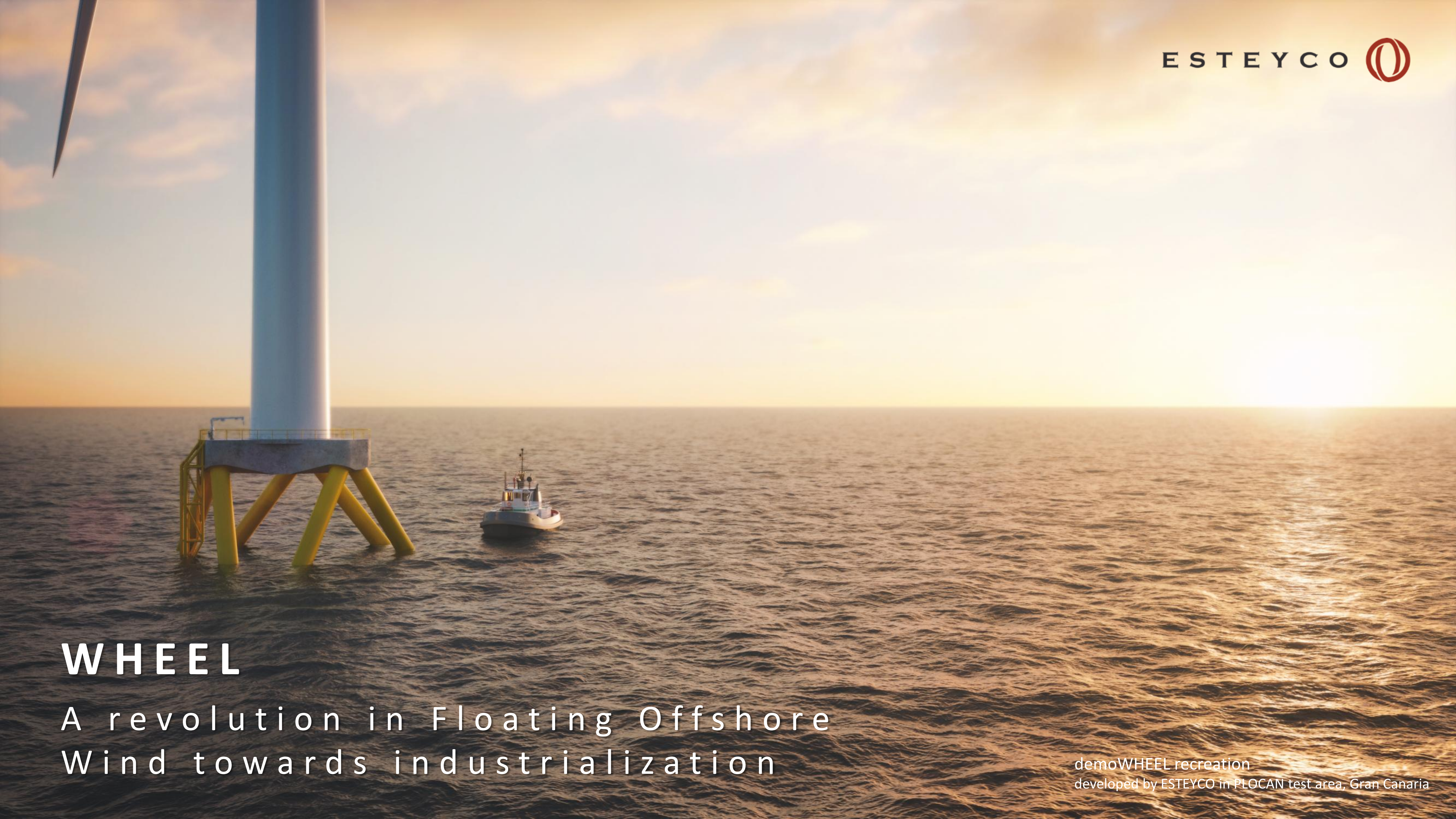
ESTEYCO



WHEEL

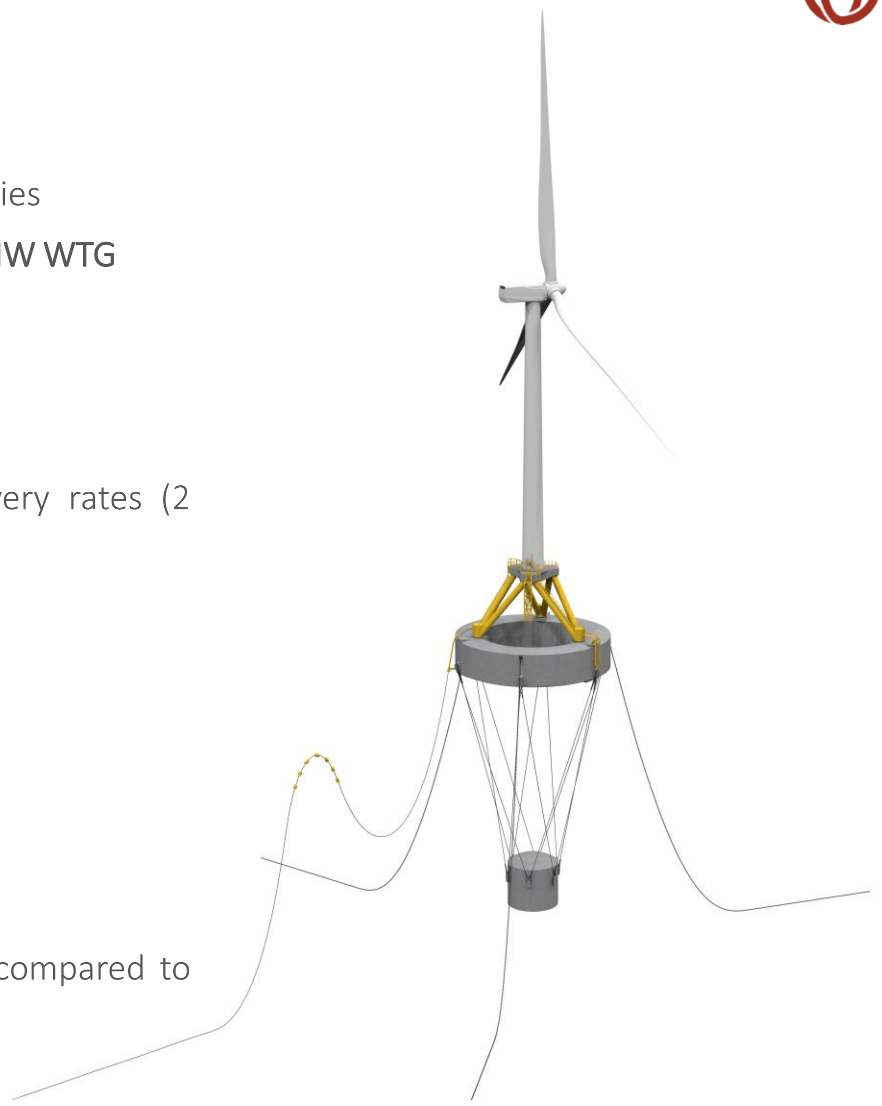
A revolution in Floating Offshore Wind towards industrialization

demoWHEEL recreation
developed by ESTEYCO in PLOCAN test area, Gran Canaria

WHEEL technology

Main Competitive Advantages

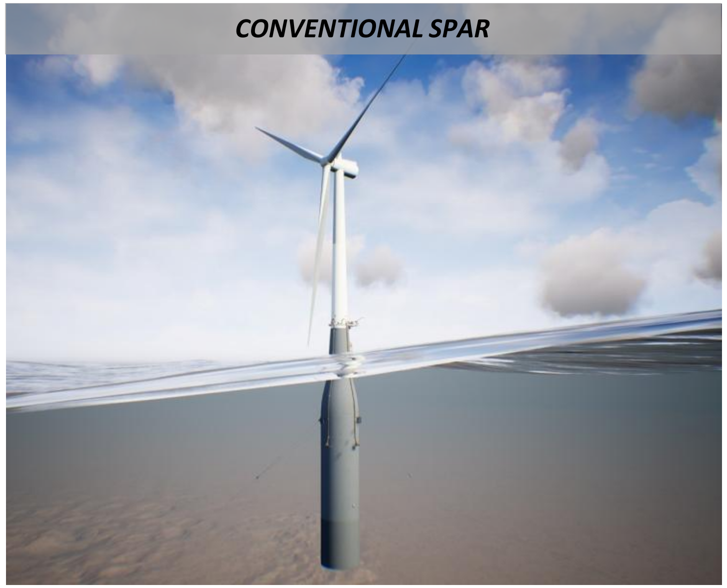
- ✓ Significant CAPEX reduction compared with other floating solutions
  - Based on well-known concrete construction techniques, available in almost all the countries
- ✓ Compact and low-draft: no more than 60m diameter and around 5m draft for float-off for 20MW WTG
  - Wide range of ports availability
- ✓ Fast industrialized production: caisson type configuration
  - Low-cost concrete construction strategies (barge-based)
  - Reduced construction yard area (less than 10Ha). 3 units/month construction delivery rates (2 production lines)
  - Overcome expected bottlenecks in floaters supply chain (steel and concrete)
- ✓ Ultra stable configuration: excellent seakeeping performance and slow motions
  - Very high mass inertia leading to high pitch natural periods ~ 40s
  - Low water plane area leading to high heave natural periods ~ 50s
- ✓ High stability and hydrostatic stiffness: no need for Active Ballast Systems
- ✓ Low-carbon and circularity enhancement
  - Less than a half material than a concrete semisubmersible and significant reduction compared to steel solutions
  - Marine life regeneration strategies linked to decommissioning (sanctuaries)
- ✓ Compatible with ATOMS technology for on-site Major Component Replacement
  - Also compatible with tow-to-port strategies, but available for a more competitive and de-risky alternative

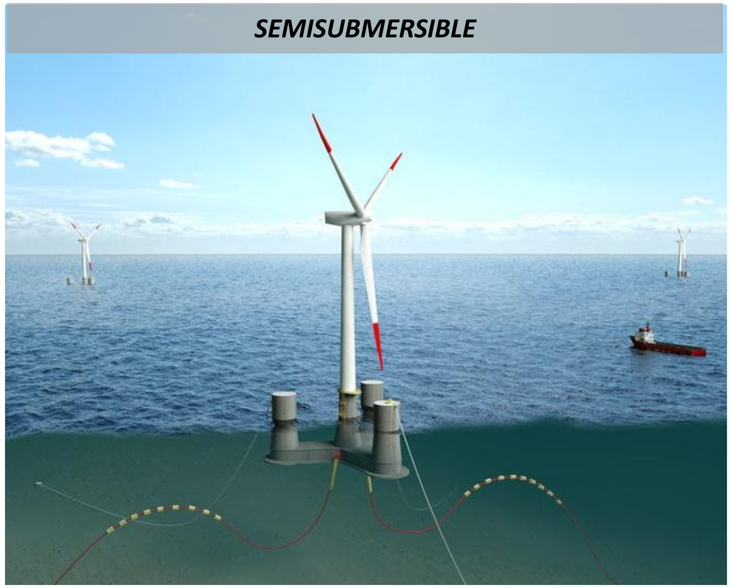


demoWHEEL recreation
by ESTEYCO

WHEEL technology

Current technologies: qualitative summary of pro & cons

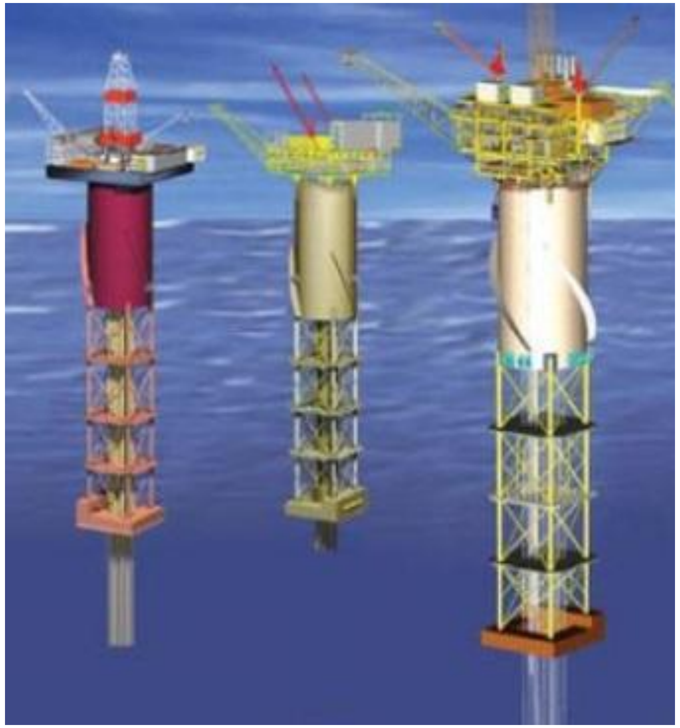


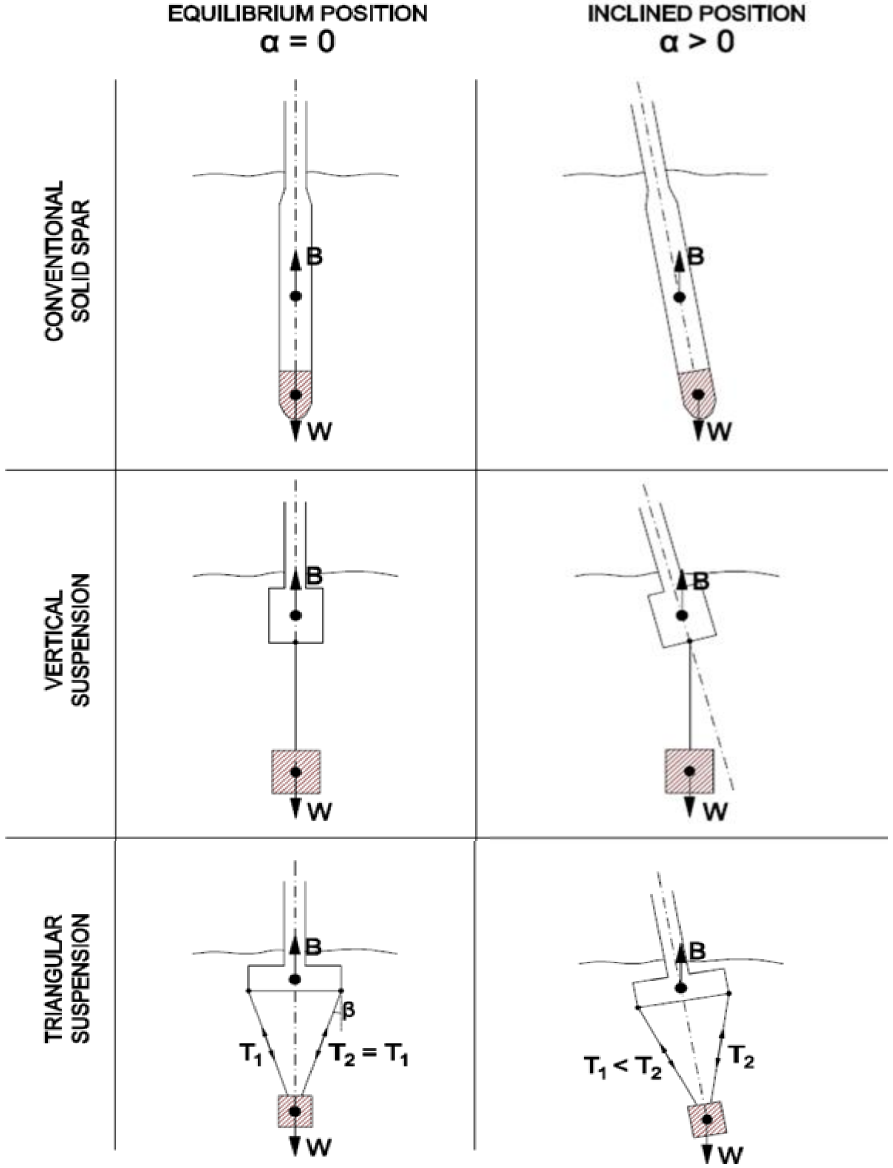


	MATERIAL USAGE	CONSTRUCTION SIMPLICITY	WTG ASSEMBLY PROCESS	FORCES ON MOORING	TRANSPARENCY TO WAVE LOADING	NATURAL PERIODS FAR FROM ACTIVE WAVE PERIODS	REDUCED SIZE AND DRAFT FOR LOAD-OUT / FLOAT-OFF
CONVENTIONAL SPAR	√	X	X	√	√	√	X
SEMI	X	≈	√	≈	≈	≈	X
BARGE	≈	√	√	X	X	≈	≈

WHEEL technology

Background





WHEEL technology

General overview of the technology

Evolved floating spar foundation for unparalleled **reduction in floater width, harbour draft, material use and carbon footprint.**

Solidary suspended ballast tank

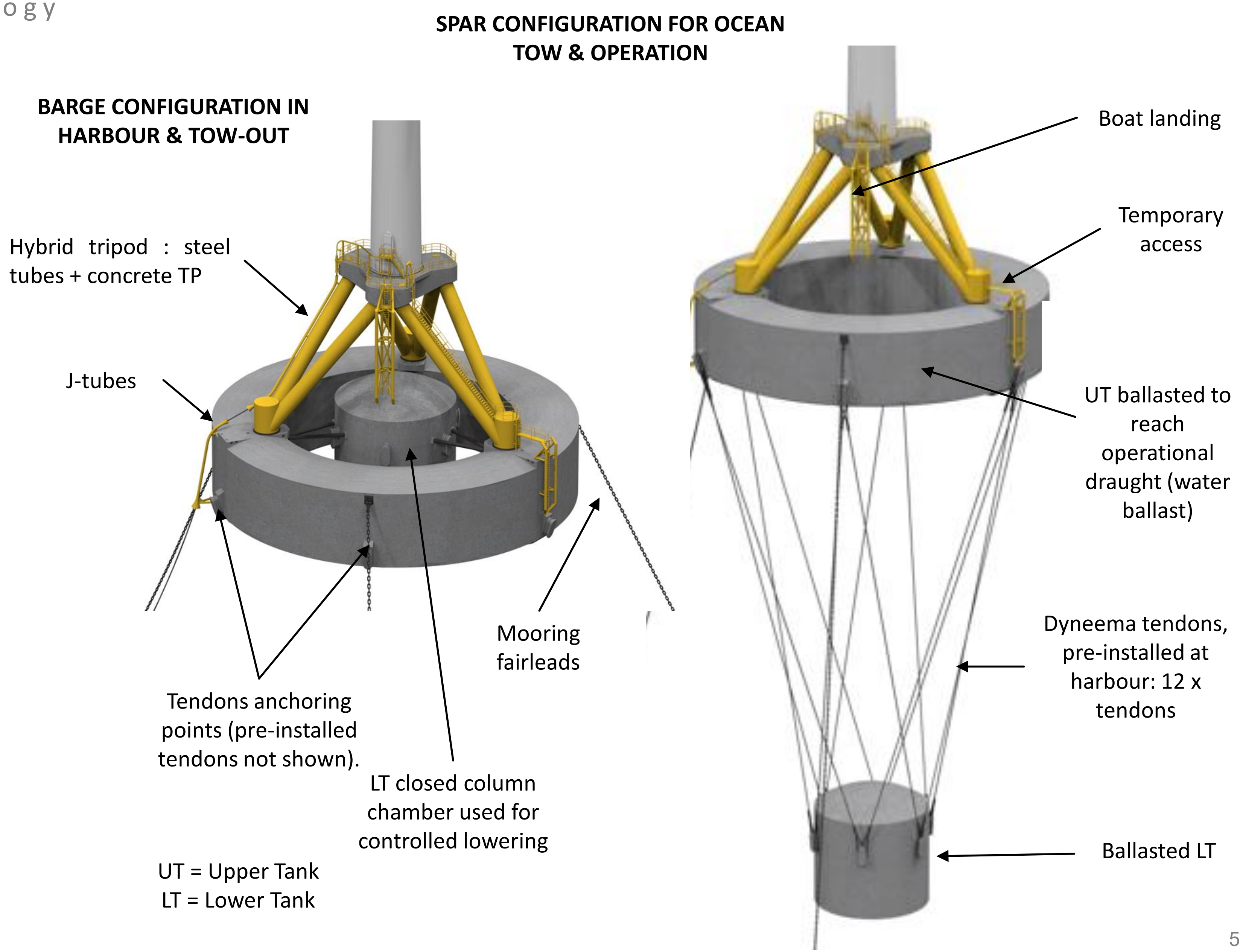
Patented by ESTEYCO © 2014

Barge Type configuration in harbour:

- Full onshore assembly like semisubs with much lower width, draft and material
- Caisson type construction

Ultra stable Spar configuration in operation:

- Transparency to sea loading
- Lower mooring costs
- Large mass inertia and very high natural periods for excellent seakeeping performance and very slow motions



WHEEL technology

Competitive advantages

WHEEL delivers simultaneously the two key advantages of the two main existing floater concepts:

- full on-shore assembly of the floater & WTG (like semisubs)
- high transparency with very low water plane area (like spars) for reduced motions, loading and mooring.

Reduced mooring as compared to equivalent concrete semisub or barge solutions.

Slow motions:

- Provide high mass inertia in operation leading to slow motions and high pitch/roll/heave natural periods in excess of 40s
- Deliver maximum accelerations and inclinations comfortably below design thresholds (in the vicinity of 50% of the typical limit values)

Reduced material usage: Less than half than a concrete semisub!

Fast industrialized production: simple geometries in the concrete tanks, well-suited for industrialized low-cost concrete construction strategies and allow for barge-based construction processes

Compact and low-draft: Maintain reduced beam (50m for 15MW) and low draft in harbour (5m for 15MW) for harbour selection flexibility and simplified yard & load-out requirements and means. Also, very relevant for scalability

High stability and hydrostatic stiffness: ABS is not required

Very Low Carbon Footprint (Less than half that a steel semisub)

Allows for on-site Large Corrective Maintenance (LCM)

	MATERIAL USAGE	CONSTRUCTION SIMPLICITY	WTG ASSEMBLY PROCESS	FORCES ON MOORING	TRANSPARENCY TO WAVE LOADING	NATURAL PERIODS FAR FROM ACTIVE WAVE PERIODS	REDUCED SIZE AND DRAFT FOR LOAD-OUT / FLOAT-OFF
CONVENTIONAL SPAR	√	X	X	√	√	√	X
SEMI	X	≈	√	≈	≈	≈	X
BARGE	≈	√	√	X	X	≈	≈
WHEEL							√

WHEEL technology

Manufacturing and assembly

<u>Lower tank & upper tank: CONCRETE</u>

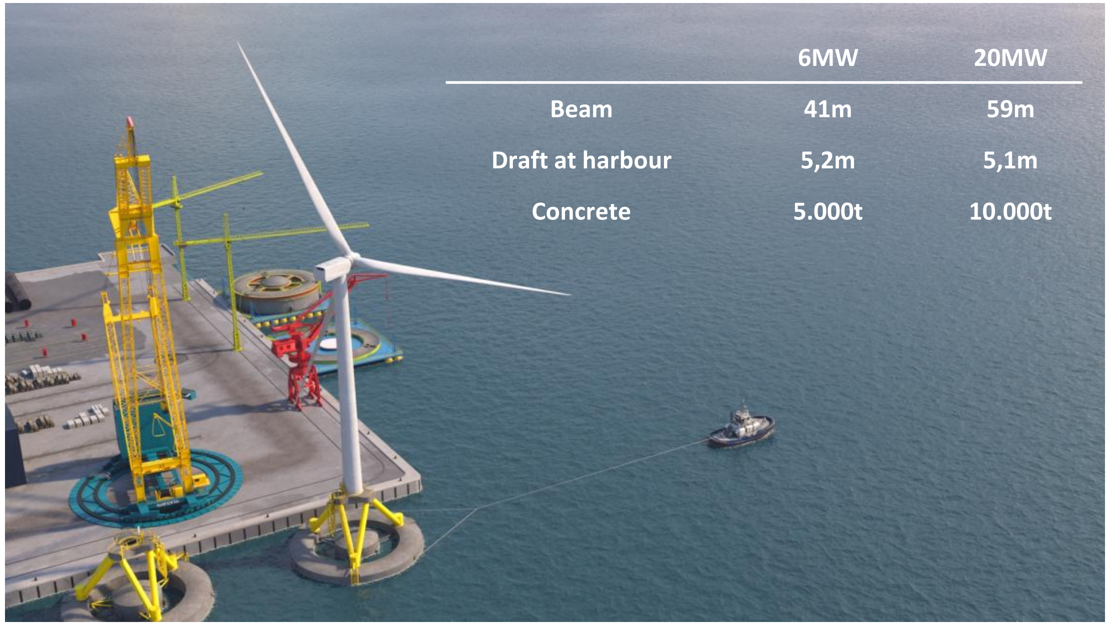
- Compact and Low Draft
- Both tanks built together at the same level
- Simple caisson like geometry for low-cost industrialized construction & load-out strategies (commercial semisub barges adapted / AIRBARGE© modular barges)
- Reduced construction yard area
- 3 unit/month construction delivery rates (with 2 production lines)
- Suitability of most harbours
- Very Intensive in Local Content

<u>Transition Piece: STEEL TRIPOD</u>

- Tubular Tower-like elements: 6MW ~ 200t; 20MW ~ 600t
- Preassembled on yard
- Robust Maintenance-free connection

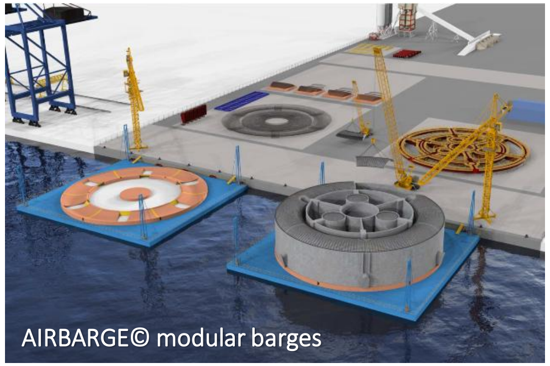
<u>Assembly:</u>

- Barge configuration: fully assembled on harbour in vertical position
- Suspension tendons completely pre-assembled
- Tripod, tower, WTG could be installed in a single operation with the same crane



	6MW	20MW
Beam	41m	59m
Draft at harbour	5,2m	5,1m
Concrete	5.000t	10.000t

Suitable for emulating serial mass production strategies very successfully used with concrete caissons



AIRBARGE© modular barges

WHEEL technology

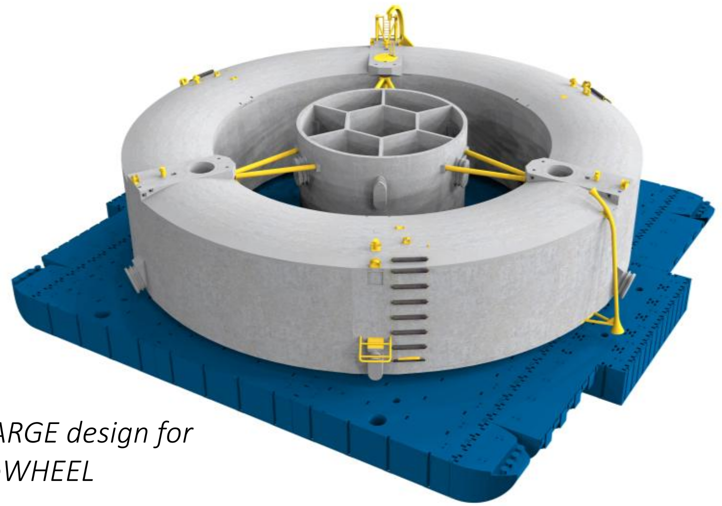
AIRBARGE: Afloat construction

Based on existing and proven modular barges which provide reliable, economic and available means very well suited for the construction and float-off of the floaters.

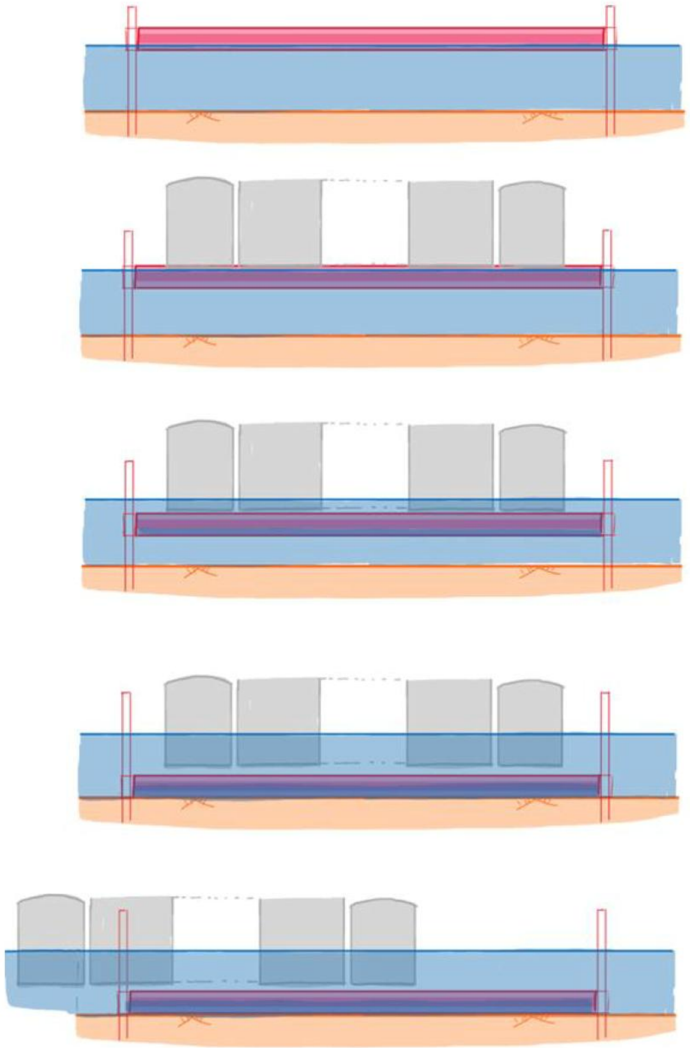
Direct construction of concrete floaters onto floating barges emulating concrete caisson construction

Very cost effective, it reduces harbor infrastructure requirements

Its modularity and linked size flexibility makes it possible to emulate concrete caisson techniques with floaters of virtually any size in any port



AIRBARGE design for demoWHEEL



Step 1: Modular pontoon platform ready to support the fabrication of the floater. The platform will use spuds to maintain position and serve as guides for vertical movement (but not as vertical load bearing elements). Platform draft due to its self-weight and will typically range between 0.4 and 0.5m depending on the type of module used.

Step 2: During the fabrication of the structure the draft of the barge will gradually increase as weight of the structure being built increases.

For most foreseen applications the construction can be completed maintaining a minimum freeboard, but it is also possible to partly submerge the structure before it is complete, thus reducing the total weight to be carried by the barge.

Such weight will remain well centred and will not require ballasting of the barge to compensate for eccentricities (which would in any case be possible if required). As a rule, the barge will remain unballasted during the whole construction process.

Step 3: The Airbarge is gradually ballasted in a controlled manner increasing the total draft until the concrete structure becomes self-floating (the WHEEL floater will become self-bouyant for drafts of approx. 4m and the ELISA GBS foundations for drafts of 5-6m approx.).

Step 4: The immersion of the barge continues until sufficient clearance between the barge and the self-floating concrete structure is reached. Submerged weight of the barge at this stage is near-zero. Reaching the seabed with the barge (as shown in the image) is only optional. The barge may also maintain a clearance with the seabed if deemed convenient.

Step 5: The floater is towed-out for wet storage.

The modular pontoon platform is deballasted and returns to the surface to initiate a new construction cycle.

WHEEL technology

Transport & Installation

Fully assembled units are towed-out with conventional tugboats.

In tow-out configuration, buoyancy forces press vertically one tank against the other, ensuring solidary behavior.

Deployment of lower tank is performed with ballast water with full control of lowering speed.

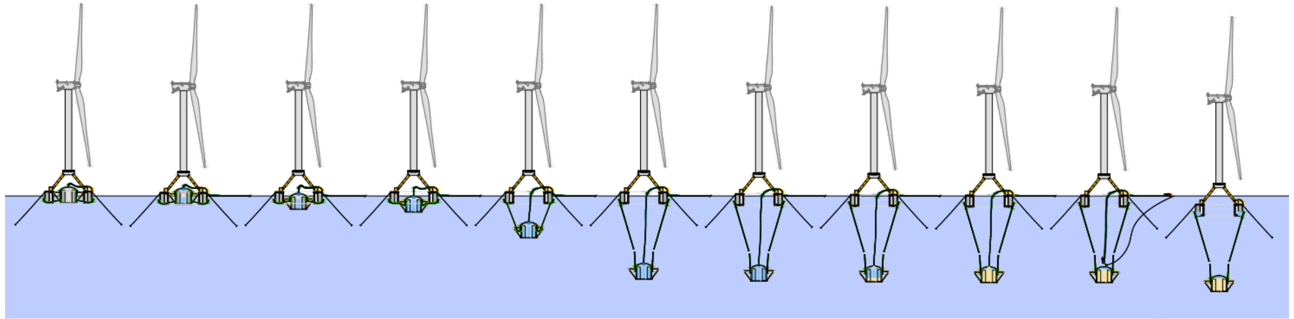
Lower Tank Deployment is a weather restricted operation (Hs<2m)

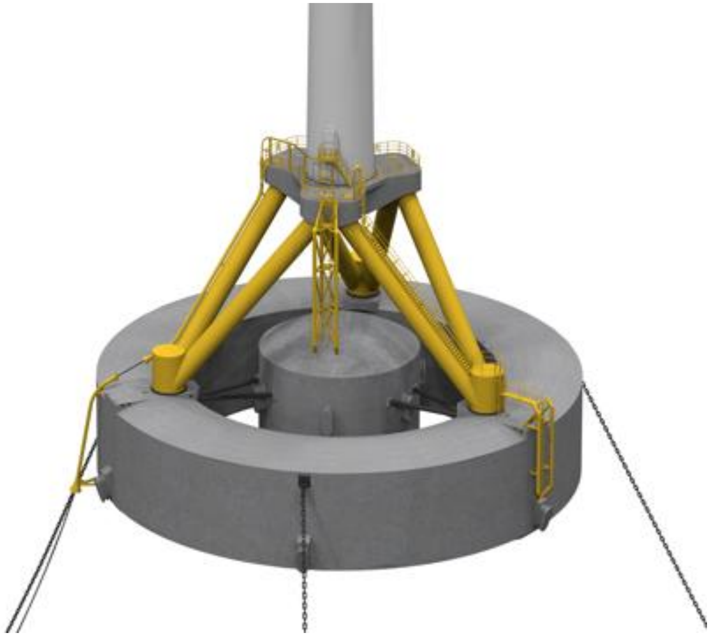
During Lower Tank deployment:

- the Upper Tank remains on the surface with large freeboard.
- Robust guiding fenders are provided between tanks
- Tendons self-deploy (no need for any external equipment).

Additional ballast weight is provided by partially filling the open chambers of the Lower Tank with sand.

The complete operation, processes and means have been analyzed in detail and validated by Boskalis.





WHEEL technology

Operation

Ultra Stable Spar configuration

High transparency with very low exposed area on the surface for reduced loading and mooring costs

Excellent seakeeping performance and slow motions

- Very high mass inertia leading to high pitch natural periods ~ 40s
- Low water plane area leading to high heave natural periods ~ 50s

Synthetic lines for suspension tendons

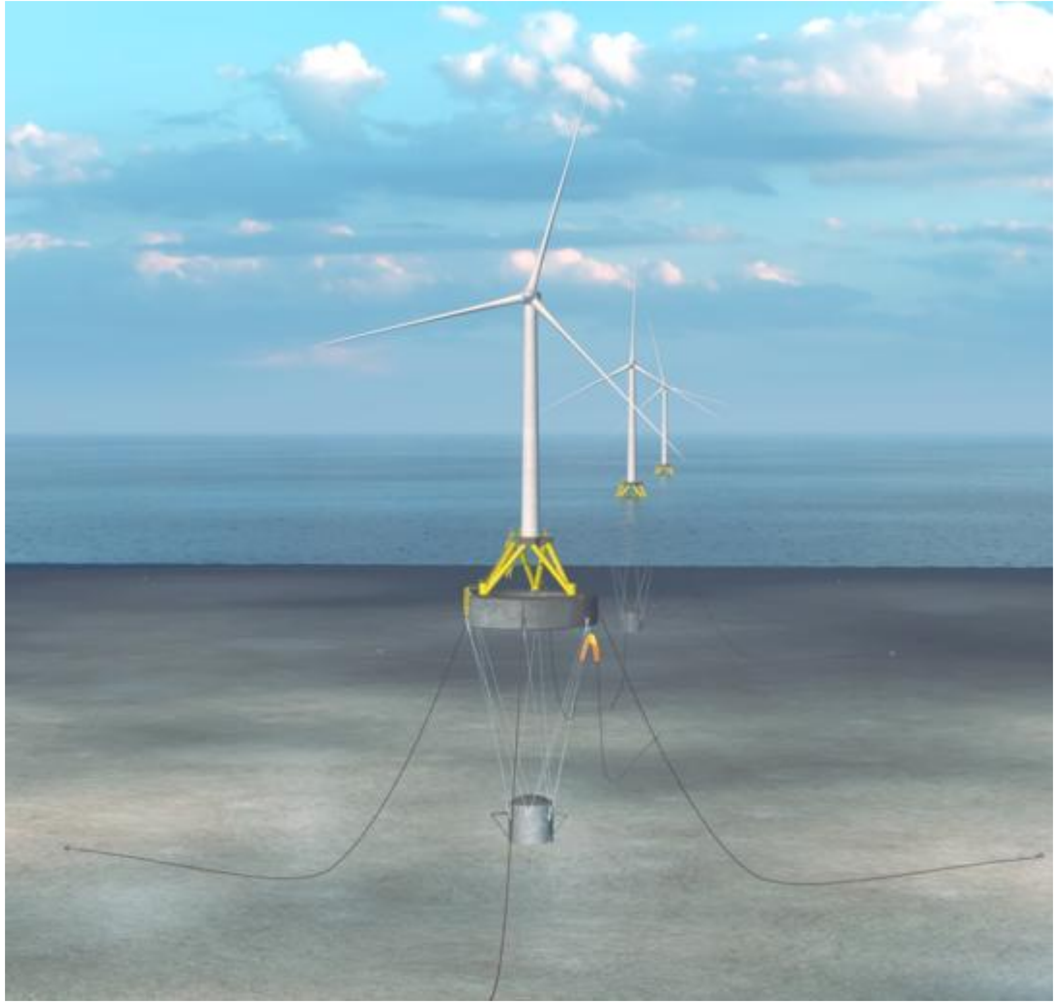
- Highly proven for multiple offshore applications
- Durable and maintenance-free
- Outstanding fatigue performance
- Redundant

Large water depth range (70m and beyond)

High stability and hydrostatic stiffness: No need for Active Ballast Systems

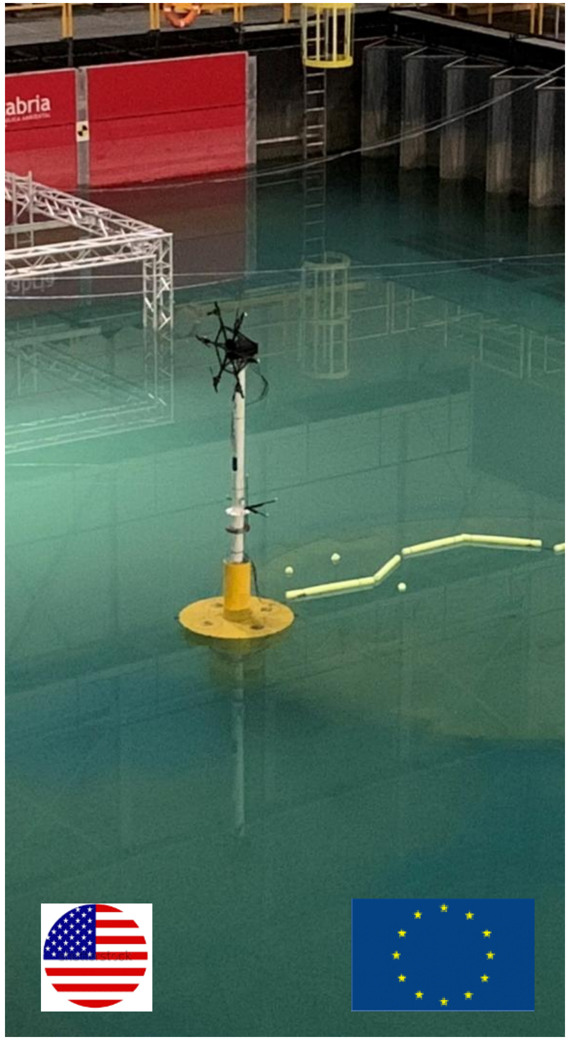
Low-carbon and circularity enhancement.

Compatible with ATOMS technology for on-site Large Corrective Maintenance



WHEEL technology

De-risking process



2015-2023

R&D (TOTAL>4.5M€)
H2020, ARCWIND, LEAF, NOWRDC

2018

ELISA PILOT UNIT
...AND COMMERCIALIZATION

2021

TETRASPAR PILOT BY SOT
(ESTEYCO HAS LICENSED SOT AND SAIPEM)

2026

demo WHEEL
FULL SCALE PROTOTYPE

WHEEL technology

Operation of an evolved spar – SOT Tetraspar

To date, the Tetraspar Demonstrator (licensed by Esteyco) has generated more than 37GWh of green energy

The 3.6MW Siemens Gamesa turbine and very high mean speeds at the MetCentre site combined to yield a capacity factor of 54%

In its first two years of operation, the availability was recorded at 97.0% and 98.3%, respectively.

For 2024, the availability has increased to 99.5% with a capacity factor of almost 63%

WHEEL technology

Maintenance strategy

<u>FOW Major Component Replacement strategies:</u>

Only commercial option for FOW: **tow-to-port** (average duration 40 days + very high cost)

As other floater concepts, **WHEEL is compatible with tow-to-port strategies**.

But we do believe that **tow-to-port** for MCR **may hold back FOW projects**

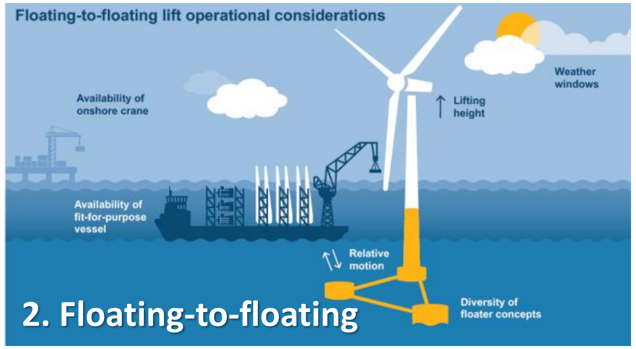
Today, there is **no other commercial solution** for on-site MCR. Working lines:

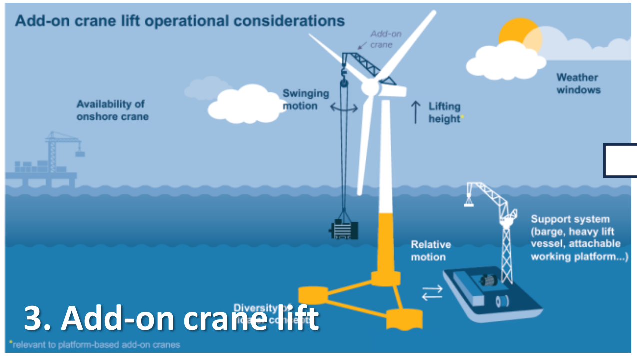
- Floating-to-floating lift → relative motion & availability of fit-for-purpose vessel
- Add-on crane lift → relative motion & support system

<u>ATOMS (ESTEYCO) + self-hoisting cranes (LIFTRA) on-site MCR:</u>

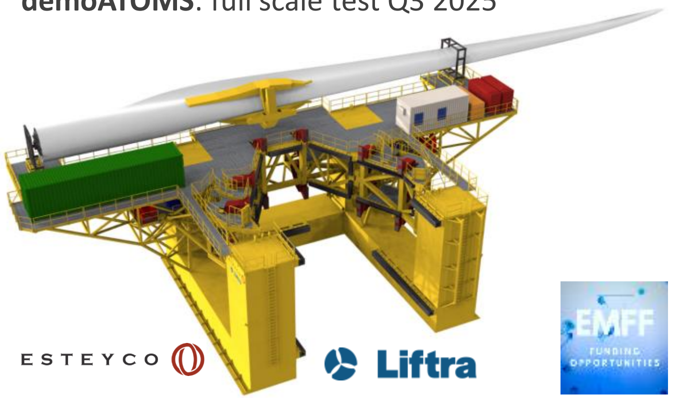
ATOMS gives the capacity to **couple to the substructure a solidary working deck** from which proven commercial **SELF-HOISTING CRANES** can be installed and operated to service the turbine.

ESTEYCO and LIFTRA have created **SOLVE WIND** to join forces to provide the market a competitive solution for onsite MCR for offshore wind, both for bottom fixed and floating.





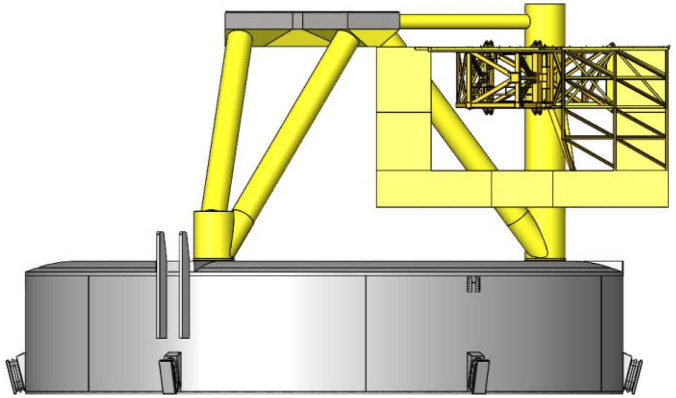
demoATOMS: full scale test Q3 2025

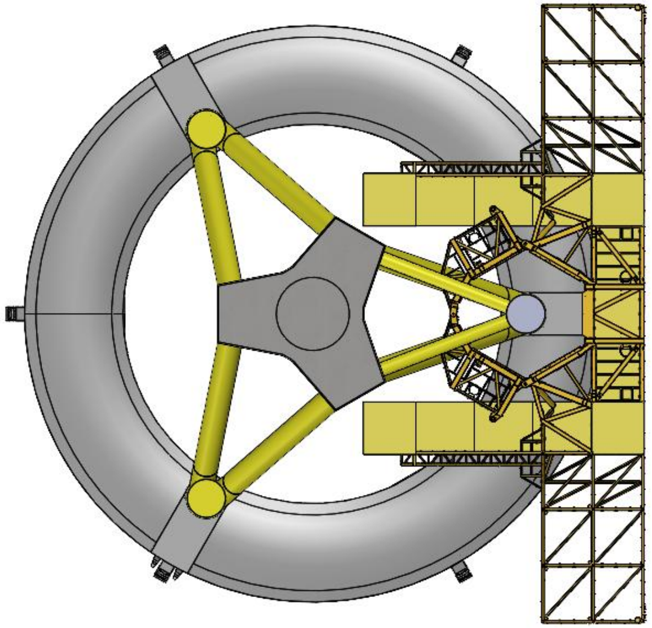


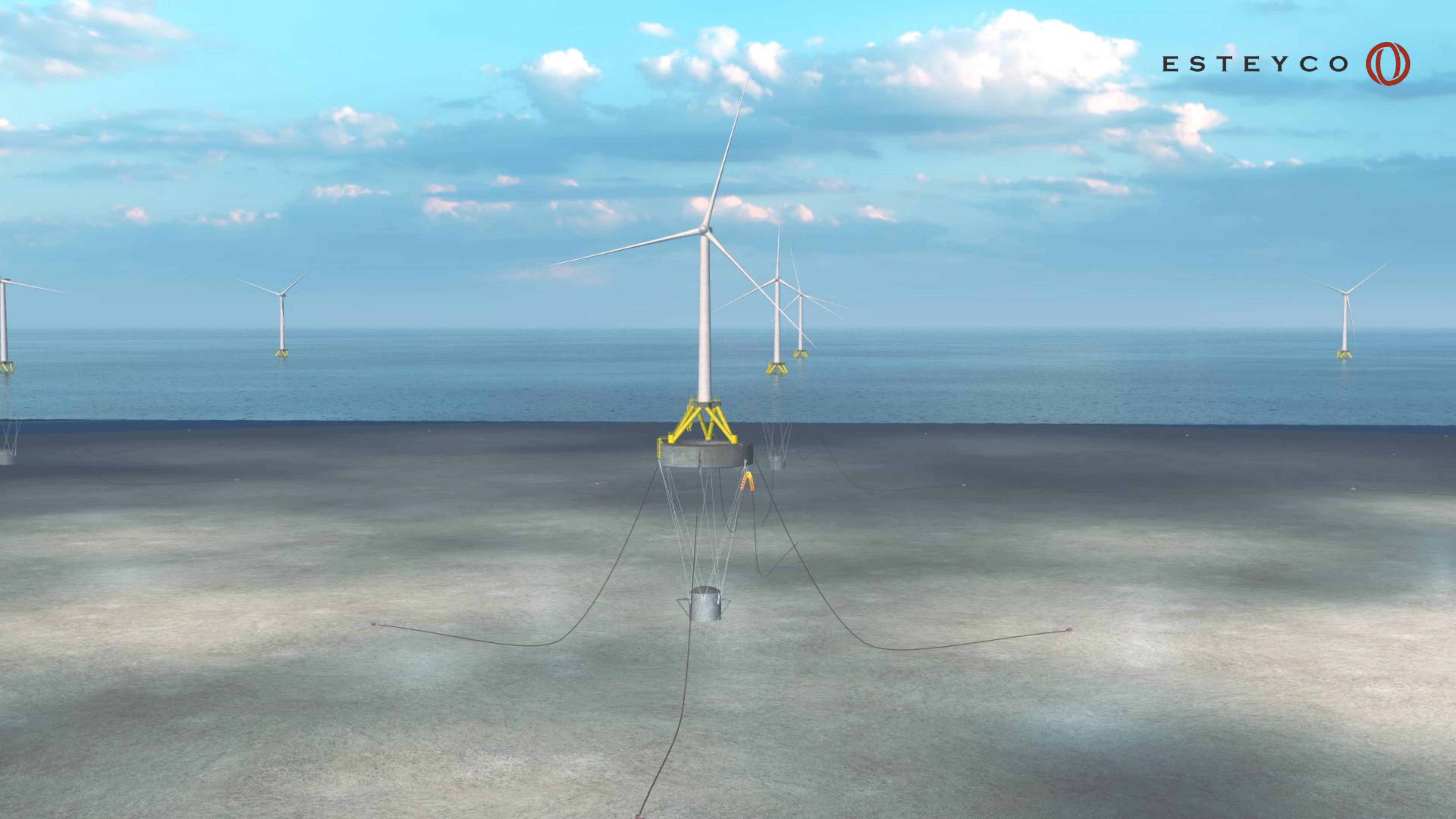
Project funded by the European Maritime and Fisheries Funds
Blue Economy SME Window call
EMFF-BEW-2019

The demoWHEEL project status

ATOMS demonstration – demoWHEEL strategy






ESTEYCO