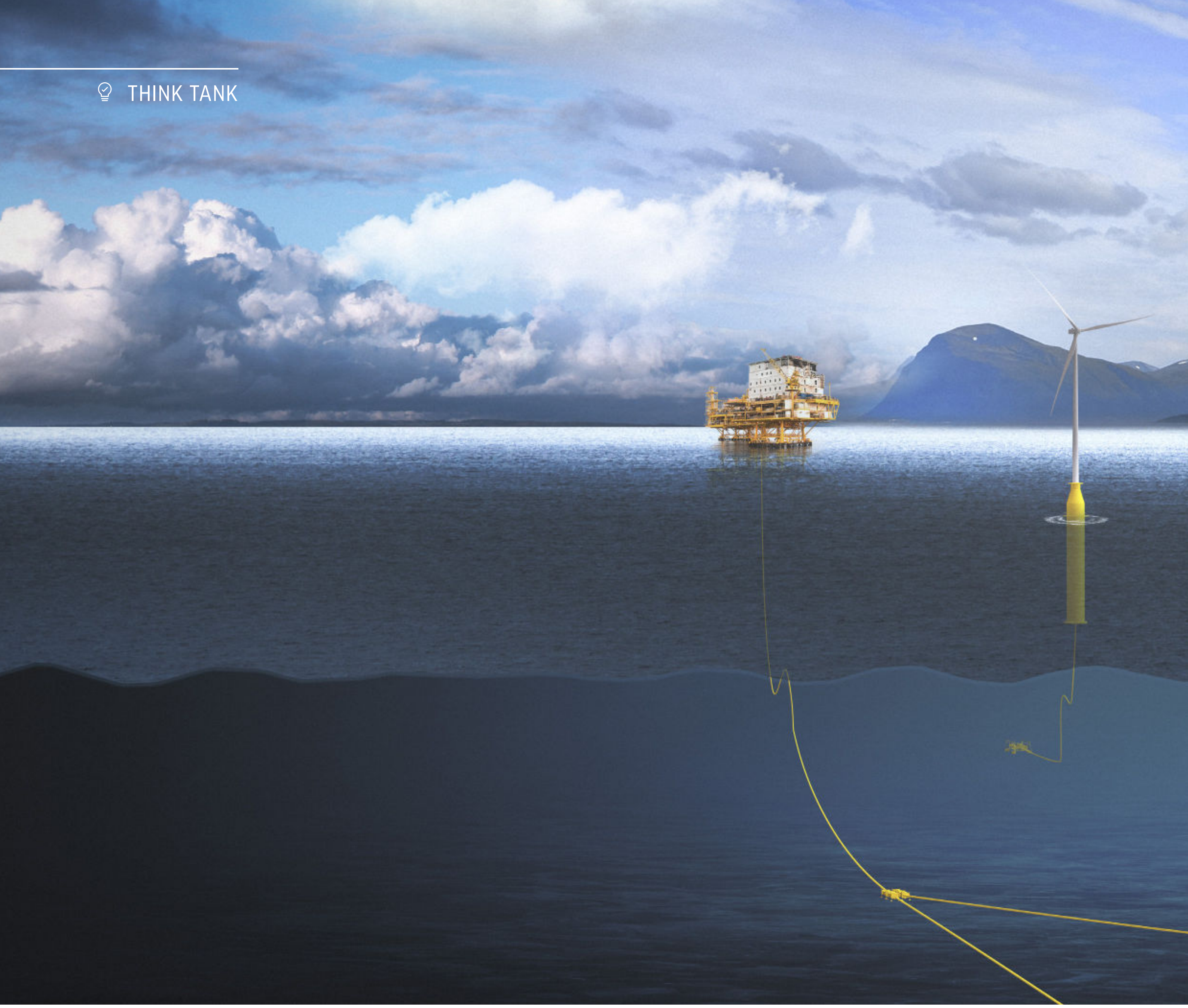


De-risking floating wind technology and deployment

Words: Zhang Minghui, Offshore Wind Segment Lead, APAC, Energy Systems, DNV
Benoit Nguyen, Head of Renewables, APAC, Energy Systems, DNV

In this article we hear from DNV on maximising opportunities from floating offshore wind which hinges on de-risking its economics, technology, logistics and operations. The global installed capacity of floating offshore wind, will grow from 88MW in 2022 to 260GW in mid-century, according to our Energy Transition Outlook 2022 (ETO) model.[1]

1 DNV Energy Transition Outlook 2022 at https://eto.dnv.com/2022

For perspective, the capacity in 2050 will be 3,000 times greater than that of the 88MW Hywind Tampen project being constructed off Norway, which will be the world's largest floating wind farm once operational. Our ETO sees floating wind's share in total installed offshore wind capacity rising from under 1% to 20% over the same period. In this sense at least, the future of offshore wind is floating.

Many floating wind systems have already been demonstrated at full scale and several pre-commercial installations exist, or will come on stream soon. Attracted by the economic and decarbonization potential of floating wind, many countries have launched or are preparing open leasing rounds for projects.

Ten proposed floating wind projects outnumbered seven fixed offshore in the 2022 ScotWind offshore wind leasing auctions in the UK, which plans further leasing rounds. India has been preparing to lease blocks for some 4GW of offshore wind capacity and is targeting 30GW by 2030. The country's offshore wind technical potential includes 112GW of bottom-fixed, 'fixed offshore wind', and 83GW of floating wind, according to the World Bank. France, Norway, Portugal and Spain, among others, are preparing.

In the APAC region, South Korea has huge ambitions for floating wind. Taiwan has also recently announced a floating wind pilot that aims to add 100MW of capacity by 2026, to allow the industry to prepare for the upcoming boom. In addition, Japan, the Philippines, Australia and China are also exploring the potential of floating wind in their markets so it's a question of when rather than if floating wind will be deployed in APAC.

Industries come together

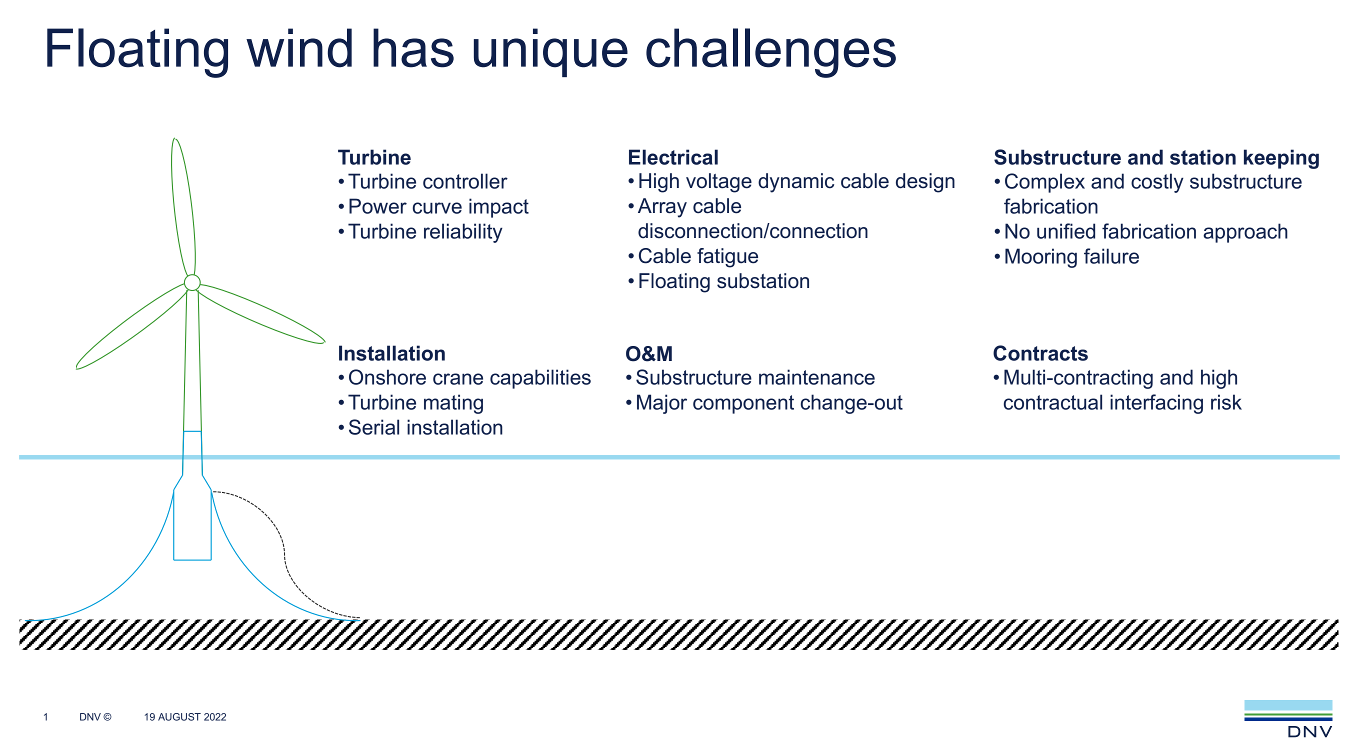
It is a compelling vision, but how can we reduce the technical, deployment and operational risks for investors, so that today's ambitions become tomorrow's reality? In discussing these themes, we draw on DNV's long standing technical advisory, qualification, and verification experience in offshore wind, oil and gas, and our growing assistance to floating wind clients to de-risk development projects, operations, equipment and integrated systems.

Many of our approaches are data-driven. They use advanced digital tools, of proven value in other industries, that we can apply to floating wind and its unique challenges (Figure 1). This underlines the important point that we will keep learning about floating wind as it develops and from the history and continuing evolution of fixed offshore wind.

Cheaper, bigger, deeper

The greatest barrier to floating wind today is that its levelized cost of energy (LCoE) is about four times that of fixed offshore wind. We are optimistic that the gap can narrow. We predict an 80% reduction to EUR 35 per MWh in floating wind's LCoE by 2050, when it will be only slightly costlier than fixed offshore wind. We also forecast that the total investment cost per MW for floating wind projects will decline from EUR 5.7 million to EUR 1.7 million over the same period. Cost reduction will come through improving what is already being done, innovation, and technological advancement.

The goalposts will keep moving. Projects need to move into deeper waters, further offshore, in new metocean and market



conditions. New technical, supply chain, and logistical issues will arise as floating wind evolves toward larger wind farms (800+ MW) with bigger turbines (15+ MW).

Getting better at what we are already doing requires more efficient and cost-effective solutions to known challenges. Examples include advanced turbine-controller design specifically for the floating environment, and new, efficient methods for system maintenance to minimise downtime, uncertainty, and cost. Rolling out technologies at greater scale can deliver substantial cost savings if supply-chain bottlenecks are identified early.

Simply repeating what we have already done, but on a larger scale, will be insufficient to maximise the opportunities. We need more innovation and demonstration projects to ensure that next-generation floating wind systems reduce costs further. Governments can assist with direct and indirect incentives driving R&D to improve yield and financial returns on projects.

Since floating wind is still a nascent industry, there is a lot of room for innovation in this technology. The floating substation Joint Industry Project (JIP) spearheaded by DNV aims to develop best practices and recommendations around the utilisation of floating substations in deeper waters. Meanwhile, another JIP from DNV focuses on the potential use of concrete as an alternative for steel in consideration of commodity risks and exposure due to uncertainties in the supply chain.

A mammoth modelling and testing task lies ahead to optimize design, production, deployment, installation, operation and maintenance (O&M) of floating wind technologies. Clearly, de-risking challenges will be greater for emerging technologies that will hopefully help reduce LCoE. We discuss three examples here: turbine size, moorings, and platforms and towers.

Technology challenges

Our research on fixed offshore wind finds cost reductions from learning and standardisation are much greater than from variations in turbine size. We expect further, though slowing, growth in turbine size in the next 10 years. Given the LCoE focus, a key question is how floating wind economics, particularly the costs of foundations and O&M, will scale with turbine size. Will we see, for example, different optimal turbine sizes and/or types for fixed and floating offshore wind?

Assembling platforms from modular units that can be made at scale in different facilities can boost commercialization and reduce cost. Challenges include managing the greater requirements for transport, storage, and logistics, and adapting the approach for varying types of material.

A trussed/guyed tower can potentially be cheaper than one that typically has to be very strong using tubular towers. Trussed/guyed towers strengthen the platform, but blades must not impact tower sections even in storm conditions. Installing the turbine downwind helps, for example. Standard, out-of-the-box design tools cannot deal with the more complex aerodynamics near the rotor; so, how do we handle these challenges?

With turret mooring systems, platforms can rotate about a point, enabling passive yawing into the wind direction and eliminating the need for yaw mechanisms. On multi-rotor turbine systems, turrets can also reduce wake effects, but how soon does the platform adjust to the correct direction? What other effects could prevent complete alignment? What is the effect of any misalignment? How should we deal with the electrical connection, and what is the risk and impact of this part of the system failing?

Synthetic fibre ropes can be cheaper for moorings than steel chains and are more suitable for deep water. The low stiffness of synthetic ropes can also reduce loads in extreme conditions. Challenges include reducing the risk of contact damage and ensuring correct installation to avoid damage or unexpected behaviour over a fibre rope's lifetime.

In addition to the above technological challenges, regional challenges like typhoons and extreme events have to also be considered.

De-risking technology

Scaling up floating wind requires strong integration between the following: designers of controllers, towers, platforms, and

'By using DNV's renewable architect tool, we are able to create bespoke and tailored solutions aimed at concept selection for new sites, allowing for more LCoE optimization.'

mooring/dynamic cables; project developers; certification bodies; tank testers; and wind turbine generator OEMs.

This is because floating wind is an active system and is highly coupled when it comes to aerodynamics, hydrodynamics, structural dynamics, electrical dynamics, mechanical systems, and controllers. Hence the need for 'coupled analysis' that calculates the internal loads and responses for each component: wind turbine, tower, platform, moorings, and so on.

It is why we extended our wind turbine design tool, Bladed, to also incorporate hydrodynamics and moorings. It lets us model the whole system, with particularly detailed granularity on the turbine and platform but also considering moorings. We complement this with digital tools, Sima and Orcaflex, that model the whole system, but with less detail on the turbine.

To produce a first representation of a turbine for preliminary design studies, we use a fully functional 'concept model' representing leading turbine models in use today, e.g. an 8MW turbine with a rotor diameter of 167m, or predictions of what will enter the market or can be made to order.

These models use data based on our experience, data entrusted to us as secure custodians, and public data which can empower non-turbine original equipment manufacturers (OEMs) to perform coupled floating-wind-turbine loads analysis. This has applications including platform design initialization; sensitivity studies; and additional structural design loops outside of turbine-OEM format loops. The models integrate different learnings for the process of wind-turbine platform design.

We assist in the selection and design of chain and fibre rope mooring systems for clients determining the design and scale of floaters for higher turbine ratings. For this, we draw on DNV turbine trend data sourced over many years; open-source floater data; and client data shared securely with us. Relevant client data includes the turbine rated power, water depth, environmental data, and other specific system constraints and definitions. This approach allows the derivation of floater dimensions and wave, thrust, and drag loads. Deriving the dimensions enables preliminary stability checks.

In addition to modelling current turbine models, it is also important to explore larger turbine models that might be used in the future for floating projects. By using DNV's renewable architect tool, we are able to create bespoke and tailored solutions aimed at concept selection for new sites, allowing for more LCoE optimization.

De-risking deployment

De-risking any offshore energy project requires early assessment of metocean conditions that will impact the development and operating phases.

In our metocean assessments, we aim for audit completeness to produce and validate data. Work scopes include spot location reports, design studies for offshore structures, numerical modelling of water flow and waves and design criteria for marine transportation of fabricated structures.

We perform multiple probability, or Monte Carlo, simulations using a digital tool called SafeTrans to design and operate marine heavy lift transports and installations of major facilities safely and efficiently using state of the art analysis methods, databases, and hydrodynamics. We calculate environmental criteria for long transports, including the effect of a vessel captain's choice of way points and safe havens to avoid storms. We also conduct a response-based assessment for high variability and directionality in sea states.

In conclusion, there are many big challenges ahead. But if we have high levels of trust and collaboration between owners, operators, supply chains, and public policymakers, we can maximise floating wind's value for decarbonizing energy and add value to local economies.

www.dnv.com