GLOBAL OFFSHORE WIND REPORT 2024

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Cover image
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Published
17 June 2024

Design
lemonbox
www.lemonbox.co.uk

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Chief Strategy Officer - Offshore Wind,
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Welcome to our 2024 Report

Our 2024 Global Offshore Wind Report comes to you at an important moment in the history of the offshore wind technology. To date, offshore wind has achieved remarkable success establishing itself as a maturing, competitive, globally diverse, and scalable industry. The growth of offshore wind is now so much more than a European, Chinese, or American story. This global industry must now "chart a course" for the tremendous growth that lies ahead.

Across the world in 2023, the industry connected 11 GW of offshore wind to the grid representing a 24% year-on-year (YoY) increase - the second-best year ever despite headwinds in key markets. The bigger story is found beyond the numbers. It's important to note the offshore wind industry and its partners in government, institutions, and civil society are now coalescing and driving momentum in anticipation of the industry's impending growth and importance as a clean energy technology.

Signals from around the world show the building momentum. Membership of the Global Offshore Wind Alliance (GOWA), a diplomatic, multi-stakeholder initiative founded by GWEC, IRENA, and the Government of Denmark has swelled to over 20 governments. These governments have pledged to collaborate towards installing 380 GW of offshore wind by 2030 and 2000 GW by 2050.

GWEC is seeing widespread recognition across industry and governments that the key drivers for offshore wind are now in place - from government commitments and sustainable economic growth, to increased consumer demand and industrial decarbonisation.

In Brazil, offshore wind is seen as the clean power source of the future for its heavy industry. In the Philippines, the government is embracing offshore wind to meet its fast-growing domestic demand and sustainable economic development agenda. Momentum continues to build in countries like South Korea, where international and domestic companies are pursuing manufacturing facilities set to create jobs and regenerate local economies. In Europe, a new wave of markets neighbouring the North and Baltic Seas, Mediterranean, and Atlantic Ocean are seeing offshore wind as a way to enable economic and industrial growth. Poland sees offshore wind as a route to stimulate industrial growth, whilst Ireland has set out an ambitious future framework for offshore wind growth.

The last year has also seen the rise of markets that were, until recently, considered to be 'emerging markets'. Through our continued engagement, along with many partners and collaborators, these markets have successfully moved further along their offshore wind pathway. For example, few would have predicted that Australian offshore wind would graduate so rapidly from its 'emerging' status. But GWEC's strong engagement with the Australian government and its agencies over the last few years, alongside our partners, has helped share lessons learned. This has allowed the Australian government to accelerate towards the award of their first ever offshore wind zone in Gippsland, Victoria.

Similarly, there is growing momentum in Japan, where GWEC has published the first offshore wind cost reduction study, which was integral for gaining political buy into offshore wind. At the time of writing, the Japanese Diet (the national legislature) is on the verge of passing a bill to enable offshore wind within the Exclusive Economic Zone, the key to unlocking larger-scale offshore wind projects. I have been closely following the Japanese market since I joined GWEC, so it was very encouraging to see engagement from across government departments and strong civil society backing at a recent GWEC/REI (Renewable Energy Institute) roundtable.

Japan, South Korea, Australia, the Philippines, Brazil, and Colombia are now taking firm steps towards a fully-fledged offshore wind industry. These countries represent a growing set of governments, both federal and subnational that have retained and indeed bolstered their commitments to develop offshore wind.

It has not been all plain sailing however, and in the US and UK markets, the industry dealt with some significant challenges in 2023. Macroeconomic headwinds combined with policy challenges in these markets have impacted what is still a relatively young industry compared to conventional energy generation sources. Our analysis suggests that the offshore wind industry is now putting these growing pains behind it and has learnt some important lessons in the process. But these experiences also show that we cannot leave the success of the energy transition up to the market; a strong and collaborative framework for growth is needed.

Our 2024 report shows a bright future for offshore wind, provided the sector is able to convert strong global and government ambitions into reality. It is imperative that our efforts are laser focused on bringing online the swathe of projects scheduled to be in the water by 2030, whilst simultaneously laying down a strong framework for the vast bulk of offshore wind which will be deployed in the 2030s. Our 2024 report aims to support industry and policy makers in achieving these goals. At the global scale we have just seven years to hit the 380 GWs of offshore wind needed to stay on a 1.5°C trajectory. There is no time to lose.

Steven B. Hedlund
President and Chief Executive Officer
Lincoln Electric

Commitment to Expanding the Global Supply Chain

As the global wind industry navigates regional economic and policy challenges, there are accomplishments to recognise in the manufacturing supply chain. Despite the headwinds experienced in 2023, the manufacturing industry responsible for towers, and fixed and floating offshore wind foundations continued to expand with more final investment decisions supporting an optimistic outlook. The transformation of steel into the key components of the energy transition was well underway during 2023 supported by record new investment commitments. The outcome of which will enable the world to build and install turbines, towers, and foundations (both fixed-bottom and floating) of immense sizes, never before realised.

New factories in Asia and the UK have moved ahead with significant industrial expansion supporting new fixed-bottom foundation production capacity. We also saw core European manufacturers announce continued investment in capacity expansion utilising the most advanced high quality manufacturing capabilities in the world. As observed across the globe, the benefits of this type of offshore wind manufacturing investment can lead to new economic opportunities in the local supply chain. The growth of foundation and tower manufacturing will support an expanding wind industry with new opportunities for other components including secondary steel and support structures. With new capacity already online or planned for essential pipe mills, offshore fabrication yards, and shipyards, regional fabricators around the world help drive one of the most rapid global industrialisation periods we have ever seen in the wind industry.

> The key to unlocking the full capacity of the supply chain is manufacturing process innovation and advanced automation technology, which drive profitable project execution.

While details of heavy industrial steel fabrication are not always front-page news for many industries, offshore wind projects are different. They present unique challenges in size and scale during manufacturing to deliver the high quality required of these immense welded structures. Since design concepts, manufacturing engineering decisions and commitments for new capacity typically occur two plus years in advance of the first steel for installation, the criticality of a resilient and successful steel transformation supply chain should not be underestimated. The industry can anticipate that as offshore wind capacity continues to increase, it will drive further global footprint expansion. This growth is likely to stimulate local economies and create jobs in the regions benefiting from these developments. Additionally, it will encourage investment in land-based infrastructure projects, supporting the broader economic

impact of offshore wind energy expansion.

Fundamental supply chain resilience for the offshore wind industry of the future requires alignment with the ambitions and timelines of its key stakeholders. With regional and country specific commitment to support continued expansion, the offshore wind supply chain of the future will need to produce at elevated production levels, the highest ever recorded. Given the present levels of investment commitment across the entire supply chain, certainty for projects is critical to a thriving metal fabrication industry.

While there have been many pieces of encouraging news across the global supply chain, more work is needed to address the practical challenges of size, scale, and installation targets forecast around the world. This year's report outlines key actions needed to continue developing a sustainable global supply chain that will be critical to meeting installed capacity targets. Our experience in this industry and others has shown that the keys to unlocking the full capacity of the supply chain are manufacturing process innovation and advanced automation technology, which drive profitable project execution. Equally essential to success is the acquisition and retention of a highly skilled workforce in the trades required to execute these projects. By aligning these resources, we will continue to see how offshore wind continues to play a pivotal role in the future energy supply chain.

José Oriol Hoyos
Chairman and CEO of Iberdrola Renewables International

Seize the momentum to build on the significant progress of 2023

After a challenging and volatile period in energy history, it finally seems that 2023 represents a turning point, as the year was marked by a social and political consensus on the need to accelerate the energy transition.

At a time of geopolitical and macroeconomic uncertainty, COP28 in Dubai delivered a major agreement on global climate action. Nearly 200 countries committed to phasing out fossil fuels and dramatically accelerating investment in electrification, with the goal of tripling renewable energy capacity by 2030. Electrification has become a essential for improving strategic autonomy, competitiveness, and for environment sustainability, while at the same time fostering industrial development and job creation.

Despite still dealing with challenging times and working our way through to promote the best approach to achieve our sustainability goals, we can also state here that 2023 has been successful for offshore wind. Close to 11 GW of new capacity was added to the grid, making it the second-best year in the technology's historic records, as featured in this year's Global Offshore Wind Report.

In particular, 2023 marks a decisive take-off of offshore wind energy for Iberdrola too. We currently have approximately 1.8 GW in operation and another 3 GW under construction, representing a total investment of over EUR 10 billion. Last year, we completed the installation of 62 wind turbines at the Saint Brieuc wind farm in France. In January, we started delivering the first power to the grid from Vineyard Wind One, which will be the first large-scale offshore wind farm in the United States. These figures reinforce our belief that offshore wind will be a key piece of the backbone that will shape the future energy system.

The next decade will be fundamental for harnessing the potential of offshore wind technology, unfolding investments and accelerating the energy and economic transition. To reach the 1.5°C climate goal, it is estimated that nearly 380 GW of offshore wind needs to be built by 2030, which is five times the current offshore wind installation capacity. To achieve this, we must continue advocating for transparent and responsible auction and seabed lease designs, stable regulatory frameworks, and faster and efficient permitting procedures.

GWEC has been doing an excellent job over recent years, spreading the sector views, sharing concerns, and facilitating common ground with key stakeholders. It is paramount that GWEC continues its engagement with government authorities, regulators, and other relevant institutions and market players to uphold everyone's commitment. The complex structure, volume, and nature of offshore wind projects require all parties to come together to find suitable and efficient solutions, ensure a fair allocation of risks and revenues and make decisions that will not be regretted.

Delving into the year-to-date statistics for 2024, it appears that

investment is soaring to a record of $76.7 billion, according to the figures in this report. However, if we want to continue building a secure and accessible energy model, based on electricity, we cannot forget that grid access, network development and financing tools must be included in the agenda, as well as strengthened industrial policies to support a healthy supply chain capable of meeting the demands of offshore wind developments.

This year represents a significant milestone in our journey towards a cleaner and greener future, and I encourage the industry to seize the momentum. Let's work together so next that year, we can proudly celebrate another record set and move another step closer to achieving our ambitions.

Mr. Zhang Qiying
President & CTO, Mingyang Smart Energy

The next decade is critical to offshore leading the energy transition

Offshore wind has been a driving force in human progress for thousands of years. Powered by wind, sailboats enabled humans to enter the 'Age of Discovery', exploring the unknown world, spreading modern civilisation and laying the groundwork for globalisation. Today, the rise of offshore wind power is endowing ocean wind with new value, bringing affordable and sustainable energy while providing solutions to replace fossil fuels and to meet the climate targets.

In the past two decades, offshore wind power has achieved remarkable success and established itself as one of the most important renewable energy technologies for supporting the global energy transition. 2023 was a challenging year for the offshore wind industry with high inflation, increased interest rates, and capital cost. Entering 2024, however, the market conditions for offshore wind have improved, with signs of market rebalancing and recovery emerging. The growth momentum is expected to resume as the recent Bloomberg NEF statistics show that global offshore wind investment has soared to a record $76.7 billion last year, despite rising costs forcing developers to delay or cancel projects.

> Technological innovation is at the heart of the energy transition. Only through technological innovation can we further reduce the cost of energy, ultimately achieving large-scale offshore wind power deployment and the global energy transition

GWEC's Global Offshore Wind Report 2024 reveals that a new wave of growth is expected from the second half of this decade, increasing the share of global new wind installations from today's 9% to at least 25% by 2033. Offshore wind will be a key building block to achieve a 1.5°C pathway. To meet this ambition, nearly 380 GW of offshore wind needs to be built by 2030. At COP 28, over 130 countries committed to the goal of tripling renewable energy by 2030, setting the stage for stable growth in this decade and beyond.

As the world's leading offshore wind turbine supplier in new installations in 2023, Mingyang Smart Energy has been dedicated to implementing the philosophy of global cooperation and sharing. We have expanded our business into the "Belt and Road" countries and other emerging overseas markets. Our business operations now cover regions such as Southeast Asia, East Asia, Latin America, Europe, and the Middle East and North Africa. In the

MINGYANG

past five years, we have secured orders in Italy, the UK, Serbia, Japan, South Korea, Vietnam, and the Philippines. Our products and services have been recognised and acknowledged by international partners and clients.

Technological innovation is at the heart of the energy transition. Only through technological innovation can we further reduce the cost of energy, ultimately achieving large-scale offshore wind power deployment, and the global energy transition. As a technology leader, Mingyang Smart Energy has achieved several milestones, including the installation of the world's first typhoon-resistant floating wind turbine, China's first "double hundred" deep-sea floating wind turbine, and the world's first jacket foundation featuring a net cage system for fish farming.

Additionally, we have launched the world's largest offshore wind turbine model with a rated power rating of 22 MW, as well as the world's largest twin-rotor floating wind platform.

According to the global wind supply chain report recently released by GWEC and Boston Consulting Group (BCG), by 2026/2027, all regions, except for China, are expected to face the bottlenecks in the offshore wind supply chain. To build a robust offshore wind supply chain, to meet the needs of a 1.5°C world, global collaboration and cooperation between governments and industry is more important than ever. We anticipate that the next decade will be a critical period for offshore wind power to lead the energy transition. Therefore, let us work together to create a better future.

EXECUTIVE SUMMARY

The Data: The offshore wind sector poised for a new wave of growth in the next ten years

Feng Zhao
Chief Research Officer,
Global Wind Energy Council

Market Status

10.8 GW of new offshore wind capacity was added to the grid worldwide last year, bringing the total global offshore wind capacity to 75.2 GW by the end of 2023. New additions were 24% higher than the previous year, making 2023 the second-highest year in offshore wind history.

China led the world in annual offshore wind developments for the sixth year in a row with 6.3 GW added in 2023, demonstrating its capability to maintain stable growth in the new era of 'grid parity'. Three other markets commissioned new offshore wind capacity in Asia last year: Taiwan (China, 692 MW), Japan (140 MW), and South Korea (4.2 MW).

Europe had a record year in 2023, with 3.8 GW of new offshore wind capacity from 11 wind farms commissioned across seven markets accounting for most of the new capacity. The Netherlands commissioned 1.9 GW of offshore wind capacity in 2023, making it the region's largest market in terms of new additions, followed by the UK (833 MW), France (360 MW), Denmark (344 MW), Germany (257 MW), Norway (35 MW), and Spain (2 MW).

In North America, offshore wind turbines were installed at two utility-scale offshore wind projects in the US before the end of last year, but no offshore turbines were commissioned in 2023.

By the end of 2023, 41 GW and 34 GW of offshore wind capacity were in operation in Asia and Europe respectively. The two regions combined made up 99.9% of total global offshore wind capacity. Although Europe has lost its world-leading position to APAC in total installed offshore wind capacity, it remains the world's largest market for floating wind and the technology hub for floating wind turbines and foundations.

Outside Europe and Asia, North America had 42 MW of offshore wind in operation at the end of last year, with all installations located in the US.

Market Outlook

2023 was a turbulent year for the offshore wind industry on both sides of the Atlantic Ocean. Challenges such as inflation, increased capital costs, and supply chain constraints created uncertainty in the sector. Considering the near-term challenges, GWEC Market Intelligence has downgraded its global offshore wind outlook for total additions in 2024–2028 by 10% compared with our 2023 projection.

Despite the headwinds experienced in 2023, governments and developers remain committed to developing offshore wind and the global offshore wind market outlook in the medium term remains resolutely promising.

The inclusion of a global goal of tripling renewable energy by 2030 in the final COP28 text is unprecedented and historic for offshore wind and other renewable energy sources. A favourable

political environment across the globe and the urgency of ensuring energy security driven by Russia's invasion of Ukraine, position offshore wind as a vital resource for achieving both objectives. Exponential growth is expected this decade and beyond.

With a compound average annual growth rate of 25% until 2028 and 15% up to the early 2030s, new installations are expected to sail past power installations from today's 9% to at least 25%.

Considering the strong growth expected in China, as well as burgeoning new Asian markets, Asia's leading position in offshore wind installations is unlikely to be challenged in the next decade, but the outlook for offshore wind in Europe remains stable and optimistic. Although GWEC Market Intelligence has downgraded the

Annual offshore wind installations are expected to triple in 2028 from 10.8 GW in 2023.

the milestones of 40 GW in 2029 and 60 GW by 2032. GWEC Market Intelligence expects more than 410 GW of new offshore wind capacity to be added over the next decade (2024–2033), of which more than two-thirds is likely to be added in the second half of the forecast period (2029-2033).

Annual offshore wind installations are expected to triple in 2028 from 10.8 GW in 2023. By 2033, they are expected to reach 66 GW, bringing the offshore share of new wind

2030 offshore wind installation outlook for the US from 25 GW (predicted in 2023) to 15 GW, North America will remain the third-largest offshore wind market by 2033, followed by the Pacific region and Latin America.

Since the release of our Global Offshore Wind Report 2023, progress has been made in every region of the world for floating wind. Following our latest global stocktake of floating wind development, however, GWEC Market Intelligence believes that the commercialisation of floating wind is unlikely to be achieved until the end of this decade (2029/2030). We have, therefore, downgraded the global floating wind forecast and predict 8.5 GW to be built globally by 2030, 22% lower than last year's projection.

Our near-term offshore wind market outlook (2024–2028), built using a bottom-up approach, is based on GWEC Market Intelligence's global offshore wind project database, which covers projects currently under construction, global auction results and announced offshore wind tenders worldwide. For the medium-term market outlook (2029–2033), a top-down approach was used alongside existing project pipelines. This takes into account existing policies and medium/long-term national and regional offshore wind targets.

There is still an implementation gap between declared targets and the rate of annual installations. The areas of permitting, finance, supply chain, and grids will remain key for forecast growth to materialise, and to propel offshore wind power development into a new phase of even faster growth.

The Story: Charting the course for offshore wind

Offshore wind is now poised for truly, global growth. 2023 was the second-best year on record for offshore wind, with 11 GW installed. The gathering momentum of offshore wind played a key supporting role in achieving this record with another strong year of installations, along with plans for long term growth from the industry and governments around the world. This 2024 edition of the Global Offshore Wind Report demonstrates that the growth of offshore wind is now so much more than a European, Chinese, or American story.

The next wave of offshore wind markets has arrived, as governments across Asia-Pacific and Latin America are embracing offshore wind as a solution to providing clean, affordable power to their people and industries. Governments, civil society, and the private sector are already working on implementing the economic, social, and environmental measures to ensure its long-term success. The priority now must be continued collaboration between industry and policymakers to overcome hurdles to rapidly scale up this crucial technology for the economic and environmental well-being of people and economies around the world.

Over the last two decades, the offshore wind sector has achieved remarkable success establishing itself as a mature, competitive, and globally scalable industry. Our 2024 report findings bear this out; despite challenging conditions in the US and, to a certain extent, in the UK, 2023 was the second-best year ever for offshore wind. 11 GW of offshore wind was installed and connected to the grid last year, representing 24% year-on-year (YoY) growth. The total amount of offshore wind globally has now reached 75GW. Progress in countries continues apace. For example, Australia recently announced the results of the Gippsland feasibility license awards, launching Australia's first offshore wind zone which could see 12 projects with combine capacity to generate 25 GW of electricity. In Japan, at the time of writing, a bill to expand offshore wind into the Exclusive Economic Zone (EEZ) is expected to pass in the next few days. The new legislation would allow wind

farms to be installed further out to sea from current territorial and internal waters, paving the way for larger scale offshore wind developments. At the same time, GWEC is working to support the government of the Philippines as the country moves rapidly towards holding its first offshore wind auction. South Korea has secured sizable investments from key manufacturing players. Vietnam recently released a draft proposal and accompanying resolution for an offshore wind pilot mechanism. In Latin America, the passage of the offshore wind law is shortly expected in Brazil and Colombia has now re-launched its offshore wind auction.

In Europe, a new wave of markets is similarly seeing offshore wind as a way to enable economic and industrial growth. Ireland has set out an ambitious future framework for offshore wind growth, whilst Poland sees offshore wind as a route to stimulate industrial growth.

Offshore wind has a key role to play in supporting the global energy system to reach 1.5°C, due to its scale and reliability. At COP 28, over 130 countries committed to tripling renewable energy by 2030, setting the stage for a new wave of growth for offshore wind beyond this decade. To meet a 1.5°C-trajectory, the world will need at least 380 GW of offshore wind by 2030 and 2,000 GW by 2050.

There are promising indicators that momentum is building and growing confidence that this goal will be achieved. Firstly, membership of the Global Offshore Wind Alliance (GOWA) has surged, with now over twenty governments from across the world recognising the crucial role that offshore wind can play in their energy and economic transition. Governments, industry, and stakeholders joining GOWA agree to collaborate to achieve these targets. GWEC's rolling ten-year outlook to 2033 shows that, with the right frameworks in place, the world can be on course to deploy 487 GW of offshore wind by the end of 2033.

Our outlook takes into account what we see in front of us. Increasingly, countries around the world are recognising the myriad benefits that offshore wind brings to their economies and are therefore placing offshore wind at the heart of their industrial growth plans. In Part 1 of our 2024 report, we outline these key drivers of offshore wind development, noting the strong case for offshore wind from an energy transition, reliability, cost, and industrial perspective.

The report finds that, despite macroeconomic trends such as the rise in commodity prices and interest rates, offshore wind remains cost competitive in comparison to other technologies. Our 2024 report shows that key offshore wind growth markets are taking important steps towards developing into maturing ones. GWEC is now seeing the rise of markets that were, until recently, considered to be 'emerging markets'. Meanwhile, in mature markets where offshore now holds a significant position in the energy mix, the technology is now proven to have the ability to save households money compared to conventional energy sources.

Through GWEC's continued engagement, along with many partners and collaborators, this new wave of markets has successfully moved along their offshore wind 'pathway'. Japan, South Korea, Australia, and the Philippines are now taking steps towards a fully-fledged offshore wind industries and are seeing offshore wind as a key tenet of their economic and industrial growth strategies. GWEC therefore notes that these countries have the potential to make considerable impacts on the global offshore wind industry and its supply chain.

To capitalise on the momentum outlined above, the 2024 report outlines new tools for achieving unprecedented collaboration between the public and private sectors to advance offshore wind. It then outlines a seven-pillar growth framework designed to scale offshore wind globally.

Unprecedented collaboration will be key in realising this ambitious growth trajectory will be predicated on governments, industry, and stakeholders working collaborating in new and unprecedented ways to unlock the growth potential and turn targets into turbines in the water.

GWEC has been cognisant for some time that we have an important role to play in this endeavour. That's why we have incubated and co-founded two key initiatives to progress offshore wind globally:

- The Global Offshore Wind Alliance, GOWA, co-founded with IRENA and the Government of Denmark, is a diplomatic alliance with now over 20 members. GOWA brings together governments with high offshore wind ambitions, with the industry, and wider stakeholders such as financiers, institutions, and other ocean economy actors. GOWA members will collaborate to unpick key challenges to offshore wind, and proactively address blockers, such as financing for offshore wind in emerging markets and developing economies (EMDEs) and scaling regional supply chains for offshore wind.
- Ocean Energy Pathway, OEP, is an independent not-for-profit organisation which works with industry, governments, and civil society organisations to accelerate offshore wind in key global markets through investing in high quality technical assistance. OEP will work with wider stakeholders to improve the social acceptance of offshore wind, forging a 'strong blue economy' vision for the technology.

A shared growth framework for offshore wind

Ultimately GWEC believes that the success of offshore wind, and indeed that of the wider sector in general, will depend on whether the industry grasps the opportunity of global market growth firmly enough. In Part 2 of 2024 report, GWEC offers a framework for this accelerated growth of offshore wind, across seven key vectors:

Vector 1. Accelerating the financing of offshore wind in mature and emerging markets, across the global north and south

Globally, there is a substantial amount of capital which is ready to deploy into the offshore wind sector but there is a shortage of 'bankable' projects which are properly structured, permitted and de-risked with viable offtakers or a viable route to market. In mature markets, the report focuses on factors which impact the cost of capital and can increase risk, including non-financial barriers. For mature markets, GWEC recommends that governments and industry work together to prioritise getting GW into the global market by stopping 'race-to-the-bottom' tender mechanisms, avoiding negative bidding and ensuring indexation of offtake prices.

The amount of capital being invested in EMDE markets lags far behind investment levels in mature markets and across the global north. GWEC proposes that these investments do not currently happen at the sufficient scale and volume due to (among other things) risk perceptions which may not be reflective of the actual underlying risk (e.g. risks may be over-stated). Blended finance is proposed as a necessary solution, but the report also notes the need for new approaches to concessional and blended finance to scale sufficiently to meet the multi-trillion dollar needs of EMDEs through 2030 and on to 2050.

Vector 2. Growing demand for offshore wind - industrial offtakers and development of green products to accelerate growth

Some industry sectors are harder to decarbonise than others, which brings the focus on offshore wind as a key agent in supporting efforts towards this challenging goal, whilst providing non-state vehicles for offtake. Representing approximately a quarter of the world's energy consumption and a fifth of total CO2 emissions, 'hard-to-abate' sectors include heavy duty vehicles, shipping, aviation, as well as industrial production processes. Iron, steel, cement, mining, and ammonia and fertiliser production in particular require very large amounts of power and heat, making them extremely emissions intensive. This section of

the report explores the opportunity for green products in general and recommends market and regulatory incentives to drive the production of green hydrogen products in particular.

Vector 3. Building the global offshore wind supply chain for a 1.5°C world

GWEC's detailed work on supply chain growth is captured in this section. To meet the level of growth needed for offshore wind to achieve 380 GW of OFW by 2030, the wind industry must not lose focus on the fundamental principle of growth to support supply chain viability and scale. Stronger volumes and stable policies will create the business environments and long-term visibility needed for a thriving supply chain. The growth opportunity ahead for offshore wind is substantial. However, the risk for the offshore wind sector is that measures put in place, especially from 2022, to increase supply chain resilience – whether in the form of local content incentive packages such as IRA or trade defence mechanisms – may result in additional hurdles for market participation, higher costs of project CAPEX, ultimately, a slowdown in deployment. The industry must respond to and prepare for the risks on the horizon, embracing better collaboration, standardisation, and sustainable innovation that can help to ride out the turbulence of the macroenvironment.

Vector 4. Accelerating permitting for offshore wind

Accelerated permitting timetables represent a tangible, solvable barrier to the rapid scale-up of offshore wind energy. This section of the report outlines the relationship between lengthy permitting lead times and increased risk exposure. The longer a project takes to permit, the more capital is spent, and the greater risk is borne by the developer in the time between securing an offtake agreement and reaching the final investment decision on a project. Governments, developers, and civil society must collaborate to remove obstacles and concentrate on robust systems with a shorter permitting lead times as well as aligning different interests in the ocean for offshore wind projects in order to provide the planning and permitting processes that will propel the shift to a net zero economy.

Vector 5. Collaborating with communities and driving social consensus

The anticipated scale-up of offshore wind development serves as a window of opportunity for countries to pursue economic and social regeneration along their coasts. However, seizing this opportunity will require a well-established policy framework and support from local communities. Drawing on lessons from community engagement for offshore wind development globally, this chapter outlines best practices and draws on lessons from key markets.

Vector 6. Realising a trained and diverse workforce

There are two very distinct opportunities to grow the workforce of the wind energy industry – up-skilling and re-skilling. To seize the benefits of job creation in the offshore wind sector, the industry, local, and national governments should put in place holistic plans to engage key stakeholders early in the offshore wind development process. Empowering the local workforce and strengthening international networks can also support offshore wind development. The economic effects of the transition to renewables through the support of re-skilling and workforce development programmes will bring sustainable value to society.

Vector 7. Building modern and efficient grids to underpin the energy transition

A common challenge facing offshore wind markets is how to scale up and coordinate transmission connections for offshore wind. There are different models available, each with advantages and disadvantages. Aligning grid infrastructure development with clear regulatory frameworks ensures not only the seamless integration of new wind energy projects but also the optimisation of existing capacities, fostering a resilient energy system capable of supporting the broader objectives of industrialisation and sustainable development.

Using these key pillars of growth, the global offshore wind industry, working together with government and key stakeholders, can chart a strong course for continued and sustained growth.

PART 1: OFFSHORE WIND AS A KEY TECHNOLOGY IN THE GLOBAL ENERGY TRANSITION

Offshore wind competitive advantage

At COP28, 130 countries adopted a historic target to triple renewable energy by 2030, demonstrating the world's commitment to accelerate the energy transition onto a Paris Agreement trajectory. To meet this level of ambition and stay on a 1.5°C pathway, at least 2 TW of wind energy will be needed by 2030, and 8 TW of wind will be needed by 2050.[1]

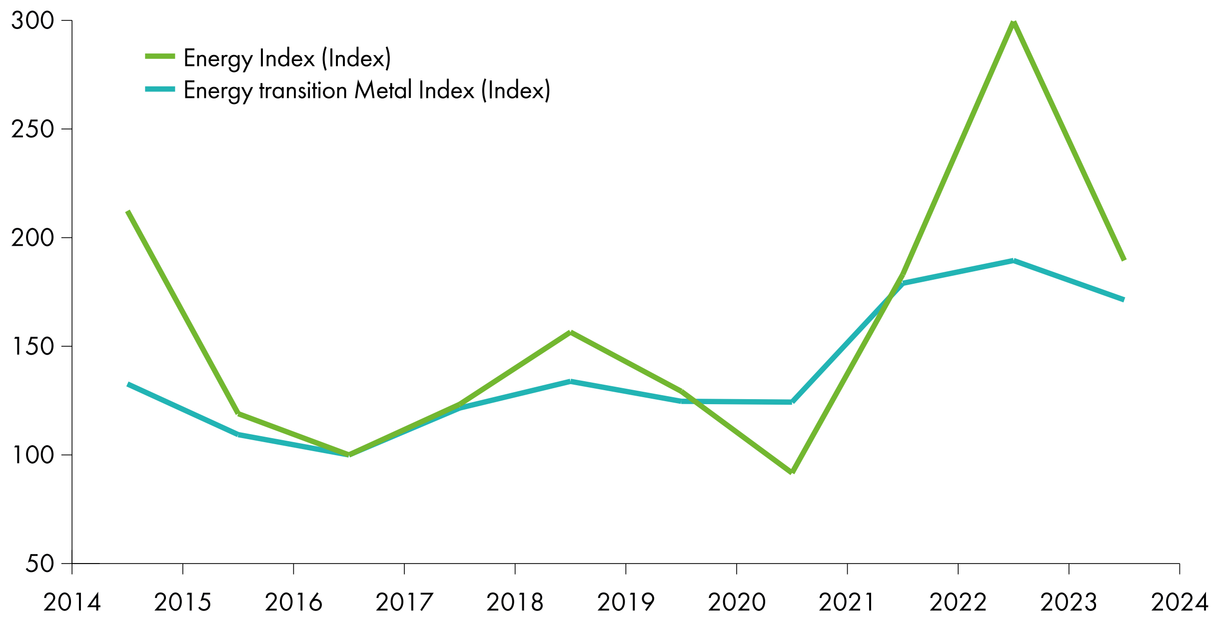
In this part of the report, we will outline compelling arguments and in-depth analysis on the competitiveness of offshore wind, examining five key perspectives: (1) large-scale, reliable power, (2) cost-effectiveness, (3) support for industrialisation and sustainable economic growth, (4) fostering a sustainable blue economy, and (5) the importance of public-private partnerships.

1. Offshore wind provides large-scale, reliable power.

Projections show that offshore wind can deliver one-third of the required global power sector emissions reductions for a net zero world by 2050. To achieve that, the world will need 380 GW of offshore wind by 2030, and 2,000 GW of offshore wind by 2050, according to IRENA's World Energy Transitions Outlook. The World Bank estimates that there is over 71,000 GW of offshore wind technical potential globally. Much of this growth will come from outside the core historic markets of Europe and China. Offshore wind presents one of our strongest assets when it comes to meeting these goals, whilst enhancing economic stability. Over the last two decades, the sector has achieved remarkable success establishing itself as **a mature, competitive, and globally scalable source of energy. Offshore wind provides large-scale, reliable power.**

Offshore wind addresses the pressing issues of energy resource diversification and enhanced energy security by offering higher capacity factor and large power output. It achieves this without competing for limited land space and effectively displaces conventional "baseload" power[1]. For example, the largest offshore wind farm, the 3.6 GW Dogger Bank in the UK, will power 6 million homes annually, once complete. This makes offshore wind

Figure 1: Commodity Index by IMF, 2014-2023



Source: IMF, 2024

1. https://assets.ey.com/content/dam/ey-sites/ey-com/en_gl/topics/power-and-utilities/ey-recai-62-v7-final.pdf ; https://www.iea.org/reports/offshore-wind-outlook-2019

Case Study: Resilience against climate change and water shortages

Offshore wind is an outstanding contributor to energy security, due to its high scale and capacity factors combined with the complementarity with other renewable resources, like onshore wind and large hydropower, as in many countries and regions in the world. This will certainly be the case of Brazil, where the nearly 100% interconnected power system allows large volumes of energy to be transferred between regions, taking advantage of spatial and temporal complementarities in this country with continental dimensions. This contributes to a secure and reliable power system, which is also resilient against climate changes. Climate change poses significant risks to traditional power generation sources. Notably, hydropower, which heavily depends on water availability, is vulnerable to fluctuations in rainfall and river flow levels. Countries experiencing droughts due to climate change face reduced hydropower capacity, threatening energy security and reliability of the power system.

For instance, in recent years, Brazil has been experiencing the impacts of climate change. The 2021 water crisis revealed that existing hydropower plants in the country, which need to be supplemented to ensure their historical role, can no longer ensure the security and reliability of the power system. The decreasing availability of water for this generation source is a current issue and may become a permanent challenge in the near future. The Ten-Year Energy Plan (PDE) 2031, developed in 2021 by EPE, acknowledged the necessity for additional generation capacity to offset the diminished contribution of hydroelectric plants to the security and reliability of the electric power system. This additional generation could reach 15 GW in the coming years, only considering operational restrictions related to the multiple uses of water, such as navigation, fishing, and other activities and community uses. Since climate change was not factored into this study, this number could be even higher once extreme events such as the 2021 drought tend to become more frequent.

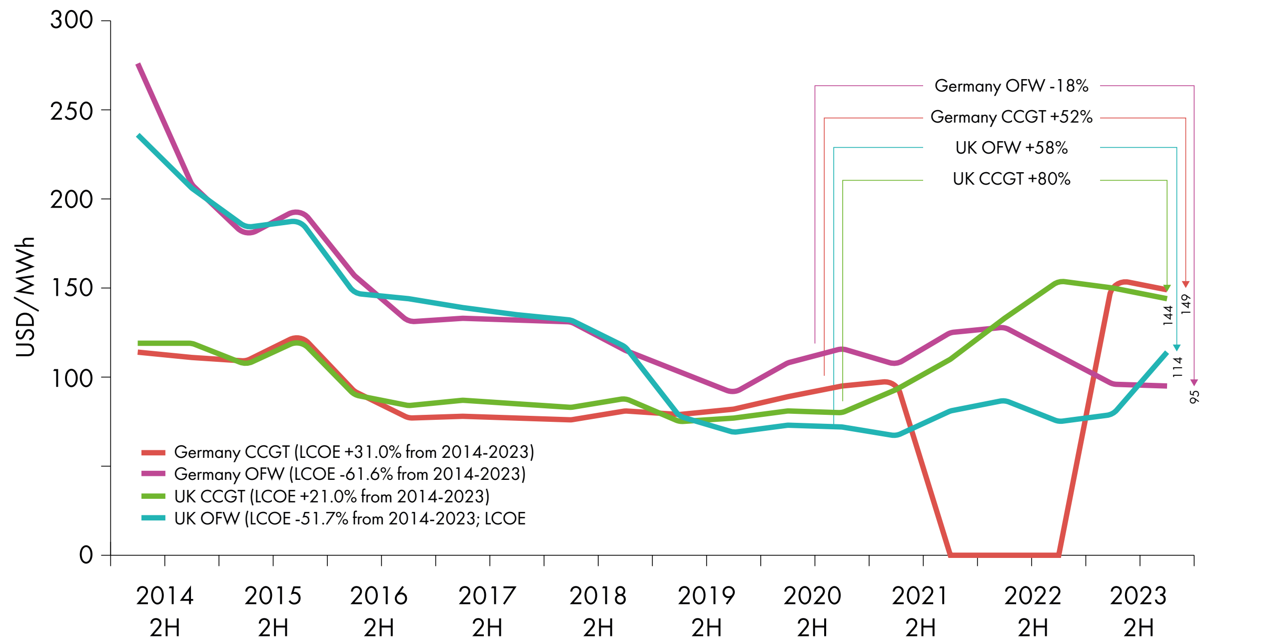
Similarly, nuclear and thermal power plants, which rely on consistent water supplies for cooling, can be compromised by hot heat waves or by droughts. These conditions can force plants to operate below

capacity or even entirely shut down, as seen last summer in France[3], when high river temperatures limited nuclear power production. Also, during an unusually warm summer in 2018, the region's hydropower reservoirs were depleted, boosting energy imports from continental Europe. Additionally, some nuclear facilities in Sweden and Finland, the region's second largest power source after hydropower plants, shut down or reduced power due to the heatwave. As said before, extreme events tend to become recurrent in the years to come, as climate change's impact.

Resilience of the power systems in climate change scenarios can be strongly supported by offshore wind at both the national and regional levels, when counting on a vast interconnection capacity. This will allow the strategically diversified electricity mix to address in many markets the climate change-related meteorological phenomena, such as water scarcity crisis, as mentioned above.

3. https://www.reuters.com/business/energy/high-river-temperatures-limit-french-nuclear-power-production-2023-07-12/

Figure 2: LCOE for UK & Germany Wind Project V.S Combined Cycle Gas Turbine (CCGT), 2014 - 2023



Source: BNEF, 2023 2H (Note :Germany CCGT data between 2021 2H - 2022 2H are unavailable hence it has been normalised to zero)

projects well suited to ensuring energy security, system resilience, and independence at a national level.[1]

2. Offshore wind is better value for money than the alternatives

Speeding up the delivery of offshore wind projects will deliver affordable electricity and savings to bill-payers. It also reduces consumer reliance on high, volatile fossil fuel prices, and enhances energy security.

Increased commodity price inflation has impacted the global economy

The post-COVID demand surge that caused global logistics and supply chain disruptions was remarkable, and the subsequent invasion of Ukraine by Russia caused massive disruptions in global markets. Increased gas prices drove energy price rises which were felt acutely and have impacted global economic growth.

According to the IMF's (International Monetart Fund) primary commodity prices index, the commodity prices index was at 300-unit points in 2023, compared to 100-unit points in 2016. This means that primary goods were three times more expensive in 2023 than they were in 2016. (see Figure 1 below)[4]. Further global logistics bottlenecks also resulted in a 'perfect storm' for price spikes. The impacts cut deeply globally, especially in developing economies which are less able to absorb higher costs for everything from grain to gas.

Nearly every form of new infrastructure and energy generation, including offshore wind projects, have seen significant costs increase due to short-term headwinds.

Offshore wind remains competitive

However, compared to other forms of electricity generation, such as gas, offshore wind remains cost competitive and experienced a lower cost increase between 2020 and 2023. Research by RenewableUK found that increasing amounts of offshore wind would actually save every UK billpayer GBP 68 per year by 2035 compared to gas, and not investing in offshore wind could expose people to the risk of being GBP 133 worse off if recent gas price trends continue[5].

Examining the broader downward trend for offshore wind costs over the last decade compared to the overall upward trend in gas prices, shows that offshore wind has become highly cost-competitive when deployed at scale. In the second half of 2023, the average LCOE

5. https://www.renewableuk.com/news/674063/Public-support-for-cross-party-consensus-on-renewables---offshore-wind-is-best-value-for-billpayers.htm#:~:text=The%20new%20analysis%20by%20Aurora,power%20from%20abroad%20via%20interconnectors.

(Levelised Cost of Energy) for offshore wind was 114 USD/MWh in the UK and 95 USD/MWh in Germany. In contrast, the average CCGT (Combined-Cycle Gas Turbines) cost was 144 USD/MWh and 149 USD/MWh during the same period, making gas generation LCOE at least one-third higher than offshore wind. While there are currently insufficient data sets for illustration purposes arising from Asia. However, the overall downward trend in LCOE trend applies to offshore wind projects in both mature and emerging markets worldwide.

In China, LCOE for offshore wind is around 48 USD/MWh in a low scenario based on the statistics released by BNEF in the second half of 2023. Several factors which have contributed to the delivery of these low prices for offshore wind. Firstly, Chinese offshore wind benefits from the economies of scale due to having the world's largest wind supply chain. Although the capacity factor is lower than projects in the North Sea, the local LCOE is still lower than Europe for several reasons: (1) the Chinese wind turbine prices are extremely competitive; (2) the cost of debt is lower than the UK and Germany as the majority of investors are state-owned utilities, and (3) commodity prices are more stable in China than in Europe, and supply chain components can be sourced domestically, helping Chinese developers to avoid the price hikes in logistics.

BNEF outlook shows that despite the near-term macroeconomic headwinds, project delays and cancellations in the US and UK, the offshore wind sector is set to grow in the long term. With an increasing number of offshore wind targets globally, the growing demand for offshore wind will effectively push down costs across the offshore wind value chain. The global LCOE is expected to decrease by over 10% by 2025 and one-third by 2035.[6]

3. Offshore wind can support industrialisation and sustainable economic growth

Offshore wind can serve as a catalyst for industrialisation by driving the expansion and modernisation of critical infrastructure. The exponential growth in the wind sector over the last ten years presents a significant opportunity for advancing manufacturing competence, developing local and global supply chains and enhancing skills and workforce capabilities.

As sectors increasingly demand energy for their operations, to align with the current energy transition scenario, companies must prioritise procuring their electricity from sustainable renewable sources. This is crucial for maintaining business attractiveness and competitiveness, by complying with local and international ESG (Environmental, Social, and Governance) commitments and providing added value to their products by decarbonising their supply chains. Large-scale offshore wind presents a significant opportunity to meet the rising demand for clean energy and realise sector's decarbonisation ambitions.

This is especially critical for industries in energy-intensive sectors and hard-to-abate industries. An important sector, which is expanding rapidly, is the technology sector, which requires a large amount of safe energy to install its data centres. Data centres and data transmission networks each represent approximately 1-1.5% of global electricity use. Offshore wind farms offer a strategic solution for meeting

6. BNEF, 2H 2023 LCOE Update: An Uneven Recovery, 2023.
7. Confederação Nacional da Indústria. Oportunidades e desafios para geração eólica offshore no Brasil e a produção de hidrogênio de baixo carbono / Confederação Nacional da Indústria. – Brasília : CNI, 2023. < id_243190_oportunidades_e_desafios_para_geracao_eolica_web.pdf (portaldaindustria.com.br) >

this demand, providing large volumes of clean energy while being situated in close proximity to consumer centres.

Furthermore, offshore wind, through the production of green hydrogen or green fuels, also has a potentially significant role to play in the decarbonisation of the refining and chemical industries. Hydrogen produced by electrolysis has the potential to develop the fertiliser market, since most of these products are nitrogenous and use ammonia as the basis of the formation process. In the steel industry, low-carbon hydrogen can be used to produce steel, known as green steel, which is emerging worldwide as an opportunity to replace fossil fuels in the industrial process. Like the steel industry, refineries are large-scale consumers of grey hydrogen. Produced from the reforming of natural gas, grey hydrogen could be replaced by low-carbon hydrogen. Another decarbonisation alternative potentially powerful is the production of methanol using low-carbon hydrogen, in addition to its applications in the transport and electrical energy storage sectors.[7]

Offshore wind farms located near major ports offer strategic advantages. These ports often feature industrial zones or export processing zones, making them ideal candidates for clean energy supply from offshore wind. This not only attracts industries seeking to reduce greenhouse gas emissions (GHG) but also optimises energy transmission and allows the establishment of marine hubs for clean energy to be transformed into ammonia or e-methanol and power vessels that travel through that port.[8]

4. Offshore wind drives a sustainable Blue Economy

As the Blue Economy opens the doors to wind energy, sustainable and equitable solutions are sought to address the current challenges in oceanic sustainable development. Offshore wind is positively contributing to ocean health, with governments ensuring equitable use of the resources with developments through transparent and strategic planning processes. These include large-scale marine spatial planning and systematic ecological and socioeconomic assessments, which are informed by social acceptance, social cost–benefit analysis, and multi-criteria decision analysis, aiming for maximum positive and synergistic outcomes.

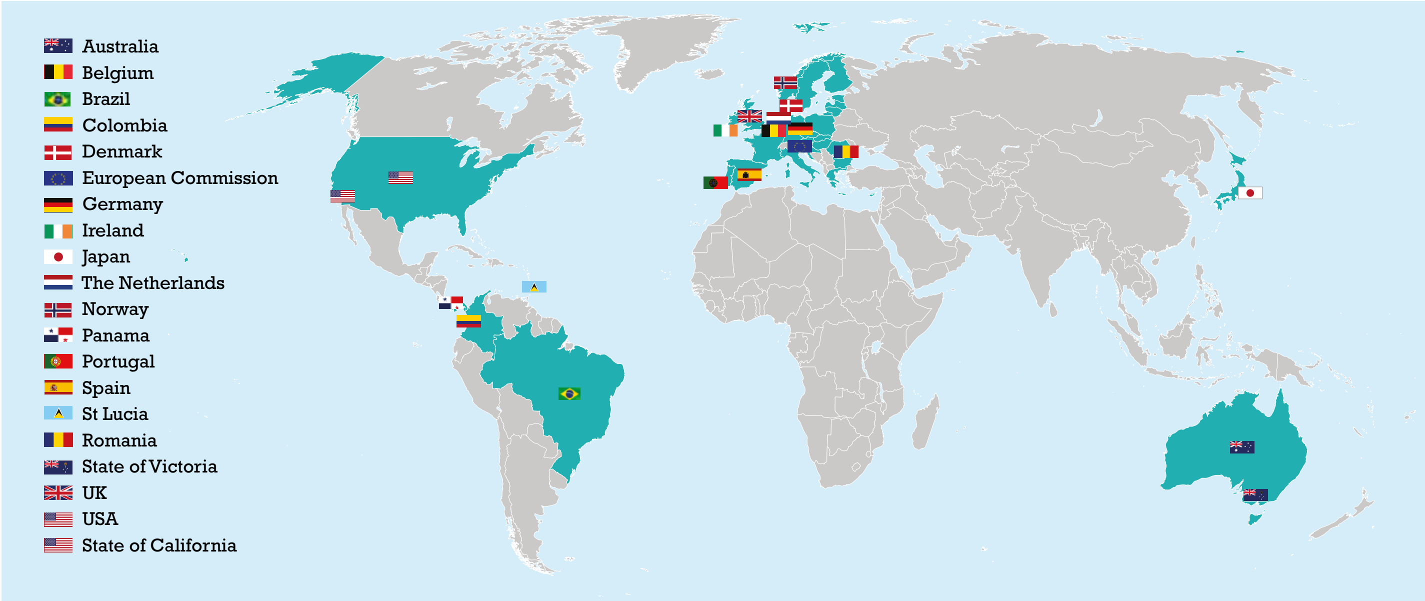
Offshore wind, through advanced technology and energy-efficient practices, fosters robust and sustainable economic growth. This approach not only sets better management standards but also enhances environmental quality, striking a balance between economic development and environmental preservation. The benefits extend beyond coastal areas where projects are located, as supply chains and service providers across countries come together to support this oceanic endeavour.

The linkages between the Blue Economy, sustainable development, and economic growth are undeniable. However, traditional economic indicators, such as GDP, can be deceptive because the wealth of the country is not fully reflected account for lacking relevant accounting in natural capital (such as it is forests, water, and minerals, nowadays which are critical to for ensuringe a sustainable growth), human capital (including education, skills, and health of the people), and social capital, including as it innovation (such as patents). An empiric approach to analysis of the EU case in EU shows reveals that the offshore

8. 2024-04 - EN_One Pager H2 (portodoacu.com.br)
9. European wind energy competitiveness report: European Technology & Innovation Platform of Wind energy, June 2023.

wind industry generated EURO 2.5bn of value added for each new GW of offshore wind. This means that, on average, every new offshore turbine added EURO 20.3m to the EU economy. It is expected projected that the economic contribution in 2030 will be 2.5 times greater than the contribution in 2022. By 2030, wind energy is expected to constitute around 0.81% of EU GDP, with close to 50% of this contribution coming from offshore wind[9].

GOWA Government members (as of January 2024)



On the opposite shore of the Atlantic Ocean the growth of The US offshore wind industry is expected to deliver significant economic benefits over the next decade and beyond. According to ACP (American Clean Power), in a high scenario with 3,000 MW installed per year and 60% domestic content, these benefits could reach $25 billion per year and support over 83,000 jobs by 2030, not accounting for additional value through tax revenues to local, state, and federal jurisdictions, emissions reductions and associated health savings, and direct payments supporting workforce development or host communities.

Outside of the manufacturing of large turbine components, offshore wind represents an opportunity for domestic manufacturing. This includes the production of steel for foundations, substations, and vessels, as well as the manufacturing of cables to transport the electricity. Additionally, there is a need for vessels to move transport components and workers to and from the project site.

5. Public-private partnerships (PPP) have been instrumental in achieving the success of offshore wind to date, and the future will require new, innovative models.

Partnership between government and industry has enabled the successful deployment of offshore wind globally, with governments having played a strong role in de-risking projects. Working together, governments and industry have achieved huge reductions in the cost of offshore wind, leading to offshore wind becoming the cheapest form of new power generation in countries like the UK, Germany, and China after onshore wind and solar PV.[10]

Realising offshore wind in line with a net zero pathway will entail new and deeper forms of public-private partnerships, as well as ways to collaborate more widely with different stakeholders. GWEC has incubated and co-developed two key initiatives committed to the concept of collaborative action to advance offshore wind.

5.1. Global Offshore Wind Alliance (GOWA): a driving force on the global stage

The Global Offshore Wind Alliance (GOWA), established at COP 27 in 2022 by the Government of

10. 1H LCOE Data, BNEF, 2023

Denmark, the International Renewable Energy Agency (IRENA), and the Global Wind Energy Council (GWEC), is a multi-stakeholder, diplomatic initiative. GOWA drives diplomatic efforts to (i) **raise ambition on offshore wind globally** amongst governments, in multilateral forums, and with wider stakeholders, (ii) **support the creation of policy frameworks** and efficient offshore wind value chains to bring new and existing markets to maturity, and (iii) **foster a mission-based approach** among governments to drive action on offshore wind deployment as a key to achieving Paris Agreement's 1.5°C target. It brings together governments, industry, institutions and other key stakeholders to address shared challenges to offshore wind and help governments and society to realise the significant socio-economic benefits of offshore wind.

GOWA's mission is to act as a global driving force for an ambitious uptake of offshore wind by helping governments boost their offshore wind ambitions and delivery. GOWA's vision is a world in which offshore wind makes a significant contribution to the energy transition and the achievement of the sustainable development goals (SDGs) through large-scale renewable power generation, benefiting regions, countries, and critical sectors such as industry and transportation. GOWA's goal is to contribute to achieving a total offshore wind capacity of a minimum of 380 GW by 2030 and an installed capacity increase of at least 70 GW per year from 2030.

GOWA brings together a community of both public and private stakeholders sharing the ambition of exploring offshore wind potential and turning targets into turbines, as part of the energy transition and global decarbonisation efforts.

GOWA works to address the major building blocks for offshore wind, such as framework conditions, financial de-risking, system integration, and supply chain development – all important drivers to reduce costs, ensure competitive market prices, and create project pipelines at national and regional levels. GOWA acts as both a diplomatic grouping for high ambition on offshore wind, and as a platform for capacity building, allowing its members to share experiences, knowledge, and best practices.

5.2. Ocean Energy Pathway: Championing a high-ambition, sustainable vision for offshore wind

Launched in December 2023, Ocean Energy Pathway (OEP) is a non-profit organisation that works to fast-track the development of a sustainable, high-ambition, global offshore wind sector, as part of a thriving Blue Economy. OEP collaborates with leaders from diverse stakeholders in the Blue Economy, including policymakers, industry, civil society, and conservation groups, to create enabling, scalable, and sustainable pathways for the offshore wind sector to thrive.

Offshore wind as a trusted partner in the Blue Economy

Accelerating the deployment of offshore wind requires a holistic approach that proactively addresses challenges and works closely with stakeholders at the heart of the Blue Economy. OEP's vision for sector development is one that grows in harmony with marine ecosystems and meets the needs of coastal communities and other ocean users.

Designing the right enabling policy framework is crucial, and this means considering impacts on interconnected sectors and stakeholders. If done well, policy and regulatory development can not only enable the successful and rapid development of offshore wind projects, but also ensure offshore wind's place as a central solution to building a sustainable, responsible, and equitable Blue Economy.

OEP knows it is possible to deliver ambitious wind energy targets and accelerate the energy transition without compromising nature and communities. Offshore wind has immense potential for socio-economic and environmental benefits, such as revitalising coastal communities through green job creation and creating new habitats for marine life through reef growth on turbine foundations.

As an accelerator and trusted partner at the heart of the ocean-energy-climate nexus, OEP fills a crucial gap by building a shared and strategic plan for a thriving sector, bringing together policymakers and leaders across industry, civil society, conservation groups, and other key stakeholders, who rely on the ocean for their livelihoods.

Building shared strategies for offshore wind across markets

An increasing number of countries with previously little track record in offshore wind are setting ambitious targets forto expanding offshore wind in their energy mix. In Asia-Pacific for instance for example, Japan has set a target of 10 GW of installed capacity by 2030, and South Korea is aiming for 14.3 GW by 2030. Coupled with the international pledge made at COP28 to triple renewable energy, offshore wind energy is poised to play a key global role in meeting energy and climate targets.

Yet market potential and political momentum alone are not sufficient to generate the exponential growth in offshore wind required to deliver the ambitious national targets and the global commitments to triple renewable energy. Especially in emerging offshore wind markets, new strategies are needed to accelerate the sustainable development of the sector. OEP's approach addresses these challenges and opportunities for a successful offshore wind market through three key pillars: enabling market and industrial dynamics, policy and regulatory readiness, and the social and political environment.

For the successful, rapid deployment of offshore wind, the market and industry must be equipped with adequate infrastructure, a skilled workforce, and competitive and sustainable supply chains to manufacture and deliver offshore wind projects. To encourage industry investment for market growth, governments must set ambitious offshore wind installation targets and prepare fit-for-purpose regulations. Permitting and leasing regimes must be streamlined to reduce uncertainty for developers. Environmental impact assessments and marine spatial planning need to be robust to address various environmental, economic, and social impacts, and to deliver in the medium to long term for the industry, the marine environment, and adjacent sectors and stakeholders in the Blue Economy. Around these developing regulations, timely and collaborative stakeholder engagement should facilitate information-sharing between the industry, local communities, and other ocean stakeholders and help build a socio-political environment favourable to rapid and sustainable offshore wind deployment.

In some emerging markets, policymakers lack the capacity, expertise, understanding, or political consensus on offshore wind, which can lead to delayed legislation and ultimately hold back potential deployment of projects. This is the case in Brazil, where offshore wind offers significant potential to support green industrialisation, but offshore legislation has been subject to politicking and delays as it passed through the senate. Consequently, much work is now required to build out regulations to ensure an investable sector. In other cases, offshore wind development faces mounting opposition from local communities, fisheries, and conservation groups. In South Korea and Japan, local communities have raised concerns about potential impacts on marine life and fishing industries. Each market may have

different challenges, but all need to foster alignment across the three categories of market and industrial dynamics, policy and regulatory readiness, and the social and political environment. OEP builds strategies and funds programmes to address challenges across these elements that form the Pathway to offshore wind.

Bespoke on-the-ground technical assistance in emerging offshore wind markets

OEP is focused on scaling offshore wind in at least ten countries with substantial offshore wind resources and at the frontier of the energy transition, including Japan, South Korea, India, and Brazil. OEP scopes and funds on-the-ground technical assistance and hands-on support for decision-makers and other stakeholders, tailored to the needs and context of each market. OEP also facilitates interfaces between industry and civil society and provide education and alignment for stakeholders in the Blue Economy.

This year, OEP has launched operations in Brazil, Japan, and South Korea. Preparations for new teams in OEP's other priority countries, including India and the Philippines, are underway. Establishing in-country operations and presence equips OEP with the expertise, capacity, and ability to understand the nuanced socio-political context in each country, respond promptly to challenges and opportunities, and build trusted relationships with local stakeholders.

In addition to tailored in-country support, OEP supports work to combat misinformation and disinformation about offshore wind power through specialised events on misinformation and a dedicated database for offshore wind. This year, OEP hosted a disinformation summit, that brought together leaders from governments, industry, civil society and experts in the community to discuss effective and collaborative approaches to tackling disinformation on offshore wind. OEP's Offshore Wind Resource Library, a bespoke, user-friendly, one-stop digital library on offshore wind, addresses the challenge of accessing reliable information. Policymakers and blue economy stakeholders often find it challenging and time-consuming to find relevant information on offshore wind as resources and data are spread across different channels and sources. By making information accessible, free, and easily searchable to global audiences, our platform encourages knowledge-sharing and tackles misunderstandings, misinformation, and disinformation often associated with offshore wind development.

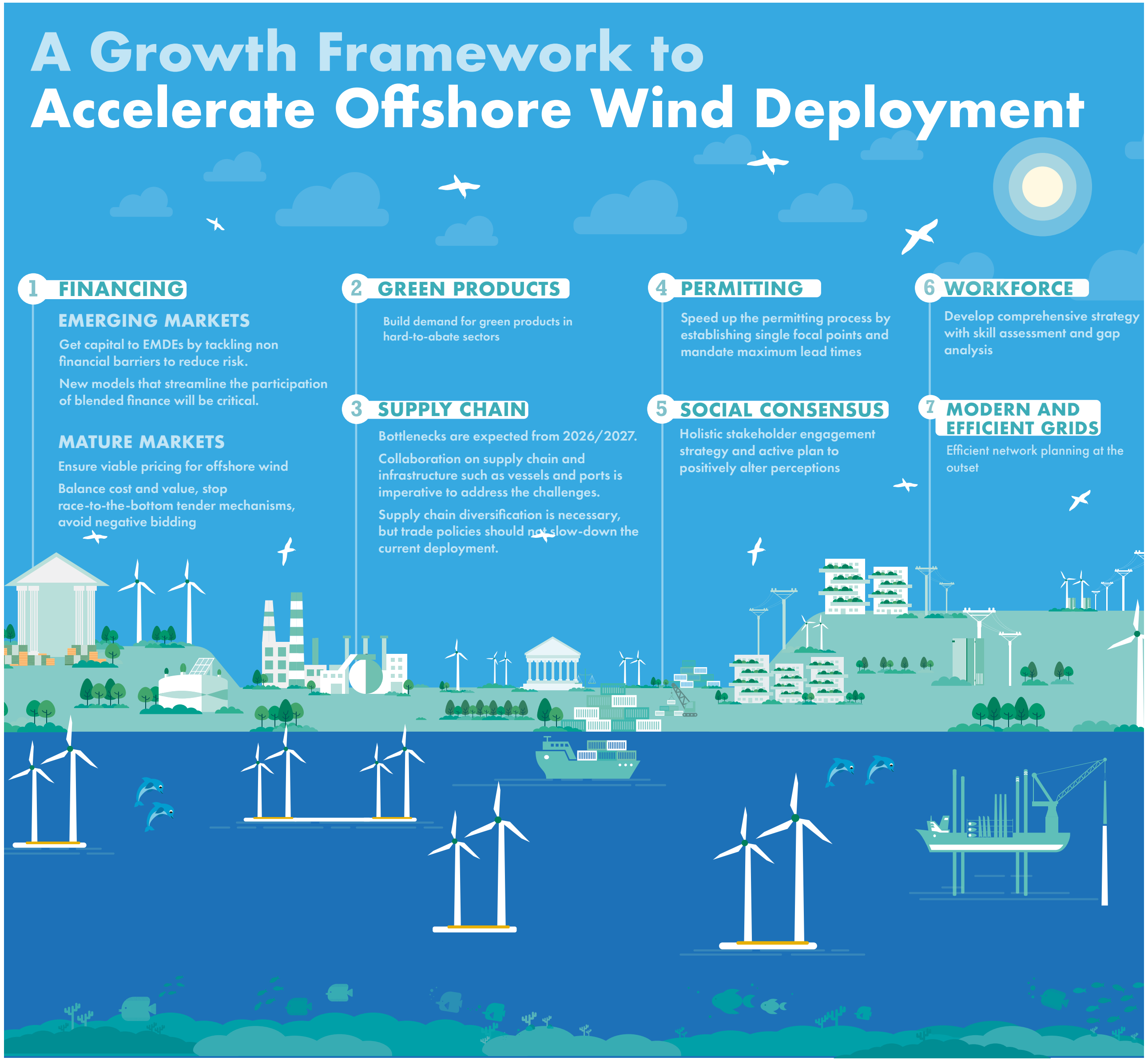
As an independent not-for-profit organisation, partnering closely with industry, OEP is positioned to deliver trusted expertise and build a shared space to establish the socio-political, policy, and regulatory environments needed to support the rapid deployment of offshore wind for a thriving Blue Economy.

PART 2: BUILDING AN OFFSHORE GROWTH FRAMEWORK TO ACCELERATE THE ENERGY TRANSITION

As set out in the introduction, the next few years are critically important for the future of offshore wind. As a large-scale infrastructure technology, with complex financing and stakeholder structures, offshore wind projects require a stable framework for growth with clear visibility of the horizon. Therefore, for offshore wind to be able to play a key role in decarbonising and sustainably growing economies in the 2030s and beyond, supportive market frameworks must be put in place now.

In this section, we set out a growth framework for unlocking offshore wind in both maturing and emerging markets. The framework covers the following key market and regulatory areas:

1. **Financing offshore wind in emerging and mature markets, across the global north and south**
2. **Growing demand for offshore wind - industrial offtakers and development of green products as a growth accelerator**
3. **Building the global offshore wind supply chain for a 1.5°C world**
4. **Accelerating permitting for offshore wind**
5. **Collaborating with communities and driving social consensus**
6. **Realising a trained and diverse workforce**
7. **Building modern and efficient grids to underpin the energy transition**



Section 1: Financing offshore wind in emerging and mature markets

Globally, there is a substantial amount of capital ready to deploy into the offshore wind sector but there is a shortage of 'bankable' projects which are properly structured, permitted, and de-risked with viable offtakers or a viable route to market.

Offshore wind is a capital-intensive infrastructure sector. One of the major costs these projects face is the cost of capital, with a significant percentage of the project cost usually comprised of borrowed capital. To attract private investors, maintaining a focus on the financial viability and bankability of projects is imperative. To enable offshore wind developers to invest, the project economics must stack up in the wider macroeconomic environment, accounting for inflation and cost of capital. At the market level, auction and market design, and the price set in auctions and tenders for offshore wind must be viable to ensure investment.

In 2023, the energy sector was hit by rising raw material costs, the effects of inflation, increased financing costs and uncertainties around logistics and supply chains. The cost of coal, natural gas and nuclear all rose[2], as did costs in other infrastructure sectors. In mature markets, with established supply chains, offshore wind remains cost-effective for consumers, compared to other energy infrastructure choices[3] but has not been immune to these macroeconomic challenges.

In recent discussions convened by the Global Offshore Wind Alliance (GOWA), participants have strongly highlighted that non-financial barriers hinder the bankability of projects, resulting in a misalignment between viable projects and available capital. These barriers include a lack of policy clarity, artificial constraints on market size artificially constraining the size of the market by limiting the amount of GW, which that can be built, onerous or unclear permitting requirements, but also, crucially, the lack of a clear route to market, or badly designed auction schemes. This section outlines practical actions that can be taken to improve these non- financial project challenges.

As GWEC has noted previously, there is also significant concern in the industry regarding 'race to the bottom auctions'. Embedding market and regulatory imbalances that favour projects with the lowest bids, coupled with auctions which cap the amount of GW that can be built have resulted in a 'race to the bottom' on wind pricing. For example, some auctions have been conducted under negative bidding scenarios[4], where the auction design requires project developers to pay for the right to build their wind farms. This, combined with inflationary pressures, has exacerbated the squeeze on profitability for the wind industry.

Well-structured regulatory frameworks and a pragmatic approach to stabilising pricing strategies can pave the way forward. The focus must shift beyond a simple comparison of offshore wind to traditional fossil fuels and instead,

Cost of Capital

The cost of capital is the minimum rate of return that a bank (when lending) or a company must earn on its investments to satisfy the expectations of its investors/shareholders. The weighted average cost of capital (WACC) represents the financing cost a company incurs to raise funds from both debt and equity sources, including the interest rate paid on debt and the return expected by equity investors.

The WACC will vary depending on many factors, a select few including:

- The current macroeconomic environment (e.g. whether there is high inflation environment, if central banks raising or lowering interest rates, etc.)
- The liquidity available to banks; if banks are flush with liquidity, interest rates are usually lower.
- Alternative uses of the funds, along with their returns and risk profiles.

1. Financing Offshore Wind, pwc, 2020
2. 1H LCOE Data, BNEF. 2023
3. https://www.iea.org/reports/renewable-energy-market-update-june-2023/how-much-money-are-european-consumers-saving-thanks-to-renewables?
4. https://windeurope.org/newsroom/press-releases/german-offshore-auctions-award-7-gw-of-new-wind-future-auctions-must-avoid-negative-bidding/

focus on how much we truly value long-term stability in our energy systems. To advance, we must devise strategies to stabilise the cost of capital, ensuring that investments continue to flow into the sector.

Recommendations for improving bankability in mature markets

- Prices for offshore wind must be viable to establish business confidence and therefore secure investment.
- Balance cost and value, stop race-to-the-bottom tender mechanisms, avoid negative bidding – prioritse getting GWs into the global market.
- Policy mechanisms should take into account inflationary effects and reflect these in strike prices/ tender parameters through indexation and other methods.
- Recognise that establishing new supply chains takes time and comes with a cost premium – measures must also ensure that supply chain investment remains protected against macroeconomic externalities to facilitate local supply chain development while maintaining global competitiveness.
- Policies should facilitate a balanced risk and reward sharing between developers and offtakers and should promote industry collaboration and reliability.

Case Study: US and UK macroeconomic challenges

In 2023, both the US and UK offshore wind markets faced acute challenges due to a combination of inflationary pressures, rising interest rates, and policy issues. Some projects, which had their offtake prices locked in during a period of historically low costs prior to the Covid-19 pandemic and the war in Ukraine, were particularly affected.

In the United States, crucial "first wave" projects vital for establishing and expanding the offshore wind supply chain were put into jeopardy. There were 12 GW of projects affected. Of these, nine projects, totalling 7.7 GW, had either their offtake agreements terminated or had the whole project development ceased. These projects faced challenges, including increasing interest rates, regulatory uncertainties, slow permitting, and unachievable local content rules, as well as growing pains encountered by a relatively young industry. The situation is now steadily improving, and in June 2024 new offtake prices for New York State projects were announced[5]. (see the USA Markets to watch section for further details).

In the UK, the recent AR5 auction ended with no bids due primarily to a lack of commodity price indexation and administrative strike prices (ASPs) being set at an unrealistically low level. The Contract for Difference (CfD) "'pot'" structure was also changed, resulting in offshore wind, solar, and onshore wind being grouped together in one pot.

However, the UK Government has since published revised ASPs for the next CfD AR6 auction, raising the maximum price ceiling by 66%[6]. These revised prices represent the upper limit of strike prices to be awarded in the next auction.

5. https://www.rechargenews.com/wind/equinor-and-orsted-sign-on-dotted-line-with-new-york-again-for-giant-offshore-wind-arrays/2-1-1655442
6. https://www.gov.uk/government/news/boost-for-offshore-wind-as-government-raises-maximum-prices-in-renewable-energy-auction

Financing offshore wind – challenges in developing economies

Introduction

To meet global climate goals and deploy offshore wind in line with global targets, the following are required:

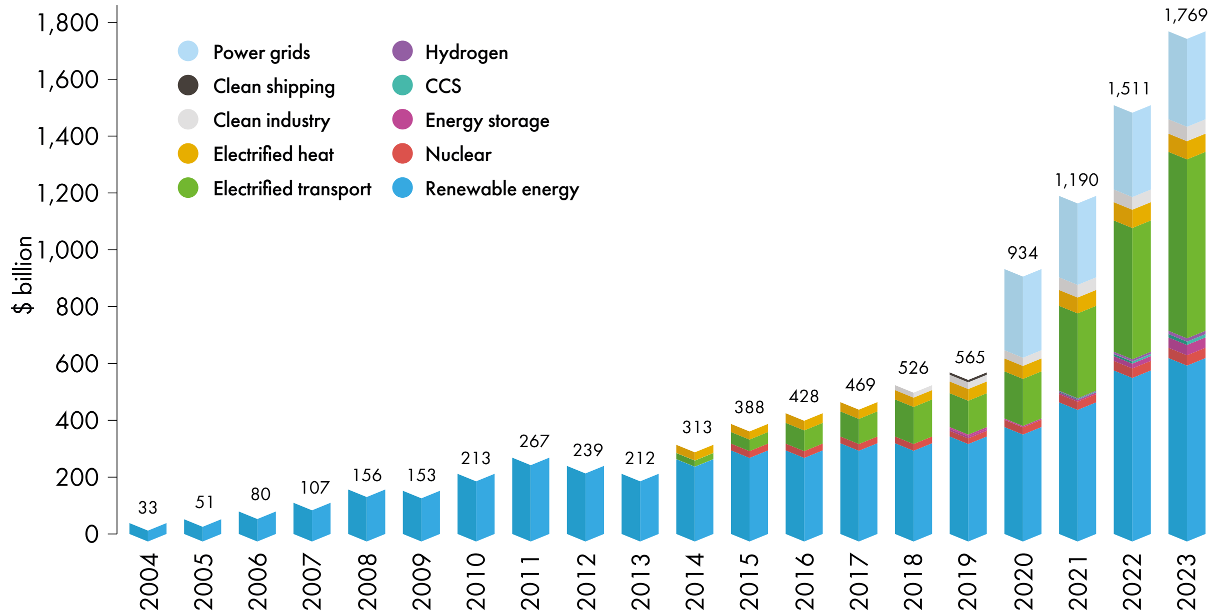
- More capital investment in offshore wind and other renewable energy (RE) in emerging market and developing economy (EMDE) countries.
- Addressing insufficient investment due to risk perceptions that may not accurately reflect the actual underlying risks (e.g., risks may be overstated).
- Utilising blended finance (See pullout box on page 38.) as a necessary part of the solution to address these risk perceptions.
- Continuing to use project finance as the preferred financing method for offshore wind, as it is for many large infrastructure projects.
- Assessing the ability of concessional and blended finance in their current forms to scale sufficiently to meet the multi-trillion dollar needs of EMDEs through 2030 and beyond to 2050.

The current situation

Bloomberg New Energy Finance (BNEF) recently released its Energy Transition Investment Trends 2024[7]. This report noted that in 2023, $1.77 trillion was invested in the energy transition, with the biggest largest amounts going to renewable energy (RE) and grids (almost $1 trillion combined). After the electricity sector, electrified transport was the largest destination of energy transition capital, which, of course, needs to run on carbon- free RE to power it to be truly 'clean'.

To meet the Paris accord's 1.5°C target as well as the net-zero commitments of many countries and companies, in addition to COP28's pledge to triple renewable energy, BNEF states that it would require $12 trillion of investment in the power system up until 2030 – an average of $2 trillion per year starting in 2024[8]. This represents a significant increase from current annual investments into RE, with much of this investment needing to be directed towards emerging markets and developing economies (EMDEs).

BNEF Energy Transition Investment Trends 2024



Source: BNEF

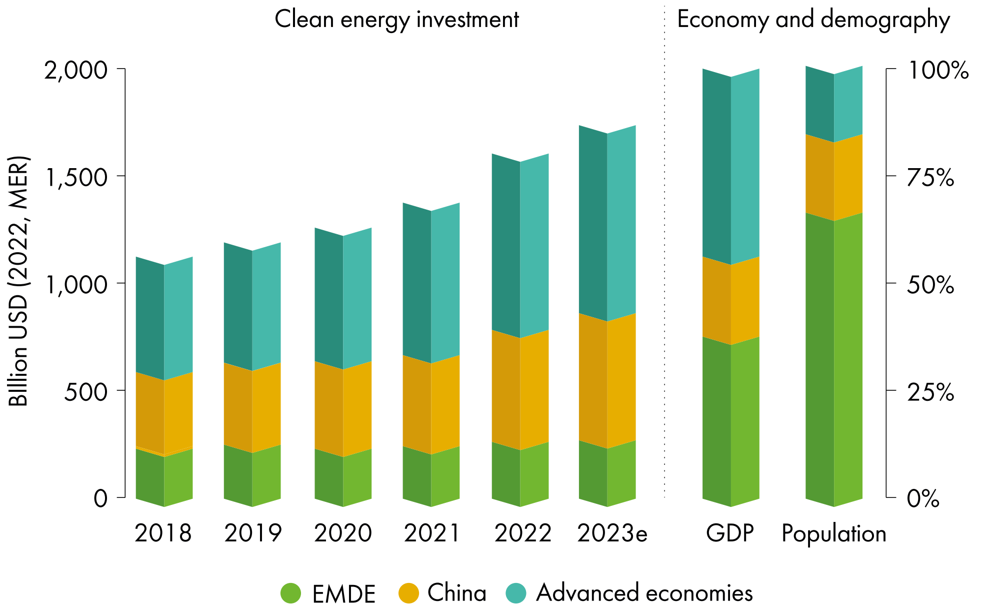
7. https://about.bnef.com/energy-transition-investment/
8. https://climateanalytics.org/publications/tripling-renewables-by-2030-interpreting-the-global-goal-at-the-regional-level

However, recent history demonstrates that investments in RE in EMDEs are falling short. The graphic below illustrates the total clean energy investment by year and category (EMDE, China and advanced economies). Meanwhile, the graphic on the right shows GDP and population by the same categories. When comparing investment in clean energy to GDP, EMDE countries receive significantly less investment compared to either China or the advanced economies.

It is critical to bring more RE and other clean energy sources to EMDEs. Over the past decade, more than 95% of the increase in greenhouse gas emissions has occurred in EMDEs, and these countries will be the source of 98% of world population growth by the end of this decade[9].

EMDE countries clearly need more investments in clean energy. We can achieve that by accelerating the deployment of offshore wind.

Clean energy investment in EMDEs, China and advanced economies



Source: IEA

Offshore wind

Offshore wind is a critical building block of any decarbonised future. Indeed, in many of the fast-growing EMDEs in Asia such as Vietnam, the Philippines, and India, offshore wind can provide large-scale, continuous power and is therefore seen as a key energy transition technology. However, in many of these countries (excluding China), the industry faces relatively high financing costs due to the perceived risks. This poses a challenge because when the cost of capital (weighted average cost of capital or WACC) is 1% higher, total CAPEX costs for an offshore wind project increases by approximately 8%. Thus, a higher cost of capital plays an outsized role in the overall costs of offshore wind. The significant increase in the cost of finance for many offshore wind projects is evident, with key interest rate indices (such as SOFR) rising from 1% to 2% in 2019 - even reaching near 0% in 2020 - to 5.4% in May 2024[10].

On top of the indices, banks typically charge premiums that depend upon their view of the market, technology and other risks related to the project. While some of the risks can be quantified and mitigated (e.g. through insurance, monitoring requirements, government guarantees, currency hedging, etc.), many cannot and rely on the 'comfort' level of the banks.

'Comfort' is a subjective measure, with different financing institutions having their own criteria and assessment, but 'comfort' is also often supported by extensive quantitative analysis. For example, a bank's market advisor may run multiple scenarios to get the bank 'comfortable' with a specific risk. There are also 'softer' risks to consider. For instance, is the bank comfortable with the team leading the project (and how do they define this)? How predictable is the regulatory structure, and does it change often? Does the government have a history of retroactively applying policies to the detriment of projects?

When banks lack understanding of risks, they tend to increase premiums. This is partly why developers spend so much time educating banks, sharing aspects of

9. https://www.dws.com/en-us/insights/dws-research-institute/dialing-up-climate-finance-in-emerging-markets/
10. https://www.newyorkfed.org/markets/reference-rates/sofr-averages-and-index

a project, building confidence in the management team, and taking the bankers on tours of completed facilities, etc. Influencing the perceptions of risk is critical if the cost of finance for EMDEs is to be reduced.

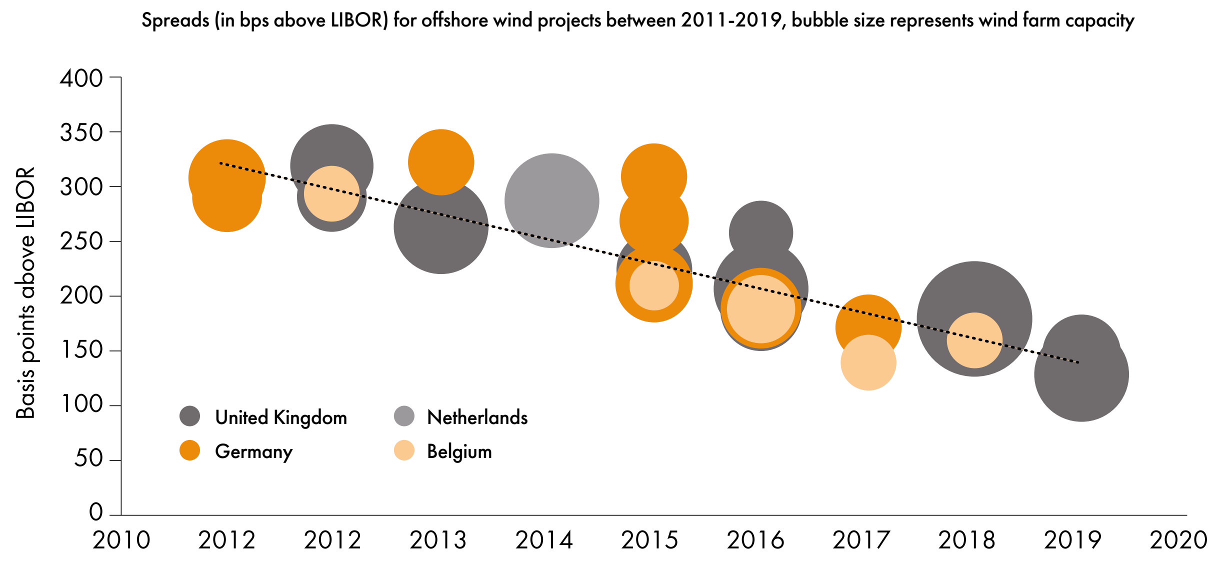
Without being able to reduce the perceptions of high risks in EMDEs, the industry will struggle to deliver decarboniszation goals, even with the support of concessional and blended finance.

What can we do to change the perceptions of financing risk in EMDEs?

Lessons from the past

WindEurope (2023) states that despite the challenging funding requirements, both traditional and new investors seem optimistic and willing to continue to invest in offshore wind. According to them, the most important risk factor is not the availability of funding but regulatory instability. Evidently, the high level of uncertainty that comes with changing regulatory frameworks has slowed down offshore wind energy deployment in many European countries, not least in the two largest markets, the UK and Germany. Nevertheless, as long as Europe ensures a stable framework for offshore wind, the required capital can be channelled into the sector[11].

Spreads for offshore wind projects decreased from 325 to below 150bps over the past decade



Source: PwC analysis based on WindEurope (2020)

A familiar refrain

The graphic above shows the trajectory of risk premiums in Europe over the early days of large-scale offshore wind projects (2011-19) – will a similar story unfold in many 'new' offshore wind markets globally, including many EMDEs?

As the European offshore wind market matured and banks became more comfortable with the way risks were managed, and policy and regulatory frameworks put in place, risk premiums reduced dramatically from roughly 325 basis points (or 3.25%) to approximately 150 basis points above LIBOR (LIBOR has been replaced by SOFR, or the Secured Overnight Financing Rate).

A drop from a 325 to a 150-basis point 'premium' could reduce the CAPEX of a project by approximately 15% - a significant change for any large-scale capital project like offshore wind (and solar, batteries, grid upgrades, etc.).

Understanding lending banks

Banks are in the business of lending money (among other financial activities). Lending banks typically do not want to:

- operate a facility/project

11. Wind Europe: Where's the money coming from? Financing offshore wind farms, November 2013: https://www.ewea.org/fileadmin/files/library/publications/reports/Financing_Offshore_Wind_Farms.pdf

- expose themselves to increasing their commitments (cost-overruns, etc.)
- liquidate a project and take ownership

Banks typically don't benefit from the upside if the project performs well (their 'upside' is full repayment of the loan and interest), unlike equity investors who enjoy the upside potential. Instead, banks are exposed primarily to downside risks such as missed loan payments. They also typically receive lower returns than equity investors, reflecting the risk they assume. During an extensive due diligence process, banks engage various advisors (technical, legal, environmental and social, etc., all paid by the project sponsors). They assess factors such as a stable policy environment, reputable contractors, experienced developers, creditworthy off-taker(s), limited country risk, and currency convertibility before extending loans to projects.

In general, banks do not want to take risk. If they must take on a risk, such as limited currency convertibility available, they adjust the premiums they charge accordingly. Higher risk loans may also impact banks' capital adequacy ratios, requiring them to keep more capital in reserve, as outlined in Basel III regulations . Consequently, lending to risky projects diminishes their available lending pool, prompting banks to potentially raise lending rates to compensate for this reduction.

How banks determine their lending rates

Bank loans will typically be benchmarked to an index, either an international index like the London Inter-Bank Offered Rate (LIBOR, now replaced with the Secured Overnight Financing Rate, or SOFR), or a local index when loans are provided in local currencies, such as the BVAL or Bloomberg Valuation index for Philippine peso fixed-income securities[14].

The bank then adds to the index a 'spread' or 'premium' to account for their margins, risks they perceive, etc., this all in the wider context of macroeconomic situation, alternative uses of the funds, etc.

A study called Project Finance: Determinants of the Bank Loan Spread[15] analysed over 2,000 project financings globally, including many in EMDE countries. The study showed that the existence of government guarantees reduces loan spreads significantly, as did the perceived level of risk. See the table below.

These are just some of the factors banks consider, but going from a low risk country with guarantees, to a high risk country without guarantees increases the cost of debt by 107 basis points (218 – 111).

Any risk that can be mitigated will reduce the 'premium' or spread that the banks charge.

Consider the following graphic prepared by ESMAP/World Bank . On the left is a hypothetical 'risk-free' cost of capital (typically SOFR, formerly LIBOR, it could be in local currency indices as well). Added to that are premiums (dark blue) for the various risks (grid, land acquisition, political risks, etc.) to

12. https://www.bis.org/bcbs/basel3.htm
13. https://www.newyorkfed.org/markets/reference-rates/sofr
14. https://www.pds.com.ph/wp-content/uploads/2018/10/BVAL-GSAC.pdf

Project finance spreads/premium charged above LIBOR (Basis Points)		
	High Risk Country	Low Risk Country
With Guarantee	150	111
Without Guarantee	218	200

come up with the cost of capital accounting for all risks, this before the mitigation of those risks. The light blue reductions in risks are the mitigation activities that are undertaken to lower the cost of capital. After all mitigation activities, there is the remaining 'residual risk' premium, i.e. the difference between the risk-free rate and the hypothetical 'improved' cost of capital.

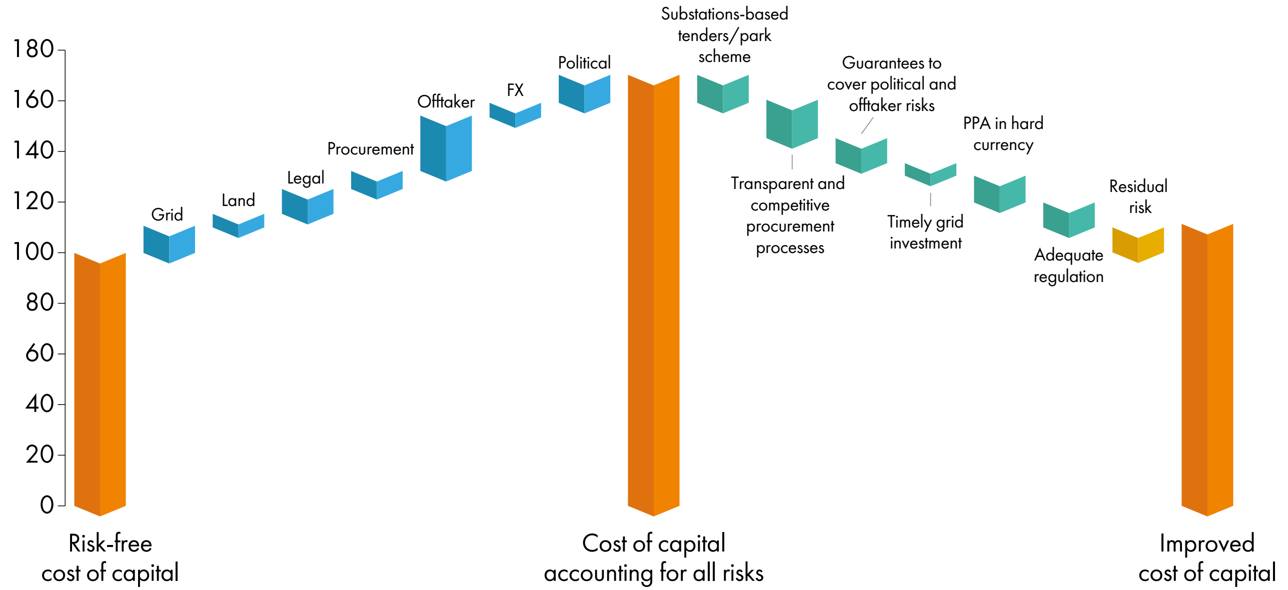
Consider the implications of each of the risks being considered in the graphic. If a conservative premium (i.e. high) is applied to each risk factor, the effect is to compound each risk premium, thus resulting in a much higher spread.

This is where additional education and other activities to increase understanding of the key issues faced by a project (or the industry in general) can help when banks are assessing each type of risk and how to price it.

Blended finance

Because commercial banks will fully price in all risks (the blue above), 'blended finance' is often brought in to provide mitigating activities, such as political risk insurance to mitigate against changes in law or regulations, or other issues that increase the

Illustrative impact on the cost of capital of operational and development risks and their associated mitigants



Source: ESMAP/World Bank

perceived risks. See the text box for the World Economic Forum's definition of blended finance.

Blended finance is not a new concept, but there has been increasing focus on it as a method to accelerate clean energy finance in EMDEs.

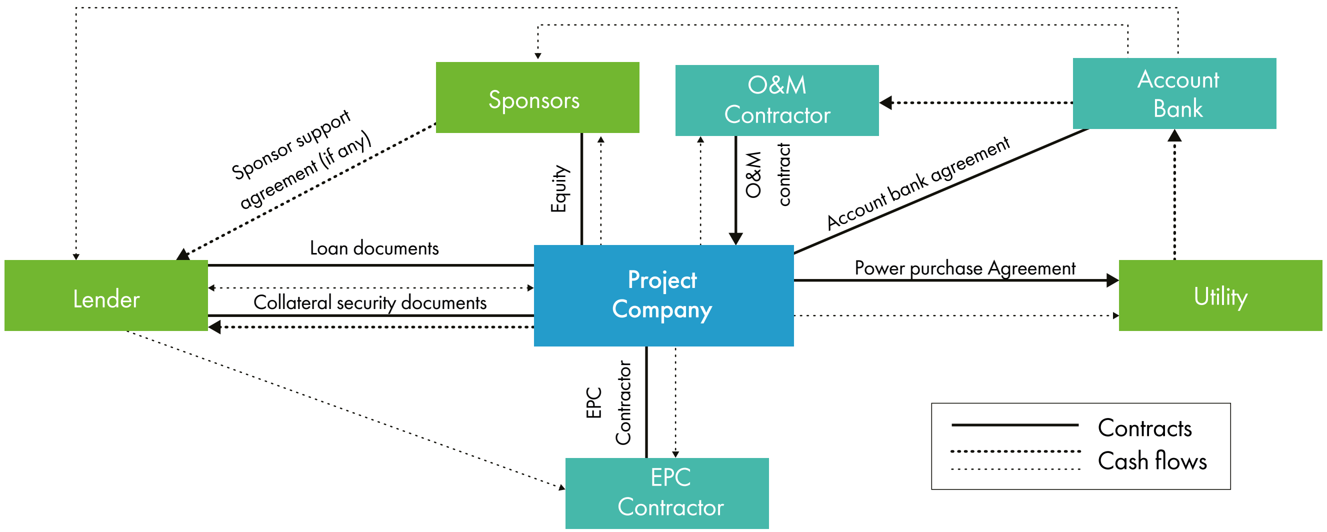
How blended finance helps to provide financing for high risk projects[18]

Blended finance combines concessional financing—loans that are extended on more favourable terms than market loans—and commercial bank financing. The International Finance Corporation (IFC), a member of the World Bank Group, the Asian Development Bank (ADB) and others carry out blended finance operations in partnership with donors. Concessional financing supported by donors is combined with Development Finance Institutions (DFI) and commercial financiers' regular investments.

A recent IFC/World Bank report[19] found that blended finance helped set in motion high-risk projects, such as greenfield projects in untested markets, projects with sponsors without a long track record of operating in a market, or innovative schemes without proof of concept. With a direct subsidy of about 2% - 5% of project costs, IFC blended finance catalysed transactions for

15. https://ijbssnet.com/journals/Vol_5_No_5_April_2014/17.pdf

Typical Structure for Limited/Non-Recourse Financing



Source: GWEC Market Intelligence, 2024

Defining blended finance – the World Economic Forum[17]

Blended finance has three key characteristics:

- Leverage: use of development finance and philanthropic funds to attract private capital into deals.
- Impact: investments that drive social, environmental and economic progress.
- Returns: financial returns for private investors in line with market expectations, based on real and perceived risks.

Blended finance identifies the main challenges that prevent private capital from being deployed into emerging and frontier markets:

- Returns are seen as too low for the level of real or perceived risks.
- Markets do not function efficiently, with local financial markets in developing economies particularly weak.
- Private investors have knowledge and capability gaps, which impede their understanding of the investment opportunities in often unfamiliar territories.
- Investors have limited mandates and incentives to invest in sectors or markets with high development impact.
- Local and global investment climates are challenging, including poor regulatory and legal frameworks.

17. https://www3.weforum.org/docs/WEF_Blended_Finance_A_Primer_Development_Finance_Philanthropic_Funders.pdf

high-risk, potentially high-impact projects, and, in some cases, mobilised other official and commercial financiers.

Blended finance provides 'de-risking' for some financial risks, but non-financial risks remain (changes in law, force majeure, slow grid development, etc.). The analysis points to the importance of the role of advisors (see below), who can reduce specific non-financial risks through recommended mitigation activities. Other interventions by the DFIs, such as assisting governments to strengthen market regulation, can also reduce regulatory risks. Thus, the blended finance instrument can be more effective in combination with other instruments to address a broader range of risks, especially in countries deemed to be high-risk (many EMDEs).

As most offshore wind (and other RE) projects in EMDEs are project financed, it is critical to understand what project finance is, as well as the complexities that blended finance brings to project finance.

18. This section draws heavily on https://ieg.worldbankgroup.org/blog/what-blended-finance-and-how-can-it-help-deliver-successful-high-impact-high-risk-projects
19. https://ieg.worldbankgroup.org/blog/what-blended-finance-and-how-can-it-help-deliver-successful-high-impact-high-risk-projects

Project finance

As most OFW projects are financed through project finance and this trend is likely to continue, it is useful to understand what project finance entails, how risks are assessed, associated timelines, and so forth.

'Project Finance' (PF) generally refers to the long-term financing of infrastructure and industrial projects based on the projected cash flows of the project (typically a 'special purpose vehicle', or SPV, a legal entity that only exists to own, operate and finance the project) rather than the balance sheets of its sponsors.

Typically, a group of sponsors (often OFW developers, utilities, or other investors) provide the equity (25 to 30%), while a syndicate of banks or other lending institutions provide the debt (70 to 75%). These loans are mostly non-recourse loans, meaning the only recourse for lenders is the SPV itself. They are secured by the project assets and fully paid from project cash flows, rather than from the general assets or creditworthiness of the project sponsors. There may be limited-recourse to the sponsors in case of cost overruns, etc. In other words, the financing is typically secured solely by the project's assets and cash flows. See diagram (page 36) for a typical project finance structure.

Advisor	Role
Financial	For the sponsors, potentially more than one depending on how many sponsors, to advise on financial structuring, help in arranging finance, assessing options to reduce financial risks, etc.
Technical	To undertake lenders' due diligence (technical issues) to give comfort to the lenders that the project is technically viable. For the sponsors to help in the selection of turbines and other technology choices, among many other items.
Environmental and social	For both sponsors and lenders, to advise on issues related to various legal and regulatory requirements, identifying issues related to fisheries, marine mammals, bird studies, etc.
Legal	For both sponsors and lenders to advise on all the various legal and other issues related to the projects, including all contractual documentation.
Market	For both sponsors and lenders. Advises on commercial, legal, regulatory, political risk, and other aspects of the market. When done for the lenders it is to assess risks. When done for the sponsors it is to justify for their boards/investment committees.

As an SPV is typically utilised and only its cashflow is used to pay back debt, risk identification and allocation are key components of project finance. Offshore wind projects often face several technical, environmental, economic, and political risks, particularly in EMDEs, hence understanding these risks is critical (see the table above detailing typical risks).

The benefits of PF are that it tends to clearly identify, characterise and quantify the risks involved (so that they can be fully understood by all parties, and priced). The disadvantages of PF are that it is typically complicated and time consuming, this is due to the process of ensuring that the risks associated with each unique project are appropriately allocated to those best able to manage those particular risks.

How offshore wind projects differ from traditional power sector project financing[20]

The scale, cost, and complexity of offshore wind projects have seen most developers adopting a multi-contract delivery strategy. This is where the developer/SPV procures separate contracts for various packages of work required to complete the project such as turbines, foundations, substation, and cabling.

In a traditional power plant financing there is a single EPC (engineering, procurement, and construct) contractor who takes on all the risks of delivery. Because of the complexities in offshore wind, no single EPC contractor wants to do this, or if they do, they include a significant risk premium in their price which most developers find unacceptable. Consequently, most OFW wind developers prefer to manage construction themselves through a multi-contracting approach.

Another significant difference is the 'up front' capital nature of OFW compared to traditional power plants. In OFW there are no fuel costs, whereas fuel costs typically account for 40-60% of a traditional power plant. Consequently, capital costs constitute the majority of the costs for OFW projects. This means that decisions made upfront (such as geotechnical assessments, design, and procurement) potentially have a more significant impact on the total cost than upfront decisions for a traditional power plant.

20. This section draws heavily from https://www.bclplaw.com/en-US/events-insights-news/offshore-wind-projects-contracts-risks-and-looking-forward.html

The adoption of a multi-contract approach creates a more complex matrix of interfacing stakeholders. Managing that interface and dealing with the resulting risks are key issues for developers of OFW projects, and the banks that lend to them.

Who is involved in project finance?

Given the complexity and the uniqueness of each PF, there are typically many advisors needed to reach financial close (all paid for by the sponsors). A partial list is shown in the table below.

Again, the complexities of each PF can be seen by the need for so many advisors, each of which is required to identify risks, options and costs for mitigation, etc.

The need for so many advisors underscores the complexities involved in each PF. These advisors are essential for identifying risks, evaluating options, and estimating mitigation costs. **Many of these advisors will be advising the lending banks on the risks, making their engagment critical to ensure that reasonable levels of risk are applied in the calculations of the risk premiums.**

Financial structure of an OFW project

In the project finance structure above, there is a 'lender' box, but typically there are multiple lenders, including commercial banks as well as Development Finance Institutions, export credit agencies, and others who provide debt that may be 'concessional' in some way (lower cost than commercial banks). There may even be some 'first loss capital' that with equity, will take the first losses (if there are any) that a project incurs. For example, in the Baltic blended finance case study (see page 40), there were 25 lending banks.

A 'capital stack' ranks the priority of different sources of capital. Senior debt creditors will be paid first in the event of financial distress, while shareholders will divide what remains after all creditors are paid. Secondly, the return profile of debt and equity is inverse to the priority list. Shareholders with an equity stake have the highest return profile, whereas senior debt creditors have the lowest.[21]

Catalytic **first-loss capital** refers to socially and environmentally driven credit enhancements provided by an investor or grant-maker who agrees to bear first losses in an investment in order to catalyse the participation of co-investors that otherwise would not have entered the deal (typically commercial banks) . An example of a first loss facility in Asia is the South East Asia Clean Energy Fund II, which reached first close in January 2024, with $127 million committed[23].

Historically, first-loss capital injections have been modest, and GWEC is not aware of any plans by DFIs, philanthropies, or others entities to fund first-loss mechanisms on the scale of billions of USD—the amounts needed to catalyse offshore wind investments in EMDEs.

Conclusion for financing offshore wind projects

Offshore wind projects in EDMEs are large infrastructure investments that require project finance and, in many EMDEs, blended finance to help the projects achieve financial close.

The uniqueness of each project finance deals raises questions the ability to substantially scale the

Participant	Note
Lenders (senior debt, commercial banks)	First to be paid in the event of financial stress.
Lenders (development institutions)	May provide some level of guarantees and insurance (political risk, etc.), but still expect to be paid in case there is financial distress.
Lenders (export credit agencies)	Often lower cost debt than commercial banks (because of the policy driven, export promotion, role of ECAs), but they also expect to be paid in case of financial stress.
Grants	Could be provided by philanthropic donors, but the scale of grants needed to substantially 'buy-down' the cost of OFW projects (hundreds of billions or even trillions of USD) is unlikely to materialise. The grants could be used on discrete aspects of a project (e.g. connection to the grid).
First loss capital	Depending on the situation, may or may not be prioritised over equity should there be financial stress. First loss capital is an evolving concept and unique to each project. (see below for definition).
Equity owners (sponsors, typically more than one)	The last to be paid when there is financial stress – all equity will be wiped out and the remaining proceeds will be distributed to the lenders in the order agreed during the financing.

21. https://corporatefinanceinstitute.com/resources/commercial-lending/senior-and-subordinated-debt/
22. https://cof.org/content/catalytic-first-loss-capital
23. https://www.climecap.com/post/clime-capital-announces-first-close-of-seacef-ii

blended finance and concessional finance models to the extent that is needed to meet the climate goals noted at the beginning of the chapter.

Risk perceptions of lenders are another challenge to the costs of offshore wind in EMDEs - reductions in these perceptions can dramatically lower the delivered cost of OFW power.

The following actions can help advance OFW in EMDEs:

- Engage international banks and DFIs: Work with international banks, development finance institutions (DFIs), and other stakeholders to raise awareness about risk perceptions. Educate stakeholders about these risks to help reduce the risk premiums charged by lending banks.
- Leverage domestic capital markets: If domestic capital markets have sufficient liquidity, collaborate with local banks to provide a local perspective on risks. Local banks can typically handle local currency risks and should be educated on risks they may not fully understand, such as OFW technology risks.
- Government collaboration: Governments, particularly those of developed countries, should work together to ensure that multilateral development banks (MDBs) are adequately capitalized. this can provide more concessional finance to lower project risks for commercial lenders and attract private capital.
- Blended finance evaluation: Conduct a clear and honest assessment of the ability of blended finance, in its current form, to scale to the magnitude needed by OFW and other

Case Study: Baltic Power achieving financial close with DFI backing and blended finance amid regulatory reforms

Poland is categorised as an emerging market (EMDE) by the International Monetary Fund (IMF). In September 2023, Poland's first offshore wind project, the 1.14 GW Baltic Power, secured a syndicated loan of EURO 4.4 billion from 25 commercial banks and export credit agencies through non-recourse financing.

As the Baltic Power project experienced high capital costs with relatively low domestic currency (Zloty) bank liquidity, there was a need for international commercial bank debt. Risks often associated with power purchase agreements (PPAs) in EMDE markets include counterparty risk, price risk and volatility, lack of alternative routes to market, and foreign exchange risk. The latter typically arises from a mismatch between the lending currency and the PPA payment currency. This situation can be exacerbated if the local currency lacks liquidity or has high interest rates.

Foreign exchange risk also exists between their international lenders' base currency and that of the loan. In the case of Baltic Power, Euro-based lenders would also need to hedge in Zloty. However, the ongoing war in Ukraine means that has become prohibitively expensive.

Polish authorities ultimately agreed to peg the Zloty-based support scheme to the Euro, essentially transferring the currency risk from lenders to the energy consumer who ultimately funds the scheme. This significantly increased access to financing and ultimately made the project bankable.

The European Investment Bank (EIB) was able to mobilise up to EURO 610 million in total loans, of which EURO 350 million were backed by the InvestEU programme[1], an impact driven programme to mobilise investment for the green transition in the European Union.[2] This robust government scheme was offered

1. The Asset, https://www.theasset.com/article/50075/baltic-power-reaches-financial-close ; Assessed: 10 May 2024
2. EIB, https://www.eib.org/en/press/all/2023-341-poland-investeu-eib-supports-one-of-the-world-s-largest-wind-farms-with-eur610-million-in-financing

and paid out in Polish Zloty.

Other development financial institutions (DFIs) involved included the European Bank for Reconstruction and Development (EBRD), as well as Danish ECA EIFO, Germany ECA KfW, and Canadian ECA EDC, through various forms of subordinated debt reassure international lenders and local commercial banks.[3]

The robust engagement of DFIs was complemented by concurrent regulatory reforms enacted under the Poland Offshore Wind Act. Additionally, securing a 25-year Contract for Difference (CfD) offtake agreement, which includes inflation indexation and grid connection provisions, bolstered confidence among commercial private lenders. This increased their interest and comfort levels in financing the project, ultimately improving risk perceptions of the project. The simultaneous advancement of regulation and the commitment from development financial institutions and export credit agencies made this financing possible. This successful structure can also be replicated in other markets.

Lenders' assessments of the bankability of offshore wind projects are typically project-specific, including factors such as identity of sponsors, procurement strategy, key equipment suppliers, and so on. However, they also consider involve country-specific conditions, such as governance, regulations, supply chain, climate, and market size. Bankability is not binary, as demonstrated in the case of Baltic Power, where every project is distinct and unique (see discussion of the scalability challenges of blended finance in this Section 1).

An agreeable revenue line was achieved through a robust support mechanism backed by blended finance. Concurrently, risks were well-allocated through financial designs and flexible regulatory requirements ensured that private investment could be incentivised and deployed in a timely and impactful manner.

3. https://www.uxolo.com/articles/7205/baltic-power-a-blended-finance-first-for-poland; Assessed: 10 May 2024

renewable energy projects. if it is not sufficiently scalable, determine how best to allocate the limited blended finance capital and explore alternative funding sources.

- Catalogue first loss capital: Identify and catalogue the available scale of "first loss" capital and other methods to reduce the initial costs of OFW projects.
- Targeted financial products: After assessing the specific risks, consider introducing financial products and interventions that address these risks, in collaboration with MDBs, DFIs, and other entities.
- De-risking activities: Continue efforts to de-risk investments in EMDEs by pursuing regulatory reforms, promoting transparency in policymaking, implementing currency convertibility reforms, and other measures that will enable banks to provide more cost-competitive capital.

Governments can work with industry to create enabling environments for private investment by establishing a clearly defined energy vision, integrated planning for the power and other sectors, accelerated policy and regulatory reform, building capacity, and implementing policies that provide strong signals to investors.

Section 2: Growing demand for offshore wind industrial offtakers and development of green products as a growth accelerator

Some industry sectors are much harder to decarbonise than others, highlighting offshore wind as a key agent in supporting efforts towards this challenging goal.

Representing approximately one quarter of the world's energy consumption and a fifth of total CO2 emissions, 'hard-to-abate' sectors include heavy duty vehicles, shipping, and aviation, as well as industrial production processes. Iron, steel, cement, mining, ammonia production, and fertiliser production in particular require very large amounts of power and heat, making them extremely emissions-intensive.[1]

Finding alternatives to fossil fuel use in these sectors is crucial for the world to reach the goals of the Paris Agreement. Renewable energy can play a crucial role in decarbonising these sectors, especially in light of the significant cost reductions experienced over the past few years and the potential for further cost savings thanks to economies of scale. With its smoother grid planning actions and permitting processes, offshore wind is well-positioned to take the lead in this role.

Direct electrification options – a viable path for reducing emissions in some sectors, such as passenger road transport – are often not easily available for these hard-to-abate sectors. High energy requirements, specific process needs, and economic pressures create additional hurdles. This is where green hydrogen becomes an interesting option to complement electrification.

Hydrogen production and application

Hydrogen can be produced in different ways, with widely different environmental impacts. While hydrogen itself – a gaseous molecule – is completely transparent, colours are used to classify the hydrogen according to the CO2 emissions caused by its production.

When hydrogen is produced through water electrolysis using 100% or near 100% renewable energy with close to zero greenhouse gas emission (less than or equal to 1 kg CO2e per kg H2, taken as an average over a 12-month period), it is called green hydrogen.[2] There is a growing appreciation that green hydrogen is the only option aligned with a 1.5°C pathway.[3]

Renewable hydrogen could be used as a reductant in the production of iron in primary steel production instead of carbon-based reductants such as coke. It could also be used

1. https://www.irena.org/Publications/2024/Apr/Decarbonising-hard-to-abate-sectors-with-renewables-Perspectives-for-the-G7
2. https://gh2.org/our-initiatives/gh2-green-hydrogen-standard
3. https://racetozero.unfccc.int/un-climate-champions-launch-guiding-principles-for-climate-aligned-hydrogen/

as feedstock for chemical industries, or in steel production. In addition, the process of electrolysis can produce green ammonia, methanol, and other synthetic fuels.

Green ammonia or e-ammonia is produced by combining green hydrogen with nitrogen captured from the atmosphere in a reactor, resulting in the synthesis of carbon-free ammonia. Green methanol or e-methanol is made from a combination of hydrogen and CO2. Methanol offers storage benefits as it does not need cooling or storage under pressure, so it can be easily stored onboard ships.[4]

Hydrogen can also be used as feedstock for olefins, making it a greener way to potentially produce a wide range of products, including plastics like polyethylene and polypropylene, synthetic rubbers, and various chemicals.

Finally, the use of hydrogen in the production of sustainable aviation fuels is projected to grow. The production of Sustainable Aviation Fuel (SAF) – e-kerosene – requires CO2 and green hydrogen as feedstocks. E-kerosene can be blended directly with fossil jet fuel and therefore can be used in the aviation industry without overhauling the existing infrastructure.

In addition, hydrogen could support the integration of a variety of renewable technologies in the electricity system by allowing the storage of electricity over days, weeks or months.

The role of offshore wind in hydrogen production

Green hydrogen produced by offshore wind has the potential to provide large volumes of clean electricity in the global energy transition. The extent to which the use of offshore wind for hydrogen production represents a realistic option depends on several factors, including local and geographical factors. The production of offshore wind is higher and more stable than that of both onshore wind and solar, allowing for more consistent production and closer to maximum capacity (higher load factor of the electrolyser) when the electrolyser is supplied by offshore wind, instead of other renewables. Therefore, the high and stable load factors delivered by OSW can significantly support and advance the green hydrogen agenda.

4. https://stateofgreen.com/en/news/green-hydrogen-derivatives-for-deep-decarbonisation/

In some countries, the case for offshore wind will depend on whether there is enough growing demand from offtakers. In other countries, building the industrial case for offshore wind from the beginning is – or should be – a vital part of the wider industrial and development offer from the renewables sector.

The realistic potential to power industrial processes and green products can in turn increase potential avenues for bankable offtake of power from offshore wind. It also creates synergies with the production of key components for the wind industry, providing an opportunity for the industry to further reduce its own carbon footprint by using green steel.

Germany is making significant efforts in this direction through its national hydrogen strategy – a comprehensive plan offering funding and incentives, as well as significant investments in infrastructure to support the transport, storage, and distribution of hydrogen.

A significant portion of hydrogen production, according to Germany's plans, is expected to come from offshore wind. For example, the AquaVentus project aims to create the framework conditions for the installation of 10 GW of green hydrogen generation capacity from offshore wind energy in the North Sea and to build the necessary transport infrastructure. This initiative gathers more than 100 companies and research institutes. The project will be located in an area of around 100 km2 in the North Sea, known as the SEN-1 area.

In the Netherlands, a consortium of RWE, Shell, Equinor, and Eneco aims to create one of the largest offshore wind-to-hydrogen setups in Europe, the NortH2 Project. This will serve industrial clusters in the Netherlands itself and Germany. It will involve a 10 GW offshore wind farm in the North Sea, powering electrolysis plants to produce up to one million tonnes of green hydrogen annually by 2040.

Germany is also seeking to work closely with the UK on the expansion of green hydrogen production and to establish an industrial hydrogen market based on the successful model used by the UK to develop its offshore wind industry, with plans to export to the EU.

The UK has also made the expansion of renewable energy part of its own national hydrogen strategy, which was unveiled in 2021. For example, the Kintore Hydrogen development in Scotland aims to take surplus electricity generated by offshore wind to produce green hydrogen which will then be used in carbon-intensive industries across the UK.

In Denmark, the Copenhagen Energy Islands project aims to use offshore wind power to generate hydrogen offshore thanks to a major investment of €150 billion. Denmark is developing hydrogen as an energy storage option, looking in particular at the potential to produce hydrogen when the electricity price is low or negative, and later sell the hydrogen to end users.

Other notable European offshore wind-to-hydrogen projects include an ESB and Ørsted partnership in Ireland to develop over 5 GW of offshore wind capacity, incorporating green hydrogen production.

Global potential

Several large-scale offshore wind-to-hydrogen projects are being developed outside of Europe, showcasing a growing interest in this innovative approach to renewable energy.

With the drop in renewable energy prices and rapid technological

advances, this is a key moment to deploy and develop this energy carrier on an industrial scale across the world. But infrastructure investments and policy support are necessary to encourage private sector engagement, especially in developing countries.

Many developing countries with good renewable energy resources can produce green hydrogen locally, generating opportunities for job creation and the economy, while reducing fossil fuel supply disruptions and volatility.

In Latin America and the Caribbean, some countries such as Brazil, Uruguay, and Paraguay have the potential to become leaders in the sector.[5] Alongside Brazil and Uruguay, several countries – Colombia, Ecuador, Costa Rica, El Salvador, and Peru –have already developed strategies or published blueprints to accelerate green hydrogen use to decarbonise heavy industry, marine transport, the food industry, and fertiliser production.

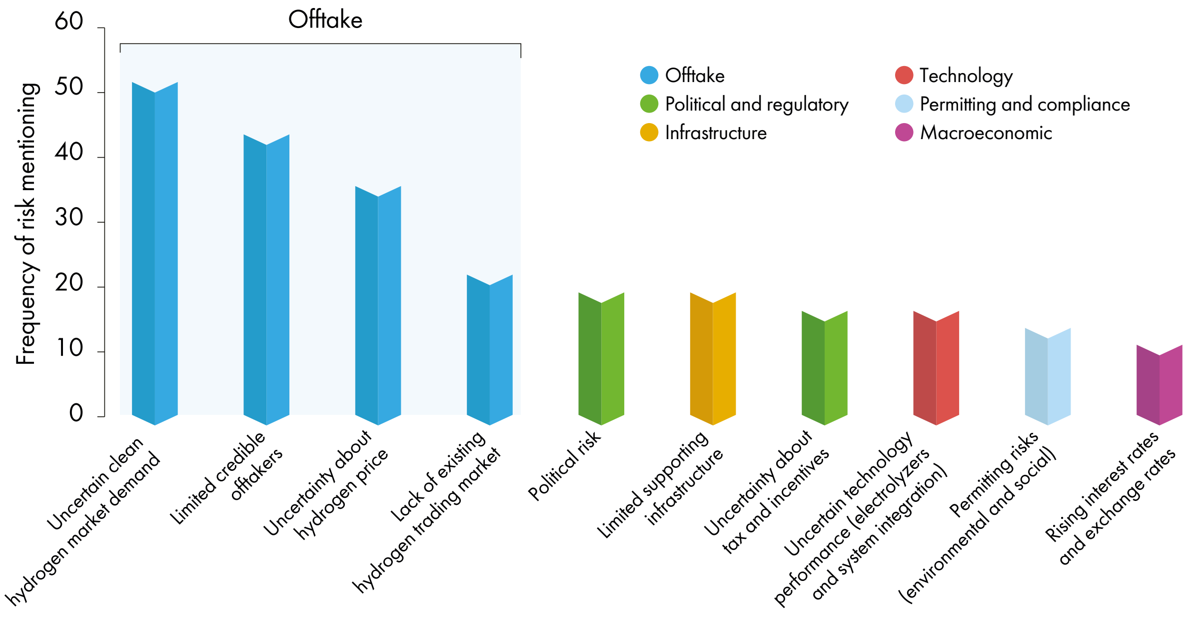
Recently, the Brazilian federal government gave the green light for the first green hydrogen hub shared infrastructure project at the industrial and port complex of Pecém, in the country's northeastern region. With a total cost of $135 million, this will constitute the World Bank's first green hydrogen shared infrastructure project. Also in Brazil, Porto do Açu, located in the state of Rio de Janeiro, has already been granted an environmental license for a hydrogen hub and low carbon emissions for an area of 100ha and up to 4 GW.

Chile is also a key country. A $150 million project – led by the World Bank – will support the country's goal of achieving carbon neutrality by 2050. The project will kickstart a new industry that is capable of creating local green jobs and value chains, as well as helping decarbonise hard-to-abate sectors and increase the competitiveness of local industries such as mining, freight and heavy transport, and agriculture.

The project will also create new export opportunities in green hydrogen derivatives, such as green ammonia and e-fuels, to support a greener and more resilient economy. Specifically, the World Bank aims to support the greening of the mining industry in Chile, which is a worldwide leader in the sector and

5. https://blogs.worldbank.org/en/energy/scaling-green-hydrogen-inclusive-growth-better-jobs-and-lower-emissions

Top 10 identified risks for clean hydrogen projects in EMDCs



Source: OECD, Scaling Hydrogen Financing for Development, page 20

holds 22% of the world's copper reserves. Therefore, green hydrogen offers an opportunity to showcase ways to decarbonise the mining industry as a whole, beyond Chile.[6]

Elsewhere, in Southeast Asia, countries like Vietnam are exploring offshore wind-to-hydrogen projects as the potential backbone of a hydrogen strategy approved in early 2024, with ambitious goals set for 2030.[7]

There are, more broadly, significant opportunities for offshore wind to contribute to hydrogen production in emerging markets and developing countries, with 39% of all global clean hydrogen projects under development in the Middle East, India, China, and Latin America.

Cost challenges can be addressed through supportive policies

Currently, green hydrogen is more expensive than conventional hydrogen produced from fossil fuels. This cost gap is the main reason green hydrogen projects can sometimes be considered as unviable.

Translating high-quality renewable endowments into hydrogen production investments remains a challenge. Only six large renewable hydrogen projects above 100 MW capacity in emerging markets and developing countries have reached the final investment decision stage.[8]

Current global production of green hydrogen represents less than 2% of total hydrogen production. As a highly capital-intensive technology, the production of green hydrogen is highly sensitive to financing conditions and policy support that can help mitigate risks.

However, BNEF estimates that from 2030 onwards, producing green hydrogen in a new plant could be as much as 18% cheaper than continuing to run an existing grey hydrogen plant in five major economies around the world, including Brazil, China, India, Spain, and Sweden. The lower cost of green hydrogen price will happen due to two factors: economies of scale and supportive policies.[9]

Conclusions and recommendations

There is a need for faster action to scale up the technologies for producing and using green hydrogen – electrolysers being a

6. https://www.worldbank.org/en/country/chile/publication/green-hydrogen-to-support-a-green-resilient-and-inclusive-economic-development-in-chile
7. https://www.reuters.com/sustainability/climate-energy/vietnam-aims-produce-100000-500000-tons-hydrogen-year-by-2030-2024-02-23/
8. https://www.oecd.org/environment/scaling-hydrogen-financing-for-development-0287b22e-en.htm#:~:text=This%20report%20on%20scaling%20up,the%20cost%20of%20hydrogen%20generation.
9. https://about.bnef.com/blog/green-hydrogen-to-undercut-gray-sibling-by-end-of-decade/

There is a huge opportunity for regulatory incentives to drive the production of green hydrogen products in particular and green products in general to decarbonise hard-to-abate sectors.

prime example – to reduce its cost. Green hydrogen projects need to become commercially attractive through financing opportunities and risk mitigation measures.

Government regulation and support are essential for creating enabling policy frameworks and for finding solutions that enable the closing of financing gaps for early projects.

The global policy environment on the development of a green hydrogen economy is currently being shaped by the US Inflation Reduction Act (IRA), the German H2Global offtake platform, and other national and regional hydrogen strategies in the European Union, the United Arab Emirates, and Australia.

Importantly, in some developing countries green hydrogen projects can potentially produce some of the lowest-cost clean hydrogen worldwide, thanks to their abundant renewable energy resources, but the right enabling frameworks need to be in place.

In addition, for hydrogen derivatives such as ammonia, methanol, steel, and jet fuel there is a lower cost differential between clean and conventional hydrogen. These commodities can also be transported more easily.

Some key recommendations include:

- **Leverage existing infrastructure** and retrofit it for hydrogen investment.
- **Develop hydrogen hubs that cluster suppliers and producers** to reduce the size of individual projects and eliminate the need for extensive transport infrastructure.
- Consider **opportunities to use green hydrogen nationally in hard-to-abate sectors,** factoring this in from the start when considering the future of hydrogen markets.
- **Involve manufacturing, shipping, and airline companies** to help accelerate the viability of green hydrogen.
- **Create a market** to bridge the cost gap with conventional fossil fuels through direct investment and operational support, contracts for differences, offtake contracts, green certificates and other tools such as demand creation through sectoral initiatives.
- Work to **lower risks** in order to attract capital such as pension funds. Among the actions for this include grid planning and smoothing the permitting process, including the social dimension.
- **Enhance financing conditions** through blended funding, international green finance and state guarantees to help reduce the cost of capital and financing costs.
- Consider the establishment of an **agency responsible for national hydrogen development.**
- **Work to facilitate deployment** by reducing unnecessary project permitting delays.
- **Improve social acceptability** by empowering local communities through participatory processes that outline the case for green hydrogen as part of the wider climate emergency and energy transition response.

Case Study: Decarbonising large industries in Brazil through renewable energy

The industrial sector in Brazil represents approximately 20% of the nation's GDP and uses more than one-third of the annual electricity consumption, totalling 600 TWh.[10] Critical areas within this sector, including mining and manufacturing, hold substantial potential for the integration of green hydrogen into their processes. The adoption of green hydrogen could lead to significant reductions in carbon emissions.

The Brazilian Mining Institute (IBRAM) has launched an Inventory of Greenhouse Gas Emissions from the Brazilian mineral sector.[11] The inventory is an important tool for organisations for helping to combating climate change and identifying the impacts of operational activities, as well as establishing strategies, plans, and goals for reducing GHG emissions. The mining industry plays a fundamental role in the search for sustainable solutions and reflects the decarbonisation of the supply chain of numerous products. Brazilian mining has publicly committed to the energy transition and has intensified its actions in line with this objective. Decarbonised minerals and green products can guarantee can add significant value to the market.

Vale, one of the world's largest mining companies, is a global leader in iron ore and nickel production and has significant operations in logistics and energy in Brazil. The company has been actively working towards decarbonising its operations. In 2023, It achieved its goal of 100% renewable electricity[12] consumption in Brazil, two years ahead of schedule. It also has a goal net zero carbon emissions by 2050. The

10. https://www.epe.gov.br/sites-pt/publicacoes-dados-abertos/publicacoes/PublicacoesArquivos/publicacao-689/topico-640/Caderno%20de%20Demanda%20de%20Eletricidade%20-%20PDE%202032.pdf
11. IBRAM, 2024. Inventário de Emissões de gases de Efeito Estufa do Setor Mineral. Ano Base 2022. IBRAM - Instituto Brasileiro de Mineração, Maio de 2024. Disponível em: Publicações - IBRAM Acesso em 28 de maio de 2024
12. https://vale.com/w/vale-reaches-100-percent-renewable-energy-consumption-target-in-brazil-two-years-ahead-of-schedule#:~:text=Today%2C%20Vale%20is%20supplied%20by,farms%20and%20Sol%20do%20Cerrado) https://vale.com/de/w/vale-and-h2-green-steel-sign-agreement-to-study-the-development-of-green-industrial-hubs-in-brazil-and-north-america

company invests in various renewable energy sources, including wind, solar, and hydropower. These energy projects not only supply power to its mining operations but also contribute to the overall energy grid in the regions where they operate.

The company has been assessing the feasibility of decarbonising its railroad networks by 2030, which are crucial for transporting ore from mines to ports and are currently fuelled by diesel. Various alternatives are being considered, such as the use of electric locomotives powered by green electricity. However, the primary focus is on decarbonising with green ammonia, produced from green hydrogen. For this purpose, in 2023, Vale established a partnership with Wabtec to develop studies on ammonia engines. The company is looking into Fortescue's pilot solution operating in Australia,[13] as a promising solution for this purpose.

In September 2023 Vale and H2 Green Steel signed an agreement for a study of the development of green industrial hubs in Brazil to produce low-carbon steel value chain products, such as green hydrogen and hot briquetted iron, using iron ore briquettes produced by Vale as an input material and renewable electricity as the energy source for its green hydrogen production.

Analysis by the Oxford Institute Energy Studies[14] indicates that to put the entire Brazilian steel industry on the green steel path would require more than 2 million tonnes per annum of green hydrogen and around 26 GW of renewable energy supply. While for the gradual conversion of the Brazilian steel industry to production of green steel by 2040, it would be necessary to produce up to 600 thousand tonnes of green hydrogen obtained from electrolysis with 6.5 GW of renewable energy.

ArcelorMittal, one of the world's leading steel and mining companies, has been actively working on decarbonising its global operations, including in Brazil. The company's global emission reduction targets are implemented in the country through a comprehensive strategy that includes transitioning to renewable energy and innovating in cleaner production processes and technologies, such as Electric Arc Furnaces. In October 2023, EDP and ArcelorMittal signed an agreement[15] to assess the feasibility of a pilot project to produce and use green hydrogen in steel production. The success of this project could determine the expansion of green hydrogen in Brazil.

These efforts illustrate the interplay between industrial operations, innovative technologies, and sustainability goals in the journey towards decarbonisation. Mechanisms such as CBAM, a European Union initiative for the taxation of products that emit Greenhouse Gases (GHG), represent the type of measure through which decarbonised mining can benefit, guaranteeing a differentiated market for its production.

The significant and pressing need to decarbonise the mining and steel sector represents a significant demand for electricity yet to be unlocked that could be met by renewable energy globally, especially in countries with scale, such as Brazil. Offshore wind has the potential to provide renewable energy in the volume required to decarbonise the mining and steel industries.

13. https://www.railwayage.com/mechanical/locomotives/zero-low-emission-locomotive-global-roundup/
14. Oxford Institute Energy Studies OIES Paper:ET33-Hydrogen-for-the-low-hanging-fruits-of-South-America.pdf (hidrogenocolombia.com)
15. https://www.edp.com/en/news/edp-and-arcelormittal-sign-agreement-green-hydrogen-project-steel-production-brazil

Section 3: Building the global offshore wind supply chain for a 1.5°C world

Bottlenecks are set to emerge across the global wind supply chain

Supply chains have become a critical topic for governments and energy sector stakeholders. The events of the last few years, from the pandemic to the invasion of Ukraine to multiple international logistics incidents, have shifted the focus on supply chains from price and flexibility to resilience and dependencies. Increased uncertainty in geopolitics and the experience of price volatility of commodities, materials, labour and logistics have prompted policymakers to shore up their own economic security while advancing the energy transition.

The risk for the offshore wind sector is that measures put in place to increase supply chain resilience – whether in the form of local content incentive packages or trade defence mechanisms – may result in additional hurdles for market participation, higher costs that must be distributed along the value chain to consumers and, ultimately, a slowdown in deployment.[16] The industry must respond to and prepare for the risks on the horizon, embracing better cooperation, standardisation and sustainable innovation that can help to ride out the turbulence of the macro environment.

At the same time, the wind industry should also not lose focus on the fundamental principle of growth to support supply chain viability and scale. Stronger volumes and stable policies will create the business environments needed for a thriving supply chain. And the growth opportunity ahead for offshore wind is substantial.

To accelerate the energy transition towards a 1.5°C trajectory, the wind industry needs to roughly triple annual installations within this decade. GWEC forecasts that we are on track to surpass the 2 TW milestone of installed wind capacity worldwide by 2030 under current policies, which includes 224 GW new projected offshore wind additions in the next seven years.

The wind industry has reached a point where it must find steadier footing for sustainable growth, just as our climate has reached the point where we cannot afford any more delays in the energy transition. For this reason, developers, turbine OEMs, and policymakers all need to work together to build an efficient, well-coordinated and sustainable supply chain.

Supply chain deep dive for balance-of-plant items and enablers

Unlike onshore wind projects, offshore wind projects require large foundations to support the turbine and transfer the load from sea surface to the soil at depth, subsea cables to connect the turbines and transfer power, specialised vessels for wind turbine component transportation and installation, and ports specifically for assembly and storage.

Lack of availability of these components or facilities has already led to several project delays, cancellations, and rising project costs, most notably on the East Coast of the US and in the North Sea of Europe. By the end of this decade, will there be enough supply of foundations and cables, and availability of ports and vessels to meet global demand? This section will provide a supply chain deep dive for selected offshore wind balance-of-plant items, including foundations and cables, as well as key enablers such as wind turbine installation vessels and ports.

Foundations

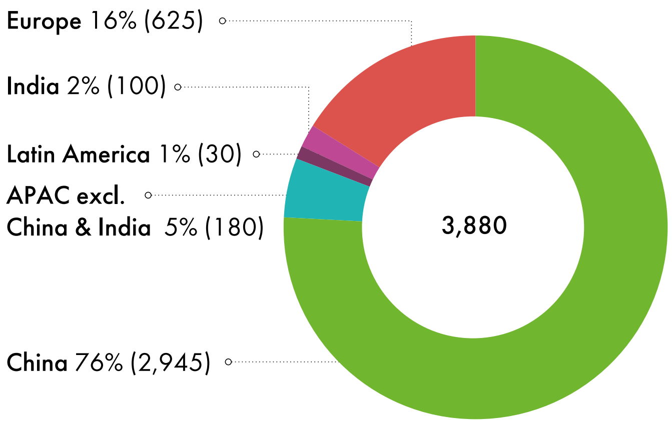
Fixed-bottom foundations consisting of steel and concrete foundations still dominate the offshore wind market, with monopiles and jackets making up 70% and 17% of the total installations by end of 2022 respectively. Floating foundations, as an emerging technology, are designed and used for projects planned in deeper waters (greater than 50m depth), but they are not expected to reach the full commercialisation until the end of this decade.

APAC region dominates the fixed-bottom foundation supply chain

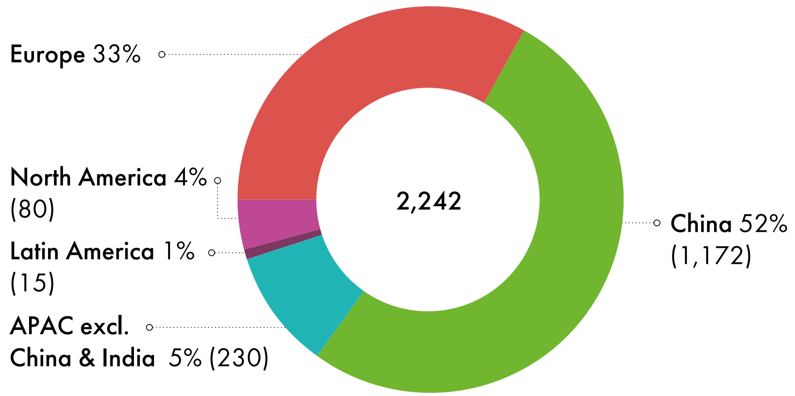
More than 30 manufacturers globally can produce 3,880 units of fixed-bottom foundations per year. Europe, historically the world's largest foundation production base, has been replaced by APAC as

Demand and supply benchmark for fixed-bottom foundations, 2023–2030

Fixed bottom foundation production capacity in 2023 (units/year)



Planned fixed bottom foundation production capacity up to 2026 (units/year)



	Fixed bottom offshore foundations (units)								
	2022	2023e	2024e	2025e	2026e	2027e	2028e	2029e	2030e
Europe	347	509	252	551	734	732	1097	1306	1639
China	683	887	1263	1411	1324	1210	1154	1071	1000
India	0	0	0	0	2	0	34	34	68
APAC ex China & India	271	241	223	263	229	253	277	288	345
NORTH AMERICA	0	42	73	193	294	339	308	294	270
LATAM	0	0	0	0	0	0	0	0	108
Africa&ME	0	0	0	0	0	0	0	0	0
Total	1301	1679	1811	2418	2583	2534	2870	2994	3430

Source: GWEC Market Intelligence, CWEA, Brinckmann, September 2023

● Sufficient ● Potential bottleneck

suppliers continue to expand their production capacity for fixed-bottom foundations in East Asia to capture offshore wind growth, particularly in China, and most recently in South Korea, Taiwan (China), and Vietnam.

According to GWEC Market Intelligence, more than 2,200 units are planned to be added worldwide by 2026, with53% from China, 33% from Europe, 10% from APAC excluding China and 3% from North America. Our latest projection shows there is enough capacity available to meet the fixed bottom foundations demand growth from 1,679 units in 2023 to 3,430 units in 2030. However, if regional-level benchmarks are applied supply challenges will remain the same for foundations from the 2025-2026 period onward.

For Europe, deficits will occur after 2025 if the planned production capacity 745 units by 2026 doesn't materialize. In any case, deficits are expected by the end of the decade. The US has an offshore wind foundation operational facility called EEW American Offshore Structures (AOS), launched in 2023-2024 and US Wind plans to establish another facility. However, this will not be sufficient to meet growing demand beyond 2025. Unavailability of jacket foundation production locally would be another issue for local sourcing.

China is in surplus and can produce close to 3,000 units. Elsewhere in APAC, considering the current and planned capacity in the region and assuming half of the predicted installations will use jacket foundations, demand throughout this decade can be covered. India and Latin America are emerging markets, and supply can be met through imports or new investment, with an average lead time of two years to get a facility built.

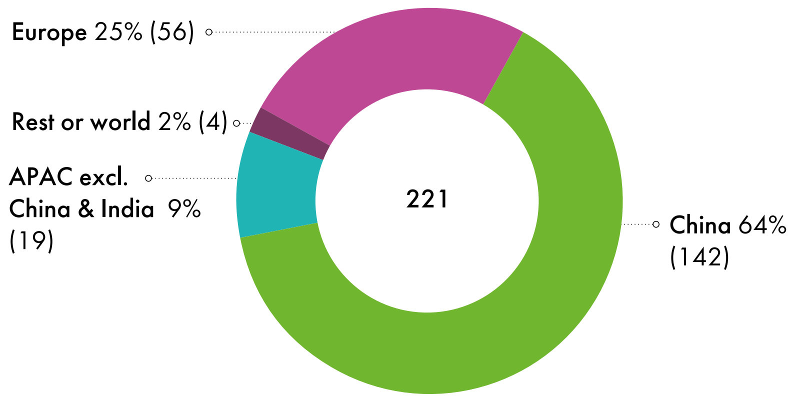
No supply bottlenecks are expected for floating foundations supply until 2030

GWEC Market Intelligence believes that floating wind will achieve commercialisation towards the end of this decade, with annual demand for floating foundations surpassing 200 units per year.

Although Europe is the world's largest market in floating offshore wind installations and has leading suppliers including Aker Solutions and Navantia, China has grown its supply chain capacity in last three years and has the biggest annual production capacity 142 units/year with four suppliers: CSSC CWHI, Wison, JUTAL, and CNOOC Offshore Oil Engineering. However, deficits are likely to occur in all regions except China if restrictive trade policies and local content

Demand and supply benchmark for floating foundations, 2023–2030

Floating foundation production capacity in 2023 (units/year)



	Floating offshore foundations (units)								
	2022	2023e	2024e	2025e	2026e	2027e	2028e	2029e	2030e
Europe	7	11	7	8	26	29	50	130	182
China	1	2	0	25	40	40	0	0	0
India	0	0	0	0	0	0	0	0	0
APAC ex China	0	0	8	0	11	32	57	75	77
North America	0	0	1	1	0	0	0	12	32
LATAM	0	0	0	0	0	0	0	0	0
Africa & ME	0	0	0	0	0	0	0	0	0
Total	8	13	16	34	77	101	107	217	291

Source: GWEC Market Intelligence, CWEA, Lumen Energy & Environment, September 2023

● Sufficient ● Potential bottleneck

Case Study: Plug plate in the offshore foundation for fast and safe wind turbine installation

Provided by: Ken Geyns, Sales Manager, HARTING Technology Group and Gerard Opsteyn, Project Director, Britt Weckx, Marketing Coordinator, Smulders

Escalating costs and supply chain disruptions are widely regarded as the biggest challenges facing the global offshore wind industry today. While increasing economies of scale or mass production can effectively address manufacturing costs, it often neglects the equally significant aspect of installation costs. Recognising this, experienced players in the offshore industry have developed effective practices to systematically reduce installation costs. Below, we present a case study involving HARTING and Smulders, one of the main suppliers for offshore foundations in the offshore wind sector."

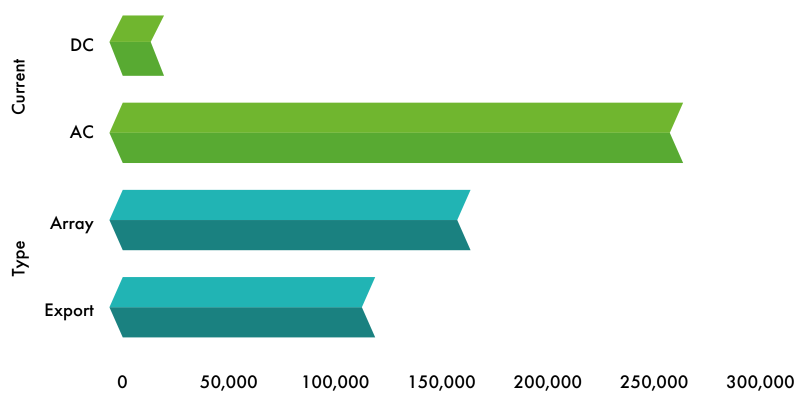
Smulders has worked with many wind turbine manufacturers in different countries around the world, presenting unique challenges. On one hand, they must comply with local electrical building and communication codes of the different countries, while on the other hand, they encounter different turbine types provided by different wind turbine manufacturers. One innovative solution was to implement a plug plate as a 'standard interface,' allowing all turbine connections to be made via 'plug & play'. This also approach simplifies interfacing and testing.

The HARTING Technology Group worked with Smulders on the plug plate to overcome technical difficulties. In addition to the basic functions of good connection and easy pluggability on site, the various special protection functions are critical for offshore wind applications. High water ingress protection of IP69K is required to remove bird droppings with a high-pressure cleaner, as the foundation may remain in the sea for months or years before the wind turbines are installed. The combination of UV, salt-spray, a wide temperature range, and shock and vibration over an expected lifetime of 25-40 years puts extreme stress on the surfaces and the seals of the connectors.

The excellent track record of Smulders and HARTING's plug plate has confirmed that standardisation of the "interfaces" via "plug & play" would lead to a significant reduction in offshore installation costs.

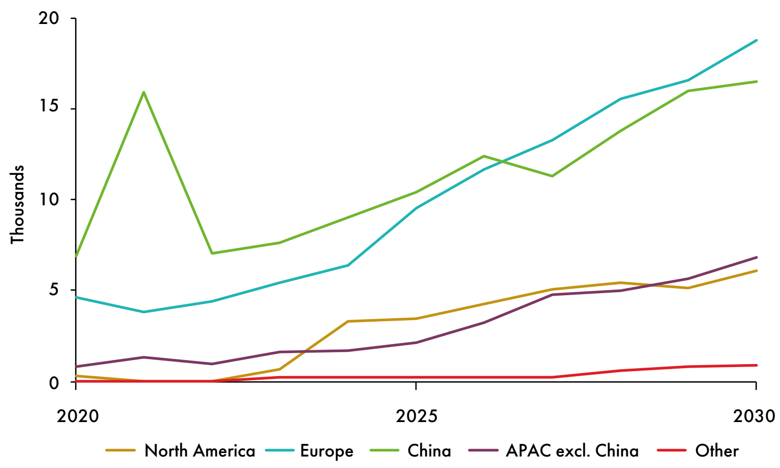
HARTING Pushing Performance Since 1945 | EIFFAGE SMULDERS

Demand for cables in offshore wind applications, 2023-2030 (core-km)



Source: CRU, September 2023

MV and HV cable demand for offshore wind applications (core-km)



Source: CRU, September 2023

requirements present barriers to a flexible global supply chain.

Cables

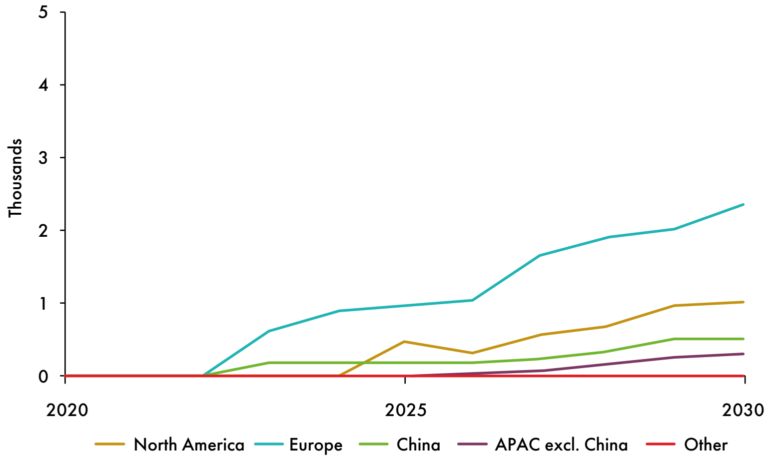
In an offshore wind farm array cables are used to connect all the turbines together, and export cables to connect offshore substations to an onshore grid location. Key trends driving cables demand are the shift from 33 kV to 66 kV array cables for larger turbines, the transition from alternating-current (AC) cables to direct-current (DC) technologies to reduce electrical losses in long distances and high-voltage direct current (HVDC) technology for power interconnection in cross border energy sharing. This integration is a key component of the EU's REPowerEU initiative, aimed at enhancing energy security.

Demand for cables, measured in core-km, is expected to grow by an average of 18% year-on-year from 2023 to 2030; while in value terms, it is expected to increase by 15% year-on-year over the same period as the industry shifts to larger and more valuable cable types. The surge in high-voltage cables production is a critical aspect as demand from rapidly growing offshore wind technologies rises quickly while cable supply and demand centres become geographically distinct.

China alone consumed 76% of total global offshore wind cables in 2021, a figure that decreased to 35% by 2023. Despite this decline, demand is expected to grow at a conservative rate of 13% per year, given China's track record of exceeding its installation targets. With its available and planned capacity (20 submarine cable plants), China may face overcapacity within next few years, potentially offering a solution to supply shortages elsewhere in the world, especially in a free trade scenario.

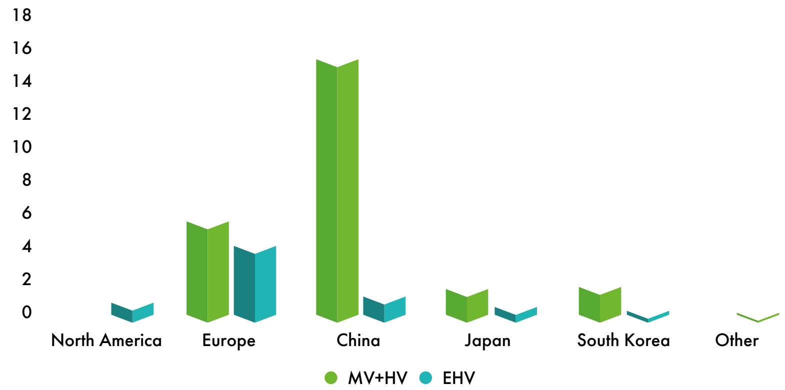
In other parts of APAC, South Korea currently houses a more than 10% share of subsea cable production capacity, with new plants under construction. Additionally, in Taiwan, NKT and Walsin Lihwa are set to launch a subsea cable factory by 2027. Demand in APAC, excluding China, is projected to grow by 18% per year to the end of the decade. To support emerging markets in the APAC region, Chinese players are likely to continue supplying in Vietnam, highlighting the importance of supply chain collaboration.

EHV cable demand for offshore wind applications (core -km)



Source: CRU, September 2023

MV+HV and EHV subsea cable manufacturing capacity, '000 core-km/y, 2023



Source: CRU, September 2023

A land cable production line manufacturing HV (high voltage) or EHV (extra high voltage) cables can potentially switch to producing submarine cables through manufacturing process changes. However, this may not be feasible due to cable manufacturing facilities in Europe having a strong pipeline of underground cable projects.

In 2022, only about 0.5% of global energy cable production facilities were capable of producing submarine cables. These highly specialised manufacturers in Europe are fully booked with multiple-year cable order backlogs. These supply bottlenecks have led to project delays and rising project costs, most notably in Europe.

Nevertheless, to tap into this growth, several new submarine cable plants and expansions have been announced in the past two years in the UK, in both England and Scotland, as well as in Sweden, Germany and Netherlands. In 2023, Europe had 27% of global offshore wind cable demand which is expected to grow by an average of 21% per year to the end of the decade.

In North America, there is currently only one operational offshore wind cable production plant, located in the US. Certainly, the region will face a shortage of offshore wind cable supply as demand is anticipated to rise from 4% in 2023 to 13% by 2030.

Vessels

Vessels used for offshore wind turbine and foundation installation fall in two categories: jack-up vessels (majorly for wind turbines) – including self-propelled vessels and barges without propulsion – and heavy lift vessels (mostly for foundations). Two major factors have impacted the availability of vessels as offshore wind turbine MW size continues to grow beyond 12 MW: the weight of nacelle (10-15 MW weighs 500 tonnes to 800 tonnes), tower (14 MW has over 2k tonnes) and foundation (XXL weighs over 1k tonnes); and turbine hub height (for 8-14 MW height ranges 109m to over 150m).

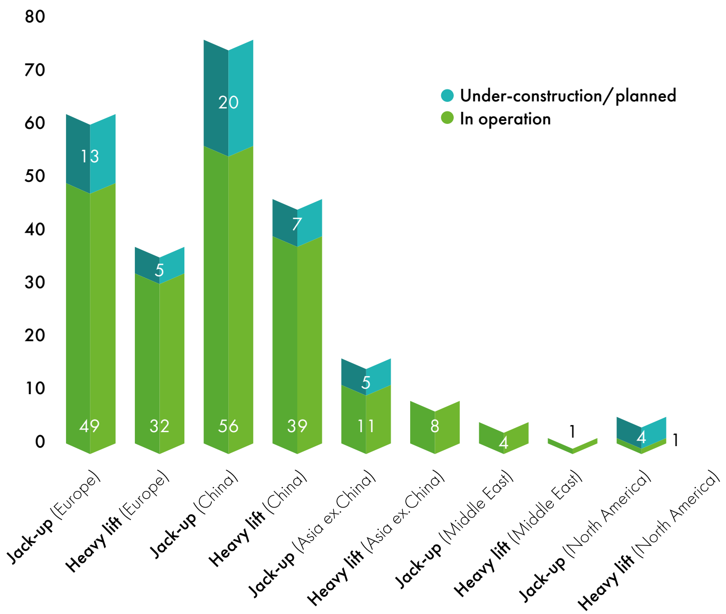
According to GWEC Market Intelligence's Global Offshore Wind Turbine Installation Vessels (WTIVs) database Update, September 2023, China and Europe operate the majority of these jack-up and heavy-lift vessels, followed by Asia (excluding China), the Middle East, and North America. And we expect no bottlenecks in meeting the global demand for offshore WTIVs up to 2026.

Looking at the 2027–2030 supply chain situation, GWEC Market Intelligence expects that China will not face WTIVs availability constraints, as the local industry can handle the challenge of installing growing turbine sizes through modified and tailor-made new vessels under construction (27 WTIVs) and planned. These Chinese WTIVs will continue to support nearshore wind turbine installation in Vietnam. In addition, China is a leader in WTIVs construction, with local shipyards such as COSCO, CIMC Raffles, and CMHI winning the majority of WTIV orders placed in the past three years by large European vessel operators, namely Cadeler, Jan De Nul, Seaway 7 ASA, Van Oord, and Havfram.

European operators would continue to release their WTIVs over the next two years to meet demands in other emerging Asian markets – primarily Taiwan (China), Japan, and the US. Consequently, these markets would need to find solutions to meet their future needs.

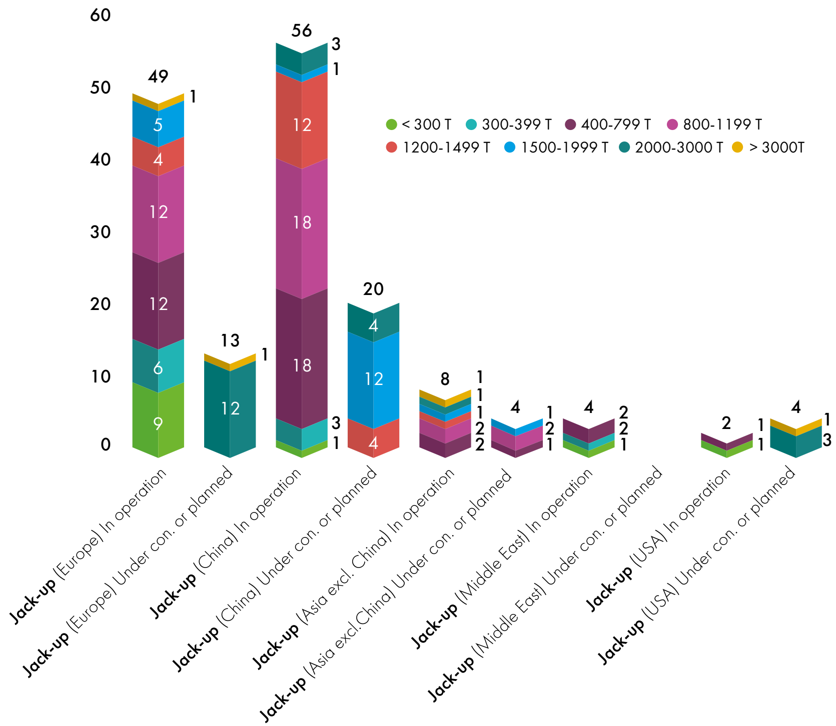
Since large offshore WTIVs are very expensive and require a skilled workforce and specific knowhow, regional cooperation in APAC is vital to ensure offshore wind deployment is not delayed, especially in new markets such as India, the Philippines, Australia, and New Zealand.

Overview of offshore wind turbine installation vessels in 2023



Source: GWEC Market Intelligence Global Offshore Wind Turbine Installation Vessel Database, September 2023

Overview of offshore wind turbine installation vessels by lift capacity in 2023



Source: GWEC Market Intelligence Global Offshore Wind Turbine Installation Vessel Database, September 2023

Case Study: Achieving serial manufacturing to drive the success of offshore wind

Provided by: Bryan O'Neil, Director, Global Offshore & Power Generation, Lincoln Electric

The offshore wind industry is built on proven technology and engineering science that has advanced the renewable energy markets beyond what some might have thought possible since its inception three decades ago. Since then, the landscape for global competition has intensified while global manufacturing and fabrication practices have struggled to keep pace. Consider the two main drivers of steel transformation costs for pipe and plate into fixed or floating offshore assets: material costs and labour costs. The push for reductions in these areas has been at opposite ends of the spectrum when you consider the extreme inflationary environment many regions operate in today. In addition, the intensification for larger turbines in challenging water and soil conditions has steered engineering design efforts towards developing even more options required for larger fixed and floating foundations. The race for the largest MW turbine capacity comes with benefits for project returns and also creates ripple effects in the global supply chain where primary steel transformation is required.

Given that the technology race in this field is not expected to change anytime soon, urgent consideration should be given to accelerating manufacturing optimisation. This includes adopting practices well-established in other industries, such as serial manufacturing. Serial manufacturing of repetitive parts and pieces depends on consistency throughout the entire supply chain, from initial concept to final design. The introduction of advanced technology and manufacturing practices should be considered as early as possible and well beyond a single project to achieve a sustainable global supply chain.

In the present environment, different regions of the world deliver projects through some technological advancements. However, in total, the manufacturing processes of some offshore wind assets haven't changed since they were first developed. Consider that some of the primary manufacturing processes used today were first developed before the 1950's. While some processes have seen incremental improvements and others have undergone revolutionary advancements, the methodology of piece-by-piece production assembly remains largely unchanged. Net impact for industry followers is that labour intensity will remain extremely high in this industry without further automation and technological advancements towards serial manufacturing as compared to others, such as shipbuilding and structural steel fabrication. Global leaders in fixed and future floating foundations are addressing both areas.

With this challenge ongoing, workforce productivity has become even more critical. A dwindling skilled workforce is not unique to the offshore wind industry. In fact, it's a trend that is already impacting other heavy industry manufacturing and is expected to accelerate, especially considering that the average age of a skilled welder in many regions is over 45 years old and the global workforce is moving away from skilled trades. To help offset the impact of this, some industry fabrication technology efforts are underway that show promise and are beginning to deliver results. Firstly, the use and adoption of robotic welding technology for secondary steel components and some parts of fixed foundation fabrication has been achieved and should be expanded more broadly. Automation provides a necessary and needed resource for meeting project deadlines, however, greater adoption is required as the industry pushes for more cost competitiveness. For floating foundations, lessons learned from other offshore industries and shipbuilding offer promise that adopting similar block fabrication approaches in new factories, where panel lines and fully automated welding stations can be employed, may simplify the immense size and scale currently under consideration.

Secondly, new opportunities are emerging for designers and fabricators to consider as the adoption of wire arc additive manufacturing (WAAM) which has significantly increased from five years ago, most notably in the military shipbuilding and oil and gas industries. Just a few years ago (WAAM) parts weighing less than 100 kg (45 lb) with some geometric features were considered state of the art. Today, parts are being printed more than 4500 kg (10,000 lb) in excess of 3.3 m (12 ft) and the scale is rapidly increasing. WAAM could provide designers and engineers with the opportunity to create critical high labour intensity parts that are simply not possible by conventional pipe or plate design and manufacturing. Internal features and optimised geometric transitions address one of the most critical variables in offshore wind, which is the high fatigue (stress concentration) present throughout the entire offshore structure.

Lastly, further implementation of new joining technologies and/or improvements in proven welding technology known since the industry's inception are possible and have been realised. Factories in some markets today are succeeding in keeping pace with project deliverables at the same or improved quality, which gives hope for meeting local content requirements set by local governments.

What we can summarise is that the industry of the future is here today, however, the speed of change will need to continue to accelerate as the world depends on renewable energy, with wind energy playing a key part of a broader energy transition solution. Manufacturing competitiveness and regional expansion in new markets will benefit the industry's ability to pivot towards true serial manufacturing to drive success.

LINCOLN ELECTRIC

In Europe region, vessel operators have begun upgrading existing WTIVs and placing orders for next-generation WTIVs (for turbines over 12 MW) in the past couple of years. The current WTIV supply chain in Europe can cope with demand, as annual installations are unlikely to reach the 10 GW level until 2027.

However, Europe will face WTIVs shortages towards the end of this decade, unless investment in new WTIVs is made before 2026/2027 – assuming a lead time of three years for delivering a new WTIV. The US currently only has one tailor-made Jones Act compliant WTIV under construction. However, with an eight-month delay, announced plans for another three WTIVs will have to be executed in the next two years.

Ports

Ports provide support from offshore wind site surveying to component manufacturing, storage, construction, operation, and decommissioning. These are named differently to reflect their offshore wind related functions: marine survey ports, manufacturing ports, marshalling ports (staging ports), and operations maintenance ports.

Regional demand and supply side benchmark, offshore, 2023–2030

Specialised equipment, a dedicated laydown area, and quayside are required to lift and store big components for large-scale, next generation offshore wind turbines before loading them onto WTIVs. We have focused on the availability of large marshalling ports to support offshore wind growth, as these facilities are emerging bottlenecks in some markets.

Worldwide, there are more than 30 large marshalling ports, of which 16 are in the APAC region, 14 in Europe, and one in the US. These can collectively support 25 GW annual offshore wind installation capacity. Currently, China has 10 marshalling ports across the East Coast, with over GW of total annual operational capacity – enough to cover its own domestic market growth for this decade. In other parts of the APAC region, the construction of utility-scale offshore wind projects was expected to commence for the first time from 2023 in Japan, South Korea, and Taiwan (China).

Expansion plans for a total of 2.4 GW per year have been announced by some of the existing marshalling ports neighbouring the North Sea. Additionally, more than 50 ports worldwide have announced plans to support offshore wind development. If all the announced plans materialise, another 45 GW of annual operational port capacity would be available for offshore wind.

In order to avoid supply bottlenecks significant investment will be needed in ports. Greater port capacity will be needed from 2026 in Europe.In the APAC region, excluding China, existing port facilities are likely to be stretched beyond their capacity to meet demand unless new port capacity is built. .With only one purpose-built offshore wind port available in the US needs more ports.

According to our survey, more than 50 offshore wind port projects are currently in the pipeline globally, theoretically sufficient to support the projected growth up to 2030. However, an estimated $18 billion investment will be required to bring these announced projects online, assuming a cost of $400 million to build a marshalling port with an annual operational capacity of 1 GW.

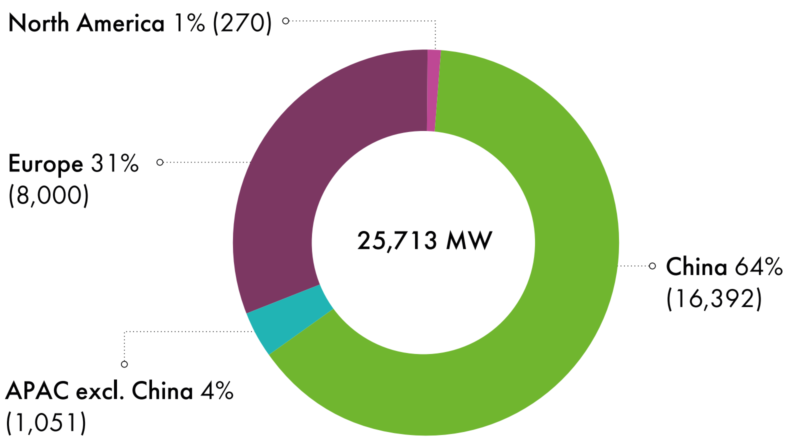
Given the size of investment required, the current macroeconomic difficulties, and the three-year lead time to build one purpose-built offshore wind marshalling port, political commitment along with regional cooperation and collaboration, is required to ensure delivery. This is especially true in the early stages of development, when a market is yet to achieve a significant scale of deployment.

Fostering regional collaboration to address supply chain challenges and unlock offshore wind potential

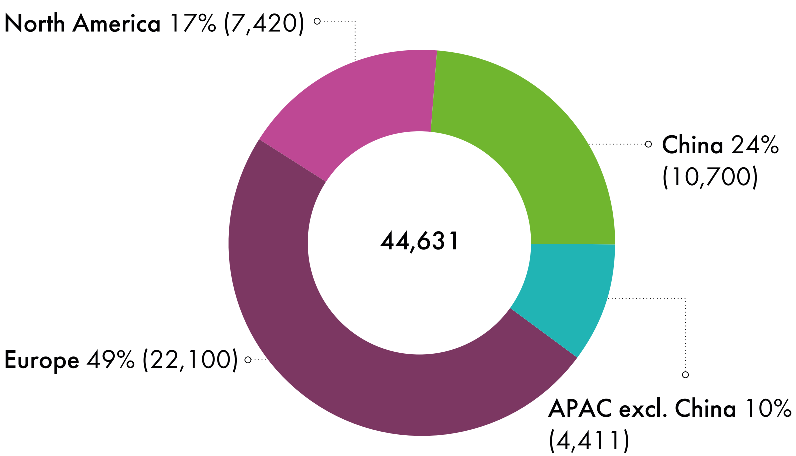
As with many other large infrastructure industries, the global wind industry has experienced increased supply chain vulnerability in the last few years. Policy and market environments remain volatile in many parts of the world, while policymakers continue to push for domestic localisation that is often at odds with the ambition and timelines of renewable energy targets. Permitting, social acceptance, and grid bottlenecks continue to create uncertainty about project realisation, although there are positive signs in Europe, the US, and other areas where these barriers are being addressed.

Demand and supply side benchmark for ports, 2023–2030

Estimated operational port capacity available in 2023 (MW/year)



Planned port capacity to support offshore wind (MW/year)



	2022	2023e	2024e	2025e	2026e	2027e	2028e	2029e	2030e
North America	0	533	955	2335	3535	4500	4500	4500	4500
Latin America	0	0	0	0	0	0	0	0	1350
Europe	2460	5148	2916	6527	9598	10808	16225	20465	26400
China	5052	8000	12000	14000	15000	15000	15000	15000	15000
Other APAC	1259	1769	1559	2884	2695	3256	5030	5535	6995
Total	8771	15450	17430	25746	30828	33564	40755	45500	54245

Source: GWEC Market Intelligence, CWEA, Brinckmann, September 2023

● Sufficient ● Potential bottleneck

Heightened trade tensions have also introduced a layer of complexity to supply chain planning, exacerbating real and perceived risks of external dependencies – but often without a measured discussion of the risks of decoupling from the global supply chain.

All of these factors have held back supply chain planning and investment in the offshore wind sector in the last few years. The IEA (International Energy Agency) recently noted that investment in wind manufacturing, covering nacelle, blade, and tower facilities, even fell in absolute terms in 2023, with nearly all new investment happening in China.[17]

GWEC Market Intelligence has been tracking the widening supply-demand gaps for key offshore wind components. To reiterate our latest findings, by 2026, we see potential bottlenecks arising in every region of the world (especially North America and Europe) except for China from the middle of the decade onwards, for multiple wind key components. These include gearboxes, generators, blades, power converters, and offshore wind compatible metal castings, towers, foundations (fixed bottom), and cables.

To address sluggish demand-side signals and lumpy investment, the supply chain will need to industrialise and standardise, embrace regionalisation of supply chains as a key growth, and support fair trade policies that build competitive industries, while pushing higher costs onto end-users or bifurcating markets.

GWEC recommends:

- Collaboration for shared infrastructure and a cost-effective supply chain is critical. Initiatives like the North Seas Energy Cooperation (NSEC), bringing together the countries around the North Sea, are a good model for other regions to follow. NSEC has resulted in blade, nacelle, tower, foundation, cable, and other manufacturing facilities developing around the North Sea market over time. Efforts are also being made to build out meshed grid systems to facilitate more efficient cross border transmission systems.[18]

- Regional cooperation is also crucial when markets achieve maturity. For example, regions can look to the cooperation between European country's ports in response to the Esbjerg Declaration for delivering increased offshore wind ambition, or to the Scottish Offshore Wind Ports Alliance (SOWPA) launched to enhance the UK's regional competitiveness.

- Regions will need to pursue supply diversification strategies and reshore/onshore some segments to grow their own capacities and build a more resilient global supply chain. Attention to strategic diversification should be paid to gearboxes, generators, power converters, and mining and refining of critical rare earth elements for which global resilience is currently low and concentration risk in China is high.

- Supply chain diversification should not manifest in measures that block current trade flows and interrupt or delay deployment. International suppliers from all countries should be encouraged to expand in markets outside of their home region to ensure that global learning benefits can transfer across borders. This is particularly important for North-South learning transfers and to ensure a just transition.

- Fair and transparent trade is essential for achieving the goals of the global energy transition and delivering economic benefits. The IRA (Inflation Reduction Act) is an example of an incentive-based approach to counteract inflation and provide financial support for supply chain investments, while the EU's Wind Power Package offers a multidimensional demand-side approach to speeding up project deployment and improving overall investment conditions for wind manufacturing and development.

17. IEA, Advancing Clean Technology Manufacturing, 2024.
18. Meshed grids the next frontier in leveraging the potential of offshore wind https://windeurope.org/newsroom/news/meshed-grids-the-next-frontier-inleveraging-the-potential-of-offshore-wind/

Case Study: Advancing the offshore wind supply chain in the APAC region

Provided by: The Global Offshore Wind Alliance (GOWA)

The APAC region is the largest regional offshore wind power market today, accounting for 55% of global total installed offshore wind capacity by the end of 2023. This region is likely to make up 59% of the total capacity expected to be added worldwide between 2024 and 2030, bringing its total offshore wind power installations from 41 GW by 2023 to 172 GW by 2030 (see page 136).

China is the largest offshore wind market today. Although offshore wind development targets have been released by the governments in Japan, South Korea, Taiwan (China), Vietnam, India, Philippines, and Australia, China will continue to dominate the growth in this region in the near-term. With the offshore wind market becoming more diversified in APAC from 2028, however, this situation is likely to change and its market share in this region will drop to 69% in 2030 from 89% in 2023 as large commercial-scale offshore wind projects will soon come online in South Korea and Japan and the first batch of offshore wind projects in emerging markets such as the Philippines, India, and Australia are expected to be built towards the end of this decade or early 2030s.

At present, the offshore wind supply chain development in this region is extremely uneven. According to the global wind supply chain report Mission Critical: Building the Global Wind Energy Supply Chain for a 1.5°C World released by GWEC and BCG at COP28, only China has enough supply chain capacity to cope with the growth required to meet the Paris Agreement target. The rest of the markets in this region cannot even meet the 2030 offshore wind projection under the current business policy scenario. Excluding China, bottlenecks are likely to occur in this region for turbine nacelles (from 2026), blades (from 2025), towers (from 2024), castings (from 2025), foundations (2023), turbine installation vessels (from 2025), and ports (from 2023).

Scaling up the local supply chain is critical to unlock the growth potential in this region. Collaboration between countries within APAC is also vital to meet the offshore wind capacity targets set by governments in APAC. Despite geopolitics complicating the move to collaboration as well as alignment between governments in this region, the newer APAC offshore wind markets can still take some key learnings from Europe's experience in working out how to balance building market confidence and helping domestic players manage external challenges such as the supply of critical materials, while also growing a supply chain but avoiding burdensome local content requirements that add costs, skew investment decisions and slow down the pace of offshore wind deployment.

To accelerate offshore wind growth in this region, political commitment and cooperation are important, as working together helps raise confidence across different countries and allows cooperation on shared challenges including grid systems, ports, vessels, and associated skills.

In the summer of 2023, GOWA kickstarted a series of closed-door roundtables bringing together high-level representatives from governments, offshore wind industry and stakeholders across the APAC region. The aim was to address supply chain challenges and explore opportunities for regional cooperation to advance the acceleration of offshore wind.

The alliance has so far convened representatives from Australia, the Philippines, Sri Lanka, India, and Vietnam, as well as state representatives from Victoria, Australia, who have shared insights into their respective offshore wind ambitions and challenges.

Conversations have emphasised the importance of aligning federal and state efforts to support collaboration in the APAC region, the shortage of capital to support the development, and scaling of the supply chain. There was recognition of the need for strategies to attract capital investment into the supply chain, which may include financial incentives, grants, and investment friendly policies.

The profitability of the offshore wind supply chain was central to discussions, particularly in the current challenging economic climate. The collective action in the North Sea has been noted as an example for lessons learned.

Participants have identified various challenges facing the offshore wind industry in the APAC region, including inconsistent policies, capital shortages, technological gaps, and a shortage of skilled human resources. However, they agree that strategic collaboration and the establishment of clear regulatory frameworks are essential for overcoming these challenges. Suggestions have included developing consistent policy frameworks, attracting capital investment, enhancing technological capabilities through R&D, and investing in education and training programs.

Despite the challenges ahead, there is a sense of optimism regarding the industry's potential for sustainable growth through collaboration, addressing supply chain issues, and focusing on community benefits. The APAC region has emerged as a promising hub for offshore wind innovation, demonstrating the transformative power of global cooperation in advancing renewable energy initiatives.

By bringing together key stakeholders and fostering dialogue, GOWA is laying the groundwork for future collaboration and innovation in supply chain development. As nations strive to meet ambitious renewable energy targets and address climate change, regional cooperation will be crucial in unlocking the full potential of offshore wind and meeting the global goal of tripling renewable energy by 2030.

Case Study: Managing quality control when expanding supply chain

Provided by: Bureau Veritas

As the wind energy sector undergoes significant expansion, particularly in offshore installations, managing project quality control across an increasingly complex supply chain is paramount. The forecasted growth in yearly installations of offshore wind towards 2030 will inevitably create stress in the entire supply chain and require a focus on quality culture.

From the projects Bureau Veritas has supported with comprehensive Quality Assurance (QA) and Quality Control (QC) services, general trends are emerging in the management of project quality. Having worked directly with fabricators and developers, providing both individual inspections and full integrated QA/QC service packages for complete offshore wind projects, the following themes have been found to determine the success of quality management in projects:

- **Cultivate a 'quality-first mindset'** among all participants in the supply chain for harmonised understanding of quality standards. Embedding quality as a core value as part of the onboarding process for all project participants from the project owner to contractors, substantially reduces risk in later phases of project execution. The multitude of quality cultures that are brought together in an offshore wind project, from joint-venture partners to contractors in diverse geographical locations, require that projects to develop their own common culture.
- **Integrating a provider of QA/QC services**, such as Bureau Veritas, early in the supplier qualification process reduces the risk of quality issues well in advance of the commencement of construction. Ensuring that a rigorous supplier certification is implemented, requiring all potential suppliers to demonstrate compliance with project quality requirements and ensure capacity to execute the scope well in advance of the project construction phase commencing.
- **Enhancing supplier collaboration and communication** through an integrated communication platform for streamlined collaboration among contractors, supporting real-time information sharing and ensuring

alignment on quality requirements. Additionally, quality agreements, clearly defining expectations, metrics, and resolution processes, were incorporated into contracts, and reviewed periodically.

Building a quality-first mindset, performing rigorous auditing, and enhancing communication addresses some of the challenges of onboarding new entrants to the industry. The next evolution for capturing value of the inspection is digitalisation and automation of the inspection and the handling of associated data generated. Advancing digital solutions as part of QA and QC processes within the wind energy supply chain will inevitably be part of addressing the expected supply chain development.

Implementing automated inspections will address part of the challenge the industry faces with the scarcity of skilled workers. Up-skilling personnel utilising digital tools such as virtual reality and augmented reality for training purposes can significantly reduce the ramp-up period for inspectors and technical staff required to ensure project quality standards are maintained. Artificial intelligence (AI) and machine learning algorithms analyse vast amounts of data from wind farms to identify patterns and predict failures. These technologies can optimise QA/QC processes by detecting defects in materials, components, and assembled turbines with higher accuracy and speed than traditional methods.

The integration of digital solutions in QA/QC has the potential to transform the wind energy supply chain. By adopting advanced technologies such as digital twins, AI, and automated inspections, the wind energy sector can achieve higher standards of quality, reliability, and efficiency. These innovations not only drive down costs and enhance performance but also support the sustainable growth of wind energy, solidifying its role as a cornerstone of the global transition to renewable energy.

Section 4: Accelerating permitting for offshore wind

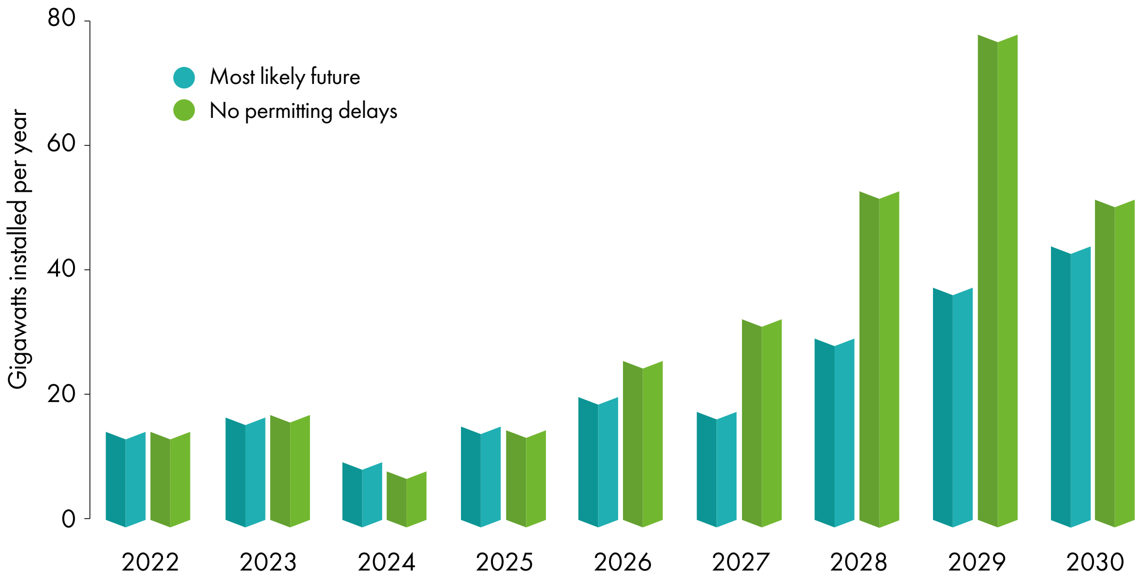
A target of 380 GW of offshore wind capacity by 2030 has been set under the UN Energy Compact signed in 2021 by GWEC and the International Renewable Energy Agency (IRENA). This is the volume required by the end of the decade to meet IRENA's 1.5°C, a net zero-compliant energy system roadmap. The burden of complex permitting procedures is greater for offshore wind projects than many other renewable energy installations because they tend to be much larger than onshore wind farms, straddle different jurisdictions or usage zones, and require the use of both land and the seabed.

Unlocking permitting bottlenecks would result in massive offshore installations coming online by 2030, increase attractiveness of offshore wind and demand for clean energy. Studies estimate there is a global pipeline of nearly 600 GW of wind projects in development, of which many could be quickly constructed within the next three years under fast-track approval measures. Research by GWEC Market Intelligence shows that on average, it takes up to nine years for offshore wind lease award to full commissioning of projects. This means that if barriers in permitting, grid access, and supply chain scale-up are resolved, these projects could materialise from the end of 2023-2025. Generally, once permitted, large-scale renewables projects can be constructed very quickly – typically in around two years for offshore wind, depending on project size.

There have been several notable updates when it comes to government action on lengthy permitting. In 2023, the EU revised the Renewable Energy Directive (REDII), setting out the establishment of "renewables acceleration areas" facilitating faster permitting and the principle of "overriding public interest" allowing renewables initiatives to receive priority status in legal obstacles that often obstruct project construction . The US government has also allocated over $1 million through the Department of the Interior (DOI) to facilitate the streamlining of permitting processes. In early 2024, the Senator for Rhode Island, Sheldon Whitehouse released the draft of a new bill to further improve permitting. The UK's Offshore Wind Environmental Improvement Package, which is a part of the October 2023 Energy Act, intends to shorten the four-year permitting process for offshore wind projects to just one year, while implementing "strategic compensatory measures" to offset any potential adverse environmental effects that might discourage permitting.

Despite significant progress, challenges persist, leaving developers uncertain about the full impact of these reforms. Governments are still not permitting enough new offshore wind farms to meet their ambitious targets. Today, hundreds of GWs of renewable capacity are still caught in the permitting process, including offshore wind. In the EU alone, 88GW of wind is currently caught in permitting, which is four times more wind energy trapped in permitting than under construction. This has put

Comparing global offshore wind capacity additions with and without permitting delays



Source: DNV, 2023

many projects at risk of becoming outdated even before being built.

Wider economics consequences of permitting delays

Lengthy permitting lead times and unclear processes also have a role in pushing up offshore wind risk premiums, which could disincentivise investors. The longer a project takes to permit, more development expenditure (DEVEX) is spent, and the more risk is borne by the developer in the time between securing an offtake agreement and reaching the final investment decision on a project. Often the intervening period can span a number of years, due to overly slow permitting procedures, during which the wider macroeconomic environment can shift towards increased commodity prices, cost of capital, labour, and logistics.

In Europe, the sluggish approval procedures for new projects and the insufficient licensing and regulatory frameworks further reduce developers' demand for turbines, despite the adoption of higher targets for renewable energy set by the EU Commission. WindEurope reported a 47% drop in total European orders for new wind turbines (onshore and offshore combined) in 2022 compared to 2021. In South Korea, the current permitting process can take between seven to ten years, and operators must obtain various licences, such as the EBL (Electricity Business License), through 29 laws and more than ten government organisations.

As emerging markets are looking to build their offshore wind framework, it is important for these countries to set up a permitting regime that considers best practices such as mandated lead times, alignment of land and ocean use, establishing one-stop-shops, stakeholder consultations, digital training courses, digital databases, emergency clearing mechanisms, and energy infrastructure permits. These practices were highlighted in GWEC and IRENA's policy brief, ''Enabling frameworks for offshore wind scale up: Innovations in permitting''[19a], which also includes several case studies to demonstrate practical relevance.

Long and multifaceted consent procedures lead to higher costs, which mean that higher buildout only creates manufacturer revenues several years later. Undue delays in

19a. https://www.irena.org/Publications/2023/Sep/Enabling-frameworks-for-offshore-wind-scale-up
19. https://energy.ec.europa.eu/topics/renewable-energy/enabling-framework-renewables_en
20. https://www.vestas.com/en/about/Our-policy-recommendations/permitting

this process mean that such projects are not built in a timely fashion, thus delaying their potential climate benefits. Higher costs due to permitting bottlenecks are holding back installations. The amount of offshore wind expected to be built around the world each year in this decade is projected to be about 30% less than what could have been achieved without permitting delays.

Permitting, therefore, represents a tangible, solvable barrier to the rapid scale-up of wind energy. If key barriers to deployment are not addressed, the Energy Transitions Commission (ETC) estimates the world could miss out on up to 3,500 TWh of clean electricity generation from wind and solar in 2030. An ETC report claims simple measures to streamline planning and permitting could more than halve offshore wind project timelines from 12 years to 5.5 years.

Faster permitting is key

Therefore, a straight-forward solution that would dramatically accelerate the offshore wind deployment is faster permitting for new projects. Moreover, this would empower the wind industry supply chain to achieve the necessary scale for driving decarbonisation, creating jobs, and fostering economic growth. Studies estimate there is a global pipeline of nearly 600 GW of wind projects in development, many of which could be quickly constructed within the next three years under fast-track approval measures. The industry sees permitting as something governments can achieve quickly through streamlined regulatory frameworks and the right level of support. While different markets will choose different approaches, it is clear that a more coordinated permitting strategy is essential for ensuring the success of offshore wind deployment everywhere.

Key recommendations to streamline permitting process

Governments, developers, and civil society must collaborate to remove obstacles and concentrate on a shorter permitting lead time as well as aligning different interests in the ocean for offshore wind projects in order to provide the planning and permitting processes that will propel the shift to a net zero economy.

Focus for policy makers

- Dedicate centralised authorities and single focal points to work with renewable developers to streamline the siting and permitting process, such as through a "One-Stop-Shop" model.
- Promote active engagement with local communities throughout the whole project development process.
- Apply the principle of deemed consent for OFW projects if permitting authorities do not meet statutory timescales.
- Mandate maximum lead times in the permitting process, the timescale should be statutory and should include all administrative work, grid permits, Environmental Impact Assessments (EIAs) and any appeals or legal challenges, as these are what can prolong approvals.
- Invest in more staff and digital resources for the various authorities which make decisions during the permitting process of a renewable energy and infrastructure project.
- Grid connection, reinforcement and deployment permits must be planned alongside the deployment of OFW
- Draw out a clear set of energy targets in national policy and give a better clarity on route to markets.
- Align land and ocean use guidance at national and sub-national level, prioritising projects which support energy security, do no significant harm (DNSH) principles, biodiversity and green economy.

Focus for offshore wind developers

- Effectively engage with stakeholders during project planning and construction to minimise environmental and social impacts and ensure benefit-sharing with local communities.
- Introduce and improve innovative initiatives and technologies to mitigate impacts of offshore wind on the ocean and the surroundings.

Focus for local governments and civil society

- Facilitate dialogues between local communities and policy makers to ensure effective mutual understanding.
- Ensure that local communities are well informed about the project progress and permitting decisions.

Section 5: Collaborating with communities and driving social consensus

Offshore wind development can act as a catalyst for job creation, providing access to renewable energy as well as enabling economic, social and environmental benefits in the local region at all stages – from planning and construction to O&M and decommissioning. Therefore, the anticipated scale-up of offshore wind development serves as a window of opportunity for countries to pursue economic and social regeneration along their coastlines. However, seizing this opportunity will require a well-established policy framework and support from local communities.

Support from local communities requires an in-depth understanding of community engagement – a concept that is both complex and nuanced.

According to the United Nations (UN) Framework, community engagement is "A foundational action for working with traditional, community, civil society, government, and opinion groups and leaders; and expanding collective or group roles in addressing the issues that affect their lives. Community engagement empowers social groups and social networks, builds upon local strengths and capacities, and improves local participation, ownership, adaptation and communication. Through community engagement principles and strategies, all stakeholders gain access to processes for assessing, analysing, planning, leading, implementing, monitoring and evaluating actions, programmes and policies that will promote survival, development, protection and participation."[21]

Community engagement sits at the intersection of five global objectives: public sector systems strengthening, accountability to affected populations (AAP), social accountability, social and behavioural change and social norms, and community systems strengthening. It connects a wide range of sector-specific development and humanitarian objectives.

21. UN, Minimum Quality Standards and Indicators for Community Engagement

For offshore wind, stakeholder engagement involves activities both onshore and offshore. Early and consistent engagement with community members by an offshore wind developer and its contractors and suppliers is key. It cultivates community understanding of offshore wind projects, promotes mutual understanding of community priorities, and provides opportunities to build upon shared objectives. Similarly, engagement with other affected parties can help identify nuanced challenges and opportunities to improve project outcomes.

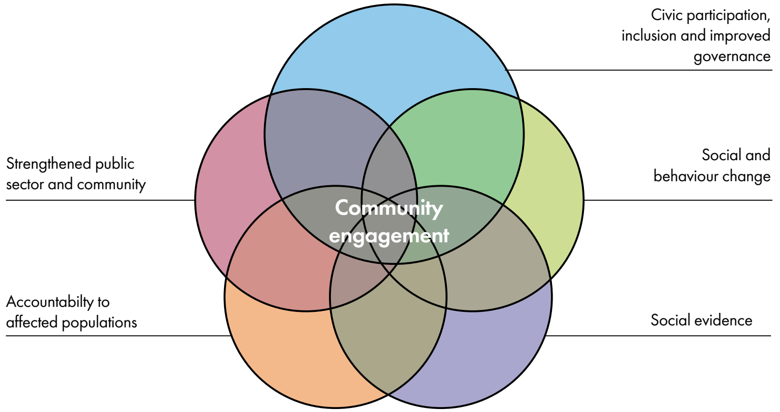
A pathway to community engagement for offshore wind

1. Social acceptance strategy
2. Stakeholder mapping
3. Permitting regime
4. Stakeholder engagement plan

Social acceptance strategy

In order to guarantee the success of offshore wind projects, coordination and collaboration between the government and the

Community Engagement in the Global Context



Source: UN, Minimum Quality Standards and Indicators for Community Engagement

industry are necessary. The lack of a cohesive industry strategy, supported by governments, has led to different approaches being taken across projects. It is crucial for project promoters to recognise the diverse nature of host communities and to tailor social acceptance strategies to meet the specific needs and values of each community.

Moreover, it is important to showcase how offshore wind can benefit communities and industries to increase public support for the development of the offshore wind industry in the local region. Offshore wind development can lead to economic, social, and environmental benefits at all stages of development – from planning and construction to O&M and decommissioning. For example, a recent study by GWEC shows that the gross value added for a single fixed OFW project in South Korea can add approximately 45.3 trillion won to the economy over seven years, while floating OFW projects can contribute around 41.7 trillion won.

A social acceptance strategy should include a co-existence/co-location plan, as conflicts may arise during offshore wind development processes without such a plan.

Coexistence between local communities and OFW development would mean a system by which both parties can exist harmoniously despite previous conflict and concerns. In this system, OFW development would be able to proceed in a manner that enables the continued activities of relevant communities.[22]

Conflicts between OFW development and local communities have been experienced in many OFW markets, including those with greater capacities of OFW installation. Various countries have initiated strategies to address specific challenges related to coexistence, emphasising stakeholder inclusion, habitat preservation, and conflict resolution mechanisms.

Achieving coexistence is challenging for several reasons, including:

- Fear of exclusion and displacement
- Lack of data on potential impacts
- Cumulative impacts of OFW farms
- Context-specific factors, such as the size and type of wind farm, the nature of the fishing activity (e.g., method and gear type), and environmental conditions
- Exacerbation of impacts on marine life through OFW impacts and habitat stress
- Accidental damage

Approaches to co-existence include:

- Utilising marine spatial planning (MSP) to balance interests of multiple sectors
- Developing regulations to support coexistence
- Implementing compensation schemes
- Establishing of collaborative platforms with the objective of supporting coexistence, and creation of best practice
- Promoting buy-in through targeted consultations[23]

Stakeholder mapping

A stakeholder map helps answer the question: Who are the stakeholders? It then defines the stakeholder's relationship to the project. Mapping stakeholders at each stage of the project helps a project manager determine the frequency of meetings and the amount of information shared with each stakeholder. Stakeholder mapping is important because every stage of a project involves stakeholders, ranging from lenders and communities, to

22. GWEC, 2024, How Offshore Wind Development Can Support Coastal Regeneration: Global Overview and Best Practices for South Korea
23. GWEC, 2024, Exploring Coexistence Opportunities for Offshore Wind and Fisheries in South Korea, link

landowners and fishers.

Permitting regime

Community engagement can play a crucial role in improving the permitting process for offshore wind projects in several significant ways. Effective community engagement can lead to a smoother, more efficient permitting process by building trust, reducing conflicts, and fostering a collaborative environment. Addressing community concerns will reduce opposition, incorporate local knowledge, leading to streamlined permitting processes. In South Korea, one of the reasons for the country's stalled OFW deployment is the lack of consultation and agreement with fishers during the siting and permitting phases. OFW projects can be delayed or halted for long periods of time due to opposition from fisheries. To help address this, there is an intention to implement a new 'government-led' centralised development process to replace the current 'developer-led' decentralised approach. This process will first establish public-private partnerships during the siting phase to identify concerns and challenges for fisheries. After site selection, operators will be selected through competitive tenders. It is hoped that this process will help overcome the opposition of fishing communities to OFW.

Stakeholder engagement plan

A stakeholder engagement plan demonstrates the developer's commitment to developing offshore wind projects that can benefit communities and industries. Early and consistent engagement with community members by an offshore wind developer and its contractors and suppliers fosters understanding of offshore wind projects, promotes mutual understanding of community profiles, and provides opportunities to build upon shared objectives.

Stakeholder engagement plans should be developed based on strong, timely, and transparent communication, consultation, negotiation, and relationship building. When considering costs, stakeholder planning and engagement represent a modest investment that yields significant value, especially given the importance and size of financial investments required to deliver an offshore project.

An effective stakeholder engagement plan should include the following:

- Inclusion of local communities during the site selection process, which aims to identify suitable locations for OFW farms. Such an initiative will involve engaging various stakeholders, particularly fishers, in the initial phases of site selection to ensure that their concerns are considered and encourage their buy-in for proposed OFW projects.
- Public-private council: Established as an institutional mechanism with the objective of increasing consensus between OFW and the local community. The local government will be responsible for convening a public-private council prior to site selection. The council will comprise government and private sector representatives, including community representatives and OFW experts, and will serve to mediate key issues concerning all stakeholders.
- Wind energy committee: A wind

Minimum Standards Table	
Part A: Core Community Engagement Standards	**Part B: Standards Supporting Implentation**
1.Particpation	7. Informed Design
2. Empowerment and Ownership	8. Planning and Preparation
3. Inclusion	9. Managing Activities
4. Two-way Communication	10. Monitoring, Evalaution, and Learning
5. Adaptability and Localisation	
6. Building on Local Capacity	
Part C: Standards Supporting Coordination and Integration	**Part D: Standards Supporting Resource Mobilisation**
11. Government Leadership	14. Human Resources and Organizational Structures
12. Partner Coordination	15. Data Management
13. Integration	16. Resource Mobilisation and Budgeting

Source: UN, Minimum Quality Standards and Indicators for Community Engagement

energy committee, composed of government ministers, can be established to deliberate and resolve matters related to OFW development. The committee's mandate includes facilitating inter-ministerial cooperation and expediting the processing of various licenses and permits required for OFW projects.

- Establishment of standards for community engagement: It is necessary to consider developing a set of standards for community engagement to exclusivity, transparency, and compliance with international regulations and standards. The UN has established minimum standards for community engagement, which includes four pillars: (A) Core Community Engagement Standards, (B) Standards Supporting Implementation, (C) Standards Supporting Coordination and Integration, and (D) Standards Supporting Resource Mobilisation. These standards help ensure that the voices of the community are heard, impacts are managed, and mutual benefits are maximised.

Recommendations

Policy makers

- Include stakeholder consultations with key groups, such as fishers, when using marine spatial planning (MSP).
- Operate public-private councils, establish wind master plans at the regional level, identify win-win solutions that are mutually beneficial to different stakeholders and provide clear guidelines on assessing the local communities that are directly impacted.
- Prepare integrated guidance or standard in terms of avoidance, mitigation and restoration strategies for local communities and the surroundings, as well as community benefit fund so that developers commonly refer to and apply to offshore wind projects regardless of region with consistency.
- Collaborate with civil society organisations and other key stakeholders to develop and implement programmes to positively change perceptions of offshore wind farm development including educational campaigns and capacity building initiatives.

The OFW industry

- Prepare both technical and social aspects for its future tenders, standardise the conduct of environment and social impact assessments and create an information-sharing system that is transparent and open.
- Focus on technological innovation measures to ensure offshore wind can coexist in harmony with nature
- Improve transparency and openness in decision-making and strengthen corporate social responsibility by adopting ESG management.
- Create an information-sharing system to ensure local communities are well-informed about OFW projects at an earlier stage, and active efforts by project operators to provide accurate information could prevent misunderstandings or potential mistrust of the overall project.

Case Study: Offshore wind siting through fishery engagement in Incheon, South Korea

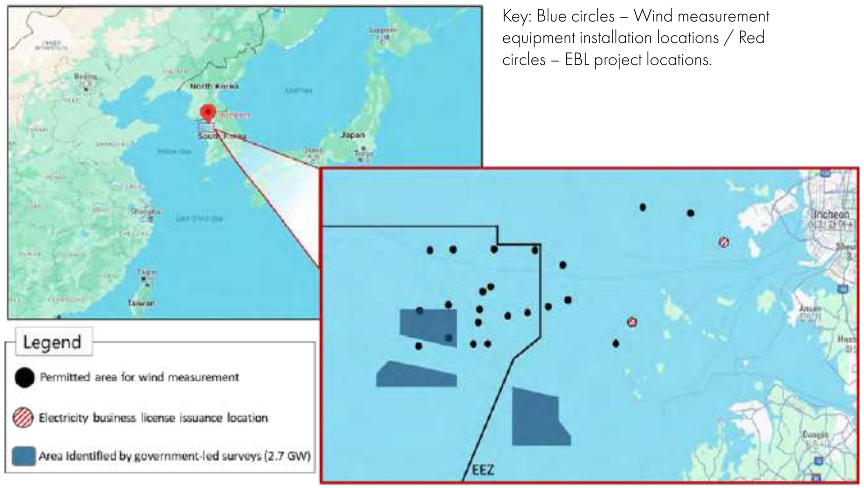
In 2023, the South Korean city of Incheon conducted a pilot programme supported by the central government to identify OFW sites by engaging fishers in the initial site survey phase. Incheon is an active area of OFW development, with 23 sites having wind measurement equipment installed for initial site surveys by 2022, and a total of 13 operators participating. Two companies have also obtained electricity business licences.

To resolve OFW conflicts, Incheon implemented a publicly supported OFW site identification programme, which aimed at identifying suitable locations for OFW farms. The programme involved engaging various stakeholders, particularly fishers, in the initial phases of site selection to ensure that their concerns were considered and to encourage their buy-in for proposed OFW projects. The programme aimed to select project sites based on economic feasibility, environmental considerations, and acceptance from the fishing community.

This programme allowed the fishing community to participate in site surveys and propose mutually agreeable locations. KEPCO (Korea Electric Power Corporation) and four public research organisations worked with Incheon City to identify suitable OFW zones. The South Korea Environment Institute (KEI) visited Incheon fishing communities to conduct a site preference survey and engaged fishers in discussions to identify areas where they opposed OFW and areas where they were willing to negotiate. This led to the creation of the 'Incheon Fishers Location Preference Map'.

The map was used to guide the selection of suitable OFW project locations. The map, which delineates the region into small grids, allows fishers to indicate their preferences which range from 'absolutely opposed', to 'negotiable', or 'in favour'. These preferences were synthesised to identify locations where consensus could be reached by the entire group. Subsequently, this map was overlaid with additional maritime spatial data, including maritime traffic patterns, military activities, and wind conditions. The integration of this information facilitated the identification of suitable zones for OFW development in Incheon.

Locations of Incheon's offshore wind projects (2022)



Key: Blue circles – Wind measurement equipment installation locations / Red circles – EBL project locations.

Case Study: Building consensus with artisanal fishing communities in Brazil

Artisanal fishing communities must be mapped and listened to for adequate planning of offshore wind farms, especially in the Brazilian northeast. In the state of Ceará, communities and NGOs have already spoken out against offshore wind farms, even before any offshore wind turbines were installed. There is a lot of uncertainty and misinformation among these communities who believe that the sea will be taken over by wind farms and they will be prevented from fishing.

In Brazil, environmental licensing for large projects is carried out in three phases. In the first phase, during planning, to obtain the LP (environmental prior license), the entrepreneur must listen to and inform the directly affected community . One or more public hearings are held to inform the local population about the project applying for the license and address their concerns. During these hearings, opportunities are provided for the local population to express their opposition, submit letters, and provide documents as part of the licensing process, ensuring their voices are heard. However, such hearings have not yet occurred because the relevant bill is still in its final stages in the Senate. Only after its approval and subsequent sanction by the President will there be area auctions, followed by environmental licensing. Nevertheless, local populations still feel excluded from the debate, as it will take some for their voices to be heard during the environmental licensing process.

In response to complaints, Ibama (Federal Environmental Agency) has visited three locations on the coast of Ceará and brought together leaders and members of fishing communities to clarify the importance of listening to the local population and demonstrate that they will be heard before the installation of offshore wind farms. It was also clarified that the sea will have multiple uses and only some areas on the immense coast, of more than 8,000 km, will be dedicated to wind farms.

This initiative of Ibama, although positive, is not sufficient. There has been a hearing in the Congress in Brasilia to address this issue and some events promoted by NGOs in the northeast. It is important that there is coordinated, strong, and consistent efforts with accurate information, transparency, and genuine listening. Misinformation among communities creates significant challenges for new projects and development when there is no engagement with local populations. It is necessary to address concerns, clarify doubts, and involve the affected communities in the planning stages, ensuring they understand the process and can participate in the opportunities and programmes associated with the project.

Section 6: Realising a trained and diverse workforce

The offshore wind sector is poised to play a crucial role in the global energy transition. In 2023, 11 GW of new offshore wind installations were commissioned, marking the second highest year for offshore wind installations. However, to ensure a just and equitable transition, it is imperative to build a capable and diverse workforce that can drive the growth of this sector while ensuring that no one is left behind.

This section will cover the importance of developing a capable and skilled workforce. It will address the challenges involved, such as the investment needed for up-skilling and re-skilling, gender disparity, and human rights and equity issues. Additionally, it will highlight the demand for skills and provide an overview of training requirements for offshore wind jobs in global markets.

Current offshore wind workforce landscape

IRENA, reporting as of 2023, indicates that the global onshore and offshore wind energy industry accounts for 1.4 million workers, and this number is growing.

However, current wind jobs are concentrated in a relatively small number of countries. China alone accounts for 48% of the global wind energy workforce. The top10 countries together employ 1.23 million people in the wind industry, with 4 of these countries located in Europe, 4 in Asia, and 2 in the Americas, due largely to being a leader in wind installation.

When looking at the overall energy sector, including fossil fuel industries, roughly 65% of the overall energy workforce is connected to new renewable energy infrastructure. There is great promise for the growth of the offshore wind energy sector to continue driving this seismic change.

In the lead up to 2030, it is forecast that by 2027, around 75,000 workers will require training for construction and installation (C&I) and operations and maintenance (O&M) of the forecast offshore wind globally. This is just a fraction of the workforce needed across the entire value chain of offshore wind, which further

includes jobs in project development, manufacturing, transport, grid connection and decommissioning.

For C&I the number of technicians anticipated to be working in the offshore wind sector is around 55,100 in 2027. In O&M, there are estimated to be 19,600 technicians by 2027.

Challenges

Investment in up-skilling and re-skilling

There are two very distinct opportunities to grow the workforce of the wind energy industry – up-skilling and re-skilling.

Up-skilling can be defined as the process of taking workers from other relevant industries and supporting their professional development to meet the requirements of the skills needed in the wind and offshore wind industry. Workers from other industries such as oil & gas may possess transferable skills that could be leveraged for a new career in the wind sector.

Re-skilling could encompass a workforce broader than just those in the wind energy or adjacent industries. This could involve exploring opportunities to include a new workforce in the industry through tailored training programmes, enabling workers to join the wind energy sector workforce.

Two of the main instruments that can be leveraged to develop the wind energy workforce are investment and education. Investment may be used to facilitate education or used along the supply chain to create demand for wind energy workers in the workforce. Education takes a variety of forms, from re-training or re-skilling programmes to outreach to wider communities.

Below are examples of industry initiatives formed to address the skills gap via up-skilling and re-skilling:

Up-skilling Case Study: Maersk Training Camp for Wind Turbine Technicians (United Kingdom)

This three-week training camp is designed to provide workers with skills in mechanical, hydraulic, or electrical engineering to transition into a role in the wind industry including the skills required to work offshore.
Previous cohorts have also seen success from those working in heavy industries, military, and emergency services, as well as construction. The four modules allow learners to obtain four Global Wind Organisation (GWO) certificates, which would then be recognised by employers in the industry, in the following:

- Basic Safety Training – Offshore
- Basic Technical Training
- Enhanced First Aid
- Advanced Rescue Training

Post-qualification, participants will be supported with industry specific careers guidance to support their journey into the wind industry.
This type of up-skilling qualification recognises the skills that can be taken from other related industries based on technical capabilities and acknowledges how these can be translated to support the development of a skilled wind energy workforce.

Re-skilling Case Study: SAWEA Wind Industry Internship Program (South Africa)

The value chain of the offshore wind energy industry is broad and requires a breadth of skills to support the rapid development of offshore wind energy required by 2030 and beyond.

As of 2021 The South African Wind Energy Association in conjunction with EWSETA collaborated to deliver the Wind Industry Internship Programme (WIIP). This programme serves as an outreach programme to invite new graduates to gain practical work experience in sustainable energy solutions.

After three successful years of running this program the WIIP also serves as a support mechanism for unemployed graduates by giving them the skills to be able to develop into the wind and renewables industry. The core objective of the ten-day programme is to address the national skills shortage and leverage the baseline of renewable energy skills of the workforce.

This positive step forward, allows not only the technical opportunities to be acknowledged by industry, but also other opportunities that are essential for developing a healthy and sustainable supply chain.
The broad set of skills included in the focus areas of this programme includes engineering, finance, infrastructure and industrialisation, HR and corporate services, law, communications and external relations, and gender studies, to name a few.

Demand for diverse skills across global markets

There is growing demand for skilled offshore wind professionals across various disciplines. This will mean a diversity of worker skills and competencies need to be targeted for training, up-skilling and re-skilling to support the sector's growth. Some examples of the required skills in the sector are as follows:

1. Planning and Development:

- **Project Management:** Effective planning and project management skills are crucial for the successful development and execution of offshore wind projects, including site selection, permitting, and stakeholder engagement.
- **Renewable Energy Policy:** Professionals with expertise in renewable energy policy and regulations play a vital role in navigating the complex regulatory landscape and ensuring compliance with industry standards.

2. Technical Expertise:

- **Engineering and Construction:** A significant portion of offshore wind jobs are in engineering and construction, requiring expertise in structural design, project management, and installation processes.
- **Turbine Technicians:** Skilled technicians are essential for the maintenance and operation of offshore wind turbines, ensuring optimal performance and reliability.
- **High-Voltage Electrical Works:** With the complexity of offshore wind infrastructure, professionals with expertise in high-voltage electrical systems are in high demand to ensure efficient power transmission.
- **Manufacturing:** As the industry aims for local content requirements, skills in manufacturing components like foundations, towers, and nacelles are essential for a robust supply chain.

3. Specialised Skills:

- **Maritime and Logistics:** Given the offshore nature of wind farms, skills in maritime operations and logistics are essential for transportation, installation, and maintenance activities.
- **Health and Safety:** Ensuring a safe working environment in offshore wind operations requires professionals with expertise in health and safety protocols specific to the marine and renewable energy sectors.
- **Environmental Impact Assessment:** Skills in environmental science and impact assessment are crucial for evaluating the ecological implications of offshore wind projects and implementing sustainable practices.

4. Training and Development:

- **Skill Transferability:** With the transition from traditional industries like oil and gas to renewables, programs for reskilling and upskilling workers are essential to meet the evolving demands of the offshore wind sector.
- **Workforce Diversity:** Promoting diversity and inclusion in the workforce is key to fostering innovation and ensuring a skilled talent pool that reflects the diverse needs of the industry.

The offshore wind industry presents a wealth of opportunities for skilled professionals across a range of disciplines. Drawing inspiration from "Building Our Potential: Ireland's Offshore Wind Skills and Talent Needs", countries aspiring to strengthen or enter the offshore wind sector can adopt a replicable model to build a skilled workforce and accelerate the development of their offshore wind capabilities:

1. Skill Assessment and Gap Analysis:

- Conduct a comprehensive assessment of the current workforce skills and identify gaps specific to the offshore wind sector.
- Analyse the transferable skills from related industries such as onshore wind, engineering, maritime, and project management.

2. Collaboration with Industry and Educational Institutions:

- Establish partnerships with industry stakeholders, educational institutions, and government bodies to align training programs with industry needs.
- Engage with offshore wind companies to understand their specific skill requirements and workforce development goals.

3. Training Programme Development:

- Design specialized training programs that focus on offshore wind technologies, safety protocols, project management, and environmental considerations.

- Incorporate practical training components, simulations, and on-the-job experiences to enhance hands-on skills development.

4. Certification and Accreditation:

- Ensure that training programs lead to recognised certifications and accreditations that are relevant to the offshore wind industry standards.

- Collaborate with industry associations and certification bodies to establish industry-recognised qualifications for offshore wind professionals.

5. Up-skilling and Re-skilling Initiatives:

- Implement up-skilling and re-skilling initiatives to transition professionals from related industries to the offshore wind sector.
- Provide opportunities for continuous learning and professional development to keep pace with technological advancements in offshore wind.

6. Government Support and Incentives:

- Advocate for government support in funding training initiatives, offering relocation grants for skilled professionals, and incentivising companies to invest in local workforce development.
- Ensure that regulatory frameworks support talent development in the offshore wind sector and encourage industry participation in skills development programs.

7. Monitoring and Evaluation:

- Establish mechanisms to monitor the effectiveness of the talent development pathway and evaluate the impact on the offshore wind industry.
- Continuously assess the alignment of training programs with industry needs and adjust based on feedback from industry partners and stakeholders.

Embracing a talent development pathway can help countries to cultivate a skilled workforce, drive innovation, and propel the growth of their offshore wind industries. By fostering collaboration, investing in training programs, and aligning with industry requirements, nations can position themselves as key players in the global transition to renewable energy.

Addressing gender equality on the path to growth

As the offshore wind energy industry continues its growth, attracting and retaining talent from all segments of society is crucial to realising the wind sector's full potential. This includes overcoming long-standing gender imbalances and ensuring equal opportunities for women across the wind energy workforce.

Currently, women represent just 21% of employees in the wind industry. Gender gaps are even more pronounced in leadership roles, with women holding only 8% of senior management positions in wind organisations. This underrepresentation of women is likely due to a combination of long-standing cultural biases, social norms that prioritise technical fields as masculine domains, and persistent workplace practices that fall short of accommodating work-life balance and career advancement for employees with families.

However, the wind sector has a tremendous opportunity in the coming energy transition to overcome these inequalities as it expands and cultivates a more diverse, equitable workforce. Increasing gender balance is not just a matter of fairness, but critical for wind companies to tap into the full pool of available talent, skills, and perspectives that women can offer. Companies embracing gender diversity have been shown to outperform competitors, benefiting from enhanced innovation, decision-making, and organisational sustainability.

To capitalise on this opportunity, the wind industry and its stakeholders must take concerted action through targeted measures such as:

- Adopting gender-inclusive policies, targets and accountability.
- Expanding mentorship, networking and training programs for women.
- Redefining workplace norms and benefits to support work-life balance.
- Partnering with educational initiatives to promote STEM (science, technology, engineering and mathematics) fields for women and girls from an early age.
- Amplifying the voices and leadership roles of women currently in the industry.

The global energy transition is about more than just upgrading energy systems – it is an opportunity to reaffirm social values that should underpin a sustainable, equitable future for all. Achieving gender equality and diversity across the wind workforce is an integral part of realising this vision. As the industry continues to rise to the challenge of transforming how we power our world, it has an obligation and opportunity to lead in empowering women as equal drivers of this transformation.

Below are examples of industry initiatives formed to address the gender gap:

Case Study: Women in Wind Initiative (GWEC & GWNET)

GWEC established Women in Wind (WiW), recognising the urgent need for gender equality in the global wind sector with a focus on the global south.

The initiative's flagship program, the Women in Wind Global Leadership Program, now in its sixth year, aims to equip women with the skills and resources needed to excel in leadership roles within the wind industry. Through mentorship, training, and networking opportunities, women are empowered to take on key positions and drive change. The programme is delivered in partnership with the Global Women's Network for the Energy Transition.

WiW's next phase is the EqualWIND Global Campaign, launching in 2024. This seven-year initiative calls on stakeholders to endorse the EqualWIND Pledge, committing to data-driven efforts for achieving 50% gender representation by 2030.

Case Study: Women into Wind (Orsted & 3t Training Services)

Orsted and 3t Training Services initiated the Women into Wind initiative to also tackle gender imbalance in the wind energy field.

This programme, offered to participants with an English postcode, provides comprehensive training endorsed by the Global Wind Organisation (GWO), equipping participants with essential skills and knowledge crucial for thriving in the industry. Graduates of the programme become eligible for placements in prominent supply chain firms and offshore wind farms.

Currently, women represent only 5% of offshore wind workers, highlighting the need for initiatives like Women into Wind.

Safeguarding workers in the value chain

The wind energy industry's expansion will also impact the upstream segments of the supply chain, particularly rare earth elements (REEs) mining and critical mineral production communities. The increased demand for offshore wind turbine components and rise in manufacturing capacity for wind energy will drive higher demand for specific materials, including REEs such as neodymium, dysprosium, and praseodymium as well as critical materials like copper, nickel, and zinc.

As the offshore wind sector expands rapidly, there is more emphasis on ensuring that it operates sustainably and with good governance across the supply chain. Sufficient policy interventions and regulatory frameworks need to be advanced to ensure the protection of mining and production communities as demand for these materials increases. For example, the Transition Minerals Tracker from the Business & Human Rights Resource Centre has identified 631 instances of human rights abuses across the mining practices for cobalt, copper, lithium, manganese, nickel, and zinc from 2010-2023, including 91 allegations recorded last year.

The wind industry must also take responsibility for stewarding its own highly globalised supply chain through strong and consistent monitoring, high procurement standards that align with international benchmarks for good practice, regular auditing, and other means of ESG assurance.

Policy recommendations for offshore wind workforce

- **Increased outreach initiatives to foster a diverse, equitable and inclusive workforce.** It is vital that the wind sector is publicly recognised as an attractive and welcoming place to work by those at different career stages, from apprentices to graduates to executive talent. Interventions may be needed in company culture, recruitment practices, DEI guidance for companies, mobility and flexibility schemes, and other areas to attract more women and minority groups to the workforce and leverage their skills.

- **Tailored pathways to re-skilling or training for access to wind industry jobs from carbon-intensive industries.** Training and assistance for workers, including re-certification for wind industry occupations, could be designed under public-private collaboration to identify communities of need and match these with anticipated workforce gaps. Collaboration should aim to support career progression pathways for workers in the fossil fuel industries into renewable energy to encourage labour mobility and upskilling, in line with Sustainable Development Goal (SGD) 8.

- **Public-private collaboration on governance and standards for mining and production communities in the renewable energy supply chain to ensure a safe and decent environment for workers.** At the international level, there should be alignment around the guidelines for working conditions and practices in mining and production communities that will be impacted by the increased demand for energy transition related critical minerals, such as via the UN Guiding Principles on Business and Human Rights.

Case Study: Offshore wind job creation in South Korea

Beyond decarbonisation, offshore wind can offer South Korea substantial economic, social and environmental benefits. The South Korean government has set a target of reaching 14.3 GW of OFW by 2030, and as of 2023, the country has 140 MW of installed capacity across six windfarms. Commercial-scale offshore wind deployment will require a significant mobilisation of the workforce as well as development of major infrastructure, creating employment opportunities not only offshore, but also in ports, the surrounding coastal communities, and across the wider supply chain. These benefits are particularly important for South Korea, whose coastal cities and towns have seen declining populations, low birth rates, and internal migration to cities by the younger populations over the past several years.

To develop a 500 MW offshore wind farm, an estimated 2.1 million direct person-days is required, in addition to indirect or induced jobs related to the economic activity of the wind farm, such as hospitality. A recent study done by GWEC highlighted the economic benefits local cities could derive from offshore wind, including job creation. By looking at the typical distribution of jobs across the development of an offshore wind farm, the report listed types of jobs that are created during the offshore wind development process.

The study finds that, assuming a total of 14.3 GW of OFW farms will be constructed by 20, offshore wind is expected to create in total 770,200 jobs, including 376,200 jobs in fixed OFW and 394,000 jobs in floating OFW as a result of CAPEX (Capital Expenditure) over the project lifecycle of the 14.3GW of OFW farms. For the O&M phase, for the year of 2030, it is estimated that 11,689 FTEs can be created in bottom-fixed OFW, while there would be an addition of 5,917 FTEs created in floating wind. Many of these jobs, especially in the construction and installation phases, and then in the O&M phase that lasts the project lifetime, would be locally deployed.

To capture the benefits of offshore wind in job creation, the industry, local, and national governments should put in place a holistic plan to engage key stakeholders early in the offshore wind development process. Empowering the local workforce and strengthening international networks can also support offshore wind development.

Value chain	Activity	Jobs
Project planning	Site screening, feasibility study, environmental impact assessment, local community participation, engineering design, and project development	Legal, real estate, and regulatory specialists, financial analysts, marine engineers, environmental and geologists, as well as seafarers
Procurement	Design specifications, procurement	Procurement specialists, engineers
Manufacturing	Manufacturing and assembling nacelles, blades, towers, as well as monitoring and control systems	Factory workers, quality control specialists, marketing and sales personnel, engineers, business managers and management executives
Transport	Parts transport and shipment	Driver, seafarers, and technical staff
Installation	Preparation of project farms, civil engineering, on-site assembly of parts	Construction workers, technical staff, marine engineers, seafarers, health and safety specialists, logistics and quality specialists
Grid connection and commissioning	Cable and grid connection, project commissioning	Construction workers, technical staff, engineers, health and safety specialists
Operation and maintenance	O&M for the project cycle (25 years in general)	Operators, electrical and marine engineers, construction workers, crane operators, seafarers, helicopter pilots, technical staff, lawyers, business managers and management executives
Decommissioning	Dismantling the project, recycling, disposing of the equipment, and clearing the site	Construction workers, technical staff, drivers, engineers, seafarers, environmental scientists, health and safety specialists

Source: GWEC, 2024, Coastal Regeneration Report, P. 18

Case Study: Navigating the Global Offshore Wind Workforce

Gigawatt-scale offshore wind growth often grabs the news, but behind the headlines, what are the workforce and training needs for these projects? GWEC and GWO's 2023 Global Wind Workforce Outlook (GWWO) showed surging growth in the number of offshore technicians needed, increasing from 52,200 in 2023 to 74,700 in 2027. These workforce needs are primarily driven by wind energy expansion in China, Europe, the US, South Korea, Japan and India.

The forecast offers a clear direction for workforce growth, but the very different needs of Construction & Installation (C&I) and Operations & Management (O&M) stages are also worth considering. During the C&I phase, offshore projects typically require a larger workforce per turbine compared to similar sized onshore projects. This is evidenced by our data in the GWWO, suggesting that offshore wind typically utilises approximately 18 personnel per turbine, reflecting the logistical complexities and specialised equipment required.

During subsequent O&M phases, offshore technician numbers are driven by the choice of O&M strategy, including turbine rating, project size, and distance from shore. Smaller wind farms in closer proximity to shore may opt for onshore-based strategies, leveraging crew transfer vessels (CTVs) for technician transport. Conversely, larger and more remote projects often necessitate a permanent on-site technician presence facilitated by service operation vessels (SOVs) or accommodation platforms (APs).

The strategic shift towards larger offshore-based O&M workforces is supported by this imperative for proactive maintenance and risk mitigation, resulting in a higher number of technicians per turbine for offshore compared to onshore installations. This trend is supportable by projected efficiency gains, with offshore installations expected to be delivered by higher MW turbines.

To manage this rapid growth and achieve a sustainable workforce, the industry must expand without compromising on safety. This requires alignment and coordination among global policymakers, industry representative bodies, employers, and educators to ensure workforce factors in commissioning and operating the fleet are sufficient without training and recruitment bottlenecks. At the same

time, it is notable how our industry's narrative of creating an injury free working environment is maturing to encompass the need for more talent pathways to achieve a just and equitable transition while not compromising on hard-won safety performance.

Luckily these two ambitions are complementary and are coalescing in workforce development projects applied at global to local scales. At the local scale, GWO's network of over 550 training providers are actively creating new hybrid private, public and interest group models for skills development. Examples include initiatives such as the National Offshore Wind Institute in New Bedford, Virginia. Bristol Community College and Maersk Training are collaborating to deliver state-of-the-art training for the offshore workforce. In China, Haijong District and China Resources, one of the top five asset owners in China, are building a vertically integrated industrial cluster in Shantou in Guangdong Province; this includes training facilities expected to qualify several thousand technicians annually to industry standards like GWO, meeting workforce needs for the 60 GW of offshore wind development proposed locally.

Meanwhile, collaboration is stepping up on an intergovernmental scale. The Jobs4Re initiative, sponsored by the Danish and Philippine Governments, with support from IRENA, Global Offshore Wind Alliance and GWO, was launched at COP28 in Dubai. The partners are moving forward to develop guidelines on training for public policy use, increasing certainty for stakeholders and driving workforce growth with a keen eye on the 574,000 workers needed by the entire global wind industry by 2027.

Section 7: Building modern and efficient grids to support the energy transition

with thanks to DNV

As offshore wind deployment accelerates, the need for robust and timely grid connections becomes increasingly critical. This is not only essential for promptly connecting a growing pipeline of new wind energy projects to the grid but also for reducing curtailment risks for existing projects.

Developers need a clear, bankable framework to apply for a grid connection. Securing a connection to the transmission network can take many years and often necessitates local or regional upgrades, depending on the capacity the developer seeks to connect and the robustness of the transmission network. The intricate interplay between developing modern transmission networks and establishing effective governance models is pivotal for the success of offshore wind projects. As the demand for robust grid connections grows, so does the necessity for streamlined and strategic approaches to grid delivery. Aligning grid infrastructure development with clear regulatory frameworks ensures not only the seamless integration of new wind energy projects but also the optimisation of existing capacities, fostering a resilient energy system capable of supporting the broader objectives of industrialisation and sustainable development.

The intricate interplay between developing modern transmission networks and establishing effective governance models is pivotal for the success of offshore wind projects. As the demand for robust grid connections grows, so does the necessity for streamlined and strategic approaches to grid delivery. Aligning grid infrastructure development with clear regulatory frameworks ensures not only the seamless integration of new wind energy projects but also the optimisation of existing capacities, fostering a resilient energy system capable of supporting the broader objectives of industrialisation and sustainable development.

Offshore grid delivery and governance models

More and more offshore wind markets are emerging with governments around the world establishing targets for the deployment of offshore wind as part of their net zero strategies. A key prerequisite for harnessing the full potential of offshore wind in any country is careful consideration of the delivery models for the offshore grid which will enable the integration of the generated electricity into the national energy system. A timely and cost-effective export system to connect offshore wind farms to the national transmission network equires offshore substations – especially if the project is far enough offshore – as well as export cables and connections onshore at a substation linked to the national network. This is not only essential for promptly connecting a growing pipeline of new wind energy projects to the grid, but also for reducing curtailment risks for the intermittent capacity that is already installed.

Developers need a clear, bankable framework to apply for a grid connection. Beyond enabling the vast amounts of electricity produced by offshore wind projects to connect to the grid, modern and digitised transmission networks are also instrumental to industrialisation and development more generally.

Offshore grid delivery usually comprises the following steps – 1) Marine Spatial Planning, 2) site investigations, 3) grid planning, 4) environmental studies and permitting, 5) tendering, 6) financing and procurement, 7) construction, and 8) operation and maintenance. Countries with a mature offshore wind sector have adopted varying models where the responsibilities for these steps are typically split between governmental energy agencies (usually subordinates of local energy ministries), transmission system owners (TSOs), and private developers.

There are some important considerations in attributing responsibilities to different actors involved in the delivery steps for the offshore grid. The global experiences in offshore wind grid delivery can be majorly classified as 'developer-led' and 'state-led' delivery models, representing the

two ends of the spectrum of model options.

1. Developer-led delivery model

In the developer-led delivery model, a private offshore wind developer takes responsibility for all stages of offshore grid delivery. The prospective site and locations are first identified (steps 1 and 2), and the interface between the developer and the TSO is established at the onshore point of connection (POC).

This development model is typically applied in the early stages of sector development. Its advantage lies in shifting most of the delivery risks onto private developers, who often possess the necessary technical competences. This differs from state agencies and transmission system operators (TSOs), who may not yet have been extensively involved in offshore grid development. Additionally, this approach may facilitate development at a faster pace, accelerating the transition towards established decarbonisation targets.

The main disadvantage of such an approach is that decentralised grid development may de-optimise overall system costs. The TSO needs to plan the relevant onshore grid reinforcements at the POC in a reactive manner, not being able to develop its system holistically. However, the availability of an offshore transmission system is incentivised directly as it impacts the revenue of the developer, who will normally seek to achieve synergies between the design of the wind farm and the offshore grid. The overall cost of the decentralised grid will depend on the risk premium factored by developers when developing the assets as well as on the cost of their capital.

Variations of this approach have been pursued in the UK and Denmark, and in initial projects in the Netherlands, Belgium, Germany, Poland and the US. This strategy has allowed these countries to stimulate early development of the offshore wind sector at pace while minimising risks to the state. The UK, for instance, utilises an independent offshore transmission owner (OFTO) as part of the implementation process. Wind farm developers build their own offshore links and then sell them to an OFTO. The OFTO receives a regulated revenue stream for managing and maintaining transmission link from the wind farm to shore. In the future, better coordination and shared infrastructure could reduce the number of offshore links needed. On a positive note, since its launch in 2009, the UK developer-led OFTO regime has successfully enabled the connection of 9.5 GW of offshore wind farms.[2]

2. State-led delivery model

In the state-led delivery model, holistic planning of the onshore reinforcements, offshore grids, and cross-border interconnections is carried out. The government (and regulated entities representing them) is responsible for all stages of offshore grid delivery.

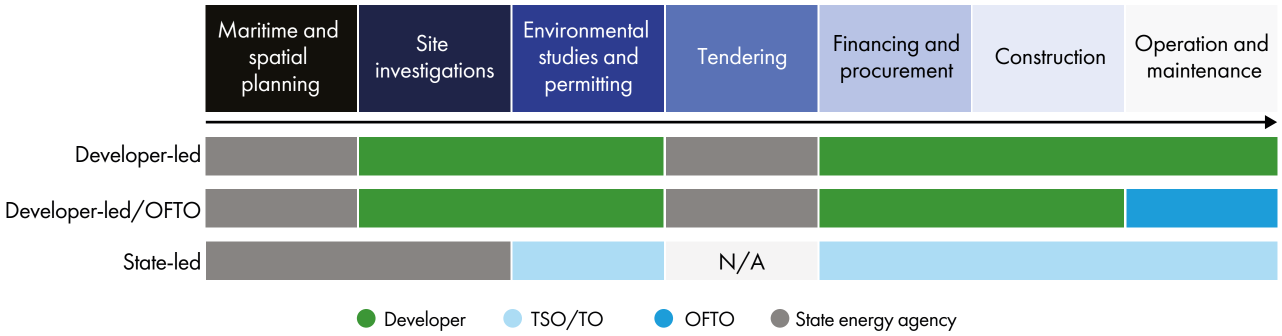
This coordinated approach to grid planning allows significant savings in total system costs as the offshore and onshore systems are planned and delivered synergistically. However, it comes at the cost of having to establish dedicated organisations responsible for the organisation of different delivery stages. When the TSO has in-house competencies in offshore grid project delivery or can attract these competencies from the labour market or through specialised advisory firms, it may achieve significant economies of scale. This can be done by defining standard functional specifications and procuring multiple projects simultaneously.

This role for the TSO may create financial exposure and burden to the state budget (assuming the TSO is not independently funded). Therefore, regulators need to review the tariff structures for the TSO and ensure the TSO remains financially viable and can recoup relevant grid development costs.

Countries like the Netherlands, the UK, and Germany (who have advanced offshore wind industries) have switched from a project-by-project approach to a holistic planning approach of their onshore reinforcements, offshore grids, and

1. https://www.blog.renewableuk.com/post/as-offshore-wind-continues-to-grow-more-coordination-is-needed
2. https://www.ofgem.gov.uk/press-release/offshore-transmission-gives-investors-steady-long-term-returns
3. https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/us-offshore-wind-boom-entangled-in-transmission-debate-65142464

Overview of offshore grid delivery models



Source: DNV

cross-border interconnections. This shift recognises the significant impact of offshore wind sector developments on the entire energy system.

Overall, in countries with large offshore wind potential, robust institutional and funding capacity, a centrally planned and state-led offshore wind delivery process may be preferred. This approach allows for the standardisation and economies of scale that can be achieved in centrally coordinating the design, delivery, operation, and maintenance of the offshore grid. However, the debate over the most appropriate approach has been intense even in countries where offshore wind farms are still in their infancy, with the US being a notable case.[3]

The case for coordinated offshore grid delivery

Several countries have begun to recognise the benefits of coordinated offshore grids. What they have in common is the adoption of some form of centrally planned offshore wind sector development and significant offshore wind potential in relation to their total national electricity supply.

What is offshore coordination?

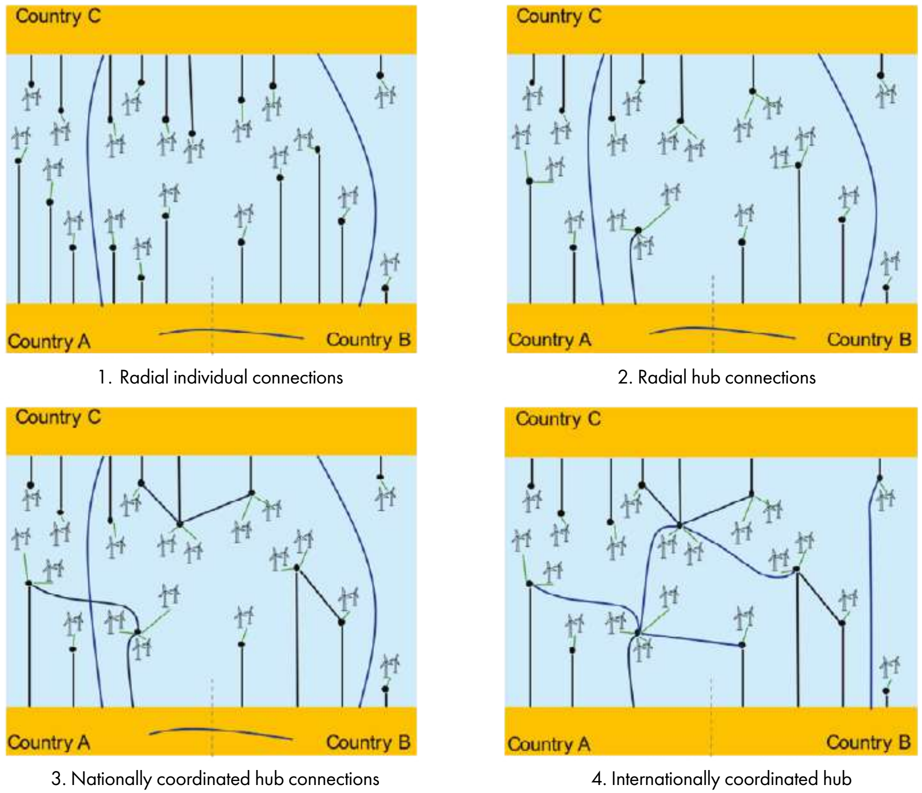
Multiple studies across different regions have highlighted significant benefits in capital and operational cost reduction, grid optimisation, and the mitigation of environmental and community impacts through a coordinated state-led approach to offshore grid development. However, drawbacks of this approach include longer lead times, which can jeopardise the timely connection of offshore wind projects, as well as the significant state resources required for planning and organising grid delivery. Additionally, there may be relatively high financial burdens for specific actors, such as TSOs, as the economic benefits of grid developments are not always directly captured by the parties bearing the bulk of the costs. Developers, facing stringent delivery deadlines and pressure to reduce risk for investors, may be hesitant to entrust the process to a TSO which may have limited institutional experience or resources for such coordination. Furthermore, banks will likely be cautious about lending to projects if there are any concerns about delays in grid completion.

Countries with limited offshore wind potential may see fewer benefits from a coordinated approach. In such cases, it may be more advantageous to follow an individual project-by-project approach, that secures fast deployment and helps manage risks at limited costs and more effectively for society.

A coordinated approach can be accomplished through conceptually different grid topologies – shown below. The default approach without coordination, foresees that each wind farm receives its own radial connection to shore (option 1). The other options (options 2 to 4) represent some form of coordination with option 4 being the most advanced. For each country or region, the optimal coordinated offshore grid can feature a combination of these.

In the standard case (1), individual offshore wind farms are connected to shore radially. Onshore grid reinforcement is then carried out to ensure that it can accommodate the power input. If countries wish to build cross-border connections (interconnectors), those are developed in parallel and independently from offshore wind connections.

Conceptual topologies of offshore grid



Source: DNV

In the simplest coordination cases (2), countries develop offshore hubs which allow multiple offshore wind farms to develop shared connections to shore. This saves onshore space and minimises environmental and community impacts.

In a more advanced version of this concept (3), countries seek synergies across multiple offshore hubs and interconnect them offshore. This approach not only creates additional redundancy but also alleviates onshore grid capacity needs by establishing offshore grid capacity.

In the most advanced coordination concept (4), countries interconnect their projects across borders to minimise system costs across a broader region. This involves coordination between wind and interconnection projects, often featuring so-called hybrid assets. Coordinated hubs at this level of development may reach significant scale, prompting governments to consider development of artificial energy islands to host offshore infrastructure. By planning regional offshore grids in coordination with onshore grids, significant savings in cost and asset footprint can be achieved for the whole system.

Scale of offshore wind and decarbonisation targets

The main factor determining the actual need and scale of potential benefits of offshore grid coordination is the topology of the onshore grid in the developing country or in the wider region if cross-border offshore grid coordination is considered. Not all countries benefit equally from coordination, and in each case the most optimal topology will differ, featuring various technologies and development approaches based on factors such as offshore wind potential, onshore grid configuration, and the level of decarbonisation ambitions. Dedicated power system planning and economic studies that consider holistic grid development against multiple generation and demand scenarios, are typically conducted to identify the optimal grid configuration.

Technology

Once the topology is identified, it is crucial to consider the technology. The key building blocks of offshore energy hubs and connections depend on the availability and maturity of technology. Choosing between HVAC and HVDC-based connections, designing control and protection strategies for the coordinated grid, standardising technology design and functional requirements, and ensuring multi-vendor interoperability are all essential for the successful delivery of a coordinated offshore grid.

Geopolitical considerations

Ensuring security of the electricity

supply and delivering electricity to consumers at the lowest cost are typically the primary responsibilities of national authorities responsible for electricity grid planning. Therefore, countries must assess whether synergies with their neighbours can be achieved by jointly planning certain projects– a practice that has demonstrated significant reliability and economic benefits in Europe. At the same time, the geopolitical context is evolving, and this trend is likely to continue. Given that offshore grids are critical infrastructure by definition, and particularly so when multiple individual projects form parts of a large connected system, it is imperative to consider potential threats and vulnerability, including cyber-attacks, sabotage, or direct military attacks. Systems should be designed to minimise the number of 'single points of failure' and provide a certain level of redundancy. This approach is crucial because damage to critical components could result in significant adverse impacts on society.

Unlocking investment

The financing of coordinated offshore grids presents a unique challenge compared to the financing of individual projects. This is because the benefits of such grids are often spread across multiple assets which individually may not yield direct monetary gains to the parties responsible for their development. Coordinated offshore grids often feature shared transmission assets or assets that are developed before the generation gets connected to them, a concept known as anticipatory investment. As a result, the role of central government becomes crucial in several aspects. Firstly, in effectively communicating the societal benefits of the infrastructure. Secondly, in engaging with potential investors and lenders to secure financing. Lastly, in providing the necessary incentives, such as subsidies or regulated revenue streams, to attract investment.

Whatever approach is used, the upgrade and buildout of a modern, efficient transmission network requires a vast step-up in public and private investment.

A strategic approach to funding, incorporating both public and private investment is crucial to meet the substantial financial requirements of such projects. In Vietnam, the government has been working on policies and mechanisms to attract investment in infrastructure projects through initiatives such as the public private partnership (PPP) mechanism.[4] However, there is a need for further clarity regarding the guidelines and implementation regulations of these initiatives.

How to pay for grid connection costs is another hotly debated topic.[5] In a so-called 'deep charging' regime, the wind farm developer covers the costs for the local upgrading of the national transmission system. These costs can be a significant proportion of the total offshore wind project CAPEX.

The 'shallow charging' approach requires that the project developer only covers costs for the assets to connect to the grid, such as an extension to an onshore substation at the grid connection point. In this case, national transmission system reinforcement costs are recovered over time by 'use of system' charges or tariffs.

While a deep charging strategy is generally simpler for the government to implement, it can become inefficient and complicated – and often inequitable – when multiple parties want to connect to the same part of the transmission system.

Permitting

Coordinated delivery of an offshore grid requires well designed and streamlined permitting procedures. Licensing and permitting processes should be taken seriously by governments, as experience in Europe has demonstrated that they can often become a bottleneck, thereby having a negative impact on the deployment timeline. Where cross-border grid coordination is pursued, the participating countries should harmonise their regulatory regimes to prevent such delays.

Workforce readiness and institutional capacity

In the planning of coordinated offshore grid development, responsibility typically lies with the relevant ministries and other regulated entities such as TSOs. However, in some of the emerging offshore wind markets, access to the qualified workforce and overall institutional capacity can often pose a barrier on the way to offshore grid coordination. To address these challenges, best practices include establishing dedicated offshore grid planning institutions across a wider region, as seen with ENTSO-E in Europe. Additionally, involving consultants with relevant experience, for support and guidance in the initial stages. In parallel, dedicated

4. Public-private partnerships in Vietnam, King & Wood Mallesons, February 2023
5. https://documents1.worldbank.org/curated/en/343861632842395836/pdf/Key-Factors-for-Successful-Development-of-Offshore-Wind-in-Emerging-Markets.pdf

upskilling programmes and education opportunities must be implemented to gradually enhance the competence in the domestic market and create sufficient capacity in the labour market.

Supply chain

In the last few years, while more and more countries globally (EU, the UK, the US, ASEAN region countries) see offshore wind as an important ingredient of their decarbonisation journey, the supply chain has become a major bottleneck for project delivery. Across all major component types, including HVAC transformers, HVDC converters, high voltage cables and support structures, there is a massive shortage of both manufacturing capacity and qualified resources. The lead times for project developers have reportedly increased by two to three years, simply due to the fact that manufacturers have their order books full for the next few years. Consequently, they cannot keep their own expansions up with the pace of the offshore transmission development plans. This has become a consequence of prolonged decision-making processes, and uncertainty of investment in renewable technology, which was a prime characteristic of many countries in the past.

For emerging countries to mitigate supply chain risks, it is important to give certainty to the supply chain by means of early engagement with it. Development of a domestic supply chain can be stimulated by favourable tax regimes (such as seen in the US), preferential treatment in permitting and licensing stages, and future pipeline certainty. All these types of instruments fall under the remit of the government.

Recommendations

The decision about which grid development model to follow—whether developer-led or state-led—depends on various factors. These include the maturity of the sector and level of institutional competences, the share of the total achievable offshore wind energy potential in the national electricity supply, access to finance and cost of capital achievable by state and private parties, onshore grid strength, supply chain constraints, geopolitical synergies or risks and, most importantly, planning capabilities.

- **Efficient network planning is critical for the development of grids**. Offshore wind farms typically require large grid capacity to connect. It is essential to carry out regular, holistic assessments of the transmission network capacity needed across the electricity system for offshore wind, other new generating capacity, and changing demand. Anticipated future grid connection availability can also help inform spatial planning and prioritise areas for leasing and procurement.
- In the planning process, the deployment of new grid technologies **should consider synergies with emerging technologies such as storage**, demand response and the exchange of electricity between neighbouring countries. This approach can ensure a smoother offshore wind integration into the onshore grid.
- The institutions and/or governments responsible for grid development should be well-equipped, with **capacity building being key** to ensuring effective grid planning. This should be supported by state-of-the-art planning practices, regulatory models, and methods to maximise the benefits of strategic network investments. This approach ensures that human resources are available to develop network projects within a regulatory setting, thereby promoting the correct cost-minimisation incentives.
- The efficient integration of offshore wind into the transmission network relies on effective **coordination among multiple stakeholders**, including offshore wind farm developers, transmission network operators and owners, energy regulators and government bodies. Recognising and aligning the responsibilities of these stakeholders across various jurisdictions is crucial to ensure a seamless and optimised integration process.

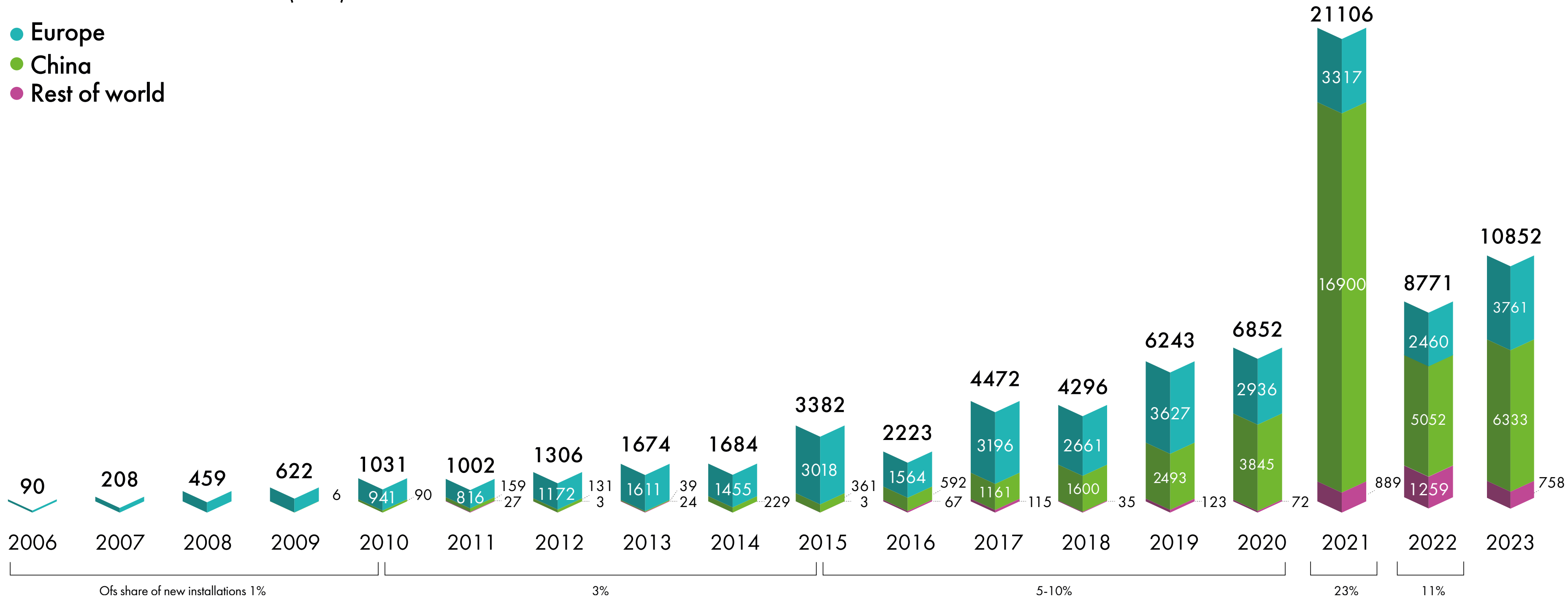
MARKET STATUS 2023

Annual Installations

10.8 GW of new offshore wind capacity was fed into the grid worldwide last year, bringing the total global offshore wind capacity to 75.2 GW by the end of 2023. New additions were 24% higher than the previous year, making 2023 the second-highest year in offshore wind history.

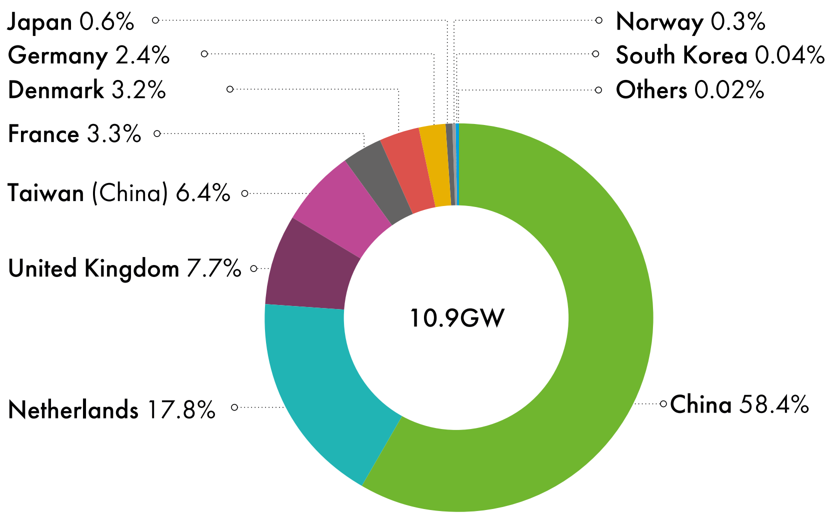
- China led the world in annual offshore wind developments for the sixth year in a row with 6.3 GW added in 2023, bringing its total offshore wind installations to 38 GW – 3.7 GW (11%) higher than Europe. Last year was the second year since the Chinese offshore wind market entered the era of 'grid parity'. Following a 70% year-on-year (YoY) decline in new installations in 2022, GWEC Market Intelligence predicted that the offshore wind growth momentum would return last year. This was based on around 15 GW of offshore wind contracts having been awarded to wind turbine OEMs in 2022 and more than 30 offshore wind projects, totalling 14.8 GW, being under construction in China by Q1 2023. However, last year ended up being relatively flat. This was mainly due to an intervention from the central government, starting in Q2 2023, to ensure that the offshore wind industry would develop at a healthy pace.
- Europe had a record year in 2023,

New offshore wind installations (MW)

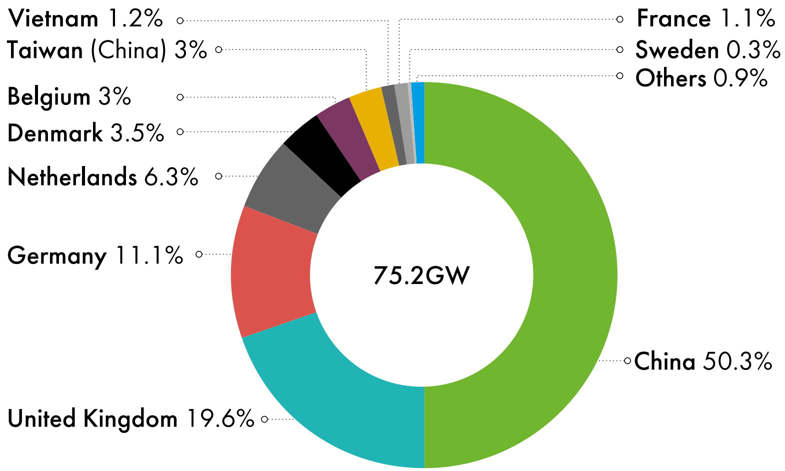


*Compound Annual Growth Rate.
Source: GWEC Market Intelligence, June 2024

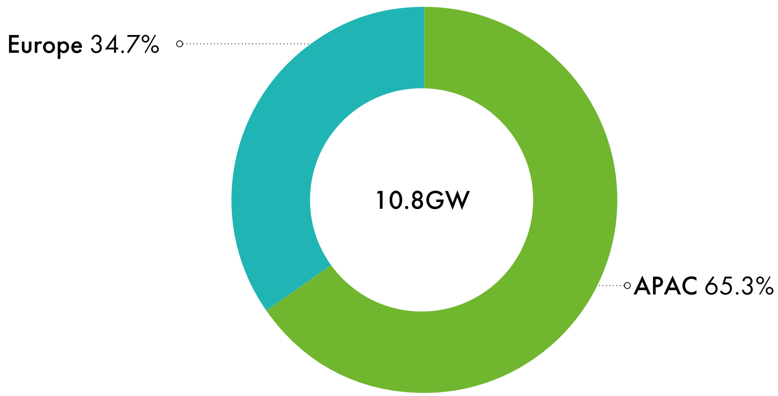
New offshore wind installations by market



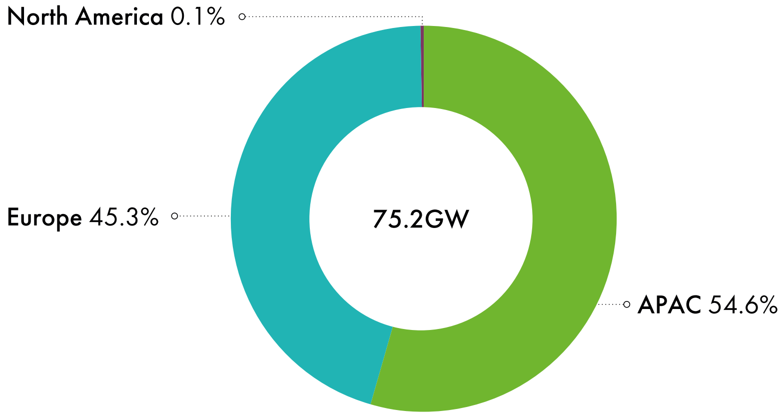
Total offshore wind installations by market



New offshore wind installations by region



Total offshore wind installations by region



Source: GWEC Market Intelligence, June 2024

with 3.8 GW of new offshore wind capacity from 11 wind farms commissioned across six markets accounting for most of the new capacity.

- The Netherlands commissioned 1.9 GW of offshore wind capacity in 2023, replacing the UK as the region's largest market in terms of new additions. More than 170 units of SGRE's SG-11 DD offshore wind turbines were connected across the Hollandse Kust Noord (760 MW) and the Hollandse Kust Zuid 1-4 (1.5 GW) wind farms.

- The UK connected 833 MW of capacity offshore, of which 820 MW from the remaining wind turbines at the 1.1 GW Seagreen and 13 MW from the 1.2 GW Dogger Bank (phase A) projects. Seven Haliade-X 13 MW offshore wind turbines were mechanically installed at the latter last year, but only one unit was commissioned. Same as in 2022, the new installations in 2023 reflect the CfD auction cycle in this market.

- France commissioned 360 MW of offshore wind in 2023. At the Fécamp (250 MW) and Saint-Brieuc (496 MW) wind farms, 49 SGRE offshore wind turbines were grid-connected. The remaining turbines (84 units) are expected to be commissioned later this year.

- Denmark installed 41 units of SGRE's SG-8.0-167 DD wind turbines at the Vesterhav Syd and Nord wind farms in the North Sea last October, with the two small projects fully commissioned at the beginning of this year.

- In the German Baltic Sea, the Arcadis Ost 1 offshore wind project comprising 27 Vestas V174-9.5 MW offshore wind turbines was fully connected to the grid before the end of 2023.

- In Norway, the remaining 35 MW of floating wind was commissioned at the 94.6 MW Hywind Tampen floating wind project.

- Outside of China and Europe, three other markets commissioned new offshore wind capacity last year. Taiwan (China) commissioned 692 MW of offshore wind turbines across Formosa II, Yunlin, Greater Changhua 1 & 2a and Changfang Phase 2 in 2023. In Japan, all the turbines at the 140 MW Akita Noshiro Port wind farm were installed by the end of 2022, but the 55 MW Akita Port project was not commissioned until the end of January 2023. Additionally, the Nyuzen offshore wind project, consisting of three units of Mingyang's MySE 3.0 MW typhoon-proof wind turbines, was completed last October. In South Korea, one unit of 4.2 MW offshore wind prototype was installed by Hanjin last year.

- The US is the only market with offshore wind in operation in the Americas. GE Vernova installed six Haliade-X 13 DD offshore wind turbines at the 806 MW Vineyard Wind 1 wind project, and SGRE also installed a few turbines at the 130 MW South Fork Wind project before the end of last year. However, no offshore turbines were commissioned in 2023 according to American Clean Power (ACP).

Cumulative installations

The global offshore market grew on average by 27% each year in the past decade, bringing total installations to 75.2 GW, which accounted for 7.4% of total global wind capacity as of the end of 2022.

- In total offshore wind installations, China took the crown from the UK in 2021 and further consolidated its global market share in the past two years. Germany, the Netherlands, and Denmark are the other three markets that make up the top five, as was the case in 2022.

- Asia replaced Europe as the world's largest regional offshore wind market in 2022. By end of 2023, more than 40 GW of offshore wind capacity was in operation in this region, of which 37.8 GW (92%) is from China, 2.1 GW from Taiwan (China), Vietnam (0.8 GW), Japan (0.2 GW), and South Korea (0.1 GW).

- The total offshore wind installations in Europe passed 34 GW by the end of 2023, making up 45% of the global total offshore.

- Outside Europe and Asia, North America had 42 MW of offshore wind in operation at the end of last year, with all installations located in the US.

Floating wind

- In Norway, the last four SGRE SG-8.6-167DD wind turbines, which were installed on a concrete SPAR-type floating foundation at the 94.6 MW Hywind Tampen wind project, were connected last year, making it the world's largest floating wind project.

- Elsewhere, a total of 13 MW of floating wind capacity was commissioned in 2023. This included a 2 MW floating demonstration model, DemoSATH, in Spain and two units – a 7.25MW anti-typhoon machine from Mingyang and a 4 MW wind turbine from Shanghai Electric – installed on three-column semi-submersible floating platforms in China.

- As the end of 2023, a total of 236 MW net floating wind was installed globally, of which 101 MW in Norway, 78 MW is in the UK, 25 MW in Portugal, 23 MW in China, 5 MW in Japan, 2 MW in France, and 2 MW in Spain.

Allocation mechanisms

With 39.4 GW of offshore wind capacity awarded worldwide, 2023 was a record year. Excluding China, where 18.2 GW of offshore wind projects were allocated under the 'grid-parity' mechanism, 21.2 GW of offshore wind capacity was awarded through auctioning, of which 15.5 GW was in Europe, 4 GW in the US, and 1.4 GW in Japan in the Round 2 offshore wind auction.

In Europe, Germany awarded 8.8 GW of offshore wind through a zero-subsidy tender. Out of this, 7 GW, across four sites, was centrally pre-surveyed and featured a 'dynamic bidding' system. The

remaining 1.8 GW, awarded across another four sites, was not centrally pre-surveyed.

Ireland awarded 3.1 GW of offshore wind capacity through its first offshore wind energy auction, ORESS 1. France also awarded 1 GW of offshore wind for the Centre Manche 1 site, and Lithuania awarded 700 MW in its first ever offshore wind auction.

No energy companies submitted bids to the UK's CfD Allocation Round 5 (AR5) auction last year, primarily due to the strike prices being too low and not reflecting rising costs.

MARKETS TO WATCH

China

China has abundant offshore wind energy resources with a mainland coastline of totalling 18,000 km in length. The electricity demand in central and eastern China accounts for more than 70% of the country's total. Therefore, the establishment of offshore wind farms in the eastern coastal areas can effectively alleviate the construction pressure of the West-East Electricity Transmission project.

Becoming a market leader in offshore wind development

China commissioned its first commercial offshore wind project, the 102 MW Donghai Bridge offshore wind farm in 2010, but the market was not ready to take off until the first offshore Feed-in-Tariff (FiT) scheme was released by the National Energy Administration (NEA) in 2014 and the Management Measures for Offshore Wind Power Development and Construction was jointly released by NEA and the State Oceanic Administration (SOA) in 2016, which resolved challenges between various government bodies and stakeholders.

Offshore wind installations in China surpassed the 1 GW milestone by the end of 2015. The country became the world's largest offshore wind market in new offshore wind installations in 2018. China has led the world in annual offshore wind developments for the sixth year in a row with 6.3 GW added in 2023, bringing its total offshore wind installations to 38 GW, which accounts for 50% of global cumulative offshore wind capacity.

Building the world's largest offshore wind supply chain

Strong political will

Offshore wind has a longer value chain than onshore wind. In addition to turbine nacelle and key components, it requires large investment in steel foundations, cables, and substations as well as offshore wind enablers such as vessels and ports. Considering the amount of job creation and local economic growth that offshore wind can stimulate, many provincial and municipal governments have shown strong political will in building offshore wind clusters. Together with other renewable energy technology, offshore wind has become one of the growth pillars contributing to China's GDP.

Although the central government has ceased subsidies for offshore wind from 2022, a small portion of financial support is still available in provinces like Guangdong, Shandong and Zhejiang to support the local offshore wind industry to reach grid-parity. Such commitments on the provincial level also help developers, wind turbine manufacturers, and component suppliers to build the confidence on their investment in the offshore sector.

China's offshore wind power industrial bases (key provinces and cities)

Source: CWEA (Chinese Wind Energy Association), 2024

Along the east coast, three provinces – Shandong, Guangxi, and Hainan – are emerging as the new markets for offshore wind development. Thanks to ambitious offshore development targets and the world's fastest permitting process, great progress has been made in these provinces since 2021. Shandong has now joined the leading provinces such as Jiangsu, Guangdong, and Fujian in

offshore wind development, with 6 GW expected to be installed by the end of 2024. In Guangxi and Hainan, a series of offshore wind projects are under construction including the phase 1 (200 MW) of China's first GW level floating offshore wind farm located off Wanning city in Hainan.

On the municipal level, cities such as Yancheng and Nantong (Jiangsu Province) and Yangjiang and Shantou (Guangdong Province) have made themselves the offshore wind manufacturing bases with tailor-made offshore wind ports established to support the growth.

With the production facilities recently invested in Zhejiang, Shandong, Liaoning, Guangxi and Hainan coming online, the annual offshore wind turbine manufacturing capacity in China is likely to surpass 20 GW.

Non-stop technology innovation

Cost reduction pressure has been a driver for Chinese turbine OEMs to launch large turbines with greater power ratings. In 2019 and 2020, the average size of new installed offshore turbines in China was 4.2 and 4.9 MW respectively while the average offshore wind turbine size in Europe was 7.2 MW and 8.3 MW. According to GWEC's latest Global Supply Side Data report, the average offshore wind turbine size in China in 2023 reached 9.7 MW, almost the same as Europe. Chinese OEMs like Mingyang, Haizhuang, Goldwind, Dongfang, Windey, and Envision have already rolled out offshore turbines in the 16–18 MW range, with Mingyang most recently launching its 22 MW turbine model, setting a new record for offshore wind.

In addition, Chinese governments provide supports on emerging technologies and demonstration projects, such as deep-water wind farms and flexible DC transmission, digitalised O&M, offshore hydrogen, energy islands and integrated energy solution, etc.

Achieving industrialisation through scale

Through 15 years of local supply chain development, China has become the world's largest wind turbine manufacturing hub, accounting for 65% of global outputs of turbine nacelle and key components including gearboxes, generators, power converters, and blades in 2023. The offshore wind supply chain development in China has benefited from the industrialisation, which allows the domestic offshore wind industry to achieve cost reduction through the scale. To date, there are about 10 manufacturers capable of supplying offshore wind turbines in China with factories for nacelle assembly as well as key components production established in the coastal provinces.

The past years also witnessed how quickly Chinese local developers and offshore EPC contractors can build and mobilise offshore wind turbine installation vessels. According to GWEC Market Intelligence's Global Offshore Wind Turbine Installation Vessel Database 2023, China had 56 jack-up vessels/barges and 39 heavy lift vessels for offshore wind turbine installation purpose. In addition, 27 tailor-made vessels are under construction, all of which can install 10 MW+ offshore wind turbines. Aside from serving the local market, Chinese shipyards are building the installation vessels for large EPC contractors based in Europe.

Ambitious targets keep Chinese offshore wind ready to explode

During the 14th Five-Year period (2021-2025), five large-scale offshore wind power bases (each with capacity around 10 GW) are to be developed in the Shandong Peninsula, the Yangtze River Delta region, South Fujian, East Guangdong, and Beibu Bay. Through decentralisation in offshore wind approval, more provincial governments have been working on offshore wind development plans since 2020. So far, ten provinces have completed their offshore wind development plans, bringing the total offshore wind development target in China to 200 GW. The industry expects that the newly installed capacity for offshore wind will exceed 10 GW in 2024. GWEC Market Intelligence predicts that 72 GW of new offshore wind capacity will be added in China in 2024-2028, contributing 52% of the global offshore wind additions in this period.

Japan

Japan has an offshore wind target of 10 GW by 2030 and 30-45GW by 2040. At the end of 2023, Japan boasted a cumulative installed offshore wind capacity of 153.5 MW. This consists of 148.5 MW of fixed-bottom installation and 5 MW of floating wind installation, solidifying its position as a key offshore wind player in Asia Pacific. The most recent winner for the 356 MW wind farm off the coast of Happo-Noshiro in Akita prefecture (Round2) was announced in March with another international developer securing the tender. The Round 3 tender is currently underway, with project proposals due by July 2024.

Floating offshore wind development in Japan's Exclusive Economic Zone (EEZ) holds immense potential. The government is actively working to capitalise on the immense offshore wind potential by strengthening the domestic supply chain, aiming to reduce fixed-bottom offshore wind costs and establish technology standards for floating offshore wind.

Unlocking the potential of the EEZ

The current Offshore Wind Promotion Act only allows for designating offshore wind sites within Japan's territorial waters (up to 12 nautical miles from shore). A Cabinet decision was made on 12 March to amend the existing law in order to tap into the vast wind potential of EEZ. A draft amendment bill is currently under review by the Diet (Japan's national legislature), with a final decision expected soon. If approved, the government will need to establish a suitable auction system for EEZ wind development. Whether they adopt the existing tender system for territorial water or introduce a new one remains unclear, although a two-stage model similar to the current UK design is anticipated.

Data published by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) indicates that the inclusion of the EEZ will increase potential development areas for offshore wind tenfold. Identifying suitable locations within the EEZ will be a significant undertaking as achieving alignment among various key sea area users - including defence, fisheries, shipping and other stakeholders - will be critical. Additionally, ensuring sufficient protection for marine environment and biodiversity is paramount. Particularly, building consensus with the fishing industry, with large-scale commercial fishing activities spanning the entire EEZ and fall outside prefectural jurisdiction, will require special attention from the central government.

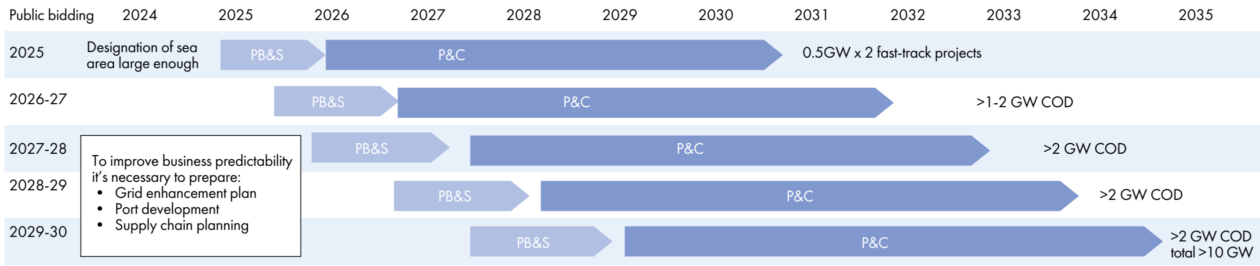
While waiting for greater regulatory clarity and a development roadmap necessary to deploy offshore wind projects, the industry will continue to advocate for a more robust auction system with a streamlined permitting and consenting process, a centralised stakeholder consultation process that ensures on-time projects delivery, and business viability for project owners.

Current effort to achieve floating offshore wind cost-reduction and technology standardisation

In October 2023, four candidate areas for floating wind demonstration projects were identified in Hokkaido,

Industry recommendations for offshore wind development in Japan's EEZ
Shorten offshore wind project development timelines Streamline permitting processes and adopt a centralised system for data sharing and stakeholder consultation, particularly between fisheries and the industry.
Balance and mitigate project development and project financing risks Achieve project and financial viability through measures like ensuring a robust auction system, project pipeline visibility, and an inflation adjustment mechanism for power pricing until the Financial Investment Decision (FID).
Plan for infrastructure upgrades Develop a plan for port, grid, and transmission upgrades in parallel with the future offshore wind project pipelines in the EEZ. This will ensure coordinated use of infrastructure and timely grid integration of offshore wind power.

Fast Track of two 500 MW projects (1 GW) to achieve COD by 2030-2031 and rapid scale up to 2035 (REI, 2023)



Note: PB&S: Public bidding and selection; P&C: Permitting and Construction

Source: Created by Renewable Energy Institute

Akita, and Aichi prefectures, supported by Phase 2 of the Green Innovation Fund (GIF). The estimated project capacities for these demonstration projects are between 77 and 210 MW and the two projects with over 30 MW capacity were selected on 11 June 2024.[23a]

Recognising the need for rapid scale-up of floating wind from MW to GW to achieve cost-effectiveness, the Floating Offshore Wind Technology Research Association (FLOWRA) was launched on 14 March. This consortium of 14 Japanese companies aims to enable mass production of floating wind technologies and develop international standards in collaboration with key offshore wind markets like the US, UK, Denmark, and Norway.

The Renewable Energy Institute (REI) has also proposed a framework to fast track floating offshore wind development within the territorial waters. This framework aims to enable the deployment of the first GW of floating offshore wind by 2030-2031.

In conclusion, Japan's offshore wind industry demonstrates a strong commitment to future growth. By unlocking the vast potential of its EEZ and capitalising on advancements in floating wind technology, Japan can solidify its position as a global leader in clean energy production for a sustainable future. While regulatory frameworks and development roadmaps are still underway, industry stakeholders remain proactive. The continued focus on streamlining regulations, fostering technological innovation, and prioritising stakeholder engagement is necessary for Japan to achieve significant growth in the long term.

23a. https://www.meti.go.jp/press/2024/06/20240611007/20240611007.html

Vietnam

Vietnam targets 6 GW offshore wind capacity in energy plan

Vietnam is a new offshore wind (OFW) market that has world-class wind resources, a long coastline, and strong fundamentals for growth which could make offshore wind a significant component of its future energy mix. The national Power Development Plan 8 (PDP8) targets 6 GW of offshore wind installations, projected to contribute approximately 4% to the total installed capacity. GWEC and its members have been pushing to formalise a route to market for offshore wind in Vietnam since 2022. As a result, the government published the first draft of a pilot mechanism for OFW in April 2024.

Vietnam's offshore wind development: Navigating the Route to Market

To date, Vietnam has not initiated any true OFW projects and has only developed intertidal wind projects situated in close proximity to the shore. The target of installing 6 GW of offshore wind capacity by 2030 presents considerable challenges. GWEC highlighted that an OFW project needs 6-8 years from greenfield to Commercial Operation Date (COD), which was adopted by the Ministry of Industry and Trade (MOIT). Consequently, connecting the first generation of OFW projects by 2030 necessitates the immediate establishment of policy and regulatory frameworks. MOIT estimates that the first pilot offshore wind project may not be completed until 2032.

Therefore, there is an urgent need for a Route to Market process to expedite the installation of over 6 GW of offshore wind capacity by 2030 in Vietnam. Key components of this process include:[24]

1) Implementing a simple remuneration mechanism for initial pilot projects.
2) Developing a streamlined permitting process to ensure timely implementation.
3) Developing a robust Marine Spatial Planning (MSP) and site allocation approach
4) Defining a clear timeline for auction implementation.
5) Enhancing Power Purchase Agreement (PPA) bankability to attract international finance.
6) Upgrading grid infrastructure for seamless offshore wind integration.

In recent years, GWEC has actively engaged with industry stakeholders and the Vietnamese government, facilitating dialogue through regular taskforce and working group meetings, as well as closed-door bilateral discussions. These efforts have been instrumental in gathering industry feedback and sharing crucial insights for advancing offshore wind development in Vietnam.

Recent developments signal significant progress in advancing offshore wind energy development in Vietnam. Firstly, preparations are underway for the submission of Marine Spatial Planning (MSP) to the National Assembly, scheduled for the upcoming meeting from 20 May to 28 June this year. Secondly, in April 2024, MOIT submitted a draft proposal for the pilot mechanism of offshore wind projects, which includes the proposal for the State Energy Steering Committee (established in November 2023) to oversee the offshore wind projects. This committee facilitates coordination between ministerial agencies such as the Ministry of Natural Resources and Environment (MONRE), the Ministry of Industry and Trade (MOIT), the Commission for the Management of State Capital at Enterprises (CMSC), the Ministry of Planning and Investment (MPI), and others. GWEC 's advocacy messages in recent years have been well-received and are reflected in the Draft Project. Finally, the PDP8 implementation plan was issued in April 2024, determining regional allocations for offshore wind development, and the Draft Law on Electricity includes regulations for offshore wind power development.

GWEC's advocacy messages are aligned with the government's policy to develop offshore wind. GWEC and its members will continue to work with governments to make this workable for the whole offshore wind industry.

Why a Route to Market is important for new markets

A Route to Market strategy serves as a fundamental driver for the direction, growth, and sustainability of new markets by establishing a framework for policy development, promoting transparency and efficiency, and fostering the growth of local industries and supply chains for offshore wind.

GWEC believes a Route to Market is important for new markets for several reasons:

Catalyst for policy development: A Route to Market process serves as

24. Route to market for offshore wind development in Vietnam, GWEC, 2022

a critical catalyst for shaping the direction and sustainability of new markets in the offshore wind sector in Vietnam. Given the early stage of offshore wind development in Vietnam, the absence of pre-existing policies necessitates the establishment of a Route to Market process. This process provides the essential groundwork for government and industry collaboration in formulating coherent offshore wind policies. By doing so, it lays the foundation for regulatory certainty and market stability, thereby facilitating the long-term growth and investment of the offshore wind sector.

Promotion of transparency and efficiency: Transparency and efficiency are paramount for attracting investment and ensuring the long-term success of offshore wind projects. The Route to Market process facilitates transparency by providing developers and investors with a clear roadmap for navigating regulatory hurdles and market dynamics. This clarity enables stakeholders to make informed decisions, assess risks, and effectively allocate resources. Moreover, by fostering a conducive business environment, a Route to Market enhances operational efficiency and reduces capital expenditure (CAPEX), thereby improving the overall competitiveness of offshore wind projects. As a result, international investors and financiers will be more open to participating in the Vietnam offshore wind market, thereby catalysing its growth and maturation.

Fostering local industry development: Beyond its immediate impact on project development, a Route to Market plays a pivotal role in fostering the growth of local industries and supply chains. By incentivising the localisation of key components and services, such as industry clusters, infrastructure, and skilled labour markets, a Route to Market creates opportunities for the development of a robust domestic supply chain ecosystem. Moreover, by nurturing local talent and capabilities, it also contributes to the broader socio-economic development goals of the country, thereby ensuring a more inclusive and sustainable energy transition.

Moving forward, GWEC will continue to work closely with industry stakeholders, policymakers, and local communities to further refine and implement an effective Route to Market process, fostering an offshore wind sector in Vietnam and beyond.

Philippines

The Philippines has emerged as a pivotal player in the offshore wind (OFW) industry, propelled by progressive policies streamlining permits, encouraging foreign participation, and the introduction of a marine spatial tool (MSP). With plans for the existing one-stop shop, EVOSS to be enhanced, developers anticipate smoother permitting processes for OFW projects. Ongoing discussions among regulators, particularly those integral to infrastructure development, underscore a concerted effort towards industry advancement. In this article, we explore crucial auction parameters the Department of Energy (DOE) should prioritise to sustain and amplify the momentum of offshore wind development in the Philippines

The Philippine Energy Plan (PEP) aims for a 35% share of renewables in the power mix by 2030 and 50% by 2040. Offshore wind will play an important role in decarbonising the economy while reducing dependence on energy commodity imports. The DOE has already approved 63 GW of offshore wind sites and are processing more applications.

The industry welcomes the DOE's plan to conduct the first OFW Green Energy Auction Program (GEAP) round by Q2 of 2025. Having a separate auction for OFW will hopefully set clear capacity targets and price expectations for the medium- to long-term horizons. This provides a stable revenue stream outlook for developers and will also create confidence from lenders to assign risk and mobilise funds specific to OFW. Below are key parameters for a successful OFW auction:

1. **Ensuring the transparency and certainty of the OFW pipeline** is paramount for fostering investment and mobilising resources effectively. By establishing a clear capacity target and Commercial Operation Date (COD) horizon, developers and supply chain stakeholders are prompted to align their services and equipment with the Philippines' goals. Moreover, this clarity enables the financing sector to timely allocate the necessary capital for project development. Emulating successful strategies from other countries that mobilised OFW, a formal long-term scenario or roadmap is essential. This roadmap should delineate infrastructure availability crucial for supporting OFW deployment.

Currently, the government is finalising key frameworks such as the Permitting Framework, Marine Spatial Planning, and Port Feasibility studies. Once completed, these frameworks will pave the way for the announcement of the auction program by the DOE. This strategic sequencing allows developers ample time to evaluate their timelines, costs, and overall project viability. Ultimately, the pipeline announcement empowers developers to make informed decisions regarding the timing of their project commitments.

2. **Employing realistic assumptions when determining auction prices** to incentivise developers and ensure

participation is crucial. Unlike more established markets, the Philippines' nascent offshore wind sector requires careful consideration of various cost components. To arrive at a realistic tariff, it's essential to map out all cost elements comprehensively - this includes pre-development expenses such as technical and social studies (e.g., wind campaigns, geotechnical assessments, ESIAs - which developers are currently undertaking). Additionally, equipment costs (e.g., wind turbine generators, foundations, towers, and construction vessels) and where they are sourced from will have a huge impact on the tariff. All of these options need to be factored in, encompassing availability, delivery, and assembly. Balance of plant expenses, including offshore substations and onshore grid connection points and which entity responsible for building for these should be well accounted for in the price discovery. Interest rates, often sourced from international financial institutions at this stage, further contribute to the overall project costs.

To make the tariff competitive, the approaches below need to be streamlined:

- Collaboration between government agencies to chart out the policy framework on the ownership of land and seabed leases, substation connection points, and infrastructure responsibility.
- Collaboration between government agencies and the private sector to gather the right input on capital expenditure (CAPEX) to determine a reasonable Green Energy Auction Reserve price for offshore wind.
- Implementation of a feedback loop on all other technical discussions, such as setting the correct level of performance bond requirements, mandating technical and ESIA (Environmental, Social, and Environmental Assessment) studies, alleviating financial burdens, project de-risking, and tariff indexation.
- The DOE and Energy Regulatory Commission (ERC) should ensure that there is a distinct model and tariff for fixed-bottom and floating offshore wind projects. The cost assumptions should be well validated by the industry stakeholders.

3. Setting prerequisites will determine which OFW developers are eligible to participate in the offtake program. The second round of renewable energy auctions for onshore technologies is less stringent in its conditions and any developer with a Letter of Intent may participate. The auction program for OFW should incorporate robust technical and financial pre-qualification, –striking a balance between wider participation and guaranteeing successful project execution rounds.

4. The imposition of performance bonds is crucial for ensuring that only serious and capable developers participate in offshore wind projects. However, the current 20% requirement may be too high given the per MW cost of such projects. Regulators should consider alternatives, such as lowering the performance bond requirement for winning bidders, and mandating specific permits and technical as well as social studies. These requirements serve as investment commitments and allow developers to allocate funds towards de-risking their projects. To further incentivise participation, the Department of Energy (DOE) should consider implementing a decreasing bond amount per year as developers commit more CAPEX. As development progresses and risks diminish, a lower bond requirement would be more appropriate. It's essential to benchmark the proper performance bond rate against those of newer markets or consult with other Asia-Pacific countries and engage with Philippine developers for insights.

Similar to previous auction rounds, clarity on the process and timing of performance bond calls is essential. Establishing guidelines for calling upon a specific percentage of the performance bond based on project delays ensures transparency and accountability throughout the project lifecycle.

5. Ensuring an aligned transmission development plan is vital for the continued progress of the offshore wind industry in the Philippines. The approach taken in the last two auctions, which divided capacity among Luzon, Visayas, and Mindanao, has been well-received by the industry. This method considers not only the number of participating developers and their capacities but also the readiness of the grid to accommodate renewable projects based on entry years. Such an approach fosters proper and segmented competition, promoting growth in each major region of the country.

Moving forward, OFW-specific auctions should adopt a similar design by setting capacities based on specific OFW zones. This departure from previous auction rounds enables the DOE to collaborate with the National Grid Corporation of the Philippines (NGCP) in identifying potential substation connecting points capable of integrating OFW power plants. This collaboration signals the grid operator's commitment to upgrading connecting points, bolstering confidence in commissioning timelines and costs for both regulators and developers.

To contribute to making the sector competitive, GWEC is also conducting an offshore wind supply chain study to outline the baseline capabilities of the Philippines. The results will be communicated to government agencies by the end of 2024 so that competitive industrial policies can be implemented to support the industry in the long run.

The government has been swift in addressing the constraints to fully develop the OFW Industry. With the President at the helm of this massive renewable energy commitment, the Philippines can continue to harness the opportunity that OFW presents – to provide a sustainable shift to carbon neutrality, to utilise an abundant and indigenous power source and with the right policies and auction design, present a lower cost of energy in the long run.

South Korea

South Korea's offshore wind potential is impressive, estimated at 624 GW, encompassing both fixed bottom and floating wind turbines. The government has committed to a 14.3 GW installation target by 2030. The current operational capacity, of just 150 MW spread across seven offshore wind farms, highlights the ongoing challenges related to regulation on permitting, market design, and underscores the critical necessity for immediate action to accelerate progress to achieve its 2030 ambitions. South Korea is a developing OFW market, meaning that supportive mechanisms will also need to be further strengthened in areas such as garnering local consensus, supply chain, infrastructure, grid connectivity, and transmission concurrently.

Permitting

Offshore wind is expected to contribute significantly to the country's plan to achieve a 21.6% share of renewables in the power mix by 2030, as stated in its 10th Basic Plan for Electricity Supply and Demand. The current offshore wind development approach operates under a system led by developers, characterised as an open-door framework. This means that the project developer bears responsibility for site investigation, wind resource assessment, and engagement with the local community, to obtain around 20 permits required, including the Electricity Business License. This is even before the Environment Impact Assessment (EIA) and seabed exclusivity occupancy permits can be applied for, which will ultimately determine whether a project is ready to enter the auction for a 20-year Fixed Price Contract. The length of the permitting process is further increased by the lack of transparency, as project owners must navigate 29 distinct laws from 10 government ministries and authorities with minimal criteria guidance.

Under the 21st term of South Korea's National Assembly (NA) which ended on 31 May 2024, the Offshore Wind Power Promotion Act, more commonly referred to as "OSS Bill", that streamlines the permitting process, was packaged with the Special Bill on Managing High-Level Radioactive Waste, and continuously discussed at multiple standing committee meetings. Whilst no resolve had been reached during the term, bi-partisan consensus on its necessity was achieved between the incumbent People's Power Party and opposition Democratic Party, in addition to the Ministry of Trade, Industry and Energy (MOTIE). The Ministry of Fisheries (MOF) and fisheries cooperatives, who had initially opposed the bill, demonstrated support after further iterations of the bill promised the inclusion of both the MOF's and the fishers' perspectives.

The bill will now require resubmission during the 22nd term of the National Assembly, ensuring bipartisan backing as well as continued consensus from the MOF and fisheries stakeholders. Moreover, there is a need for enhanced guidance and clarity on the treatment of projects that have already successfully obtained an Electricity Business License (EBL), ensuring that EBLs are not retroactively revoked, which could hinder substantial progress towards bringing these projects online before 2030. GWEC will continue to work with local ecosystem partners to advocate for streamlining of the permitting process.

Market Design

South Korea operates a Renewable Portfolio Standard (RPS) scheme as its main support mechanism,

mandating large generators to produce a minimum proportion of their power with renewable energy. Generators and power producers will enter into 20-year fixed price contracts through an auction process specific to wind energy, held yearly by KEPCO. However, there are several challenges prevalent in this current framework. The bidding criteria places a large emphasis on price, which attributes to 60 out of 100 points in the evaluation scoring.

The final price is determined by the system marginal price of electricity added onto the total of the renewable energy certificate (REC) multiplied by a predetermined multiplier. The REC multiplier methodology is set by MOTIE and varies according to the renewable technology, reassessed every three years. For offshore wind technology, the multiplier is further categorised based on the distance from shore and water depth. However, the overall variability of this methodology, particularly the the potential changes in the REC multiplier over the 20-year period, is likely to affect the bankability of the project.

An offshore wind project awarded with a Fixed Price Contract in South Korea must achieve completion, including the Pre-Use Inspection within five years of the date of signature. Under existing regulations, the criteria for extending this period and the accompanying financial penalties are ambiguous, elevating the perceived risks for lenders and heightening the pressure on project owners to meet these obligations. The extended lead times and heightened logistical complexities inherent to large-scale OFW projects, coupled with the nascent state of South Korean's supply chain and the industry's limited experience in floating technology, may further exacerbate these pressures.

Overall, the South Korean government has signalled that it intends to gradually move away from the RPS system in the coming years, after assessing that the renewable energy market is mature and competitive enough to be incorporated into a competitive auction system. GWEC will continue supporting industry-led dialogue to identify the optimum transition mechanism for this process in South Korea.

Over 19 GW worth of EBLs, commonly considered as the key milestone in the initial stage of development, have been granted in South Korea. This signals a strong interest and bullish market outlook. It is imperative to keep up the momentum of this strong project pipeline through addressing the regulatory shortfalls related to permitting and market design. Ensuring the sustainability of the offshore wind industry and its positive impact on the South Korean economy also necessitates meticulous consideration when refining any current regulatory frameworks.

Australia

The Australian offshore wind sector continues to progress at a rapid rate. The results of the Gippsland feasibility licencing process were released on May 1, 2024, marking an important moment in Australia's offshore wind journey and for many, the successful culmination of years of work. The Australian Government has granted the first set of feasibility licences for offshore wind projects off the coast of Gippsland in Victoria to six projects. These projects are:

1. High Sea Wind (Ocean Winds)
2. Gippsland Skies (a consortium comprising Mainstream Renewable Power, Reventus Power, AGL Energy, and DIRECT Infrastructure)
3. Blue Mackerel North (Parkwind/ JERA Nex)
4. Kut-Wut Brataualung (Copenhagen Infrastructure Partners and Gunaikurnai Land and Waters Corporation)
5. Ørsted Offshore Australia 1
6. Star of the South Wind Farm (Copenhagen Infrastructure Partners, NZ Super, and Cbus Super)

The government also announced its intention to grant a further six licences to:

1. Iberdrola Australia OW for its Aurora Green wind farm
2. Greater Gippsland 2 OWP Project (Gippsland Dawn)
3. Navigator North Project
4. Ørsted Offshore Australia 1 (Gippsland 02)
5. Kent Offshore Wind
6. Great Eastern Offshore Wind Farm Project Co.

All six are expected to have been granted a feasibility licence by the time of this publication. Twenty-five other bids were rejected by the Minister in the first instance.

The licence area has the potential to bring 25 GW of offshore wind into Victoria's energy mix if all 12 projects are built. The awarding of the licences follows at least six years of collaboration between the industry and the federal government and its agencies, including the Department of Climate Change, Energy, the Environment and Water (DCCEEW), the Offshore Infrastructure Regulator, and the National Offshore Petroleum Titles Administrator (NOPTA). The Australian Government has been thoughtfully and productively engaged on the topic of offshore wind at both national and international levels through the Global Offshore Wind Alliance (GOWA).

On April 12, 2024, DCCEEW opened a public consultation on proposed regulations supporting the Offshore Electricity Infrastructure (OEI) Act 2021, which closed on May 12. Initial industry feedback indicates that the Department has made efforts to balance the use of marine areas by all users in both the near and long term. However, there are still areas for improvement, such as the ambiguity of the language and the short time allowed for feedback.

As with all emerging markets in the early stages of development, the government, industry, and civil society are collaborating to address the challenges of bringing these projects to life. In Australia, there has been a strong focus from the outset on tackling the issues that have delayed projects in other countries, including grid connection, permitting, and market design, among others.

The next section takes a closer look at two of these topics: grid connection and the rise of misinformation in the consultation process.

Reinforcing Transmission Infrastructure

As offshore wind projects are projected to come online in 2031 by GWEC Market Intelligence, there is a need to improve transmission infrastructure to ensure no energy is wasted. The Federal Government introduced the "Rewiring the Nation" program to make clean energy accessible and affordable for Australian consumers. The program is investing in new transmission lines to deliver affordable, reliable renewable energy to cities, towns, and regional communities.

Being a pioneer in upgrading the transmission system, the Victorian Government released the Offshore Wind Energy Implementation Statements in March 2023 to guide industry stakeholders and communities in the development of the offshore wind sector. VicGrid, a division of the Victorian Government Department of Energy, Environment and Climate Action, is directing the development of transmission infrastructure for offshore wind projects. VicGrid's approach aims to centralize transmission infrastructure, prevent a "spaghetti effect" of uncoordinated private lines, and disincentivize private developers from creating their own transmission lines. The Victorian Government plans to achieve 2 GW of offshore wind by 2032, requiring transmission infrastructure for 2-5 GW connection capacity in Gippsland and Portland, with potential for further growth.

Misinformation

As other offshore wind zones are announced and opened for consultation in Australia, there are concerning reports of increased levels of mis- and disinformation in the market. Misleading reports concerning whale mortality have been introduced into local narratives, causing confusion and anxiety, and potentially limiting sector expansion. Campaigns against offshore wind often use false or exaggerated claims related to the fishing and tourism industries, frequently copying content from anti-offshore wind playbooks from other markets worldwide.

Triggered by a social media post in the Facebook community group "No Offshore Wind Farm," these campaigns referenced a University of Tasmania study, allegedly published in Marine Policy, which estimated that upcoming offshore wind projects "could kill up to 400 whales per year." However, this article does not exist.

Researchers at the University of Sydney assert that these claims are exaggerated and lack empirical evidence. There is no scientific proof that wind turbines cause harm to whales or other marine animals, and these false claims have been widely disregarded by marine scientists. In contrast, research from the University of New South Wales (UNSW) supports the benefits of offshore wind, suggesting that offshore wind structures can facilitate the formation of artificial reefs, aiding in the restoration of marine ecosystems. This highlights the multifaceted benefits of transitioning to renewable energy, extending beyond energy production to environmental regeneration.

To ensure the successful development of Australia's offshore wind sector, it is imperative that the government, industry, and civil society continue to collaborate closely. There must be an emphasis on transparency and robust public engagement to counteract misinformation and build community support. Moreover, the government should implement clear communication strategies to disseminate accurate information about the environmental and economic benefits of offshore wind.

India

The progress in India's wind energy sector underscores its role as a pivotal player in the global shift towards renewable energy. Currently ranking fourth globally with over 45 GW installed wind capacity, India is pushing forward with ambitious goals. By 2030, India plans to achieve a cumulative 140 GW installed wind energy capacity. India also holds significant potential for offshore wind energy. The Ministry of New and Renewable Energy (MNRE) aims to harness an estimated 70 GW of offshore wind energy capacity off the coasts of Gujarat and Tamil Nadu, highlighting the strategic importance of this resource in India's energy landscape[25].

Opening of a new offshore wind market

The National Offshore Wind Energy Policy, notified in 2015, lays the groundwork for the strategic and comprehensive development of offshore wind projects up to the country's Exclusive Economic Zone, which extends 200 nautical miles from the coastline. India's strides towards operationalising its offshore wind capacity are marked by the issuance of its first offshore wind seabed lease tender. In early February 2024, the Solar Energy Corporation of India (SECI) announced the "Request for Selection" (RFS) for 4 GW of seabed lease off the coast of Tamil Nadu[26]. This development is part of a broader strategic initiative, detailed in 'Strategy Paper for Establishment of Offshore Wind Energy Projects', which comprises a tentative tender trajectory for the award of 37 GW of seabed lease capacity by 2030. The notification of India's "Offshore Wind Energy Lease Rules, 2023[27]," further supports this initiative by regulating the allocation of sea blocks to developers, thereby ensuring a structured development pathway. The success of tenders floated by the government in the current financial year shall mark the opening of a new offshore wind market in the region.

Offshore wind: A potential catalyst for local economic growth

The development of offshore wind projects in India is expected to generate substantial economic activity in the regions adjacent to installations. Major benefits include job creation during the survey, construction and commissioning phases, as well as during ongoing operations and maintenance, and later during the decommissioning stage of the wind farms. The construction of power transmission and evacuation systems, and ports further adds to job creation opportunities. Offshore wind projects require a diverse range of skills from engineering to logistical support, thereby providing varied employment opportunities. Additionally, the establishment of such large-scale renewable infrastructure is likely to stimulate local economies through the development of supporting industries such as vessel manufacturing, operations, maintenance services, and the manufacturing of offshore wind equipment and components such as turbines, generators, and blades. The Ocean Energy Pathway (OEP),[28] has commissioned a study to estimate the socioeconomic benefits of an offshore wind manufacturing ecosystem in Tamil Nadu, and is likely to publish its findings this year.

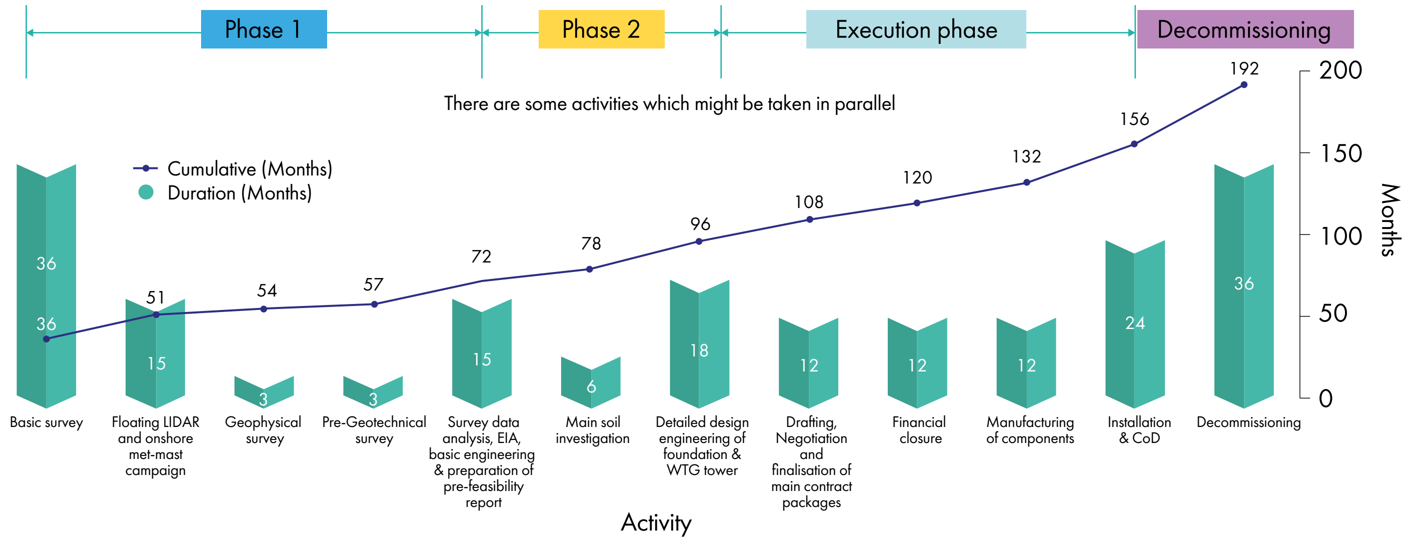
Addressing challenges

Offshore wind projects demand substantial initial investments and involve three broad stages after the award of tender – study/survey; project construction and

25. https://mnre.gov.in/off-shore-wind/
26. https://www.seci.co.in/whats-new-detail/2606
27. https://mnre.gov.in/notice/offshore-wind-energy-lease-rules-2023/

commissioning; as well as decommissioning. Project activities may span up to 7-10 years across these stages. This implies market barriers must be eliminated to cut investor risk and encourage healthy participation from leading offshore wind project developers. To facilitate this, the central government has planned a 10 GW grid infrastructure for offshore wind projects in Tamil Nadu and Gujarat. The state governments have also committed to purchasing power from initial capacities that are commissioned at a tariff of INR 4 per unit.[29] However, this may still make offshore power expensive as compared to onshore wind and solar PV. Hence, innovative financial instruments and policy measures will have to be leveraged to drive the uptake of power generated from offshore wind facilities. The central government has approved the facilitation of viability gap funding (VGF) for an initial 1 GW of offshore wind capacity, with additional support including an ISTS waiver until 2032, which exempts these projects from certain grid usage charges. The central government is likely to notify tenders linked to VGF in this financial year.

Key activities and estimated timeline in offshore wind projects



Based on consultation of GWEC offshore working group

To support India's strides, the India Offshore Wind Working Group has submitted a series of industry representations to the central government emphasizing the readiness of grid and port infrastructure. In addition, the Working Group has pressed for reconsideration of financial clauses, and timelines in the RFS which was earlier notified by the SECI. The Group has also shared inputs on the need for a robust permitting and clearance mechanisms to fast-track offshore wind project development and commissioning. The central and state government agencies have also partnered with a range of multi-lateral/bilateral organizations, think tanks and expert groups to steer the provisioning of a robust enabling environment for the offshore wind industry in the country.

The way forward for offshore wind in India

India's offshore wind sector is poised for rapid growth, supported by strategic policy interventions, financial incentives, and a commitment to overcoming logistical and infrastructural challenges. The government's proactive approach in setting a clear trajectory for capacity addition and streamlining regulatory frameworks provides a solid foundation for the future expansion of this promising sector. With continued focus on reducing costs and enhancing infrastructure, India is well on its way to becoming a leader in offshore wind energy on the global stage.

28. https://oceanenergypathway.org/
29. https://sansad.in/getFile/loksabhaquestions/annex/1712/AU1258.pdf?source=pqals

Colombia

The Colombian electricity system is calling for increased resilience in the context of the country´s droughts, driven by the aim to accelerate decarbonisation through the increase of non-conventional renewable energy developments. Colombia's electricity matrix is hydro-dominated and thus highly vulnerable to weather variability, notably El Niño Southern Oscillation (ENSO) events. Roughly 80% of Colombia's electricity is produced from hydro resources, with the remaining 20% mainly supplied by natural gas and coal-based generation.

The National Development Plan 2022-2026 approved by the Congress envisages a productive economic transformation with a focus on climate action. One of the targets of the plan is to accelerate the development of renewable energy in the country to achieve a fair, safe, reliable, and efficient energy transition.

Beyond its excellent onshore wind resources, Colombia has an offshore wind technical potential of 109 GW, according to the World Bank Offshore Wind Development Program, comprising 31 GW of fixed wind potential and 78 GW of floating potential. Most of the best offshore wind resources are located in the Caribbean Sea in the Northern extremes of the country, particularly off La Guajira's coast, where some areas have annual average wind speeds exceeding 10 m/s.

The Offshore Wind Roadmap for Colombia[30] explores opportunities in the country's waters and identifies challenges for the deployment of up to 50 GW in various scenarios, which may build a project pipeline to ensure resilience and increase energy security in Colombia once technical, social, and environmental screening is addressed.

In order for this to happen, the Government of Colombia has established a robust process to enable investment and development activities, aligning its energy, marine, and Oil & Gas agencies and institutions to develop a policy

30. https://www.minenergia.gov.co/es/micrositios/enlace-ruta-eolica-offshore/

framework for awarding offshore wind power seabed areas and concessional use for project developments. This process will run in five stages via a competitive tender process assessed under international standards with significant stakeholder engagement.

Developers are targeting these regions with a pipeline of 11 projects counting over 5 GW already registered at the energy planning body UPME (Unidad de Planeacion Minero Energetica).

Resolution 40284[31] of August 2022, establishes the rules, requirements, and minimum conditions for the competitive temporary allocation of seabed process in Colombia's waters for the purpose of offshore wind project development. As a result, the responsible bodies (Ministry of Mining and Energy, and the National Authority of Hydrocarbons) started working on the development of a seabed tender for offshore wind energy projects on the Caribbean coast, evidencing Colombia's strong commitment of to an energy transition and its goals of becoming a leader in renewable energy in the region.

In December 2023, the Ministry of Mining and Energy published the Resolution 40712, a policy document establishing adjustments for Resolution 40284; the adjustment completes the structure of the competitive process for allocating temporary occupation permissions. The process was launched during COP28 with the announcement by the President of the Republic, Gustav Petro and the Ministry of Mines and Energy, Andres Camacho. On 21 December, the prequalification stage was officially opened.

The seabed areas included in this first call will account for approximately 12,000 km2 on the coast of the Atlantic region, for projects sized over 200 MW, with the expectation of reaching between 1 GW and 3 GW of total installed capacity.

Bidders will first have to pass through a prequalification process, including demonstrating technical experience and track record in the development of offshore wind projects.

The terms for the qualification were reviewed in the first instance on 13 February 2024, by the National Hydrocarbons Agency, according to an updated timetable.

Subsequently, on 30 April 2024, the responsible bodies reported changes to the bidding rules in response to the comments and observations submitted by stakeholders during the first Colombia Offshore Wind Energy Round. These changes were also influenced by revisions announced in Addendum No. 1 of the Bidding Documents of the Competitive Process, which is currently under analysis. The aim is to strengthen the conditions for competition and participation in the Round.

The issues under review are focused mainly on the following topics:

1. Technical and financial capacity requirements for the qualification phase.
2. Requirements for obtaining a maritime concession.
3. Procedure for the Nomination of Areas.
4. Modification of the holder of the temporary occupation permit and of the maritime concession.
5. The form of the performance bonds required during the Temporary Occupancy Permit and the Maritime Concession.

The clarifications, adjustments, changes, and the final version of the Round Schedule are expected to be announced in shortly.

More recently, the terms for qualification were revised in Addendum No. 2 to postpone the qualification date to 27 September 2024, and subsequently the timeline beyond this milestone.

The tender will meet its targets when developers of the existing project pipeline can fully secure the seabed areas of their interest.

The development of offshore wind energy projects requires the construction of specialised ports infrastructure to support the procurement, installation and maintenance of these projects. The infrastructure must be designed to accommodate the large vessels and heavy equipment required for offshore wind projects and be located in areas with suitable water depths and access to the electricity grid. To support the development of OSW projects in Colombia, the government is seeking to raise awareness and build capacity to understand the impact of coastal and maritime infrastructure development, paving the way for the fulfilment of the offshore wind roadmap.

31. https://www.minenergia.gov.co/documents/8462/res-40284-2022.pdf
32. https://www.anh.gov.co/documents/24753/Adenda_No._2_RECA-_Modifica_Cronograma_22.05.2024.pdf

Brazil

Brazil has great potential for the development of offshore wind energy, estimated at around 700 GW, with high-capacity factors above 52% in coastal areas up to 50 metres deep, according to the Offshore Wind Roadmap[33]. The roadmap highlights states in the Northeast, Southeast, and Southern regions of the country as promising for offshore wind.

The country has several ports that are favourable for implementing OSW after some adaptations. Additionally, there is an onshore wind supply chain and an offshore industry that can be adapted to attend OSW. To facilitate energy flow, it is necessary to reinforce transmission lines for entrepreneurs who want to connect to the grid, and it is desirable to increase financing options for the technology.

There are currently 234 GW of OSW projects submitted to Ibama[34] (the Federal Environmental Institute). However, to analyse and authorise any project it is necessary to have a law that establishes the regulation of marine use rights.

Bill No. 576/2021, which regulates OSW, is authored by former senator Jean Paul Prates. It was approved in the senate in 2022 and underwent modifications in the Chamber of Deputies, some of which dealt with issues unrelated to the OSW sector, such as incentives for generation of gas, coal, and small hydroelectric plants. The Bill was approved in 2023 and is currently awaiting final approval in the Senate under the report of Senator Weverton Rocha.

The expectation is that senators will approve the regulation in 2024. Subsequently, the bill will then go to presidential approval. After that, it will be necessary for the executive to regulate marine area auctions. In Brazil, the energy transition agenda involves the Ministry of Mines and Energy (MME), the Ministry of Finance, the Ministry of Industry, Foreign Trade and Services (MDIC), the Ministry of the Environment (MMA), as well as key institutions for development of OSW, such as the National Development Bank (BNDES).

The "New Industry Brazil", a new industrial policy aimed at boosting national development until 2033, includes provisions for investments of R$300 billion until 2026 to finance the neo-industrialisation process. This initiative will require a significant increase in renewable energy supply, driven by the decarbonisation efforts of large energy consumers and the attraction of new industries interested in producing with a lower carbon footprint. This additional demand for renewable energy can be met by OSW.

The development of clear policies, investment in infrastructure, and cooperation between the public and private sectors, and local communities will be crucial for capitalising on Brazil's OSW potential.

On the global stage, Brazil is hosting the G20 and the Clean Energy Ministerial in 2024. The priority themes of the MME's Energy Transition Work Group (ETWG) are: (i) Financing for energy transition, focusing on emerging countries; (ii) Social dimension of the energy transition; and (iii) Development of sustainable fuel markets.

In addition, as part of the commitment of the tripling of renewable energy by 2030 and as a recognition of the

33. EPE – Empresa de Pesquisa Energética (2020). Roadmap Eólica Offshore Brasil – Perspectiva e caminhos para a energia eólica marítima 2020, 1ª edição
34. Mapas de projetos em licenciamento - Complexos Eólicos Offshore — Ibama (www.gov.br)

importance of the OFW to reach this purpose, Brazil joined the Global Offshore Wind Alliance (GOWA), during COP28, in Dubai.

Brazil doesn't have a Marine Spatial Planning (MSP) yet. With a coastline spanning more than 8,000 km establishing an MSP in Brazil presents significant challenges. However, the Interministerial Commission for Marine Resources (CIRM) and the Ministry of the Environment (MMA) are working together to develop the MSP, taking into account synergies between various government agencies. The Brazilian maritime space has been divided into blocks, with MSP development initially focused on the southern region. This first planning cycle was funded by BNDES[35] and will serve as a pilot to test methods and approaches that can be applied in other regions. The consultancy firm selected through a bidding process has already commenced its activities.

The development of MSP for the northern and southeast regions will also be supported by BNDES[36], while the northeast will be developed through a technical and financial partnership with the Brazilian Fund for Biodiversity (Funbio)[37], financed with resources from a Commitment Agreement between Petrobras and Ibama. The optimistic forecast for the development of Brazil's MSP is approximately six to seven years. Based on global experiences, such planning is crucial and must be implemented for the optimal use of marine resources. It is a "living" instrument, which must be constantly updated and can be developed, as occurred in Spain, simultaneously with the growth of the offshore wind industry and the development of other offshore activities. As a member of GOWA, Brazil stands to gain from international collaboration in advancing its MSP.

35. BNDES: PEM in the South of Brazil
36. BNDES: PEM in the Southeast of Brazil
37. PEM in the Northeast of Brazil

Europe

Europe was the early adopter of offshore wind technology and quickly emerged as the world leader in offshore development. The first offshore wind farm, Vindeby, was installed in Denmark in 1991. Currently, Europe maintains its prominent position, with 45% or 34 GW of total global offshore wind installed capacity in operation, making it the second-largest region in this sector.

The invasion of Ukraine by Russia and its use of gas supplies as a political tool have led to an unprecedented energy security crisis in the EU, resulting in a sharp rise in prices. The EU has taken decisive actions by introducing REPowerEU which aims to eradicate energy dependence on Russia, enhance energy security, increase the share of renewables from 40% (1,067 GW) to 45% (1,236 GW) by 2030, ensure overall resilience through domestically sourced affordable renewables, and reduce prices over time.

The forward looking strategies introduced in 2023 to enhance energy security through offshore wind include the EU's Offshore Renewable Energy (ORE) generation goals across its five sea basins, aiming for approximately 111 GW by 2030, nearly twice the at least 60 GW set out in the EU Offshore Renewable Energy Strategy[38] in November 2020, and around 317 GW by 2050[39]. Additionally, there are plans to build 300 GW in the North Seas by 2050 under the Ostend Declaration. The Baltic Sea countries have a target of 19.6 GW by 2030 under 'The Vilnius Declaration'[40]. Moreover, nine countries of the North Seas Energy Cooperation (NSEC) are collectively planning auctions for around 15 GW annually, aiming to award almost 100 GW between 2023 and 2030.[41,42]

2024 – a turning point for accelerated offshore wind growth

Europe has a promising offshore wind projects pipeline up to 2030. GWEC forecast around 77 GW new offshore capacity to be grid connected between 2024-2030 and approximately 84 GW between 2031-33, far behind the expected ORE target. However, efforts are

being made by governments to reach the target.

According to WindEurope, EURO 30 billion of new investments were confirmed in Y2023, covering 9 GW projects that will be built in the coming years. According to the GWEC Market Intelligence Auctions Database Q1 2024 Update, more than 40 GW offshore wind announced in auctions capacity in Europe is expected to be awarded in 2024 and 2025. Additionally, at

38. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2020:741:FIN&qid=1605792629666
39. https://energy.ec.europa.eu/news/member-states-agree-new-ambition-expanding-offshore-renewable-energy-2023-01-19_en
40. https://windeurope.org/wp-content/uploads/files/newsroom/press-releases/20240410-Vilnius-Declaration-of-Energy-Ministers.pdf
41. https://energy.ec.europa.eu/system/files/2023-11/231117%20NSEC%20tender%20planning%20-%20November%202023_0.pdf
42. https://energy.ec.europa.eu/news/north-seas-conference-hague-national-goals-joint-action-offshore-wind-energy-2023-11-20_en#:~:text=The%20tender%20planning%20translates%20NSEC,and%20allow%20for%20better%20collaboration

least 46 GW of new offshore wind auctions capacity is expected to be announced between 2024-2030 as per scheduled auction pipeline by countries.

Germany alone plans to award 8 GW of auctions in 2024 while the other top four countries – Denmark, the UK, France, and Netherlands – along with relatively new markets Portugal, Finland, Estonia, and Lithuania are expected to award auctions in the next two years. Notably, it is commendable that the UK government raised the ceiling price by 66% for the upcoming offshore auction round (AR6) to tackle the market issues of inflation and higher input prices and attract record investment in 2024.

Investment to address bottlenecks is a key to offshore wind growth

According to GWEC Market Intelligence, Europe would face potential supply chain bottlenecks from 2026/2027 onwards for multiple offshore wind key components, in particular gearboxes, generators, blades, power converters and offshore wind compatible metal castings, towers, foundations (fixed bottom), and cables.

In addition to inflation, uncapped negative bidding, and higher interest rates the unavailability of these components or facilities cumulatively led to several project delays, cancellations, and rising project costs in the North Sea of Europe.

To address these bottlenecks timely investments and actions are required. Some positive signals indicating progress in this direction are:

- NSEC has led to the development of manufacturing facilities for blade, nacelle, tower, foundation, cable, and other components around the North Sea market over time.
- Several new submarine cable plants and expansions have been announced in the past two years in the UK, in both England and Scotland, as well as in Sweden, Germany, and Netherlands.
- New manufacturing (or the expansion of) factories are planned for blades, towers, foundations, offshore substation, converter platforms announced in Poland (by Vestas, Windar Renovables, Baltic Towers), Denmark (by Baltic Structures, Bladt Industries), Germany (Smulders and Neptun Werft), the Netherlands (by Sif), the UK (by SeaH), and Spain (Dragados).
- Cooperation between European countries' ports in response to the Esbjerg Declaration for delivering increased offshore wind ambition and the Scottish Offshore Wind Ports Alliance (SOWPA) launched to enhance the UK's regional competitiveness.
- European vessel operators started upgrading existing WTIVs and placing orders for next-generation WTIVs (for turbines over 12 MW) in the past couple of years. Its current WTIV supply chain can cope with demand as annual installations are unlikely to reach the 10 GW level until 2028.
- Efforts are being made to build out meshed grid systems to facilitate more efficient cross border transmission systems. The European Network of Transmission System Operators for Electricity (ENTSO-E) has published EU Offshore Network Development Plans (ONDP), the first comprehensive cross-border review of existing offshore grid capacity and future offshore grid requirements at sea basin level.
- The industry is demonstrating willingness to invest in hybrid offshore wind farms. According to the ONDP, 14% of all offshore renewables could be connected as hybrids.
- To ensure energy security, clean technology development, 'made in Europe', and fair-trade, the EU's Wind Power Package and the Net-Zero Industry Act would offer a multidimensional demand-side approach to speed up project deployment, improving overall investment conditions for wind manufacturing, protect the internal market against trade distortions and threats to security and public order.

These constructive efforts have led to increased predictability for the offshore wind sector in the region from financial planning to supply chain (cables, pipes, vessels) plans to port and grid infrastructure, as well as access to resources.

However, in order to realise affordable offshore wind growth led by innovation, greater attention is needed on the following: implementation of EU rules for wind energy and grid permitting, system digitalisation, long-term supply chain availability, right cross-border cost sharing mechanisms, clear revenue perspectives for hybrid offshore wind farm models, and investments into large scale grid and port infrastructure. Additionally, the 'made in Europe' strategy should not manifest in measures that outright block current trade flows, increase cost burdens, and interrupt or delay offshore wind deployment.

South Africa

Contributed by SAWEA

South Africa's wind energy market has matured over the past decade, largely due to the inclusion of wind as a core element in the country's energy planning. The allocation of wind procurement in the Integrated Resource Plan (IRP) of 2010 paved the way for utility-scale wind projects, with the first wind farms reaching commercial operation in 2014 under Bid Window 1 of the Renewable Energy Independent Power Producer Procurement Programme (REIPPP). The revised IRP 2019 further allocated 1,600 MW of wind energy annually from 2021 to 2030.

Currently, South Africa has completed 34 wind farms with a total output of 3,442 MW, demonstrating steady growth in the wind energy market. The addition of these megawatts to the country's electricity system through private sector investment has positioned South Africa as a prime onshore investment destination in the region. However, more progress is needed in developing offshore wind energy.

Offshore wind pipeline in South Africa

South Africa's energy planning policies continue to evolve, with the Draft IRP 2023 released for public consultation in the first quarter of 2024. While onshore wind has been included in the envisaged energy mix, offshore wind is yet to be incorporated.

There have, however, been several desk studies undertaken, most notably by CSIR in 2022 (Draft Final Report: Potential of offshore wind energy as a power source for South Africa) to assess the feasibility of establishment of offshore wind farms on the South African coast.

The report states that South Africa has an annual offshore wind energy production potential of 44,52 TWh of electricity if wind turbines are be installed in shallow waters (depths of less than 50m) and 2 387,08 TWh with wind turbines in deeper waters (depths less than 1 000m). Meaning that South Africa's offshore wind potential is equivalent to eight times the electricity needs of the nation.

It further outlines that although the country has vast high-quality offshore wind resources, exploiting them would likely only occur in the long term. This is because the government would need to take a leading role in developing a clear policy framework that integrates offshore wind in the country's long-term energy mix. This would also require extensive consultation and thorough assessments to take into consideration all possible favourable and adverse scenarios.

In 2023 the World Bank begun the studies to create the Offshore Wind Roadmap for South Africa which is due to launch later in 2024. A World Bank Group (Going Global: Expanding Offshore Wind in Emerging Markets) estimated that South Africa has the potential of 852 GW for floating and 49 GW for fixed offshore wind farms.

Offshore wind farm licensing and permitting process

The ownership and permitting process for the establishment of an offshore wind farm is one of the greatest uncertainties in the development of such a project. South Africa's coastline is owned by the government with permits issued to various companies for fishing, recreation, conservation, and mineral exploration. It is likely that offshore wind developments would have to follow a similar approach to obtain permits from the Department of Forestry, Fisheries and the Environment (DFFE), the South African National Defence Force (Navy) and others in order to build a wind farm.

While there is growing interest in developing an offshore wind facility, the significant costs associated with this, as well as the unclear permitting regulatory framework, has made the development of a project very difficult. Details about any kind of progress are scarce. However, South Africa certainly has offshore wind potential given its 2,798km coastline, with the Western Cape accounting for over 1,000km, the longest stretch of the four South African coastal provinces. Energy generated from the country's coastlines could help increase South Africa's energy supply and accelerate the transition to a low-carbon future.

MENA

The case for offshore wind the Middle East

The Middle East has been at the epicentre of the oil and gas industry for over a century. The energy transition has been challenging for the region, despite the ambitious renewable energy targets set by MENA governments. Given the weather conditions and geographical location, the Middle East is often positioned as an ideal spot for solar developments, at times overlooking its equally significant wind potential. However, it is important to note that countries such as Saudi Arabia, Morocco, Egypt, and Oman boast significant wind potential, in both onshore and offshore locations. Given the larger investments involved in offshore wind and the readily available onshore locations in most of the Middle East, the region has yet to see any real development of its offshore wind market. However, trends are shifting in the Middle East: Efforts to diversify energy sources, potential development of subsea interconnectors to Europe, and the potential of green energy/green product exports may encourage MENA countries to reconsider their original stance on offshore wind.

Highlight: Morocco

The Kingdom of Morocco is heavily reliant on energy imports, with over 91% of its energy coming from external sources. Despite this, the Moroccan government has made significant progress in the field of renewable energy, and currently has a target of reaching 51% renewable energy by 2030. Although there are no set targets for the development of offshore wind, the government is taking serious steps in considering the possibility of this technology in the region.

The European Investment Bank (EIB) recently awarded the Moroccan Agency for Sustainable Energy (MASEN) a $2 billion grant to conduct a feasibility study for offshore wind in Morocco. The study will assess the potential of turning Morocco's Atlantic coast into an offshore wind energy hub, taking into consideration the technical, environmental, and economical requirements of these projects. Both parties are hopeful that this feasibility study will lead to the imminent development of offshore small-scale pilot projects, paving the way for large-scale rollout in the future.

Morocco's desire to position itself as a regional green hydrogen hub and a main exporter of green electricity to Europe (through the much-anticipated Xlinks project) will further contribute to the case for offshore wind development. According to a previous GWEC study, Morocco's offshore potential is around 200 GW.

Highlight: Saudi Arabia

Another potential country for offshore development is Saudi Arabia, with an overall offshore capacity of 106 GW along its eastern and western coasts. The oil-rich kingdom currently has only one onshore wind farm in operation (Dumat al Jandal) but has ambitious further renewable energy plans. By 2040, the country aims to generate half of its energy supply from renewable energy sources and to reach net zero by 2060. In addition, futuristic endeavours such as NEOM have promised to turn Saudi Arabia into a frontrunner in the energy transition race. The launch of green hydrogen schemes and the potential to export of green products, including green hydrogen derivatives, are encouraging for the development of both onshore and offshore wind. However, timelines for these plans are unclear, and there is a lack of transparency on the future projects, both onshore and offshore.

Offshore Wind Outlook

The total offshore wind potential for the Middle East is around 1,400 GW, however, currently the only offshore activities in the region are that of offshore oil and gas. The wind industry is considered a nascent industry in the Middle East, with only a few champion countries, such as Morocco and Egypt. The significant potential of offshore wind indicates that there may (and should) be development in the Middle East region. However, this depends greatly on the investment environment, national regulations, and permitting procedures, as well as the availability of a skilled workforce with experience in this industry.

United States

The US only had 42 MW of offshore wind capacity in operation by the end of 2023, the same figure as previous year. However, the situation is expected to change as four projects with a combined capacity of 4.3 GW are currently under construction, with another 50 GW of offshore wind projects in the development and planning stages. In addition to owning one of the world's largest project pipelines, the US has an ambitious offshore wind target of 30 GW by 2030. At the state level, with new offshore wind targets signed into law in Maryland, Maine, and California in 2023, eleven states have a combined offshore wind procurement target of 84 GW.

2023 – a year full of headwinds for the US offshore wind industry

Challenges such as inflation, increased capital costs and supply chain constraints – including for vessels and foundations – created uncertainty in the US offshore wind sector, forcing developers either to renegotiate the signed offtake agreements or, in the worst cases, terminate PPAs and cease project development.

By January 2024, 13 US offshore wind projects off the east coast totalling nearly 12 GW were affected by the 'storm'. Of these, nine projects, totalling 7.7 GW, have either had their offtake agreements terminated or seen the whole project development ceased, which triggered multi-billion-dollar write-down by large European and US developers.

Due to the turbulence experienced by the US offshore wind sector, GWEC Market Intelligence has downgraded the 2030 US offshore wind outlook to 15 GW from the 25 GW predicted in the previous year's outlook.

Correcting the course of the offshore wind sector

After a period of turmoil in the last 18 months, the more recent weeks in the US market have witnessed some key policy strides aimed at correcting the course of the offshore wind sector. These strides are marked by key announcements, regulatory levers, and strategic planning initiatives.

At the **federal level**, acknowledging the collective hurdles faced by both industry and government amidst prevailing macroeconomic conditions, in an official address to industry recently, the US Deputy Secretary of Energy, David Turk reiterated the federal administration's endorsement of the substantial progress underway in offshore wind energy across the country. The governing Biden administration remains committed to supporting projects through tax incentives delineated in the Inflation Reduction Act (IRA) and various supply chain loan programmes. A recent US Treasury rule change in the IRA enables offshore wind developers to qualify for higher subsidies, including a domestic content bonus and energy community bonus. This change is expected to boost the equity returns to a double-digit rate. The Department of Energy' recently published the Offshore Wind Liftoff Report (April 2024), alongside the allocation of $48 million in research and development funding aimed at advancing offshore wind technology and bolstering domestic manufacturing capabilities.

The Bureau of Ocean Energy Management (BOEM), in collaboration with the Bureau of Safety and Environmental Enforcement, also announced the modernisation of offshore renewable energy regulations. This effort aims to provide clarity for developers while ensuring the protection of vital natural and cultural resources.

At the **state level**, in response to the challenges facing the US offshore wind industry, the Request for Proposals (RFP) for 2 GW of offshore wind generation capacity issued by the Connecticut Department of Energy and Environmental Protection (DEEP) in November 2023 include a few new provisions, such as an indexed pricing option that adjusts for inflation.

One month later, New York State launched its fourth, expedited offshore wind solicitation. The procurement process, which also includes an indexed pricing option, allowed projects that previously petitioned the Commission for financial relief to participate. In February 2024, the New York State Energy Research and Development Authority (NYSERDA) selected Equinor's Empire Wind 1 (810 MW) and Ørsted and Eversource's Sunrise Wind (924 MW) projects in the state's fourth offshore wind solicitation. Both projects had previously secured agreements with the state and rebid in the latest procurement round to negotiate new 25-year contracts.

Furthermore, the New York State Energy and Research Authority, has iterated New York's fifth offshore wind solicitation round and confirmed ongoing efforts to formulate the state's second offshore wind master plan.

The New York State Energy and Research Authority (NYSERDA), has shared details on New York's fifth offshore wind solicitation round, underscoring the state's ongoing endeavours in crafting its second offshore wind master plan. The strategic timing of the Request for Information (RFI) for the fifth solicitation round is aimed at instilling confidence in the sector after a series of setbacks.

NYSERDA has reaffirmed the unwavering dedication to offshore wind development while addressing concerns pertaining to New York solicitation Round 3. Subsequent to the provisional award announcement, material modifications to projects bid into New York's third offshore wind solicitation caused technical and commercial complexities between provisional awardees and their partners. This led to the provisionally awarded parties being unable to come to terms, resulting in the cancellation of the awards. These awards collectively represented a combined capacity of over 4 GW.

As a step to remedy the impacts, NYSERDA has been advocating for withholding the disclosure of future solicitation round winners until final contract signing to fortify negotiation strategies. The agency has called for feedback on discontinuing the practice of announcing provisional winners before final contracts, seeking to enhance the transparency and effectiveness of the award announcement process.

Additionally, NYSERDA is soliciting input on a coordinated $300 million Major Component Supply Chain request for proposals, with responses requested by 21 May 2024.

In New Jersey, the Board of Public Utilities (BPU) selected in January 2024, two new offshore wind projects with a combined capacity of 3,742 MW through its third offshore wind solicitation. The contract awarded by the BPU also includes a one-time inflation adjustment mechanism to compensate for changes in construction costs environment until the final investment decision. According to the developer who won the solicitation, there was a guaranteed level of Offshore Renewable Energy Credit (OREC) revenue, with a first-year set price of $131/MWh after the start of commercial operations, inflated

yearly by 3%, and the benefit of a 30% Inflation Reduction Act (IRA) tax credit.

On 30 April, New Jersey launched its fourth round of offshore wind solicitation, aiming to award between 1.2 GW and 4 GW of generation capacity. The application window will stay open until 10 July 2024. One month later, BPU announced to move up its fifth solicitation for additional offshore wind projects from the third quarter of 2026 to the second quarter of 2025, demonstrating the state remains committed to developing offshore wind.

Lease solicitations- a fresh start for offshore wind in 2024

Most notably, the department of Interior unveiled in April 2024, a new five-year schedule of offshore wind leasing rounds, aiming for up to 12 lease sales by 2028. This year marks the commencement of leasing rounds in the Central Atlantic, Gulf of Maine, Gulf of Mexico, and Oregon regions. Subsequently, another leasing process is slated for the Gulf of Mexico in 2025. In 2026, a second tender in the Gulf and Central Atlantic is scheduled. In 2027, another round in the Gulf of Mexico and the subsequent New York Bight lease will be initiated, followed by additional auctions in California and the Gulf of Maine, along with the inaugural auction for US territory Hawaii in 2028.

Year	U.S. Outer Continental Shelf Region
2024	Central Atlantic, Gulf of Maine, Gulf of Mexico, and Oregon
2025	Gulf of Mexico
2026	Central Atlantic
2027	Gulf of Mexico and New York Bight
2028	California, a U.S. Territory, Gulf of Maine, and Hawaii

Gulf of Marine and Oregon

In March 2024, BOEM designated a final Wind Energy Area (WEA) in the Gulf of Maine, which has the potential to support 32 GW of offshore wind capacity. In April, the US Department of the Interior (DOI) proposed lease sales for offshore wind areas off the coast of Oregon and in the Gulf of Maine, collectively offering potential for over 18 GW of offshore wind generation. Since all of the areas are in deep water, floating offshore wind is expected to be deployed.

The first-ever offshore wind auction in the Gulf of Maine WEA would include eight lease areas off the coasts of Maine, Massachusetts, and New Hampshire, with the potential to generate approximately 15 GW of clean power.

The proposed lease sale in Oregon includes two lease areas with one in the Coos Bay WEA and the other in the Brookings WEA. Collectively, these areas have the potential to generate more than 3 GW of offshore wind capacity.

Gulf of Mexico

In addition to lease sales in the Gulf of Mexico launched in July 2023, with RWE securing the rights to develop an offshore wind project at the Lake Charles Lease Area off Louisiana, the DOI proposed in March 2024, a second offshore wind energy lease sale in the Gulf of Mexico, with four areas of the coasts of Louisiana and Texas to be auctioned.

Multi-State Collaboration and Procurement Efforts

Several north-eastern states, including Rhode Island, Massachusetts, and Connecticut, are collaborating on developing a multi-state approach to offshore wind procurement. This collaborative effort aims to leverage collective buying power and maximise operational efficiencies. In March 2024, four developers submitted bids in response to the combined Connecticut-Massachusetts-Rhode Island offshore wind solicitation with the tenders totalling 6.8 GW.

Small Islands Developing States

contributed by World Bank Group ESMAP

Islands represent a unique opportunity and challenge for future offshore wind development.

Islands, whether classified as Small Island States or regions within countries (referred to as Small Islands Developing States - SIDS), can emerge as strong candidates for offshore wind development from economic, technical, and climate policy perspectives. Firstly, they are often surrounded by strong wind resources and bathymetric conditions suitable for either fixed or floating foundation offshore wind projects. As an indication, mapping by the ESMAP-IFC Offshore Wind Development Program in the Caribbean islands revealed an offshore wind technical potential of 751 GW, enough to satisfy regional electricity needs many times over.[43] Secondly, many islands are faced with the dual problems of high energy costs and energy insecurity from imported fossil fuels. Looking at the case of Barbados, the country has retail electricity tariffs well over 30 US cents/kWh and spends approximately 7% of its annual gross domestic product (GDP) on imported fuel. Thirdly, limited land availability means that islands often face constraints when trying to build out their onshore renewable energy resources. In these cases, exploiting a plentiful offshore resource may be very sensible.

One of the main economic resources underpinning the development of SIDS is to take advantage of the attraction of their extraordinary natural and environmental resources for tourism. As an indication, tourism is the main driver of the economy in the Eastern Caribbean. It accounts for 50% of regional Gross Domestic Product (GDP) and some 40% of employment. Nowadays, the tourism sector is increasingly aware of and demanding of a commitment for environmental sustainability, which for SIDS can be incompatible with their dependency on imported fossil fuels. These fuels are subject to unpredictable high and rising prices, their supply is uncertain and they pose a significant threat to the environment over time.

Unleashing the Blue Economy in Caribbean islands, and SIDS worldwide through offshore wind strategic marine spatial planning and systematic ecological and socioeconomic assessments, based on social acceptance, social cost–benefit, and multi-criteria decision analyses, will drive enormous economic growth and provide long lasting resilience to the traditional activities in the SIDS.

The challenge of scale currently facing offshore wind in SIDS can be turned into real opportunities when addressing energy planning with a regional integration approach, as interconnecting SIDS grid systems and electricity markets each other so as to the continent will provide a perfect playing field to address energy efficiency and security through offshore wind, which is calling for a much stronger support and institutional cooperation to envisage development at the convenient scale. The global offshore wind industry has developed rapidly due to economies of scale in both the turbines themselves and the projects they are a part of. As of 2024, offshore wind turbines typically exceed 14 MW capacity and are installed in wind farms of 1,000 MW or more, with a total capital expenditure (CapEx) exceeding $3 billion USD. This steadily increasing scale is also found in the infrastructure needed to make the projects happen, notably the vessels that install the turbines, foundations, cables and substations. As a result, vessels built to accommodate the previous generation of offshore turbines (e.g. those under 8 MW) have become outdated whereas the vessels needed to install the next generation of turbines are in critically short supply. It may also represent an opportunity for medium scale developments as there are indeed cases where offshore wind can be a viable part of an island's long-term energy planning.

So, what are some of the factors that policymakers and island populations should take into consideration when unlocking offshore wind?

Technical resources, including wind speeds, water depths and general seabed conditions, should be considered. The Global Wind Atlas provides a good reference for wind resource and bathymetry[44]; generally, significant areas with wind speeds over 7 m/s and water depths

43. https://documents1.worldbank.org/curated/en/261081586847581050/pdf/Technical-Potential-for-Offshore-Wind-in-Caribbean-Islands-Map.pdf
44. https://globalwindatlas.info/en

less than 70 m are desirable. For reference, the World Bank Group's Offshore Wind Development program has produced viability maps for 56 countries and regions . Once areas have been identified, it is critical to assess the social and biodiversity risk factors that may impact the developable area. The World Bank has recently released a report on Integrated Environmental and Social Sensitivity Mapping: Guidance for Early Offshore Wind Spatial Planning (SenMap) which is intended to guide this assessment. This evaluation is particularly important for islands, which often have high concentrations of sensitive species. Assuming the resource is reasonable, and there appears to be areas of low environmental and social sensitivity, it is necessary to determine the desired project scale. Lessons learned in mature markets show that to achieve a significant scale-up of offshore wind the development and planning for the grid should look beyond national borders and cover the entire sea basin, calling for a wider energy integration. This planning should increasingly consider the possibility of multi-functionality, such as hybrid projects, or at a later stage, a more meshed grid. Such developments would enable the uptake of further renewable energy devices and new marine activities. Offshore wind plays a perfect role as a generation source for green hydrogen production or e-methanol conversion, which is particularly meaningful to decarbonising oil & gas exploration and production activities taking place in some SIDS, like Trinidad and Tobago. Assuming the economics are favourable, this increased power demand may similarly raise the project size threshold.

Assuming the above conditions are met, the question then becomes how the project could be carried out. Attention then turns to the most appropriate turbines, the vessels for their installation. In some cases, using the "latest and greatest" turbines may not be advisable. Instead, a better choice might be a "previous generation" offshore wind turbine or even a marinised version of an onshore wind turbine. For turbines under 8 MW, much of the existing fleet of installation vessels, cable-laying vessels, and crew transfer vessels can be deployed. This approach not only facilitate smaller-scale project development but may also reduce project costs, as charter rates for the smaller vessels are significantly lower than those for the larger vessels in high demand.

Looking to the future, floating wind may also present a viable option for islands that meet the above criteria. Although floating wind has a higher levelised cost of electricity (LCOE) than fixed foundation wind, it does not have the same on-site installation requirements (e.g., the use of jack-ups for foundation and turbine installation). Floating turbines can be constructed at an appropriate port (likely in a developed market) and then towed out to an island for installation by smaller vessels. The issue of scale may be addressed in this case if multiple projects are built at one port, allowing for large-scale production of turbines, with small groups of turbines being deployed to different islands.

In all cases, existing stakeholders of the marine space need to be engaged early on to ensure that the new activities contribute positively to economic, social, and environmental considerations. Early identification of these stakeholders and inclusive dialogue are essential to create projects that are welcomed by communities and can be delivered efficiently.

45. https://www.esmap.org/esmap_offshorewind_techpotential_analysis_maps

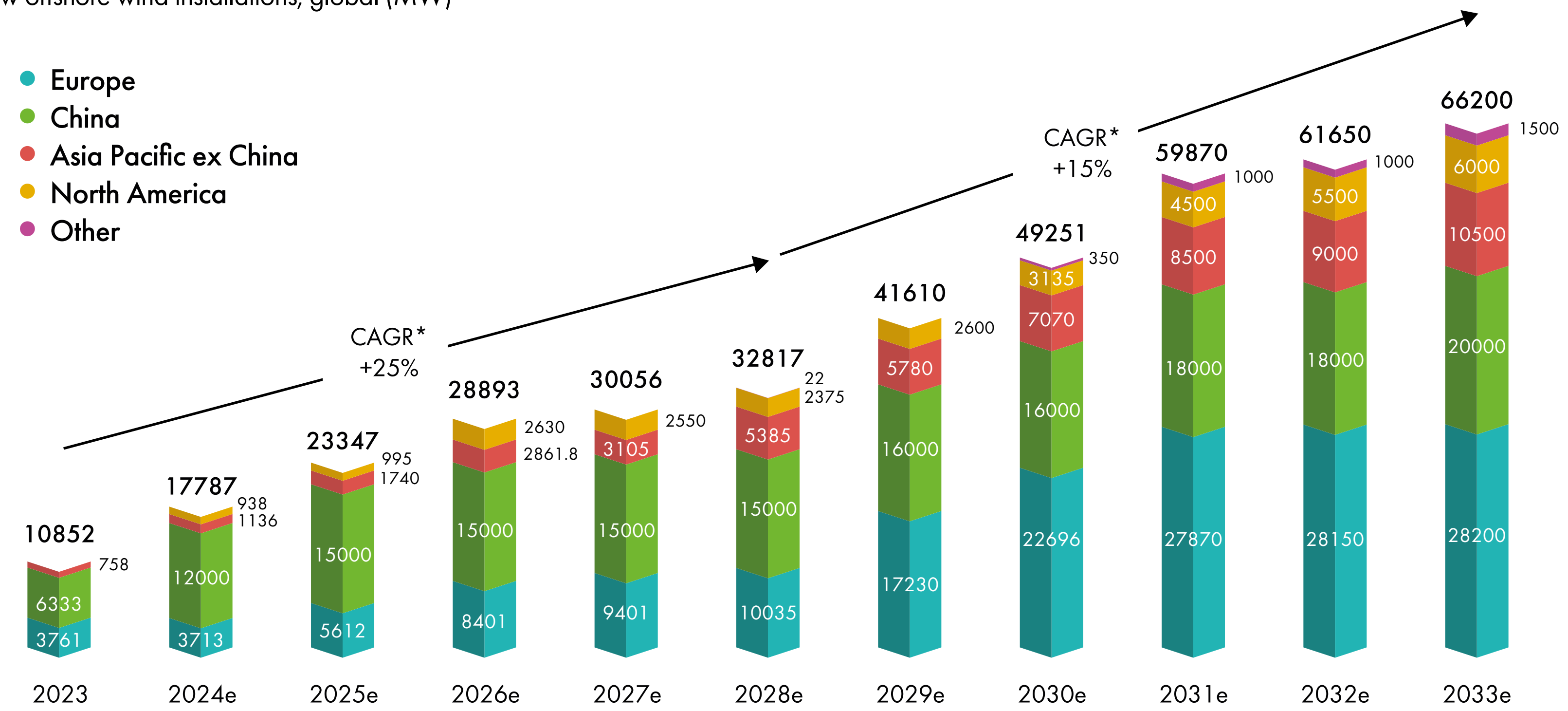
MARKET OUTLOOK 2024 - 2033

Global Offshore Market Outlook to 2033

Moving beyond the turbulence in 2023
2023 was a monumental year for offshore wind. The inclusion of a global goal of tripling renewable energy by 2030 in the final COP28 text is unprecedented and historic for offshore wind and other renewable energy sources. A favourable political environment across the globe and the urgency of ensuring energy security driven by Russia's invasion of Ukraine position offshore wind as a vital resource for achieving both objectives. Exponential growth is expected this decade and beyond.

But 2023 was also a turbulent year for the offshore wind industry on both sides of the Atlantic Ocean.

New offshore wind installations, global (MW)



* Compound Annual Growth Rate.
Source: GWEC Market Intelligence, June 2024

Challenges such as inflation, increased capital costs and supply chain constraints created uncertainty in the sector. No developers submitted bids to the UK's Contracts of Difference (CfD) AR5 auction last year due to the strike prices being too low and not reflecting rising costs. Those same challenges forced some project developers to renegotiate signed project contracts or terminate offtake agreements and cancel project development.

The 1.4 GW Norfolk Boreas offshore wind farm that won the UK's CfD AR4 auction in 2022 and 13 fixed-bottom offshore projects off the US east coast, totalling nearly 12 GW, were all affected by such challenges. Of these, nine projects, totalling 7.7 GW, had either had their offtake agreements terminated or had the whole project development ceased by January this year.

Despite the headwinds experienced in 2023, governments and developers remain committed to developing offshore wind. The industry's consensus is that the worst has passed, and the offshore wind sector has entered 2024 poised for a new wave of growth.

In the US, New York State launched its fourth, expedited offshore wind solicitation in December 2023. This allowed projects that previously petitioned the state's Public Service Commission for PPA renegotiation and financial relief to participate. In February 2024, The New York State Energy Research and Development Authority (NYSERDA) selected two projects totalling 1.73 GW in the state's fourth offshore wind solicitation. Both projects had previously secured agreements with the state and rebid in the latest procurement round to negotiate new 25-year contracts.

In the UK, in response to the challenges facing the wind industry, the government increased the strike prices under the CfD AR6 in November 2023. The following month, RWE took over the entire Norfolk offshore wind development site from Vattenfall and resumed the development of the Norfolk Boreas project that the Swedish utility halted the previous summer. In March 2024, the government announced that it would provide GBP 800 million (EUR 936 million) to support offshore wind in the CfD AR6, which is expected to procure approximately 4-6 GW of offshore wind.

According to GWEC Market Intelligence's global wind auction database, 2024 will be a record year in offshore wind auctions, with more than 60 GW of offshore wind capacity expected to go through auctions and lease processes.

Global offshore wind market expected to grow 20% on average each year

Considering the near-term challenges, GWEC Market Intelligence has downgraded its global offshore wind outlook for total additions in 2024–2028 by 10% compared with our 2023 projection. Nevertheless, the global offshore wind market outlook in the medium term remains resolutely promising. With a compound average annual growth rate of 25% until 2028 and 15% up to the early 2030s, new installations are expected to sail past the milestones of 40 GW in 2029 and 60 GW by 2032.

GWEC Market Intelligence expects more than 410 GW of new offshore wind capacity to be added over the next decade (2024–2033), bringing the total offshore wind capacity to 486 GW by the end of 2033. However, less than one-third of this projected new volume will be added in 2024–2028.

Annual offshore wind installations

are expected to triple in 2028 from 10.8 GW in 2023. By 2033, they are expected to reach 66 GW, bringing the offshore share of new wind power installations from today's 9% to at least 25%.

After being the world's largest regional offshore wind market for decades, Europe lost the title to Asia-Pacific in 2020 for new installations, and in 2022 for cumulative installations. Considering the strong growth expected in China as well as burgeoning new Asian markets, APAC's leading position in offshore wind installations is unlikely to be challenged in the next decade. GWEC believes that 52% of the predicted global offshore wind additions in 2024–2033 will come from this region.

The offshore wind outlook for Europe remains stable and optimistic. Driven by the dual objective of achieving energy independence from Russian oil and gas, while delivering on climate change commitments, the continent's annual installations are likely to surpass the 10 GW milestone in 2028 and 20 GW in 2030.

Although we have downgraded the 2030 offshore wind installation outlook for the US to 15 GW from the 25 GW predicted in 2023, North America will remain the third-largest offshore wind market by 2033, followed by Latin America. No offshore wind installations are expected in Africa and the Middle East during the forecast period, as in our previous forecast.

By 2033, annual offshore wind installations are expected to reach 66GW, bringing the offshore wind share of new wind power installations from today's 9% to at least 25%.

China and Europe made up 95% of the world's total offshore wind installations by the end of 2023. Although the two markets will continue to dominate offshore wind growth going forward, their global market share in cumulative installations is expected to drop to 88% in 2028 and 80% in 2033, primarily because of growth in other APAC markets and the US. With a project pipeline of more than 180 GW in Brazil and some progress made in Colombia, the first utility scale offshore wind project is likely to come online in Latin America in the early 2030s.

Our near-term offshore wind market outlook (2024–2028), built using a bottom-up approach, is based on GWEC Market Intelligence's global offshore wind project database, which covers projects currently under construction, global auction results and announced offshore wind tenders worldwide. For the medium-term market outlook (2029–2033), a top-down approach was used alongside existing project pipelines. This takes into account existing policies and medium/long-term national and regional offshore wind targets. There is currently an implementation gap between declared targets and the rate of annual installations. The areas of permitting, finance, supply chain, and grids will remain key for forecast growth to materialise, and to propel offshore wind power development into a new phase of even faster growth.

Europe

The world's first fixed-bottom and MW-scale floating offshore wind projects were installed in Denmark and Norway in 1991 and 2009 respectively, making Europe the birthplace of offshore wind. After three decades of development, fixed-bottom offshore wind technology has matured, with supply chain and infrastructure becoming established and many jobs being created in markets neighbouring the North and Baltic Seas. Although Europe has lost its world-leading position to APAC in total installed offshore wind capacity, it remains the world's largest market for floating wind and the technology hub for floating wind turbines and foundations.

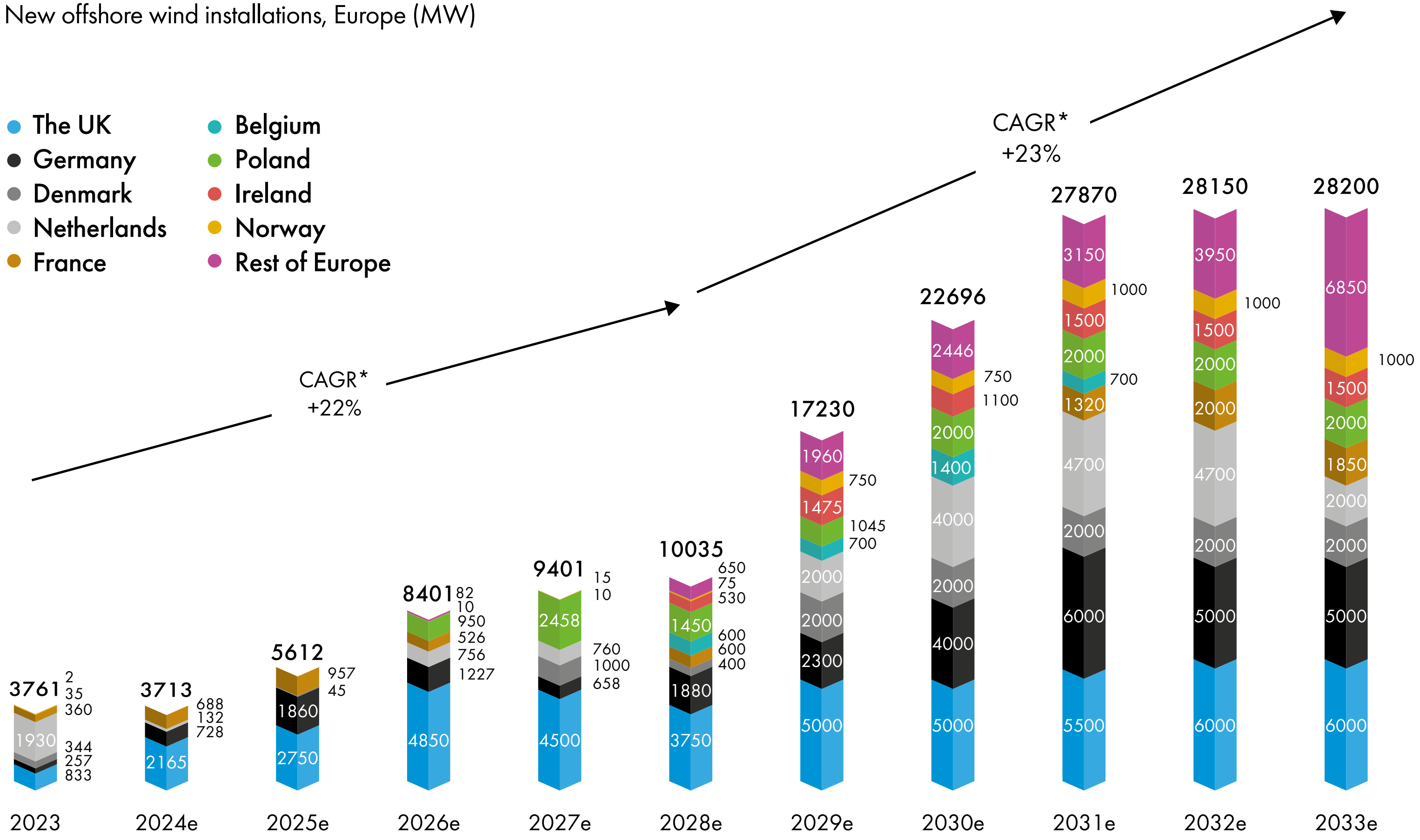
Our ten-year growth projection for Europe is based on the following elements:

1) The EU's new energy security strategy, REPowerEU, is likely to accelerate offshore wind and renewable hydrogen deployment on the back of Europe's urgency to replace fossil fuels with renewables to achieve energy security in the aftermath of the Russian invasion of Ukraine.

2) The EU Wind Power Package published by the European Commission in October 2023, as well as the European Wind Charter, endorsed by 26 EU member states and more than 300 companies from the wind sector in December, have shown a commitment to strengthening the competitiveness of Europe's wind value chain.

3) A Communication to deliver on the EU's offshore renewable energy ambitions under the Wind Power Package has raised the EU's offshore renewable energy target for 2030 to

New offshore wind installations, Europe (MW)



*Compound Annual Growth Rate.
Source: GWEC Market Intelligence, June 2024

111 GW, from the 60 GW set out in the 2020 EU Offshore Renewable Energy Strategy, and to around 317 GW for 2050, up from the 300 GW set out in the EU's net zero commitments under the EU Green Deal.

4) Belgium, Denmark, France, Germany, Ireland, Luxembourg, the Netherlands, Norway, and Sweden, together with the European Commission, agreed last November to joint planning of offshore wind tenders. They are set to auction off 15 GW each year in order to increase predictability while allowing for better collaboration and coordination.

5) Fixed-bottom offshore wind has become the most competitive electricity generation technology after onshore wind and solar PV, but with considerable advantages in terms of being able to deploy at scale.

6) The commercialisation of floating wind will unlock the potential in deep waters in the North Sea, Atlantic Ocean, and Mediterranean Sea.

GWEC Market Intelligence maintains a double-digit growth rate projection for this continent in the next ten years, but a 10 GW level of annual offshore wind installation is unlikely to be achieved until 2027 or 2028.

Offshore wind additions in the near term (2024–2025) are expected to be relatively slow, with average annual installations staying at the 4.7 GW level. This is mainly due to lower activity levels in established markets such as Denmark, Netherland, and Belgium in this period. However, with multi-GW wind projects from Round 3 and 4 auctions in the UK coming into operation and utility-scale projects becoming connected in new markets such as Poland and Ireland, new installations in Europe are likely to pass the 10 GW milestone in 2028.

If GW-scale projects materialise from announced auction plans in the Baltic

The latest offshore wind targets in Europe

Unit: GW	2027	2030	2035	2040	2045	2050
EU Wind Power Package		111				317
UK		50*				
Germany		30	40		≥70	
Netherlands		22.2		50		70
Denmark		12.9				
Belgium		5.7		8		
France			18			45
Poland	10.9**					
Norway				30		
Ireland		7		20		37
Spain		3				
Greece		2				
Portugal		10***				
Esbjerg Declaration****		≥65				≥150
Marienborg Declaration*****		19.6				
Ostend Declaration******		120				300

*Including 5 GW floating wind power
**Either in operation or under development by 2027
*** Capacity to be awarded through auctions
**** North Sea countries have set a joint target through the Esbjerg Declaration (Germany, Denmark, Belgium, and the Netherlands)
***** Baltic Sea countries have set a joint target through the Marienborg Declaration (Denmark, Germany, Estonia, Latvia, Lithuania, Poland, Finland, and Sweden)
****** North Sea countries have set a joint target through the Ostend Declaration (Belgium, Denmark, Germany, Netherlands, France, Ireland, Luxembourg, Norway, and the United Kingdom)
Source: GWEC Market Intelligence, May 2024

Sea as well as mature markets such as Germany, Denmark, the Netherlands, and Belgium, annual growth in Europe can potentially reach 20 GW by the end of this decade and 30 GW in the mid-2030s. This is based on the assumption that the supply chain, including vessels, and infrastructure such as ports and grid transmission, can cope. Around 77% of the total volume predicted to be added in Europe in the next ten years will be built in the second half of this period (2028–2032).

The UK

The UK remains the largest offshore wind market in Europe and the second largest in the world. As of May 2024, 12.3 GW was under construction and more than 100 GW was at different stages of development.

In July 2022, almost 7 GW of new offshore wind projects won the UK's CfD Allocation Round 4 (AR4) auction. However, no developers submitted bids to the UK's CfD AR5 auction last year, primarily due to the strike prices being too low and not reflecting rising costs. In response to the challenges facing the wind industry, last November the bid price ceilings under CfD AR6 were increased to GBP 73/MWh (€83.9/MWh) for bottom-fixed offshore wind and to GBP 176/MWh (€202.3/MWh) for floating offshore wind. In early March, the UK government unveiled a GBP 800 million budget for offshore wind under the CfD AR6 auction round, which officially opened later in March.

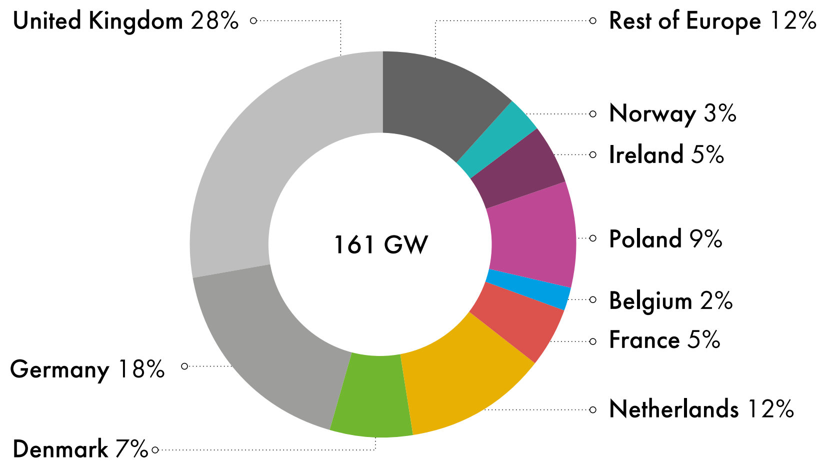
With regards to seabed leasing, in October 2023, the Crown Estate boosted the Celtic Sea floating wind leasing round, known as Round 5, from 4 GW to 4.5 GW. In February 2024, it opened the Round 5 seabed leasing process, which is expected to be the first phase of offshore wind development in the Celtic Sea. The UK Government intends to unlock space for up to a further 12 GW of offshore wind capacity in the Celtic Sea.

To achieve the offshore wind target of 50 GW by 2030, the Crown Estate last November revealed plans to enable up to an additional 4 GW of generation from several existing offshore wind projects that were awarded rights in either Offshore Wind Leasing Round 3 or the 2017 Offshore Wind Extensions opportunity.

In March, the UK's electricity system operator (ESO) proposed a GBP 58 billion grid investment with a vision for incorporating an additional 21 GW of offshore wind into the grid by 2035, which would potentially bring the country's total offshore wind capacity to 86 GW.

In April, four industry bodies including RenewableUK, the Crown Estate, and Crown Estate Scotland released an Industrial Growth Plan setting out how to triple offshore wind manufacturing capacity over the next ten years in the UK. They identified five key technology areas including blades, towers, foundations, and cables for the UK to prioritise investment.

Total offshore wind added between 2024 and 2033



Source: GWEC Market Intelligence, June 2024

Germany

As the second-largest offshore wind market in Europe, Germany has connected four small projects, totalling 836 MW, in the past four years. This was mainly due to unfavourable market conditions and a lack of mid-term visibility. However, this slow growth period will come to an end when the 2.5 GW of capacity awarded through its first and second round of offshore wind auctions comes into operation in 2024–2025. In addition, the German Offshore Wind Energy Act (WindSeeG), amended by the new German

government through the 'Easter Package' in April 2022 and approved by the EU in December 2022, provides long-term visibility to the market. The amended offshore wind legislation requires 30 GW of operational offshore wind by 2030, 40 GW by 2035 and at least 70 GW by 2045.

Through the amended WindSeeG, the government also introduced two-track auction systems: one with sites centrally developed by state authorities and another with non-predeveloped sites, and allowed for 'negative bidding'. In addition, the new Act will procure offshore wind power for green hydrogen production through six annual tenders, each with 500 MW of capacity, from 2023.

Last year, Germany launched and awarded 8.8 GW of offshore wind via a zero-subsidy tender. Out of this, 7 GW, across four sites, was not centrally pre-surveyed and featured a 'dynamic bidding' system. The remaining 1.8 GW awarded across four sites in the North Sea was centrally pre-surveyed. Entering 2024, the country has launched two tenders: one with 2.5 GW of non-centrally pre-surveyed capacity across two sites and another with 5.5 GW of centrally pre-surveyed capacity across three sites – all in the North Sea.

To reduce its reliance on Russian fossil fuels, Germany signed a cooperation agreement on offshore wind development and green hydrogen with three North Sea countries through the Esbjerg Declaration, eight Baltic Sea countries through the Marienborg Declaration, and eight North Sea countries through the North Seas Energy Cooperation and Ostend Declaration.

To support the country's offshore wind target, Germany's Federal Maritime and Hydrographic Agency (Bundesamt für Seeschifffahrt und Hydrographie or BSH) released in January 2023, an offshore wind area development plan for the North Sea and the Baltic Sea mapping out 36.5 GW of offshore wind buildout by 2030. However, BSH expects offshore wind grid connection delays, which will impact the capacity scheduled to be online by 2030.

Denmark

As the birthplace of offshore wind, Denmark is not only a hub for

offshore wind technology, but also home to the world's largest offshore wind turbine supplier (Vestas) and the world's largest offshore wind port (Esbjerg). To secure its energy independence from Russia's oil and gas while supporting the EU's energy security strategy, the country hosted three North Sea countries and eight Baltic Sea countries in May and August 2022 to sign the Esbjerg and Marienborg declarations, respectively.

At the beginning of 2022, the government announced a plan to put 9 GW of new offshore wind capacity out for tender by the end of the year. However, there were no developments until April 2024, when Denmark launched its largest offshore wind tender, with 6 GW of capacity across six sites in the areas of North Sea I, Kattegat, Kriegers Flak II, and Hesselø. The announced capacity can be increased to 10 GW after an 'over-planting' option was agreed. The state will own a 20% stake in these offshore wind farms.

The government suspended the processing of offshore wind farm projects under the open-door scheme in February 2023 for fear the scheme may be in breach of EU law. Although nine projects totalling 3.6 GW were released and can continue with the development, 24 of the 33 offshore wind projects proposed under the scheme have been cancelled.

Netherlands

The Netherlands is the third-largest offshore wind market in Europe with nearly 5 GW of offshore wind capacity in operation. To meet the EU's CO2 emissions reduction target, the country has increased its 2030 offshore wind target from 11.5 GW to 22.2 GW.

In June 2022, the Dutch government disclosed tendering timelines and locations for nine offshore wind projects with a combined capacity of up to 13.4 GW. The projects, individually ranging from 700 MW to 2 GW, are scheduled to be put out to tender between the second quarter of 2025 and the end of 2027. In February 2024, the government opened the tender for the IJmuiden Ver Alpha and Beta sites, each of which can house around 2 GW of offshore wind capacity.

Since the 50 GW by 2040 and 70 GW by 2050 offshore wind targets were announced last September, the Dutch Ministry of Economic Affairs and Climate Policy (EZK) has been identifying further offshore wind areas with a draft roadmap pending to be released. However, in April, EZK informed the government that its 2030 offshore wind target will be delayed to 2032 due to permitting constraints, the lead times for grid connections, and pressures on the supply chain.

Belgium

Despite having no projects in the pipeline since the 487 MW Seamade and 219 MW Northwester 2 came online in 2020, Belgium remains Europe's fifth-largest offshore wind market in operational offshore wind capacity.

In October 2021, the Council of Ministers approved a proposal to increase from 2.25 GW to up to 3.5 GW the capacity to be offered at upcoming tenders for the Princess Elisabeth offshore wind zone. It also approved connecting the wind farms in this zone to an energy island. Belgian transmission system operator (TSO) Elia received an EU grant, under the Recovery and Resilience Facility (RRF), for the energy island in December 2022, and secured the environmental permit in October 2023.

In April 2024, foundation work started at the world's first artificial energy island. Construction work is expected to last until August 2026. Once the Princess Elisabeth offshore

wind zone is fully connected by 2030, Belgium's total offshore wind capacity will reach 5.76 GW. To reinforce its energy independence, reduce energy bills, and cut CO2 emissions, the country plans to quadruple its offshore wind capacity to 8 GW by 2040.

France

By the end of 2023, France had installed 842 MW of offshore wind capacity. Eight projects totalling 2.1 GW are under construction, of which three are demonstration floating wind projects.

According to the multiannual energy programme (Programmation pluriannuelle de l'énergie or PPE) released by the French government in 2020, 8.75 GW of offshore wind capacity will be put out to tender by 2028. Last June, the country's Energy Regulatory Commission (CRE) said France should launch a 10 GW offshore wind auction before 2027 in response to the Ministry of Energy Transition's consultation on accelerating the development of offshore wind power. Early in the European summer, the Minister of Economy and Delegate Minister for Industry presented the updated schedule for offshore wind tenders. This included building larger wind farms further out at sea but also extending the size of existing offshore wind sites by 2.5 GW.

One fixed-bottom and three floating wind projects, totalling 1.8 GW, have been floated for auction so far, with the 1 GW AO4 project and the 250 MW AO5 awarded in March 2023 and May 2024 respectively. Another floating project, the 250 MW AO6, is expected to be awarded later this summer. In addition, two offshore wind auction rounds of 1.2 GW and 1.5 GW (AO7, AO8) will be launched in August, with another two auction rounds of 2.5 GW and 10 GW (AO9 and AO10) expected to take place in 2025 and 2026 respectively.

To reach its 2050 net zero target, the French government has signed an offshore sector deal with the country's wind industry, aiming to achieve 40 GW of offshore wind by 2050 spread over 50 wind farms. Last year, France raised its offshore wind target for 2050 to 45 GW, with an intermediate target of 18 GW by 2035.

Poland

In late 2020, Poland's Council of Ministers adopted a draft bill

supporting the development of offshore wind energy in the Baltic Sea. Signed into law in January 2021, the bill allows for 10.9 GW of offshore wind capacity to be either operational or under development by 2027.

By the end of June 2021, the Polish Energy Regulatory Office (ERO) had awarded a CfD to seven offshore wind projects totalling 5.9 GW. According to the Polish Offshore Wind Act, the second phase of development will include two auctions, the first in 2025 and the second in 2027, each with 2.5 GW of capacity.

In April 2023, the government announced a more ambitious target. It now plans to hold four auctions, two auctions of 4 GW each and another two of 2 GW each, in the second phase of offshore wind expansion. This will allow the country to have 18 GW of offshore wind capacity at different stages of development by the end of the decade.

Poland had installed no offshore wind turbines by the end of 2023. The 1.1 GW Baltic Power offshore wind project reached financial close last September, and construction work is expected to start this year.

With a new turbine nacelle assembly factory under construction in Szczecin, the Danish turbine supplier, Vestas recently announced the plan to invest a new factory at the same location to produce blades for its V236-15.0 MW offshore wind turbine.

Norway

Three floating offshore wind projects, totalling 100.5 MW, are currently in operation in Norway, making the country, for now, the world's largest floating market.

In March 2023, the government officially opened the application window for Norway's first offshore wind auction. The application deadline for the 1.5 GW Sørlige Nordsjø II Phase 1 and the 1.5 GW Utsira Nord floating was 1 September 2023. The winners were due to be announced by the end of the year. However, considering the higher risk profile of floating wind projects, the Norwegian government proposed that the sites in the Utsira Nord lease area be selected based on qualitative criteria, rather than through an auction. For reasons associated with state aid, the process was delayed and the winner for the Sørlige Nordsjø II Phase 1 was announced in March 2024. The award of 1.5 GW of

floating wind capacity has been postponed to 2025.

In May 2022, the newly elected government launched a large-scale green investment plan aimed at allocating sea areas to develop 30 GW of offshore wind capacity by 2040, with the next round of licence awards for offshore wind in the new areas expected to launch in 2025. To achieve this ambitious target, in February this year, DNV was selected by the Norwegian Water Resources and Energy Directorate (NVE) to carry out a strategic impact assessment of 20 new areas for offshore wind development.

Ireland

There are only 25 MW of offshore wind in operation in Ireland, but the country aims to have 7 GW of offshore wind by 2030.

In December 2022, the Irish Government issued Maritime Area Consents (MACs) for the first phase of seven offshore wind projects, enabling phase-one projects to participate in ORESS 1, the first auction for offshore wind under the Renewable Electricity Support Scheme (RESS).

In May 2023, four projects with a combined capacity of nearly 3,100 MW were awarded under ORESS 1. Early last summer, the Irish government opened the consultation process for ORESS 2 with the first auction, ORESS 2.1 for 900 MW, planned for the end of 2023 or early this year. Additionally, the government plans to have 2 GW of floating wind capacity in development by 2030.

In May 2024, the government launched the Future Framework for Offshore Renewable Energy, which sets out Ireland's pathway to delivering 20 GW of offshore wind by 2040 and at least 37 GW by 2050. To support the long-term roadmap, the Irish government has published the draft South Coast Designated Maritime Area Plan (DMAP), which identifies four proposed areas off the south coast of Ireland for offshore wind projects and represents the country's first-ever spatial plan for renewable energy at sea.

Portugal

Portugal's only offshore wind installed to date is the 25 MW WindFloat Atlantic (WFA) floating wind farm. The country planned to put 3–4 GW of floating wind capacity up for auction in the summer of 2022. The auction was postponed to 2023 but the planned capacity was upgraded twice to 10 GW.

In January 2023, the government released draft areas for 10 GW of offshore wind, but the interministerial working group proposed putting the areas out to tender in phases, with three areas totalling 3.5 GW to be offered in 2023 through one or more competitive procedures, and the remaining capacity to be allocated in subsequent phases until 2030. The three areas that the group pinpointed for the first tenders are located in Viana do Castelo (1 GW), Leixões (500 MW), and Figueira da Foz (2 GW). In October 2023, the government launched the initial stage of the offshore wind competitive procedure by issuing a call for expressions of interest (EoIs) and 50 developers from ten countries have submitted their EoIs.

Spain

Spain has 12 MW of offshore wind capacity in operation, of which 2 MW is floating wind, but the Roadmap for the Development of Offshore Wind and Marine Energy, approved in December 2021 by Spain's Council of Ministers, sees the country reaching up to 3 GW of (floating) offshore wind by 2030.

Sweden

Sweden has commissioned five offshore wind projects since in 1997. The country's net offshore wind capacity was 202 MW at the end of 2023, making it the seventh-largest offshore wind market in Europe.

In 2022, the Swedish government set an annual offshore wind generation target of 120 TWh and assigned to the Swedish Energy Agency the task of designating new areas to support this target. In April 2023, the agency outlined areas where the 120 TWh of offshore wind can be produced and called for offshore wind energy production to be prioritised over other uses.

Finland

With around 60 MW of offshore wind capacity in operation, Finland is the eighth-largest market in Europe. In December 2021, the Finnish government approved an auction model for the leasing of public water areas, overseen by Metsähallitus, the enterprise in charge of managing the state's lands and waters, to be used for the development of offshore wind farms. In July 2022, the government approved the lease of state-owned sea areas for two commercial-scale offshore wind projects, one off the coast of Korsnäs and the other off Tahkoluoto, Pori. Last November, Finland adopted a resolution to launch the tendering procedure for five offshore wind projects in public water areas. In May 2024, Finland's transmission system operator (TSO) Fingrid Oyj identified five preliminary areas where offshore wind farms could be connected to the mainland grid by the 2030s.

Estonia

No offshore wind turbines have been installed in Estonia yet. Last November, Estonia's Consumer Protection and Technical Regulation Authority (CPTRA) announced that two online auctions would be held for the development of offshore wind farms in the Liivi 1 and Liivi 2 sea areas. The auction for Liivi 2 was awarded in December 2023, while the auction for Liivi 1 was awarded in January 2024. In April, Estonian regulatory body CPTRA received 10 applications for another three offshore wind sites, with auctions expected in June.

Lithuania

No offshore wind turbines are in operation in Lithuania. In March 2023, Lithuania's National Energy Regulatory Council (NERC) launched its first offshore wind auction with the winner announced in October. According to the developer, the 700 MW wind farm is scheduled to begin operations by the end of this decade. In January 2024, NERC launched the country's second offshore wind tender for another 700 MW offshore wind project, but the auction was discontinued when only one bid was received.

Greece

The country passed its first offshore wind legislation in the summer of 2022 with the goal of building at least 2 GW of offshore wind by 2030. In November 2023, the Hellenic Hydrocarbons and Energy Resources Management Company (HEREMA) announced the draft National Development Programme for Offshore Wind. This plan, which has already been submitted to the Ministry of Environment and Energy for Spatial Planning, qualifies ten eligible areas for offshore wind development by 2030-2032, with a combined capacity of 4.9 GW, of which, the majority is for floating wind.

Romania

No offshore wind project has been built at Black Sea so far. Romania adopted the Offshore Wind Energy Bill in April 2024, potentially bringing the country on track to build the first offshore wind project in Black Sea by 2032. The country's Ministry of Energy published a draft law in the summer of 2023, which would enable auctioning off 3 GW offshore wind through a CfD support scheme.

Turkiye

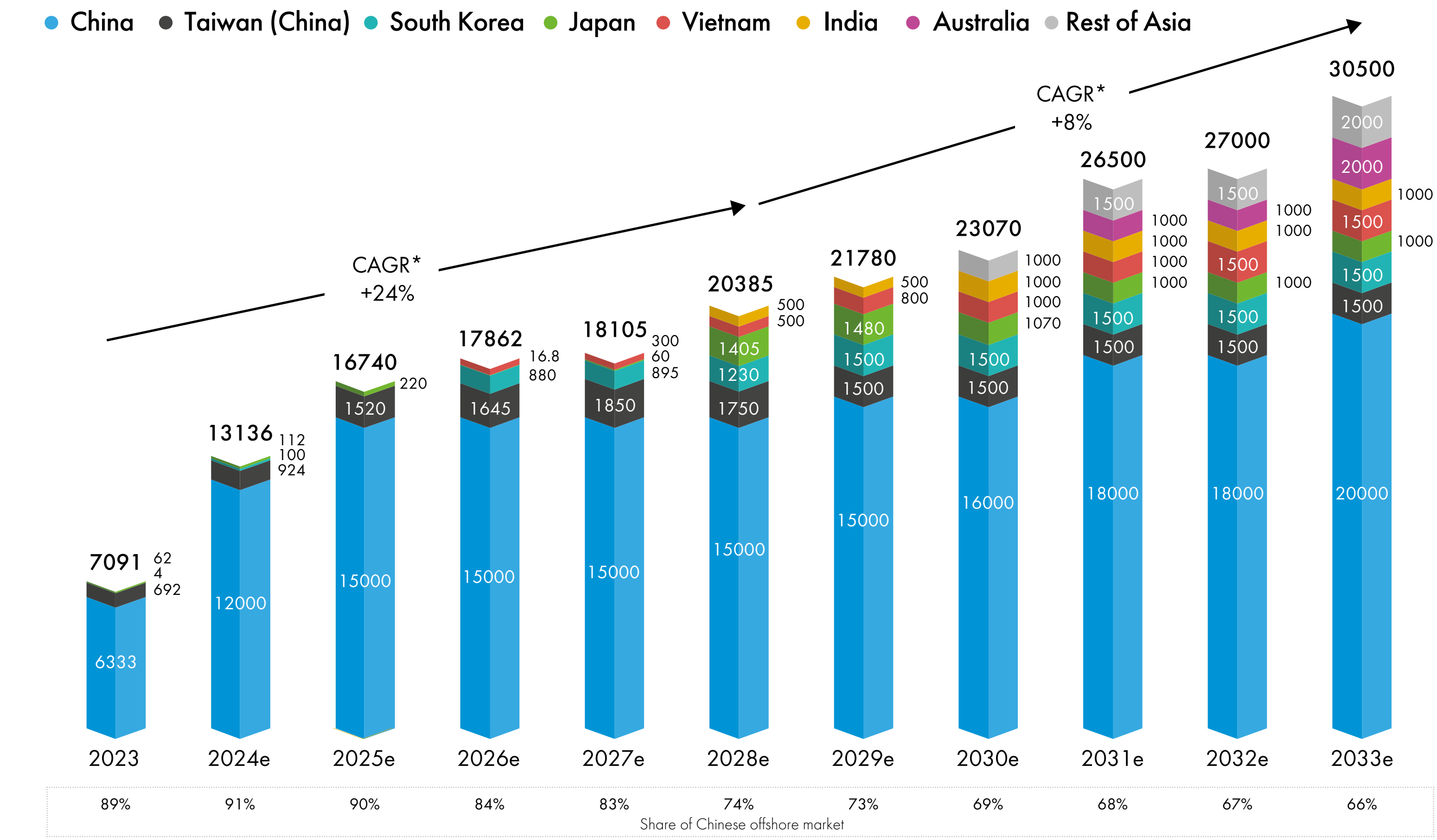
Turkey invited applications for the development of a 1.2 GW MW offshore wind project in 2018. This tender was, however, postponed mainly due to limited site preparation, according to Ministry of Energy and Natural Resources (MENR). In June 2023, MENR launched a tender for the delivery of site investigations and consultancy services for three development zones in the Sea of Marmara, which is expected to pave the way for its first offshore wind auction. The country aims to have 5 GW of offshore wind installations by 2035 under its National Energy Plan which was released in 2022.

Asia Pacific

APAC built its first offshore wind project in Japan two decades ago, but the region had very little offshore wind development until 2017, when the Chinese offshore wind market started to take off. Thanks to strong growth in China, APAC replaced Europe as the leading regional offshore wind market in new installations in 2020 and in cumulative installations in 2022.

GWEC Market Intelligence's latest market outlook shows that China will continue to be the dominant market in the region in the near term (2024–2027), with market share in

Offshore wind growth to 2033 in Asia Pacific (MW)



*Compound Annual Growth Rate. Source: GWEC Market Intelligence, June 2024 the range of 80% to 90%. As the offshore wind market becomes more diversified in this region from 2028, we predict that China's market share will drop to 69% in 2030 and 66% in 2033, as utility-scale offshore wind projects start coming online in Japan and South Korea. A first batch of offshore wind project development is likely to take place in emerging markets such as the Philippines, India, and Australia towards the end of the forecast period.

In total, 211 GW of offshore wind capacity is predicted to be added in the next ten years, of which 40% will be built in 2024–2028 and the remainder in 2029–2033. The top five markets in APAC additions in the next ten years will be China, Taiwan (China), South Korea, Japan, and Vietnam.

As the world's largest offshore wind market, China has the most mature offshore wind supply chain in this region (see China profile on page 95). Driven by local content requirements, an offshore wind supply chain has been gradually established in Taiwan. Two European turbine suppliers – Siemens Gamesa and Vestas – are now capable of producing offshore turbine nacelles locally. Based on government offshore wind investment plans and partnerships between local and European players, similar success is likely to be achieved in South Korea and Japan. Other markets in this region where offshore wind is in the early stages of development are still facing the challenge of developing a local supply chain while building the necessary skills and workforce. To unlock APAC's offshore wind potential and further bring down the cost of offshore wind energy, regional cooperation in supply chain and infrastructure is imperative.

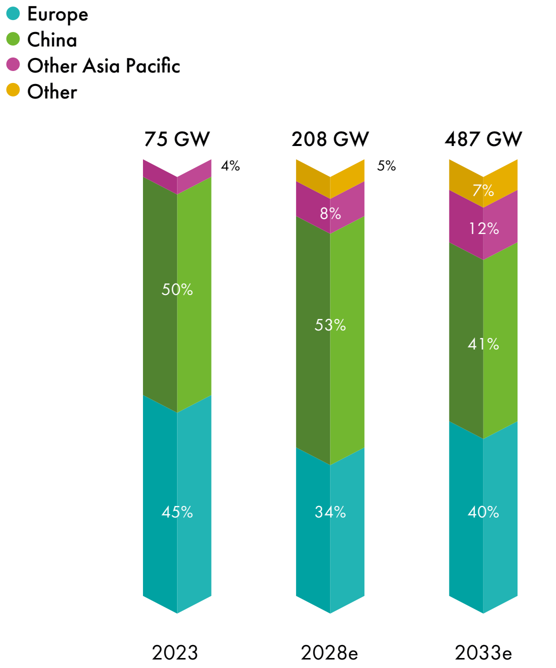
China

After explosive growth in 2021 driven by the cut-off of the feed-in tariff (FiT), annual offshore wind installations dropped dramatically but the market did not collapse. Connecting 5 GW in 2022 and 6.3 GW in 2023 of new offshore wind without financial support from central government demonstrated the resilience of the domestic offshore wind industry and showed its capability to maintain stable growth in the new era of 'grid parity' – whereby the electricity generated from offshore wind will receive the same remuneration as that from coal-fired power plants. GWEC Market Intelligence's global offshore wind project database shows more than 17 GW of capacity was under construction at offshore wind projects in China at the end of May 2024.

According to statistics from China's Renewable Energy Engineering Institute (CREEI), ten provinces have completed their offshore wind development plans for the 14th five-year period (2021–2025), bringing the country's total offshore wind development target up to 200 GW. The majority of the offshore wind capacity installed in the country is nearshore wind. However, the situation is expected to change during the 15th five-year period (2026–2030). The Chinese National Energy Administration (NEA) is currently drafting the Management Measures for Offshore Wind Power Development in Deep Water and has already tasked CREEI with designating new areas to host deep-water offshore wind.

Considering China's plans to transition from nearshore to deep-water installations by the end of 2025 – and the fact that China has the world's largest and most mature wind supply chain – GWEC Market Intelligence predicts that 160 GW of offshore wind capacity will be added in the coming decade, further strengthening China's leading position in the offshore wind sector.

Total added between 2024 and 2033

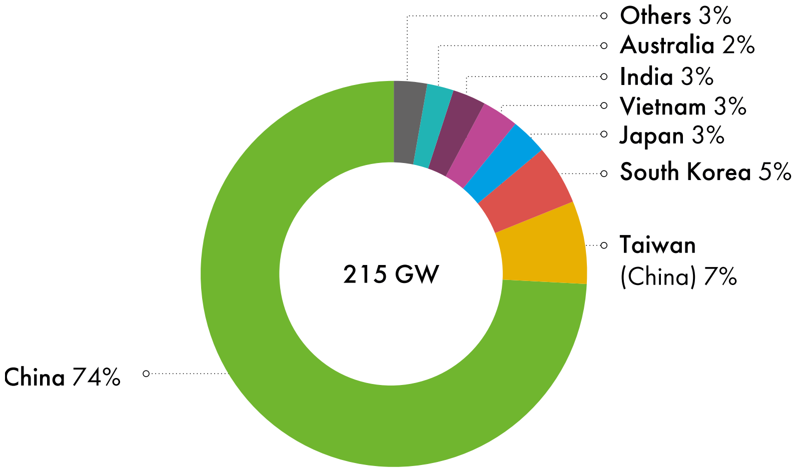


Source: GWEC Market Intelligence, June 2024

Taiwan (China)

Despite the disruption caused by the COVID-19 pandemic, typhoons, and seabed challenges, Taiwan grid-connected nearly 2 GW of new offshore wind capacity in the 2021–2023 period, making it the second-largest offshore wind market in the APAC region.

Total offshore wind added between 2024 and 2033



Source: GWEC Market Intelligence, June 2024

At present, 2.9 GW of offshore wind capacity is under construction. Based on the updated CODs, we believe that Taiwan is unlikely to reach its 5.6 GW by 2025 offshore wind target.

In August 2021, the government officially announced its Round 3 offshore wind allocation plan for 2026–2035, with seven projects totalling 3 GW allocated through Round 3, phase 1, in December 2022. In August 2023, Taiwan's Energy Administration announced provisional rules for the country's planned offshore wind auction Round 3.2, with local content still a key focus. In April 2024, six developers submitted bids for eight offshore wind projects totalling 3.6 GW of capacity, with awards expected later this year. If all of the anticipated projects from the Round 3 offshore wind auctions are allocated and come online on time, Taiwan is likely to maintain its number-two position in the region.

Japan

With the 112 MW Ishikari Bay New Port offshore wind farm fully commissioned in early January this year, Japan has 300 MW of offshore wind capacity in operation, of which 5 MW is floating wind. It is the fourth-largest market in APAC. The country built its first offshore wind project in 2003, but only set an offshore wind development target in late 2020, when the Japanese government approved the 'Vision for Offshore Wind Industry', which aims to achieve 10 GW of offshore wind by 2030 and 30–45 GW by 2040.

The country's first floating tender (16.8 MW) and first fixed-bottom offshore wind auction (1.7 GW) were completed in 2021. The second fixed-bottom auction with a combined capacity of 1.8 GW across four sites was launched in November 2022, with winners announced in December 2023 and March 2024, respectively. The third fixed-bottom offshore wind tender with a combined capacity of 1.1 GW across two sites was opened in January 2024, with results due by the end of the year.

In April 2023, the government released a plan to allow offshore wind projects to be built in its exclusive economic zone (EEZ). In March 2024, the Japanese government passed an amendment to the "Act on Promoting the Utilization of Sea Areas", allowing offshore wind farms with operation timelines of up to 30 years to be deployed in the EEZ. Following this new legislation, a consortium of Japanese companies has initiated the Floating Offshore Wind Technology Research Association (FLOWRA), with the goal of accelerating the large-scale commercialisation of floating offshore wind.

South Korea

South Korea only had 159 MW of offshore wind capacity in operation at the end of 2023, making it the fifth-largest offshore wind market in APAC. Under the 10th Basic Plan for Power Distribution published in 2023, the Ministry of Trade, Industry and Energy (MOTIE) announced a target of 21.6% of renewable energy in South Korea's total energy mix by 2030, and 14.3 GW of installed offshore wind capacity. This offshore wind target is 2.3 GW higher than the one set under its Renewable Energy 3020 Implementation Plan in 2018.

As of December 2023, more than 22 GW capacity of offshore wind projects had received an electric business licence (EBL) from the Electricity Regulatory Commission under the Ministry of Trade, Industry and Energy. However, only 203 MW of projects have reached a final investment decision. This is primarily due to slow permitting caused by bureaucratic delays and opposition from local communities and the fishing industry.

In January 2024, four fixed-bottom offshore wind projects, totalling 1.4 GW, secured contracts in South Korea's latest renewable energy auction. Floating wind development needs to start gaining momentum in the second half of this decade if the government is to achieve its ambitious offshore wind target.

Vietnam

Vietnam remains the third-largest market in the APAC region in nearshore wind installations. By the end of 2023, nearly 600 MW of installed nearshore (intertidal) capacity was still waiting to go through the PPA negotiation process with Electricity of Vietnam (EVN). Despite the Ministry of Industry and Trade setting a price ceiling for wind power in January, which helps to initiate PPA negotiations for installed projects awaiting commissioning, the motivation for developers is low as the price ceiling is 20-25% lower than the previous FiT prices.

In May 2023, the government approved the long-awaited Power Development Plan VIII (PDP 8), which sets a 6 GW offshore wind installation target for 2030 – excluding intertidal projects. Considering that the regulatory framework to support offshore wind development under PDP8 is still underdeveloped, as well as the 6–8-year project development lead time, GWEC Market Intelligence believes that no real offshore wind development will take place until route-to-market policies and potentially new law(s) are in place. GWEC expects Vietnam to miss its 2030 offshore wind target.

The Philippines

The Philippines has been exploring its offshore wind potential since 2020. In 2022, the Department of Energy (DOE) launched the country's first offshore wind roadmap while the Marcos administration removed foreign ownership restrictions, enabling 100% foreign-owned companies to invest in the renewable energy sector. This immediately motivated large European developers to sign offshore wind development plans with the Philippine government. Aiming for a 35% share of renewables in the power mix by 2030 and 50% by 2040, the DOE in April 2024 awarded 92 offshore wind energy service contracts with a potential capacity of 65 GW. The President has issued an executive order directing the DOE to put together a policy and administrative framework to support offshore wind development – and to commence grid development work – with a view to having at least 10 offshore wind projects with a combined capacity of 6.7 GW generating power by 2028. But in practice, it will be difficult.

Australia

No offshore wind turbines have been installed in Australia yet, although the country has some of the world's best wind resources. There are no offshore wind targets at the federal government level, but the Victoria state government released an Offshore Wind Policy Directions Paper in March 2022, which sets a target of 2 GW of offshore wind online by 2032, 4 GW by 2035, and 9 GW by 2040.

Since the Australian government nominated the Bass Strait off Gippsland as the first offshore wind area in 2022, five more areas have been identified: the New South Wales (NSW) Hunter region, the Southern Ocean Region off Victoria and South Australia, the NSW Illawarra region, and the Bunbury region in Western Australia.

In April, the Australian government awarded the first feasibility licences for six offshore wind projects, totalling 12 GW, to be built offshore Gippsland in Victoria. Developers can now begin detailed assessment work to determine feasibility, including environmental studies and management plans. After establishing their projects' feasibility, companies can then apply for commercial licences to build the projects. According to the state energy minister, Victoria is sticking with its offshore wind target announced in 2022 and expects to launch its first offshore wind auction in late 2024, with contracts awarded in 2026.

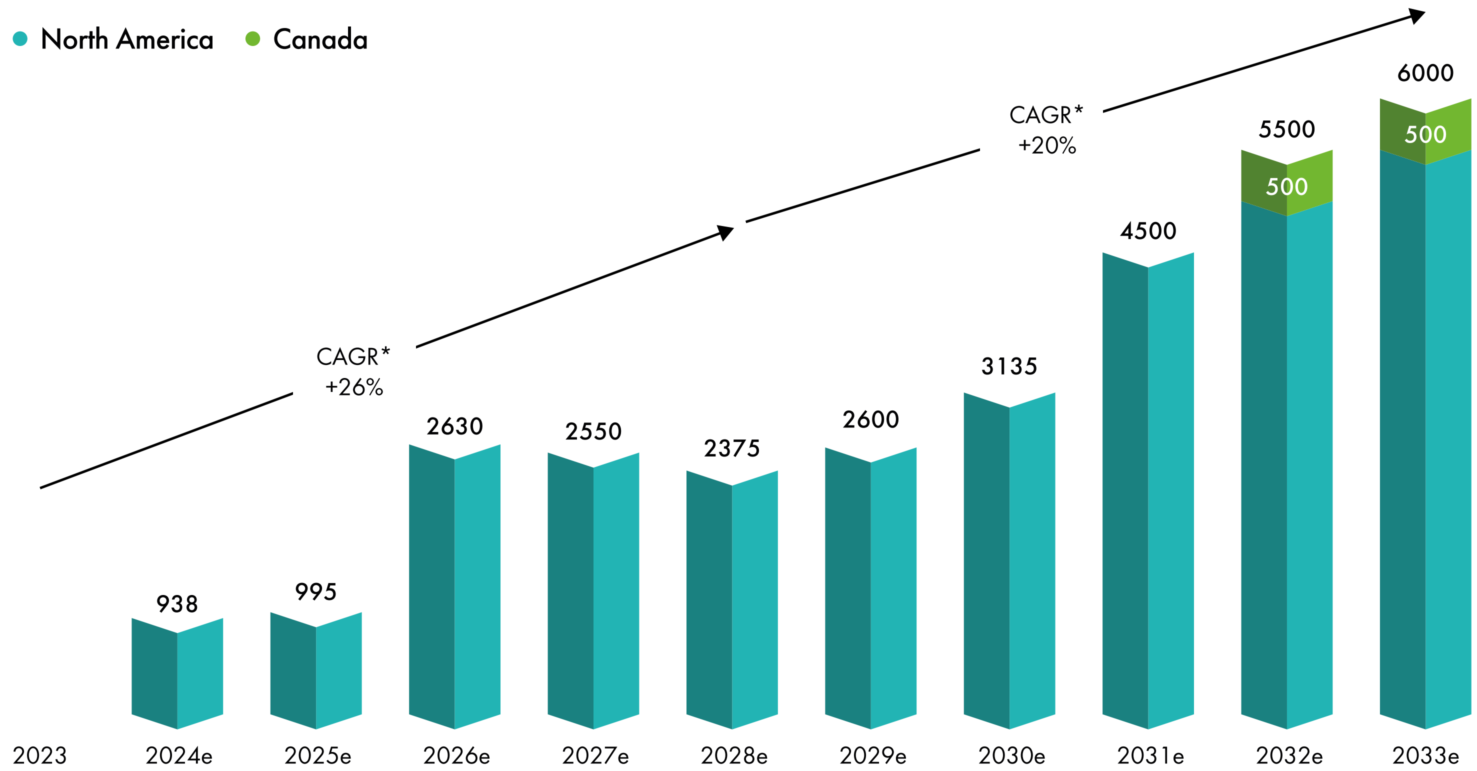
North America

North America is still the only region with offshore wind projects in operation outside of Europe and Asia Pacific. At the end of 2023, only two small-scale offshore projects, the 30 MW Block Island in Rhode Island and the 12 MW Dominion Virginia demonstration project, were in full operation in this region, although a handful of wind turbines had been installed at two utility-scale offshore wind farms, the 130 MW South Fork wind farm and the 806 MW Vineyard Wind 1 wind farm.

In total, 31 GW of offshore wind is predicted to be built in this region in the next ten years (2024–2033), of which 97 % will be in the US and the rest in Canada. Due to delays in projects off the US eastern coast that were expected to be commissioned over the next five years, only 9.5 GW (30%) of the projected capacity for the next ten years is likely to be delivered by 2028.

United States
The US only had 42 MW of offshore wind capacity in operation by 2023, but four projects with a combined capacity of 4.3 GW were under construction as of May 2024, with

New offshore wind installations, North America (MW)



*Compound Annual Growth Rate.
Source: GWEC Market Intelligence, June 2024

another 50 GW of offshore wind projects in the planning and development stages.

To support the Biden Administration's offshore wind target of 30 GW by 2030 and floating wind target of 15 GW by 2035, the Bureau of Ocean Energy Management (BOEM) held four lease sales in 2022. In addition to lease sales in the Gulf of Mexico, BOEM announced the final Wind Energy Area (WEA) in the Central Atlantic and also identified draft WEAs in the Gulf of Maine and Oregon in 2023.

In April 2024, BOEM released a new five-year offshore wind leasing schedule, which includes up to 12 potential offshore wind lease sales through 2028. The Biden administration has a goal of approving 16 Construction and Operation Plans (COPs) by 2025. As of May 2024, six COPs, which can support 7.5 GW of offshore wind capacity, have been approved by BOEM.

At the state level, with new offshore wind targets signed into law in Maryland, Maine, and California in 2023, eleven states have combined offshore wind procurement targets of 84 GW.

Although the US has made great progress at both the federal and state levels, 2023 was a turbulent year for the US offshore wind industry. Challenges such as inflation, increased capital costs, and supply chain constraints, including for vessels, created uncertainty in the US offshore wind sector, forcing developers either to renegotiate the signed offtake agreements or, in the worst cases, terminate PPAs and cease project development.

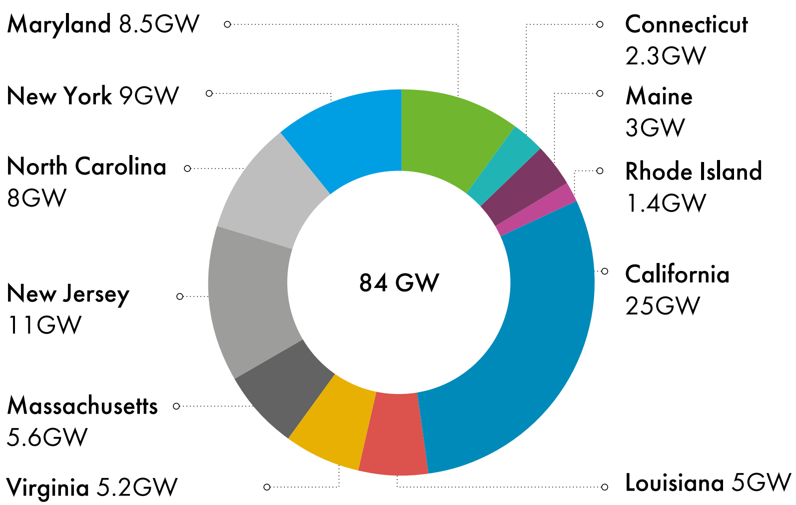
According to GWEC Market Intelligence's offshore wind database, by January this year, 13 fixed-bottom offshore wind projects off the east coast totalling nearly 12 GW were affected by the 'storm'. Of these, nine projects, totalling 7.7 GW, had either their offtake agreements terminated or their entire development ceased.

Four projects located in New York tried to renegotiate their PPA price last year, but their requests were denied by the New York State Public Service Commission. However, the state launched its fourth expedited offshore wind solicitation in December 2023 and allowed projects that previously petitioned the Commission for financial relief to participate.

In February 2024, the New York State Energy Research and Development Authority (NYSERDA) selected Equinor's Empire Wind 1 (810 MW) and Ørsted and Eversource's Sunrise Wind (924 MW) projects in the state's fourth offshore wind solicitation. Both projects had previously secured agreements with the state and rebid in the latest procurement round to negotiate new 25-year contracts.

Considering the growing pains that the US offshore wind industry is experiencing, we have downgraded our 2030 offshore wind outlook for the US to 15 GW from the 25 GW predicted in the previous year's outlook.

US State-level offshore wind development targets



*Announced plan, not yet signed by law

Floating Offshore Wind

The world's first MW-scale floating offshore wind turbine was installed in the North Sea in 2009. Following more than a decade of testing with demonstration projects already installed in Europe, North America and Asia, floating wind technology passed the demonstration stage and entered the pre-commercial phase in the early 2020s.

Based on the existing global floating wind project pipeline, which topped 240 GW a year ago, and the announced project commercial operation date (COD), we predicted in our previous reports that floating wind would pass the pre-commercial phase in the middle of this decade, with full commercialisation to be reached in 2026/2027. Following our latest global stocktake of floating wind development, however, GWEC Market Intelligence believes that the commercialisation of floating wind is unlikely to be achieved until the end of this decade (2029/2030). The rationale behind our adjustment includes:

- Floating wind is expensive compared with bottom-fixed projects. Macroeconomic challenges such as inflation and increased capital costs have made floating wind even more expensive.
- Floating foundation technology is not mature and standardisation for existing floating foundation designs remains low, which makes it hard for developers to mitigate risk and cost.
- There is a lack of port infrastructure that can accommodate foundation manufacturing and assembly, as well as increased demand for mooring and anchoring vessels that can support the installation.
- Bottlenecks in the implementation of floating foundation projects is likely to occur if restrictive trade policies and local content requirements come to play.

GWEC Market Intelligence therefore has downgraded its global floating wind forecast and predicts 8.5 GW to be built globally by 2030, 22% lower than the previous year's projection.

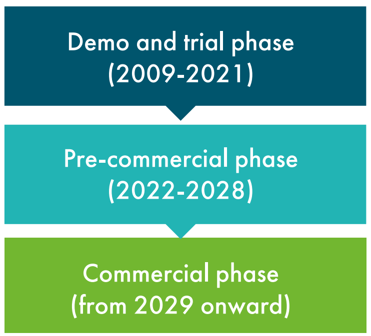
Norway, the UK, Portugal, China, and Japan are the top five markets in net floating wind installations today. By the end of 2030, the UK, South Korea, China, the US, and Portugal are likely to be the top five floating markets.

GWEC Market Intelligence predicts floating wind to become fully commercialised towards the end of this decade, with multi-GW levels of new installations expected to be achieved from 2029. Therefore, only 8% (2.5 GW) of the total projected new additions (31GW) will be installed in the first half of the forecast period.

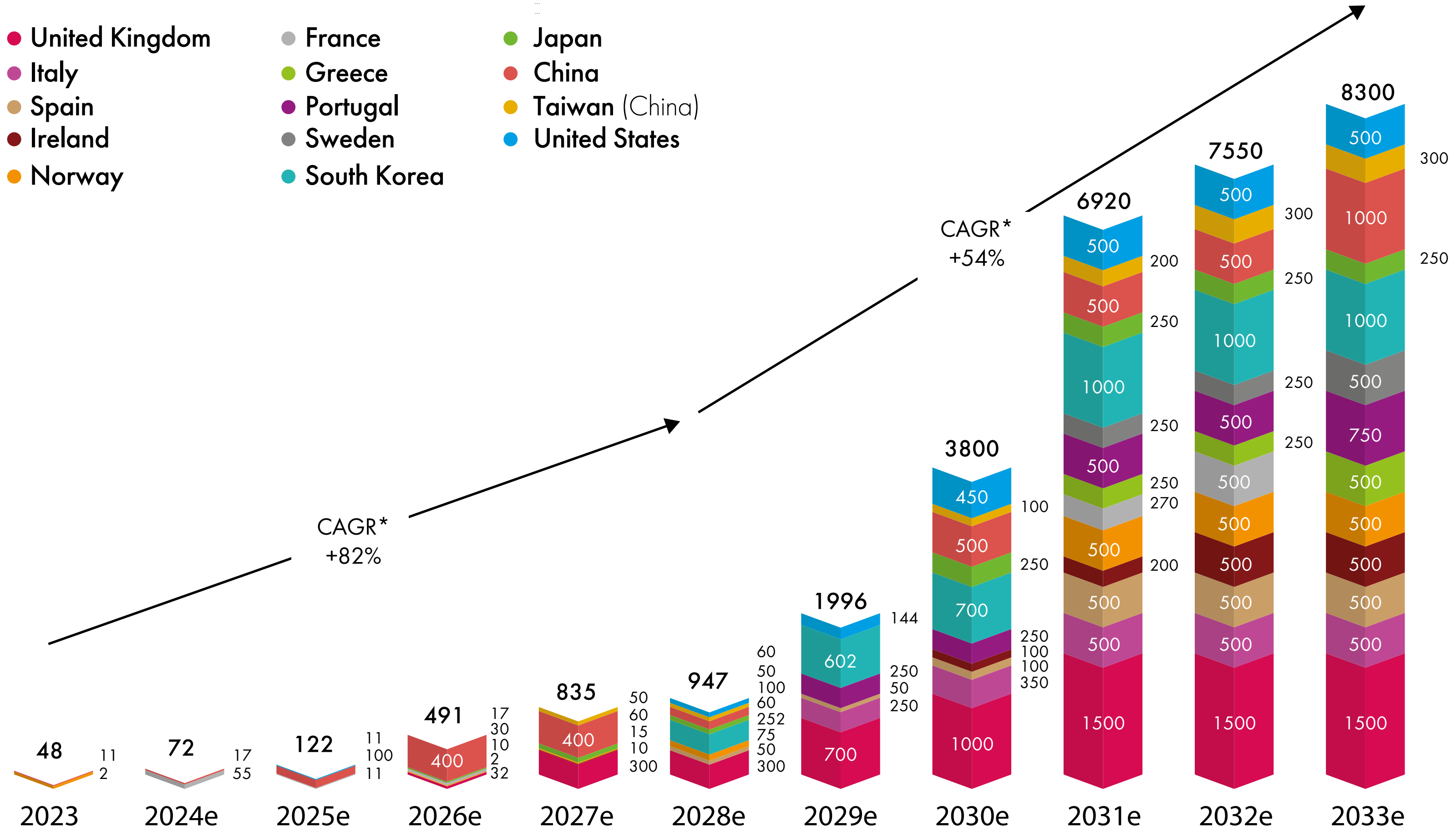
As for regional distribution, we expect Europe to contribute 60% of total installations added in 2024–2033, followed by APAC (33%) and North America (7%). By the end of 2033, a total of 31 GW of floating wind is likely to be installed worldwide, bringing its contribution to total offshore wind installations from today's 0.3% to 6%.

Our near-term (2024–2028) outlook is primarily based on the existing global floating offshore project pipeline. However, the top-down approach which was applied for the medium-term (2029–2033) outlook, takes into account national floating wind targets, announced auction plans and the project pipelines announced by major offshore wind developers.

Roadmap of floating offshore wind commercialisation



New floating wind installations, Global (MW)**



*Compound Annual Growth Rate., **Note: this floating wind outlook is already included in GWEC's global offshore wind forecast.
Source: GWEC Market Intelligence, June 2024

Global stocktake of floating wind development

Europe

The UK government has an ambitious target of installing 5 GW of floating wind by 2030. The country has already awarded nearly 18 GW of floating wind capacity through the ScotWind leasing round. In March 2023, 13 floating offshore wind projects with a combined capacity of around 5.5 GW were selected by Crown Estate Scotland in the Innovation and Targeted Oil and Gas (INTOG) leasing round. Despite the delay, Crown Estate boosted Celtic Sea floating offshore wind leasing round (Round 5) to 4.5 GW from 4 GW last October and launched the Round 5 seabed leasing process in February 2024, making it the first phase of development in the Celtic Sea. Last November, the UK Government also confirmed its intention to unlock space for up to a further 12 GW of capacity in the Celtic Sea.

In response to the inflation and supply chain challenges that caused the CfD AR5 auction to fail, the UK government increased the maximum strike price for floating offshore wind by 52%, from GBP 116/MWh to GBP 176/MWh, ahead of AR6, which opened in March 2024. In April, the 560 MW Green Volt floating wind farm that won the INTOG lease secured all planning approvals and remains on track to be the first large-scale floating offshore wind farm connected in Europe.

In **Norway**, to support floating wind technology development and bring down the cost of energy, the Marine Energy Test Centre (METCentre) at the end of 2023 was granted final approval for new test concessions for five new wind turbines. Considering the higher risk profile, however, the award of 1.5 GW of floating wind capacity in the Utsira Nord lease area has been delayed to 2025.

France received the green light from the European Commission last December to support the construction and operation of two floating offshore wind farms of 250 MW each in the Gulf of Lion with EUR 4.12 billion. In May 2024, Belgian company Eolico and German company Baywa.re won France's first 250 MW commercial-scale floating wind tender off the coast of Brittany. The bid of EUR 86.45/MWh is just one cent/kWh higher than the strike price offered for fixed-bottom offshore wind in the UK's CfD AR6, showing the developers' confidence in the commercial success of floating wind.

North America

To achieve **the US** federal government's 15 GW by 2035 floating wind target, BOEM held lease sales off central and northern California in December 2022, with more than 4.6 GW of floating wind capacity expected to be built to contribute to this target. In July 2023, the Maine Legislature passed a bill calling for the state to procure 3 GW of offshore wind by 2040, of which the majority is expected to be floating wind. One month later, BOEM identified two draft Wind Energy Areas offshore southern Oregon. In April 2024, the federal agency announced two proposals for offshore wind energy auctions off the coast of Oregon and in the Gulf of Maine with the potential to generate more than 18 GW of offshore wind energy. All of the areas are in deep water and will therefore require floating wind.

Asia Pacific

China's Renewable Energy Engineering Institute approved in September 2022 the feasibility study for phase one of the 1 GW Wanning floating wind demonstration project. Last December, four local wind turbine OEMs – Shanghai Electric, Dongfang, CRRC, and Windey – were selected as the suppliers for the 100 MW prototype demonstration phase. With the construction partners announced in April 2024, six wind turbines in the size range of 16-18MW are scheduled to be connected by the end of 2025. According to the initial development plan, the remaining capacity of this project will be added by the end of 2027.

In addition, China's largest floating wind turbine supplier, Mingyang, has recently commissioned its OceanX floating foundation. Two 8.4 MW wind turbines will be installed on the same V-shaped foundation, making it the world's most powerful floating wind foundation when installation completed.

In **South Korea**, Europe-based developers and oil & gas companies have joined forces with South Korean companies to develop the local floating pipeline. In April 2023, they launched the Ulsan Floating Offshore Wind Association with the aim to promote the development of the offshore wind industry in Ulsan together with the Ulsan Chamber of Commerce and Industry (UCCI). By the end of 2023, more than five large-scale floating wind projects had received the EBL from the Electricity Regulatory Commission under the Ministry of Trade, Industry and Energy, of which two projects, nearly 2 GW, have announced their preferred turbine suppliers. According to the latest project plan, the construction of phase 1 of the 1.5 GW Gray Whale project (504 MW) is due to begin in 2025, with a commercial operation date of 2028.

In **Japan**, the Goto floating wind farm consortium has postponed commissioning the 16.8 MW Goto City offshore wind project that won Japan's first floating wind auction in 2021 by two years, from 2024 to 2026, due to the discovery of defects in the floating structures to be used for the project. Nevertheless, progress has been made by the government in supporting floating wind development, notably by setting aside a JPY 85 billion ($58 million) subsidy to support two large-scale floating demonstration projects. The tenders are expected to be launched later this year. The Akita Prefectural government has already proposed the Yurihonjo offshore sea area as a potential site for these demonstration projects.

In March 2024, the Japanese government passed an amendment to the "Act on Promoting the Utilisation of Sea Areas", allowing offshore wind farms including floating wind to be deployed in the EEZ. Following this new legislation, a consortium of 14 Japanese companies has established the Floating Offshore Wind Technology Research Association (FLOWRA), with the goal of accelerating the large-scale commercialisation of floating offshore wind. Japan's Ministry of Economy, Trade and Industry has approved the initiative. The government has allocated JPY 4 billion ($27.1 million) to support floating offshore wind technology, plus up to another JPY 400 billion to be funded through so-called green transformation bonds to build related supply chains. FLOWRA members could qualify for a portion of this funding.

The Japanese government passed an amendment to the "Act on Promoting the Utilisation of Sea Areas", allowing offshore wind farms including floating wind to be deployed in the EEZ.

APPENDIX

Global Offshore Wind Report 2024 - Methodology and Terminology

Data definitions and adjustments

GWEC reports installed and fully commissioned capacity additions and total installations. New installations are gross figures not deducting decommissioned capacity. Total installations are net figures, adjusted for decommissioned capacity.

Historic installation data has been adjusted based on the input GWEC has received. GWEC has made the adjustments to both new and cumulative installations over the course of time.

All currency figures given in $ are in US Dollars.

Definition of regions

GWEC adjusted its definition of regions in 2018 and maintains these in the 2024 edition, specifically for Latin America and Europe.

Latin America: South, Central America and Mexico

Europe: Geographic Europe including Norway, Russia, Switzerland, Turkey, and Ukraine

Sources for the report

GWEC collects installation data from regional or country wind associations. For supply side information, GWEC collects data directly from wind turbine OEMs and component suppliers.

Used terminology

GWEC uses terminology to the best of our knowledge. With the wind industry evolving certain terminology is not yet fixed or can have several formats and connotations. GWEC is continuously adapting and adjusting to these developments.

Acronyms

AC	Altering Current
AOS	American Offshore Structures
APAC	Asia Pacific
APs	Accommodation Platforms
BCG	Boston Consulting Group
BNEF	Bloomberg New Energy Finance
BOEM	The Bureau of Ocean Energy Management
BPU	Board of Public Utilities
C&I	Construction and Installation
C&I	Construction & Installation
CAPEX	Capital Expenditure
CBAM	Carbon Border Adjustment Mechanism
CfD	Contract for Difference
CMSC	Management of State Capital at Enterprises
COD	Commercial Operation Date
COPs	Construction and Operation Plans
CPTRA	Technical Regulation Authority
CREEI	China's Renewable Energy Engineering Institute
CTVs	Crew Transfer Vessels
DC	Direct Current
DCCEEW	The Department of Climate Change, Energy, the Environment and Water
DEEP	Department of Energy and Environmental Protection
DFFE	Department of Forestry, Fisheries and the Environment
DGP	Gross Domestic Product
DOE	Department of Energy
DOI	Department of the Interior
DOI	The US Department of the Interior
EBL	Electricity Business License
EEZ	Exclusive Economic Zone
EIAs	Environmental Impact Assessments
EIB	European Development Bank
ENTSO-E	The European Network of Transmission System Operators for Electricity
EPC	Engineering, Procurement, and Construct
ERC	Energy Regulatory Commission
ERC	Energy Regulatory Commission
ERO	The Polish Energy Regulatory Office
ESG	Environmental Social Governance
ESIA	Environmental Social Impact Assessment
ESO	Electricity System Operator
ETC	Energy Transitions Commission
EVH	Extra High Voltage
EVN	Electricity of Vietnam
EVOSS	Energy Virtual One Stop Shop
EWSETA	Energy and Water Sector Education and Training Authority
EZK	The Dutch Ministry of Economic Affairs and Climate Policy
FiT	Feed-in-Tariff
FLOWRA	Floating Offshore Wind Technology Research Association
GEAP	Green Energy Auction Program
GOWA	Global Offshore Wind Alliance
GW	Gigawatt
GWO	Global Wind Organisation
GWWO	Global Wind Workforce Outlook
HEREMA	Energy Resources Management Company
HV	High Voltage
HVDC	High Voltage Direct Current
IEA	International Energy Agency
IRA	Inflation Reduction Act
IRENA	IRENA International Renewable Energy Agency
ISTS	Inter State Transmission System
KEI	The South Korea Environment Institute
KEPCO	Korea Electric Power Corporation
MACs	Maritime Area Consents
MASEN	Moroccan Agency for Sustainable Energy
MENR	Energy and Natural Resources
MNRE	The Ministry of New and Renewable Energy
MOIT	Ministry of Industry and Trade
MOIT	Ministry of Industry and Trade
MONRE	Natural Resources and Environment
MPI	The Ministry of Planning and Investment
MSP	Marine Spatial Planning
MW	Megawatt
NEA	The Chinese National Energy Administration
NGCP	National Grid Corporation of the Philippines
NOPTA	the National Offshore Petroleum Titles Administrator
NSEC	North Seas Energy Cooperation
NSW	New South Wales
NYSERDA	New York State Energy Research and Development Authority
O&M	Operation & Management
OEI	The Offshore Electricity Infrastructure
OEP	Ocean Energy Pathway
OFW	Offshore Wind
ONDPs	EU Offshore Network Development Plans
ORE	EU's Offshore Renewable Energy
PDP8	Power Development Plan 8
PEP	Philippine Energy Plan
PPA	Power Purchase Agreement
R&D	Research & Development
REDII	EU's Renewable Energy Directive-Recast to 2030
REEs	Rare Earth Elements
RESS	Renewable Electricity Support Scheme
RFS	Request for Solution
SECI	Solar Energy Corporation of India
SIDs	Small Islands Developing States
SOFR	Secured Overnight Financing Rate
SOVs	Service Operation Vessels
SOWPA	Scottish Offshore Wind Ports Alliance
STEM	Science, Technology, Engineering and Mathematics
TSO	Transmission System Operator
TWh	Terawatt hour
UPME	Unidad de Planeacion Minero Energetica
VGF	Viability Gap Funding
WACC	Weighted Average Cost of Capital
WEA	Wind Energy Area
WIIP	Wind Industry Internship Programme
WTIVs	Offshore Wind Turbine Installation Vessels

About GWEC Market Intelligence

GWEC Market Intelligence provides a series of insights and data-based analysis on the development of the global wind industry. This includes a market outlook, country profiles, policy updates, deep-dives on the offshore market among many other exclusive insights.

GWEC Market Intelligence derives its insights from its own comprehensive databases, local knowledge and leading industry experts.

The market intelligence team consists of several strong experts with long-standing industry experience across the world.

GWEC Market Intelligence collaborates with regional and national wind associations as well as its corporate members.

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GWEC Market Intelligence Products in 2024

Product	Frequency	Expected Release date
1. Wind Energy Stats/Market Data		
Wind Stats 2023 (historic annual, accumulative, decommission data)	Annual	April 2024
Global Wind Report 2024	Annual	April 2024
Wind Energy Statistics (wind energy generation data, wind energy penetration rate, jobs)	Annual	April 2024
2. Country Profiles/Policy Updates		
Country Profiles Onshores/Country Profiles Offshore	Annual	April 2024 (onshore)
Ad-hoc Policy Updates	Ad-hoc	September 2024 (offshore)
3. Market Outlook		
Global Wind Market Outlook 2024-2028 (Q1 and Q3) Database + Report	Semi-Annual	April 2024 (Q1 Outlook) November 2024 (Q3 Outlook)
India Market Outlook Report 2024-2028	Annual	September 2024
4. Supply Side Data		
Global Wind Turbine Supply Side Data Report 2023 (by OEM, by technology, by turbine ratings, models and drive train, etc)	Annual	May 2024
5. Auctions/Tenders		
Global Wind Auction	Quarterly	Q4 2023 results - February 2024
Auction Trends and Learnings	Quarterly	Q1 2024 results - May 2024
		Q2 2024 results - August 2024
		Q3 2024 results - November 2024
6. Offshore Wind Market		
Global Offshore Wind Report 2024	Annual	September 2024
Market Entry Opportunities (database)	Annual/Quarterly	After each Global Offshore Wind Task Force meetting
Global Offshore Project Pipeline (database, in operation and under construction)	Annual/Quarterly	June 2025
Global Offshore Turbine Installation Vessel Database and Report	Annual/Quarterly	October 2024
7. Components Assessment		
Generator (Q4 2024), Global Wind Supply Chain Deep Dive (Q4 2023), Gearbox (Q4 2022), Blades (Q4 2020)	Special Report	December 2024
8. Wind Asset Owners/Operators		
Asset Owners and Operators Database (Onshore & Offshore Ranking)	Annual	June 2024
Asset Owners and Operators Status Report (including strategical trends)	Annual	
9. O&M		
O&M Service Provider Database (ISP - OEM - Self-perform)	Annual	January 2024
O&M Service Provider Status Report (including regional trends)	Annual	
10. Energy transition, Digitalisation, New Technologies		
Auction design and non-price criteria, community engagement and social acceptance for permitting, supply chain policy analysis, repowering	Special Report	Throughout the year

GWEC Global Leaders

The Global Wind Energy Council's Global Leaders are an exclusive leadership group of decision-makers and top-tier members who form the basis of the Association's Executive Committee, which drives the work programme and plays a major role in shaping GWEC's priorities for its efforts in the short and long-term strategy.

SIEMENS Gamesa RENEWABLE ENERGY

A pioneer from the outset, Siemens Gamesa has been a core player in the wind industry for the last 40 years. By working together with our customers and partners, we have installed 137 gigawatts in 80 countries. And step by step, we're further expanding wind energy: to tackle the pressing challenge of climate change; and to provide sustainable, affordable, and reliable energy to societies across the world – all the while increasing energy security through renewable energy for generations to come.

Shell is building a global integrated power business spanning electricity generation, trading and supply. Shell entered the offshore wind business in 2000 as part of a consortium that installed the first offshore wind turbine in UK waters. Today, we have deployed, or are developing, over eight gigawatts (GW) of wind across North America, Europe, the UK, and Asia. We see offshore wind as a critical way of generating renewable electricity for our customers and moving Shell towards its target of being a net-zero emissions energy business by 2050 or sooner, in step with society.

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.

GE Renewable Energy

GE Renewable Energy harnesses the earth's most abundant resources – the strength of the wind, the heat of the sun and the force of water; delivering green electrons to power the world's biggest economies and the most remote communities. With an innovative spirit and an entrepreneurial mindset, we engineer energy products, grid solutions and digital services that create industry-leading value for our customers around the world.

Iberdrola

With over 170 years of history behind us, Iberdrola is now a global energy leader, the number one producer of wind power, and one of the world's biggest electricity utilities in terms of market capitalisation. We have brought the energy transition forward two decades to combat climate change and provide a clean, reliable and smart business model, to continue building together each day a healthier, more accessible energy model, based on electricity

Vestas

Vestas is the energy industry's global partner on sustainable energy solutions. We design, manufacture, install, and service wind turbines across the globe, and with +151 GW of wind turbines in 86 countries, we have installed more wind power than anyone else.
Through our industry-leading smart data capabilities and +129 GW of wind turbines under service, we use data to interpret, forecast, and exploit wind resources and deliver best-in-class wind power solutions. Together with our customers, Vestas' more than 29,000 employees are bringing the world sustainable energy solutions to power a bright future.

equinor

We are looking for new ways to utilise our expertise in the energy industry, exploring opportunities in new energy and driving innovation in oil and gas around the world. We know that the future has to be low carbon. Our ambition is to be the world's most carbon-efficient oil and gas producer, as well as driving innovation in offshore wind and renewables. We plan to reach an installed net capacity of 12-16 GW from renewables by 2030, two-thirds of this will be from offshore wind. With five decades of ocean engineering and project management expertise, focus on safe and efficient operations, in depth knowledge of the energy markets, skilled personnel and a network of competent partners and suppliers, Equinor is uniquely positioned to take a leading role in the offshore wind industry. From building the world's first floating wind farm to building the world's biggest offshore wind farm we are well underway to deliver profitable growth in renewables be a leading company in the energy transition.

CORIO

Corio Generation is a specialist offshore wind business dedicated to harnessing renewable energy worldwide. Our 20+ GW development portfolio is one of the largest in the world, spanning established and emerging markets, as well as floating and fixed-bottom technologies.

With our leading industrial expertise and deep access to long-term capital, we work closely with our partners in the creation and management of projects from origination, development and construction, and into operations.

Corio Generation is a Green Investment Group (GIG) portfolio company, operating on a standalone basis. GIG is a specialist green investor within Macquarie Asset Management, part of Macquarie Group.

Founded in 2012, Copenhagen Infrastructure Partners P/S (CIP) today is the world's largest dedicated fund manager within greenfield renewable energy investments and a global leader in offshore wind. The funds managed by CIP focuses on investments in offshore and onshore wind, solar PV, biomass and energy-from-waste, transmission and distribution, reserve capacity, storage, advanced bioenergy, and Power-to-X.

CIP manages ten funds and has to date raised approximately EUR 19 billion for investments in energy and associated infrastructure from more than 140 international institutional investors. CIP has approximately 400 employees and 11 offices around the world

SSE Renewables is a leading developer and operator of renewable energy, headquartered in the UK and Ireland, with a growing presence internationally. Its strategy is to lead the transition to a net zero future through the world-class development, construction and operation of renewable power assets and it is building more offshore wind energy than any other company in the world. Part of the FTSE-listed SSE plc, SSE Renewables is taking action to double its installed renewable energy capacity to 8GW by 2026 as part of its Net Zero Acceleration Programme, and increase renewables output fivefold to over 50TWh annually by 2031.

ReNew is the leading decarbonisation solutions company listed on Nasdaq (Nasdaq: RNW, RNWWW). ReNew's clean energy portfolio of ~13.4 GWs on a gross basis as of December 31, 2022, is one of the largest globally. In addition to being a major independent power producer in India, we provide end-to-end solutions in a just and inclusive manner in the areas of clean energy, green hydrogen, value-added energy offerings through digitalization, storage, and carbon markets that increasingly are integral to addressing climate change.

Envision Energy is a world-leading green technology company, providing renewable energy system solutions for global enterprises, governments, and institutions. With the mission of 'solving the challenges for a sustainable future', Envision Energy continuously reduces the production, storage, and synergy costs of renewable energy through technological innovation. Encompassing three major business sectors - Smart Wind Turbines, Energy Storage, and Green Hydrogen Solutions, Envision Energy collaboratively constructs comprehensive solutions for energy transformation. It also manages Envision-Hongshan Carbon-Neutral Fund and owns Envision Racing Formula E team, who conquered the Formula E Teams' Championship in 2023.

Today, Envision Energy leverages its global network of R&D and engineering centers across China, the United States, UK, France, Germany, Denmark, etc. to continuously lead global green technology development. Envision Energy joined the Science Based Targets initiative (SBTi) and committed to achieving the "Business Ambition for 1.5°C" in 2021. It has achieved carbon neutrality across its global operations by 2022 and will achieve carbon neutrality throughout its value chain by 2028.

Envision was ranked second in Fortune's 2021 "Change the World" list and was ranked among the Top 10 of the 2019 'World's 50 Smartest Companies' by the MIT Technology Review.

Abu Dhabi Future Energy Company (Masdar) is the UAE's clean energy champion and one of the world's fastest-growing renewable energy companies, advancing the development and deployment of renewable energy and green hydrogen technologies to address global sustainability challenges. Established in 2006, Masdar has developed and partnered projects in over 40 countries, helping them to achieve their clean energy objectives and advance sustainable development. Masdar is jointly owned by Abu Dhabi National Oil Company (ADNOC), Mubadala Investment Company (Mubadala), and Abu Dhabi National Energy Company (TAQA), and under this ownership the company is targeting a renewable energy portfolio capacity of at least 100 gigawatts (GW) by 2030.

The Suzlon Group is one of the leading renewable energy solutions providers in the world with
~20.7 GW* of wind energy capacity installed across 17 countries. Headquartered at Suzlon One Earth in Pune, India; the Group comprises of Suzlon Energy Limited and its subsidiaries. A vertically integrated organisation, with in-house research and development (R&D) centres in Germany, the Netherlands, Denmark, and India, Suzlon's world-class manufacturing facilities are spread across multiple locations in India. With over 29 years of operational track record, the Group has a diverse workforce of over 6,200 employees. Suzlon is also India's No. 1 wind energy service company with the largest portfolio of over 14.7 GW in wind energy assets. The Group has ~6 GW of installed capacity outside India. Suzlon offers a comprehensive product portfolio led by the 2 MW and 3 MW series of wind turbines.

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