not enough available
- Towing to Shore
  - Expensive
  - Slow
  - Susceptible to sea conditions
  - Service interruption



Competition

Current lifting methods

- Conventional floating crane
- Wind turbine towed to shore
- Leg encircling floating crane
- Uptower cranes/climbing cranes

Crew/Load Transfer problem to Vessels

- Jack-up crane: not for FOW

250 Tonnes, Any Height, Any Reach

SkyLifter Design

- Aerostat, Control Pod, Pilot/Crane Operator, Motors, Batteries, Winches, Hook, Water Ballast
- Lifting Gas in Aerostat
- Unique lens shape - can move in any direction
- Changes direction instantly, holds position precisely
- Electrically powered, no CO2, no URN
- 180m diameter, low centre of gravity = stable platform and stable hook
- Unaffected by sea conditions
- 80km/h top speed, much faster than floating crane
- No height or reach limitations
- Load stabilisation, load positioning

Indicative Specifications

Load Transportation

- Load/Blade drawn up to and connected with control pod
- Prevents load pitch, roll and yaw during transportation

Indicative Specifications

SkyLifter Capabilities

- 2,000 km range
- Reach Hornsea 1 wind farm in 1.5 hours (120km) offshore
- Flies maintenance crews and tools safely to site and back
- MCE Procedure validated by a leading FOW operator
- 1,000 tonne SkyLifter possible
- Highly innovative designs: Design rights, 2 patents, more to follow

Cost of Main Component Exchange for a Single WTG

Current Hire Cost

Total

€4.4M over 39 days

Crane from quay to barge €10k, 1 day

Barge from port to pylon €147k, 21 days

Sea Crane transfer and install €4.25M, 17 days

SkyLifter Hire Cost

Total

€0.6M over 6 days

SkyLifter collect & install €600k, 6 days

SKYLIFTER

Faster and Smarter

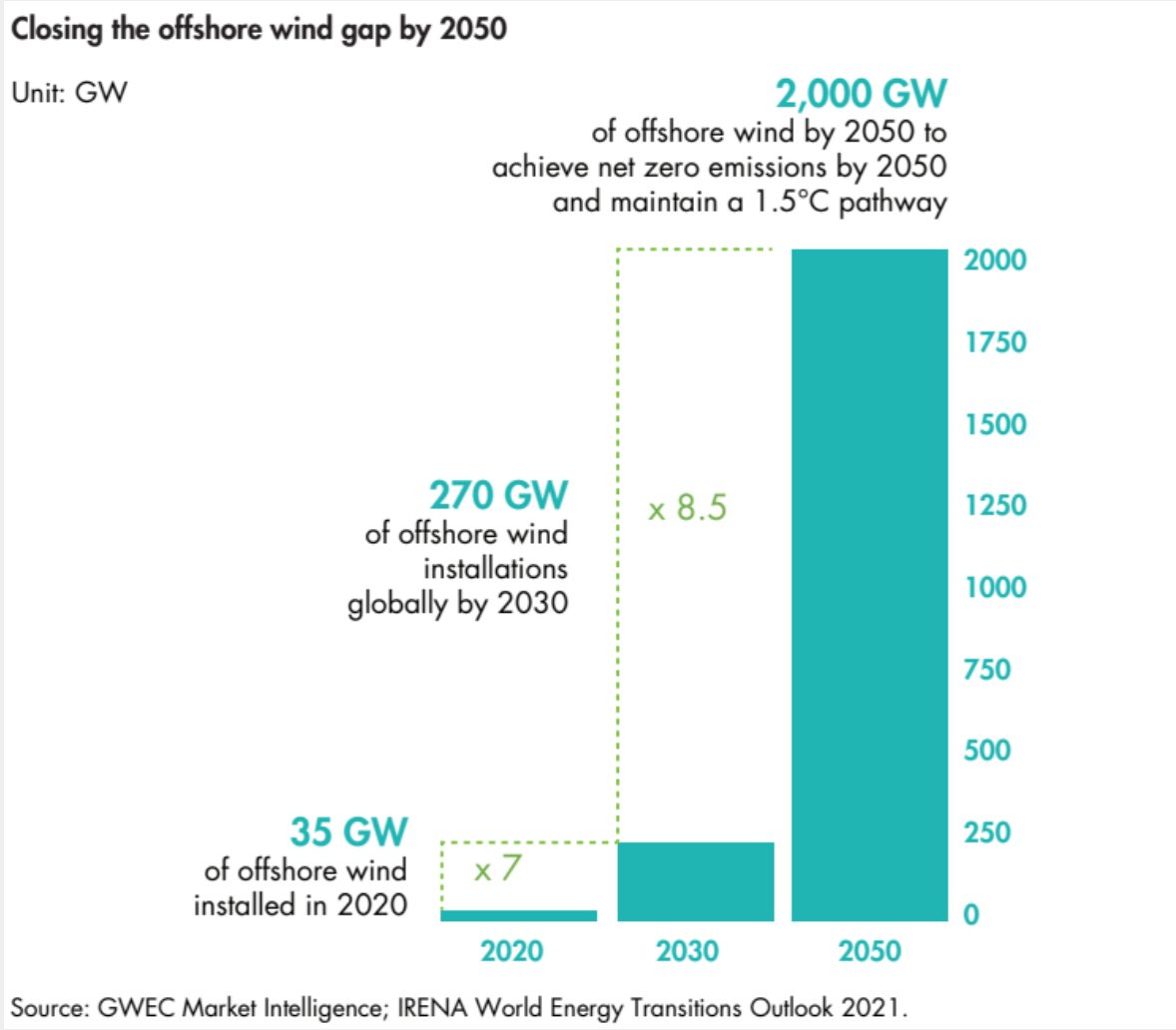
Offshore Wind

Total & Addressable Market

- 2,000 GW by 2050
  - 100,000 x 20 MW WTG addressable
  - 10,000 WTGs need to be maintained each year

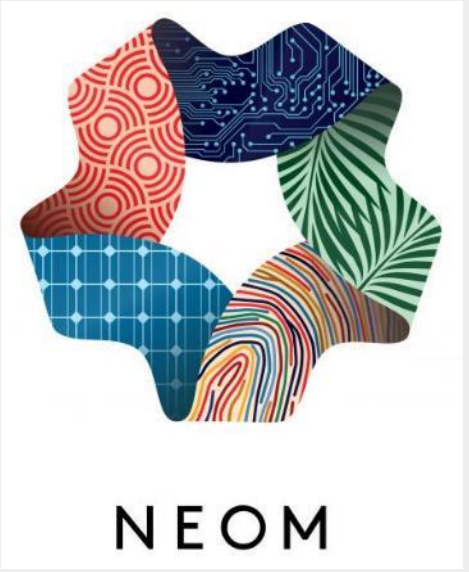
- Costs to service 10,000 WTGs pa:
  - 1,538 x Floating Cranes: €44.6BN pa
  - 235 x SkyLifters: €5.88BN pa

7 times faster = 7 times less expensive



Market Traction

- Bringing together parties who will benefit from SkyLifter's availability for building, repairing and maintaining WTG offshore and help bring SkyLifter to the market
- Parties who might pre-order or hire SkyLifters
- Early adopter advantage: Price and Equipment



Industry Experts

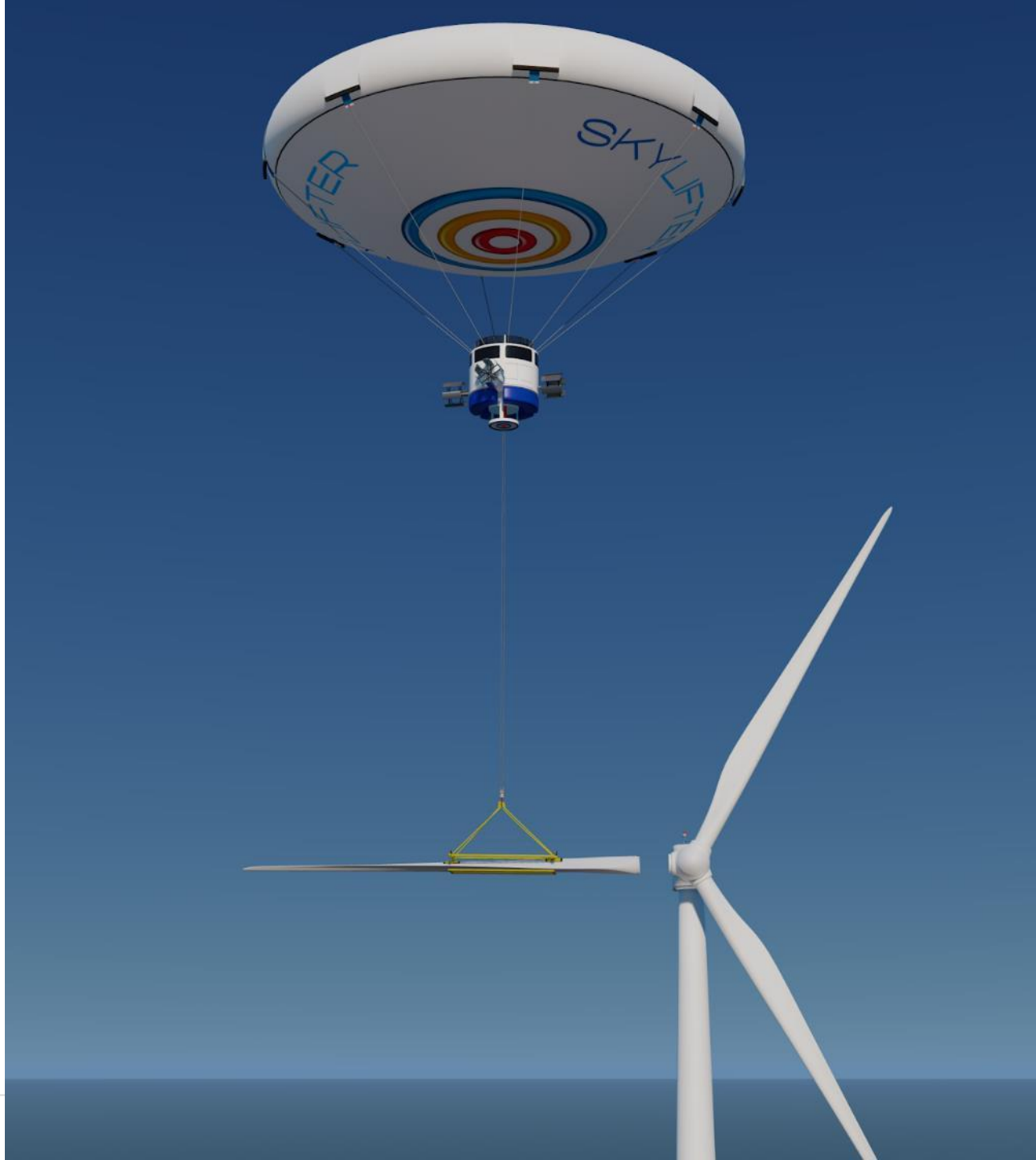
Best in class HIGHLY EXPERIENCED TEAM

- Design, Engineering, and Manufacture
- Safe Operations & Certification
- Maintenance and Service
- Commercial, Finance & Legal
- Project management

In Summary

SkyLifter Air-Crane

- SkyLifter is a Flying Crane, Load Transporter and Crew Carrier
- Solves the problem of Main Component Exchange
- Major reduction to the cost of operating Offshore Wind Farms
- Major time savings
- Vital tool to accelerate move to Net Zero CO2 and Global Energy Security



Thank You!

skylifter.eu

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Q&A Session

Thank you

Email:- paul.obrien@hient.co.uk

Image: Principal Power

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Floating Offshore Wind Subgroup