# OFFSHORE WIND: ACHIEVING WORLDWIDE POTENTIAL

## How to make the most of this renewable energy resource, accelerate progress toward net zero and support the future green hydrogen supply chain

September 26, 2022

Offshore wind is a rapidly maturing renewable energy technology with great potential to advance the global transition to green energy. The International Energy Agency (IEA) has identified the magnitude of future capacity, citing a potential to generate more than 420 000 Terawatt-hour (TWh) per year worldwide—more than 18 times global electricity demand today.[1]

According to the Global Wind Energy Council (GWEC), 2021 was the second best year for the global wind industry and best year ever for the global offshore wind industry (amid the COVID-19 pandemic)—in terms of new capacity connected to the grid—but new wind installations must quadruple by the end of the decade for the world to meet net zero by 2050.[2]

The following article brings together insights from some of WSP's advisors and technical specialists around the world—to shed light on the issues and complex considerations influencing the advancement of the offshore wind industry and to help shape decision-making that enables accelerated progress.

*Contributors: Michael Drunsic, USA; Ian Finnie, Australia; Helen Jameson, United Kingdom; Tara Kennedy, Australia; Frank Lin, Asia; Colin McGovern, Australia; Per Møller-Jensen, Denmark; Jonas Sahlin, Sweden; Alex Scott, United Kingdom (Contact information is available at the end of the article.)*

[1] IEA *Offshore Wind Outlook 2019* highlights.
[2] Global Wind Energy Council: highlights from *Global Offshore Wind Report 2022* and *Global Wind Report 2022*.

# ARTICLE SECTIONS



**Pertinent Facts**:

- In terms of cumulative offshore wind installations, the top spot has been held by the UK since 2009, but China took over the position by the end of 2021. The other markets in the global top-five are: Germany, The Netherlands and Denmark. (*GWEC Global Wind Report 2022*)
- Offshore wind growth worldwide is expected to decline 40% in 2022 following the exceptional four-fold jump last year in China due to the national subsidy phase-out deadline. Despite this decline, 2022 global offshore wind capacity additions will still double compared to 2020, due to the continuation of provincial incentives in China and the expansion in the European Union. (IEA update, May 2022)
- In September 2022, the North Sea Energy Cooperation group of countries (Belgium, Denmark, France, Germany, Ireland, the Netherlands and Norway) set a non-binding aggregate target of 260 gigawatt (GW) of offshore wind capacity online by 2050. The need for accelerated permitting procedures was highlighted as a key facilitator for this target. (North Seas Energy Cooperation joint statement)

- Compared to continuing with a fossil fuel-based system, a rapid green energy global transition will likely result in trillions of net savings, as much as $12tn (£10.2tn) by 2050, according to a University of Oxford report.

## RESOURCES: PEOPLE, COMMUNITIES, GOVERNMENT

**Helen Jameson**: The offshore wind industry is currently facing a shortage of skilled people as expansion outpaces recruitment, training and development of staff. Developers, regulators, environmental stakeholders and consultants are all fishing from the same limited pool of expertise and more attention needs to be given to increasing the size of that pool.

**Jonas Sahlin**: The potential for offshore wind is enormous—the market is in its infancy in many countries while mature in others such as the UK, Denmark and the Netherlands— and the commercial opportunities are huge. In the Nordics, we currently see an explosion in demand for services within this sector starting with the preplanning and permitting phases. The demand for marine biologists and permitting specialists has never been higher and is quickly spreading to related technical services such as geoscience, structural engineering, transmission design, ports and infrastructure. Demand for marine specialists able to support offshore wind deployment will continue to increase for at least a decade, probably much longer, which means that we need to plan ahead to achieve long-term sustainable growth in this area.

**Frank Lin**: Taiwan is the first country in Asia to engage the global offshore wind supply chain to implement offshore wind power. The first offshore wind farm, which is 900 megawatts, is expected to be connected to the power grid before the end of 2022. During the journey, we [WSP], as engineering consultants, have found there are many gaps in skilled labor, experts, and vessels. The government is still negotiating with global developers to strike a bargain on power tariffs, balancing the lower costs that the global supply chain could deliver versus investment in the local offshore wind supply chain and the associated higher near-term costs. The governments of Japan and Korea are still thinking about how to develop their offshore wind power. From a governmental perspective, how to attract global investors to contribute their experience, expertise and financial capital to invest in offshore wind is the most crucial factor for success in Asia in terms of developing local offshore wind power.

**Helen Jameson**: Offshore wind skills development and green jobs in general is often cited as one of the most significant benefits of the industry, as is local investment in coastal communities closest to the development. As local supply chains develop across countries and geographical regions, there is the potential for significant economic boost and emergence of new export industries that will also contribute to the energy transition, such as the export of green hydrogen.

**Per Møller-Jensen**: Creating an energy sector that is entirely new in many countries calls for particular skill sets and insights. As we transition away from carbon-heavy industry, expertise from these sectors must be transferred and embedded into new carbon-neutral industries, such as offshore wind and green hydrogen, as efficiently as possible.

**Helen Jameson**: Transitioning personnel from oil and gas to offshore wind operations should be an easy win, but currently there is some misalignment in training and certification between the sectors that is presenting a barrier to this shift. Prioritizing the transition of expertise from other sectors in the short term is important, but equally important is the long-term picture and increasing access to graduate schemes, apprenticeships and educational programs that emphasize future opportunities in renewable energy and sustainable development.

I would also like to draw attention to the skills needs in the project development phase, which is often overlooked in favour of highlighting opportunities in construction and offshore operations. There are a vast number of projects entering development globally, a process that takes a good five to 10 years; this is where the immediate need is—there will be nothing to install until projects are designed, developed, consented, and investment is secured.

**Tara Kennedy**: Working with communities to build their awareness and support of offshore wind is critical. Government expectations are high that the benefits of offshore wind will flow to local communities. Building and maintaining social licence to operate is essential to overall project success.

**Michael Drunsic**:  In certain markets, native or Indigenous peoples represent key stakeholder communities whose engagement in offshore wind will be critical to the success of projects and the industry at large. For many such communities, marine and coastal areas are deeply tied to their economic, cultural, spiritual, ceremonial and/or traditional rights and way of life. Early engagement with such communities to understand their concerns, requirements and objectives with respect to offshore wind will facilitate effective and equitable decision-making. Alignment on a comprehensive mitigation program approach for economic and cultural marine and coastal uses will be crucial to ensure sustainable offshore wind development in these areas.

**Per Møller-Jensen**: It is unquestionably important to engage all local communities regarding the actions that will help to meet net-zero requirements, but the regulatory environment is lagging behind people's anxiousness to tackle climate change. Although political support for offshore wind tends to be high, permitting processes are often complex, inefficient and overly precautionary, and this is obviously exacerbated by the overall complexity of the energy transition.

## SUPPLY CHAIN

### OVERVIEW

**Michael Drunsic**: The offshore wind supply chain includes all companies that contribute to the development, construction, operation, and eventual decommissioning of offshore wind farms. Until recently, the offshore wind supply chain had been centered in Europe as this was the birthplace of offshore wind and where most of the project activity was. As other markets have emerged, the supply chain has developed globally, reflecting the drive for local economic development in emerging markets as well as the pressure for cost reduction, and these objectives may compete.

### CONSIDERATIONS AND ISSUES

**Helen Jameson**: Supply chain related considerations and issues are extensive. One of the main drivers behind most national offshore wind/energy transition strategies is the hope of realizing a potential boost to local, meaning country specific or regional, supply chains. In some countries, such as the UK, developers must submit detailed supply chain plans to demonstrate where their investment will be focused throughout the lifetime of their projects, with an emphasis on local supply, in order to secure rights to develop their preferred area of seabed and/or to secure government subsidies. In some cases, there are prescribed minimum percentage targets for local supply, and these tend to increase over time as there is an expectation that local supply chain capabilities will improve as time goes on, but it isn't always that simple.

Given that the major infrastructure components (turbines, foundations, offshore substations in particular) constitute such a significant proportion of a project's total investment, if these have to be sourced and manufactured overseas, that's a significant proportion of total project investment that isn't being made locally. Developers may be willing to invest more locally, but in many cases the supply chain does not exist, and where it does the conflicting pressure to minimize LCoE [Levelized Cost of Energy] means, as Michael noted, they may need to compromise optimum economics in order to source locally. In other words, local economic development may result in higher prices for offshore power, at least for early mover projects.

**Tara Kennedy**: Relative to local development, the supply chain for offshore wind can be particularly vulnerable to challenging local conditions. For example, the logistics associated with mobilizing equipment and materials for the construction of an offshore wind project in Europe is very different to doing a similar exercise for an offshore project in the Asia Pacific region, with its different seabed conditions.

**Per Møller-Jensen**: While we are addressing the supply chain topic, it's important to note that increasing demand will not only exert greater pressure on supply chains—a constant no matter the location—it raises another issue: embodied carbon. Industry is paying increasing attention to reducing embodied carbon, and this effort also applies to offshore wind, which represents a great opportunity to accelerate progress to net zero. Renewable energy projects especially have a responsibility to dig deeper into the embodied carbon reduction issue, making sure that the project lifecycle supports carbon reduction. Just because the end result is green does not mean that stakeholders are making sure the whole process is green.

**Helen Jameson**: Embodied carbon reduction should thread through all projects and will be increasingly relevant to offshore wind as supply needs to rise to meet increasing demand. Local facilities can bring benefits here too. Currently approximately 60 percent of global offshore wind turbine manufacturing capacity is in China, 30 percent is in Europe and the remainder is in Southeast Asia. Development of local manufacturing facilities and ports infrastructure presents a significant opportunity for increasing local supply and could bring with it significant growth in jobs both directly and within supporting supply chains. However, whether new suppliers can establish at the pace required to meet this demand is not yet known, and there is currently a great deal of instability in supply chains as a result of the energy crisis and rising inflation.

**Michael Drunsic**: For suppliers of major components such as wind turbines, cables, or foundations, investment in a new market will be difficult to justify unless and until there is a significant pipeline of offshore wind capacity in development and a high level of certainty associated with that pipeline. Therefore, building a domestic supply chain in an emerging market requires commitments from developers, regulatory authorities, and offtake parties (utilities), as well as support from local communities.

**Frank Lin**: The government of Taiwan is trying hard to develop local manufacturing/maintenance capacity to develop offshore wind power. Korea is very strong in terms of the manufacturing of jacket foundations, pin piles and wind turbine towers, and Vietnam is building heavy-industry capacity in jacket foundations. Ørsted [renewable energy company based in Denmark] supported the biggest manufacturer in Vietnam, PTSC, to develop this capacity. Therefore, Asia has the opportunity to build its regional supply chain through collaboration, with global investor professional support.

## INSTALLATION VESSELS

**Helen Jameson**: Offshore wind turbines are less constrained in terms of their size as those sited onshore—there are usually reduced visual impacts and the logistics of getting large components to site is more straightforward than onshore. Larger machines with longer blades and higher hub heights allow access to stronger and more consistent wind resources away from the turbulence of the sea surface. Larger turbines means a greater output per machine, thus requiring fewer turbines per wind farm to achieve a given capacity, and offshore wind turbines have grown substantially in recent years. For example, 10 years ago offshore wind turbines averaged three-to-four megawatt [MW] output per unit; in 2022, 13-MW GE Haliade-X machines are being installed for the first phase of Dogger Bank in the North Sea. A one-GW wind farm could now consist of around 75 turbines, whereas a decade ago that number would have been closer to 300. This relationship is the reason behind much of the cost reduction we have seen in offshore wind over the past decade—smaller numbers of larger turbines means reduced cost of raw materials, installation, and operation and maintenance activities.

The Voltaire, the world's largest jack-up installation vessel, is at work on Dogger Bank and stands at 325 metres—just taller than the Eiffel Tower at its full vertical extension (from seabed to the tip of the crane). Projects in development now are looking at 20-MW machines with heights of around 350 metres above water level, and some even beyond this—as there are no signs yet of the pace of turbine technology development slowing. These huge machines will need vessels and supporting infrastructure able to accommodate components and assemblies, transport them to site and then install them safely.

In addition, the move to deeper waters and floating wind farms will bring new installation challenges. It is not only turbine installation vessels that are under pressure but those required for foundation and cable installation as well as the range of smaller support vessels involved in the installation process. Existing vessels service projects across the globe; therefore, as the global pipeline grows there is greater demand for these vessels. Vessel availability is likely to create bottlenecks and delays to construction schedules if upgrades and production of new vessels cannot keep pace with this demand. Given that demand continues to grow and lead time for production of new vessels can be two to five years, and is dependent on shipyard capacity and equipment availability at the right time, investment needs to happen now to avoid shortages becoming a real problem towards the end of the decade.

Another problem is finding suitably qualified and experienced personnel to crew these vessels and, as with other industry resource shortages, this is likely to become more difficult over time and lead to increased risk in installation operations.

## RAW MATERIALS

**Helen Jameson**: Whilst the energy produced from wind is renewable, that does not mean the entire supply chain is sustainable. Raw materials such as copper, aluminium, rare earth metals and other minerals such as molybdenum, manganese, chromium and nickel are fundamental to the industry as components of permanent magnets and steel alloys. However, their supply chains are fraught with geopolitical instability, environmental impacts and human rights issues. The main existing natural sources of some materials are restricted to certain geographies, and it can take decades to find new sources and establish new mining activities, so bottlenecks and unexpected disruption to supplies can result. Paradoxically, the global green energy transition has the potential to increase environmental and social pressures associated with extraction activities—such as water scarcity, increased waste, biodiversity loss, air and water pollution, and human health socioeconomic impacts. This is a truly global concern and can only be tackled if those at the demand end of the spectrum take responsibility for supply chain due diligence and work with local regulators to ensure appropriate environmental and ethical controls are applied. Material substitution research is also a key piece of the puzzle in order to relieve pressure on existing minerals supply chains and open up new opportunities.

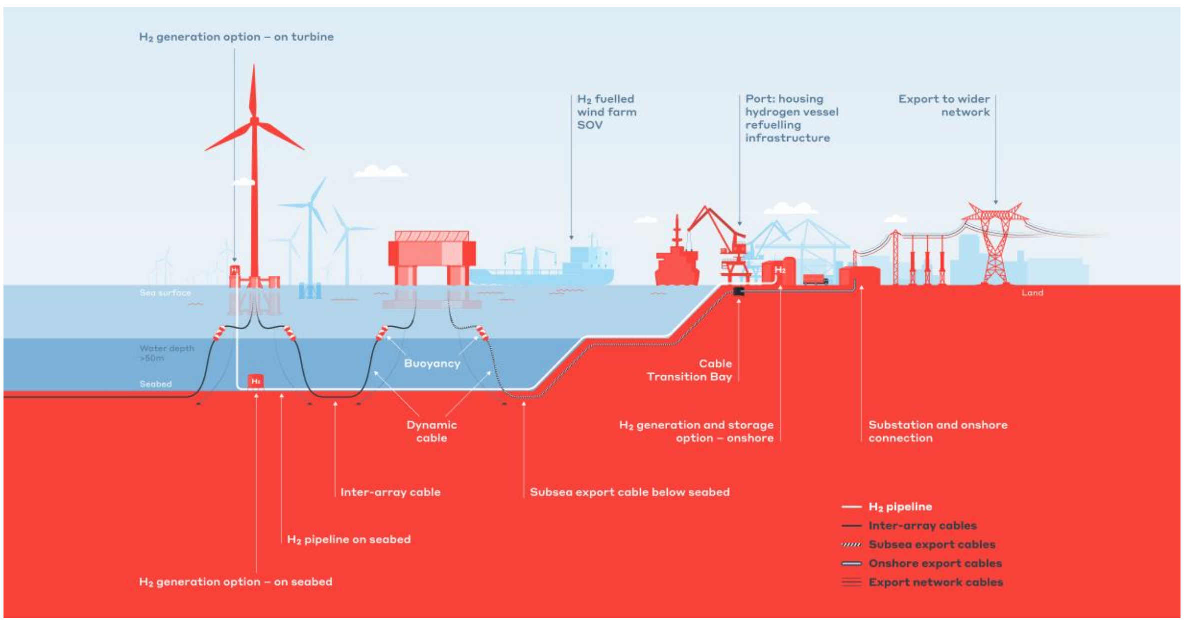


Figure 1 – Steps and components in offshore wind power generation and grid connection, incorporating green hydrogen generation into the energy system

# PORTS

## THE ROLE OF PORTS

**Michael Drunsic**: Ports represent a critical infrastructure component for construction of offshore wind projects and serve as hubs for development of key aspects of the offshore wind supply chain. As a maritime industry, offshore wind relies on ports and harbors for all phases of the project life cycle. During the development phase, ports are necessary to support the vessels that are required for various surveys and site investigations as well as deployment of measurement buoys or other monitoring equipment. For manufacturing and construction, ports are critical for delivery of components from manufacturing facilities to the project site or to a marshalling port where components may be stored and/or assembled prior to transportation to the project site for installation. During operations, ports serve as a base for operations and maintenance crews to operate from, supporting vessel-based operations as well as other operational functions such as parts storage, repair shops and crew training. From an economic development perspective, a port that can provide services to the offshore wind industry can serve as an anchor for industrial development. Major component manufacturing facilities need to be located at or adjacent to ports to facilitate transportation of manufactured components. Such facilities attract manufacturers of subcomponents to co-locate or locate nearby to reduce transportation costs and take advantage of the local workforce.

## INFRASTRUCTURE AND THE EMERGENCE OF FLOATING WIND TECHNOLOGY

**Tara Kennedy**: For those regions where substantial investment in port facilities has already occurred, offshore wind represents an opportunity to transition port infrastructure from a dependence on fossil fuel exports, such as coal, oil and gas, to supporting renewable energy generation. Reutilizing this existing infrastructure where possible reduces cost and overall environmental impacts of offshore wind projects.

**Michael Drunsic**: In certain nascent markets where offshore wind is developing, port infrastructure may not be suited to construction of offshore wind projects. In such regions, new port facilities or upgrades to existing facilities may be required. This infrastructure development can take years to plan and execute and can require billions of dollars of investment. Additionally, suitable locations for such port facilities may be very limited.

**Helen Jameson**: The time taken to develop and execute ports upgrades is a significant threat to projected offshore wind deployment rates. There are about 40-50 floating substructure concepts in development, and this brings uncertainty in terms of future port infrastructure needs and where exactly to target investment. Specific requirements include large laydown areas, deep water quaysides and heavy lifting capabilities.

The emergence of floating wind technology has tripled the area of global seabed that is suitable for offshore wind and the global pipeline is growing rapidly. Much of the world’s current ports infrastructure is not ready to accommodate the magnitude and rate of expansion that is predicted, particularly in terms of floating wind where the space requirements are so vast.

## LINKING OFFSHORE WIND AND GREEN HYDROGEN

**Helen Jameson**: There is an opportunity for ports to play a significant role in terms of the future green hydrogen value chain, both as a location for hydrogen plants and as an offtaker if vessels transition to green hydrogen. A wind-linked hydrogen plant could be located offshore—on the turbines themselves, an individual platform, or perhaps directly on the seabed—with the hydrogen gas produced then piped to shore, or via an electrolyzer sited onshore at the port that is powered by a private supply of electricity directly from the wind farm.

There are several possible advantages to linking hydrogen generation to offshore wind and also bringing ports into the mix for siting of a hydrogen plant and end use of the hydrogen product. Maritime uses of hydrogen for fuel are promising when it comes to decarbonization of this sector; having the hydrogen end user at the port itself would remove the need for downstream logistics operations like the use of tankers to transport hydrogen gas potentially long distances from where it is generated to where it is used.

As ports tend to be fairly industrial, hydrogen generation and storage facilities are likely to fit in well with the existing landscape and interactions with other land uses. Stakeholders could potentially be eliminated, reducing risk of planning conflicts that might be encountered closer to residential or recreational areas. Finally, if port users transition their vessel fleets to use hydrogen fuel, and this approach is adopted widely, demand for green hydrogen will increase, costs will come down, and developers will have the confidence to invest in green hydrogen generation. Hydrogen-fuelled crew transfer and service operation vessels would mean the hydrogen generated by a wind farm could then be used to maintain it—wider supply chain decarbonization potential and a nice circularity to things.

## TRANSMISSION

### GRID CONNECTION AND CABLES

**Tara Kennedy**: Regardless of location, all offshore wind farms require an onshore connection point, either into the electricity grid or direct to consumers. Securing a grid connection, preferably a secure one with no onerous conditions, is a perpetual challenge for wind projects. It is becoming increasingly so as demand for connection capacity increases and grid upgrades to accommodate large volumes of intermittent renewable generation struggle to keep up the pace, which can significantly delay project timeframes. Early engagement with connection authorities can assist with mitigating this risk—as demonstrated in the Star of the South offshore wind farm project in Australia, where WSP is helping to facilitate risk mitigation through its role as onshore owner's engineer. This includes working with our client to understand and respond to stakeholder concerns regarding transmission impacts, as onshore transmission infrastructure can be some of the most controversial on any project given the environmental and human interactions involved.

**Frank Lin**: Our experience of developing offshore wind in Taiwan relative to transmission has shown that the landing pipeline is too congested. There are many transmission lines going to the landside from the sea. The submarine cable needs a certain level of protection, and there is not enough space at the landing point to accommodate so many offshore wind developers' transmission lines.

**Helen Jameson**: As projects move further offshore the transmission technology of choice switches from HVAC [high-voltage alternating current] to HVDC [high-voltage direct current], and new dynamic cable technologies are being developed for use on floating wind projects. Stakeholders are also pushing for a more strategic approach to transmission design for offshore wind—a move away from project-by-project individual transmission design towards multi-project or interconnection approaches. How this might work in practice is illustrated by the Kriegers Flak Combined Grid Solution project, which interconnects Danish Kriegers Flak and Baltic 1 and 2 offshore wind farms, as well as incorporating an interconnection between Danish and German national grids. Delivered in 2020, the Combined Grid Solution was developed in partnership between Danish and German transmission system operators Energinet and 50Hertz and is the world's first interconnector project that also incorporates offshore wind farm generation. This design not only allows the bidirectional flow and international trading of electricity associated with a traditional interconnector it also enables the feed in of renewable electricity generated by the offshore wind farms to either national grid via the same transmission system. This brings benefits in terms of system stability, utilization, security of supply and cost effectiveness for the consumer.

**Alex Scott**: It is important to note that cable manufacturers are coming under increasing pressure too, particularly with respect to HVDC cables. In mature markets and potential markets, the siting of offshore wind farms tends to be further from the shore, either because the near shore sites have already been developed or because of considerable resistance to wind farms in near shore areas; this increases the likelihood that export cables will be HVDC, bringing them into competition for manufacturing space with interconnector cables, with hundreds and in some cases thousands of kilometres of cable required. Whilst investment in this area is likely to be high with potential new entrants, there is not the same incentive to increase HVAC export and array cable capacity without a significant pipeline of OWFs [offshore wind farms] in development.

**Per Møller-Jensen**: Deployment of interconnectors at sea will enable the large variation in production to be brought to a large market. For example, the vision of making the North Sea equal to an offshore wind energy production facility calls for interconnectivity from Italy to Norway with a capacity that can transmit the needed offshore wind energy.

## SITE SELECTION, PLANNING, ENVIRONMENT

### OFFSHORE SITE INVESTIGATIONS

**Colin McGovern**: Conclusions drawn from desktop studies are often based on low resolution, regional datasets. These can be used to build an early-stage wind model or ground model, for instance, and highlight obvious red flags for the development, but the models require refinement and validation through high resolution, site-specific data. For example, a global wind dataset may provide a (modelled) estimate of the expected wind resource, but LiDAR [light detection and ranging] buoys deployed at site can record actual wind speeds, direction and seasonal variations at the relevant altitude. Similarly, regional bathymetry datasets, seismic data and borehole logs, if at all available, can provide an understanding of the expected large-scale processes and geological domains, but site-specific high-resolution geophysical data is essential to characterize the seafloor and sub-seafloor structure and identify geological hazards and constraints. Based on the newly acquired geophysical data, suitable locations for geotechnical samples and tests can be identified to ground-truth any previous interpretation of geological units and derive geotechnical parameters from advanced soil and rock laboratory tests, which will directly feed into the engineering and design phase.

**Ian Finnie**: Offshore site investigations present one of the earliest major cost outlays in the project development cycle due to high costs of mobilizing and operating suitable survey platforms. These costs are often not fully anticipated, which can result in poorly executed investigations that do not necessarily meet the project requirements. Seabed surveys are not just a box-ticking exercise, as they provide value-adding information that enables cost savings within the project. A lack of seabed information, on the other hand, often has disproportionately large deferred cost implications in terms of design and construction. Local seabed conditions can vary significantly across OWF regions, both on a global and national scale, which means some equipment might be suitable for one region but not for the particular site that the developer is looking at. Timely engagement with consultants that have the crucial local knowledge and experience and are able to provide reliable and truly independent advice will ensure the site investigation strategy is tailored to the local conditions with rationally selected survey equipment. The knock-on effect of sub-optimal site investigations to the overall project should not be underestimated. Inadequacies in the survey activities, if not identified and addressed in time, can ultimately lead to the need to repeat the campaign, over-conservation in design or, worse, major problems during construction resulting in costly remedial work.

**Frank Lin**: In our experience developing offshore wind in Taiwan, offshore site investigation is very important, especially the seabed soil investigation. In one instance, the developer, trying to save money, did not carry out a complete soil investigation. When carrying out the pin pile construction work, the pin pile went down too deep, way below the original pile length. As a result, the developer had to abandon this site, and the effort for this task was in vain.

## PLANNING AND ENVIRONMENT

**Tara Kennedy**: Planning and marine impact assessment in the offshore environment can be challenging. Generally, multiyear studies are required to understand the existing environment and how this may be impacted by the offshore wind development. Engaging with the community to understand and respond to their concerns is also a key consideration. Significant community opposition can delay or prevent offshore wind development. Working with regional associations/networks in affected community, as early as possible, ensures that community concerns are understood and incorporated into project development.

**Helen Jameson**: For new markets, the lack of precedent in impact assessment of offshore wind can present a challenge—how best to approach collection of baseline data, the best assessment methodology to use and what mitigation measures are appropriate. These factors, together with precaution in relation to new technology and inefficient planning processes, can hinder advancement.

New markets have the option to draw on experience from mature markets; however, regulators and stakeholders often prefer to forge their own path. In mature markets, the issue of cumulative impacts is becoming more prominent as the number of projects increases and traditional precautionary approaches to cumulative impact assessment are no longer fit for purpose. This brings the issue of minimal "ecological headroom" remaining to accommodate future projects, and predictions of likely significant effects where there may not be any.

Floating technology has only been deployed on a limited scale to date, and there are multiple concepts in development. Many developers take a "design envelope" approach to environmental impact assessment, where worst-case parameters are defined and used as a basis for impact modelling. When there are multiple possible options for foundation designs that haven't even been fully developed yet, there is potential for uncertainty, ambiguity and complexity in the EIA [Environmental Impact Assessment], methodological uncertainty, stakeholder and regulator precaution, and an increased risk of planning delays.

## ENVIRONMENTAL IMPACTS

**Tara Kennedy**: Onshore energy projects are becoming increasingly constrained, with limited opportunities for the development of greenfield projects. This is due to a focus from regulators on managing community and environmental impacts, such as terrestrial biodiversity loss. Moving projects offshore can reduce this impact, particularly from a community perspective.

**Helen Jameson**: Moving wind generation offshore does bring some benefits in terms of reduced environmental and human impacts. For example, visual impacts are, usually, significantly reduced and operational noise from the turbines is pretty much eliminated from a human perspective, though subsea noise impacts on marine fauna remain a key issue—the bigger the turbines get, and they are always getting bigger, the greater the hammer energy required for piling operations. However, one of the key potential environmental benefits of floating wind is removing the need for monopile installation, thereby reducing subsea noise emissions significantly. Conversely, the newness of these technologies brings uncertainty in other areas—for example, in the way marine mammals, fish and benthic communities interact with the structures, and impacts to marine traffic, commercial fishing and recreational users. Commercial fishing is a significant contributor to the local economy and cultural heritage of many regions. Floating offshore wind substructures have the potential to alter and in some cases potentially increase impacts on fisheries. Such impacts may include exclusion from fishing grounds, entanglement or gear loss, and alteration of species assemblages. A key concern is the sheer number of potential floating substructure concepts in development. Until you know what you're planning to build, you can't understand how a particular structure will interact with fishing activities and what can be done to reduce that impact—you don't know what you're trying to mitigate. This uncertainty can make impact assessment and fisheries coexistence planning very complex.

## MOVING FORWARD IN CONCERT

**Helen Jameson**: There are a few ways developers and wider industry stakeholders can take positive steps towards addressing permitting barriers. Early and constructive engagement at the project level is necessary in order for developers to get to know their local stakeholder communities and the pressures they face. It is worth taking the time to establish positive relationships early on as many will need to last the lifetime of the wind farm. Aside from the project-specific engagement, industry-level partnerships can help to pre-empt likely conflicts in particular regions, identify appropriate mitigation options, and produce best-practice guidance for developers. Industry-level work may also include jointly funded research programmes to address data gaps and improve understanding to the benefit of the whole industry, rather than individual developers trying to reinvent the wheel whilst in the grip of project time pressures.

Potential conflicts are best dealt with early, openly and collaboratively. By getting involved in offshore wind discussion fora, working groups, research projects and consultations on legislative reform, organizations can shape the future regulatory landscape in their market.

On a project-specific level, a clear program for design development from the outset and realistic design freeze milestones at key stages that allow sufficient time to revise modelling, impact assessments and revisit requirements for mitigation are imperative for an efficient EIA and planning process.

Planning and engineering teams must work closely throughout development—if you want to ensure your project is buildable, don't wait until you have your permit before involving the design team. And finally, learn lessons from the successful projects out there and ensure your stakeholders are taken on the journey with you—the earlier they are engaged the better, to avoid undesirable surprises for all involved.

Michael Drunsic
Vice President, Offshore Wind Lead, USA
Michael.Drunsic@wsp.com

Ian Finnie
Technical Director, Australia
Ian.Finnie@wsp.com

Helen Jameson
Technical Director, Offshore Renewables, United Kingdom
GlobalT&I@wsp.com

Tara Kennedy
Energy Sector Lead, Australia
Tara.Kennedy@wsp.com

Frank Lin
General Manager, Asia
Frank.Lin@wsp.com

Colin McGovern
Associate Geoscientist, Australia
Colin.Mcgovern@wsp.com

Per Møller-Jensen
Market Director, Denmark
Per.Moller-Jensen@wsp.com

Jonas Sahlin
Mission Leader, Earth and Environment, Sweden
Jonas.Sahlin@wsp.com

Alex Scott
Associate, Marine Cable Installation Advisor, United Kingdom
Stephen.Scott@wsp.com

## *About WSP*

As one of the world's leading professional services firms, WSP exists to future-proof our cities and environment. We provide strategic advisory, engineering, and design services to clients in the transportation, infrastructure, environment, building, energy, water, and mining sectors. Our 66,000 trusted professionals are united by the common purpose of creating positive, long-lasting impacts on the communities we serve through a culture of innovation, integrity, and inclusion. Sustainability and science permeate our work. In 2022, WSP derived more than half of its $11.9 B (CAD) revenues from services that support the UN Sustainable Development Goals. The Corporation's shares are listed on the Toronto Stock Exchange (TSX:WSP). To find out more, wsp.com