
GLOBAL OFFSHORE WIND REPORT 2020



Table of Contents

Foreword	5
Market Status 2019	9
Market Outlook 2030	13
Taking Offshore Global	31
Offshore Wind Technologies	80
Conclusion	95
Appendix	98
Abbreviation	99



Global Wind Energy Council

Rue Belliard 51-53
1000 Brussels, Belgium
T. +32 490 56 81 39
info@gwec.net
www.gwec.net

Lead Authors

Joyce Lee, Feng Zhao

Contributing Authors

Alastair Dutton, Ben Backwell,
Liming Qiao, Shuxin Lim, Anjali
Lathigaralead, Wanliang Liang

Published

5 August 2020

Design

Aspire Design, New Delhi

Sponsored by



Foreword

Rapid Growth

It's been quite a journey since I first got involved in the offshore wind industry 20 years ago.

Offshore wind energy took its first steps in the 1990s and has been growing in scale ever since. In recent years, however, growth has accelerated. From being 1% of global wind installations by capacity in 2009, offshore wind has grown to over 10% in 2019. Measured in investment terms that figure is much greater.

Offshore wind is now a mature industry, but is only just beginning its expansion in earnest around the

world. Given that more than 70% of the planet is covered by sea, and wind speeds are considerably stronger offshore than onshore, the fundamentals are promising.

Going Global

Offshore wind is going global, country by country. This piecemeal development is unhelpful for a supply chain which is seeking to make sound investments and continue to reduce costs. However, there are a number of initiatives which aim to accelerate offshore wind's deployment:

- GWEC's Global Offshore Wind Task Force, established in

September 2018, has brought together the major industry players in offshore wind. Key interventions have been in Taiwan, Vietnam and Japan to assist market development.

- The World Bank's ESMAP Offshore Wind Development Program, launched in March 2019, is focused on expanding offshore wind to developing countries. The program is engaging numerous countries which will form part of the wider global market in years to come.
- The Ocean Renewable Energy Action Coalition (OREAC), launched in Dec 2019, targets 1.4 TW of offshore wind by 2050. This industry body is in answer to the UN High Level Panel for Sustainable Ocean Economy call for action in Sept 2019.

These initiatives are in co-operation and complement each other for greater effect.



Alastair Dutton

Chair of Global Offshore Wind Task Force, GWEC
alastair.dutton@gwec.net

Themes

As we push through 30GW global capacity for offshore wind we see a number of themes.

- In Europe, the market that started it all, the installation rate is accelerating.
- Asia is picking up the pace with China installing more capacity in 2019 than any other country. This leadership is expected to continue through this decade.
- The message that the price of power from offshore wind has fallen to out-compete fossil fuels and nuclear, has been understood in many parts of the world.

Future Markets

- Existing markets are hungry for more, notably UK, Germany, Denmark, Netherlands, Belgium and China. As an example, the UK is targeting 40 GW by 2030, up from 10 GW today.
- Emerging markets include Taiwan, US Atlantic Coast, Japan, South Korea and Vietnam. Not only do these markets want low cost electricity to decarbonize their footprint but they are keen to establish their own supply chains to benefit their economies. However, inflexible local content requirements could frustrate those economic hopes by raising the cost of electricity and creating inefficient local suppliers not able to compete on a regional or global market.
- New markets are in the preparation phase. Examples include Brazil, Mexico, India, Sri Lanka, Australia and many more. In Europe the existing market will expand into Ireland, Poland, Lithuania and others.

- Floating technology will come of age this decade, tripling the technical potential for offshore wind across the world. Initially the key markets are France, Japan, South Korea, Scotland, Norway, Portugal, Spain and US Pacific Coast. Once commercial scale projects are established and costs come down many other locations will come into play, for example South Africa, Canada, Philippines and many island states.

Lessons Learned

- Much has been learned from the last 30 years of offshore wind deployment in Europe. Those lessons are being taken worldwide by developers and consultants. Governments are adapting those lessons in the context of their particular political and fiscal backdrops.

- One of those lessons is the UK Sector Deal which outlines targets and plans for government and industry to work together to dramatically progress the sector for the benefit of all. This best practice is now being adopted in other markets such as Japan and Poland.

COVID-19

To date offshore wind has been less impacted than most energy sectors by the pandemic, and stands ready to be a material part of a green recovery package.

Conclusion

The potential of offshore wind to achieve the energy transition within the right time frame and contribute to post-COVID recovery is increasingly being understood around the world. At GWEC, we look forward to working with you all to realise this potential

From being 1% of global wind installations by capacity in 2009, offshore wind has grown to over 10% in 2019

Offshore Wind – The technology that is changing the world

Sometimes, significant moments in history slide past relatively unnoticed as they are happening. Other times, the events are so huge that they have an immediate impact on society and radically alter the course of the world.

When these two worlds collide, technologies that might have previously been on the periphery are catapulted into centre stage as the answers to global questions, and previously unheralded advancements now take on much greater significance. Offshore wind is such a technology.

A pioneering industry

The offshore wind pioneers of the early 90's might have known that they were creating something special by unlocking the power of wind at sea, but not even the most optimistic analyst at the time could foresee the truly transformative impact that

offshore wind would have on the world's energy mix.

30 years ago, there was not a single MW installed offshore, but if current market predictions are accurate, there could be up to 1,400 GW installed worldwide over the next 30 years.

Offshore wind technology has also advanced dramatically over the past few decades. A single offshore wind turbine now has more capacity than the output of the world's first two offshore wind parks combined. New technologies such as floating foundations enable installation in deeper waters than previously considered, paving the way for new opportunities for offshore wind.

Exponential growth ahead

2020 was always destined to be a big year for our industry. Many nations, having underachieved with their 2020 climate goals, see offshore wind as

one of the key pillars to ensuring that they successfully reach their next generation, decarbonisation strategies to keep global warming under 1.5°C.

From the pivotal role offshore wind will play in delivering the European Green Deal, to rapid growth in the APAC region, now home to the largest market in China, to continued progress in US federal and state waters, offshore wind is beginning to witness exponential growth across the world.

GWEC and its partners are also working tirelessly to ensure that the next round of emerging markets such as those in Latin America, India and elsewhere capitalise on the lessons learned from the three decades of experience in Europe and increasingly APAC and the USA. If GWEC is successful here, the rate of uptake would significantly increase



Philippe Kavafyan

CEO, MHI Vestas



the chances of the industry reaching its global potential by 2050.

Lessons learned

What learnings can be shared as an increasing number of countries look to deliver many more projects further out to sea whilst reaping the industrial benefits of offshore wind?

The gradual, organic build up in the European supply chain has seen the rejuvenation of coastal communities, the growth of second and third tier suppliers across the continent, and skill development pathways to help transition workforces from sunseting to sunrising industries.

With such immense economic value and the continual reduction in cost of energy, it is easy to see why offshore wind is so appealing. The success seen in Europe has created expectations around the globe that offshore wind will generate economic value as well as deliver a low cost of energy to power sustainable, green economies – however, the right regulatory frameworks must be in place in order to reap these benefits

Representing a wind turbine manufacturer with a sole focus on offshore wind, we are beginning to

see that some nations are caveating their offshore wind ambition with supply chain targets. While it is understandable that nations investing in offshore wind expect to see some return on that investment, solving the supply chain puzzle is not a parochial challenge and must be solved regionally to generate the maximum economic benefits.

The industry has demonstrated that the supply chain will come with volume organically. As turbines become even larger and more powerful, offshore logistics dictate that supply chains have to be regional and draw upon the cheapest, highest quality suppliers of components from the region.

There is also an ever-increasing gap between the “raw” MWs that many nations are targeting ahead of 2030-2050 renewable energy plans and the “qualified” MWs that can actually be installed by 2030-2050. As the size and complexity of projects increase, greater emphasis must be placed on reducing inefficiencies during the permitting process to ensure projects can be delivered on time and reach these targets. The industry has clear vision on the stakeholders and challenges that typically cause

delays, and these challenges must be addressed and resolved by collaboration with the industry and policymakers before MW targets can be considered qualified and offshore wind can grow as a sector.

The COVID-19 effect

Without a doubt, COVID-19 has changed the world forever. When the pandemic first hit, the industry's focus was on ensuring continuity of business in both the supply chain and on offshore wind parks' operations, including construction and service, and the industry is to be congratulated on its successful efforts.

Having risen to the initial challenge, the industry now has the opportunity to utilise funds set aside for green recovery stimulus packages to accelerate the uptake of offshore wind by investing in the infrastructure that will help unleash the potential of the oceans and the economic potential of many countries.

Investment in grids, ports, Power-to-X projects and the like all have the potential to rapidly increase deployment of offshore winds. If the delays in the permitting process can also be minimised through renewed

political willpower, then offshore wind is ready to deliver on its potential.

Rising to the challenge

John F Kennedy once said, “these are extraordinary times. And we face an extraordinary challenge. Our strength as well as our convictions have imposed upon this nation the role of leader”, and while he may have originally been speaking about freedom, it is an apt quote for the offshore industry to adopt. We are leaders of the green energy transition, and we have a very important role to play guiding the world through these exceptional circumstances en route to reaching global decarbonisation targets.

This GWEC report provides a snapshot of the industry today, and the potential we have to work together in partnership to realise our ambition and ensure the future of our planet.

MARKET STATUS 2019





Annual installations

With 6.1 GW new capacity added, 2019 was the best year in history for the global offshore wind industry.

- China achieved a new record in 2019, installing 2.4 GW offshore wind in a single year. The United Kingdom came in second place, although it also had record installations of 1.8 GW in 2019. With 1.1 GW of new installations, Germany took the third place, followed by Denmark and Belgium.
- The results from the UK CfD Allocation Round 3 announced in September 2019 showed record low strike prices ranging from £39 to £41/MWh (in 2012 prices), which is about 30% lower than the auction held in 2017. In total, more than 5.4 GW offshore wind projects were awarded.
- In The Netherlands, Vattenfall won the second Dutch zero-subsidy offshore wind tender, totalling 760 MW, in July 2019 (repeating the zero-priced bids of the first round in 2018 and meaning that the project will only receive the wholesale price of electricity and no further support/payment). Those results prove how offshore costs have come down through technology innovation and economies of scale.
- The US offshore sector made great progress last year. The country's total offshore wind procurement targets increased from 9.1 GW in 2018 to 25.4 GW in 2019 after New York and New Jersey upgraded their offshore targets, and more states released their offshore wind targets. Six states had selected more than 6 GW of offshore wind through state-issued solicitations as of December

With 6.1 GW of new capacity added, 2019 was the best year in history for the global offshore wind industry.

2019 and more solicitations are expected to be issued in New York and New Jersey in 2020. The industry is now moving a phase of project construction planning and execution as more than 15 offshore projects are expected to be built by 2026.

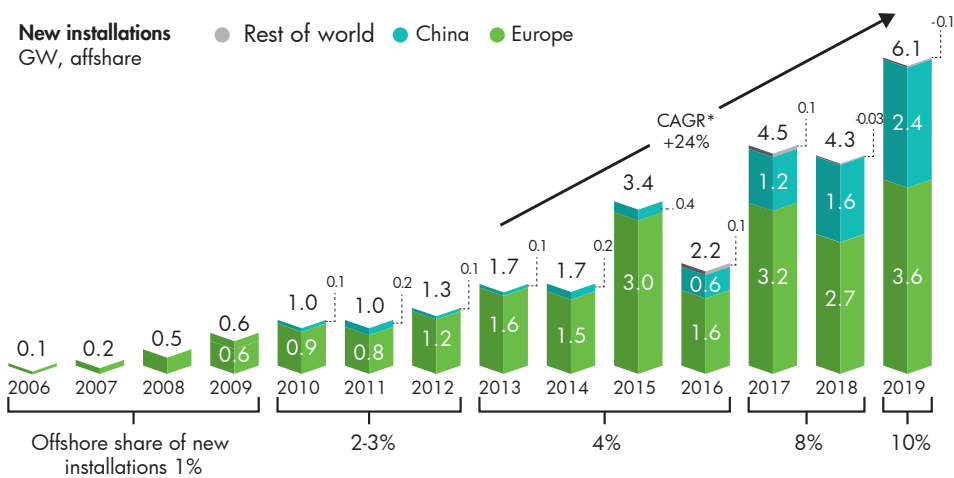
- Development in the Asian offshore markets was also positive in 2019 – Taiwan connected its first utility-scale offshore project to the grid. On top of the 5.6 GW offshore wind to be installed by 2025, a further 10 GW is planned to be built offshore from the island between 2026 and 2035. Positive steps were also made in Japan last year to accelerate offshore wind development with its first offshore wind auction launched in summer 2020.
- Globally, offshore wind installations have grown from 3.4 GW in 2015 to 6.1 GW 2019, bringing its market share in global new installations from 5% to 10% in just five years.

Cumulative installations

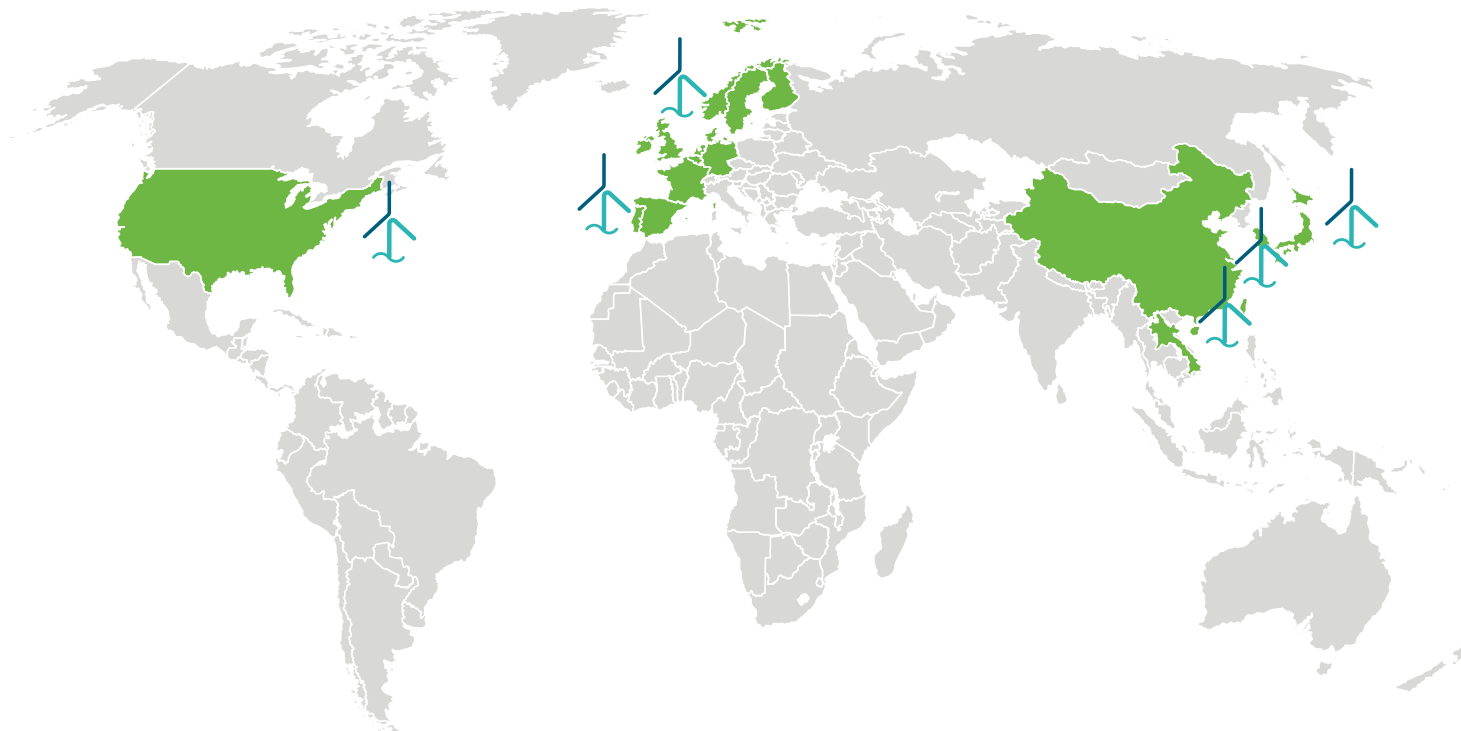
The global offshore market grew on average by 24% each year since 2013, bringing the total installations to 29.1 GW, which accounted for 5% of total global wind capacity as the end of 2019.

- Europe remains the largest offshore market as the end of 2019, making up 75% of total global offshore wind installation.

- However, the activity level in Asia keeps increasing with China taking the lead followed by Taiwan, Vietnam, Japan, and South Korea.
- North America has only 30 MW offshore wind in operation in the US as of 2019 but deployment will accelerate in the coming years.
- The top five offshore wind market in total installations are: The UK, Germany, China, Denmark and Belgium.



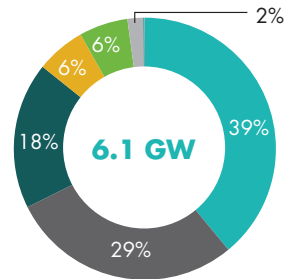
* Compound Annual Growth Rate
Source: GWEC Market Intelligence, March 2020



FLOATING WIND

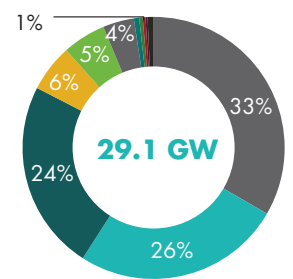
- 11.4 MW floating wind installed in 2019, of which 8.4 MW is from Portugal and 3 MW from Japan;
- As of the 2019, a total of 65.7 MW floating wind was installed global, of which 32 MW is located in the UK, 19 MW in Japan, 10.4 MW in Portugal, 2.3MW in Norway and 2 MW in France

New offshore wind installations by country



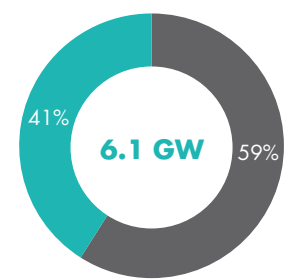
China The UK Germany Denmark
Belgium Taiwan Portugal Japan

Total offshore wind installations by country



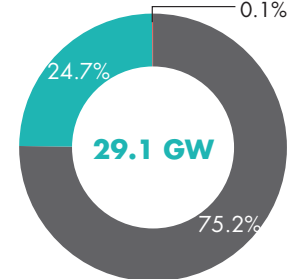
The UK Germany China Denmark
Belgium Netherlands Sweden Taiwan
Vietnam South Korea Others

New offshore wind installations by region



Europe APAC

Total offshore wind installations by region



Europe APAC North America

MARKET OUTLOOK 2030



Offshore Market Outlook to 2030

The global offshore wind market outlook to 2030 has grown more promising over the past year as governments raise their ambition levels and new countries join the market. With an average annual growth rate of 18.6 percent until 2024 and 8.2 per cent up to the end of the decade, new annual installations are expected to sail past the milestones of 20 GW in 2025 and 30 GW in 2030.

GWEC Market Intelligence expects that over 205 GW of new offshore wind capacity will be added over the next decade. Three-quarters of this new volume will be installed in the latter half (2025-2030), as projects currently in planning get connected to the grid.

Offshore wind already accounted for 10 percent of global new wind power installations in 2019. Buoyed by expansion into new markets and acceleration of the global energy transition, GWEC Market Intelligence foresees offshore wind playing an increasingly important role in the

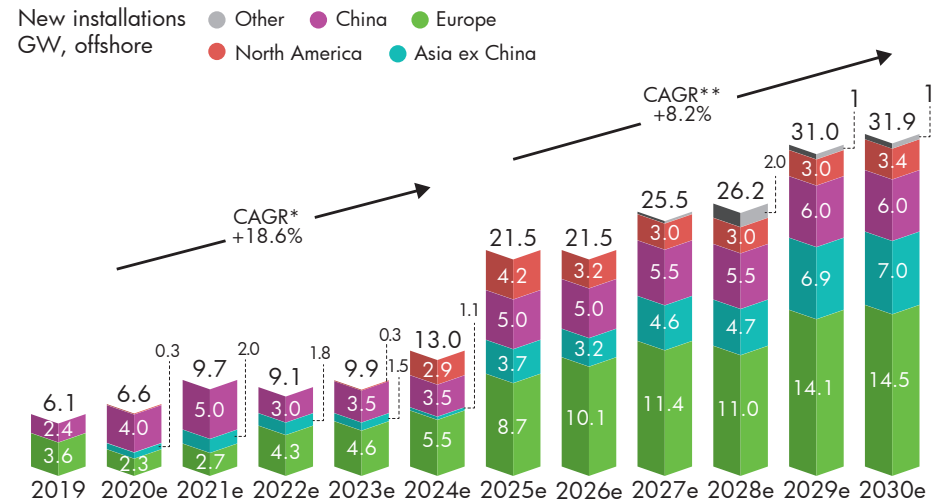
overall growth of the global wind market, and expects offshore wind to contribute more than 20 percent of total wind installations by 2025.

As the world's largest regional offshore wind market, Europe is expected to maintain steady growth, but new installations outside Europe, predominantly from Asia and North America, are likely to surpass Europe in 2020 for the first time and continue exceeding volume in Europe through 2030. In the near-term (2020-2024), the majority of growth outside of Europe will primarily come from China and Taiwan, with the contribution from the US becoming sizeable from 2024 when the first utility-scale offshore project comes online.

Our near-term offshore wind market outlook was built using a bottom-up approach and 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, aside from existing project pipelines, a top-down approach has also been used, which takes into account existing policy, support schemes and national level offshore wind targets.

Global offshore wind growth to 2030



* CAGR = Compound Annual Growth Rate
Source: GWEC Market Intelligence, June 2020

Europe

Europe is the birthplace of the offshore wind industry. Since the world's first offshore wind turbine was installed in Denmark in 1991, Europe has been taking the lead in both offshore wind installations and turbine technology innovation. After three decades of research and development in Europe, offshore wind has established itself as a cost-competitive power generation of choice for governments and a mature industry. Through collaboration among European markets and experienced stakeholders, a robust offshore wind supply chain has been built in countries neighbouring the North Sea and Baltic Sea. In the past decade, the European offshore wind market enjoyed double-digit annual growth (11 percent), making it the world's largest regional market as of the end of 2019.

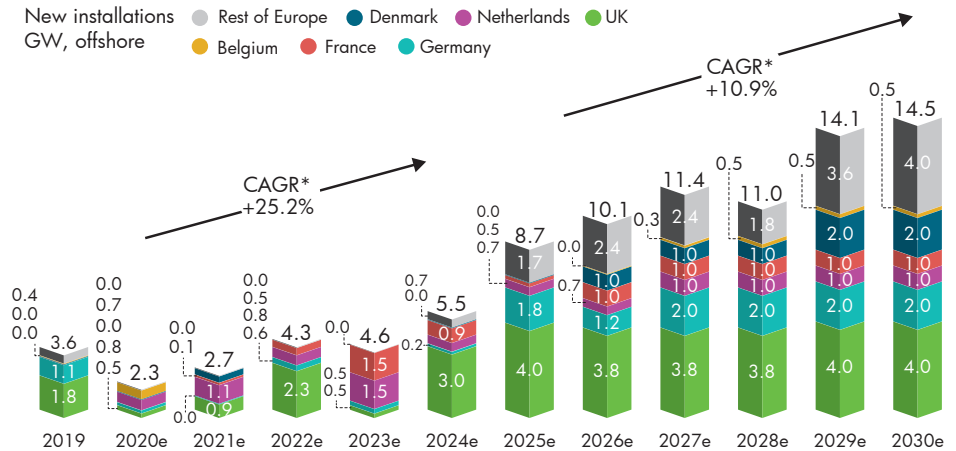
Looking at potential growth in the decade ahead, GWEC Market Intelligence forecasts that the European offshore wind market will continue to grow strongly, as new offshore wind projects are both cheaper to build and operate than new nuclear power and gas-fired power plants, making it a core energy source to help Europe to meet its NDCs and achieve carbon-neutrality goals by 2050.

The European Commission estimates that total offshore wind installations between 240 and 450 GW will be needed by 2050, making offshore wind a crucial pillar in Europe's power mix.

In GWEC Market Intelligence's pre-COVID market outlook, 2020 and 2021 were expected to be relatively quiet years, with new installations below 3 GW in Europe.

New installations are likely to exceed 20 GW in 2026 and then potentially reach 15 GW by 2030

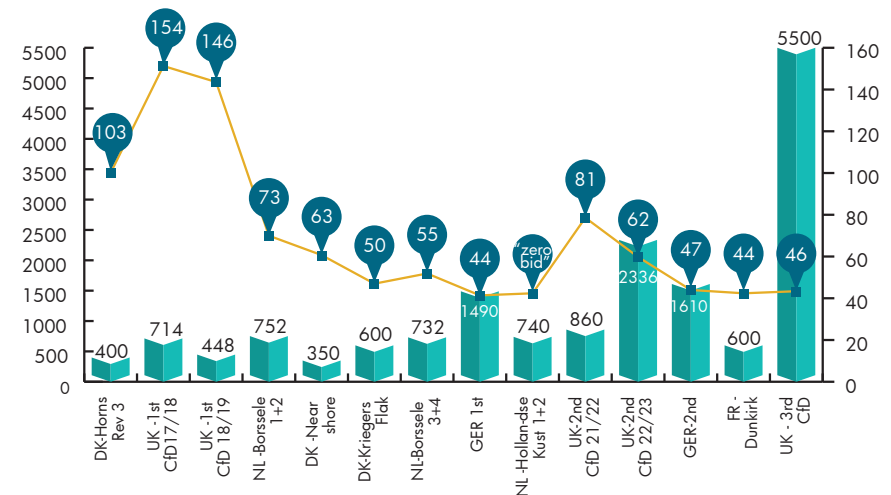
Global offshore wind growth to 2030 in Europe



* CAGR = Compound Annual Growth Rate
Source: GWEC Market Intelligence, June 2020

European executed offshore tenders/ auctions 2015-19

Awarded capacity (GW), average winning bid (EUR/ MWh)*



* Tenders above 100MW capacity and no innovation auctions, tenders in order of execution from 2015 to end of 2019
Source: GWEC Market Intelligence, GWEC Auction Database May 2020



This growth forecast is unchanged in our post-COVID scenario. After a slow start in the beginning of 2020s, however, the European offshore market is likely to bounce back in 2022 when all the UK's CfD 2 projects will come online. New installations in Europe are likely to reach 8.7 GW in 2025.

Taking into account recently increased or proposed offshore wind targets from established markets and activities in new European markets, such as those around the Black Sea, GWEC Market Intelligence expects more offshore wind to be built in the second half of the decade. New installations are likely to exceed 20 GW in 2026 and then potentially reach 15 GW by 2030.

The United Kingdom

As the world's largest offshore wind market, the UK continues to tell a successful story through its 2019 Sector Deal, reached between the government and industry, through its new government target of 40 percent of UK power from offshore wind by 2030, and through the 30 percent cost reduction achieved from CfD Rounds 2 to 3. CfD Round 4, which seeks to award up to 8.5 GW of

projects, is underway with Invitation to Tender (ITT) Stage 1 submission period concluded. In early June, Crown Estate Scotland also launched the ScotWind seabed leasing round for offshore wind projects, followed by the UK Committee on Climate Change (CCC)'s recommendation to the government in June to deliver at least 40 GW of offshore wind by 2030.

Germany

The German wind industry has been struggling with the federal government's conservative offshore wind target. The good news is that Germany's Federal Cabinet has approved the amendment to the Offshore Wind Act (WindSeeG) in June 2020. Not only does the bill increase the 2030 offshore wind target from 15 GW to 20 GW, but

it establishes a long-term offshore target of 40 GW by 2040. The amendment has been welcomed by the industry, as it brings in volume, scale, jobs and long-term visibility.

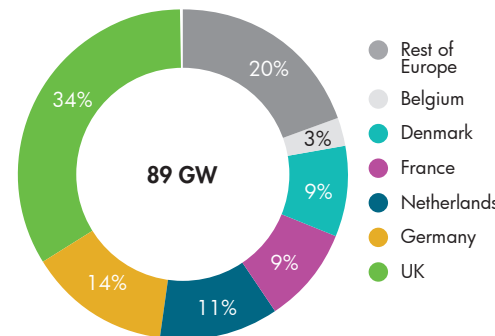
France

The Multiannual Energy Programme (Programmation pluriannuelle de l'énergie (PPE)) that came into force in April 2020 shows that France will tender up to 8.75 GW of offshore wind capacity from 2020 to 2028. The PPE also increases the intended operating offshore wind capacity to between 5.2 GW and 6.2 GW by 2028. The 2023 operating capacity target is 2.4 GW. From 2024 onward, France will tender 1 GW per year of either fixed-bottom or floating wind capacity, depending on the cost.

Denmark

In June 2020, the Danish parliament approved a new Climate Action Plan which calls for the development of two "energy islands," one in the North Sea and one in the Baltic Sea (with a combined capacity of 5 GW planned by 2030) and also approves the development and construction of one more wind farm in the Baltic Sea with capacity of up to 1 GW.

Total added between 2020 and 2030
GW, offshore



Asia

Japan built Asia's first offshore wind project with two units of V47-660kW turbines in 2003. However, the Asian offshore market was not ready to take off in earnest until 2014, when the Chinese central government released the National Offshore Wind Development Plan (2014-2016). In 2017, China passed the 1 GW annual installation milestone; one year later, it surpassed the UK as the world's top market in new installations.

GWEC Market Intelligence's latest market outlook predicts that China will continue to dominate the Asian offshore wind market in the first half of this decade, with more than 70 percent market share. Taiwan is expected to be the largest offshore market in Asia after China in new installations in the same period.

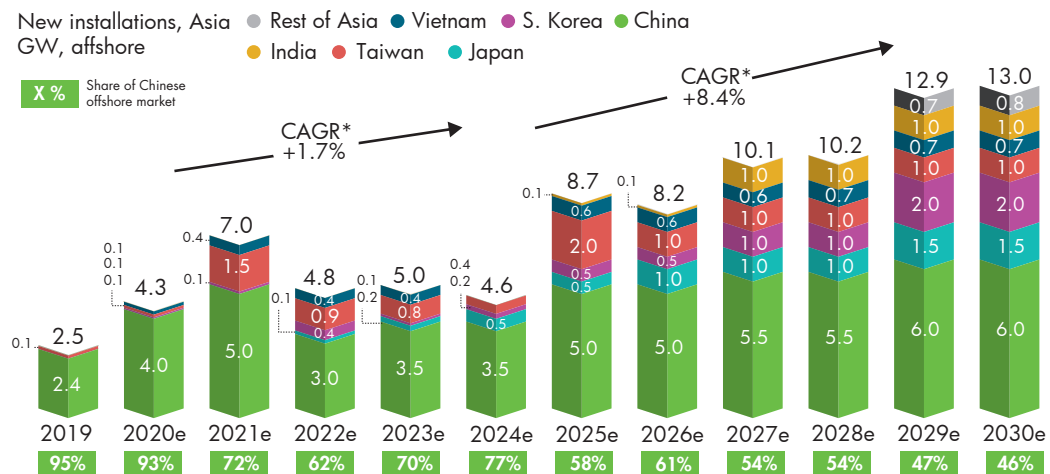
However, the scales will tip from 2025, when more utility-scale offshore wind projects get connected in Japan, South Korea and Vietnam. GWEC Market Intelligence forecasts that China's market share in this region is likely to drop to 58% in 2025 and

will continue to decline when offshore projects expand to new markets with high resource potential, like India and the Philippines, towards the end of the decade.

The average annual growth rate in Asia will stay at the level of 1.7 percent in the first half of this decade, but is likely to increase to 8.4 percent in the second half. The top five markets in this region in new



Global offshore wind growth to 2030 in Asia

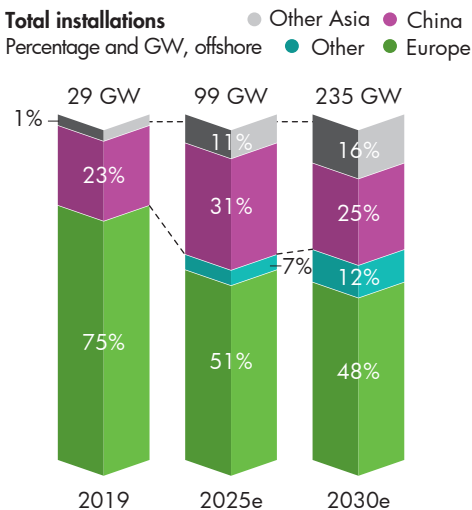




installations in this decade will be China (52 GW), Taiwan (10.5 GW), South Korea (7.9 GW), Japan (7.4 GW) and Vietnam (5.2 GW).

Excluding China, the Asian offshore wind market is still at the early stage of development. Each market is facing the challenge of developing a local supply chain and the necessary competencies and capabilities to build an offshore wind industry.

Total installations
Percentage and GW, offshore



The early experience from Taiwan has proven that collaboration with European partners across markets in this region is essential for success.

GWEC Market Intelligence predicts that Europe will remain the largest regional offshore wind market in terms of total installations by 2025 and 2030. Nevertheless, Asia's share of the global market is expected to grow from 24 percent in 2019 to 42 percent in 2025, where it is likely to remain until the end of the decade.

China

China was the world's No. 3 offshore market in total installations as of the end of 2019 (after the UK and Germany). At present, project developers and investors are rushing to commission their projects before the end of the 2021 deadline in order to capitalise on the 0.85RMB/kWh FiT for offshore wind. Considering extraordinary volume of new capacity (4-5 GW/year) will be built in 2020 and 2021, GWEC Market Intelligence expects China will surpass the UK as the world's largest offshore market

in total installations by 2021, if not 2020. However, new installations will decline dramatically from 2022, when the central government will terminate the subsidy for offshore wind. Annual offshore wind growth in China in the future will depend on whether subsidies provided by provincial governments will be available and whether offshore wind industry can reach grid parity before 2025.

Taiwan

With 128 MW offshore wind capacity online at present, Taiwan is positioned to become the second-largest offshore wind market in this region. It will connect 5.5 GW of new offshore wind by 2025 and another 10 GW will be tendered by the government through the Round 3 auctions for commissioning by 2035, providing the long-term visibility needed to generate a local offshore wind industry and supply chain.

China will continue to dominate the Asian offshore wind market in the first half of this decade with more than 70 per cent market share



South Korea

Although the “green growth” strategy announced almost a decade ago has failed to boost its offshore wind development, the Democratic Party led by President Moon Jae-in seems intent on reviving the green agenda. To reach the “Renewable Energy 3020” target of 20 percent renewables in the power mix by 2030, South Korea is targeting 12 GW of new offshore wind capacity to be built by the end of this decade.

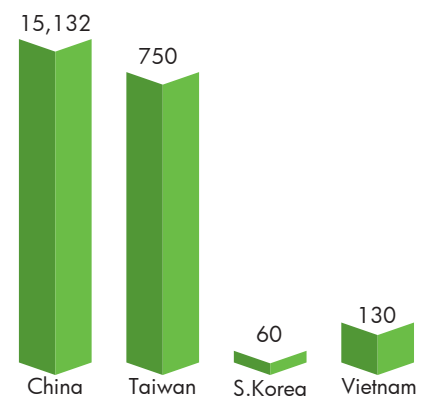
Japan

The development of Japan’s offshore wind sector has been stymied by a lack of ambitious targets and a cumbersome permitting and licensing framework, but there has been a growth in momentum at both the policymaking and industry level since 2017. In July 2020, the government nominated four offshore wind zones and launched the first offshore wind auction for a floating offshore wind farm offshore from Goto City. GWEC Market Intelligence expects the Japanese offshore wind market to take off from the middle of this decade.

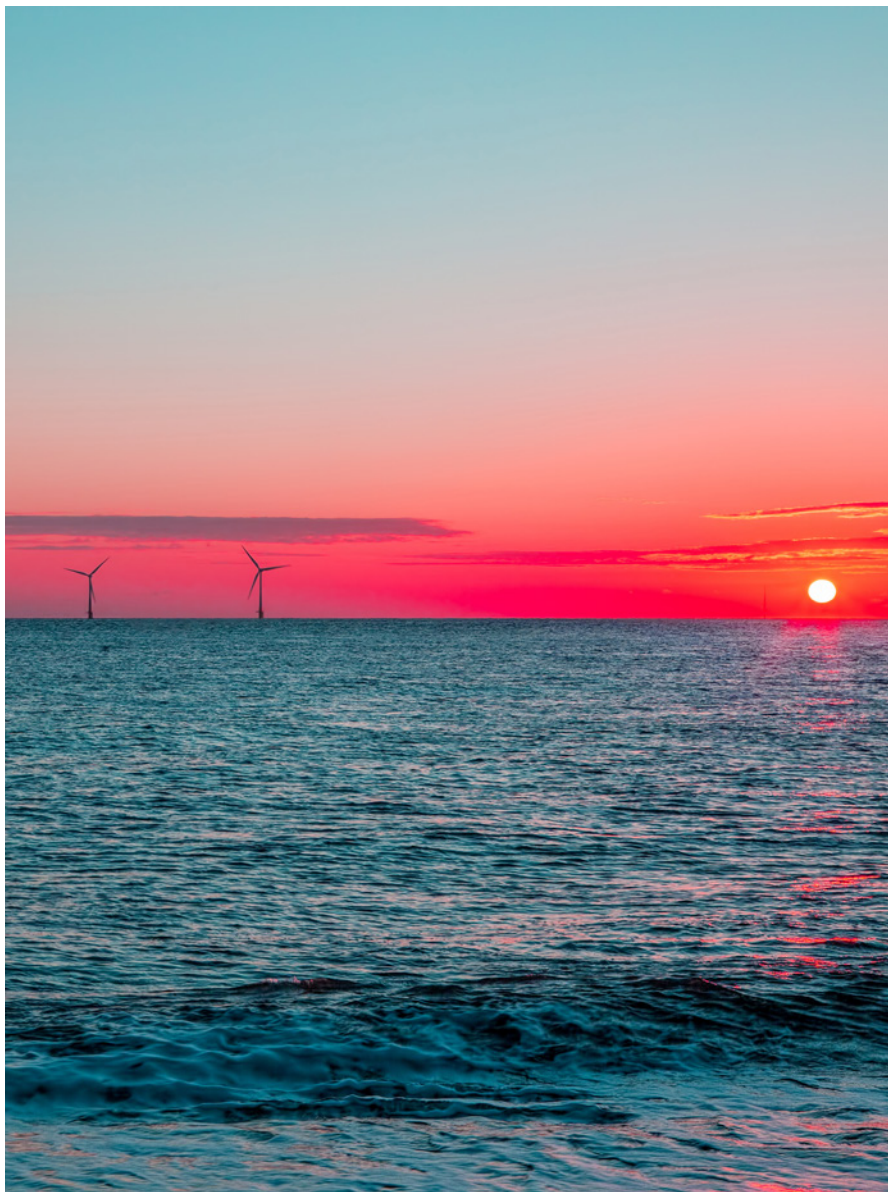
Vietnam

More than 500 MW offshore wind projects in the pipeline were expected to come online before the current FiT deadline of November 2021. Taking into account the recent announcement of a FiT extension to the end of 2023 followed by an auction system from 2024, which was officially sanctioned by the Prime Minister in June, GWEC Market Intelligence predicts a total of 5.2 GW offshore wind capacity to be built between 2020 and 2030.

Projects under construction 2020*
MW, offshore (Status as Q1 2020)



* Construction defined as beginning of foundation work
Source: GWEC Market intelligence, May 2020

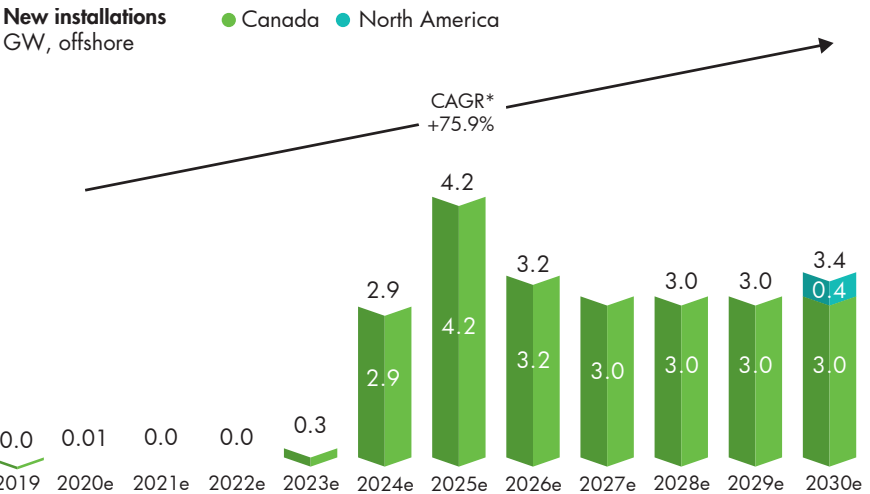


North America

North America installed its first test offshore wind turbine, a 1/8th geometric scale of a 6 MW turbine, off the coast of Maine in 2013, and connected its first commercial wind project to the grid in Rhode Island in December 2016. As of the end of 2019, 30 MW of offshore wind capacity was spinning in North America, making it the only region with commercial offshore wind outside of Europe and Asia.

Based on GWEC Market Intelligence's global offshore wind project pipeline, no utility-scale offshore wind project will come online in North America before 2024. In total, 23 GW of offshore wind is predicted to be built in this region in this decade, of which less than 1 GW is expected to come from Canada, despite its high technical resource potential.

Global offshore wind growth to 2030 in North America



* CAGR = Compound Annual Growth Rate
Source: GWEC Market Intelligence, June 2020

United States

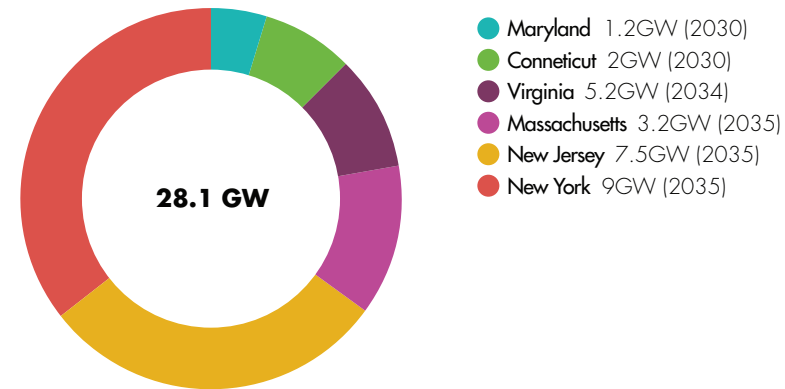
The sole demonstration project in the US, a 12 MW pilot project in Virginia, was completed in June 2020 as the first offshore wind project to be approved by the Bureau of Ocean Energy Management (BOEM) and installed in federal waters. However, the level of offshore wind development activity remains impressively high. As of the end of 2019, BOEM has auctioned 16 active commercial leases for offshore wind development that could support more than 21 GW of generating capacity.

On the state level, the East Coast cluster consisting of Maine, Connecticut, Massachusetts, New York, New Jersey, Delaware, Maryland, Virginia and North Carolina is driving strong demand for offshore wind energy with the total announced offshore wind procurement targets reaching 28.1 GW as of Q1 2019. GWEC Market Intelligence predicts a total of 22.6 GW of offshore wind could be built in the US by the end of this decade.

To realize such potential, however, the following key challenges need to be addressed:

- Slow project permitting processes have delayed the ramp-up of the US offshore wind industry, which has more than 2,000 GW of technical resource potential and must be streamlined.
- Establishing a local supply chain and fostering investment and long-term planning in grid and port infrastructure must be achieved across states through a collaborative approach.

Offshore wind development targets in the US



Floating Offshore Market Outlook to 2030

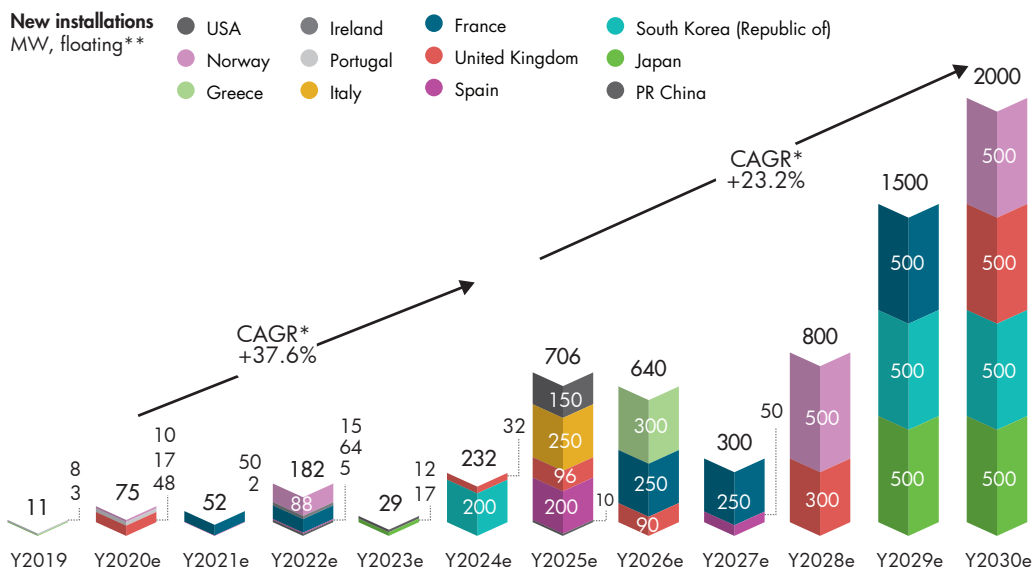
The world's first MW scale floating offshore wind turbine was grid-connected by Equinor in Norway in 2009. As of the end of 2019, a total of 66 MW of floating wind capacity has been installed worldwide.

After a decade of development, floating offshore wind is no longer simply an R&D area. With more oil majors such as Shell and TOTAL starting to focus on floating wind, this sub-section of offshore wind

is ready to progress quickly to full commercialisation.

At present, the 2030 floating offshore wind forecast ranges from 3 GW to nearly 19 GW, depending on how quickly LCOE can be brought down to an affordable level and its adoption by new markets.

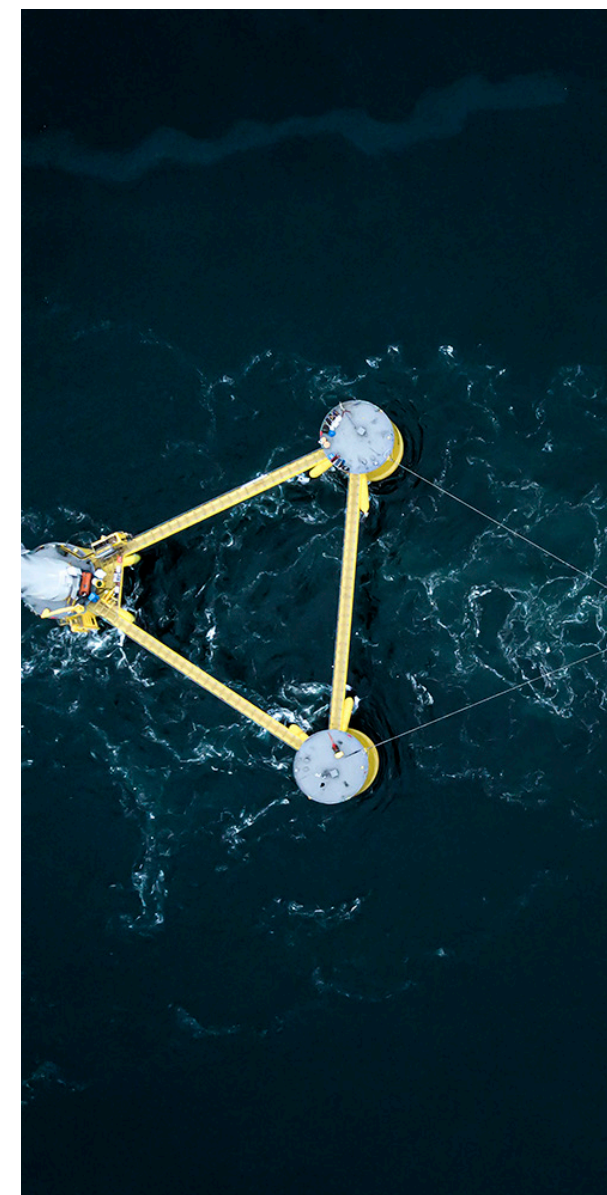
GWEC Market Intelligence predicts 6.2 GW of floating wind is likely to be built in the next 10 years. This outlook is primarily based on the existing global floating offshore project pipeline as well as announced investment plans. Out of the 6.5 GW floating wind installations, we expect less than 10 percent to be built in the first half of this decade; the majority of new volume will come online in the latter half, when large-scale floating wind projects tendered through auctions are expected to be installed.



* CAGR = Compound Annual Growth Rate

** Note: this floating wind outlook is already included in GWEC's global offshore wind forecast

Source: GWEC Market Intelligence, June 2020





Courtesy of Principle Power. Artist name: Dock90

Currently, the UK, Portugal and Japan are the top three markets in total floating wind installations. By the end of this decade, South Korea, France and Norway are likely to replace those markets as the top floating markets. Considering the tremendous wind resources available at shallow water depths, at present we expect only demonstration floating wind projects to be built in China.

Floating wind's current contribution to total wind installations is fairly small, but it will play an increasingly important role toward the end of this decade, accounting for 6 percent of global new wind installations in 2030. GWEC Market Intelligence

expects that floating wind will prevail when it is commercially viable as another foundation solution, rather than a sub-sector of offshore wind. Consolidation of floater designs and modularisation of production will be the keys to bringing down LCOE. GWEC launched its Floating Offshore Wind Task Force in July 2020 to unlock future potential.

Global floating offshore wind resource map



Source: QFWE

Impact of COVID-19 on Global Offshore Wind Market



2020 was on track to be a record year in global wind history with more than 76 GW to be installed. However, the COVID-19 crisis, which disrupted global wind supply chains and project construction execution, is expected to lead to a more modest 61.4 GW this year, 19 percent lower than our pre-COVID forecast made in Q1 2020. Most of the impact will be felt by the onshore wind sector, and new wind installations are likely to bounce back to make 2021 a record year with annual installations reaching 77.7 GW.

The COVID-19 pandemic has shocked the global energy sector, forcing projects to suspend work to comply with social distancing regulations, challenging the investment conditions of markets bracing for economic recession and slashing power demand by [up to 10%](#) in some regions in 2020. The size of that decline is around seven times greater than during the 2008-2009 global financial crisis, according to the IEA, and has hit demand for oil, natural gas and coal the hardest.

But renewable energy will see an overall increase in its share of global power generation this year, due to its cost-competitiveness and priority dispatch in many markets. And the

offshore wind sector, with longer project development timelines, will largely be shielded from the short-term supply chain disruptions which impacted project execution in onshore markets across the world. In 2020, the wind capacity lost to the pandemic is estimated by GWEC Market Intelligence at around 15 GW – most of the downgrade will affect onshore wind, with volume shifting to come online by 2021 instead.

Impact of COVID-19 on global offshore outlook

Over the next five years, the leader for offshore wind installations by far will be **Mainland China**, where 19 GW is expected to be commissioned

COVID-19 will not significantly impact the global outlook, due to longer project timelines and concentration of installations in the latter half of the decade.

off the coasts of Jiangsu, Fujian, Guangdong, Zhejiang, Hebei and Liaoning provinces. Driven by an offshore wind FiT for projects which will be grid-connected by 2021, the market has sufficient runway and production capacity to rebound from the slowdown in activity during the first half of 2020. The delay for offshore wind project construction in China is estimated at six months, due in part to restrictions on imported bearing materials from Europe and imported blade materials like balsa wood and PVC from Ecuador and Italy.

Since the grid-connection deadline extension proposal sent by the local wind industry to the National Energy Administration (NEA) seems unlikely to be approved at the time of writing, the Chinese offshore industry is currently running in full steam in project construction. Based on the latest offshore wind market dynamics and feedback from leading suppliers and developers in China, GWEC has kept its 19 GW pre-COVID forecast unchanged for China for the next five years.

In **Europe**, the expected new installations in 2020 and 2021 were already low in our pre-COVID

outlook. The projects scheduled for commission in both years are currently under construction in the UK, Germany, the Netherlands and Belgium. GWEC members report that construction work is proceeding during the pandemic, with the two big projects Borssele I & II and Seamade generating first power in April and July, respectively.

In addition, the market leader, the UK, has maintained its offshore wind auction timeline for 2021, with the industry even **calling** to accelerate procurement through annual Contract for Difference auctions. Germany, the No. 2 offshore market in Europe, recently raised its offshore wind capacity target to 20 GW by 2030 and 40 GW by 2040, and **implemented** a law streamlining permitting procedures for wind projects. The government is also making offshore wind a cornerstone of its national hydrogen economy strategy.

In **the US**, the 12 MW Dominion Virginia demonstration project was successfully installed in June 2020, but the combination of prolonged lead time to secure federal permits, especially the Construction and Operations Plan (COP) from BOEM, and the effects of the

COVID-19 pandemic have delayed projects previously scheduled for commissioning in 2022 and 2023. Thus, GWEC Market Intelligence has pushed back the commissioning year for those projects by one year.



Green Recovery



The pandemic has highlighted the opportunity to make wind power a cornerstone of economic growth and recovery packages. [GWEC's global statement on "Re-building Better"](#) for the future, signed by leading wind companies and associations representing 98 percent of installed onshore and offshore wind power worldwide, highlights wind power as a source of affordable, clean and zero-carbon electricity, which can bring significant socioeconomic benefits to local communities (see page 26 "Driving millions").

By mid-2020, as lights around the world flickered back on and assembly lines restarted, global carbon emissions have already [sharply rebounded](#). It is critical for the health, welfare and prosperity of the global community that the clean energy transition becomes a core component of economic stimulus and growth packages. Studies show that investing in renewables will have a multiplier effect on economic growth: \$1 spent to advance the

global energy transition returns \$3-8, [according to IRENA](#), while clean energy infrastructure construction generates [twice as many jobs](#) per \$1 million spent as fossil fuel projects.

Offshore wind offers compound value for investment, with high capacity factors and [average global costs declining](#) more than 50 percent over the last decade. In decarbonisation terms, 1 GW of offshore wind power avoids more than 3.5 MT CO₂ – giving it [more potential for carbon avoidance](#) as a technology to displace fossil fuels than even onshore wind, solar, hydro or efficient gas power.

Keeping global warming within 1.5-2 degrees of pre-industrial levels will require at least 100 GW of new onshore and offshore wind capacity to be installed on an annual basis through 2030, with the accompanying scale-up of investment. True “green recovery” by national and regional governments will enable this magnitude of

deployment, through higher capacity targets, transparent pipelines and policy measures to resolve the severe existing bottlenecks around permitting and licensing of new projects. Increasing investment to undertake modernisation of grid and transmission infrastructure will also be key to integrating large volumes of offshore wind.



Driving Millions of Sustainable Jobs in the Energy Transition


At a time when governments are considering maximum impact per dollar of economic stimulus, it is worth highlighting that offshore wind farms have greater labour requirements than onshore wind farms, due to more complex construction, assembly and installation activities.

Offshore wind offers a range of job opportunities across the value chain – from project planning and financing to manufacturing and transport to construction and operations and maintenance (O&M). A 2020 [study](#) by the American Wind Energy Association found that the sector offers “good, well-paying jobs requiring a diverse technical workforce spanning an estimated 74 occupations... [including] electricians, welders, turbine technicians, longshoremen, truck drivers, crane operators, ironworkers, pipe-fitters, pile drivers, engineers,

mechanics, scientists, and offshore equipment and vessel operators.”

Based on data from IRENA, gathered during a 2018 [study](#) of nearly 30 stakeholders, GWEC estimates that **17.3 direct jobs (defined as one year of full-time employment for one person) are created per MW of generation capacity over the 25-year lifetime of an offshore wind project.**^[1] With nearly 51 GW of new offshore wind capacity forecast to be installed worldwide by 2024, that equals nearly 900,000 jobs in offshore wind created over the next five years – a figure which can only increase if offshore wind deployment scales up.

[1] This is a generalised calculation for demonstration purposes only, and does not account for technology evolution, application of various platforms or installation technologies, economies of scale, productivity rates or learning excellence. Comprehensive studies are required to determine job creation potential for offshore wind for specific markets.



17.3 direct jobs (defined as one year of full-time employment for one person) are created per MW of generation capacity over the 25-year lifetime of an offshore wind project.^[1]

Nearly 900,000 jobs in offshore wind are likely to be created over the next five years.

Maximising local economic activity will require policymakers to make strategic choices on how existing workers can be leveraged for high-growth areas

For near-term local employment, a study by GWEC, Global Wind Organisation and Renewables Consulting Group found that 2.5 persons were required to construct and install 1 MW of offshore wind – an indication of potential job creation for already licensed projects.

Once the wind farm is connected, jobs in operations and maintenance (O&M) last over the lifetime of the project – roughly 25 years for offshore wind. O&M spans a variety of needs, from contract management to wind turbine maintenance to offshore logistics. As well, remote automated control is increasingly employed in O&M, via a SCADA system, radio telemetry and artificial intelligence applications. These areas require highly skilled workers with a background in data science, mechanical and computer engineering and telecommunications.

Maximising local economic activity will require policymakers to make strategic choices on how existing workers can be leveraged for high-growth areas. Where possible, re-skilling offshore oil and gas workers for the growing wind sector should be a priority to encourage low-carbon economic growth and competitiveness. This is also a fair response to labour market disruptions from the energy transition and pandemic, including dislocation of jobs for offshore oil and gas workers.

Outside of manufacturing turbine components, offshore wind generates jobs in the manufacturing of steel for foundations, substations and installation vessels, sub-sea cables to evacuate electricity from offshore farms to onshore grids and trucks and vessels for transport of equipment and workers. All these areas can leverage the capabilities

and supply chains of the offshore oil and gas sector.

Potential short-term investment areas to support a just and inclusive transition include targeted education and training schemes, industrial upgrades and promotion of public-private partnerships. Long-term investment areas include supplier development programmes and national roadmaps to develop industrial clusters in strategic areas of need.



Looking Beyond 2030

Beyond the next decade, key government and industry bodies are setting their sights even higher for offshore wind. The EU's staggering [450 GW aim by 2050](#) foresees industrial clusters in the North Sea (with nearly half of the targeted capacity), Atlantic Ocean, Baltic Sea and southern European waters. Installations will be mainly concentrated in the UK, Netherlands, France, Germany, Denmark and Poland, with several other EU markets home to double-digit volumes.

The Ocean Renewable Energy Action Coalition (OREAC) is a global group of leading offshore wind developers, technology providers and stakeholders including GWEC, launched in December 2019 in response to the UN High Level Panel for Sustainable Ocean Economy's call for ocean-based climate action. OREAC envisions offshore wind reaching [1.4 TW of installed capacity by 2050](#), driven by the sector's ability to drive investment, generate jobs and severely cut emissions worldwide. This goes

far beyond current forecasts from international institutions, but according to OREAC, reaching this ambitious target would be possible with strong collaboration between government and industry, policy stability, market transparency and responsible development, allowing offshore wind to thrive among other sustainable ocean uses.

World Bank's ESMAP Offshore Wind Development Program, launched in March 2019, targets the acceleration of offshore wind development in non-OECD countries around the world. As a partner of this programme, GWEC works with the World Bank to engage policymakers on recognising and delivering the offshore wind potential in their market through national

roadmapping and workshops. (see page 74)

Progress made over the next ten years will lay the foundation for how high and how far offshore wind can scale in the decades beyond. With strong economics, exciting technology evolution and growing interest from coastal markets around the world, offshore wind is set to be a game-changer in the global energy transition.

Progress made over the next 10 years will lay the foundation for how high and how far offshore wind can scale in decades beyond.

TAKING OFFSHORE GLOBAL



Part 1. Lessons learnt

a. Support scheme

From 2 GW of offshore wind installed capacity in 2009 to nearly 30 GW in 2019, offshore wind has grown exponentially over the past decade, benefiting from technological advancements, declining costs and strong support schemes. Most of this growth has been concentrated in the UK, Germany, mainland China, Denmark, Belgium and Netherlands. Particularly around the North Sea, a bedrock of supply chain, finance, innovation and expertise has emerged. Now, the offshore market is taking off in Asia and North America, with promising developments in Pacific, Latin America and Africa in the medium-to-long term.

Over the last 10 years, policy stability, financial support schemes and innovation clusters have improved the economics and scalability of offshore wind, moving it from an emerging technology to a critical part of global decarbonisation roadmaps.

[2] Probable Upcoming Scheme; GWEC Analysis

Support schemes in key offshore wind markets

Key Market	Former Schemes	Current Schemes	Upcoming Schemes
UK			n/a
Denmark			
Germany			
The Netherlands			n/a
Taiwan			
China			
Japan			n/a

Source: GWEC Market Intelligence, June 2020

Beginning with federal support for demonstration projects, the sector has evolved towards Contract for Difference (CfD) mechanisms and even zero-subsidy bids in certain markets. Of these, the CfD scheme has delivered large volumes in UK, the offshore wind market leader (below), accounting for competitive pricing and market reference pricing while granting revenue certainty over a long duration.^[2]

Renewable Obligation Certifications
Feed-in-Tariff
Guaranteed price auctions with Premium Tariff
Demonstration Incentive Program
Contract for Difference (CfD)
Competitive Bidding
Auctions with Zero-subsidy
Centralised Auctions
Corporate PPAs with T-REC (Taiwan Renewable Energy Certification)
Premium Tariff through Tendering System
Auction with capping price regulated
Feed-in-Premium (SDE)

UK

- The Renewables Obligation (RO/ROC), a subsidy scheme for large renewable electricity projects applied in 2002, supported deployment of 5 GW offshore wind installation until March 2017.
- Currently, the UK employs a CfD scheme, introduced in 2013 under the Electricity Market Reform, which: 1) Provides direct protection from volatile wholesale prices to consumers and developers and 2) Incentivises the upfront investment costs for offshore project developers.

Denmark

- Denmark financed RE projects through the PSO (Public Service Obligation) tariff. During the liberalisation of the Danish electricity sector (2000-2002), a guaranteed price with balancing subsidy for the first 10 years from the grid connection and premium FiT with balancing subsidy until 20 years was provided. This was followed by: 1) Feed-in-premium for up to 22,000 full load hours, with balancing subsidy for the entire life through the competitive tendering process; 2) FiT for up to 50,000 full load hours (i.e. ~11-12 years of operation), wherein connection to the grid was an additional subsidy given to offshore wind farms and paid by consumers.
- In 2016 an agreement established that the PSO tariff would be phased out from 2017-2022 and projects would be financed through national budget.
- In November 2019, Denmark chose the CfD model for the Thor offshore wind farm (800-1000MW) under which subsidies in the form of a price premium for a 20-year period will be provided. This model would encourage investors to invest for upcoming projects for the development of two energy islands totalling 5GW by 2030 and the up to 1GW Hesselo offshore wind farm.

Germany

- The FiT was introduced in Germany under the German Renewable Energy Act (EEG) that came into force in April 2000. It provided greater funding support to RE operators through two FiT funding models: Basic Model and Acceleration Model. The EEG has been modified several times since then and remained applicable as the guideline for wind farms. Following the EEG Reform (EEG 2017) in 2017, the tariff-based auction was made compulsory for offshore wind projects.
- While guaranteed support schemes shifted to an auction-based mechanism in 2017, Germany had two zero-subsidy bids until 2018. No schedule for offshore wind project allocation was provided during 2019-2020.
- From 2021, Germany plans to hold a centralised auction model* to ease project financing risk, with the annual volume caps of 700-900 MW for bids^[3].

[3] To latest note: German Federal Council (Bundesrat) did not accept the Centralised offshore wind tendering model with open arms at its latest session on 3 July 2020. The Council found the new model, introduced in a bill amending the existing Offshore Wind Act (WindSeeG), should go more along the lines of CfDs as Council referred to tendering systems such as CfDs as low-risk in terms of project costs and its significant contribution to maintaining the diversity of players. <https://www.offshorewind.biz/2020/07/06/germany-federal-council-recommends-against-proposed-offshore-wind-tendering-model/>

The Netherlands

- During 2003-2007, MEP subsidy (Milieukwaliteit Elektriciteitsproductie subsidie) was implemented through two policy instruments: FiT and a reduced ecotax.
- Although MEP FiT was effective, it cost too much for the government without leading to decrease the amount of FiT support in five years (2003-2007). Thus, it was replaced with Sustainable Energy Incentive Scheme (SDE: Feed-in Premium) for the period of 2008-2011 intending to develop at least 450 MW of offshore wind project before 2011. With lead-time between the submission of three application in 2009 and the realization of a project, Dutch government supposed projects expensive despite there was sufficient budget hence, it did not lead to installation of new capacities until 2011.
- In 2011, the Netherlands established a tendering scheme with subsidies (premium FiT) under the Dutch Sustainable Energy Incentive Scheme (SDE+), targeting 4.5 GW offshore wind power capacity by 2023. Through the auction competing for lowest price in a number of rounds, two first offshore wind projects were secured at Borssele sites in 2016.
- Soon after the target announcement, a prerequisite target of '40% cost reduction over the period 2015-2019' was achieved in first phase tenders during 2017, following the German precedent of zero-subsidy bids at Hollandse Kust.

Taiwan

- For the implementation of targets set in its “Thousand Wind Turbines Promotion Project”, Taiwan offered a “Demonstration Incentive Program” grant scheme designed to award two offshore wind farm projects in 2012. A guaranteed PPA with the FiT mechanism was provided since 2013 with gradual reduction in FiT rates.
- To capture cost reductions, a competitive bidding process with lower FiT rates was introduced in 2018 and the offshore wind target was increased to 5.5 GW by 2025, Initial 3.5 GW out of 5.5 GW is allocated through FiT and 2 GW is allocated through the Competitive Bidding to drive down the price. According to recent announcement, the next 10 GW offshore wind auctions (termed Round 3) will likely be conducted across two phases with the first phase starting in 2021.
- To address the effects of FiT reduction and support project financing, corporate PPAs can be a driver in Taiwan.

Mainland China

- The Renewable Energy Law was released in 2006, as the foundation for policy of offshore wind power planning and development, economic incentive policies, grid connection policy and technical standards.
- China’s first round of concession bidding started in 2010. In 2014, FiTs were introduced for offshore wind farms (CNY 0.85/kWh for offshore projects, CNY 0.75/kWh for intertidal projects).
- Following the new regulation released in 2018, offshore projects approved in 2019 and 2020 will go to competitive auction, with the price cap set at CNY 0.80/kWh and CNY 0.75/kWh respectively. In January 2020, the Chinese central government announced it would completely stop subsidies for offshore wind from 2022 onward, but subsidies provided by provincial governments are encouraged to provide continuity of support.

Japan

- Following the approval of the Renewable Energy Bill in 2011, Japan introduced a FiT for wind energy in June 2012. At the time, offshore wind was priced the same as onshore, although that has since changed. In March 2014, the Ministry of Economy Trade and Industry (METI) announced new wind tariffs for 2014/15 (¥22/kWh (€ 0.17/kWh) for onshore and ¥36/kWh (€0.28/kWh) for offshore) for 20 years. Although the purchase prices were high, complex permitting, and approvals made wind energy development a daunting process in Japan.
- In November 2018, Japan introduced competitive bids for pre-identified promotion zones in a new national framework for offshore wind projects. Under the Act, developers will compete not just on tariff, but also on the suitability of their occupancy plans in promotion zones.
- In March 2020, METI announced FIT prices for fiscal year 2020. This sets off from FiT to auction system for fixed bottom offshore wind power and floating offshore wind at 36 ¥/kWh, to further boost investor interest.



The seven markets above (the UK, Denmark, Germany, Netherlands, mainland China, Taiwan, and Japan) represent more than 27 GW of installed offshore capacity, as of 2019, driven by a combination of support schemes. As the economics of offshore wind strengthened, permitting timelines eased and capacity targets increased, support schemes gradually transitioned towards mechanisms that encourage market competition while providing long-term price visibility.

Case study: UK's CfD model delivering high volumes at low costs

Offshore wind is a monumental success story for the UK, which is home to around one-third of the total resource potential in the EU^[4]. The Renewables Obligation (RO) was the first support mechanism for offshore wind, coming into effect in 2002 and obligating UK electricity suppliers to source power from renewable sources. Up to 5 GW of offshore wind was procured under the RO until 2017.

Under the Electricity Market Reform (EMR) planned in 2013, the government targeted reliable and affordable clean energy sources, introducing a transition from the RO to CfD mechanism. CfD is a private contract between a low-carbon electricity generator and the government-owned Low Carbon Contracts Company (LCCC), which limits the requirement for subsidies. The generator receives support when remuneration is lower than the agreed tariff (set based on reference wholesale prices) and returns the profit to the state when remuneration is higher than the pre-agreed price

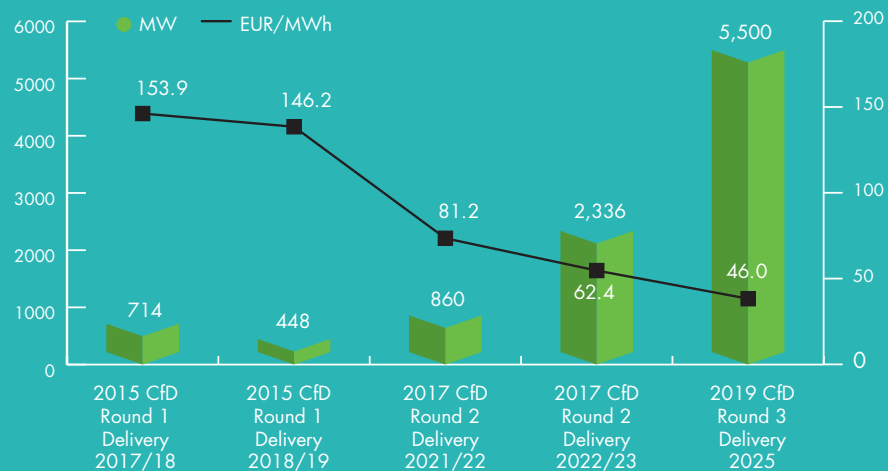
(strike price). It therefore creates predictability for project owners by guaranteeing a price for power generated, while reducing exposure to wholesale price risk.

The CfD model has steadily delivered high volumes of offshore wind capacity while driving down costs, including grid charges, to below €46/MWh (£41.7) in the 2019 round 3, down from €154/MWh (£120) in the 2015 round 1. The UK's Offshore Sector Deal foresees offshore wind costs will further

decline, driven by the affirmed 40 GW by 2030 target.

The mechanism is being employed in other markets too. Poland has proposed a CfD model in draft legislation for its first phase of procurement ending December 2022. Denmark has agreed to award Thor Offshore Wind farm through CfD and will launch a tendering process in Q3 2020. To reach 20 GW by 2030, Germany is reviewing different auction models, with the wind industry pushing for CfD.

UK support scheme - CfD rounds leading to cost reduction for offshore wind



[4] https://www.irena.org/documentdownloads/publications/gwec_uk.pdf



Case study: The Netherlands - specific conditions for zero-subsidy bids

The Netherlands' Energy Agreement for Sustainable Growth announced a 4.5 GW offshore wind target by 2023, prompting the inclusion of offshore wind in the SDE+ regulation (Stimulating Renewable Energy). SDE+ is a support scheme wherein the government provides both guarantees and risk reductions to renewable energy developers via a tendering scheme with subsidies.

With a 40% cost reduction achieved in the first SDE+ tender in 2016, the Netherlands launched its first zero-subsidy offshore wind tender in 2017 and awarded it in 2018 (see Figure 2[2]) to Vattenfall for Hollandse Kust Zuid site mainly due to: the availability of larger turbines which reduced capital costs; and reductions in project risk via the government assuming responsibility and cost for grid connections. Following a second zero-subsidy bid in 2019, the Hollandse Kust Zuid site recently reached FID, becoming the world's largest subsidy-free offshore wind farm at 1.5GW, due to be commissioned in 2023. The Dutch government has also organized the tender for

the Hollandse Kust Noord offshore wind farm zone in April 2020 that is one of three offshore wind areas chosen by the Dutch government to be developed by 2023, as part of the country's Energy Agreement for sustainable growth.

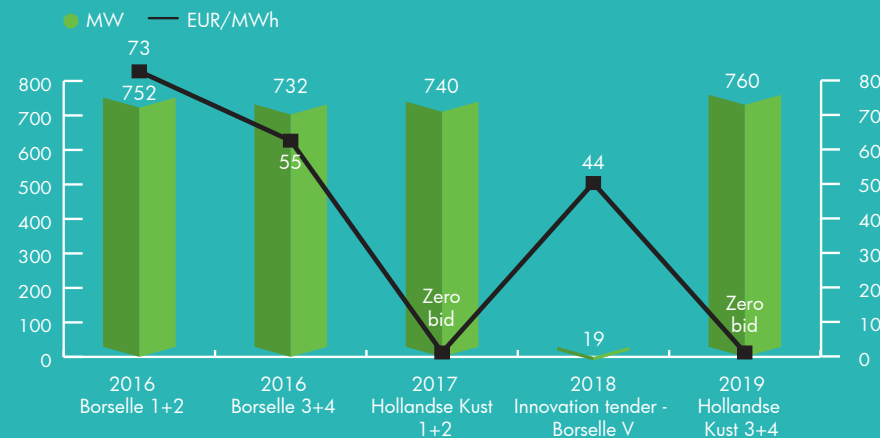
The risk profile of zero-subsidy bids mean higher financing costs – as much as 2.5% - making the scheme suitable only for specific projects under the right market conditions.^[5] In the future, the Ministry of Economic

Affairs is targeting bidding with and without subsidies to deliver its target of 1GW new installations per year from 2023-2030. This scheme would account for variance in project site complexity and technical/permitting requirements, while recognising the role of revenue stability in sustaining investor confidence to generate a steady pipeline of projects.

Support schemes have been one of the drivers of the offshore wind market in Europe to date. The CfD

model has been widely deployed as it limits the burden of subsidies for government and consumers and hedges the risk of exposure to volatile wholesale power prices or negative pricing as well as creating revenue certainty. Such procurement schemes which provide long-term visibility and stronger investment cases will be key to scaling offshore wind to emerging markets, particularly at the volumes necessary to drive system-wide decarbonisation.

Falling offshore wind cost to zero-subsidy bids in Netherland



[5] <https://renews.biz/59118/negative-bidding-could-endanger-german-offshore/>

b. Industrial development and job creation

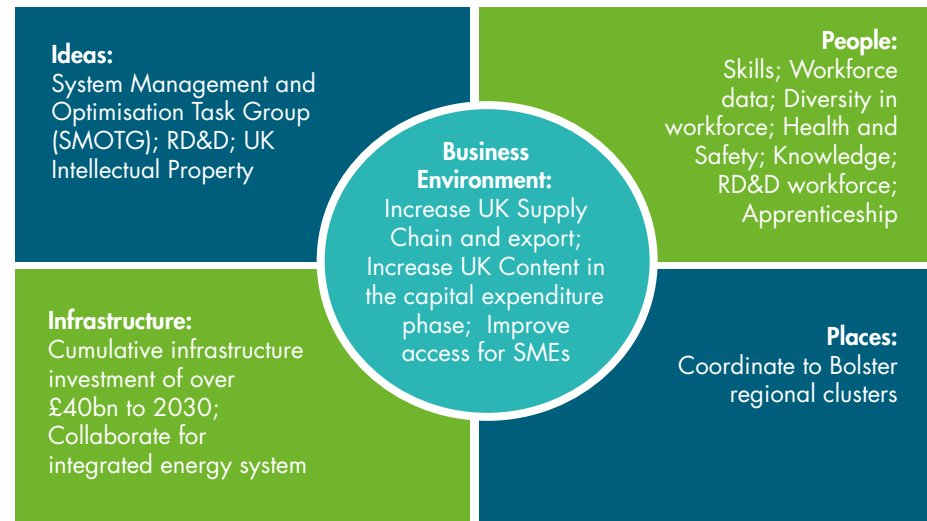
Offshore wind has already proven itself as an affordable, scalable, zero-carbon energy source. It also has the capacity to generate enormous socioeconomic benefits, particularly for coastal communities in close proximity to projects. Maximising the economic growth potential of offshore wind has required a collaborative approach between government and industry. This approach aims to upgrade market design, set clear long-term capacity targets, undertake forward-planning in infrastructure and interconnections as well as deliver collective investment in skilled workforces and a local supply chain.

Important insights can be gained from the experience of leading European offshore wind markets, which demonstrate the opportunities and potential barriers for fostering industrial development in the offshore wind sector. The UK's "Offshore Wind Sector Deal" emphasises high ambition, industrial clustering and government support and dialogue with industry. Denmark, with first-mover status in the wind industry, has fostered an advanced supply

chain through steady public-sector steering and investment in R&D. Germany's offshore wind workforce has grown with government investment in training programmes and apprenticeships, although the industry could develop faster with the right enabling policies. More detailed cases on the UK, Denmark and Germany are presented below.

Despite being an emerging offshore wind market, Taiwan has already

demonstrated that active dialogue between government and industry and a steady pipeline of projects can generate supply chain investments to transform local industry. In 2020 alone, new partnerships were announced to domesticate the production of nacelles, wind turbine blades and the first Taiwan-built offshore wind installation vessel, the Green Jade.



Case Study: UK Sector Deal steers industrial growth

The trajectory of the UK's offshore wind sector is guided by the Industrial Strategy Offshore Wind Sector Deal, published in March 2019. The document outlines the target to reach 30 GW of offshore wind capacity by 2030, which was extended to an ambitious 40 GW by the end of 2019 by the incoming government, and a roadmap for delivering benefits to the UK

economy and public. As a result of strong collaboration between government and industry, the first-of-its-kind integrated approach to sector development is built on five pillars: ideas, people, infrastructure, business environment and places (see figure below).

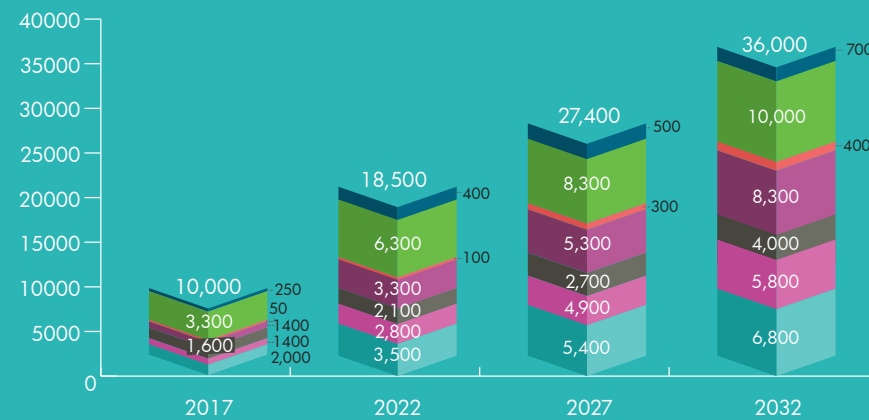
Scale has been key to successful localisation in the Sector Deal. Top OEMs have invested in manufacturing

hubs in the UK to de-bottleneck capacity constraints, allowing them to deliver large volumes while meeting non-binding local content requirements in this deal. In partnership with the government, the offshore wind sector supported 7,200^[6] full-time equivalent jobs in communities around the country between 2014–2018. Through manufacturing hub, SGRE's wind turbine blade factory works created 1,000 jobs in 2016 at Hull, while in 2018 MHI Vestas employed 1,100 new employees for its expanded wind turbine blade factory at Isle of Wight.^[7]

As a result of strong collaboration between government and industry, the first-of-its-kind integrated approach to sector development is built on five pillars: ideas, people, infrastructure, business environment and places.

Cumulative jobs in the UK offshore wind sector

- Specialist Transport
- Construction & Installation
- Decommissioning/Repowering
- Operation & Maintenance
- Specialist Support Services & Other
- Manufacture & Design
- Site planning & Development



[6] Low Carbon and Renewable Energy Economy Final Estimates, Office for National Statistics (January 2019)

[7] <https://www.gov.uk/government/publications/offshore-wind-sector-deal/offshore-wind-sector-deal>

Case Study: Denmark as a model for public commitment and ambition

The Danish wind cluster has become a world-leading example of industrial growth fostered by long-term political commitment to wind energy. Following the global energy crisis in the 1970s, Denmark pivoted to wind power with early subsidies of equipment, and later a feed-in-tariff. It is now home to top turbine manufacturers, top offshore wind farm developer, excellent R&D facilities and strong industrial cluster collaboration.

Apart from subsidies on price, the government also supported the sector by investing in R&D. The test and certification center for turbines funded by the state were opened by Risoe National Laboratory, which has become a part of the Danish Technical University (DTU) since 2008. These early R&D investments formed the bedrock for companies like Vestas and Siemens Wind Power (now Siemens Gamesa Renewable Energy). More than 500 suppliers are present within the current Danish wind cluster, spanning the whole value chain from lightning tests to foundation manufacturing. The cluster

today offers around 30,000 jobs and is responsible for 4 percent of Denmark's GDP.

Since land scarcity became a problem in Denmark, local developers started building offshore wind farms from 1991. The liberalisation of the energy market led to the creation of the modern DONG Energy. Following the divestment of its oil and gas business in 2017 to focus 100% on green energy, the world's largest offshore wind farm owner-operator changed the name from Danish Oil and Natural Gas (DONG) to Ørsted.

As the world's largest offshore wind port, Esbjerg in western Denmark is a hub for offshore wind exports, with turbines leaving the port for offshore wind farms in the UK, Germany, and Netherlands. To further support the domestic and regional offshore wind project development, other Danish ports like Grenaa, Roenne and Hvide Sande have expanded either to support offshore project construction or to serve as project O&M base. The Danish wind sector is a powerhouse for the Danish economy and creates

employment all across Denmark. Wind industry exports accounted for nearly 4% of total exports in Denmark in 2017.

However, the successful story of Danish wind industry doesn't stop there. With a net-zero emissions commitment by 2050, the Danish government has set a target to install at least 2.4 GW across three new offshore wind farms by 2030.^[8] In June 2020, the Danish parliament approved an ambitious new climate act that includes building two energy islands, one in the North Sea and another in the

Baltic Sea, with a combined capacity of 5 GW, and installing another 1 GW offshore wind farm, the second of the three 1 GW offshore wind farms proposed in the Energy Agreement 2018. As the world's first energy island, it will connect offshore wind and host electricity storage and Power-to-X (excess electricity will be converted into green hydrogen and processed into fuels for aircrafts, trucks, ships and heating). It is expected that 7 GW of new offshore

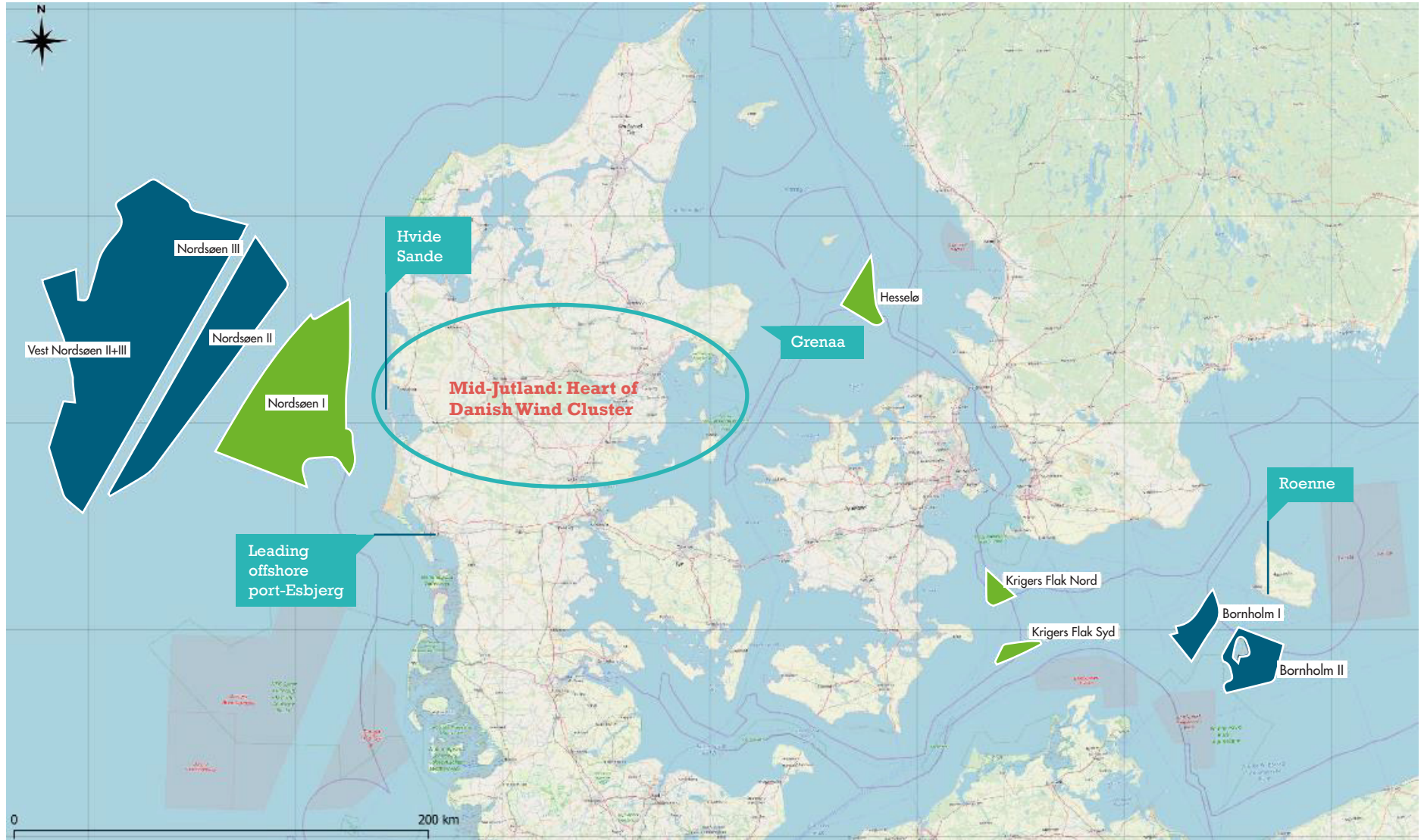
capacity will be added before 2030. In total, Denmark has mapped out areas suitable for development of up to 18 GW of offshore wind capacity. Guided by these targets, the government estimates that up to 2,200 temporary jobs and 550 permanent jobs could be created on an annual basis up to 2030.^[9]



[8] https://ens.dk/sites/ens.dk/files/Vindenergi/offshore_wind_tendet_thor_marketing.pdf

[9] <https://www.groennejob.dk/nyheder-fra-groenne-job/groenne-job>

Danish wind cluster (and ports), mapping of offshore wind development



Source: Danish Energy Agency, GWEC Market Intelligence, June 2020

Case Study: Germany expresses ambition for growth, but needs policy stability and forward-planning

Although its onshore wind market been rocky, Germany's offshore wind market holds strong promise and has already delivered 7.5 GW of capacity. The sector employs around 27,000 people, fosters EUR 9 billion in annual turnover and has attracted a cumulative EUR 25 billion in investment over the last 20 years.^[10] It is also a pillar of the country's energy transition and plan to create a hydrogen economy.

Key to signalling strong public commitment to growing the offshore sector is policy stability. The German government has amended its sector development goals twice in the past: It initially outlined 10 GW by 2020 and 25 GW by 2030 in its Renewable Energy Sources Act (EEG), but reduced these targets to 6.5 GW and 15 GW, respectively, in 2014, due to the high prices of the early offshore wind sector. As offshore costs declined dramatically, pressure increased on the government to raise its targets; while public sector representatives indicated this would

happen by the end of 2019, it was not implemented.^[11]

Finally in June 2020, the Federal Ministry of Economy and Energy drafted a bill outlining a target of 20 GW by 2030, which would then double to 40 GW by 2040.^[12] The bill followed agreements by federal and state authorities, as well as Transmission System Operators (TSOs) to better capitalise on Germany's offshore wind resource potential and address related grid needs. But it also introduced a two-round tendering process designed to drive bid prices down, which could exert additional pressure on an already strained domestic supply chain.

Growth of Germany's offshore wind sector at the scale of 40 GW by 2040 could potentially address the capital and labour displacement experienced in its struggling onshore wind sector. Offshore wind has already brought large benefits to coastal regions in Germany, with

ports such as Bremerhaven and Cuxhaven on the North Sea hosting large turbine manufacturing facilities, foundation systems and shipyards for offshore wind services. Jobs have also been created across the value chain in inland cities, for the manufacturing of bearings, gearboxes, generators and other components. To deliver the industrial development potential ahead, the government must remain steadfast in its new offshore wind commitments, and implement a sensible procurement scheme that can sustain investments in the local supply chain.

[10] <https://www.wind-energie.de/themen/anlagentechnik/offshore/>; <https://windeurope.org/newsroom/press-releases/german-offshore-wind-can-deliver-more-legal-framework-for-at-least-20-gw-by-2030-required/>

[11] https://www.focus.de/regional/schleswig-holstein/energie-offshore-offensive-fuer-mehr-windraeder-auf-nord-und-ostsee_id_11216814.html

[12] <https://www.offshorewind.biz/2020/06/01/germany-drafts-offshore-wind-bill-with-40-gw-by-2040-goal-dynamic-tendering-process/>



c. Grid Connection

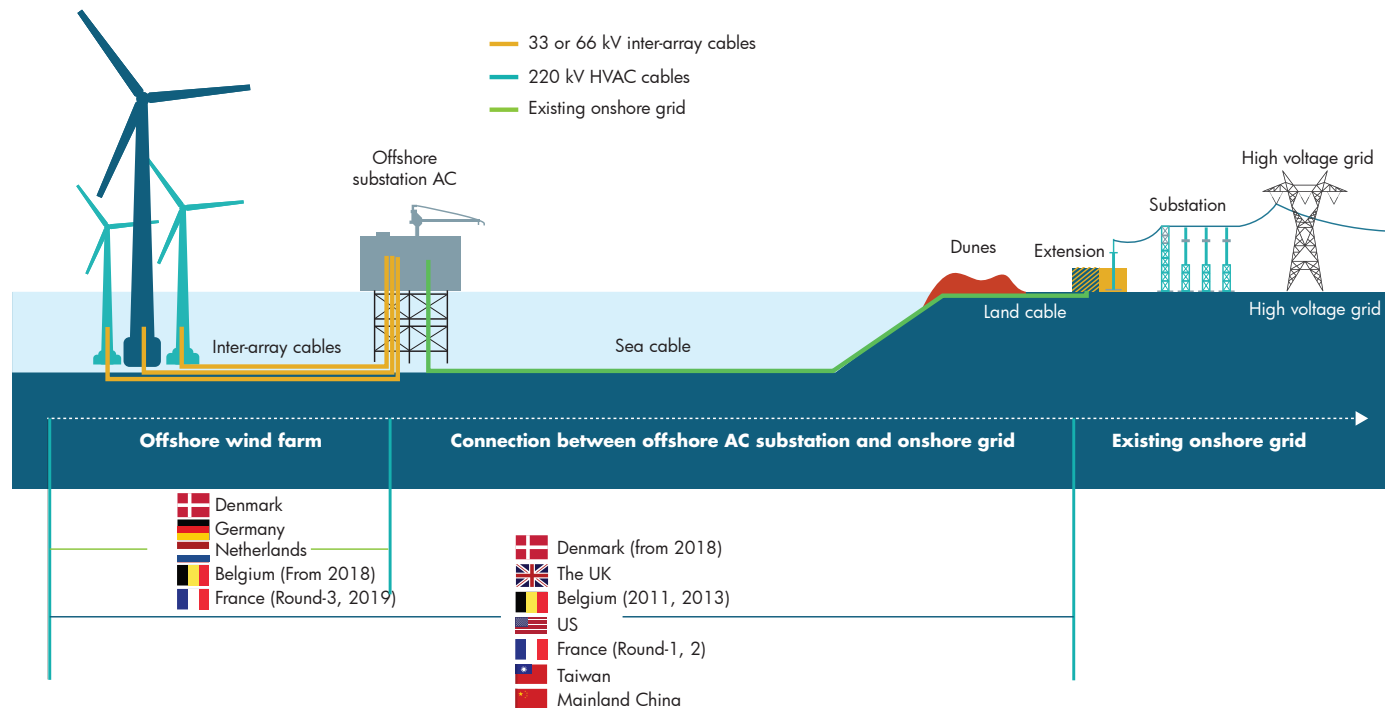
The expansion of the global offshore wind market presents a formidable challenge to electricity grids, requiring forward-planning for transmission infrastructure and interconnections, grid-fault and stability analysis, priority dispatch for renewables and a flexible system to integrate large volumes of renewable energy. As an indication

of the additional capacity required, WindEurope estimates that 380 GW of offshore wind could be developed in the North Sea region alone, and would need to be integrated into mainland grids, in order to achieve climate neutrality targets set by the European Commission.^[13] With more and larger wind farms expanding farther into the sea –

Equinor’s floating Hywind Tampen project, for instance, will be located 140 kilometres off the Norwegian coast – major investments, planning capacity and expertise are needed to ensure reliable and expeditious grid connections.

Offshore wind grid connection normally consists of two parts: 1.) offshore wind turbines are connected via 33 or 66 kV inter-array cables to an offshore AC substation, and 2.) then the AC offshore substation is connected via a 132-220 kV HVAC export cable with an onshore substation, from where electricity to be connected to the mainland grid^[14]. The scope of responsibility for these connections, and up to what point, varies between markets and falls either to the transmission system operator (TSO) or the project developer.

Grid connection responsibility in different offshore wind markets



Source: GWEC Market Intelligence, TenneT

[13] <https://windeurope.org/about/wind/reports/our-energy-our-future/>
 [14] The transmission system has two types: AC and DC. HVAC is generally employed for shorter distances, while HVDC connections are generally employed for longer distances to the main grid. In the German North Sea, for example, many offshore wind farms are first connected with an offshore AC substation and then the offshore AC substation can be connected to grid at shore through HVDC converter station and HVDC cables.

In leading European offshore wind markets like Germany, Denmark (up until 2018), the Netherlands, Belgium (from 2018), and France (from Round-3, 2019), the connection from the offshore AC substation to the mainland grid has been the responsibility of the TSO, mandated by national government (see Figure 2). This has generally been a successful model which ensures a coordinated approach to building offshore assets and onshore reinforcements, while TSOs can access financing costs which tend to be more favourable. In the UK, US, Denmark (from 2019), and Taiwan, project developers pay for the connection from the wind farm to the onshore substation, while in Mainland China developers are still responsible for financing and constructing transmission facilities for connecting the offshore project to the grid, although local government in Yangjiang, Guangdong province is considering to separating connection into two parts and requiring the

TSOs to take the responsibility for the connection between offshore AC substation and the mainland grid.

In 2018, Denmark decided to shift responsibility for grid connection for three offshore wind farms commissioned up to 2030 from the TSO to the project developer.^[15] While construction and operation of the offshore substation and export cables was previously managed by the Danish TSO Energinet, this activity will be included within the scope of tenders for three North Sea projects, including the 800 MW - 1 GW Thor wind farm scheduled to be awarded in 2021.^[16] The developer will be responsible for financing the transmission assets, which would be calculated within its bid for a two-way Contract for Difference (CfD) agreement.

This model is similar to the UK, where responsibility and cost for grid connection are included within tenders for a long-term CfD

agreement with government.^[17] The CfD scheme incorporates negotiation and prequalification to ensure project feasibility, while allowing for market competition and balance of price risk between the developer and the off-taker (see page 30). The resulting revenue stability has been shown to support the investment case for projects where developers must finance and develop substation and cable assets.



[15] https://ens.dk/sites/ens.dk/files/Vindenergi/brief_tender_for_thor_offshore_wind_farm_30march2019.pdf
[16] Energinet will remain responsible for the financing and construction of the onshore substation to the transmission grid.
[17] Developers can either take responsibility for construction of the offshore transmission assets before transferring them to a third-party operator, or commission a third-party operator to construct the assets. To date, the de facto model has been for project developers to be responsible for financing, development and construction of the transmission assets. The developer's CAPEX costs for transmission assets would be recovered through payments from the operator of the assets after completion; the operator in turn receives revenue from the grid authority for operation, maintenance and decommissioning of these assets.



A 2019 study by DIW Econ, commissioned by Ørsted, found that the UK market design, where development of grid connection is included within a competitive tender, reduces overall costs of the transmission assets.^[18] A model integrating grid connection into the overall project tender also incentivises cost reduction and allows for synergies in planning and construction between the offshore wind farm and transmission system.

These findings can be considered alongside another study by Navigant in 2019, wherein analysis of data from the UK, Denmark, France and the Netherlands found that making the TSO responsible resulted in lower CAPEX/MW of installed grid connections, as well as lower costs for cables and onshore substations (although costs for offshore platforms are generally comparable).^[19]

Each market has its own distinct policy, consenting and fiscal characteristics. There is no universal model for grid connection responsibility, but rather general

guidance that a model should prioritise time and cost-efficiency without burdening the economics of the tendering process for offshore wind – particularly as cost reduction potential for grid connections is lower than that for offshore wind technology.^[20]

Transmission is a vital part of the sector's development, ensuring that communities benefit from a secure and reliable supply of power from offshore wind. Given its centrality to the growth of offshore wind, grid connection must be carefully considered by policymakers in the context of local market design and cost/investment dynamics. Whether integrated into a capacity tender or shouldered by the TSO, the risks and costs for grid buildout should be adequately organised in a way that will not dampen the investment case for offshore wind or slow down its deployment.

[18] Construction and then operation of the offshore transmission assets are competitively tendered in the UK.

[19] <https://guidehouse.com/-/media/www/site/downloads/energy/2019/2019-navigant-comparison-offshore-grid-development.pdf>

[20] <https://guidehouse.com/-/media/www/site/downloads/energy/2019/2019-navigant-comparison-offshore-grid-development.pdf>

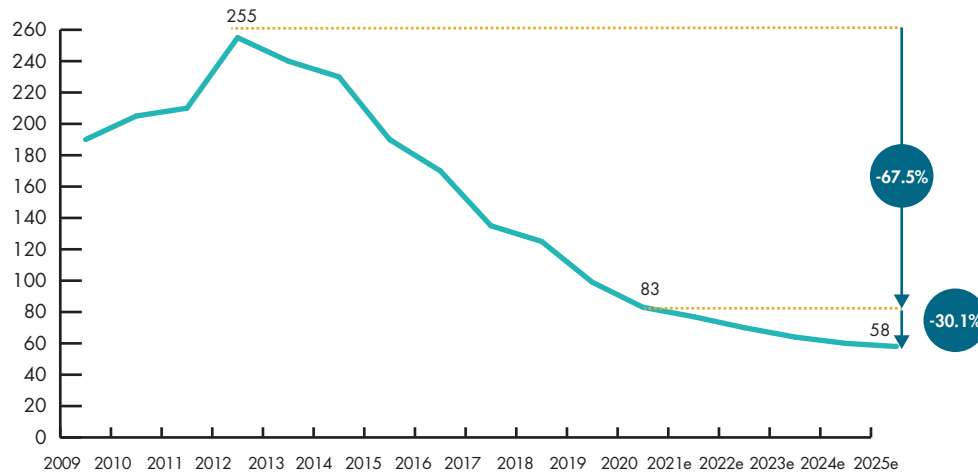
d. Cost reduction and supply chain

Offshore wind power is a unique opportunity that promises carbon-free, utility-scale power generation and contributes enormously to the security of electricity supply. Policy support such as feed-in tariffs (FiT) and renewable obligation certificates (ROCs) have kickstarted the offshore wind industry in many countries from the beginning. After three decades of development, offshore wind has grown from a niche to a reliable

energy source and is expected to play a crucial role to support the global energy transition. Although great progress has been made in cost reduction, especially in the past decade, political pressure now requires the sector to become subsidy-free and to compete head-to-head with fossil fuel-based energy on economic terms.

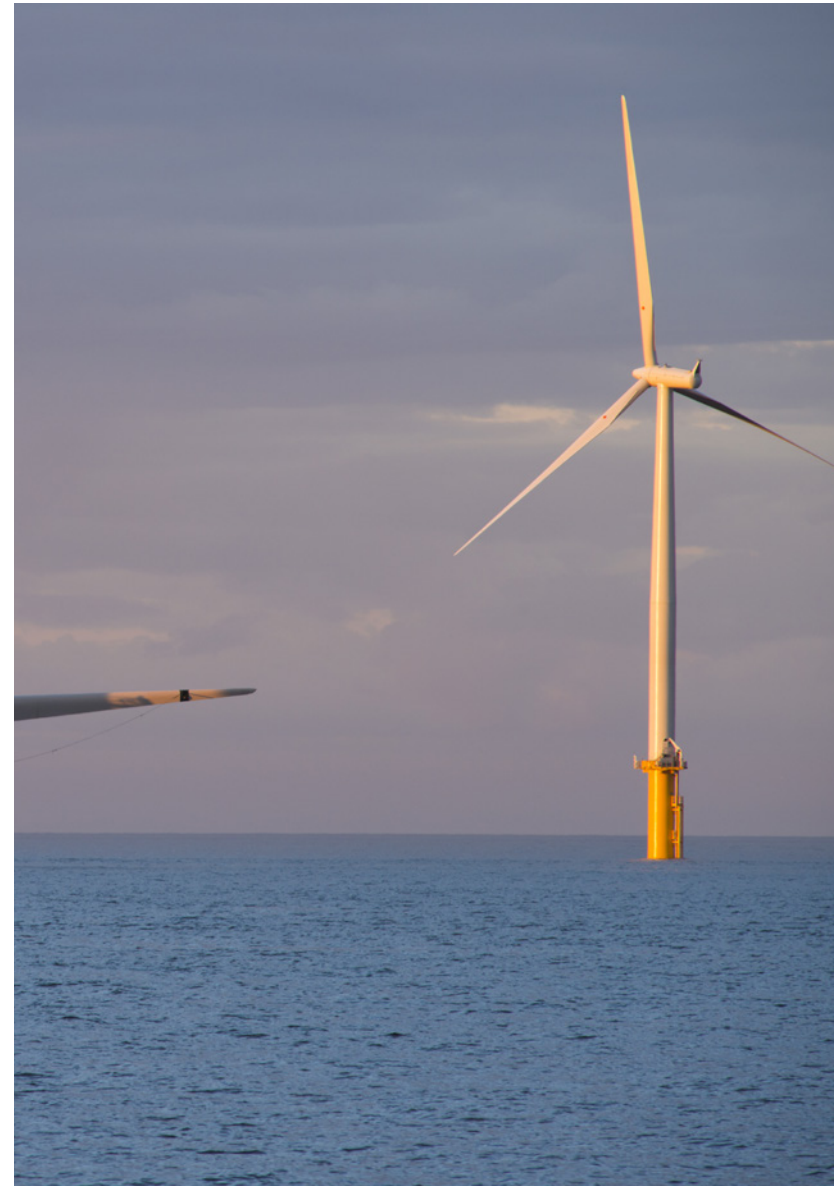
According to BNEF, the global offshore wind average LCOE has dropped 67.5% to US\$84/MWh since 2012. Cost reduction of offshore wind

Levelised cost of electricity offshore wind
USD/MWh



Methodology: BNEF LCOE scope for offshore wind farms includes all transmission costs up to the project's onshore substation, which is also included. The outlook from 2020-2025 is a fitted curve best reflecting future levelized auctions bids (it mixes auctions including and excluding the cost of transmission to shore).

Source: BNEF LCOE Database Jan 2020, GWEC Market Intelligence



is set to continue and expected to hit US\$58/MWh by 2025 thanks to the scale provided by GW-level projects, the newly introduced supersized offshore wind turbines and the reduction in the cost of capital.

Recent auction results show that offshore wind has become already competitive in some mature European markets (for example, zero-subsidy auctions completed in Germany and the Netherlands) and is on the cusp of competitiveness even in some less mature markets (notably France).

From an industry life-cycle perspective, the current stage of offshore wind can be classified as the growth phase, to accelerate further cost reduction and eventually become completely subsidy free, a strong project pipeline, long-term visibility, and a well-managed global supply chain that increases competition and capacity will all be paramount to the growth of the wind industry as well as technology-based innovation.

Conflicting paradigms of development

Concurrent to driving down LCoE, driven by political motivations to justify financial support, the wind industry is challenged by local

content requirements (LCRs) – regulatory provisions on how much of a wind project must be manufactured locally.

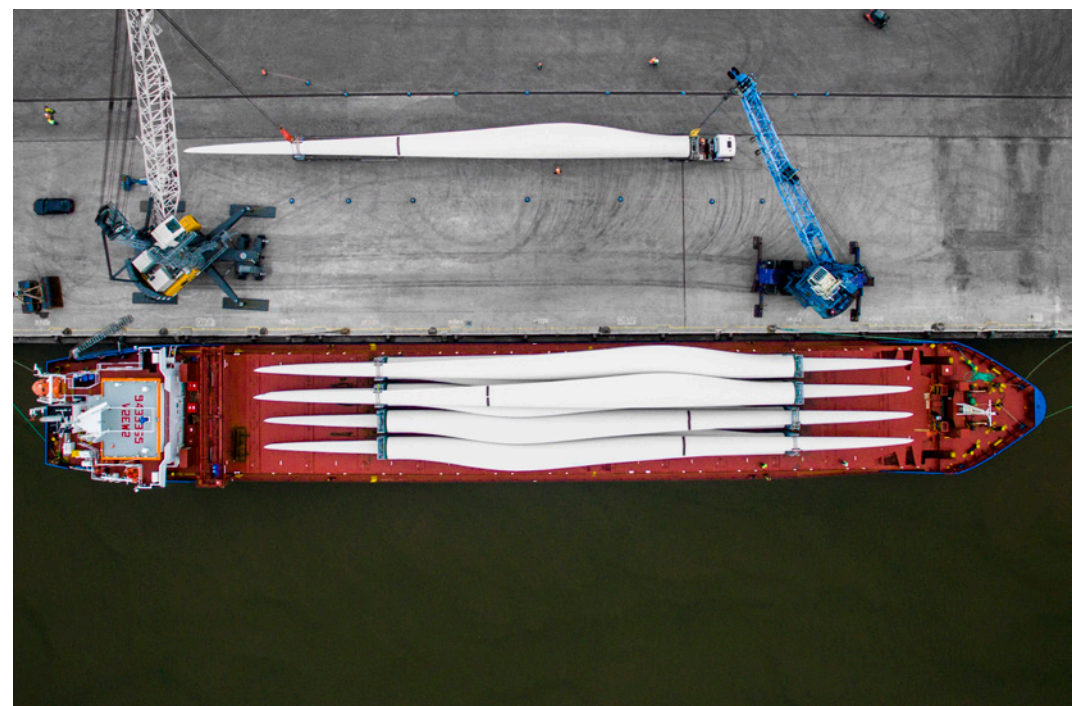
While on the one hand, an inward-looking perspective sees LCR as a means to maximise local job creation and economic prosperity, on the other hand, an outward-looking view, sees LCR as an instrument to drive down costs and facilitate domestic companies' integration into international supply chains.

Experience in Europe has proven that strict local content requirements frustrate economic hopes of wind industry players by raising the cost of electricity and creates inefficiency by enforcing local suppliers to play a much bigger role during the take-off of the offshore deployment in many new and emerging markets.

For an industry such as offshore wind that naturally offers a high degree of localisation due to the large size of components, such as blades and towers, and complicated and costly logistics, overly restrictive local content requirements are not justified. Overly restrictive requirements can be counter-productive to the original intention and ultimately, slow down a

growing industry. The offshore wind industry in France is an example of this.

Overall, to drive cost reduction with a strong supply chain demands high commitment from governments and the industry. The UK offshore wind industry is a success story of global reach which has created jobs and economic growth, as well as billions in export value.

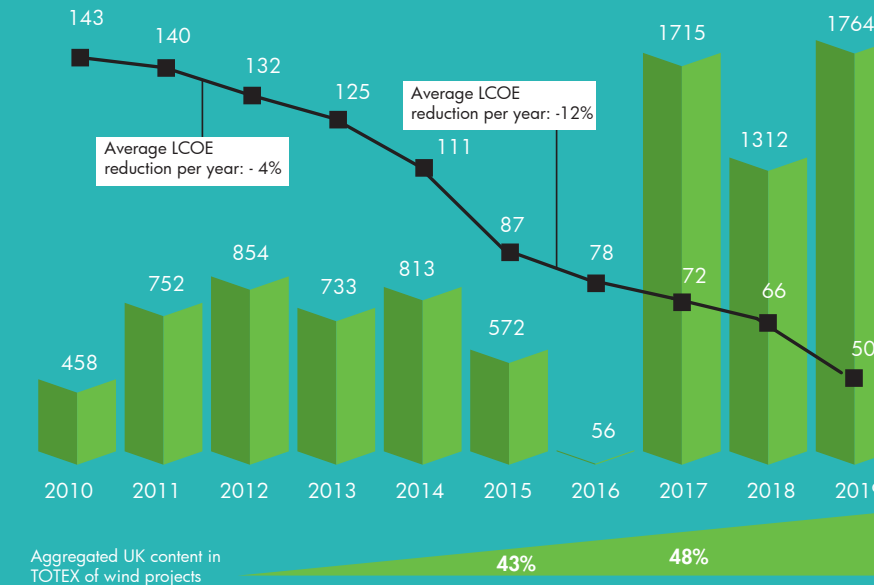


Case Study: UK - Volume drives down costs, and localisation follows

The UK is now an offshore wind leader and export hub. From its first 4 MW pilot project in Blyth in 2000, to 9.7 GW of installed capacity today, the progress of the UK's offshore wind is phenomenal. The UK Offshore Wind Sector Deal has done well for encouraging investment and attracting commitments from turbine and component manufacturers to build capacity with its market certainty by providing the right market and regulatory frameworks that instilled confidence for action to mitigate potential supply chain bottleneck impacts.

The UK has exemplified that with an increased market certainty and volume visibility, scale is one of the keys that support competition and innovation in the supply chain to drive competitiveness and reduce costs. In retrospect, the cost of the latest (third) CfD round in late 2019, fell by around 30% compared to the second round in 2017, and has fallen as much as 66% compared to the first round held in 2015. Projects are now being delivered for as low as US\$50/MWh making offshore wind one of the lowest cost options for new power in the UK

New installed offshore capacity versus offshore LCOE*
MW and USD/MWh



LCOE refers to projects signed during the given year, but not the LCOE of the installed volume: time lag between project signature and installation is 4-5 years
Source: GWEC, BNEF H2 2018 Wind LCOE Update, BVG Associates, Renewable UK, Press, UK Office for National Statistics.

– cheaper than new gas and nuclear power.

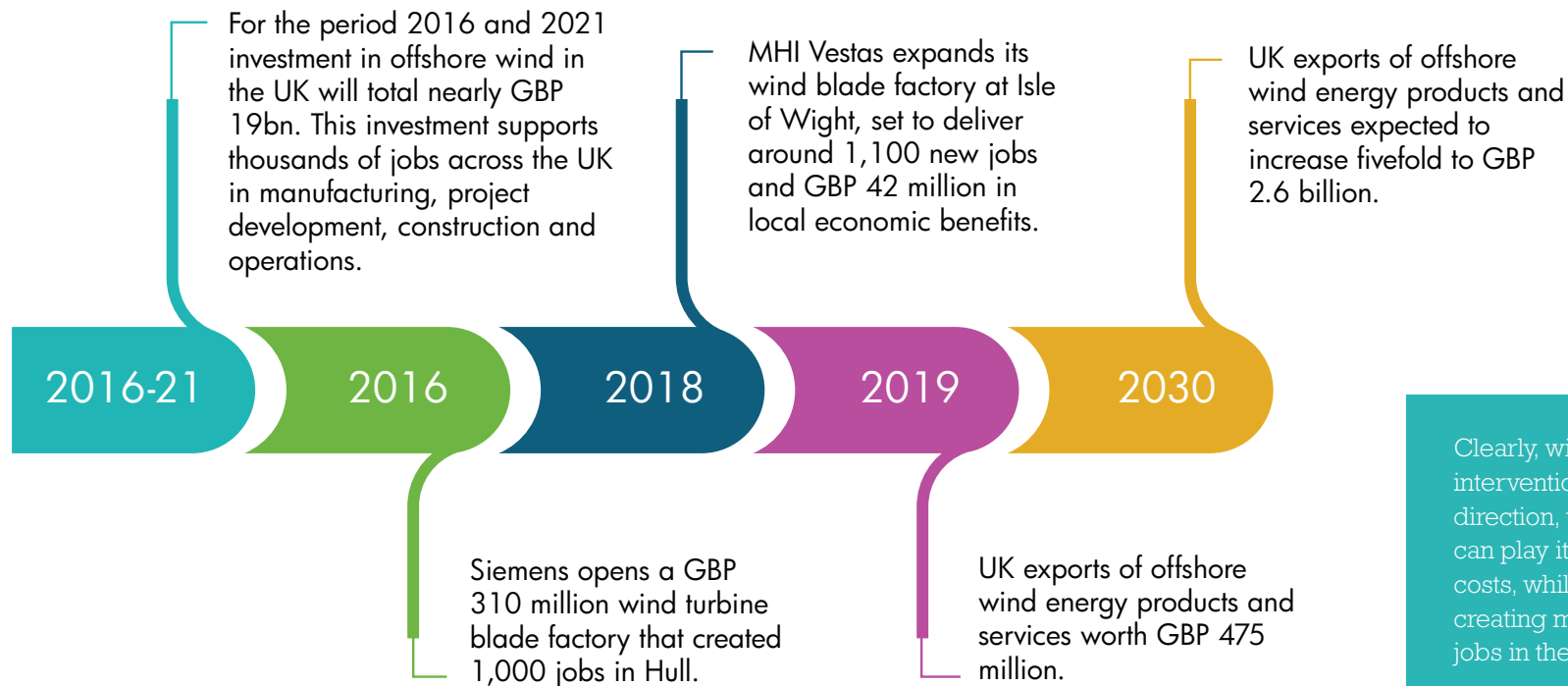
With current ambitions of 40 GW by 2030 and meeting the net-zero carbon emissions target by 2050, the UK provides a large enough market to attract turbine manufacturers each with a prediction of a reasonable

market share. With that, the increasing competition in the UK offshore market is expected to continue to drive cost reduction through downward pressure on pricing and via the benefits of scale, learning and innovation combined with socio-economic benefits such as local job creation.





Achievements

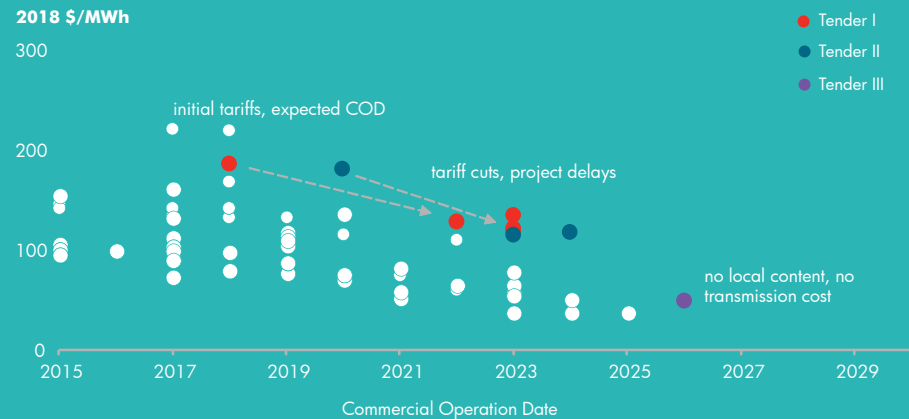


Case Study: France - Top-down localisation slows down market with 2nd highest offshore wind potential in the EU

In many respects, France is an ideal country for wind energy with 11 million square kilometres of marine territories on the English Channel, Atlantic Ocean and the Mediterranean Sea. As an indication of this potential, France's long-term offshore wind potential is estimated to be 90 TWh per annum. A total of six offshore wind projects with a combined capacity of 3 GW were selected in the Round 1 tender in 2012 and the Round 2 tender in 2014 that has never taken off.

A fundamental issue that hampered progress was the need for renegotiation of earlier contracts which priced at around EUR200/MWh, a tariff that is over-priced for the French government in these days of zero bidding. At the time the projects were awarded, such prices were the norm as they needed to cover the cost of fulfilling the top-down localisation content requirements (LCRs) that includes grid connections and an industrial component, whereby the manufacturers linked to the winning bids, Alstom (now part of GE), and Areva (now Adwen under Siemens Gamesa), committed to building local factories.

France levelised offshore wind auction bid prices



Source: BloombergNEF. Note: Levelized price, takes into account tariff price and length, inflation, a merchant tail assumption and a 25-year project lifetime. White dots represent other European markets.

Despite France's huge potential and ambitious targets of 6 GW by 2020 and to generate 15,000 direct and indirect jobs, none of these outcomes were accomplished mainly due to the implementation of strict LCRs before a local supply chain emerged.

Nonetheless, in the latest Dunkirk offshore tender (June 2019), with the localisation rules drastically relaxed – WTC are no longer requested to procure locally, instead emphasize on certain share of investment to source

from SMEs in the region – the winning price of EUR44/MWh came as an excellent news for the offshore wind outlook in France.

This case study exemplifies that without strict need for local content, offshore wind projects can deliver at competitive pricing and the industry can be rebooted given the right policy direction and frameworks in place.



Case Study: China – Early termination of central government support forces the local industry to reach parity

China commissioned its first commercial offshore project, Donghai Bridge Wind Farm, in 2010. The market, however, was not ready to take off until the first offshore FiT scheme and the National Offshore Wind Development Plan (2014-2016) were released by NEA (National Energy Administration) in 2014. This was followed in 2016 with joint release of The Management Measures for Offshore Wind Power Development and Construction by NEA and SOA (State Oceanic Administration), aligning guidelines between various government bodies and stakeholders.

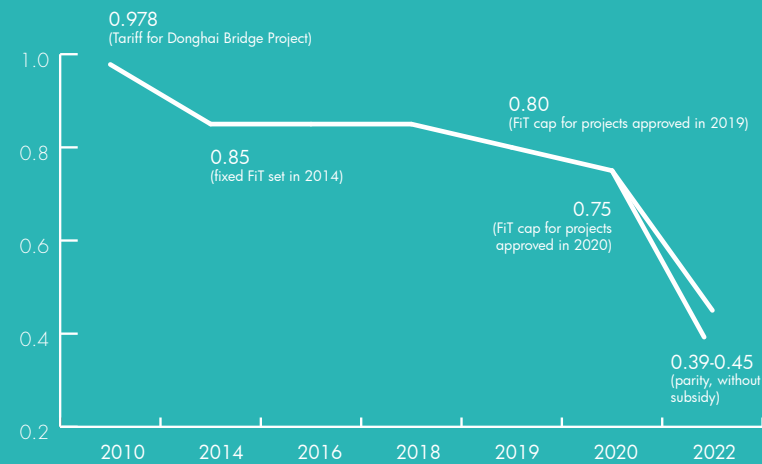
Within less than a decade of Donghai Bridge, China passed the 1 GW milestone for new offshore wind installations in 2017, surpassing the UK as the world's leading offshore market in new installations one year later. Following a new policy released by the Chinese National Development and Reform Commission (NDRC) in May 2019, project developers and investors are rushing to commission their projects before the end of 2021 in order to capitalise on the current CNY 0.85/kWh FiT.

As of the end of 2019, China has nearly 7 GW offshore wind in total installations, making it the third-largest offshore wind market after the UK and Germany. Thanks to a robust onshore wind supply chain and rapid growth in annual installations over the past three years, the offshore wind supply chain in China has developed very quickly. To date, eight Chinese turbine OEMs have released offshore turbines greater than 5 MW, of which six are listed among the world's top ten offshore wind turbine suppliers in 2019.

On 23 January 2020, the Chinese central government announced it would cease subsidies for offshore wind from 2022 onward, albeit subsidies from provincial governments are encouraged to provide continuity for the sector.

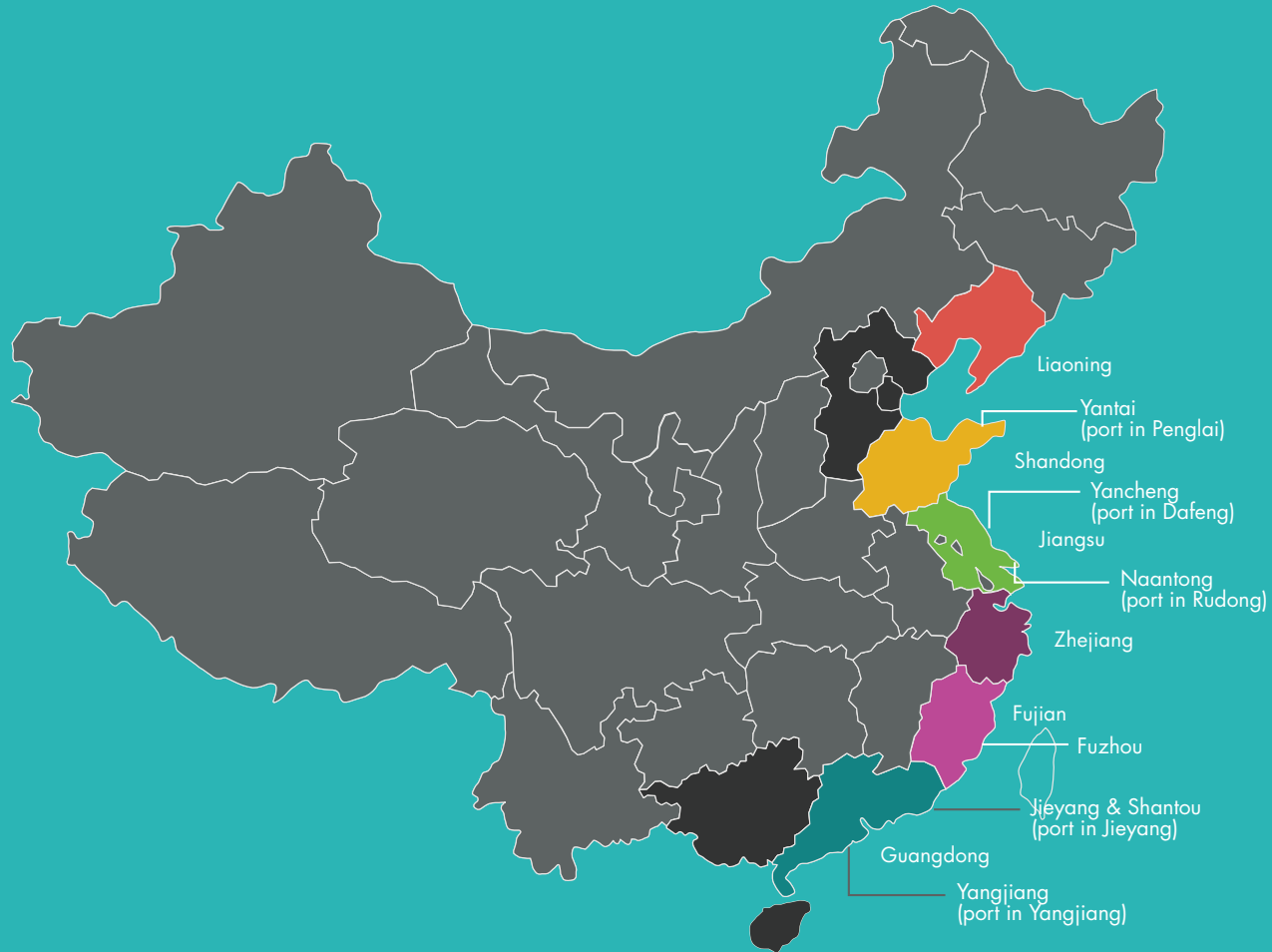
Although offshore wind CAPEX has been reduced by 40-50% in China over the past decade, the current LCOE for the Chinese offshore market is still at the level of CNY 0.64/kWh (EUR 0.08/kWh), according to State Grid Energy Research Institute

Evolution of Chinese offshore wind support schemes



Source: GWEC Market Intelligence, June 2020

Chinese offshore wind provinces and emerging offshore wind clusters



Source: GWEC Market Intelligence, June 2020



(SGERI). In China, the parity tariff for renewables is regulated to be set at the same level as coal-fired power generation, which varies by province. At present, the tariff for electricity generated by coal-fired power plants in China's coastal provinces is in the range of CNY 0.39-0.45/kWh – at least 30% lower than the current offshore wind LCOE.

Since no provincial government has so far committed to post-2021 support scheme for offshore wind, the local Chinese offshore wind industry states that the early termination of the central government FiT brings great uncertainty for the sector in the medium term.

GWEC Market Intelligence believes that the termination of support by central government is likely to force the Chinese offshore wind industry to reach grid parity earlier than expected. The following factors may mitigate the financial uncertainty of subsidy-free procurement, and further drive down LCOE:

Ambitious targets set by the coastal provinces

Guangdong plans to build 30 GW offshore wind by 2030, followed by

Jiangsu (15 GW), Zhejiang (6.5 GW), Fujian (5 GW) and Shandong (3 GW). Other coastal provinces, namely Liaoning, Hebei, Guangxi, Hainan and Shanghai, also have their own offshore wind development plans, although their targets are much lower than the five leading provinces. Offshore wind targets close to 60 GW by 2030 provides long-term visibility and scale for local industry.

Technology innovation

The average annual offshore wind turbine size in China in 2019 was 4.2 MW – 3 MW lower than Europe. However, this is expected to change, as six Chinese turbine manufacturers have introduced larger offshore models of greater than 8MW in the past 18 months. After a 10 MW PMG turbine prototype was rolled off the production line at Dongfang Electric and a 10 MW model released by CSIC Haizhuang in 2019, Mingyang unveiled its MySE 11 MW-202 medium speed turbine in June 2020, making it the largest hybrid-drive turbine in the world. In addition, international player GE Renewable Energy is building a factory in Jieyang, Guangdong province, with the aim of producing its Haliade-X

12MW offshore turbines from H2 2021.

Industrialisation

The local offshore wind industry will benefit from the current investments made by leading turbine OEMs and key component suppliers along the coastal cities, as well as plans from the local port cities such as Yangjiang and Nantong to make themselves offshore wind manufacturing bases. The Chinese offshore wind cluster is expected to be built along the coastline.

Lessons learned from onshore wind

China is the world's largest manufacturing base for onshore wind, with a mature local supply chain already in place. The Chinese onshore wind industry has committed to reaching grid parity by the end of 2020 – earlier than any other established onshore wind market. The offshore sector can greatly benefit from the onshore experience in this transition.

International cooperation

The offshore wind installation rush has already helped to accelerate international cooperation. Not only

will this cooperation help address current bottlenecks throughout the supply chain, it will also import experience in project execution and operation from Europe through foreign-local partnerships (for example, the joint venture between EDF Renewables and China Energy for two offshore wind projects located in Jiangsu province).

Conclusion

China has already demonstrated rapid reduction in LCOE for onshore wind via large magnitudes of volume and investment, a maturing supply chain and technological innovation. Although the central government is eager for local offshore wind to become subsidy-free – and several factors are in place for further cost reduction – GWEC Market Intelligence believes that post-2021 financial support by provincial governments should be considered to support the transition. A support scheme will be crucial to ensuring that the Chinese offshore wind sector can remain on a steady path to achieve grid parity around 2025, and will bear insights for other offshore markets on how to balance government support with the maturation of local industry.

e. Health and safety as a key to scaling global offshore wind

Workforce safety is paramount to the success and sustainability of offshore wind. As the industry expands its footprint in established and emerging offshore markets, the sector's focus is to strive for an injury-free working environment.

Globally recognised regimes of safety and technical training standards have been developed to the extent that the industry today can call upon almost 100,000 people trained to GWO standards in 40+ countries, around a third of whom are trained to work safely in offshore wind.

In the recent report co-authored by Global Wind Organisation and the Global Wind Energy Council [Powering the Future – Global Offshore Wind Workforce Outlook](#), six emerging markets are forecasting over 31GW of new installations between 2020-2024, with an associated need for over 77,000 trained workers (see table). This imminent expansion of offshore

Forecast installations (in MW) for key markets to 2024 and associated workforce requirements

Market	Forecast installations (MW)	Calculated workforce requirement
North America	5,720	14,300
China (mainland)	19,000	47,500
Taiwan	3,579	8,948
Japan	860	2,150
Vietnam	1,100	2,750
South Korea	560	1,400
Total	30,819	77,048

Source: GWEC Market Intelligence, GWO and RCG

wind in China, Japan, Vietnam, South Korea, Taiwan and the United States presents a huge opportunity for the industry to collaborate with owners and primary contractors, policy makers and wind energy associations to deploy established regimes that already work well in existing markets.

The goal is to support the safety profile and working cultures in these countries to help scale the industry

sustainably, making offshore wind a sector of choice.

Successes have been possible through a commitment to collaboration and transparency. GWO standards have achieved almost universal acceptance in many established offshore wind markets, and as it grows into new markets, the industry is mindful of existing systems of health and safety,

The industry today can call upon almost 100,000 people trained to GWO standards in 40+ countries

workforce regulations and legislation around the world. An open platform for collaboration that acknowledges these variables, can avoid any notion that perceived best practices are being imposed onto markets where local experience about how to keep people safe will often represent the best-informed opinion.

Early signs of success include the fast work by GWO's China and North American Committees. Large manufacturers and owner operators in these two markets use the tools and methodologies GWO members designed to create training standards and make them work better at a regional level. Global training standards like GWO contain learning objectives for skills and knowledge which generally apply everywhere, and the collaborative process to agree their deployment locally, is helping them grow in scale as a sustainable element of the supply chain.

Of course, training is only a part of the safety matrix in offshore wind. Another urgent priority is to ensure hazards are correctly identified, risk assessed and mitigated. A system of collecting incident data on a global basis using standardised

methodologies has been called for at the very highest levels of the industry and early stage developments are in progress. Sometimes known in the industry as 'lagging indicators', this data can help identify causal links between work activities and injuries or fatalities in the wind industry, after the fact. They already exist to a considerable degree of sophistication on a company by company basis so the next step will be standardisation, most likely led by organisations with experience such as G+ Offshore Wind and Safety On, based in the UK, and the American and Canadian Wind Energy Associations. Steps to formalise reporting between these organisations and their members will be challenging but fruitful in understanding and improving the safety performance of the offshore wind industry as it grows.

Paul Robbins – Global Subject Matter Expert, HSE, Vestas. Chairman of Global Wind Organisation (GWO)



Part 2. Emerging markets

Taiwan

Taiwan is heating up as the second-largest offshore wind market in the Asia-Pacific region, after Mainland China. Ambitious capacity targets set by the DPP government have attracted eager interest from leading offshore wind developers and technology providers. Already, 128 MW of offshore capacity has been installed at Formosa 1, Taiwan's first commercial-scale offshore wind farm in Miaoli County, and a further 109 MW is due to come online from the Changhua County project by the end of 2020.

Offshore wind is a key component of Taiwan's green economy vision, which charts a nuclear-free pathway to generate 20% of electricity through renewable energy by 2025. The government is aiming to install 5.7 GW of offshore wind by 2025, and in late 2019 announced that it would double its ambitions to 10 GW over the 2026-2035 period. While the 5.7

GW tranche was procured across a selection round and auction, the next 10 GW (termed Round 3) will likely be conducted across two phases; the first phase (2026-2030) will prioritise projects at water depth of less than 50 metres.

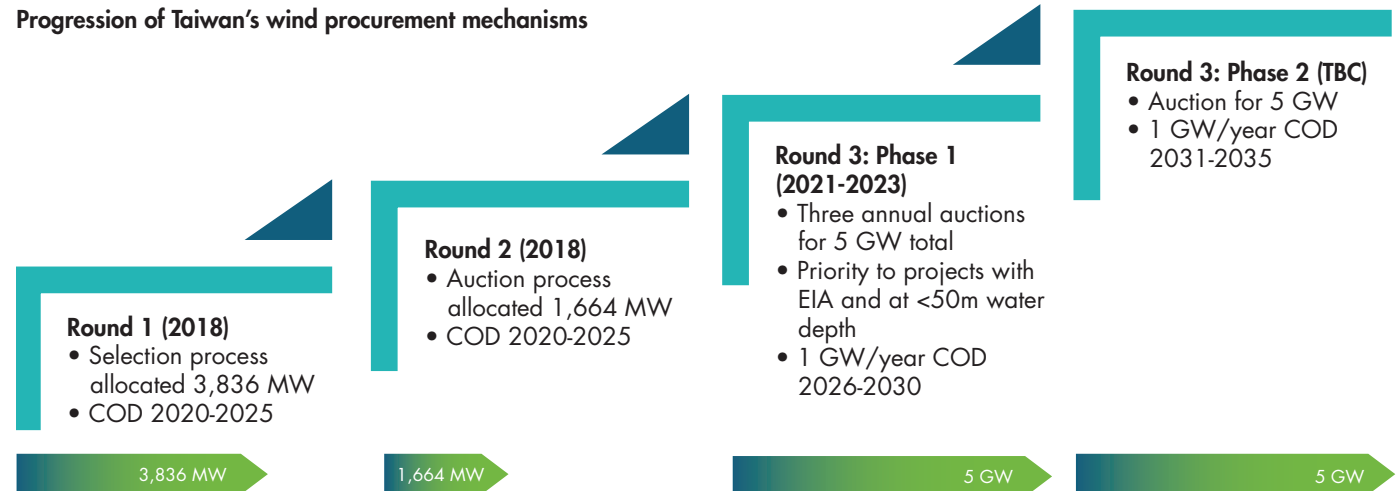
Following government delays due to COVID-19, a draft version of the Round 3 framework, including how

much volume will be allocated and when, is due to be published by end of this year, with the first phase of allocation conducted from Q2 2021 to Q2 2023.

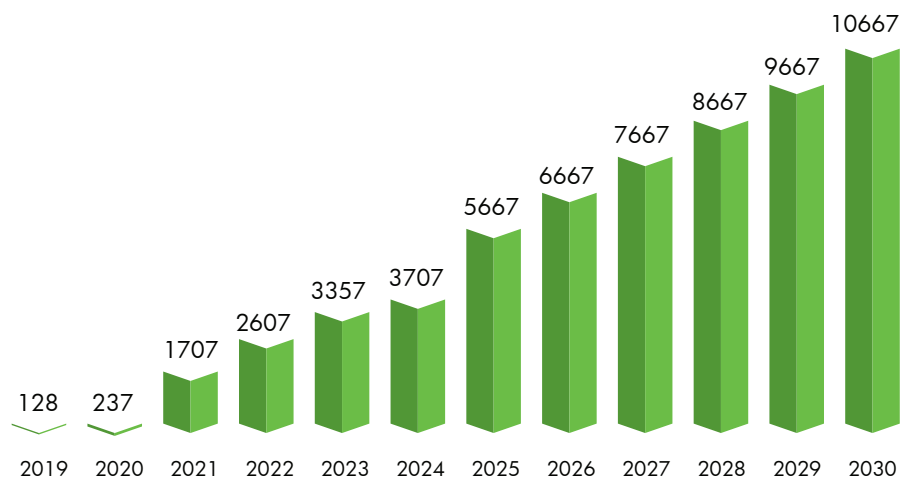
Critical to the steady progression of the market will be the government's localisation strategy, which aims to consolidate the entire supply chain in Taiwan, from turbine components

to submarine cables to shipbuilding. The industry must balance growth with local content requirements that are expected to be higher in Round 3. In 2020, positive signs have already been marked by announcements for an MHI Vestas-Tien Li blade manufacturing facility in Taichung, an SGRE nacelle production facility in Taichung and CDWE's work on

Progression of Taiwan's wind procurement mechanisms



Market outlook for cumulative installed offshore wind capacity in Taiwan (MW)



Source: GWEC Market Intelligence, June 2020

the first Taiwan-built offshore wind installation vessel. But how flexible the localisation requirements are in the forthcoming Round 3 framework will be key to determining whether the nascent offshore wind industry can develop into a sustainable and competitive market.

Within the next decade, Taiwan will achieve more than 10 GW of installed offshore wind capacity, becoming an experienced market with an established domestic supply chain. The sector is supported by a Feed-in-Tariff, a four-year wind power

promotion plan and a relatively open investment environment. Limited land space and high energy insecurity further compels Taiwan to look to coastal zones for power production.

Power sector reform is also on the horizon, with amendments in 2017 to the Electricity Business Act which mandated the unbundling of utility Taipower's generation, transmission and distribution business, and the liberalisation of the electricity market to enable multiple business models for direct procurement of renewable energy.





Japan

Asia's first offshore wind market at crossroads

Japan's offshore wind market has taken time to develop, with the first pilot projects going into the water back in 2003. In the years following the Fukushima nuclear accident in 2011, there was renewed commitment and activity, with both fixed and floating foundations being deployed. To date, no commercial-scale offshore projects greater than 20 MW have been installed and the development of a viable market structure is emerging at a slow pace.

But 2020 marks an inflection point for Japan's offshore wind sector. The government launched the first offshore wind auction in the general common sea in June 2020 and the other four promising sea areas nominated in July 2019 are ready for auction after the approval on 21 July 2020, four more sea areas were nominated as promising area in the same month. In addition, there is a strong sense of growing momentum in both policy and industry, as many

leading global players have now formed joint ventures with local Japanese companies and/or set up local operations. The coming period will be crucial, as the wind industry seeks to work with government to create a strong sector based on large volumes and competitive prices, rather than a small sector which could remain an expensive niche within Japan's wider energy picture.

In March 2020, GWEC and the Japan Wind Power Association (JWPA) set up a new Japan Offshore Wind Taskforce (JOWTF), which will play a key role in working with the government to develop a sustainable wind industry, as well as produce a detailed Cost Reduction Study to identify different price/volume scenarios and investment and industrialisation opportunities.

A regulatory drag on Japan's offshore development until now

The feed-in tariff (FiT) for wind power was approved in Japan in 2012, but the tailor-made offshore FiT was not

available until March 2014, when the Ministry of Economy, Trade and Industry (METI) approved the ¥36/kWh (€0.28/kWh) FiT for offshore wind. Despite the rate being the highest available anywhere for offshore wind, Japan only had 66 MW of offshore wind installed by the end of 2019, including five floating turbines (totaling 19 MW) and 23 near-shore wind turbines. The slow uptake is attributed to Japan's overly complex Environment Impact Assessment (EIA) system and market uncertainty. It can take four to five years to pass through Japan's strict environmental assessment process, and the lack of clarity and coordination between different government bodies has prompted industry to call for a "one-stop shop" approach. As of January 2020, 14.8 GW of offshore wind projects are in the EIA pipeline.

Positive steps to accelerate offshore wind development

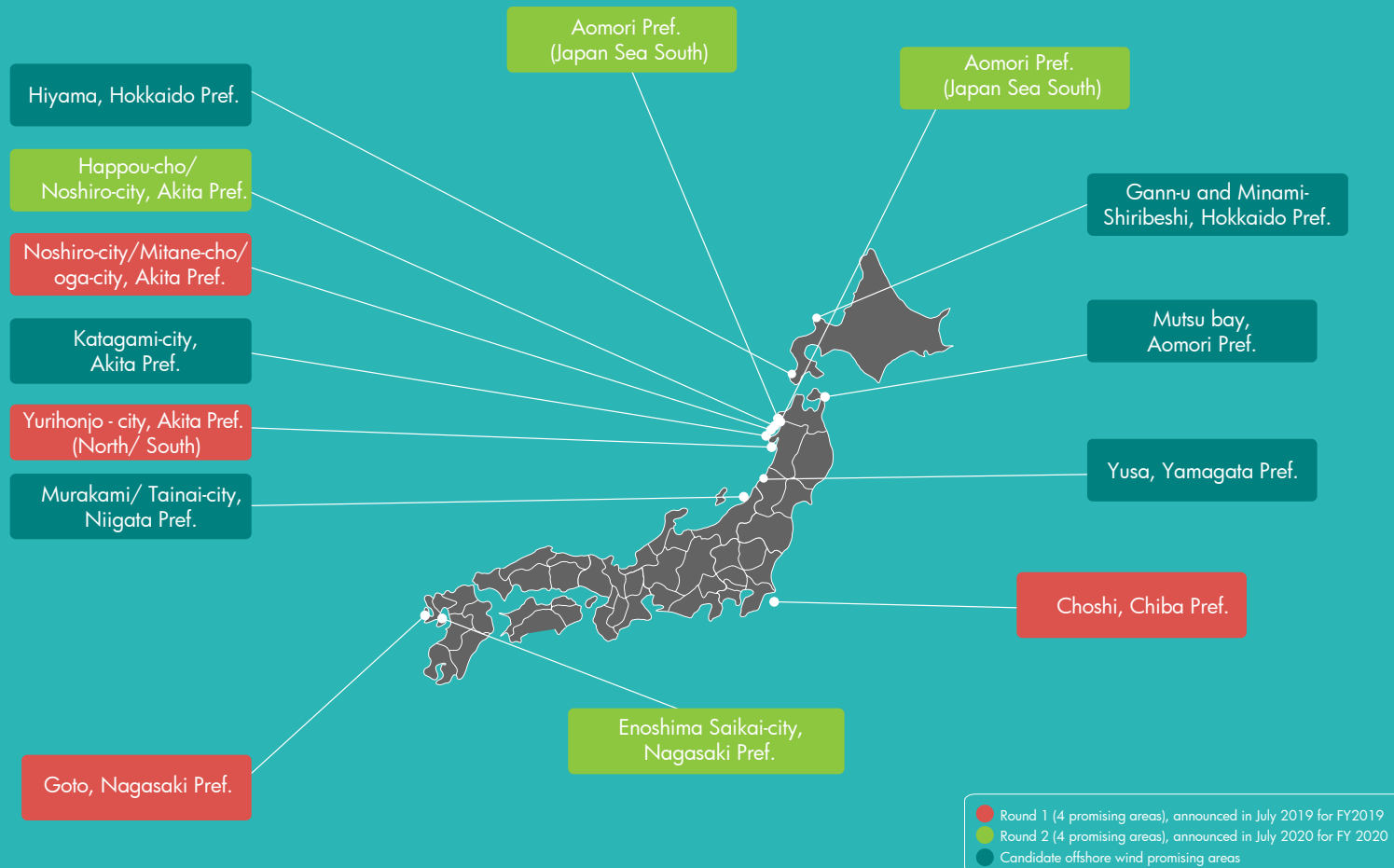
To address these challenges, the government has been streamlining

regulation since 2017, when the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) amended its Port and Harbor Law to promote offshore wind power development in Port-associated Sea Areas. In March 2018, the Japanese Cabinet decided on a bill to establish basic rules for development of offshore wind power in the General Common Sea Area. Further progress was made in 2019 with METI and MLIT announcing the first nomination of 11 offshore wind promotion zones in July for fiscal year (FY) 2019. Four of these zones (Goto in Nagasaki, Choshi in Chiba, Yurihonjo in Akita, Noshiro in Akita) have been nominated as promising areas where local authorities and residents have agreed to cooperate to develop offshore wind projects. Goto in Nagasaki Prefecture was nominated as the first zone for promotion of offshore wind in December 2019.

Although COVID-19 prolonged public consultations, METI and MLIT launched Japan's first auction in July 2020 for a floating offshore wind farm (8 turbine, not less than 16.8 MW) off Goto City in Nagasaki Prefecture, to run until December 2020.

According to METI, the operator will be selected in June 2021. The other

Round 1 & 1.5 Candidate offshore wind promotion areas in Japan



Source: METI, MLIT, JWPA, July 2019

three promising areas nominated for FY2019, were nominated as the zones for promotion of offshore wind on 21 July 2020. Of these areas, Yurihonjo area in Akita has been divided into two areas, Yurihonjo North and Yurihonjo South, to promote competition.

Furthermore, METI & MLIT announced the second nomination of 10 offshore wind promotion zones in July 2020 for FY2020. Four of these zones (Aomori Japan Seaside North, Aomori Japan Seaside North South, Happou and Noshiro in Akita, Saikai in Nagasaki) have been newly nominated as promising areas.

The progress that Japanese offshore wind development has made in the past 12 months is summarised in the table below.

Offshore wind in Japan's long-term energy strategy

Japan has hesitated to announce a long-term offshore wind target because the METI still maintains its commitments with the nuclear and coal industries. The official wind power target in Japan is only 10 GW by 2030, including both onshore and offshore, representing 1.7%

Japanese offshore auction progress list

Stage of progress	Round 1 (FY2019)		Round 2 (FY2020)
	Initial (July 2019)	Progress (July 2020)	Initial (July 2020)
Promotion zones	Japan Sea side North, Aomori Japan Sea side South, Aomori Mutsu bay, Aomori Happou-cho & Noshiro, Akita Kisakata, Akita Murakami & Tainai, Niigata Enoshima Saikai-city, Nagasaki		Gann-u and Minami- Shiribeshi, Hokkaido Hiyama, Hokkaido Mutsu bay, Aomori Kisakata, Akita-city, Akita Yusa, Yamagata Murakami & Tainai, Niigata
Promising areas	Noshiro, Akita Yurihonjo, Akita Choshi, Chiba		Japan Sea side North, Aomori Japan Sea side South, Aomori Happou-cho & Noshiro, Akita Enoshima Saikai-city, Nagasaki
Official promotion areas	Goto, Nagasaki	Noshiro, Akita Yurihonjo North, Akita Yurihonjo South, Akita Choshi, Chiba	
Areas with auction already launched		Goto, Nagasaki	

Source: JWPA, July 2020

of the country's annual electricity production. This situation, however, is expected to change gradually. The trends of global energy transition and decarbonisation have made the Japanese government change their future energy plan. METI's minister Hiroshi Kajiyama recently declared the closure of 100 old & low performance coal-fired power plants by 2030 (out of 140 existing coal-fired power plants) and announced that

the country's energy strategy would prioritise decarbonisation over the current "energy mix" plan (fossil, nuclear and renewables). This change will be reflected at the next "Japanese long-term energy vision" revised in 2021 (it is revised every three years). As coal-fired generation supplies about one-third of Japan's electricity, renewable energy and particularly offshore wind is expected to play a big role to fill the gap.



Japanese offshore wind “sector deal”

On 17 July 2020, METI & MLIT held the first government-industry dialogue in Tokyo to promote offshore wind power development in Japan. This dialogue works as a system that can increase the voice of the industrial world from various power sources and is a concept similar to the Sector Deal in UK. During the first government-industry dialogue, JWPA proposed the 10 GW by 2030 and 30-45 GW by 2040 offshore wind targets. The government suggested the intention to nominate 3 or 4 candidate sea areas (each area has 300-350 MW in capacity) a year (about 30 projects in total). If this plan can be executed, it would bring Japan's total offshore wind capacity to about 10 GW by 2030.

Building the local offshore wind supply chain

A more streamlined regulatory environment has drawn the attention of large local utilities including TEPCO, which signed an MOU with leading offshore wind developer Ørsted to work jointly on offshore wind projects in Japan and abroad. In addition, Kyuden Mirai, a subsidiary of

Kyushu Electric Power Co, J Power and Tokyo Gas Co. also signed the partnership with RWE, Engie and Principle Power respectively with the focus on the offshore development.

Local and international suppliers are also entering the offshore wind value chain. For example, Tokyo-based Penta Ocean took delivery of Japan's first jack-up offshore wind turbine installation vessel (OWTIV) in 2019, while another three OWTIVs are expected to be delivered in 2022 by local companies including Shimizu, Kajimay, Yorigami, Obayashi and Toa. International-local partnerships, such as Van Oord/NYK and Northern Offshore Group/NYK, have been established to capitalize on the emerging opportunities in foundation and turbine installation and wind farm operation. However, the government may need to find a new strategy to revive its local offshore turbine manufacturing industry as two local turbine OEMs, Japan Steel Works (JSW) and Hitachi, have discontinued turbine production in recent years; this could leave room for MHI Vestas (a joint venture between Mitsubishi Heavy Industries and Vestas), SGRE,

GE Renewable Energy and others to move in.

In March 2020, MHI Vestas gained its first firm order in Japan, to supply turbines to the 139 MW Akita Noshiro offshore wind project owned by a Marubeni-controlled subsidiary, while in November 2019, it signed a preferred supplier agreement to supply its V174-9.5 MW turbines to the 220 MW Hibikinada offshore wind farm. In April 2020, MHI Vestas was selected to supply turbines for the 700 MW Akita Yurihonjo project, one of the largest offshore wind farms planned in Japan.

Conclusion

2020 is expected to be an important year for Japan's offshore wind sector, with the launch of the first wave of commercial projects and the announcement of the framework for further tenders.

MHI Vestas gained its first firm order in Japan, to supply turbines to the 139 MW Akita Noshiro offshore wind project owned by a Marubeni-controlled subsidiary, while in November 2019, it signed a preferred supplier agreement to supply its V174-9.5 MW turbines to the 220 MW Hibikinada offshore wind farm.

South Korea

Offshore wind is a golden opportunity for South Korea, offering the chance to accelerate its phaseout of fossil fuels and nuclear generation

Nearly a decade ago, South Korea adopted an ambitious Green Growth Strategy that aimed to reduce greenhouse gas emissions by 30% by 2020. This strategy marked the beginning of “green growth” as the direction of travel for South Korea’s economic growth, sparking the interest of domestic industrial conglomerates (such as Samsung, Hyundai, Doosan and STX) in renewable energy project development and equipment supply.

Following a 2.0 MW STX direct drive offshore turbine and a 3.0 MW Doosan geared drive turbine installed in early 2010s’ for testing purpose, the 30 MW Tamra offshore wind farm came online off Geumdeung-ri in Jeju Island in 2016. However, the sector has been generally slow to take off, due to public opposition on environmental and livelihood (fishing) issues. Long permitting periods and

a low initial feed-in tariff (prior to the introduction of the Renewable Portfolio Standard scheme) also dampened growth.

As a result, South Korea’s initial foray into “green growth” and a clean energy transition saw little translation into action for the better part of the last decade.

South Korea prepares to push the reset button on offshore wind

Nonetheless, at the start of a new decade, the momentum for offshore wind in South Korea is picking up with the passage of President Moon Jae-in’s Green New Deal and a groundswell of interest from ambitious consortia of local and international wind energy developers.

1. Policy support

Growth in modern South Korea is built upon energy-intensive industries such as electronics, automotive and shipbuilding, many of which are difficult to decarbonise. As such, the nation is still embroiled in public



Over 12 GW of new offshore wind capacity needs to be installed to reach the country's 2030 renewable energy target.

debates over its commitment to coal, gas and nuclear power, imposing a drag on the transition to cleaner and more secure renewable energy sources.

Now, with President Moon in office and the re-election of the Democratic Party in 2020, South Korea can press ahead with its newly adopted Green New Deal. To boost the green sector, South Korea plans to invest a total of 12.9 trillion won (US\$10.8 billion) in green buildings, urban forests and low-carbon energy production by 2022 and create 133,000 jobs in the process. Under this plan, South Korea has become the first country in East Asia to pledge to reach net-zero emissions by 2050.

Through its Third Energy Plan, released in June 2019, South Korea's "Renewable Energy 3020" target for 20% of total electricity consumption to come from renewable energy

by 2030 (currently around 6%) and to increase that share to 30-35% by 2040. Given insufficient land available for onshore wind and low solar radiation, attention has moved offshore. Over 12 GW of new offshore wind capacity needs to be installed to reach the country's goals.

2. Strong local industrial base

South Korea's industrial experience in steel, shipbuilding and logistics could translate to competencies in offshore engineering and supply chain efficiencies, smoothing the pathway to developing a localised offshore wind industry.

For instance, its marine and offshore industry will play a critical role fabricating offshore wind jacket foundations, with local shipyard company Samkang already delivering jacket foundations to the Changhua Demonstration project in Taiwan. South Korea also has the advantage of high R&D intensity in shipbuilding and cabling, allowing Samsung and Hyundai to build offshore wind installation vessels and local company LS Cable & System to manufacture offshore cables for markets in Europe and the US.

South Korea also has its own wind turbine manufacturers. Of these, Doosan has the longest track record in offshore wind with 96 MW installed, and is expanding its products line-up to 8 MW platform from the current 3 MW and 5 MW models. In addition, local turbine suppliers Unison and Hyosung are seeking opportunities in offshore developments.

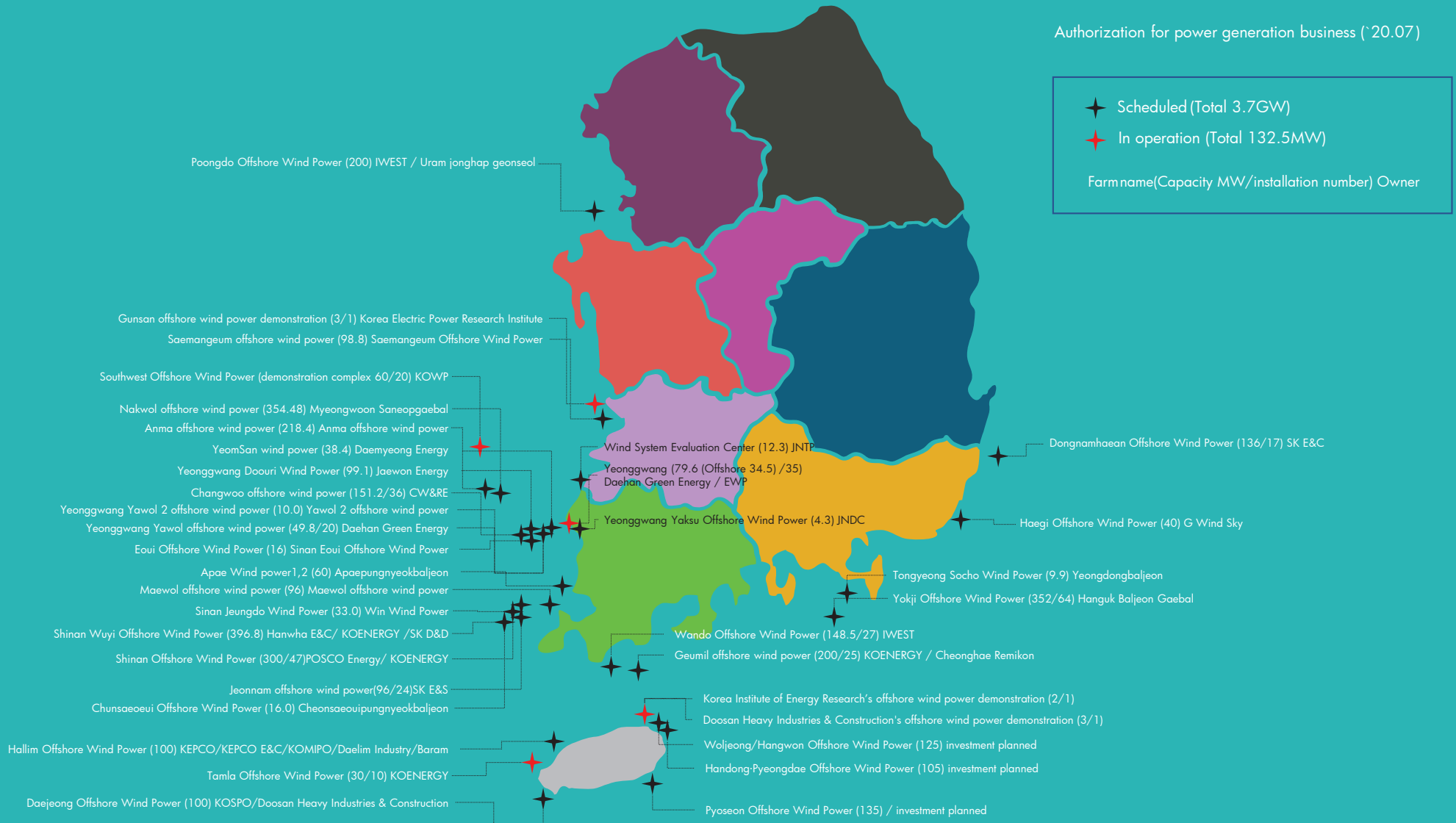
A strong locally supply chain also exists for forging, with local companies Hyundai Forging, Hyunjin Materials, Kofco and Taewoong, as well as slewing bearings manufacturers Shilla and CS Bearing, already exporting products to overseas offshore markets.

3. International partnerships

Leading international offshore players have recognised the potential for offshore wind (particularly floating offshore) in South Korea and are piling into the market.

Early last year, the port city of Ulsan signed an MOU with four domestic and foreign partners and investors (including Royal Dutch Shell and CoensHexicon, South Korea's energy company SK E&S and Denmark's Copenhagen Infrastructure Partners,

Status of Offshore Wind Farms in Korea



Source: Korea Wind Energy Industry Association

Macquarie's Green Investment Group (GIG) and Korea Floating Wind (KFWind)) to explore large-scale floating offshore wind development. In February 2020, Canadian power producer Northland Power acquired local wind developer Dado Ocean, which owns a portfolio of early-stage offshore wind projects in South Korea.

In addition to partnerships and acquisitions, large-scale floating projects are being developed by international-local consortia. The 200 MW Donghae 1 floating offshore wind farm, nearly 60 kilometres offshore from Ulsan, is being developed by Equinor, the Korea National Oil Corporation (KNOC) and Korea East-West Power Corporation, for commissioning in 2024. In proximity to this project, Equinor recently commenced LiDAR installations to conduct metocean data measurements for a potential 800 MW floating offshore wind project.

By 2030, South Korea is expected to emerge as East Asia's hottest floating offshore wind market, housing some of the world's biggest floating offshore wind farms, boosted by significant developer and investor appetite.

Fulfilling the promise of South Korea offshore wind

As of June 2020, there are currently 5 operational offshore wind projects totalling 132.5 MW, including the latest and largest 60 MW demonstration Southwest Offshore Wind Project completed in January – the first phase of a massive 2.5 GW project. Over 23 offshore wind projects are in preliminary development (totalling 7.3 GW), as shown in the project map on page 56.

Despite its slow start, South Korea's offshore wind sector is now benefiting from the financial clout coming from both state-owned and foreign investors, and buoyed by its existing industrial infrastructure. GWEC Market Intelligence forecasts that a total of 7.8 GW of offshore wind is likely to be built in South Korea by 2030, of which 1.2 GW is expected to be floating wind.

However, South Korea remains a challenging market with respect to terrain complexity, turbulent wind conditions and strong incumbent energy and marine actors, particularly among the coal and fishing industries. Coupled with criticism that government rhetoric

does not always match action, the market will need steadfast public steering and ambitious long-term targets to drive decarbonisation and diversify the power mix. Still, with sufficient government commitment and industry experience from neighbouring countries to smooth the learning curve, the future of South Korea's offshore wind sector looks bright indeed.



Vietnam

Since commissioning its first 16MW intertidal wind farm in Bac Lieu in 2013, Vietnam has emerged as the offshore wind market to watch in South East Asia. Now with 99MW of offshore wind installed capacity, and 200MW due to come online in 2020, Vietnam has drawn significant interest amongst international developers, investors, and financiers as a fast-growing market.

Vietnam's market growth is supported by strong fundamentals including a steep rise in energy demand, rapid industrialisation and a growing population. While currently dependent on fossil fuel generation, the Vietnamese government has sought to accelerate the production of electricity from renewable sources, targeting 10% renewables in its 2030 power mix in PDP 7, the country's master energy plan. But for a market known for its technical and legal complexity, clarity on regulation, grid access and bankability of projects remain critical challenges.

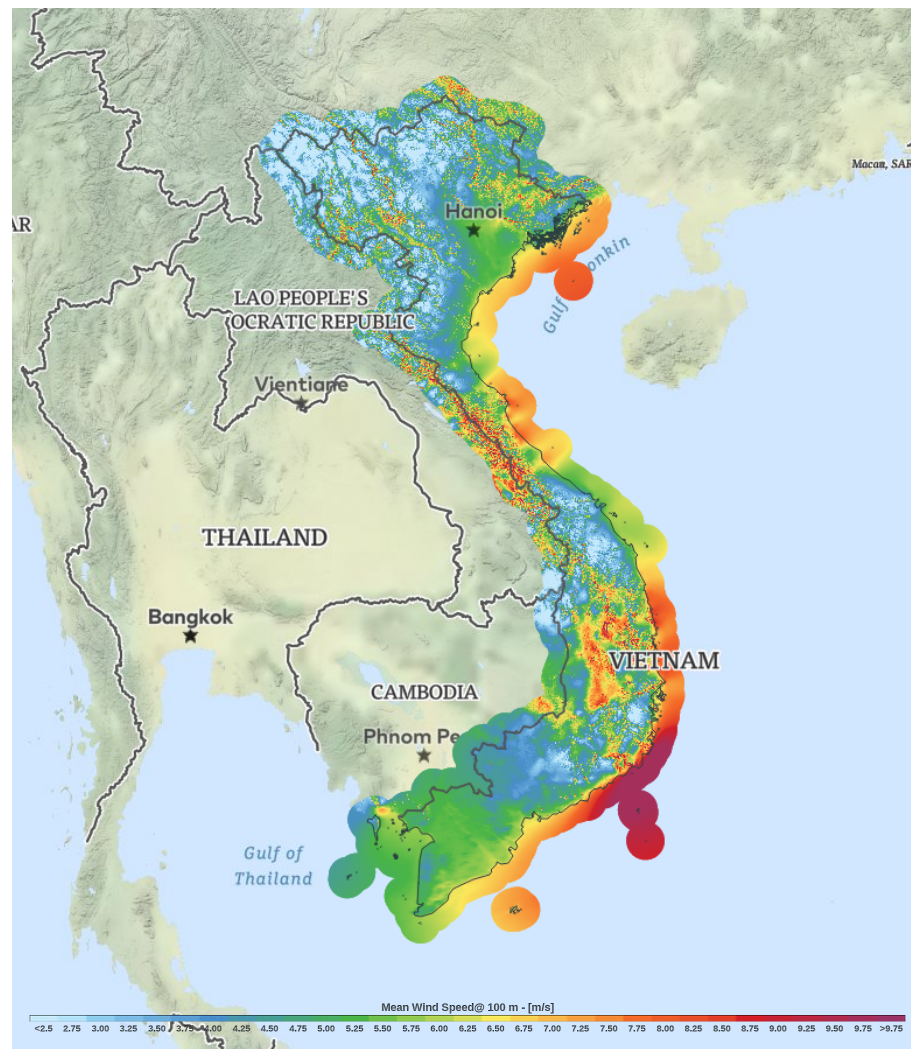
Steady strengthening of Vietnam's wind project pipeline

PDP 7 aims for 800MW of onshore and offshore wind energy by 2020 and 6GW by 2030 – which pales in comparison with the country's technical potential. With a coastline of more than 3,300 kilometres and average wind speeds of 8-9m/s in the south, up to 475 GW of fixed and floating offshore wind resource potential has been identified by the World Bank Group.^[1] Due to growing industry appetite to develop offshore wind power in Vietnam, the market is expected to reach around 2.0 GW of offshore wind capacity by 2025 and 5.2 GW by 2030.

Offshore wind is prioritised in the government's plan to build a "blue economy" – developing marine-based renewables to meet energy needs – and achieve energy security. Since revising PDP 7 in 2016, the Vietnam government has been reorienting its reliance on coal to

[1] <http://documents.worldbank.org/curated/en/716891572457609829/pdf/Going-Global-Expanding-Offshore-Wind-To-Emerging-Markets.pdf>

Onshore and offshore wind speed in Vietnam



Map obtained from the Global Wind Atlas 3.0, a free, web-based application developed, owned and operated by the Technical University of Denmark (DTU). The Global Wind Atlas 3.0 is released in partnership with the World Bank Group, utilizing data provided by Vortex, using funding provided by the Energy Sector Management Assistance Program (ESMAP). For additional information: <https://globalwindatlas.info>

prioritise clean energy sources. Resolution No. 55-NQ/TW, published in February 2020, outlines measures to liberalise the energy sector and reduce the share of coal-fired generation in the power mix.

Just last month, the government formally approved a list of 91 additional wind projects totalling 7 GW,^[2] on top of the 4.8 GW of planned wind capacity (78 projects) already approved under the current master plan. Projects in operation (377 MW) and those with power purchase contracts with EVN (1,662 MW) are excluded from the figures above. All of these puts Vietnam on track for a total wind power generation capacity of nearly 14 GW latest by 2030.

The added wind capacity is viewed as necessary to plug the power shortage left by delayed coal plants, which may not come online until 2023. While Vietnam remains a net coal importer for now, the declining economics of new coal generation vis-à-vis wind and solar power are driving the shift to utility-scale renewable generation.

[2] <https://tinnhanhchungkhoan.vn/dau-tu/danh-tinh-91-du-an-dien-gio-vua-duoc-bo-sung-quy-hoach-dien-333024.html>

Despite the ambition for decarbonisation and attractive resource potential, pursuing a least-cost transformation of the energy system will require transparent policy, streamlined administration and a flexible grid. The lack of policy differentiation between onshore, nearshore and large-scale offshore wind projects of Vietnam is holding the sector back. PDP 8 is expected to deliver more concrete policy frameworks for large-scale offshore wind developments, including zoning, marine spatial planning, and ports infrastructures plans and permitting processes. A key issue will be the design challenges for grid upgrades, and whether public or private bodies will be responsible for investments in grid connections and transmission infrastructure.

Promising developments for PDP 8

PDP 8, expected by the end of 2020, will outline a two-year extension to the current FiT framework for offshore wind, as well as higher capacity targets out to 2030. In April 2020, the Ministry of Industry and Trade of Vietnam (MOIT) officially proposed an extension of the FiT mechanism for wind projects from 1 November 2021 to 31 December 2023. By 2024, the government is planning to transition wind procurement to an auction system.

This development followed policy engagement with GWEC Asia, which highlighted the supply chain disruptions, labour shortages and construction delays brought by the Covid-19 outbreak, as well as the permitting delays to several wind projects which made it unfeasible



The government formally approved a list of 91 additional wind projects totalling 7 GW, on top of the 4.8 GW of planned wind capacity (78 projects) already approved under the current master plan.

to meet the 2021 commissioning deadline under the original FiT framework.

A direct power purchase agreement (DPPA) pilot programme could also generate new revenue opportunities and demand for renewable energy from industrial consumers. Currently, national utility Vietnam Electricity (EVN) and its subsidiaries act as the sole offtaker of electricity from generators. However, the government has announced its vision for a competitive power market, with this DPPA pilot scheme operating from 2021 to 2023, paving the way for a retail electricity market.

A bankable PPA is a building block of successful offshore wind markets that require huge volumes of capital, and is widely perceived as a constraint on Vietnam's wind sector development and financing. Bankability of the DPPA and verification of renewable energy attributes according to international standards will both be required for the secondary market to take off.

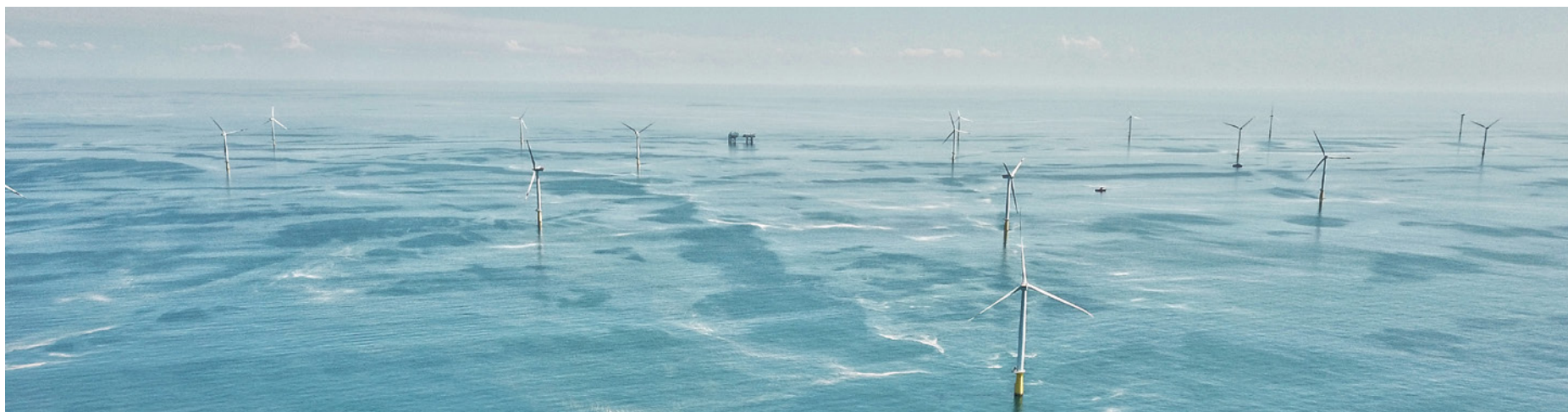
Offshore wind project outlook

Further regulatory clarity, especially in the process of obtaining seabed leases and approvals for offshore wind projects, will be critical to attracting the international capital and interest that can sustain a boom in offshore wind development in

Vietnam. The country has a solid pipeline for offshore wind, most of which are nearshore, with three projects in the build phase (142MW Bac Lieu Phase 3, 40MW Khai Long I and 48MW V1-1 - Truong Long Hoa project) and 10 in the pre-construction phase, as of June 2020.

Worth highlighting is the mammoth Thang Long project at 3.4GW – making it one of the world's biggest offshore wind farms once completed – which has already obtained approvals from the government. The project is still in the early stage and its first 600MW phase is planned to be completed by 2022.

Offshore wind is set to play a critical role in Vietnam's clean energy transformation, bringing in local and foreign investment, creating local and sustainable jobs, delivering carbon reduction and positioning the country as an energy leader in South East Asia. To deliver this potential, the government must expedite its improvements to the current regulatory framework, streamlining permitting processes and reducing the legal and technical complexities of offshore developments. It must also focus on risk mitigation mechanisms and reforms to the standard PPA, which can increase investor and off taker certainty and reduce the cost of capital for wind projects.



US

The US offshore wind market has picked up strong momentum since the 30 MW Block Island Wind Project came online in Rhode Island in December 2016. Despite a complex regulatory scene with differing rules across the offshore states, large-scale projects are advancing and developer appetite has been at fever pitch. And with technical resource potential for US offshore wind exceeding 2,000 GW, there is vast room to grow.

Regulatory progress at both federal and state levels

On the **federal level**, the Bureau of Ocean Energy Management (BOEM) is responsible for managing development of offshore resources in federal waters. In 2009, the Department of the Interior (DOI) announced final regulations for the Outer Continental Shelf (OCS) Renewable Energy Program, which provides a framework for issuing leases, easements, and rights-of-way for OCS activities that support production and transmission of energy from sources other than oil

and natural gas. Since the regulations were enacted, BOEM has issued 16 commercial offshore wind energy leases, including three commercial leases in 2019. In total the 16 offshore wind leases could support more than 21 GW of generating capacity. BOEM is now in the planning stages for leasing areas off the coast of New York, South Carolina, California and Hawaii and expects to hold two lease sales in 2020, one in the Atlantic in the New York Bight and one in the Pacific off California.

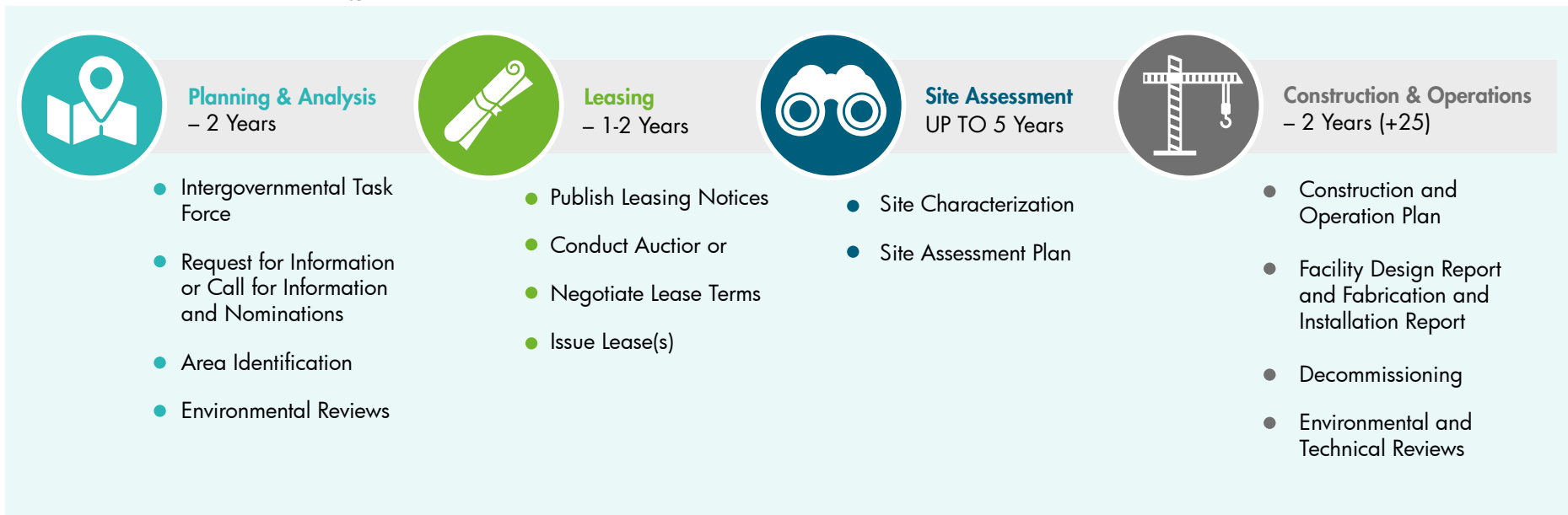
The issuance of leases and subsequent review of energy development activities on the OCS is a staged decision-making process. BOEM's renewable energy authorization process is comprised of four distinct phases (Figure 2). The lease does not provide the lessee the right to construct particular facilities; rather, the lease provides the right to use the leased area to develop its site assessment and construction and operations plans, which must be approved by BOEM before the lessee can move on to the next stage of the

East Coast offshore wind project and lease areas



Source: BOEM, AWEA, January 2020

Phases of BOEM's Offshore Wind Energy Authorization Process



Source: BOEM, AWEA, January 2020

process. On the last phase, BOEM conducts environmental and technical reviews of the plan submitted by project developers and decides whether to approve, approve with modification or disapprove. At the end of lease, project developers must decommission facilities in compliance with BOEM regulations.

On the **state level**, the East Coast cluster consisting of Maine,

Connecticut, Massachusetts, New York, New Jersey, Delaware, Maryland, Virginia and North Carolina is driving strong demand for offshore wind energy. To date, more than 10 states have offshore projects in development, of which six states have offshore wind procurement targets through either legislation, conditional targets or executive orders. The recently increased offshore wind targets in New York, New Jersey

and Virginia together with the 2030 offshore wind targets released in Connecticut and Maryland have brought the country's total offshore wind procurement targets from 9.1 GW in 2018 to 28.1 GW in 2020 (see figure on page 17 on Global Market Outlook section).

According to AWEA, as of June 2020, six states had selected nearly 6,300 MW of offshore wind projects

through state-issued solicitations, which are the calls for proposals from offshore wind developers to deliver offshore wind energy to an state. The top four states by total volume of solicitations are: New York (1,696 MW), Massachusetts (1,604 MW), Connecticut (1,108 MW) and New Jersey (1,100 MW). The state-level solicitations are expected to continue in 2020.



Developers expect 15 offshore wind projects, totalling 10,603 MW, to be commissioned by 2026.

In January 2020, New York State Energy Research and Development Authority (NYSERDA) filed a petition with state regulators to initiate a regulatory proceeding for the authorization of a second large-scale solicitation for at least 1 GW of offshore wind. Developers expect 15 offshore wind projects, totalling 10,603 MW, to be commissioned by 2026.

According to AWEA, as of April 2020 the US offshore wind pipeline totalled more than 26 GW in federal lease areas issued to date. According to GWEC Market Intelligence, out of this pipeline, developers expect 15 offshore wind projects, totalling 10,603 MW, to be commissioned by 2026. Out of the 10,603 MW of offshore wind capacity, 25% is likely to be built in Virginia, followed by New York (17.2%), Massachusetts (15.2%), North Carolina (14.0%), Connecticut (10.5%) and New Jersey (10.4%). With regards to the project

ownership, more than 70% of the capacity to be delivered by 2026 is controlled by European developers, of which Ørsted is taking the lead (2.5 GW). The Danish utility is closely followed by Avangrid Renewables, a subsidiary of Spain's Iberdrola (2.3 GW), Equinor (816 MW), CIP (804 MW), EDPR (402 MW) and Shell (402 MW).

Market ready to take off from 2024 with European suppliers dominated the current pipeline

Although the 12 MW Dominion Virginia demo project was successfully installed in June 2020, compared to GWEC Market Intelligence's pre-COVID outlook, the combination of prolonged lead time to secure federal permits and the effects of the COVID-19 health crisis has caused delays for projects previously scheduled for commission in 2022 and 2023. Thus, we have

pushed back the commission year for those projects by one year.

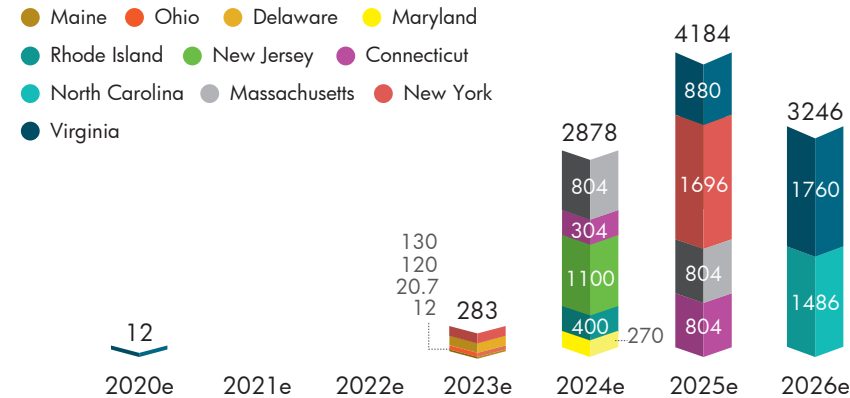
As of the end 2019, offshore developers have selected or announced preferred turbine suppliers for nine offshore projects. Thanks to Dominion Energy's 2,640 MW project off the coast of Virginia, Siemens Gamesa is so far the largest winner with a 4,366 MW order backlog in the US, followed by GE Renewable Energy (1,220 MW) and MHI Vestas (804 MW). SGRE's SG14-222 DD (the world's largest offshore model released in May 2020), GE's Haliade X- 12MW DD and MHI Vestas' V164-9.5 MW turbines are the most popular models selected for those projects.

Challenges need to be addressed to achieve growth

With activity level accelerating along the East Coast, GWEC Market Intelligence predicts a total of 22.6 GW of offshore wind could be built in the US by the end of this decade. To realize such potential, however, the following key challenges must be addressed:

- Slow project permitting processes can delay the

Expected annual offshore wind installation by state, 2020-2026



Source: GWEC Market Intelligence, June 2020

ramp-up of an industry with huge growth potential and strategic alignment with economic recovery objectives. The final approval from BOEM for the Construction and Operations Plan (COP) has been particularly prolonged for developers, and has already impacted projects scheduled to be online in 2022-2024. In addition, for future commercial lease sales, engaging stakeholders – including federal, state and local agencies, fishing and marine use communities

- and the public – throughout the development and construction process is essential.
- Establishing a local supply chain and investing in grid and port infrastructure through a collaborative approach will be essential to the sector's success in the US. Commitments and investments in the supply chain, including Jones Act-compliant offshore wind installation vessels, adequate grid buildout and port infrastructure, as well as a trained and skilled workforce, are critical

factors to fulfil timelines and meet ambitious targets. Individual states have defined programs, including tax incentives and research grants, to attract private investment. The challenge here will be defining a collaborative approach and planning strategy in order to set up an efficient supply chain across individual states.

France

With a total 16.6GW of installed onshore wind capacity, and a solitary 2MW pilot floating turbine spinning, France is undoubtedly late to the offshore wind boom when compared to its European neighbours. The first wave of French offshore wind projects was auctioned in 2012 (1.9GW allocated) and 2014 (1 GW allocated), but public opposition and project delays linked to fishing industry, aviation and national security concerns stalled progress for years. This was followed by retroactive tariffs cuts in line with the rapid decline in offshore wind prices since the auctions.

The reboot of the French offshore wind industry

Nonetheless, at the start of this new decade, France's offshore wind sector is finally advancing. Backlogged projects from Tender 1 have resolved their permitting disputes, clearing the path to financial closure. These are expected to come online by 2022, starting with the 480MW Saint-Nazaire project, followed by the

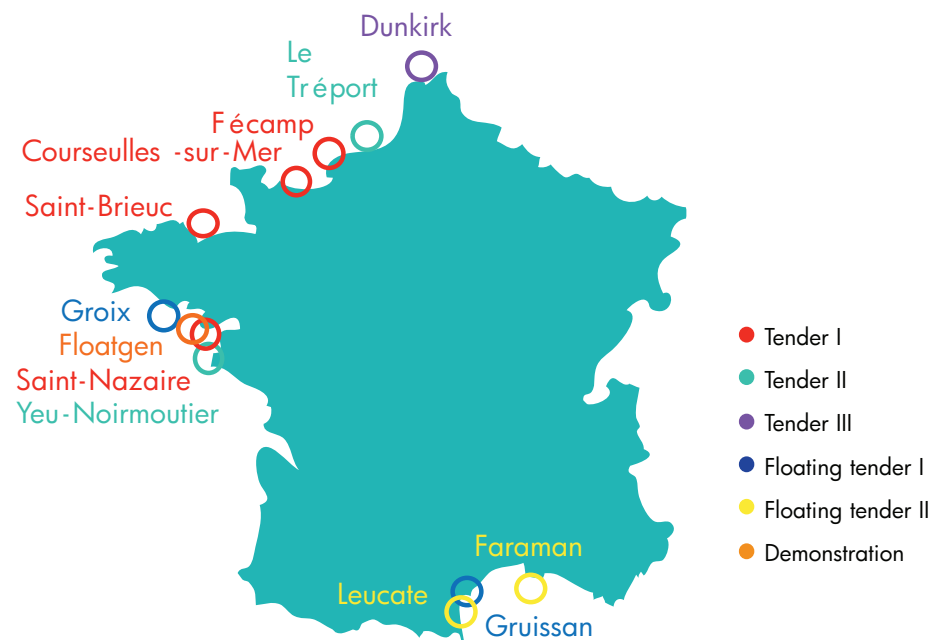
496MW Saint-Brieuc project in 2023. Projects from Tender II are still waiting to be cleared and expected to be commissioned in 2023/2024.

In France's third offshore wind auction in 2019, an EDF-Innogy-Enbridge consortium won the right to develop a 600MW offshore project off Dunkirk with a winning bid of EUR44/MWh. This particular tender featured a number of regulatory changes that facilitated competitive bidding, faster project developments and low bid prices. Dropping local content requirements, shifting transmission cost to the Transmission System Operator (TSO) and pre-tender public participation all contributed to producing a successful procurement round, securing prices 69% cheaper than previous French tenders.

Following the third tender, the French government is committing strongly to both onshore and offshore wind. In April 2020, France's 10-year National Energy and Climate Plan (NECP) was submitted to the European Commission, setting an impressive

target of 5.2-6.2GW installed offshore wind capacity by 2028. Taking it one step further, the revised Multiannual Energy Programme (Programmation pluriannuelle de l'énergie, or PPE) raised its target to put up to 8.75 GW of offshore wind capacity out to

French offshore wind projects



tender from 2020 to 2028. If this target is realised, GWEC expects France would become the eight-largest offshore market globally by that time.

Promising offshore wind outlook ahead

By 2030, GWEC Market Intelligence expects 8.5 GW of offshore wind capacity to be installed in France. This includes the 3.5 GW of approved projects from Tenders I, II and III, as well as four demonstration floating wind projects and volume outlined in future tenders.

According to government plans, the next tender will take place in H2 2020 for a 1GW offshore project in the Manche Est-mer du Nord region, followed by further 1 GW tenders in 2021, 2022 and 2023. Separately, a total of 750MW floating offshore capacity will be allocated through three projects in Brittany, Occitanie and Provence-Côte d'Azur, expected to be awarded in 2021 and 2022. The Environment Minister recently announced that from 2024 onward, France will tender 1 GW per year of either fixed-bottom or floating wind capacity, largely depending on the cost.

Other positive developments from industry in 2020 include:

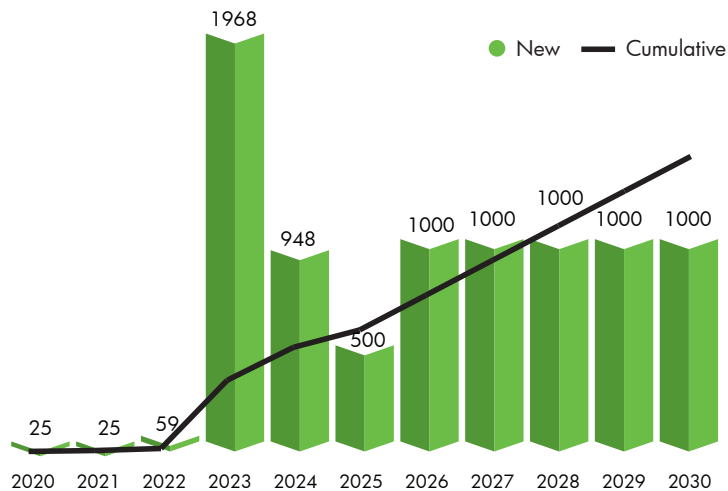
- European Investment Bank (EIB) has granted a €450 million (US\$507m) credit line to co-finance the construction of the 497MW Fécamp offshore wind project expecting to come online in 2022;
- Spanish energy company Iberdrola announced an investment of EUR 3-4 billion in renewable energy projects in France, and plans to start construction on the EUR 2.5 billion Saint-Brieuc project in 2021;
- Siemens Gamesa Renewable Energy (SGRE) is expected to start construction of its blade manufacturing facility in Le Havre, creating around 750 direct and indirect jobs, scheduled for completion in 2023;
- LM Wind Power announced plans to recruit 250 employees at its blade manufacturing facility in Cherbourg in 2021;
- Prysmian secures over €150 Million (US\$169m) from RTE to develop two submarine and land export power cable systems to connect offshore wind farms

located between the islands of Yeu and Noirmoutier to the French national grid.

Conclusion

Although the French market had a slow start, the government's recent PPE commitment and 2028 target have put offshore wind back in the spotlight. If it can realise its capacity targets and maintain a streamlined permitting and consenting process, the country is expected to be among Europe's top five offshore wind markets by 2030, as well as one of the world's leading markets in floating wind.

France offshore outlook, 2020-2030e



Source: GWEC Market Intelligence, June 2020

Part 3. Exploring new markets

World Bank Group – Offshore Wind Development Program

Background

The World Bank Group (WBG) launched a new global initiative on offshore wind in March 2019. The Offshore Wind Development Program is being funded and led by the Energy Sector Management Assistance Program (ESMAP) in close partnership with the International Finance Corporation (IFC, the private sector arm of WBG). GWEC collaborates with WBG on execution of key elements of this initiative.

Core funding was received from the UK Department for Business, Energy and Industrial Strategy (BEIS). Additional funding has been sourced and further funds are expected across the 5 year duration of the program.

The objective is to support the inclusion of offshore wind into the

energy sector policies and strategies of WBG client countries and support the work needed to build a pipeline of bankable projects. Key activities include conferences and study tours, knowledge creation, capacity building, strategic country roadmap studies and technical assistance.

Conference and Study Tours

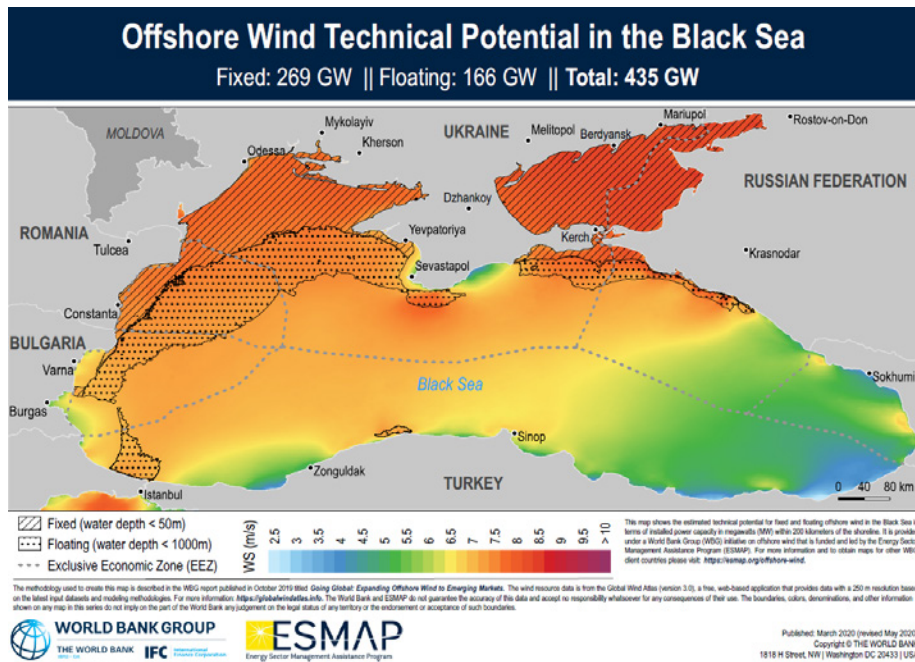
UK Study Tour, June 2019

- GWEC organised a week-long study tour to the UK, attracting delegates from 12 WBG client countries. The week started with a private conference at BEIS, followed by a day at the Global Offshore Wind conference. The delegation was then taken up to NE England to see various offshore wind activities including research, manufacturing, ports and a training facility.



Virtual Study Tour, September 2020

- For 2020 WBG has chosen to move to a virtual event and, again, GWEC is leading the organisation. The virtual approach gives certain advantages; more delegates



can attend, more locations can be “visited” across multiple geographies and all with a dramatic reduction in carbon footprint.

Knowledge Creation

The first report from the program was released in Oct 2019, entitled “Going Global: Expanding Offshore Wind To Emerging Markets”. The report gives a general background on the offshore wind market, the dramatic fall in prices and lessons learned. It provides an estimate of the offshore wind technical resource potential in 8 developing countries, including India, Vietnam, South Africa, Brazil and Turkey. The report concludes that the resource is massive and emerging markets are well placed to benefit from growth of the offshore wind sector.

The second knowledge output has been the preparation of 48 maps of WBG client countries and regions (see example above) which have an offshore wind resource. The total

technical resource potential estimated across these 48 markets is 15.6 TW.

Countries Engaged

- Following the UK Study Tour a number of countries have asked for technical assistance on offshore wind, including:
- Vietnam, where a roadmap study is nearing completion and a draft report is with the Ministry of Industry and Trade for consultation across government.
- Turkey and Sri Lanka, where roadmap studies are being commissioned in Summer 2020
- Brazil, where a virtual event with stakeholders and government is planned for July 2020.
- Ongoing engagements with governments in India, South Africa, Colombia, Azerbaijan, Philippines, Nicaragua and others.

For further information see
<https://esmap.org/offshore-wind>

Exploring New Markets

From the perspective of GWEC Market Intelligence, it is important to highlight the potential development for offshore wind in newer markets. Even if actual installations will not happen immediately. The five selected markets, Ireland, Poland, Estonia, India, Australia, are representative of markets with high offshore wind potential but varying political support and targets to date. Still, in all five markets there is an increasing awareness that offshore wind can provide an at scale, cost-competitive and efficient solution for these countries.

GWEC Market Intelligence is monitoring activities in 46 markets on a regular basis to document the opportunities and progress of taking offshore wind global.



Country	Development stage	Political support	Challenge	Next milestone
Ireland	Pre-approval of 7 offshore wind projects by government, totalling 3.5 GW, awaits auction in 2021.	Strong and clear support for offshore wind on the Programme for Government ("PfG"), published in mid of June by Ireland's prospective new government, with policy targets to include 5 GW of offshore wind off the Eastern and Southern coasts by 2030 and an assessment of the potential for 30 GW of floating Atlantic offshore wind, coupled with commitments to hold the first offshore wind auction in 2021, developed an Options Paper on offshore grid models and the enactment of the Marine Planning and Development Bill within 9 months (presumably from Government formation).	Strategic investment to build an indigenous and economically sustainable local supply chain including improving port infrastructure.	Steps need to be taken to grow the local supply chain, currently, no port in Ireland meets all the requirements for offshore wind projects.
Poland	Up to 5.9 GW (instead of 4.6 GW announced in Jan 2020) in projects would be granted a fixed CfD support by end of 2021 and another 2.5 GW each in 2025 and 2027 to be tendered off in competitive CfD auctions.	10 GW of offshore wind envisaged to be built by 2040 that could generate 25% of Poland's energy according to Energy Policy of Poland until 2040 (EPP 2040).	Depends on strengthening and modernising Poland's transmission network, especially in the north.	Await the regulatory frameworks for permitting, tendering and development to be finalised so as to kickstart the industry with international financing entering.
Estonia	Initiated the construction permit approval process for Eesti Energia's 1 GW offshore wind project in the Gulf of Riga, together with Latvia.	Renewable energy to account for 50% (currently, at 30%) of final consumption of domestic electricity by 2030 as announced in Estonian Energy Development Plan (ENMAK 2030).	Strengthen Estonian-Latvian cooperation in marine spatial planning of joint wind farms, in attempt to avoid past halted offshore projects due to national security concerns.	Estonia and Latvia work to develop guidelines for a collaborative project and have companies' part of the discussion to intensify the cooperation for projects to come online.
India	Nearly 70 GW potential area has been earmarked for offshore wind development, however the tender for the first 1 GW offshore wind project in the Gulf of Khambhat (Gujarat) has been delayed, attention has now turned to the stronger wind resource area off Tamil Nadu.	India had announced a national target to have 5 GW installed capacity by 2022 and 30 GW by 2030, the first target is now not feasible and the second would require a rapid deployment.	Offshore wind in India is expected to compete with cheaper land-based renewables and it has stalled the market.	Proper plans for the tender of the first projects, possibly beginning with a demonstration scale project.
Australia	Progress continues on Australia's ground-breaking 2.2 GW Star of the South offshore wind energy farm, with contracts signed for the design of the project's onshore transmission network and grid connection.	At the start of the year, a plan for an offshore clean energy bill was issued by the Department of the Environment and Energy. Once implemented, the framework will fill an existing regulatory and legislative gap that can kick-start a viable offshore clean energy industry in Australia.	Patchy track record on general support and policy measures to back renewable energy generation, especially with respect to long-term certainty for measures such as its Feed-in-Tariff scheme.	Policy formation.

OFFSHORE WIND TECHNOLOGIES



Courtesy of Principle Power. Artist name: Dock90

Next Generation of Offshore Wind Turbine Technology

When the world's first offshore wind farm, Vindeby, was installed in Denmark in 1991, the turbine size was only 450kW (Bonus B35). Since then, the offshore wind turbine size has grown significantly with the global average offshore wind turbine size reaching 1.5 MW in 2000 and 6.5 MW in 2018. In Europe, the average turbine size for new installations in 2019 is even higher, 7.2 MW.

GE Renewable Energy launched its Haliade X 12 MW DD turbine in 2018 with the first prototype installed in Rotterdam for onshore testing from November 2019. When the Haliade X, which was the world's largest offshore wind turbine model at the time, was released, the company stated that 12 MW was not the end, it was the beginning and will get bigger. This was proven true when its competitor, the world's largest offshore wind turbine supplier in total installations, Siemens Gamesa, released its SG14-222 DD model in May 2020. This new

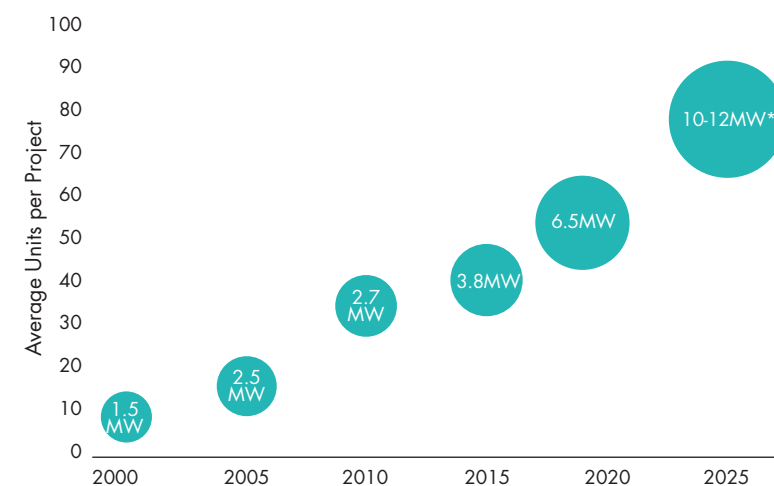
turbine which can reach 15 MW with Power Boost will be commercially available from 2024.

The increase of offshore wind turbine size has been driven primarily by the goal of reducing the levelized cost of wind energy (LCOE). When the bigger offshore turbine is released with a higher nameplate capacity, rotor diameter and tower height, the technical capacity factors are higher, which in turn increases the annual energy production (AEP).

Although larger turbines per unit are more costly than smaller ones, it saves the CAPEX for foundations, cables and installation as well as the OPEX due to lower turbine units.

With offshore wind power developed from a costly alternative to a competitive source of energy, it is expected to play a big role in the global energy transition, helping countries to reach their committed

Evolution of Offshore wind turbine and project size



* Expected average turbine size in markets outside China where average size is likely to be 7-8 MW
Source: GWEC Market Intelligence, June 2020

climate change targets. However, with wind power penetrations increased, challenges are imposed on the electricity grid due to the characteristics of wind. A new study by Berkeley Lab, however, shows that in addition to the reduction in

levelized costs, significant increases in wind turbine size can, in fact, enhance the value of wind energy to the electricity system and provide other 'hidden' benefits including reduced transmission expenditure (due to greater transmission utilization), lower balancing costs for the electricity system (due to lower aggregate wind output variability), and lower financing costs (due to less

long-term wind output uncertainty). Considering the system benefit provided by supersized offshore turbines as well as the increasing pressure for offshore wind to reach grid parity, GWEC Market Intelligence believes that the offshore wind turbine size will continue to grow if wind energy is to reach its full potential. The offshore wind technology road maps in both Europe

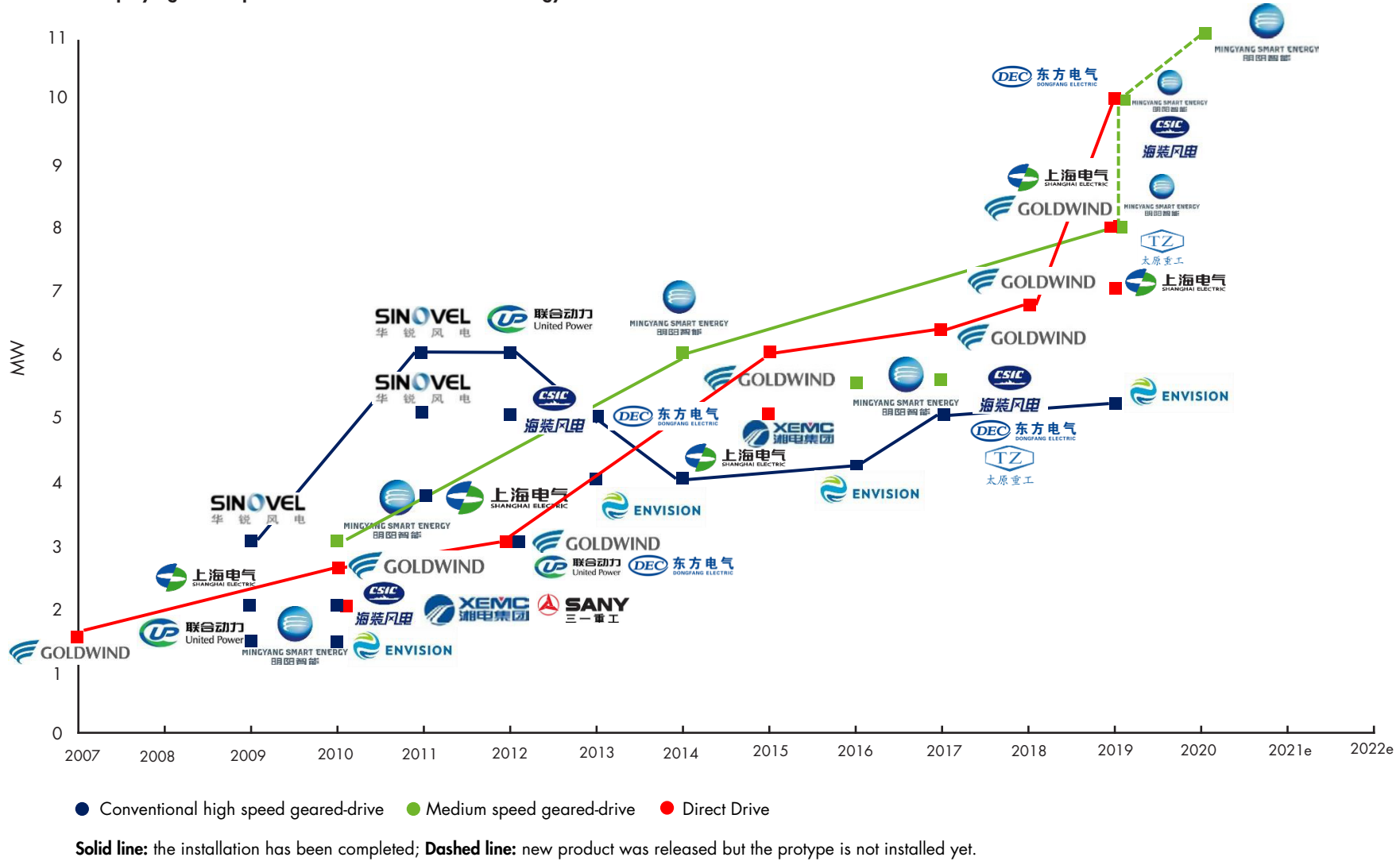
and China (see figures on page 81-82) also illustrate such trends.

Our offshore wind ambassador and the offshore wind pioneer Henrik Stiesdal predicted in GWEC's recent Global Offshore Wind Technology webinar that the next generation of offshore turbine technology could probably be around 20 MW with a 275m rotor diameter by 2030.

However, at what point the future offshore turbine size will plateau will be determined by factors such as continued turbine technology innovations, drive-train optimization, alternative materials, regulatory barriers, and logistical constraints for both transportation and installation.



China is playing catch-up in Offshore Wind Turbine Technology



Source: GWEC Market Intelligence, June 2020

Floating Offshore Wind Technologies

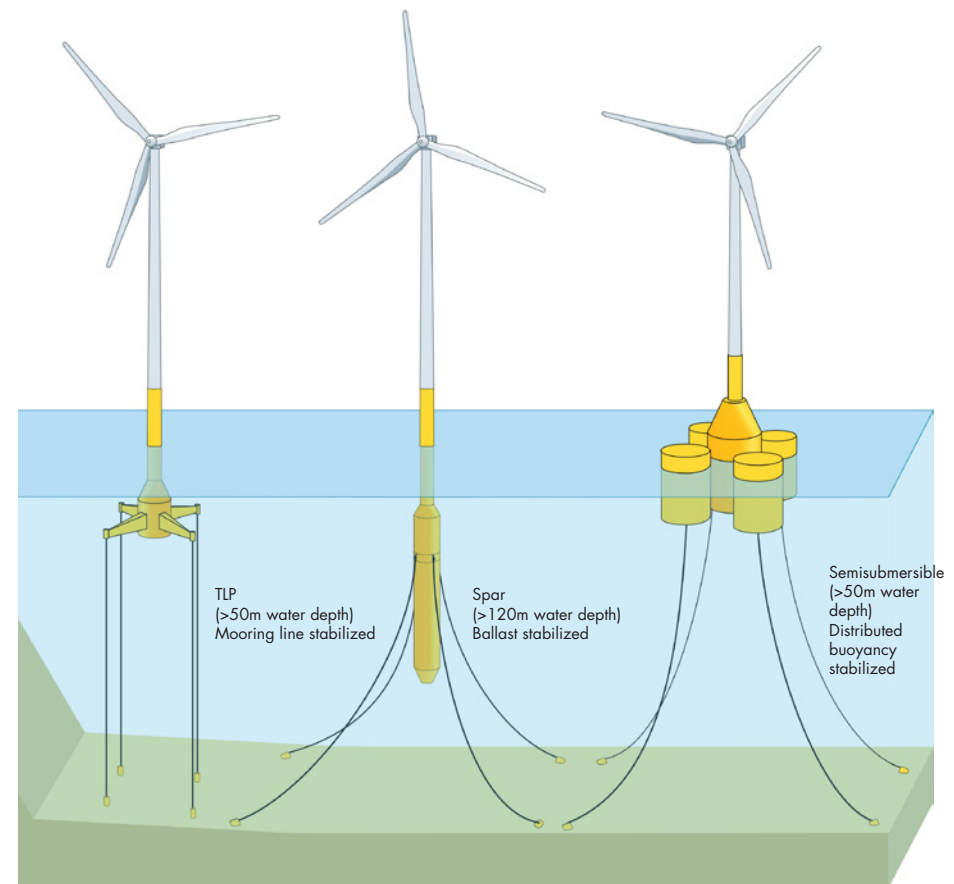
Offshore wind has enormous potential and is expected to play a big role in future energy mix. However, 80% of the world's offshore wind resource potential lies in waters deeper than 60m^[1]. To fully harvest the global offshore wind potential and expedite the energy transition and maintain a 1.5°C pathway in line with IPCC recommendation, it has become imperative for the wind industry to quickly commercialise floating offshore wind technology (FOWT). As well as providing even better wind resources and larger technical potential than bottom-fixed offshore wind, floating wind could help create socio-economic benefits such as jobs and facilitate a smooth energy transition by bringing expertise from the Oil and Gas (O&G) industry into offshore wind while re-skilling workers who may be dislocated from the fossil fuel sectors

Northern Europe, the US and the east coast of China have maximum nearshore water depths of 30-50m favourable for bottom-fixed offshore wind. The best resources for floating wind are located in Europe, Japan, South Korea, Taiwan, off the west coast of the US and off the south coast of China (see map on page 10).

Floating wind technologies

Beginning with the early floating offshore wind turbine concept in the 1970's, the first small scale tests in the 1990's and the first MW-scale installation in the 2000s, the offshore industry connected the world's first commercial floating offshore wind project, the Hywind Scotland (with a single floating cylindrical spar structure), in the UK in 2017 and commissioned the world largest offshore wind turbine, MHI Vestas V164-8.4MW model, in Portugal in 2019.

Floating offshore wind platform types



Source: Aqua-RET

[1] NREL, EIC Global Offshore Wind Report 2019: Norwep, Equinor, internal analysis

The benefits and challenges associated with three basic floater concepts

Spar	Semisubmersible	TLP
<p>Overview:</p> <ul style="list-style-type: none"> • Simplest concept and attractive dynamics • Minimum depth 80m during whole installation process • Achieves stability through ballast installed below its main buoyancy tank • Complex manufacturing and Weight for 6 MW: ~3.500 t 	<p>Overview:</p> <ul style="list-style-type: none"> • Most popular concept and less attractive dynamics • Typically requires moveable water ballast to limit tilt • Requires dry dock for fabrication • Achieves static stability by distributing buoyancy widely at the water plane • Weight for 6 MW: ~3.000 t 	<p>Overview:</p> <ul style="list-style-type: none"> • Attractive dynamics but not widely deployed • Achieves static stability through mooring line tension with a submerged buoyancy tank • Typically requires purpose-built installation vessel • Weight for 6 MW: ~2.000 t
<p>Benefits:</p> <ul style="list-style-type: none"> • Inherent stability • Suitable for even higher sea states • Soil condition insensitivity • Cheap & simple mooring & anchoring system • Simple fabrication process • Low operational risk • Little susceptible to corrosion 	<p>Benefits:</p> <ul style="list-style-type: none"> • Heave plates for reducing heave response • Broad weather window for installation • Depth independence • Soil condition insensitivity • Cheap & simple mooring & anchoring system; Overall lower risk • Simple installation & decommissioning as specialized vessel required 	<p>Benefits:</p> <ul style="list-style-type: none"> • High stability, low motions • Having a good water-depth flexibility • Small seabed footprint and Short mooring lines • Simple & light structure, easy for O&M • Lower material costs due to structural weight of the substructure • Onshore or dry dock assembly possible
<p>Challenges:</p> <ul style="list-style-type: none"> • High cost, 5-8 mEUR/MW (based on the 30 MW demo); • Heavy weight, with long mooring lines and long & heavy structure • Deep drafts limit port access and Large seabed footprint • Relatively large motions • Assembly in sheltered deep water challenging and time-consuming • High fatigue loads in tower base • Specialised installation vessels needed 	<p>Challenges:</p> <ul style="list-style-type: none"> • Non-industrialized fabrication • Higher exposure to waves leads to lower stability and impacts on turbine • Labour intensive and long lead time • Large and complex structure, so complicated in fabrication • Foundation always built in one piece, requiring dry dock or special fabrication yard with skid facilities • Lateral movement presents potential problems for the export cable 	<p>Challenges:</p> <ul style="list-style-type: none"> • Unstable during assembly, requiring the use of special vessel • High vertical load moorings • Complex & costly mooring & anchoring system making it the most expensive floater design type • Mooring tendons presenting higher operational risk in case of mooring failure and add requirements on site seabed conditions

Source: Stiesdal AIS, NREL, DNVGL, Carbon Trust, IRENA

There are three basic floating base types^[2] which are mainly derived from oil and gas experience namely, Deep-water floating Spar, Semisubmersible and Tension-leg platform (TLP). Associated benefits and challenges of the basic floaters are presented in table below.

In the past, the deep-water floating spar was most used in floating pedestals, but the development of the semi-submersible floating base has gained popularity. According to GWEC Market Intelligence's global floating offshore wind database, cumulatively 15 floating projects will come into operation by the end of 2020, of which ten (67%) use the semi-submersible floater, and five use Spar (33%). The [study](#) completed by University of Strathclyde Glasgow, DNV.GL and other two organizations in 2019 also predicts the semi-submersible floater to be the market leader with a share of about 62% by 2022. Although TLP has better flexibility in shallower and deeper waters; its current market share is relatively lower due to complex installation and needs a cost reduction strategy for mooring installation. Moving forward, offshore wind

experts expect that the direction of floating base development will be to design a common floating platform that can host several types of a turbines, combined with hybrid renewable energy sources such as wave, solar and Power to X generation.

Current status of commercialization

Although different floating technologies have been tested through demonstration and pilot projects in the past decades, current floater production is not industrialised yet and has just entered the pre-commercial phase. However, according to GWEC Market Intelligence's global offshore floating wind project database (see table 2), floating wind installations are likely to take off from 2025 (when four 150-200 MW floating projects will be online) and full commercialisation is expected to be achieved by the end of this decade (when GW-level large scale floating projects could be connected in both Europe and East Asia).

Our projection for the commercialisation of floating wind

[2] Barge is also mentioned as a floating type in other studies, but not widely deployed so far due to heavy structure (concrete) and weight.



Global Floating Offshore Wind Project Pipeline

Operational Projects (Demonstration and trial phase)	Projects under Construction or plan to be built by 2025 (Pre-commercial phase)	Projects announced in developing partnerships or auctions and to be operational by 2030 (Commercial phase)
Hywind Demo, Norway (2.3 MW)- 2009	EolMed project, France (24.8 MW)- 2021	JERA, ademe and Ideol project (2000 MW)- Japan
WindFloat 1 Prototype, Portugal (2 MW)- 2011	Provence Grand Large floating, France (25.2 MW)- 2021	Equinor & KNOC floating projects (800MW)-South Korea
Kabashima Floating, Japan (2 MW)- 2013	DemoSATH, Spain (2 MW)- 2021	Ulsan 1GW floating (1000 MW)- South Korea
Fukushima FORWARD, Japan (2 MW)- 2013	Hywind Tampen, Norway (88 MW)- 2022	Equinor floating project (300 MW)- Greece
Fukushima FORWARD, Japan (7 MW)- 2016	Atlantic Marine Energy Test Site, Ireland (30MW)- 2022	FLAGSHIP Iberdrola (10 MW)- Norway
Hywind Scotland, UK (30 MW)- 2017	Les Éoliennes Flottantes du Golfe du Lion, France (30 MW)- 2023	Erebus demonstration (TOTAL) project (96 MW)- UK
Floatgen, France (2 MW)- 2017	Groix Belle Ile wind farm, France (28.5 MW)- 2023	Parque Eólico Gofio (50 MW)- Spain
Fukushima FORWARD, Japan (5 MW)- 2017	CTG first floating tender, China (10 MW)- 2022	Industry proposed floating projects (1000 MW)- Norway
Kincardine, UK (2 MW testing)- 2018	Aqua Ventus, USA (12 MW)- 2023	Celtic Sea Floating (1000 MW)- The UK
Hibikinada KitaKyushu Demo, Japan (3 MW)- 2019	Goto (GCS) Floating, Japan (21MW)- 2023	French floating auctions (750MW)- France
PLOCAN's Test Site, Spain (0.2 MW)- 2019	Celtic Sea Floating, UK (32MW)- 2024	
WindFloat Atlantic, Portugal (25.2 MW)- 2020	Equinor floating Canary Islands, Spain (200 MW)- 2025	
Nezzy2 Floating, Germany (testing-1.5 MW)- 2020	Donghae 1, South Korea (200 MW)- 2024	
Kincardine, UK (48MW)- 2020	Redwood Coast offshore wind project, USA (150 MW)	
TetraSpar Demo, Norway (3.6 MW)- 2020e	Sicilian Channel TetraSpar floating project, Italy (250MW)- 2025	

Source: GWEC Market Intelligence, June 2020

could also be justified by recent commitments and partnerships made primarily by oil majors, large European utilities and technology providers in the past 18 months. Selected activities in this business segment by three groups are summarised below:

Oil majors

Equinor, a pioneer in floating wind, was recently joined by other oil majors, such as Shell and Total, to start working in partnership with the utilities/developer in the floating offshore wind business segment. Aside from the Hywind Tampen project in North Sea to be built by 2022, Equinor plans to develop floating wind projects in Spain, Greece and South Korea. Through the partnership with Korea National Oil Corporation (KNOC), Equinor recently commenced LiDAR installations to conduct metocean data measurements for a potential 800 MW floating offshore wind project in South Korea. In early 2019, **Shell** joined seven other partners and signed a Memorandum of Understanding (MOU) with the City of Ulsan in South Korea to explore large-scale floating offshore wind development. Shell

also took over EOLFI, a pure-play French floating wind developer, to enhance its existing expertise in the floating wind section at the end of that year. Following a partnership established with Simply Blue Energy in March 2020 to develop a 96 MW floating project in the Celtic Sea, UK, the French oil major **Total** joined Offshore Renewable Energy (ORE) Catapult's national Floating Offshore Wind Centre of Excellence (FOWCoE) together with Shell, Equinor and other seven offshore wind developers in summer 2020.

Utilities and large developers

Following a commitment made in 2018 through Innogy to build the TetraSpar demonstration project with Shell in Norway, **RWE Renewables** has recently set up a joint pilot project DemoSATH with Spanish Saitec Offshore Technologies to start testing it offshore the Basque Coast in Spain where the Spanish **Iberdrola** decided to step into the floating wind business sector as well. The utility is now leading a consortium aiming to test a 10+ MW floating turbine at the FLAGSHIP project in Norway and also plans to deploy another floating wind power prototype in Spain. In France, French utility **EDF** has

been supporting the development of floating technology and will soon install the 25 MW Provence Grand floating project in the Mediterranean. In Germany, utilities **EnBW** joined forces with Aerodyn to accelerate the commercial development of the radical 15MW Nezzzy2 twin-rotor offshore floater. In Spain, through the offshore wind joint-venture created in 2019, European utilities **EDP** and **Engie** are also interested in floating wind. In China, **CTG** announced the plan to launch its first floating offshore tender for a pilot project off Guangdong province in 2021 and **CGN** also invested in Eolfi's 24 MW floating project in France.

Technology providers

There is a long list of technology providers who are active in the floating wind sector, some of whom focus purely on floating design. Those who have already installed floating turbines include Principle Power and IDEOL and those who are installing or are ready to install a floating turbine project include Stiesdal OT, Saitec, Naval Energies, Olav Olsen, Saipem and SBM Offshore. In 2020, two French floater designers expanded their business development out

of Europe. Aside from exploring opportunities in Europe, the France-based pure floating foundations player Ideol signed a MOU with Kerogen Capital in May 2020 to assess the benefits of using offshore wind to power oil & gas platforms in South Korea. Additionally, Naval Energies, a sub-system engineering firm with floating project already locked in France, signed a MOU with Japanese partner Hitachi Zosen to extend their collaboration after completing a floating wind technology feasibility study in Japan in June 2020. In the same month, the company also joined the Offshore Wind California coalition, which gathers offshore wind developers and technology companies supporting a goal of 10 GW of installed offshore wind capacity in California by 2040.

Challenges for floating offshore wind development

As presented in Market Outlook section, GWEC Market Intelligence predicts a total of 6.5 GW floating offshore wind projects to be built by 2030. To reach this level of installations, however, the following challenges and barriers need to be addressed through a cross-industry approach and collaboration.



- Floating wind energy cost is high, almost double the cost of fixed bottom offshore wind energy.
- According to Carbon Trust, there are around 40 different floating wind concepts at various stages of development, this prevents the floating offshore wind from reaching the standardisation and industrialisation.
- The right policy frameworks tailor-made to support floating are in general missing in most markets, which is a barrier for getting the private sector engaged and also increases financial cost compared with bottom-fixed solution due to a lower level of technology readiness.

In order to address these barriers and provide best practices to this fast-moving offshore wind sector, GWEC launched a [Floating Offshore Wind Task Force](#) with key global industry players on 7 July 2020. GWEC Market Intelligence believes that floating offshore wind is at a critical turning point and it will succeed if prioritisation can be made in the following areas:

- Making floaters commercially viable as standardised foundation solution, rather than a sub-sector of offshore wind. This can be done through adaptation of an optimised engineering approach together with market consolidation in floater design.
- Achieving cost reduction through standardisation, modularisation, increase of technology readiness level, lowering cost of project finance and economy of scale.
- Coordination amongst the leading market players via strategic partnerships and sharing experiences from pioneer markets such as Norway, UK, Portugal, France and Japan with emerging floating markets such as South Korea, Spain, Greece, Ireland, Italy and the US.
- Strong policy obligations with long term visibility, such as 2030, 2040 and even 2050 floating wind targets.
- Making floating wind a part of global green recovery strategy with dedicated funding for both floating projects and infrastructure.
- Favourable regulatory frameworks and support schemes tailor-made for floating wind to reduce investment risk and attract investment from private and institutional investors.
- Cross industry collaboration, especially O&G and Power-to-X, needs to be addressed and developed for commercialisation of the FOW sector and to achieve cost reduction.

Power-to-X

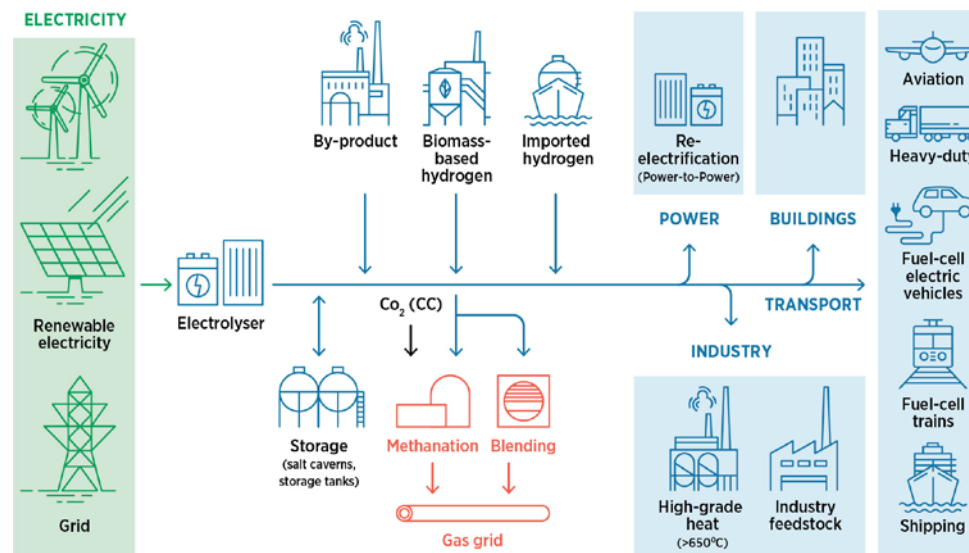
Power-to-X - the missing puzzle piece of the global energy transition

As the world races against time to fight climate change, there is a growing consensus that Power-to-X (PtX) could be the solution to help decarbonise some of the most fossil fuel dependent sectors such as heating, transport and industrial processes such as steel and iron making. Power-to-X refers to the conversion of surplus renewable energy into liquid or gaseous chemical energy sources through electrolysis and further synthesis processes. Continued advancements in Power-to-X technology and falling offshore wind costs, along with anticipated changes in policy, suggest that this combination could constitute an emerging economically viable business model.

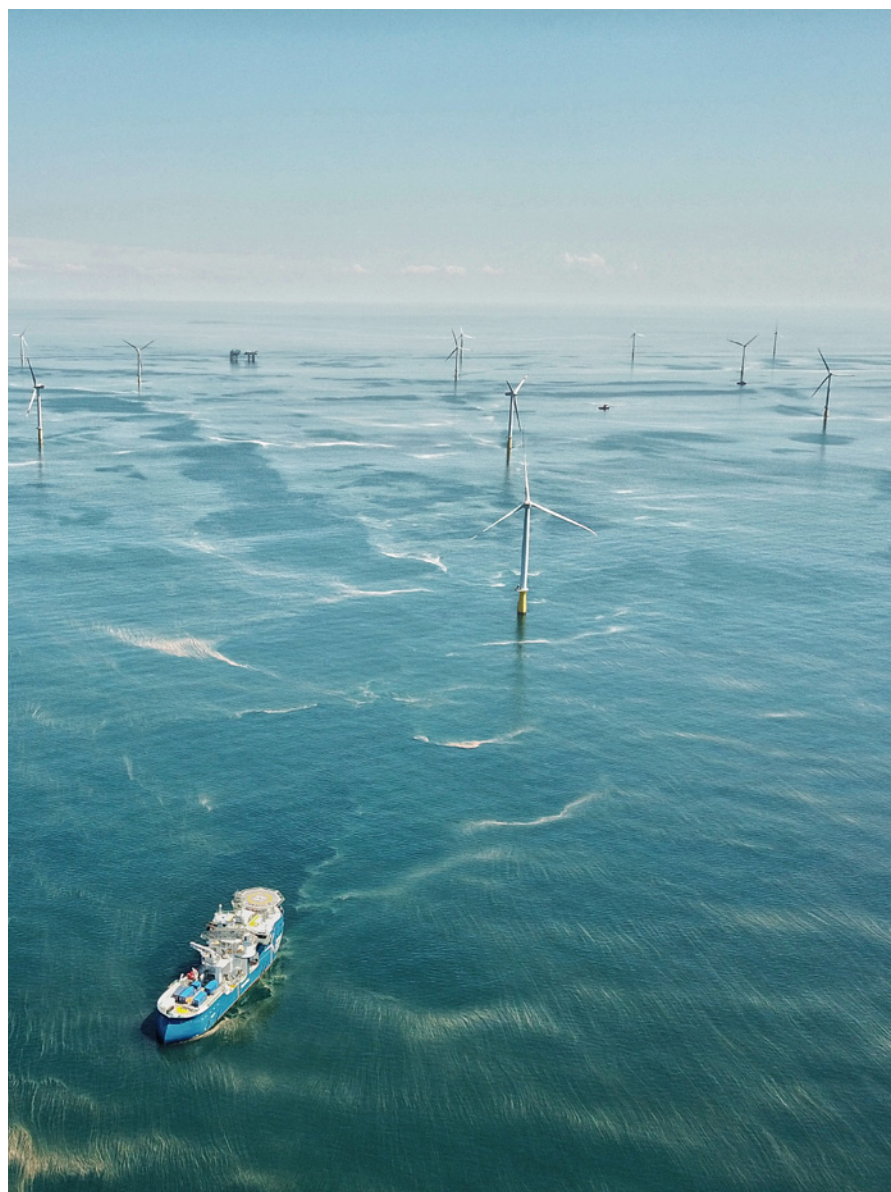
Offering further market growth opportunity for offshore wind

Power-to-X is one of the most promising storage options for offshore wind that minimises waste and maximises efficiency by deploying stored power for a myriad of uses. Stored electricity can be electrolysed into hydrogen to be used as feedstock to produce bulk chemicals like methanol or ammonia for industrial processes (a concept known as power-to-gas or power-to-chemicals) or combined with captured CO₂ to make carbon-neutral liquid fuels such as crude, gasoline, diesel and aviation fuels (power-to-liquid fuels). It can also generate heat through heat pumps or electric boilers for houses and factories (power-to-heat). Or it can be stored in underground formations like salt domes and fed back to the grid when needed.

Power-to-X : Integration of renewable energy into end-uses



Source: IRENA, 2018d.



Power-to-X is one of the critical components to reach power systems based on 100% renewable energy sources for its ability to increase reliability and quality of demand-side power management, energy independence, and climate change targets. In addition, PtX internalises the cost of the positive externalities with the potential for offsetting investments elsewhere such as in transmission networks or energy storage. As system balancing costs and risk to the electricity suppliers would be reduced, this provides a route to affordable hydrogen that is also a desirable investment.

Capital cost is high but expected to fall when scale is achieved coupled with government incentivisation

The technology itself has already proven to be technically feasible, however, success now lies on the economic performance and hence the willingness to invest in Power-to-X technologies. Prices are set to fall just as with offshore wind power, from the current US\$2.50 to US\$6.8 per kilogram^[1] for the high-cost renewables powered electrolysis

process to US\$0.8 to \$1.6/kg in most parts of the world before 2050^[2], making it price-competitive with its fossil fuel substitutes.

Nonetheless, this technology is now limited by the scale of projects, making it too expensive to be widely deployed at this stage. But the industry is primed to take the next step, so it's just a matter of "when".

The most economically competitive option: offshore wind-to-hydrogen

With electrolyzers just in their infancy and still expensive, the potential for cost reductions is enormous. Of all the renewable electricity options, wind has the highest potential to produce sustainable hydrogen because of its economic competitiveness - the price of wind turbines fell by 67.5% between 2012 and 2020^[3].

As the best wind resources are out at sea or in rural areas, Power-to-X complements offshore wind perfectly. It aids the integration of more offshore wind by avoiding curtailment or constraint due to the lack of transmission capacity and decouples renewables power generation

[1] <https://www.bloomberg.com/professional/blog/how-green-hydrogen-could-make-green-steel-real/>

[2] <https://about.bnef.com/blog/hydrogen-economy-offers-promising-path-to-decarbonization/>

[3] BNEF LCOE Database Jan 2020

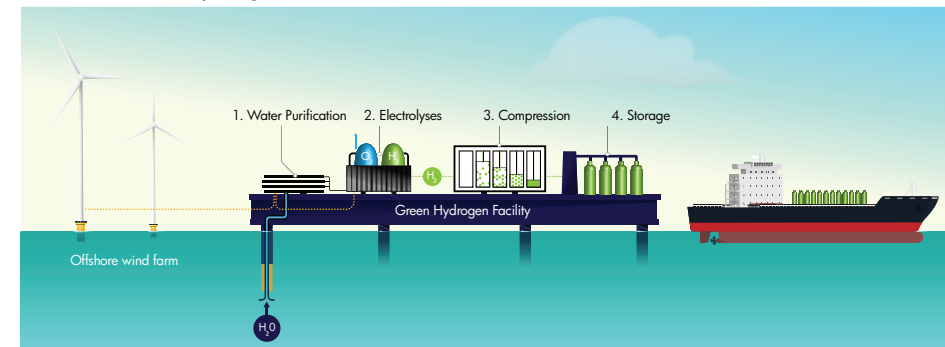
from demand. The hybrid solution brings about increasing flexibility of the power grid, greater energy security and lower price volatility. At present, there are two types of widely explored offshore wind-to-hydrogen solutions.

In the first offshore wind-to-hydrogen solution, surplus offshore wind energy that would otherwise be curtailed - or purpose-built offshore wind capacity for hydrogen generation - will power electrolyzers that split water molecules into hydrogen and oxygen. Green hydrogen is then compressed and stored in a tank system, waiting to be offloaded when energy is needed.

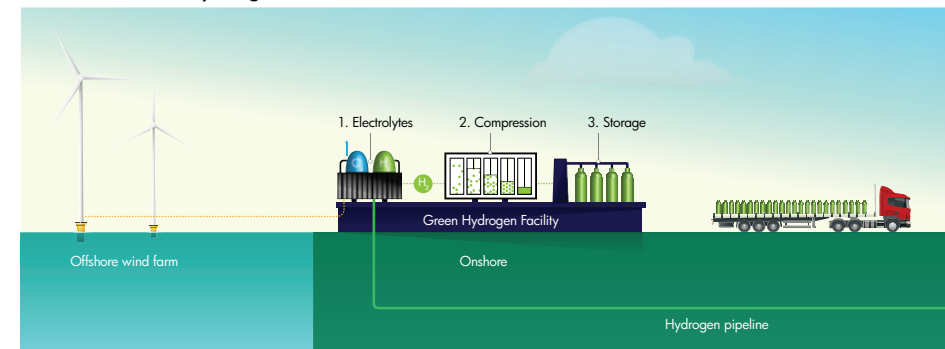
With an offshore hydrogenation platform available, liquid hydrogen (LH₂) can be converted to synthetic natural gas (SNG), better known as methane, before being shipped to end-users for multiple purposes. As shipping is a relatively expensive form of transportation, electrolyzers can also be deployed in coastal areas connected by HV subsea cables to substations to transport the green hydrogen directly with on-land hydrogen pipelines or by truck after compression.

Another innovative offshore wind-to-hydrogen solution aims at using excess offshore wind energy to power electrolyzers located on oil and gas platforms to produce green hydrogen from seawater. The green hydrogen is blended into the gas export line and transported to land via existing gas infrastructure. This solution is already widely used by industrial gas producers to supply chemical and refining industries. It is expected that up to 20% of hydrogen by volume can be mixed into existing gas pipeline flows. While blending green hydrogen into existing natural gas pipelines cannot achieve 100% decarbonisation, it can still be a contributing solution in the short term as the existing natural gas supply will continue to be used to balance power systems in the immediate future and blending green hydrogen helps to partially decarbonise this flow.

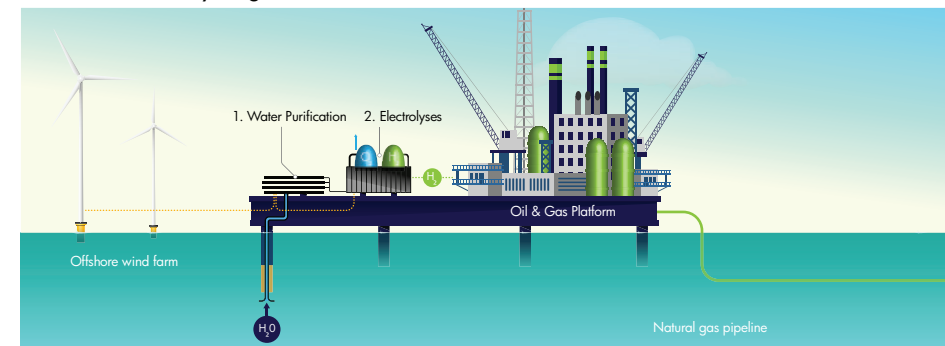
Offshore wind to hydrogen solution 1(a)



Offshore wind to hydrogen solution 1(b)



Offshore wind to hydrogen solution 2



Future of offshore wind to power-to-X economy

The unprecedented momentum around the world, coupled with Power-to-X, could finally accelerate global decarbonisation efforts towards 100% renewable energy as well as other benefits such as greater energy security, socioeconomic benefits and boosted economic activity. Offshore wind to Power-to-X could be a game-changer within this decade considering the falling hydrogen cost and pilot projects coming online. The two energy islands in the North and Baltic Seas (5 GW combined capacity), recently approved by the Danish government along with another 1 GW offshore wind farm are examples of how government can use offshore wind and Power-to-X as solutions to reach a net-zero commitment by 2050 and be a global leader by utilising cutting edge technologies while creating more green jobs. However, unlocking the benefits of a Power-to-X economy will require policy coordination across government, the right policy frameworks for private investment and subsidies over the next few decades, just as was done with renewables back in the early 2000s.



CONCLUSION



Offshore Wind: A Decade of Steep Growth Ahead

At the beginning of this new decade, offshore wind is in a dramatically different position compared to 10 years ago. Having multiplied from 1 GW of installations primarily in Europe in 2010, the offshore wind market is now primed to accelerate in markets around the world. Mainland China is set to lead in new capacity, while emerging markets in the Asia-Pacific region and North America are seeing increased momentum, with Europe expected to maintain steady growth. Through 2030, GWEC Market Intelligence forecasts more than 205 GW of new offshore wind capacity to be added globally.

This is a 15 GW upgrade from the previous business-as-usual outlook in the [Global Offshore Wind Report 2019](#) – buoyed by policy ambition, declining technology costs and international commitments to decarbonisation, offshore wind is increasingly viewed as a critical provider of large-scale, affordable

and zero-carbon energy. While the COVID-19 pandemic has impacted energy consumption and supply chains around the world, the offshore wind sector is expected to be largely shielded in the long term, due to longer project development timelines and increasing cost-competitiveness. Employment in offshore wind's diverse and highly skilled value chain offers a huge opportunity for governments to invest in the sector for green recovery.

As the offshore wind market matures, new areas of innovation will boost growth. Floating offshore wind shows enormous promise, with 66 MW already installed and significant investment from oil majors and leading wind developers. Floating technology will sail through the demonstration stage in the first half of the decade to achieve commercialisation by 2030, when GWEC Market Intelligence forecasts more than 6 GW installed in markets like South Korea, Japan, France, Norway and the UK.

Key takeaways

- 2019 was a year of record growth, with 6.1 GW of capacity added and cumulative global installations of 29.1 GW.
- Europe is the largest region for installations, but the market is primed to take off in the Asia-Pacific region, where Mainland China is the global leader in new capacity and markets like Taiwan, Vietnam, Japan and South Korea set to accelerate to 2030.
- More than 205 GW of new offshore wind capacity is forecast through 2030 – a 15 GW increase from last year's business-as-usual outlook.
- COVID-19 will not significantly impact the global outlook, due to longer project timelines and concentration of installations in the latter half of the decade.
- Floating offshore wind is an area of opportunity, set to reach commercialisation by 2030 with more than 6 GW installed globally.
- Turbine technology is also set to improve in both efficiency and resilience, resulting in LCOE reductions and increased adoption.
- Offshore wind can be a core pillar of the global energy transition, supported by Power-to-X solutions, public commitment to decarbonisation and widescale electrification.
- Industry must continue horizon-scanning for new areas of innovation, learning and improvement to accelerate offshore wind deployment.

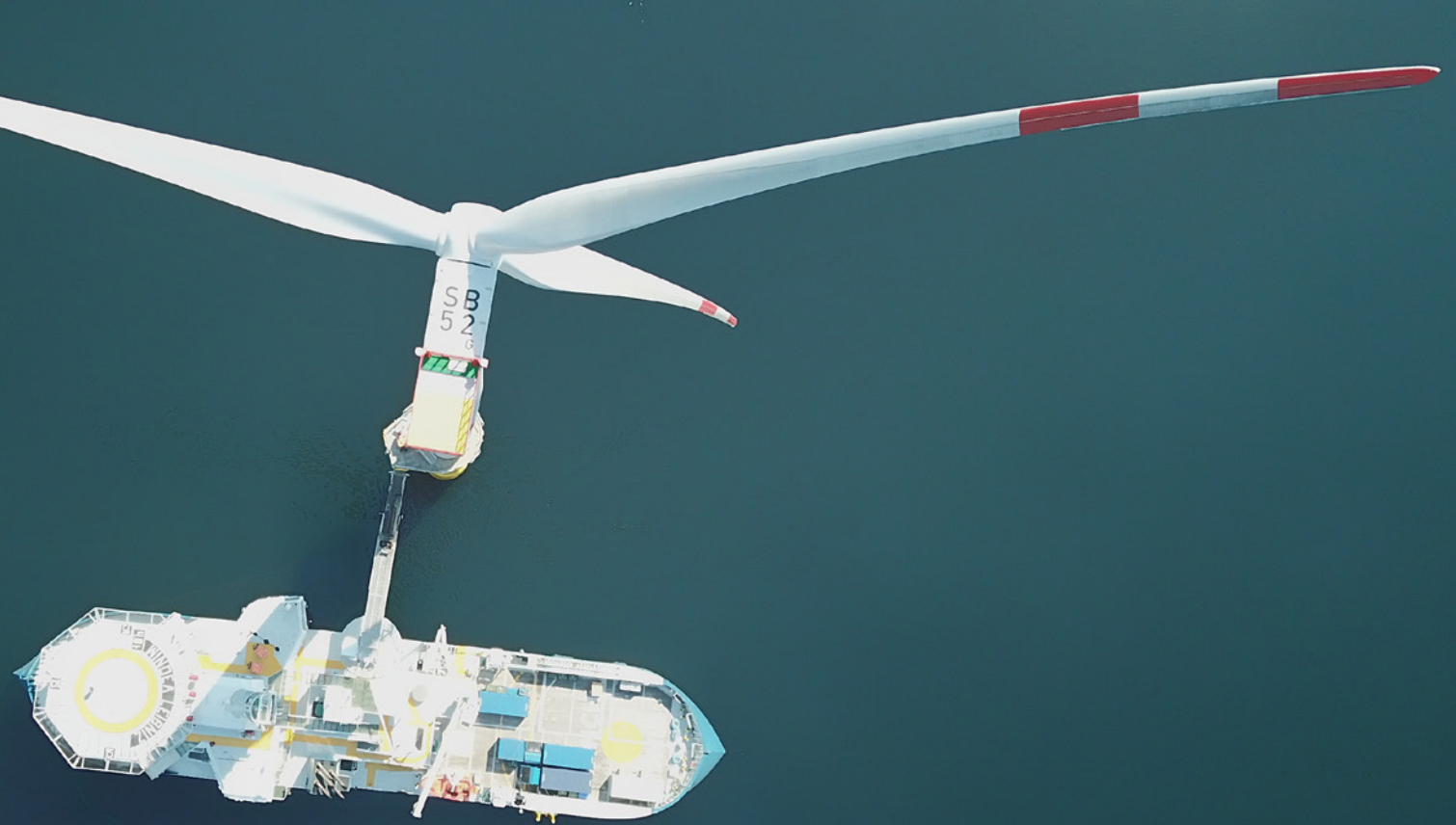
Turbine technology is another area to watch, with European and Chinese OEMs improving capacity and resilience to achieve LCOE reductions and application in a wider range of marine environments. The average size of installed turbines is on track to be 10-12 MW by 2025 – nearly double the size today. As hydrogen costs fall and cross-industry collaboration takes place, Power-to-X offers a potential solution to allow offshore wind to scale exponentially and support the decarbonisation of fossil fuel-dependent sectors.

These innovations, however, require adequate policy coordination and supportive frameworks, a formula which allowed renewables to take off over the last decade. As summarised in this report, there are already plenty of lessons to be gleaned from early offshore wind markets regarding support schemes, grid integration, cost reduction and industrial development. There are still further areas for R&D and investment, with GWEC and industry players continuing to scan the horizon for opportunities to innovate, learn and improve offshore wind in order to accelerate its deployment. Combined with steadfast commitment and collaboration with government, the

industry can build on these to deliver offshore wind's potential as a core pillar of the global energy transition.



APPENDIX



Abbreviation

BEIS	Business, Energy and Industrial Strategy	MoU	Memorandum of Understanding
BOEM	Bureau of Ocean Energy Management	MT	Metric Tons
CAPEX	Capital Expenditures	MW	Megawatt
CfD	Contract for Difference	NDRC	National Development and Reform Commission
COP	Construction and Operations Plan	NEA	National Energy Administration
DPP	Democratic Progressive Party	NREL	National Renewable Energy Laboratory
ESMAP	Energy Sector Management Assistance Program	O&M	Operation and Maintenance
FID	Final Investment Decision	OEMs	Original Equipment Manufacturers
FiT	Feed-in-Tariff	OFTO	Offshore Transmission Owners
FOW	Floating Offshore Wind	OPEX	Operating Expenses
FOWT	Floating Offshore Wind Technology	OREAC	Ocean Renewable Energy Action Coalition
GDP	Gross Domestic Product	PDP	Vietnam Power Development Plan
GW	Gigawatt	PPA	Power Purchase Agreement
GWO	Global Wind Organization	R&D	Research and Development
HVAC	High Voltage Alternate Current	RD&D	Research, Development and Demonstration
HVDC	High Voltage Direct Current	ROC	Renewables Obligation Certificate
IRENA	The International Renewable Energy Agency	SGRE	Siemens Gamesa Renewable Energy
JWPA	Japan Wind Power Association	SMEs	Small Medium Enterprises
LCOE	Levelized Cost of Energy	TSO	Transmission System Operators
LCRs	Local Content Requirements	TW	Terawatt
METI	Ministry of Economy Trade and Industry		
MLIT	Ministry of Land, Infrastructure, Transport and Tourism		
MOEA	Ministry of Economic Affairs		
MOIT	Ministry of Industry and Trade		

About GWEC Market Intelligence

GWEC Market Intelligence provides a series of insights and data-based analysis on the development of the wind industry. This includes a market outlook, country profiles and policy updates, deep-dives on the offshore market among other insights.

GWEC Market Intelligence derives its insights from its own comprehensive databases, local knowledge and leading industry experts.

The intelligence team in GWEC consists of several strong experts with long-standing industry experience.

GWEC Market Intelligence collaborates with its regional and country member wind association as well as with its corporate members.

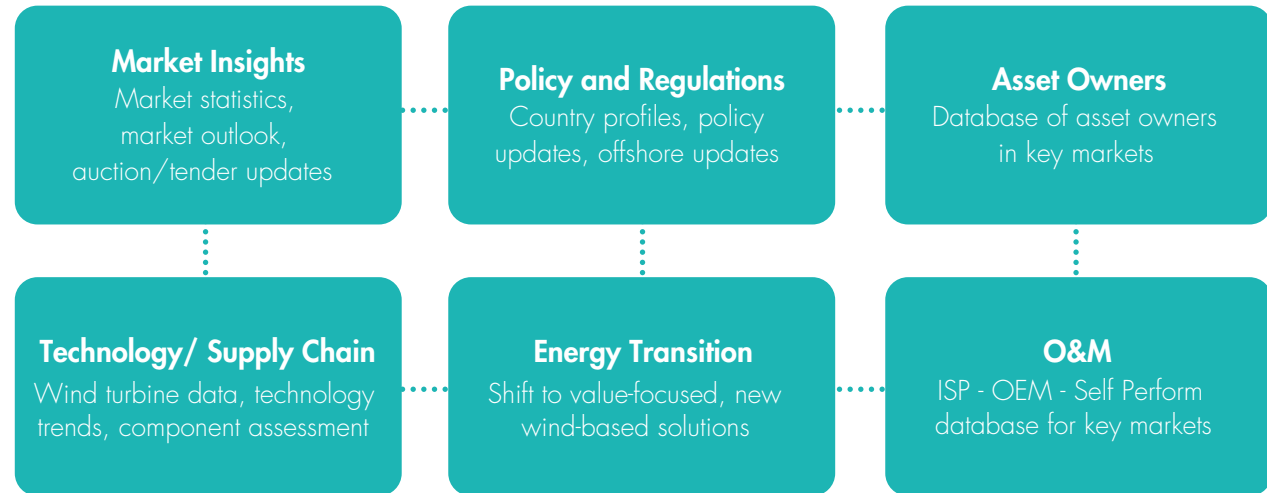
How to access GWEC Market Intelligence

- Corporate GWEC-Members
- Wind energy associations
- Non-GWEC Members

Subscription

Contact Feng Zhao feng.zhao@gwec.net

GWEC Market Intelligence Areas



GWEC Market Intelligence created a Member only area to provide more in-depth market intelligence to GWEC's members and their employees.

[Click here](#) to get your login

Reports	Frequency
1. Wind Energy Stats/Market Data	
Wind stats 2019 (and historic) Global Wind Report Wind Energy Statistics (wind energy penetration rate, jobs)	Annual Annual Annual
2. Country Profiles/Policy Updates	
Country Profiles Onshore/Country Profiles Offshore Ad-hoc policy updates	Quarterly/Ad-hoc Ad-hoc
3. Market Outlook	
Global Wind Market Outlook for next five years (Q1 and Q3)	Semi-Annual
4. Supply Side Data	
Global Wind Turbine Supply Side Data Report (by market, by technology, by turbine size and numbers)	Annual
5. Auction/ Tenders	
Auction Trends and Learnings Global Auction Results (database)	Annual/Quarterly Annual/Quarterly
6. Offshore Wind Market	
Global Offshore Wind Report Market Entry Opportunity (database) Global Offshore Project Pipeline (database, in-operation and under-construction) Global Offshore Turbine Installation Vessel Database	Annual/Quarterly Annual/Quarterly Annual/Quarterly Annual/Quarterly
7. Components Assessment	
Gearbox (Q4 2019), Blade (2020), followed by other components	Special report
8. Wind Asset Owners/ Operators	
Ranking of Wind Asset Owners and Operators Globally (Onshore & Offshore)	Annual
9. O&M	
O&M service provider database (ISP - OEM - Self-perfrom)	Annual
10. Energy transition, Digitalization, Hybrids	
Position papers/ studies - Value shift, Corporate PPAs Government support to wind and other ("true cost of coal") New Solutions, GWEC policy recommendations	Special report Special report Special report

Global Wind Energy Council

Rue Belliard 51-53,
1000 Brussels, Belgium
T. +32 490 56 81 39
info@gwec.net

 @GWECGlobalWind
 @Global Wind Energy Council (GWEC)
 @Global Wind Energy Council

www.gwec.net

