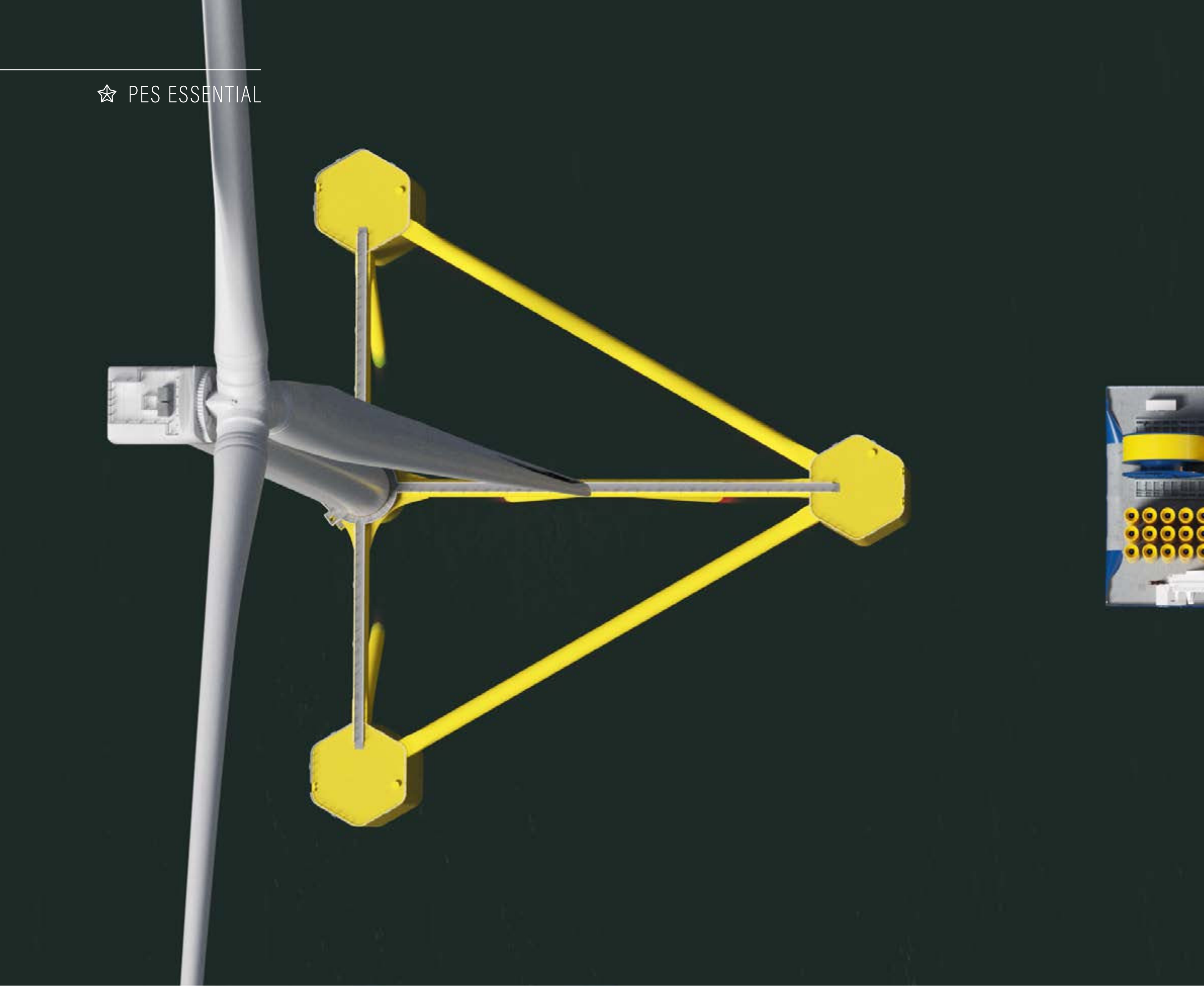
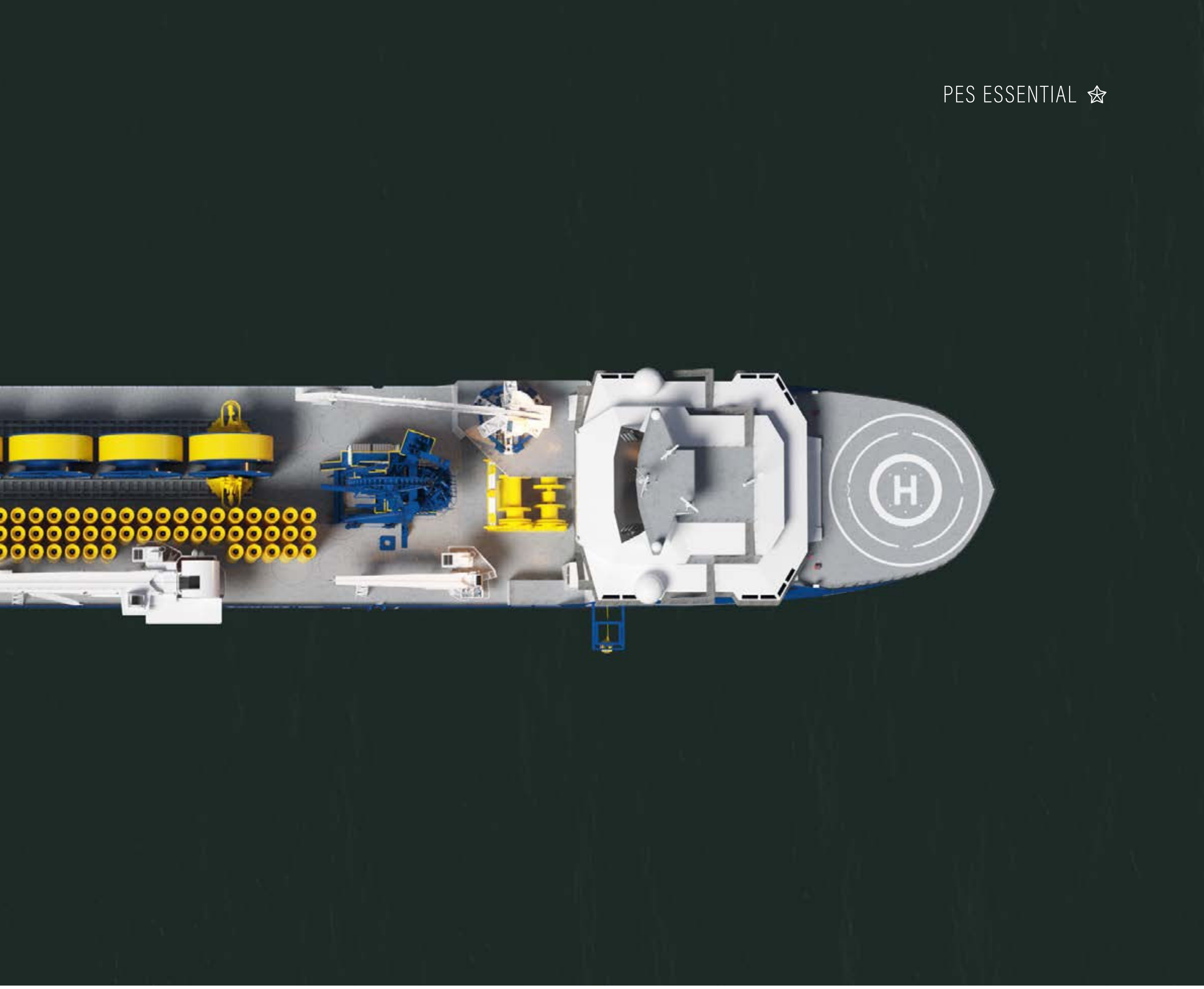


The next step for offshore wind and what it will take to get there

The global energy landscape is undergoing a significant transformation as the demand for clean, renewable energy sources continues to grow. Wind power, in particular, is playing a pivotal role in this transition. Floating offshore wind is a promising technology that holds significant importance in the renewable energy sector.



Unlike traditional fixed-bottom offshore wind turbines, floating offshore wind turbines are not limited to shallow waters. They can be deployed in deeper waters where wind resources are often more abundant. As each phase of a floating wind project intersects with the next the need to look from a holistic viewpoint is imperative. This will allow for the right solutions and strategies to be developed and ensure the flexibility in both to allow for the inevitable challenges that we will face as an industry ahead.

The new 'prize'

Developments in turbine design are leading to ever growing hub heights to increase the blade swept area in order to catch enough wind to maximize the output of these machines. This also needs the higher, more consistent wind speeds to make these turbines economical. This combination pushes offshore wind outside the traditional ≤ 60 m water depths traditionally associated with fixed wind.

For many countries exploring offshore wind this is simply not available. Countries such as Japan, France, Italy and the US, particularly on the West coast, are turning towards floating wind turbines as the key technology to harness great wind resources and meet their renewable energy production commitments.

Looking closer to home, ~80% of Europe's offshore wind resources is in water depths greater than 60 m with a total estimated potential of 4,000 GW floating wind capacity. The numbers for the US and Japan are 60% and 80%, with 2,450 GW and 500 GW potential from floating wind capacity, respectively.

The journey towards floating wind

At last count, more than 120 floating wind foundation designs are in the market. Although there are many differences between them, they can be categorized into three main types: semi-submersible, spar and tension leg platform (TLP). Over the past 10 years these designs have been engineered, modeled and tested to point where full-scale demonstrators were built. These proof of concepts have allowed small scale Floating Offshore Wind (FOW) farms to be developed with the most recent Hywind Tampen project delivering power in 2023.

The next step in this journey is commercial scaled FOW farms. Europe is leading the way with licensing in place and over 40 GW of planned capacity to go into construction by 2035. This equates to roughly 50% of the forecasted global capacity that will be under construction for that period.

Commercial floating wind and its challenges

Like fixed bottom wind, floating wind requires scale to be commercially viable. The difference however is the size of turbine that will be required to make this market cost effective. FOW's base case turbine size is 15 MW with the majority of planned wind farms being in excess of 1 GW in size. These two factors will require FOW to 'hit the ground running' and not have the steady build out that fixed wind was afforded.

The holistic approach

This young industry is very fragmented, with a lot of innovative companies trying to solve the same challenges. To help deliver fit for purpose solutions a more holistic approach was taken in GustoMSC for floating wind.

By looking at the life cycle of a project a thorough understanding of the main challenges were identified. There are of course, other hurdles to manage and control such as regulatory and environmental regulations which can differ greatly between regions, countries and even companies.

Three of the main challenges for FOW are technology development, supply chain capacity and installation and maintenance. By looking at these as a whole it is clear that the design stage plays a critical role by ensuring the ability to fabricate, scale and protect the projects commercial viability during the life cycle of these projects.

This is where a design company that has access to developers, contractors and tier one suppliers of the major components that will affect the performance can be of great value.

Technology development: floating turbine foundation design

The need to produce a design that is safe, scalable, and sustainable was at the cornerstone of the GustoMSC Tri-Floater design. This semi-submersible design started back in 2002 and builds on GustoMSC's experience and track record in the semi-submersible market.

The Tri-Floater design is characterized by a combination of excellent motion performance at nacelle level, fit for mass production, and local assembly. Once constructed, its stability properties, suitability for shallow port access, and low-risk installation, disconnection and access procedures provide a robust operational profile. Operation and maintenance are minimized through a lean design with limited active components onboard and advanced monitoring capabilities.

Recognizing the high unit volumes that are required to make the floating wind industry an enabler for renewable energy production at scale, efficient manufacturing has been an absolute priority in the design of the Tri-Floater.

To enable an efficient build out, flexibility in the supply chain globally is essential for all designs. The Tri-Floater has this in mind with hexagonal stiffened thin-walled buoyancy columns being optimized for automated panel production lines widely available within the shipbuilding industry. The unstiffened thick-walled column supporting the wind turbine column is a continuation of the wind turbine tower. The highly optimized manufacturing facilities of monopile fabricators and wind turbine tower supply chain can be leveraged for efficient manufacturing.

Assembly, installation and maintenance

Assembly

The supply chain and marshaling port infrastructure that FOW will demand is currently not available. The development of these ports will involve a collaboration between, amongst others, wind farm developers, fabricators, port authorities and governments to ensure that the infrastructure is aligned to the specific requirements for FOW.

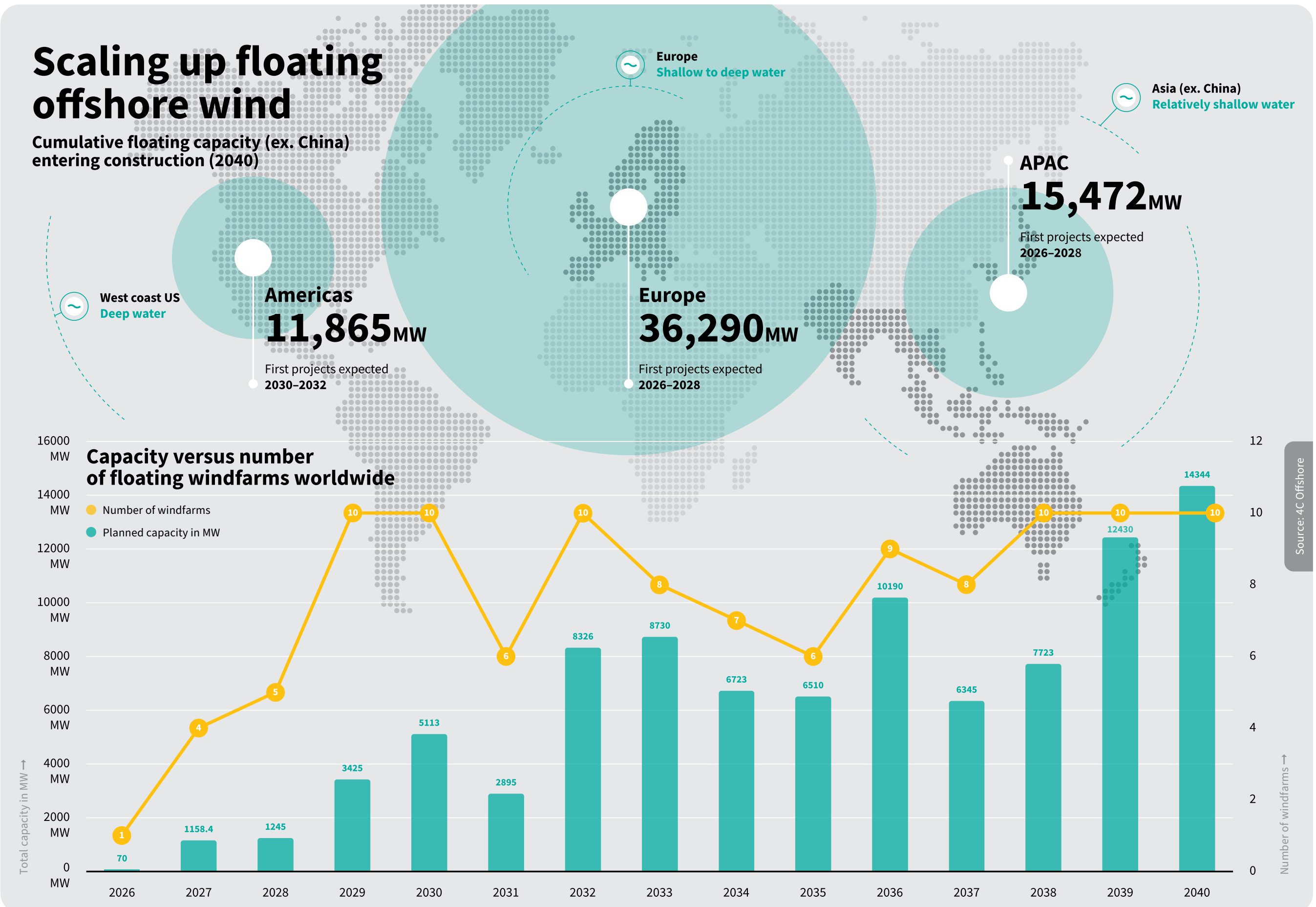
A few of the key requirements for such facilities will be the water depth, quayside specifications, and proximity to the floating wind farm itself.

Flexibility of fabrication strategies, possibility to use existing and local supply chains can be a great contributor.

A cluster port strategy where multiple ports are used to deliver specific work scopes could provide not only a cost-effective solution but also accelerate the build out.

Installation

The water depths for FOW will dictate that installation campaigns and long-term Operations and Maintenance programs for FOW will be conducted by vessel based solutions. Lessons of course can and will be taken from the fixed wind market but the



added complexity of new technology, the physical size and scale, along with the harsh environmental conditions will require new strategies and solutions to be developed.

FOW installations are foreseen to be delivered in a campaign-driven methodology, with the majority following the sequence of pre-lay of mooring lines; hook-up and tensioning of mooring lines to the Floating Offshore Wind Turbine (FOWT); and dynamic cable installation and/or connection to the FOWT.

These operations are similar in scope to floating production unit installations but on a much larger scale. Commercial floating wind farms are expected to need 50 or more turbine installations. This introduces both a challenge in capabilities, as mooring systems of FOWTs commonly are in league with the largest mooring systems known, and logistics, as efficiency is driven by reducing non-productive time such as sailing back and forth to the marshalling port to pick up new mooring systems.

At GustoMSC the Enhydra Floating Wind Installation Vessel (FWIV) combines these work scopes and logistics in one flexible and modular asset that will provide the industry with a strategic asset class that can not only enable the industry to build out the FOW farms efficiently but also to be able to manage the unplanned challenges that will come with such a new market.

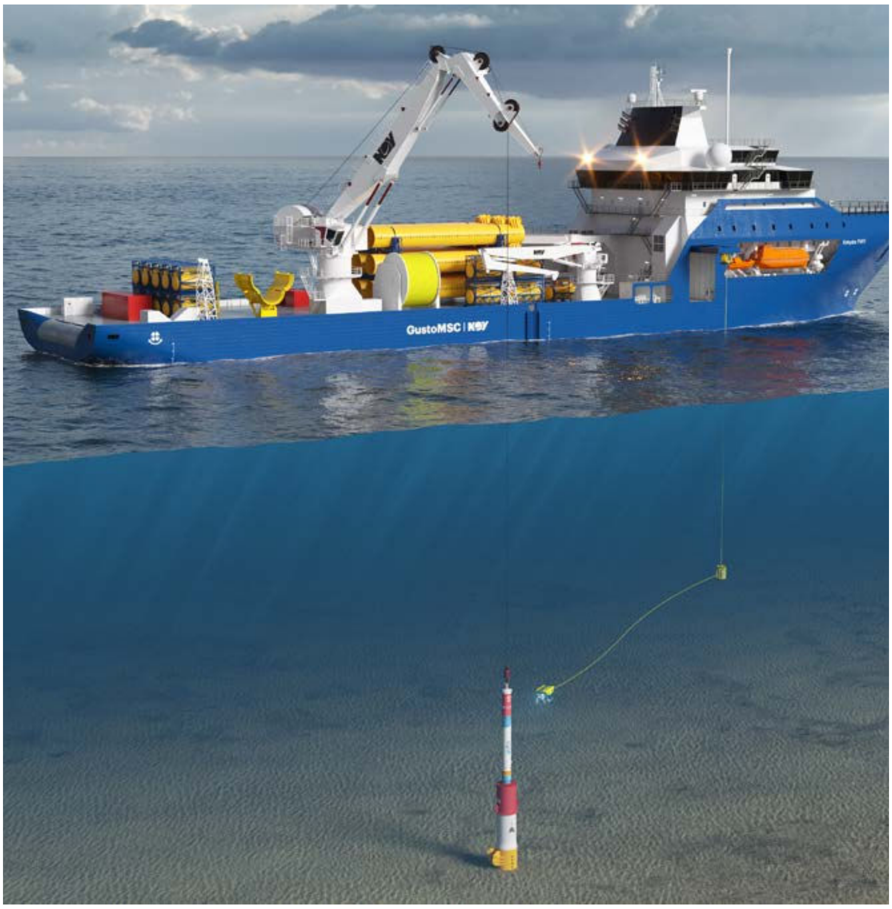
The Enhydra FWIV's key design features enable the commercial-scale development of floating offshore wind farms. This includes vessel design, incorporating inputs and requirements from developers, vessel owners, and industry experts and versatility, with the ability to execute the full scope of mooring, hookup and cable installation. Logistics is important too, understanding the operational sequence and how the vessel design plays a key role in enabling this.

Operations and Maintenance (O&M)

O&M is the biggest contributor to the overall costs of any offshore wind farm making up almost 1/5th of the combined investment needed.

These historical figures from fixed wind will be comparable to FOW to a certain extent although the actual costs will be higher especially in the early days. The added complexity of FOW with its two moving objects in a more dynamic environment will prove harder to manage. This has been highlighted during the demonstrators and small scale FOW farms the industry has deployed so far. Access, standoff and additional O&M scopes for FOW will dictate that we cannot simply copy the fixed winds strategy and asset types for O&M work.

Then the day to day maintenance work will require a larger vessel to provide a more stable platform to maximize the operating window and accessibility to these FOWTs.



Major Component Exchange (MCE) is a challenge for offshore wind in general and how to make this cost effective. In the FOW market there are currently two strategies being discussed, a tow to port and an in-field solution.

A tow to port strategy will need access to vessels able to disconnect the FOWT from the subsea infrastructure and have the bollard pull and equipment to tow the units to port, but also the ability to hook-up and reconnect the FOWT again when back into the windfarm.

An in-field solution will need new innovative solutions such as motion compensated cranes of high SWL and self-erecting cranes to perform the MCE work scopes. Both solutions will need to operate from a vessel or semi-submersible platform that has the required performance and specification to efficiently perform such works.

Until now, access to vessels of opportunity has been fairly straightforward, although sometimes challenging. With the recent uptick in oil and gas and the aging fleet at large this is fast becoming not the case, certainly not when an increased number of installed FOWTs is factored in.

This new market will need to be self-supportive. The strategies and assets to deliver them has to be tailored to it and as such new vessels and technologies will, and must be considered.

GustoMSC is developing these solutions to ensure technology readiness in developing plans for the realization of commercial scale windfarms. A specifically developed variant of its Enhydra MSOV concept is available to address the accessibility challenges for walk-to-work operations in FOW and at the same time offer a ready tow-in/tow-out capability for the FOW farm.

Options for MCE are under development as well, looking at the various angles in cooperation with the market and its own FOWT team to ensure solutions are available when needed.

Future prospects

The use of FOWTs is poised to further expand the offshore wind industry. As technology continues to advance, we can expect even more demand for efficient and innovative solutions to effectively assemble, install and maintain these structures. The deployment of these solutions and strategies will enable the industry to unlock the offshore wind energy potential, reduce carbon emissions, and contribute to the global transition toward clean energy.

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