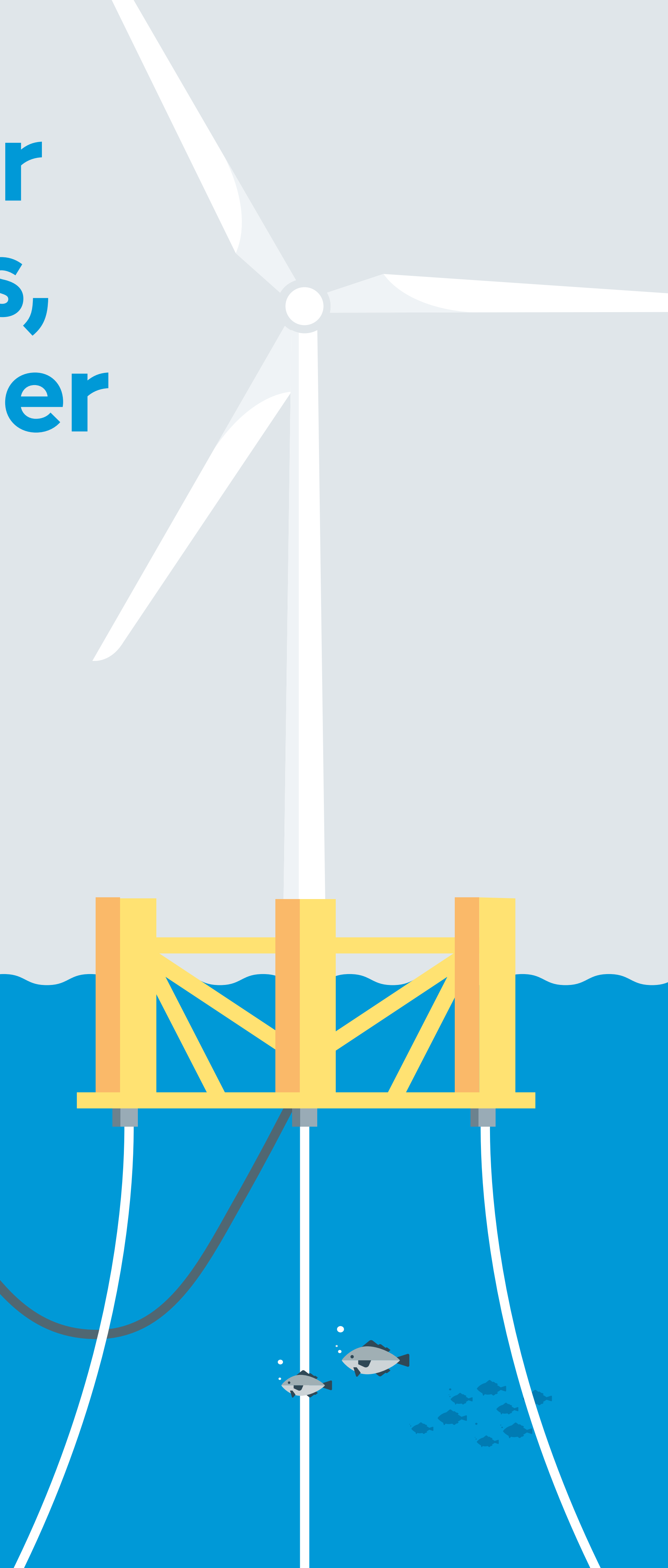
Deeper waters, stronger winds

How floating offshore wind can be scaled



Ørsted

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It is clear we need to accelerate the global deployment of renewable energy as much as possible – but we must also take care to do it right, in accordance with nature and with local communities.

Mads Nipper
CEO, Ørsted

How floating offshore wind can be scaled

The world is faced with three global and interconnected crises: An energy crisis, led by supply disruption and skyrocketing costs of energy; a climate crisis, caused by our historic and current greenhouse gas emissions; and a biodiversity crisis, marked by habitat degradation and biodiversity loss. These megatrends influence and exacerbate each other, making it imperative to consider them together when developing effective responses.

The energy crisis stems from our economies' strong reliance on fossil fuels for energy, which also contributes 73 %[1] of anthropogenic greenhouse gas emissions, accelerating the climate crisis. In turn, climate change deepens and widens the biodiversity crisis by impairing both resilience and the ability of natural systems to respond and adapt to the climate crisis. Finally, the energy crisis is made worse by droughts, floods, heatwaves, and wildfires, attributable to climate change, which impacts electric system resiliency and thus reliability.

With our fossil fuel dependence at the very root of all three problems, converting our energy system from fossil fuels to renewable energy sources is the single most important lever to address all three on a global scale. It is clear we need to accelerate the global deployment of renewable energy generation as much as possible – but we must also take care to do it right, in accordance with nature and with local communities. One technology with an immense, yet untapped, potential is floating offshore wind. By placing offshore wind turbines on floating foundations, new and deeper waters become accessible to clean energy generation, bringing the benefits of offshore wind generation to new coasts and communities. But floating offshore wind is also still entering its first phases of commercialisation.

At Ørsted, we believe floating offshore wind can be an integral part of a world running entirely on green energy. We are actively developing projects in several markets – including Scotland, Norway, Spain, and Vietnam – and are working to add new projects to this list. We are committed in bringing our world-leading experience and expertise to bear in commercialising and scaling up floating wind. And we believe it is possible because we have done so before with seabed-fixed offshore wind.

Mads Nipper
CEO, Ørsted

1. Ørsted (2020) Taking action to stay within 1.5°C

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Floating offshore wind will be able to build on the developments made in seabed fixed offshore wind to reach scale even faster – much as today's offshore wind industry was built on achievements onshore. However, such growth will not happen automatically.

Gabriel Davies
Program Director, Floating Wind, Ørsted

Introduction

A decade ago, seabed-fixed offshore wind was a new and niche technology. At the time, a handful of large-scale projects had been completed in Europe, and the project pipeline ahead was steadily increasing. Yet, offshore wind was far from the scale and commercialisation needed to become a competitive alternative to other energy sources. However, through the hard work of Ørsted and other industry leaders dedicated to optimising, standardising, and industrialising design, components, and processes, economies of scale were achieved. Since then, offshore wind has become the fastest-growing energy technology globally, and costs have been reduced by more than 65 %[2], making it both a crucial lever to decarbonise energy use, and critical infrastructure in modern economies' efforts to secure a resilient supply of energy.

Floating offshore wind is today at an inflection point as was the case for seabed-fixed offshore wind ten years ago. While floating wind technology and pilot projects have been in place for more than a decade, only about 50 floating offshore wind turbines have been commissioned as of October 2022[3]. This stands to change, as the global stock is expected to exceed 5 GW by 2030 and 25 GW by 2035. In fact, floating offshore wind will be able to build on the developments made in seabed-fixed offshore wind to reach scale even faster – much as today's offshore wind industry was built on achievements onshore.

However, such growth will not happen automatically. Just as with seabed-fixed offshore wind, it will require investment and development efforts to standardise and commoditise floating offshore wind foundations and solutions. At the same time, scaling up floating offshore wind will present both new challenges and opportunities that reach beyond just the wind farms. The build-out of floating offshore wind must be done in balance with oceanic life, ocean users, and local communities. This means implementing both existing and new solutions to assess and mitigate potential adverse effects, while amplifying the positive effects on local environment and communities.

With this paper, we want to look ahead, outline and initialise some of the important themes that must be understood and addressed by industry, policymakers, and societal stakeholders for floating offshore wind to play its part in the green transformation.

As a global leader in offshore wind, we understand the importance of broad industry collaboration in finding the right solutions to both known and new challenges that arise as offshore wind is taken to new waters beyond the horizon of seabed-fixed offshore wind. And just as Ørsted was an integral part of making seabed-fixed offshore wind mature and affordable, we will bring our long experience and market-leading status to bear in scaling up and commercialising floating offshore wind.

Gabriel Davies
Program Director, Floating Wind,
Ørsted

2. Bloomberg NEF, 1H 2022 LCOE Update, and generic offshore wind, Northwest Europe with FID 2012.
3. 4C Offshore, cummulative floating turbine count.

Executive summary

Floating offshore wind is a rapidly maturing technology with an enormous potential to increase offshore wind generation in existing markets – and enable offshore wind in new geographies.

Whilst seabed fixed offshore will likely remain the lower cost technology in many cases, floating has the clear potential to be an increasingly attractive supplement for countries with deeper waters. Compared to seabed-fixed offshore wind, floating foundations offer several advantages.

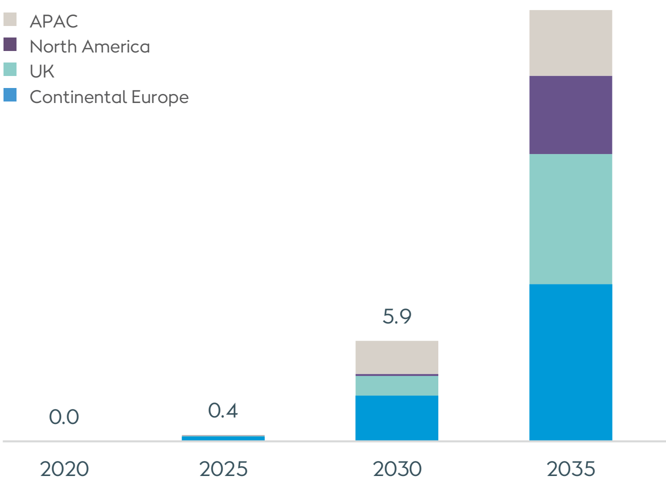
They can be installed in deeper waters or where the seabed is otherwise unfit for fixed foundations, granting more geographies access to the benefits of offshore wind generation. They can be installed further offshore, where winds generally blow stronger, while also making them less interfering to other sea users, reducing visual impacts from shore, and potentially further out of the way for many bird feeding grounds or migration routes. Installation does not entail piling of large monopile foundations into the seabed, and the floating foundations can generally be assembled quayside, reducing complexity and decreasing or even removing the need for jack-up vessels. However, floating offshore wind also poses new questions, including:

- How can design and processes be optimised to reduce the total cost of energy? *See pages 8-9.*
- How does a floating offshore wind farm impact and interact with the oceanic environment; how can environmental and biodiversity benefits be amplified – and how can potential adverse effects be mitigated? *See pages 12-13.*
- How can floating offshore wind co-exist with other ocean users? *See pages 14-15.*
- How can policymakers and industry collaborate to both accelerate the build-out of floating offshore wind, while also ensuring floating offshore wind creates value to the communities where it is implemented? *See pages 16-18.*

These questions must be addressed, while floating offshore wind is still undergoing its journey towards scaling up and driving down costs. Doing so will require partnering and dialogue. Between industry; between project developers, investors, and component suppliers; with conservation groups and academia who have the experience with local maritime wildlife; with fisheries and other users of the oceans; with ports and local communities; and with governments, regulators, and policymakers.

At Ørsted, we are committed to deploying floating offshore wind – in the right manner. For the energy system. For the industry and supply chains. For local communities and for other sea users. And for the environment.

Cummulative global installations of floating offshore wind, GW



Source: Bloomberg NEF

How can policymakers help speed up development of floating offshore wind?

Policymakers, who wish to support floating offshore wind development and who want to seize the first movers' advantage for floating offshore wind, could consider:

1. Avoid pitting floating offshore wind directly against seabed-fixed offshore wind for the time being.
2. Introduce non-price criteria to tenders.
3. Facilitate investments into new deep-water port infrastructure.
4. Acknowledge the balance between developing a local supply chain and growing a global industry.

If you only have 5 minutes...

Floating offshore wind has an immense role to play in decarbonising the global energy system. It is currently more expensive than seabed-fixed offshore wind and must scale and undergo a cost-out journey, just as seabed-fixed wind did. However, scale and cost-out do not happen automatically.

This means that...
Maturing and scaling floating offshore wind will require significant volumes and serious investment to kick-start the commercialisation journey, both for developers to reach the scale necessary to begin costing out, and for suppliers to have a visible pipeline upon which to justify the needed investments to scale up. Floating offshore wind can generally not be expected to compete directly with seabed-fixed offshore wind in the near-term future – pitting the two technologies directly against each other too early, e.g., in tenders or seabed auctions can become detrimental to the development of floating offshore wind.

Floating offshore wind farms come with impacts on the environment. Some are well known from seabed-fixed offshore wind, some are new. Some are positive, some are potentially adverse.

This means that...
To establish and grow floating offshore wind as a sustainable and mature technology, the specific interactions with local marine environment must be understood and steps taken to avoid and minimise impacts. This can be done by working with developers and the supply chain to identify solutions, and by introducing biodiversity criteria in tenders for floating offshore wind.

Floating offshore wind will share maritime space with many other ocean users, including commercial fisheries. Floating wind developers can draw upon the extensive catalogue of solutions for co-existence, while acknowledging different solutions may be required depending on the market.

This means that...
Thorough investigation, including fisheries monitoring surveys in sites and along cable routes, can be an important tool to identify and see potential adverse impacts. The offshore wind industry already has in place practices for proactively engaging with fisheries to find solutions for co-existence. Floating offshore wind developers should be encouraged or incentivised to seek out and implement both existing and new best practises – both for how to engage in ongoing dialogue with the fishing industry and for managing potential impacts on commercial fisheries.

Floating offshore wind presents an opportunity to establish and localise a supply chain position in an emerging industry. However, there are potential trade-offs to be addressed, and supply chains should be developed strategically, including consideration for regional synergies.

This means that...
Decision makers wanting to seize the opportunity to create a strong local industry within floating offshore wind solutions should carefully analyse and identify existing competences and play to the relative strengths of local suppliers. Ultimately, floating offshore wind will be a global market, meaning the goal should be to help suppliers become as competitive as possible – that way, they will not only win in home markets but also abroad.

Governments can engage with industry and developers to identify and facilitate new investments, including in port infrastructure required to assemble and launch floating offshore wind turbines. At the same time, policymakers are presented with a balance between, on the one hand, nourishing a local supply chain, growing and spurring job creation and domestic economic activity; and on the other hand, the ambition to bring down costs by establishing a regional and even global industry. As a guiding principle, decision makers should seek to facilitate local industry in leveraging its relative strengths – while also allowing industry neighbouring markets to leverage from their relative strengths.

Floating offshore wind and its potential

Oceans cover more than seven tenths of our planet, and the winds that blow above the waves hold enough energy to power our civilisation many times over. In a 2019 study, the International Energy Agency (IEA) found the global technical potential for offshore wind power generation to exceed 420,000 TWh per year – or more than 18 times the current global power demand[4]. Four fifths of this potential is in waters deeper than 60 metres, beyond the feasible technical range of most seabed-fixed foundations.

The ability to launch floating offshore wind farms firmly moored to the seabed and connected by dynamically suspended cables is an important enabler for unlocking this enormous potential for renewable energy.

Floating offshore wind is not a new technology. Rather, it is a new subset of components and subsystems that are combined with existing turbines, substations, transmission to shore, and connection to the onshore grid we know from seabed fixed offshore wind projects. This also allows floating offshore wind to piggyback on existing solutions and supply chains, enabling an accelerated cost-out compared to the one undertaken by seabed-fixed offshore wind over the last decade.

Scale doesn't come automatically

By the mid-2030s, it is predicted that one in every nine new offshore wind turbines could be placed on a floating foundation[5], thus both complementing seabed-fixed offshore wind and allowing access to large-scale renewable energy generation to coastal and island communities in new geographies.

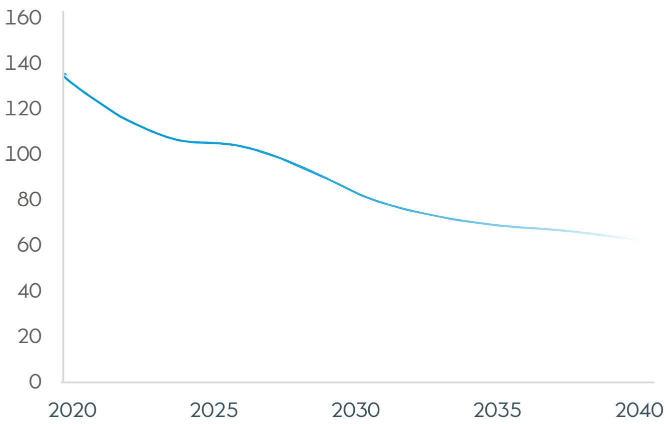
This scaling up is at the same time contingent on driving down costs. However, this will not happen automatically. It will require investments in establishing and growing the supply chain, optimisation of components and design, and executional excellence in both construction, operation, and maintenance.

While all three factors generally follow from implementing new and larger projects, they also rely on visibility and political prioritisation. In order to justify investments into manufacturing capacity, such as for mooring systems and floating foundations, and to effectively take the commercialisation journey to the next level, a firm pipeline of projects is needed. It is also through a pipeline of consecutive projects both developers and suppliers can implement learnings and improve the design of both components, systems, and processes. Much as was the case in the mid-2010s, where, for instance, the UK government provided a significant amount of FID-enabling contracts for difference for seabed-fixed offshore wind, thus helping build momentum in the industry.

While political ambitions for floating wind in Europe, North America, and Asia-Pacific have increased significantly over the last few years, such ambitions have in some cases yet to materialise in concrete tenders and projects.

Projected Levelised Cost of Energy

Floating offshore wind, EUR/MWh[6]



Key implication

Maturing and scaling floating offshore wind will require significant volumes and serious investment to kick-start the commercialisation journey, both for developers to reach the scale necessary to begin costing out, and for suppliers to have a visible pipeline upon which to justify the needed investments to scale up. Floating offshore wind can generally not be expected to compete directly with seabed-fixed offshore wind in the near-term future – pitting the two technologies directly against each other too early, e.g., in tenders or seabed auctions can become detrimental to the development of floating offshore wind.

4. IEA, Offshore Wind Outlook 2019. The technical potential includes offshore wind situated up to 300km from coastlines and in depths up to 2000m. It excludes environmental protection zones, buffer zones for existing infrastructure, oil and gas exploration, shipping lanes and fisheries.
5. Bloomberg NEF 1H 2022 Offshore Wind market outlook. 6. DNV GL and 4C, Wind Europe.

What is Ørsted's contribution?

From the world's first offshore wind farm in 1991 to the world's largest operating offshore wind farm, the 1,320 MW Hornsea II, commissioned in 2022, we have installed a total of more than 7.5 GW of offshore wind. With a further 3.5 GW under construction, Ørsted is the global leader in offshore wind development and the largest offshore wind developer by capacity.

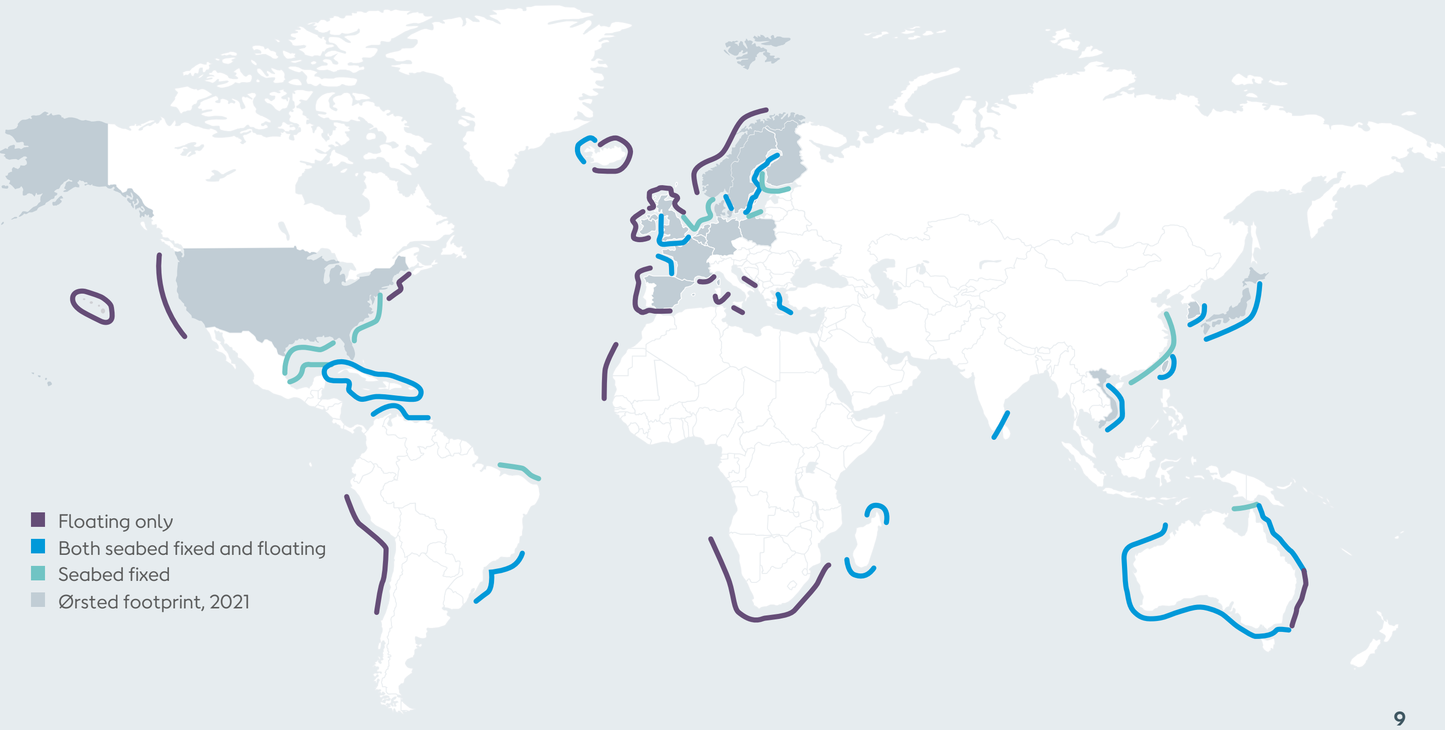
This is the experience we will bring to bear in our efforts to develop floating offshore wind projects and partnerships at scale, to scale up the technology and bring down costs. We are seeking out floating offshore wind opportunities in all the regions and markets where we are present. And we are exploring opportunities in the new markets floating wind is enabling.

Among these, Ørsted is partnering with offshore project developer Simply Blue on the 100 MW floating project Salamander in Scotland, with the aim of establishing a stepping stone project for the floating wind supply chain in the region. Ørsted is also part of the joint venture behind the Scottish project Stromar, which in 2022 was awarded a site for approx. 1 GW of floating offshore wind off the north-east coast of Scotland. We have also announced partnerships in Vietnam, Spain, and Norway to develop and scale-up floating offshore wind and are intending to participate in upcoming tenders for floating offshore wind in additional markets.

Which will be the winning designs?
Floating foundations for offshore wind come in many shapes and configurations as do mooring systems and dynamic, suspended cables. And different designs are fit for different purposes. For instance, some foundations are better suited for deeper waters, some for shallower waters. And some foundations are more labour-intensive during production, while others require more materials.

At Ørsted, we do not focus on just one design. Just as we have all major types of seabed-fixed foundations in our portfolio, we are taking the same agnostic approach to floating foundations, working with supply chains to figure out the best solutions, which are optimised to the local context, and which lend themselves best to industrialisation. This entails potentially using different foundations for different sites, and it requires close collaboration with supply chains to ensure a strong local anchoring.

Global areas with potential for floating offshore wind
Illustrative and non-exhaustive



How a floating offshore wind farm is built

1.

The foundations are constructed either at port site or in different locations and assembled at the port on land.

3.

The tower, nacelle, and blades are likely to be installed quayside by a crane placed on land, reducing complexity in the staging and assembly process, limiting or even removing need for specialised installation vessels.

2.

Each foundation is launched into the water quayside on a barge.

4.

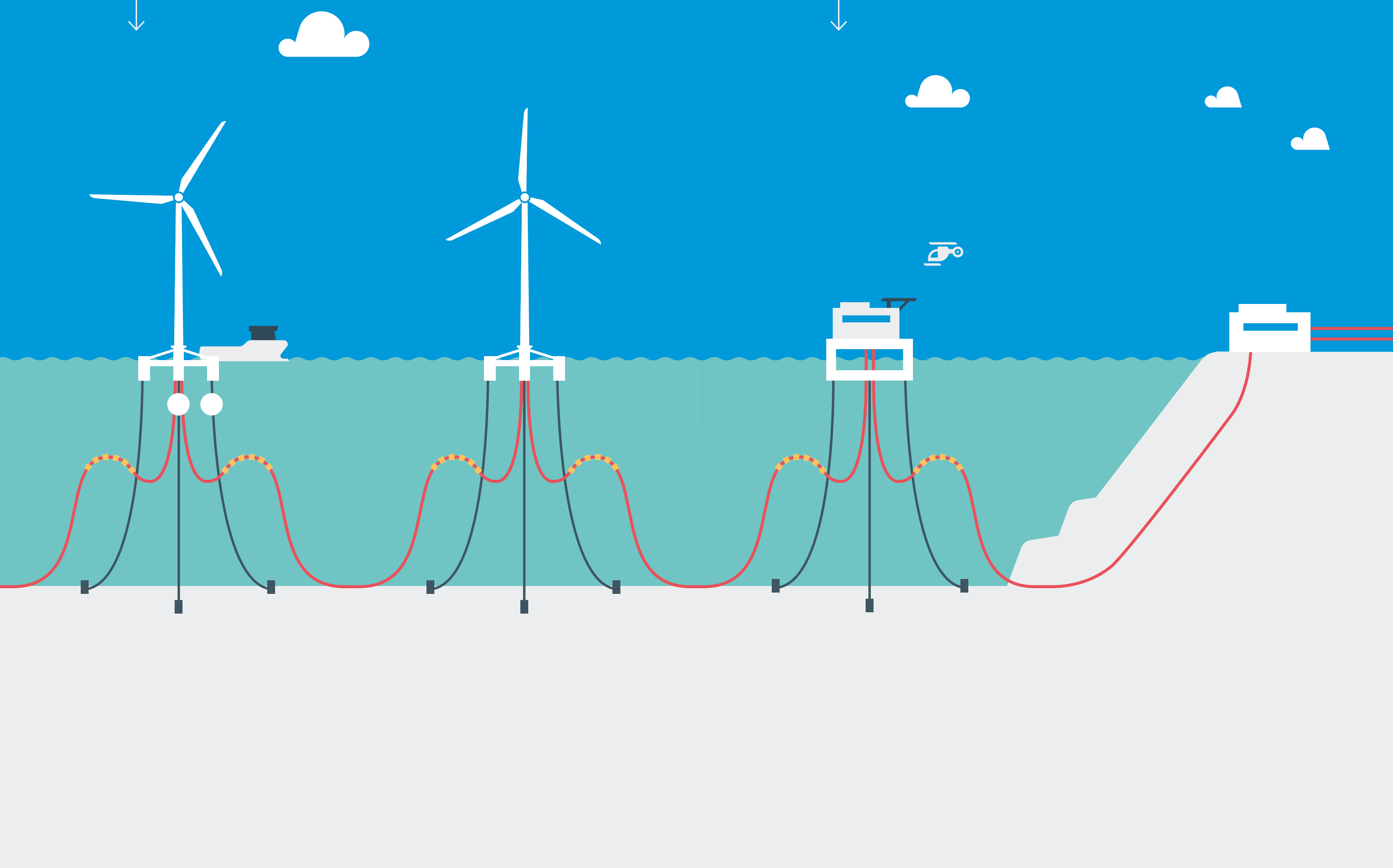
The assembled foundation and turbine is towed by tugboat to the site offshore.

5.

The structure is hooked up to array cables and mooring lines, which are already in place, suspended by buoys. The mooring lines, which are fixed to the seabed by anchors, keep the foundation firmly stable on the ocean surface, even in high winds and waves.

6.

Energy from each turbine is sent trough dynamically suspended array cables and collected at a substation. This can also be placed on a floating foundation – or potentially fixed to the seabed. From here, power is transmitted to shore.



Floating in balance with nature

Every day, all over the world, we witness the tell-tale signs of an ecosystem in distress. This is also evident in and near oceans, where biodiversity loss and habitat degradation is the result of many complex and interwoven environmental factors, including ocean pollution and overexploitation of marine resources. But above all, climate change and ocean acidification, both caused by atmospheric CO_2, impact life in and above water. They act both as causes in themselves and as multipliers to the other threats to marine biodiversity.

Renewable energy, onshore and offshore, is key to reducing climate-related pressure on maritime habitats and species. Siting wind energy in the ocean introduces the potential positive effects not only of reducing carbon emissions and, by implication, the impacts of climate change on the marine environment, but also providing opportunity for biodiversity enhancement through project design and implementation – for instance, by providing a hard surface for marine life, such as mussels, to grow. However, offshore wind energy must still be implemented carefully to understand, avoid, or mitigate potential adverse effects on marine life from installation and operation activities.

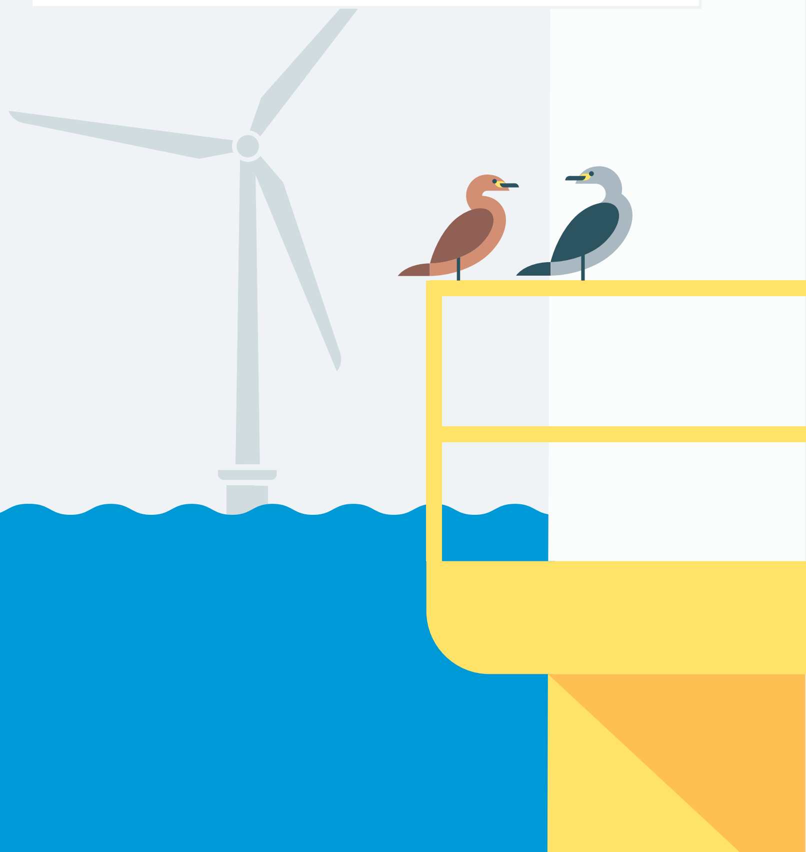
A positive impact for life above and below

In some ways, floating offshore wind interacts with its surroundings like seabed-fixed, and thus the solutions are in many cases the same. In other ways, floating offshore wind presents new challenges – and opportunities. Floating wind does not require pile driving of, e.g., large monopile or jacket foundations and can therefore be installed with less subsea noise and thus less disruption to noise sensitive species such as many marine mammals. And dependent on location, floating offshore wind can be installed further offshore, beyond the foraging ranges of breeding birds. However, interactions with the seabed with anchor spreads and mooring lines will require special attention, monitoring, and development of new solutions to mitigate adverse impacts on life below sea and on the sea floor. As will interactions with other marine users such as commercial fisheries.

Development sites proposed for floating offshore wind farms must undergo thorough impact assessments to identify potential impacts. Such impact assessments must consider both local and regional effects and involve relevant stakeholders, such as conservation groups, NGOs, academia, and representatives from other ocean users. As an added benefit, this approach can also help build local support for the projects, as concerns are addressed, and benefits augmented. Regulators and policymakers have a special role to play in ensuring floating offshore wind is implemented to maximise the benefits, while avoiding and mitigating potential adverse impacts by introducing a regulatory framework which incentivises developers to innovate, document, and implement biodiversity positive solutions in floating offshore wind, for instance through tender criteria.

Key implication

To establish and grow floating offshore wind as a sustainable and mature technology, the specific interactions with local marine environment must be understood and steps taken to avoid and minimise impacts. This can be done by working with developers and the supply chain to identify solutions, and by introducing biodiversity criteria in tenders for floating offshore wind.



What is Ørsted's contribution?

As a global sustainability leader with a strong commitment to protect biodiversity, Ørsted has committed to deliver a net-positive biodiversity impact from all new renewable energy projects commissioned from 2030 at the latest. This requires finding the least impactful ways of constructing and operating floating offshore wind.

Over the years, we have gained extensive experience in protecting local biodiversity from impacts of our offshore wind projects. And we will continue to work with academia and global and local conservation groups to better our understanding of our interaction with wildlife and to explore new and innovative biodiversity initiatives.

Some solutions are relatively simple, or low-tech. For instance, in some cases, increasing the distance from the ocean to the area swept by the turbine blades as they rotate. Or modifying array layout, where possible, which can reduce collision risk with birds. Other solutions are more complex or are not physically within the wind farm area, such as saltmarsh or seagrass restoration. Floating wind, while subject to many of the same challenges as seabed-fixed wind, also presents new questions. For instance, we need to increase the understanding of how dynamic cables and mooring lines interact with its natural environment – and seek out solutions for any adverse effect. Ørsted is committed to both, not least through our 2030 biodiversity positive pledge.

Our work towards biodiversity net-positive projects follows the principles of the 'mitigation hierarchy'. This implies always trying to avoid impacts as much as we can, followed by mitigation and restoration efforts to minimise any unavoidable impact. Then work to offset any adverse effects that cannot be mitigated – all while at the same time doing our best to maximise any positive impacts on nature and biodiversity of our projects, thereby ensuring our overall impact will enhance the environments we operate in.

How we work to understand and improve the environments we are part of

Collaborating to understand impacts on marine wildlife
Ørsted is working with interest groups and academia to support independent research and improve understanding of how offshore wind farms interact with its surrounding marine environment. For instance, in Bridlington, on the English North Sea Coast, we have long worked with Holderness Fishing Industry Group, most recently on establishing a community laboratory and research hatchery to conduct vital research on fishing grounds in the North Sea.

Artificial reefs to help replenish fish stock
As an example of nature-inclusive design, Ørsted is exploring and implementing different ways to establish artificial reefs that provide shelter and feeding grounds for larger fish species, including the Atlantic Cod. In our Borssele 1&2 offshore wind farms in the Netherlands, we have worked with Wageningen Marine Research to introduce formations of concrete pipes to the sea floor, creating cavities for fish to hide and forage. Similarly, in Kattegat, Ørsted has worked with WWF Denmark to install 'bio huts' and custom, 3D-printed concrete reefs to help improve the local stock of cod, and thereby helping to maintain the marine ecosystem's delicate balance by preying on other species, such as green crabs.

Artistic representation

An experimental haven to grow new corals
In Taiwan, Ørsted is collaborating with the Penghu Marine Biology Research Center to test a new, experimental method for introducing lab-incubated coral larvae to the offshore foundations of our Greater Changhua offshore wind farms. Here, we seek to help the larvae settle and grow, as the foundations provide a unique environment, combining the more stable water temperatures of deeper waters with the sunlight penetration nearer to the surface. If successful, we hope the jacket foundations can become a new safe haven where corals can flourish and support some of the 1.75 million species estimated to live in coral reefs globally.

Co-existence with fisheries

While it is often easy to imagine the ocean as a vast and open expanse, many ocean-based activities and interests must co-exist. Especially near-coastal waters, extending all the way up to about 200 kilometres from shore, lend space to shipping lanes, fossil and renewable energy production, resource extraction, subsea infrastructure, commercial fisheries, military defence, recreational activities – and, of course, nature conservation areas.

For offshore wind to play its part in establishing a stable and adequate energy supply and in replacing fossil fuels with renewable energy, it must be scaled significantly, from globally around 50 GW today to more than 560 GW by 2040[7]. This requires societal prioritisation and thorough marine spatial planning ensuring all key stakeholders are considered.

We know from existing seabed-fixed offshore wind farms that survey and installation work will inherently interact with some ocean users, including fishing. But both during construction and during the following long-term operation, steps can be taken together with fishing groups to design, construct, and operate offshore wind farms in ways that reduce and mitigate adverse impacts, and to support stocks of important species.

The same is the case for floating offshore wind. Specific impacts on other ocean uses, including commercial fishing, will vary and must therefore be addressed on a case-by-case basis. Successful co-existence relies first and foremost on dialogue between offshore wind developers, fishing groups, and maritime authorities with an aim to maximise the potential for co-existence and navigational safety, while exploring options relevant to the type of fishing and types of gear used at specific sites.

Key implication

Thorough investigation, including fisheries monitoring surveys in sites and along cable routes, can be an important tool to identify and see potential adverse impacts. The offshore wind industry already has in place practices for proactively engaging with fisheries to find solutions for co-existence.

Floating offshore wind developers should be encouraged or incentivised to seek out and implement both existing and new best practices – both for how to engage in ongoing dialogue with the fishing industry and for managing potential impacts on commercial fisheries.

7. IEA sustainable development scenario, table A.2., 2019 Offshore Wind Outlook.

Scientists from the Holderness Fishing Industry Group examining shellfish size structure and catch rates on the MV Huntress in Westermost Rough Offshore Wind Farm.

What is Ørsted's contribution?

Ørsted has extensive experience in leading initiatives to develop co-existence with commercial fisheries and have identified management strategies to minimise impacts on fisheries. We build proactive, long-standing, and trusting relationships with all relevant stakeholders, fisheries included, involving them from the early development stage, long before projects have consent, or the first turbines are in the water.

We work closely with local fishing groups and academia to study any potential risks and impacts our offshore wind projects might have on the local environment and fishing stocks, and we will continue to seek positive collaboration with the fishing industries to solve co-existence challenges in floating wind. This has included ground-breaking research into crustacean stocks on one of our wind farms in the UK, showing no significant negative impact on crustacean catch from the construction and operation of offshore wind turbines.

Floating offshore wind turbines are spaced widely apart and fixed in place, moored firmly to the ocean floor. They are lit and marked according to relevant regulation and their positions are reflected accurately on maps, enabling safe navigation. But mooring lines and dynamic cables are areas, where we and other industry players need to investigate impacts on fisheries – and ways to mitigate them. We do not hold all the answers yet, but we have long-standing and good working relations with fishing industry groups and are confident that potential conflicts can be solved constructively.

We all share an interest in protecting the ocean environment and biodiversity – including from climate change. Ørsted's engagement with the fishing industry supports better understanding of research topics or knowledge gaps which we could consider addressing to support co-existence between floating offshore wind and fishing. And while not all conflicts can be resolved through research and communication alone, open and honest interaction helps to manage conflicts when they arise and identify ways to avoid or mitigate impacts that may occur.

Following this principle, we have also implemented a fishing gear loss prevention and claim procedure in the US. While we believe most such instances can be avoided with the right communication and training, gear loss caused by or resulting from our offshore activities cannot be ruled out altogether, which is why we have put gear loss compensation procedures in place.

Building an industry

Building a modern offshore wind farm – sometimes consisting of more than a hundred wind turbines situated tens, or even more than a hundred kilometres offshore, is an immense undertaking, involving thousands of people, all highly skilled and many uniquely specialised for offshore wind.

A recent study of the Danish offshore wind supply chain found that a modern 1 GW seabed-fixed offshore wind farm will create upwards of 18,400 direct and indirect jobs during development, construction, 25 years of operation, and decommissioning[8]. With job creation somewhat evenly distributed between component suppliers with a regional spread and local service providers and O&M technicians within relative geographic proximity to a project, offshore wind projects promise beneficial economic impact both locally and globally.

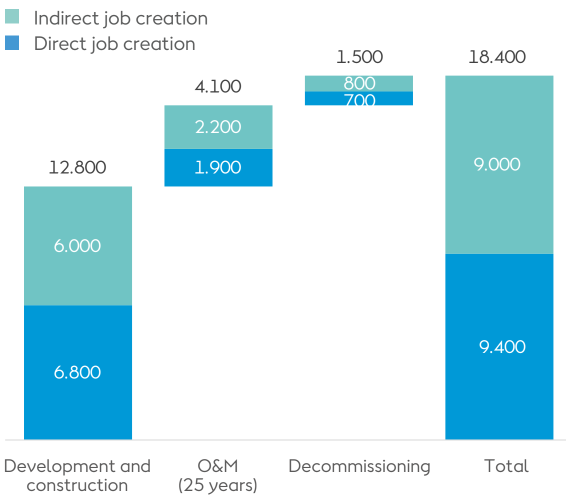
While fewer direct economic impact studies have been made for floating wind farms specifically, their impact can be expected to be similar. For manufacturing, most components are the same as seabed-fixed, including nacelles, blades, towers, and most of the electrical systems – with the exception of foundations and mooring lines. These are significantly more complex structures than the monopiles most commonly used for seabed-fixed offshore wind. This will also mean larger labour and materials input, in turn generating more jobs.

Engineering and construction of floating offshore wind farms are also somewhat similar to seabed-fixed, although as floating offshore wind turbines will likely be assembled quayside at a nearby port, staging and installation will, in general, be less complicated than installation of seabed-fixed offshore wind.

Floating wind will also require new skillsets and new supply chains, first and foremost in design, production, handling, and installation of floating foundations, mooring lines, and dynamic array cables. And between expected build-out of seabed-fixed offshore wind in the near and mid-term, and a rapid scale-up of floating offshore wind, the market will possibly face shortages of relevant skillsets and suppliers.

In several countries, governments and industry players are leaning in to capture an early part of growing the market for floating offshore wind solutions. A window of opportunity has opened for companies, ports regions, and countries that are able to leverage from both existing and new competences to build a localised leadership position as new links are added to the global supply chain for offshore wind.

A 1 GW offshore wind creates app. 18,400 jobs[8]



However, seizing such an opportunity will require a strategic approach, public and private partnering, and willingness to invest. Decision makers must also be mindful of potential tradeoffs between, on the one hand, the goal of spurring local industry growth and, on the other hand, the cost-out potential stemming from combining relative strengths across a larger region.

Key implication

Decision makers wanting to seize the opportunity to create a strong local industry within floating offshore wind solutions should carefully analyse and identify existing competences and play to the relative strengths of local suppliers. Ultimately, floating offshore wind will be a global market, meaning the goal should be to help suppliers become as competitive as possible – that way, they will not only win in home markets but also abroad.

Governments can engage with industry and developers to identify and facilitate new investments, including in port infrastructure required to assemble and launch floating offshore wind turbines. At the same time, policymakers are presented with a balance between efforts to nourish a local supply chain, to grow and spur job creation and domestic economic activity; and on the other hand, the ambition to bring down costs by establishing a regional and even global industry. As a guiding principle, decision makers should seek to facilitate local industry in leveraging its relative strengths – while also allowing industry neighbouring markets to leverage from their relative strengths.

8. QBIS, 2020: Socio-economic impact study of offshore wind. Full time equivalent years.

What is Ørsted's contribution?

As a leading developer of offshore wind, Ørsted has a long-standing experience of working with strategic partners to develop both local and global supply chains. As we seek to capitalise from economies of scale by establishing offshore wind farms in large 'clusters', we strive to build long-standing relations to the local communities that host us, and to help invest and spur supply chain growth.

This is not least the case in Grimsby and the Humber Region on the British east coast. Ørsted first established a base at the port of Grimsby in 2012 when the 210 MW Westermost Rough offshore wind farm was installed. Since then, Ørsted activities in the Humber region have contributed with more than GBP 980m in Gross Value Added[9], while at the same time investing more than GBP 45m directly into the local community, education, and skills development.

Another example is in New Jersey on the US Eastern seaboard, where Ørsted has partnered with steel pipe manufacturer EEW to unlock USD 250m investments into the Paulsboro monopile foundation facility, representing the single largest investment in the US offshore wind supply chain to date.

Ørsted is taking the same industry-building approach with floating offshore wind. For instance, in our Scottish project Salamander, we are working with suppliers and other developers to realise a 100 MW floating offshore wind project as a stepping stone towards full-scale projects upwards of 1 GW. This works by both reducing technology risks before going full scale and also securing sufficient volume to enable valuable initial experience with 'assembly line' type manufacturing and construction of a floating offshore wind farm.

9. Opergy Ltd. 2022, Economic Impact Study of Ørsted Investments in the Humber Region. Gross Value Added (GVA) is a measure of productivity – which Ørsted's direct investment has contributed to the economy.

How Ørsted works to develop skills and local supply chains

Joining forces with North America's Building Trades Unions

In 2020, North America's Building Trades Union (NABTU), organising more than 3 million skilled craft professionals, and Ørsted agreed to enter a partnership with the purpose of transitioning US Union construction workers into the offshore wind industry. Ørsted and its partners will work with NABTU to identify the skills needed to accelerate deployment of offshore wind energy off the US coast, and to then work to fill that need by matching up against the available workforce.

Investing in STEM to prepare the future workforce for offshore wind

As part of our Skipjack Wind project off the Maryland-Delaware coast, Ørsted is committing USD 10m to STEM education and workforce development programs in Maryland. The investment will convene educational institutions, apprenticeship programmes, and other relevant community organisations to promote equitable and sustainable access for students to the offshore wind industry.

Growing a floating offshore wind supply chain in Scotland

Stromar floating wind project is a joint venture between lead developer Ørsted, Falck Renewables and Bluefloat Energy. Stromar will be located off the coast of Scotland and has a seabed lease agreed for up to 1GW. Stromar aims to share the benefits of floating offshore wind with the Scottish supply chain and communities by establishing and improving the right skillsets in the workforce. This could be in the form of STEM activities in schools, upskilling, or reskilling nuclear or oil and gas workers, thereby supporting the Scottish Government's Climate Emergency Skills Action Plan.

Conclusion

Together, we have come a long way. In ten years, offshore wind has reached scale and become cost-competitive and now has the potential to revolutionise the global energy system. Floating offshore wind is poised to play a significant role in the mid to long-term global rollout of renewable energy generation, also in conjunction with other new technologies, such as renewable hydrogen production and Power-to-X.

To fully play its part, floating offshore wind still has some way to go. The technology has to be standardised and commoditised, and supply chain investments are needed to scale up and, ultimately, bring down costs of new floating offshore wind projects. But projects of ever-increasing scale are quickly emerging, and the pipelines are firming up in many markets. And most recently, with the Biden administration's announcement of a 15 GW dedicated floating offshore wind target by 2035, policy ambitions for floating wind have never been higher.

Floating wind is not altogether new. The development will be able to leapfrog from the long industrial experience with seabed-fixed foundations – and from floating solutions developed in the offshore oil and gas industry. In a sense, floating offshore wind is 'just' offshore wind, with different foundations. This implies we can expect floating offshore wind to become cost-competitive even faster than was the case for seabed-fixed offshore wind. Maybe already by the early 2030s.

But this will not happen by itself. Maturing floating wind will also rely on policy support and on an enabling regulatory environment. And it will require solving both the technical challenges pertaining to floating offshore wind itself and finding even more ways to make the build-out stakeholder inclusive and nature positive.

Policymakers who want to support floating offshore wind development and who want to seize the first movers' advantage for floating offshore wind could consider:

1 **Avoid pitting floating offshore wind directly against seabed-fixed offshore wind for the time being**
Implement floating wind through dedicated tenders, fit for purpose CfD type schemes, or other supportive mechanism, until floating wind can compete on equal terms with more established technologies.

2 **Introduce non-price criteria to tenders**
To grow an industry, we need to solve all the questions outlined in this paper, including local value creation, biodiversity, and co-existence with other users. Tenders selecting solely on cost do not give headroom for developers to innovate and do not incentivise implementation of much-needed solutions.

3 **Facilitate investments into new deep-water port infrastructure**
While design and production of components and development of offshore wind farms should generally be handled by private companies, the supportive port infrastructure is generally a shared responsibility, calling for public and private partnering to unlock the needed investments.

4 **Acknowledge the balance between local regional supply chains**
Analyse and identify existing strategic competences and leverage them in strengthening the local industrial supply chains, while also allowing for regional and international clusters to grow.

About Ørsted

The Ørsted vision is a world that runs entirely on green energy. Ørsted develops, constructs, and operates offshore and onshore wind farms, solar farms, energy storage facilities, renewable hydrogen and green fuels facilities, and bioenergy plants. Moreover, Ørsted provides energy products to its customers. Ørsted is the only energy company in the world with a science-based net-zero emissions target as validated by the Science Based Targets initiative (SBTi). Ørsted ranks as the world's most sustainable energy company in Corporate Knights' 2022 index of the Global 100 most sustainable corporations in the world and is recognised on the CDP Climate Change A List as a global leader on climate action. Headquartered in Denmark, Ørsted employs 6,836 people. Ørsted's shares are listed on Nasdaq Copenhagen (Orsted). In 2021, the group's revenue was DKK 77.7 billion (EUR 10.4 billion).

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