BLACK & VEATCH

Decarbonizing Asia Pacific: Optimizing Offshore Renewables Projects

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Execution certainty is best served by partners able to manage the complex interfaces which define offshore renewables projects.

Offshore Generation is Crucial to Decarbonization

In the drive to decarbonize, offshore generation of electricity has an established role. From a low start today, much future potential exists off the coasts of multiple maritime Asia Pacific nations. Fixed offshore wind holds sway currently, but floating wind's potential is starting to be realised. As it matures, tidal energy, the most predictable form of renewables, is growing in significance.

Unlike fixed offshore wind, floating offshore wind is not restricted to shallow waters. It can be developed further out to sea, enabling it to capture more powerful and reliable winds.

As well as generating electricity, offshore energy assets can make a meaningful contribution to the production of power-storing green hydrogen, extending the offshore renewables sector's role in meeting carbon reduction goals.

In the Asia Pacific region, country specific goals point to rapid development in the coming years.

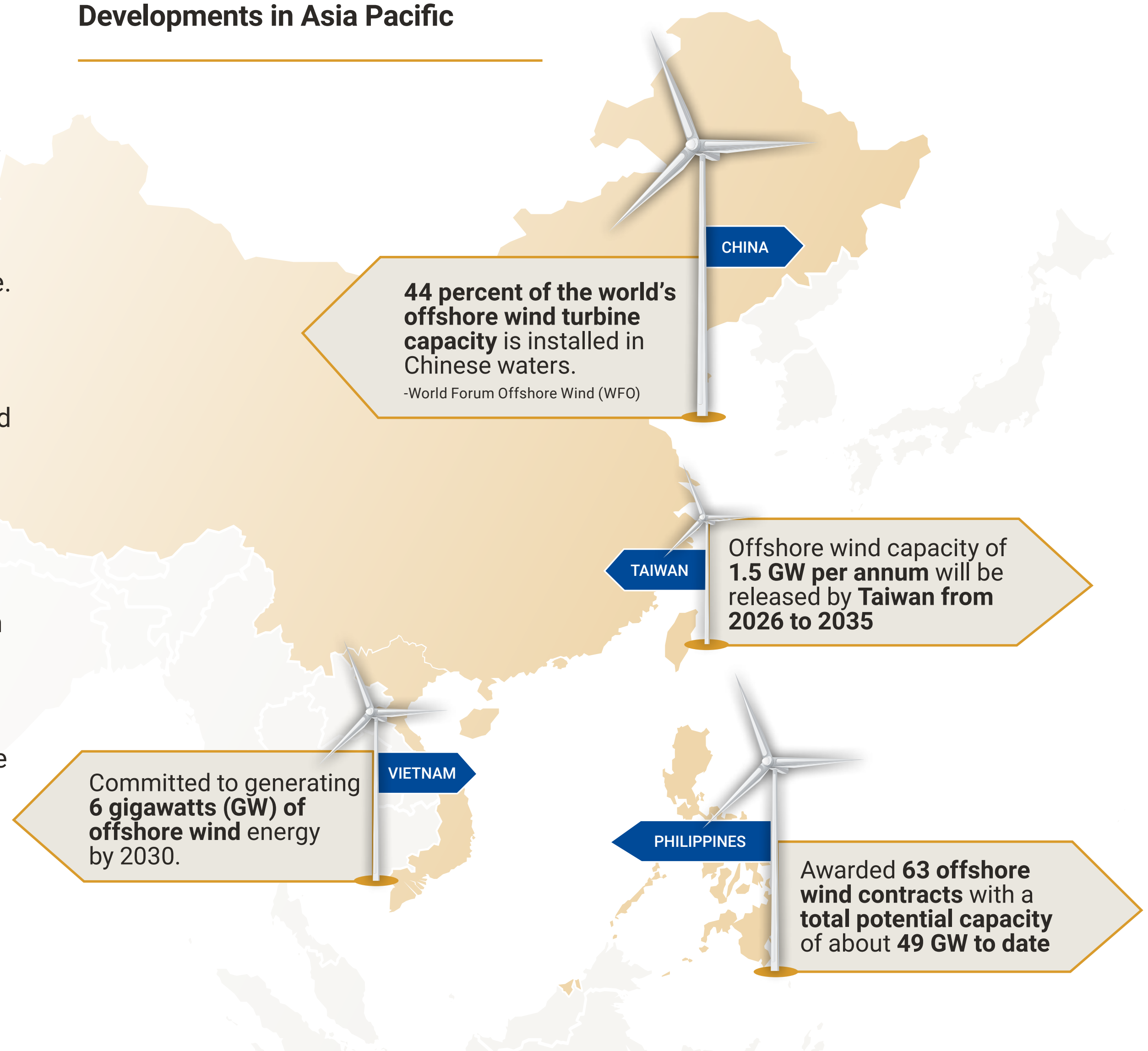
Vietnam has committed to generating 6 gigawatts (GW) of offshore wind energy by 2030 in its Power Development Plan (PDP) 8. The World Bank estimates that the offshore wind industry could generate up to almost 30 per cent of the country's electricity output by 2050.

The Philippines Offshore Wind Roadmap launched in 2022 estimates the country's potential offshore wind resources to be 178 GW. The country has awarded 63 offshore wind contracts with a total potential capacity of about 49 GW to date.

Taiwan is celebrating the completion and grid integration of its third offshore wind farm, Formosa 2. The wind farm's 47 wind turbines [8 megawatts (MW) each] have a total installed capacity of 376 MW and is expected to supply clean wind power to approximately 380,000 households every year. Offshore wind capacity of 1.5 GW per annum will be released by Taiwan from 2026 to 2035 as it continues to promote offshore wind installations.

China remains the frontrunner of offshore wind developments. A report from World Forum Offshore Wind (WFO) reveals that 44 percent of the world's offshore wind turbine capacity is installed in Chinese waters. China added close to seven gigawatts of offshore wind capacity in 2022, says the report.

Offshore Wind Energy Developments in Asia Pacific



The Rising Importance of Sea Power

The predictability of ocean currents and tides give marine energy projects a significant advantage in terms of energy security and stability of supply, although the early stage of the industry means that current levelized cost of energy (LCoE) for tidal and wave projects are around four times higher than for solar or wind.

But a forecast fall in LCoE and continued rise in the demand for low-carbon energy, coupled with the reliability and stability of marine energy, means global investment is predicted to triple from US$350 million in 2021 to US$1 billion in 2026.

The maturity of tidal energy developments varies across regions. According to Bloomberg New Energy Finance (BNEF) data the UK leads the world with a tidal and wave energy project pipeline of more than 5 GW.

In Asia Pacific, tidal energy is nascent. Singapore, for instance, has launched a Proof of Value (POV) project to harness hydrokinetic energy off the island of Pulau Satumu as an alternative to transporting diesel to generate power for facilities supporting Raffles Lighthouse (RLH). The island city will be assessing the potential of scaling up the use of tidal energy for other waterfront facilities and electric charging locations for vessels in Singapore.

Execution Certainty in Unforgiving Conditions

Be it marine energy or offshore wind, offshore electricity generation's role in decarbonization strategies across Asia Pacific is only going to grow; and, regardless of technology, all offshore generation projects share the common challenge of needing to succeed in some of the most unforgiving conditions facing any power generation assets.

This means, especially with maturing or nascent floating wind and marine energy systems, that the level of execution certainty will be increased greatly by choosing a partner with not just offshore wind or marine energy technology experience, but one able to augment that with a full understanding of the influence of metocean conditions - such as wave, current and wind - on all aspects of the project lifecycle; and proven experience in the transmission element of offshore power projects. A partner with this spread of expertise and experience will not only be the one best placed to advise on individual aspects of the project but will also successfully manage the complex interfaces between technologies and disciplines that define offshore generation projects.

Site-Specific Metocean Data Means More Accurate LCoE Forecasting

By affecting the ability to undertake both planned maintenance and reactive repairs, metocean conditions have a significant impact on the effective operation and maintenance (O&M) of offshore electricity generation assets. Unless site-specific metocean data has been incorporated in a project's early development, it is possible that the built assets may not be able to consistently achieve the performance forecast – because the ability of metocean conditions to hamper O&M activities has not been accounted for in sufficient detail.

Site Optimization for O&M

Consider a hypothetical offshore wind project as an example. A higher wind yield at Location A meant it was considered preferrable over Location B as it offers a higher financial return. However, Location A has a more challenging metocean environment in which to operate than the more benign Location B.

Location A's environment makes maintenance teams' ability to access both surface and subsea assets more difficult as fewer suitable weather windows exist and/or more expensive access methods have to be employed. Unless this was accounted for during project development there is a risk performance forecasts will not be achieved, because equipment cannot be maintained as planned, and timely failure repairs may not be possible or be more costly.

As a result of the inability to perform required maintenance or increased O&M cost, Option A's higher wind yield is significantly reduced.

The same principle applies to marine energy projects. The influence of site-specific metocean conditions on O&M regimes has to be factored into cost forecasts from the outset so they reflect the actual conditions that will be encountered. And these factors will then help identify the optimal location for the best overall whole-lifecycle cost for the generation and transmission assets as well as the optimal O&M strategy.

Incorporate OPEX from the Outset

During the development of some offshore wind and marine energy projects, there has been an understandable focus on identifying the location that offers optimal wind or current resources, and swiftly progressing design for that location, thus helping bring the project to faster financial close. Given this initial focus, the project developer may not have fully engaged with O&M experts, particularly with reference to site-specific impacts of metocean conditions on O&M strategies and costs. This approach presents the possibility of 'locking in' substantial amounts of operational expenditure (OPEX) that could potentially be reduced with greater involvement of O&M considerations during early project development.

This is not to suggest developers are unaware of the need to incorporate metocean data in their project planning. But the extent to which such data is accounted for from an O&M perspective, and the detail and sophistication of the data used, varies to a significant degree.

Adopting modelling capable of accurately incorporating site-specific metocean data into an assessment of the effect of O&M costs and downtime on a project's LCoE will assist with the development of a more informed long-term projection of a site's profitability, aiding in site selection, in addition to helping optimize O&M strategies for specific site conditions.

Minor changes in offshore asset design and location can cascade into significant effects on cost and performance, giving rise to potentially meaningful changes in a project's bottom line.

Accurate LCoE Calculation

The modelling sophistication required to accurately calculate a project's LCoE is possible by pooling data sets not typically analyzed, together, and processing them using algorithms configured to inform data-driven O&M planning for site-specific conditions. Such data sets can include site-specific metocean data analyzed alongside equipment failure rates, original equipment manufacturer (OEM) maintenance schedules and generation asset power curves. The result is a greater level of O&M optimisation because of the sophistication of the site-specific, rather than generic, data being analyzed. This includes the ability to schedule predictive maintenance during times of lower energy generation, thereby maximising energy-based availability.

This level of sophistication is important because metocean data are very complex and often highly interdependent. Minor changes in offshore asset design and location can cascade into significant effects on cost and performance, giving rise to potentially meaningful changes in a project's bottom line. A tool which gives visibility and insights into the consequences of such changes will help enable more fully informed decisions shaping the project from the outset.

Real-World Challenges

Once offshore operations commence, understanding actual on-site metocean conditions, as opposed to what is predicted, can greatly assist in operational planning. Since weather and current predictions do not necessarily match up with the on-site conditions operations are sometimes aborted as a result of unsuitable metocean conditions. Having real-time on site metocean data feeds can prove invaluable in allowing detailed operational planning.

Incorporating more complete and accurate metocean data brings a new level of sophistication to the O&M element of the development of an offshore generation project. This can help reduce the risk of performance modelling, and hence forecasts, being affected by an insufficient understanding of the ways in which metocean conditions can influence developers' ability to ensure an asset can consistently deliver the performance upon which the business case is built.

In addition, using sophisticated metocean data creates opportunities to further optimize O&M strategies and develop fuller, more accurate projections for the O&M element of a project's costs and yield.

Transferable Offshore Wind Experience

Haven Array 985 MW Fixed and Floating Offshore Wind and Green Hydrogen Electrolysis

Black & Veatch modelled the entire project lifecycle: development expenditure, capital expenditure, operational expenditure and decommissioning expenditure for all of these assets. The modelling helped shape phase 1's final scope informing the client's choice of onshore, rather than offshore, electrolysis; and decision to convert the hydrogen into green ammonia.

Block Island, Rhode Island

Black & Veatch was involved in the first offshore wind project in the United States - Block Island, Rhode Island, providing engineering design and conceptual exploration services for the transmission system and the wind farm. The projects included a new 35 kV armored submarine power cable, approximately 35 kilometers.

Welsh Waters of the Celtic Sea

Black & Veatch provided design coordination of subsystem design, systems engineering and the certification of Marine Power Systems' unique and flexible floating wind and wave energy generation hardware. Working as an extension of Marine Power Systems' technical team, Black & Veatch is leading specific elements of the project, providing technical quality assurance and helping identify and manage technical and programme risk.

Transmission Infrastructure: Technical Expertise is Key

Subsea Cable Routing

The transmission element of offshore renewables projects presents many challenges and mitigations common to both marine and wind projects.

Identification of a subsea cable routing that will satisfy the necessary planning and consenting permissions must be given appropriate consideration and resource allocation in a project's formative phase. Early engagement with permitting bodies can help mitigate much of the consenting, program and cost risk.

The value of developing a full understanding of subsea cable routing conditions is often overlooked; but detailed seabed analysis during early design will help account for the risk presented by common factors such as rock, unexploded ordnance ship-wreck and mobile sediments. Accurate seabed geotechnical analysis and cable routing will also help minimize installation delays and unexpected costs. In addition, early-phase seabed analysis aids specification of the correct cable type for the conditions, and appropriate subsea cable protection measures, both elements are vital in ensuring reliable operation of the transmission system in the long-term.

Making Landfall Successful

Landfall infrastructure poses some unique challenges. Assessing site suitability requires an understanding of metocean conditions, and ground conditions in the intertidal zone; the latter may give rise to the high cost of site investigations offshore. Establishing whether a trenchless crossing will be necessary is another important element of early planning, as is ensuring suitable access for installation, both of these factors will inform the scope of the site investigations. Additionally, to be consentable the landfall solution needs to give sufficient consideration to third-party use of the landfall site.

Planning and Consenting

Acknowledging the importance of planning and consenting permissions is also essential to the successful delivery of a projects' onshore infrastructure. The landfall site, onshore cable routing, substation and grid connection all require locations and characteristics that meet the requirements necessary to secure planning and consenting permissions.

A major factor in achieving planning permission and consenting is the ability to create an integrated, onshore infrastructure design capable of meeting the challenges of local engineering constraints, but also the diverse requirements of a wide group of stakeholders - typically including environmental regulators and authorities, utilities, the relevant transport authority, drainage boards, local authorities, third-party asset owners and landowners.

The Value Of Stakeholder Engagement

Designing cost efficient onshore assets that meet the requirements of the project, planning authorities and – by extension local community - requires a partner with demonstrable expertise in combining the technical requirements of the project and value engineering with effective local stakeholder engagement.

Grid Connection

A partner with proven stakeholder engagement, as well as technical ability, is also essential to the grid connection element of offshore renewables projects, because at this point projects interface with live, critical infrastructure.

Successfully connecting the assets to an existing network requires a robust and buildable design solution that accounts for the specific technical requirements of the applicable network owner/operator, sensitivities of a working substation and existing services and infrastructure. The structural and electrical solution needs to meet the requirements of the project, the party responsible for the substation, and the grid operator.

Transferable Grid Integration Experience for Offshore Renewables

Block Island Wind Farm and Transmission Line Project

Black & Veatch was involved in the engineering design and conceptual exploration services for the Block Island Transmission System and Block Island Wind Farm Project. The submarine cable installation project consisted of three horizontal directional drills and three temporary cofferdams. Each of these HDDs exited into cofferdams and the product pipes were pulled through successfully.

Shallow Water Submarine Cable Installation for Offshore Wind Interconnection

This project entailed a feasibility analysis for the installation of multiple submarine cables within an inland shallow-water bay for the purpose of interconnecting an offshore wind farm. Black & Veatch performed a constructability review of the proposed cable route and identified feasible construction methods and competent installation contractors, developed indicative project cost estimates and preliminary schedules to aid the client in planning and permitting discussions and performed a permitting review of the proposed project scope.

Hydrogen Production a Viable Alternative to Electricity

Green hydrogen can be used as zero-carbon fuel, feedstock and energy carrier, and as a method of energy storage. As a result, green hydrogen is a cornerstone of decarbonization strategies across EMEA. Producing green hydrogen with electricity generated by offshore assets represents a significant opportunity for owners and developers of offshore energy installations, and can offer a commercially attractive alternative where grid connections and local demand for electricity is limited, and grid curtailment can be an issue.

Producing green hydrogen using marine energy is currently at the demonstration stage, having been achieved at the European Marine Energy Centre, in Orkney, Scotland; with transmission lines bringing the electricity to the on-shore electrolyzer. There is also interest in ocean current energy: combining turbines in large-scale in ocean currents with offshore electrolysis technology; using tankers or pipelines to bring the hydrogen ashore.

Producing green hydrogen using offshore wind electricity, is also becoming a reality. In ScotWind - Crown Estate Scotland's January 2022 auction of offshore wind seabed development rights - successful bidders included the Total, GIG and RIDG 2 GW West of Orkney wind farm, which is set to power the Flotta Hydrogen Hub on Orkney. There was also a green hydrogen component to BP and EnBW's successful 2.9 GW project bid.

As well as projects using offshore wind to power onshore electrolyzers, Europe's North Sea is also home to pilot schemes investigating the feasibility of undertaking electrolysis at source – at the offshore windfarm.

Transferring best practices from global projects to other regions, like Asia Pacific, will help to accelerate their energy transition.

Offshore Electrolysis

The PosHYdon pilot project will see electricity generated by offshore wind powering an electrolyzer housed on Neptune Energy's Q13a oil and gas platform. Alongside RWE, Neptune is also a partner in the H2opZee demonstration project, which aims to build 300-500 MW of offshore wind powered electrolyzers in Europe's North Sea by 2030.

While these projects use separate wind arrays and electrolzser assets, Siemens Gamesa and Siemens Energy are developing an integrated turbine and electrolzser system capable of directly producing green hydrogen. Full-scale offshore demonstration is expected by 2026.

Floating wind infrastructure offers the potential for greater predictability, and volumes, of green hydrogen production. The Dylan project is piloting a combination of electrolysis, desalination and hydrogen production on a floating wind platform being developed in the Celtic Sea.

Offshore green hydrogen projects are first-of-a-kind in terms of both technology combinations and location. Successfully utilizing offshore wind, or marine energy, for the production of green hydrogen requires the expertise in - and integration of – a diverse range of technologies and disciplines. Ideally developers and owners need a partner with not just offshore wind or marine energy technology experience, but one able to augment that with – for example – knowing how a full understanding of using site-specific metocean data can deliver more accurate LCoE forecasting.

The most effective support for a project's business goals will come from organizations able to couple these disciplines with similarly comprehensive expertise in the fields of hydrogen electrolysis, desalination, marine structures and marine power transmission and, crucially, how to make all of these elements work in concert in a hostile marine environment.

While helping organizations develop green hydrogen projects, many first of a kind, Black & Veatch has identified six core considerations that require close attention in a project's earliest stages, in order to ensure a successful outcome. Click here to read our core considerations.

Green Hydrogen Experience

Green Hydrogen Production and Storage in Vietnam, The Green Solutions (TGS)

Black & Veatch studied the production and storage of green hydrogen utilizing solar or wind power supplied through the grid. The study also included: the development of a green ammonia production plant; plant configuration & technology review; technology evolution risk & tentative mitigation; conceptual design; order of magnitude cost estimates; & levelized cost calculations.

Click for more details

Green Hydrogen Production in Indonesia, Augustus Global Investment

Black & Veatch has conducted a feasibility study on the generation of green hydrogen in Indonesia. The project envisions green hydrogen production using electrolyzers powered by grid-supplied renewable energy. The study finds that the project can be technically and economically feasible and has the potential to contribute significantly to Indonesia's energy transition.

Click for more details

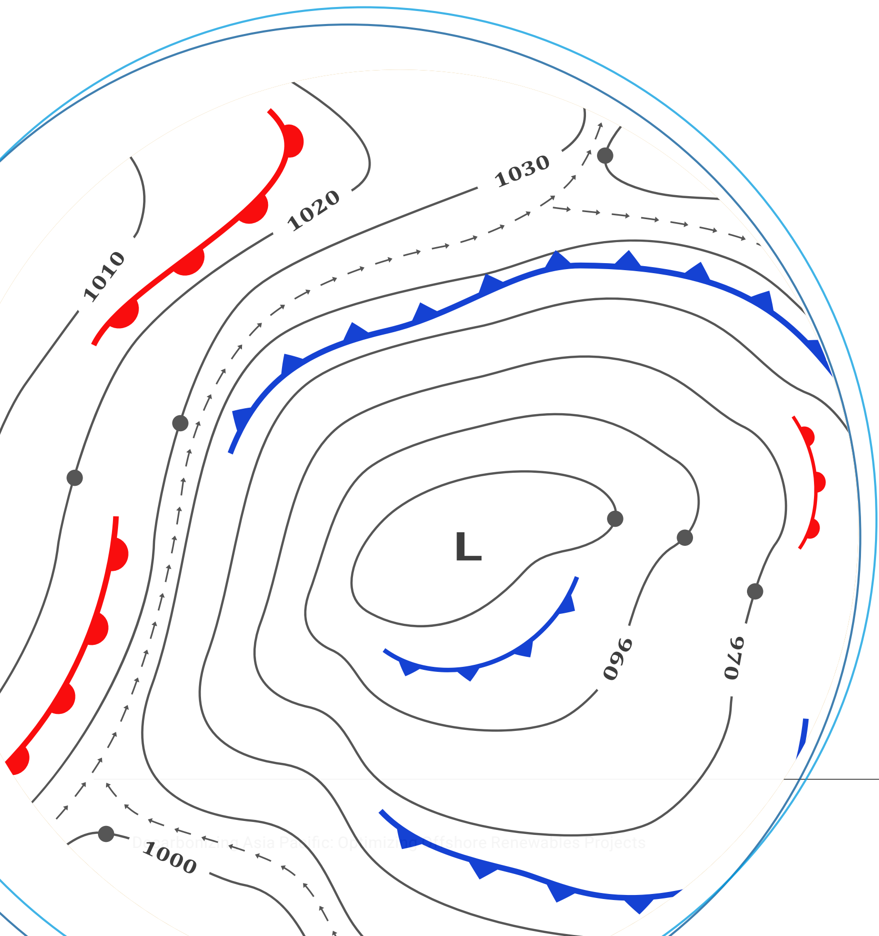
Advanced Clean Energy Storage Hub, ACES-Delta

One of the world's largest industrial green hydrogen production and storage hub will convert more than 220 MW/d of renewable energy into 100 tons of green hydrogen, stored in salt caverns.
Black & Veatch's Scope:

- Turnkey EPC
- Full facility, switchyard through connection to caverns
- Full wrap of critical equipment

Click for more details

Digitalization Key To Reaching Offshore Wind's Potential



Digitalization is necessary to achieve the capacity targets anticipated for offshore wind. To do this we need to move from met masts to lidar as the primary source of wind data. Wind is a time-varying three-dimensional vector field. We can no longer rely on simplifying this as a "wind speed" of the sort acquired by met masts.

Managing Complexity

With lidar we gain detailed insights into phenomena such as wakes and complex shear which can have a significant effect on the bottom line of a wind project throughout the asset's lifecycle, from demonstrating project bankability pre-construction right through to optimized O&M. As offshore turbines and arrays get bigger, the impacts of these phenomena are becoming more important.

Engineering approximations of wind conditions tend to assume that wind gradually increases with height. In Europe's North Sea complex, intermittent - and crucially - unanticipated wind shear phenomena associated with variations in atmospheric stability have been directly observed using lidar.

These phenomena impose mechanical loads on the turbine blades that propagate through the rotor nacelle assembly and drive train. Thanks to lidar data we now understand some of the loads that had been observed on offshore wind farms which were previously unexplained.

Lidar has also helped reveal the importance of atmospheric stability on wake propagation. Wake losses downwind of a wind turbine have been seen to increase at night, compared to day-time operations, because more stable night-time atmospheres meant that wakes propagated further.

Reducing Uncertainty

The benefits of lidar lie in grappling with the inherent complexity of the problems we are trying to solve as we seek to develop profitable offshore wind farms. By helping manage complexity, digitizing the wind using lidar reduces uncertainty and increases confidence in offshore wind project outcomes by allowing this inherent complexity to be accommodated in our models and calculations.

Lidar data can be combined with mid-fidelity wake models for validation, and to support wind farm control methods.

Using a met mast leaves gaps in the information upon which a project is based which are filled with assumptions. Lidar helps close these gaps and reduce the possibility of surprises later in the project lifecycle when adverse wind conditions - that could have been predicted and mitigated with a properly designed and executed lidar measurement campaign prior to construction – come to light through unforeseen consequences in terms of component failure and unscheduled downtime.

Component or structural failures that could have been proactively mitigated during design or construction, or accommodated into a properly informed O&M strategy, become instead the subject of reactive remedial work, which is rarely the most cost-effective approach to operations and maintenance.

This issue is especially pertinent to offshore wind assets where inspection, repair and maintenance represent a significant program cost and consideration. Unless site-specific wind data has been incorporated into a project's early development, it is possible that the built assets may not be able to consistently achieve the performance forecast.

Floating lidar systems are the primary source of offshore wind data where there are no other opportunities to install equipment to acquire site data, for example, when undertaking the pre-construction wind surveys to support wind resource assessment and energy yield estimation.

Ultimately this all feeds into greater confidence in the quality of LCoE analysis which enhances bankability for developers and gives owners and operators greater confidence when evaluating energy production - and ultimately – profitability.

Transferable Offshore Digitalization Experience

Marine Power Systems (MPS)

MPS appointed Black & Veatch to undertake a LCoE analysis and to support the design and optimisation of their Pelaflex floating wind platform and megawatt-scale demonstrator development.

Click for more details

Offshore Wind Feasibility Study – Client Confidential

Black & Veatch supported the pre-feasibility and programme management of a proposed 50 MW floating wind farm in Mediterranean waters.
Black & Veatch's scope:

- Project and programme management
- Floating platform, environmental and commercial study review
- Production of a project implementation plan
- Development of combined pre-feasibility study

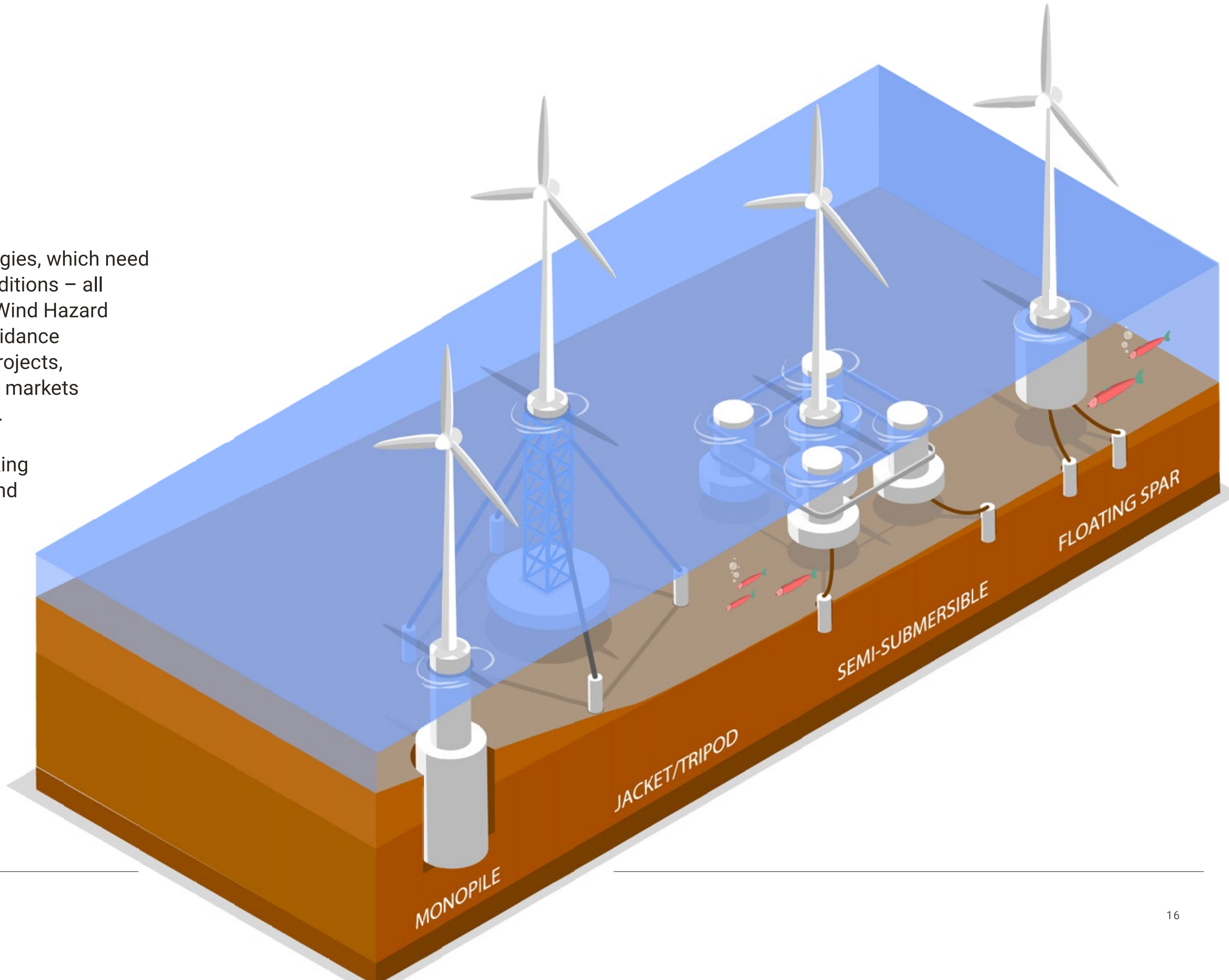
Offshore Wind Performance Upgrade Study – Client Confidential

For a utility scale UK offshore wind farm Black & Veatch delivered an assessment of the production enhancement potential of different asset upgrade scenarios.

Setting Standards To Reduce Risk

Floating wind and marine energy are maturing technologies, which need to be built, operated, and maintained in unforgiving conditions – all factors that increase risk. As the G+ Floating Offshore Wind Hazard Identification report noted there are gaps in industry guidance for constructing and operating floating offshore wind projects, including the risk of novel technology being deployed in markets with no offshore experience nor regulatory frameworks.

This risk profile means there is significant value in working with partners who are helping develop the standards, and thus fully understand the risks and mitigations, that are being created to nurture the sector's long-term viability. Black & Veatch's regional and global experts have a wealth of such expertise.



Let’s Talk

While fixed offshore wind is a mature technology, marine energy and floating wind – both in the ascendency – are developing technologies; as is producing green hydrogen with power generated offshore. By definition all of these technologies are built, operated and maintained in challenging conditions.

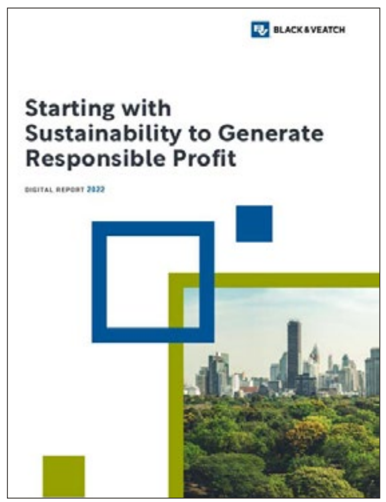
To succeed, and minimize risk, projects to generate electricity offshore need partners expert in the established technologies as well as helping nurture the developing ones to commercial viability. The most complete support, in addition, needs to be technology agnostic; and based on proven experience in the transmission as well as generation of electricity offshore.

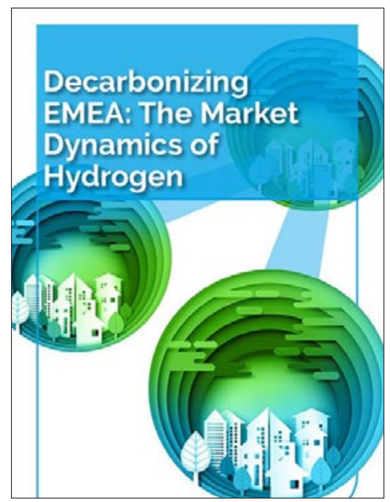
Finally, execution certainty is best served by partners with demonstrable experience of adding value at every point in the project lifecycle, and managing the complex interfaces between the differing disciplines and systems offshore energy projects encompass. Let’s talk and see how we can help you and your project.

Learn more about Black & Veatch at bv.com

At Black & Veatch, our mission is to build a world of difference through innovation in sustainable infrastructure. We help organizations integrate a range of technologies to cost-effectively achieve resilience, sustainability, and growth.

Read Our Other eBooks to Stay Ahead of the Net-Zero Curve





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