Allianz Commercial

A turning point for offshore wind

Global opportunities and risk trends

Foreword

2023 has been an historic year for the Earth's climate. July was the hottest recorded month in human history, and severe events, including wildfires blazing with ferocity and extreme flooding, have increasingly dominated the news as the devastating impacts are seen in Hawaii, Northern India, and São Paulo in Brazil. It has also been a pivotal moment for the energy transition, as the threat of climate change has loomed large, renewable energy usage has ramped up, geopolitical tensions continue, and governments have implemented far-reaching policies to reduce carbon emissions and diversify power sources.

Allianz is accelerating its activities to support the energy transition. We recently announced our first net-zero transition plan[1] with the goal of achieving net-zero emissions in our proprietary investment and Property & Casualty (P&C) underwriting portfolios by 2050. We are actively driving the transition towards renewable energy sources and have committed to achieving 150% profitable growth in revenues from renewables and low-carbon technology solutions in the commercial insurance segment by 2030 versus 2022. As an investor, Allianz is investing an additional €20bn in climate and clean-tech solutions, while within our own operations, we aim to be carbon-free by 2030.

Offshore wind will be integral to the energy transition, generating clean, renewable power in areas of the world's oceans that have vast untapped potential. With long-standing experience in legacy offshore activities, Allianz Commercial has amassed engineering and underwriting expertise that we are now applying to offshore wind developments across the globe. We are committed to the sector's expansion and supporting its development with significant underwriting and investment capacity, risk transfer solutions, and unlocking access to finance.

Allianz Commercial is insuring some of the most exciting offshore wind developments ever seen, projects that are breaking new ground in scale, ingenuity, and power potential. The insurance industry has a major role to play in supporting the growth of such trailblazing initiatives. Our underwriters and risk engineers are partnering with offshore wind clients to share their knowledge, exchange data, and develop bespoke insurance and risk consulting solutions. They collaborate continually to develop loss-control services that evolve with the sector's fast-changing technologies – and a changing climate.

As well as providing insurance, Allianz has been investing in renewables since 2005, including Hollandse Kust Zuid (HKZ) 1-4 wind farm in the Netherlands, which will produce enough energy to power over 1.5 million households, and the NeuConnect direct power link between Germany and the UK, a project for which we are also a lead insurer. We are keenly exploring promising ancillary innovations that are developing alongside offshore wind, such as green hydrogen and carbon-capture, and we are empowering innovation in the sector, with representation on the judging panel of the Energie Baden-Würtemburg (EnBW) and German Aerospace Center's exciting Offshore Drone Challenge.

The Natural Resources and Construction team at Allianz Commercial is aware that generating returns for our shareholders calls for careful underwriting and a keen understanding of the exposures we are taking on. By partnering with a willing client base and exchanging knowledge between all stakeholders, including governments, institutions, and between nations, we can ensure the turbines of the offshore wind industry keep turning in a cleaner, greener future.

This report celebrates the great strides already made by the industry, explores the challenges it faces as it prepares for growth, and discusses the emerging risks and hazards that must be mitigated as offshore wind rolls out to new territories across the world.

Anthony Vassallo, Global Head of Natural Resources, Allianz Commercial

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Introduction

Summer temperatures reached record or near-record levels in Europe, the US and Asia this year amid a climate of instability that has ensured concerns about energy security remain high.

With climate deadlines looming, the number of offshore wind installations is proliferating around the world as their potential to power the net-zero transition and bolster energy security is increasingly realized. With 8.8GW of new offshore wind capacity added to the grid last year, 2022 was the second highest year in history for offshore wind installations. Global installed offshore wind capacity at end 2022 reached 64.3GW, compared to just 5.4GW in 2012.

The Global Wind Energy Council (GWEC) expects 380GW of offshore wind capacity to be added across 32 markets over the next 10 years (2023-2032). Nearly half of that growth is expected to come from the Asia Pacific region, followed by Europe (41%), North America (9%), and Latin America (1%).[2]

Around 2,000GW of installed offshore wind capacity will be needed to limit global temperature rise to 1.5°C above pre-industrial levels, a key target of the 2015 Paris Agreement, and achieve net zero by 2050.[3]

As the climate crisis continues to intensify, the role of offshore wind and other renewable power sources in the world's power mix becomes increasingly urgent. In this report, we explore the full potential of offshore wind, discuss the emerging risks that could accompany its development, and explore some of the challenges facing the industry as it strives for deployment on a global scale.

Executive summary

Allianz Commercial's **A turning point for offshore wind** report identifies emerging trends and a number of risk challenges facing the sector as it prepares for global growth.

The climate crisis, carbon deadlines and geopolitical instability have galvanized investment in global offshore wind, with international governments committing to rollout in regions far beyond the traditional North Sea hub of the industry.

Last year, 8.8GW of new offshore wind capacity was added to the grid, making 2022 the second highest year in history for offshore wind installations. Global offshore wind capacity at end 2022 reached 64.3GW with China, the UK and Germany accounting for 84% of offshore wind installations. The Global Wind Energy Council (GWEC) expects 380GW of offshore wind capacity across 32 markets to be added over the next 10 years (2023-2032).

Global developments ↘ page 8

More than 99% of total global offshore wind installation is in Europe and Asia Pacific, but the US is investing heavily in the pipeline, directing federal funding to deploy 30GW of offshore wind by 2030 (enough to power 10 million homes), boosting the development of floating technologies, and supporting 77,000 jobs.

China has overtaken Europe as the world's biggest market, with half the world's offshore wind installations in 2023 expected to be in the country. China's operating offshore wind capacity has already reached 31.4GW – more than the whole of Europe's. India has set a target of 37GW by 2030, with South Korea targeting 12GW and Japan 10GW by 2030. Fledgling offshore wind projects are also poised for significant growth in Australia and Brazil.

Widescale deployment and the barriers to development ↘ page 16

The deployment of offshore wind at scale is an exciting prospect for the energy transition, potentially creating millions of jobs, but all is not plain sailing for developers and barriers remain. Spiraling costs have halted major wind projects in recent months and the industry is afflicted by inflation, capital expenses, rising interest rates and geopolitical instability. The costs of materials and vessel hire have risen with inflation and because of ever-larger wind turbines. Supply chain bottlenecks, lengthy permitting procedures, and delays to grid connections are also bringing pressure to bear.

A global rollout of offshore wind will require the expansion of manufacturing footprint, port facilities, and infrastructure. Supply chain diversification is likely to become a priority to strengthen local supply chains and avoid overreliance on certain markets, particularly China, which currently produces around 60% of onshore and offshore nacelles (the heart of a turbine that houses key mechanical and electrical equipment) and dominates the supply of gearboxes, generators, castings, towers, and flanges.

Multi-purpose wind farms and next-generation connectivity ↘ page 19

Novel approaches to offshore electricity transmission seek to optimize economies of scale, including 'energy islands', which share power between grids and nations, and multi-purpose wind farms that produce green hydrogen or house battery storage facilities.

Floating offshore wind comes of age

↘ page 21

Most offshore wind power at present is fixed-bottom and suitable for waters up to 60m (197 feet) deep. Given that 80% of offshore wind around the world blows over seawaters deeper than that and further away from shore, the rapid advance of floating wind technologies could open up access to vast expanses of deeper ocean with higher, more consistent, wind speeds away from the North Sea to the Pacific, the Atlantic, the Mediterranean and elsewhere. Countries beyond Europe are exploring the feasibility of floating offshore wind, including South Korea, Japan, China, Taiwan, Australia, as well as the US.

China, the UK and Germany accounted for

84%

of offshore wind installations at the end of 2022

380GW

of offshore wind capacity across 32 markets to be added over the next 10 years

As much as

53%

of offshore wind losses by value can be attributed to cable damage or failure

Offshore wind: risks, challenges and mitigation ↘ page 23

Both the energy sector and the insurance industry have considerable expertise when it comes to the perils of offshore wind activities. Although turbines are engineered to work within certain conditions, risks and challenges to the sector remain, including the known perils of the impact of hazardous marine environments and extreme weather. While the growth of offshore wind has been impressive, the rapid advance of technologies is introducing new risks across the supply chain. There is little technological maturity in new construction methods, operations, and turbines as well as a lack of real-world data concerning their use. This could affect the quality of installations if contractor expertise falls short.

The increasing size of wind turbines is perhaps the most striking change the industry has seen in recent years. In the last 20 years they have almost quadrupled in height, from around 70m/230ft to around 260m/853ft – nearly three times taller than the Statue of Liberty. Rotor diameters of wind turbines have increased fivefold in the past 30 years. This increasing size of turbines has introduced corresponding exposures, with larger components, machinery and vessels required for their installation. Faults in new technologies or manufacturing processes might take longer to come to light. The lack of standardization in floating offshore wind technologies could delay repairs or replacements as they require specific facilities, which are currently limited. In other respects, floating offshore wind turbines can reduce construction risk as they can be assembled in the relatively safe environment of a dry dock or near shore.

With the increasing size of wind farms comes a corresponding increase in cable length and complexity. Based on Allianz Commercial's experience in one of its largest offshore wind insurance markets, Germany and Central Eastern Europe, 53% of offshore wind claims by value over six years related to cable damage or failure. From the loss of entire cables during transport to the bending of cables during installation, cable losses have incurred multi-million-dollar losses in offshore wind. The consequences of cable failure can be considerable, potentially putting a whole network of turbines out of commission.

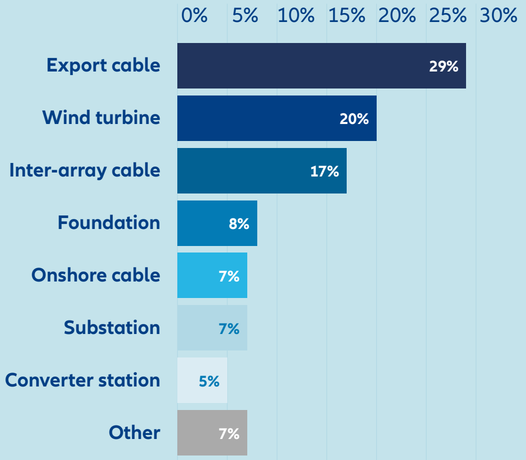
Allianz Commercial's experience of wind turbine losses, which accounted for 20% of offshore wind claims according to value over six years, shows the most common causes relate to rotor blades, main bearings, gearboxes and generators.

As offshore wind expands around the world, particularly in the US and Asia, it will face new risks from harsh environments, natural catastrophe, and extreme weather events. This is likely to affect support vessels and ancillary activities more than turbines, potentially reducing the window of opportunity for installation and repairs.

The speed of the global rollout is creating supply-chain bottlenecks and placing pressure on infrastructure, the supply of materials and components, and the availability of vessels. Access to the right contractor expertise is also a potential challenge, with possible consequences for quality and workmanship.

Top causes of claims

Over half of offshore wind losses by value are related to cable damages (inter-array cable, export cable and onshore cable) according to Allianz Commercial claims data across Germany and Central and Eastern Europe. Wind turbine losses mostly relate to rotor blades, main bearings, gearboxes and generators.



Source: Allianz Commercial. Based on 126 claims across Allianz Commercial's offshore wind portfolio in Germany and Central and Eastern Europe from 2014 to 2020 and 100% claims amount.

A bigger fleet of specialist vessels will be required to support global deployment as most specialist vessels currently operate out of Europe. There is an urgent need to expand port facilities to accommodate the required increase in vessel numbers. Research indicates that $20bn of investment is needed globally to build 200 new ships if the renewables sector is to meet its 2030 targets for offshore wind.

Navigating issues around ESG ↘ page 30

Sensitive development will be needed to mitigate the sector's impacts on biodiversity and coastal communities, with demand for ocean space likely increasing fivefold by 2050. Businesses could also face exposures related to the mining of crucial minerals and metals, including concerns about human rights, emissions, and biodiversity. Project owners should have adequate levels of engagement with stakeholders and communities who may be affected.

Future-gazing: tech innovations that break the mold ↘ page 32

Novel approaches such as 3D-printed reefs and offshore fish farms offer potential solutions to ESG concerns, while disruptive technologies are heralding a new age of drone usage in operations and maintenance. Prototype technologies are also challenging traditional turbine design, giving a glimpse of what could come on stream in the years to come.

Offshore wind farms are highly complex projects requiring many different areas of expertise. The lessons learned from past losses are essential for the industry to improve and continue to grow more sustainably. It is important the technology is understood and that the risks are assessed across the whole marine spread. Risk identification of any project should include installation methods, independent verification/certification processes, quality control, safety procedures, and structural health monitoring. Ultimately, interface management and communication between all the various project parties is a critical success factor.

Global developments

Geopolitical instability and the climate crisis have galvanized investment in global offshore wind, with international governments committing to rollout in regions far beyond the traditional North Sea hub of the industry.

Around the world, policymakers in industrialized nations are forging ahead with legislation, regulation, investment strategies, and international alliances to spur the deployment of renewable power sources and accelerate their rollout.

Many are using the year 2030 as a deadline for their carbon-reduction goals. Globally in 2022, 42 new offshore wind farms went into operation in France, UK, Germany, Spain, Italy, China, Vietnam, Japan and South Korea.[4]

In Europe, where overreliance on Russian gas was most keenly felt in the wake of the Ukraine invasion, the REPowerEU plan from 2022 targets a 45% share of energy from renewables by 2030. This was followed by the Green Deal Industrial Plan in February 2023, which aims to relocate energy supply chains in Europe and boost the competitiveness of the bloc's clean tech sector (largely in response to President Joe Biden's Inflation Reduction Act 2022 *[see below]*).

Two months later, in April 2023, nine European nations, including the non-EU countries UK and Norway, pledged to increase offshore wind farm capacity in the North Sea by eight times the current levels with the aim of boosting capacity to 120GW by 2030 and 300GW by 2050.[5] The Ostend Declaration aims to turn the North Sea into "the world's largest green power plant".

Of the 37GW of offshore wind capacity expected to be built in Europe between 2023 and 2027, 41% is likely to be in the UK, 16% in Germany, 9% in the Netherlands, 8% in Poland, 8% in France, which installed its first large-scale offshore wind farm at Saint Nazaire in 2022, and 6% in Denmark.[6] Italy also inaugurated its first commercial offshore wind project in 2022.

More than 99% of total global offshore wind installation is located in Europe and Asia Pacific.[7] However, the US, which currently has only 42MW of offshore wind capacity online,[8] is investing heavily in the pipeline, although these initiatives have not been without their setbacks.[9] The landmark Inflation Reduction Act (IRA) of 2022 earmarks $369bn in federal funding to galvanize the energy transition and boost energy security. The Biden-Harris administration aims to deploy 30GW of offshore wind by 2030, enough to power 10 million homes with clean energy and support 77,000 jobs.

With two thirds of US offshore wind potential lying in ocean waters too deep for traditional 'fixed-bottom' turbines, President Joe Biden has also launched the Floating Offshore Wind Shot, an initiative that seeks to support the innovation and development of floating technologies, potentially cutting the costs of these by more than 70% by 2035. The administration's goal is to achieve 15GW of capacity from floating offshore wind by the same year, in addition to the 30GW by 2030 from fixed-bottom technology, cutting carbon emissions by 26mn metric tons annually.[10]

China now the world's biggest offshore wind player

Although Europe has led the way in the development and deployment of offshore wind, it has now been overtaken by China as the world's biggest market. Half the world's wind installations in 2023[11] are expected to be in the country, where unprecedented levels of investment are being made in renewable power and whose leader, Xi Jinping, has committed to reach carbon neutrality in energy by 2060. China's combined solar and wind build-out is moving at such a pace it is on track to meet its 2030 target of 1,200GW five years early.[12]

For offshore wind, China is targeting 100GW by 2025 and 1,000GW by 2050[13] with some forecasts predicting it will install 70-80GW annually for the rest of this decade.[14] Its operating offshore wind capacity has already reached 31.4GW and exceeds that of all of Europe.[15] In Chaozhou – a city in the country's eastern Guangdong province – plans have been unveiled for a 43.3GW facility in the Taiwan Strait so enormous it could power 13mn homes and generate as much power as all of Norway's power plants combined.[16]

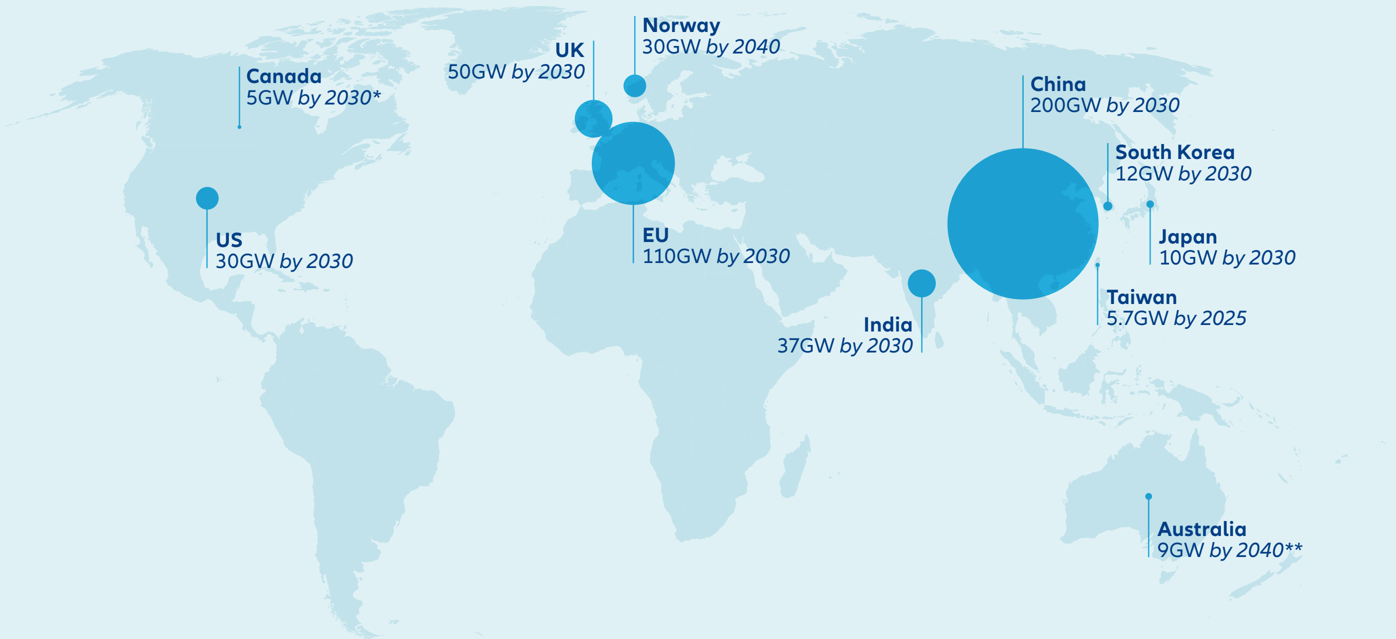
Elsewhere in Asia Pacific, Taiwan is targeting 5.7GW by 2025, South Korea 12GW by 2030, and Japan 10GW by 2030. India has set a target of 37GW by 2030 *(see map)*.

Australia's fledgling offshore wind sector also looks poised for significant growth, with the country having the potential to generate 2,000GW of power[17]. Six regions have been earmarked for offshore wind development, with the state of Victoria leading the way and setting a target of 9GW by 2040.

In Latin America, the potential of Brazil's offshore wind power is estimated at 700GW and applications for 183GW of offshore wind projects have been presented to the country's federal environmental licensing agency, Ibama,[18] while Colombia has identified 50GW of offshore wind development potential and has announced plans for the country's first auction for offshore wind projects.[19]

Global ambitions for offshore wind

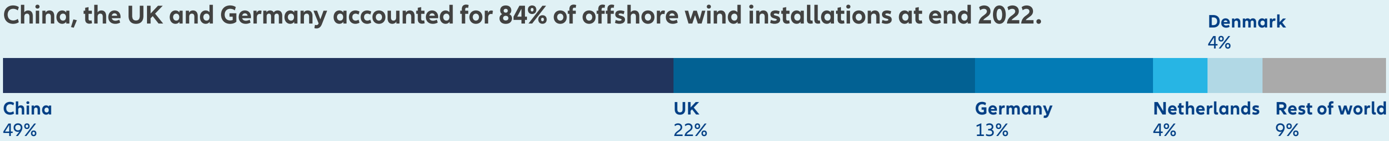
The Global Wind Energy Council (GWEC) expects 380GW of offshore wind capacity across 32 markets to be added over the next 10 years (2023-2032). The total offshore wind capacity at end of 2022 was 64.3GW, but governments, states and provinces around the world are setting ambitious targets for installations that will ramp up capacity globally, with 2030 a key year for many.



Source: Government.no, GWEC, United Kingdom Government, Wind Europe.
Data is from selected countries only.
*Province of Nova Scotia. **State of Victoria

Total offshore wind installations (%)

China, the UK and Germany accounted for 84% of offshore wind installations at end 2022.



Total: 64.3GW

New offshore wind installations in 2022

China led global offshore wind development in 2022, accounting for 58% of new installations, but this was 70% lower than 2021, which was a record year driven by the end of the country's feed-in tariff to support deployment of offshore wind.

Total: 8.8GW

Source: GWEC. Global Offshore Wind Report 2023, August 28, 2023

Allianz in offshore wind

Allianz is supporting some of the most exciting developments in the offshore wind space, whether as investor or insurer.

Allianz plays a key role regarding investments in the renewable energy industry, which has developed into a well-established and sustainable business over the past 25 years. It has long recognized wind power as a good, long-term value investment, and a source of stable, long-term cash yield profile with low risks. Allianz's investment portfolio includes more than 100 wind farms and solar parks around the world, including some of the largest offshore wind farms in the world such as Hollandse Kust Zuid (HKZ) 1-4 in the Netherlands and He Dreiht in Germany. These investments in wind and solar energy projects are instrumental in advancing the share of renewable energy around the world and reinforcing its goal of achieving a carbon-neutral portfolio by 2050.

Allianz also insures many of the most high-profile offshore wind developments in the world and the company has underwritten around 130 projects in the last five years. Insurance solutions for the offshore wind sector include Construction All Risks, which includes coverage for physical damage during the construction phase of the wind farm, such as during transit and installation, as well as any resultant Delay in Start-up (DSU) coverage, if purchased, in the event of recoverable delays to the commercial operations date. It would also include operational cover for physical damage during the operational phase of the wind farm, including to the turbines, cables, and substations, as well as any resultant business interruption coverage, if purchased.

Allianz is keen to support the transition to renewables, whether it is through investment impact, or through partnerships such as the United Nations convened Net-Zero Asset Owner Alliance, where it champions ambitious decarbonization strategies that can be effectively implemented at scale.

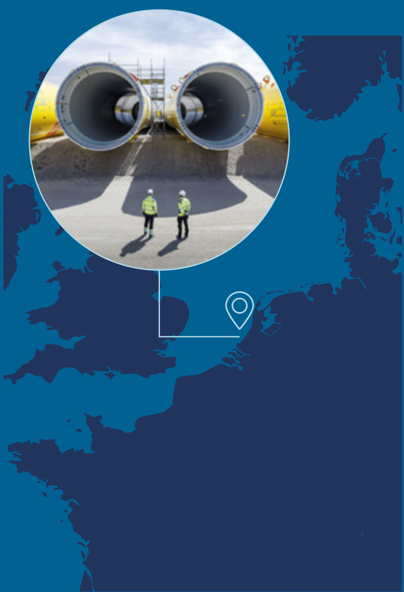


Photo: Vattenfall/Jorrit Lousberg

Hollandse Kust Zuid (HKZ) 1-4, Netherlands

What is it? A 1,500MW wind farm expected to start operations by Q1 2024. The project consists of 139 11MW turbines (Siemens 200DD) capable of powering more than 1.5 million households. The project will also be the world's first subsidy-free offshore wind project and represents an important milestone for the offshore wind industry.

Where is it? In the North Sea, near shore and in shallow waters, around 18-35km (11-22 miles) off the coast of Noordwijk in the Netherlands.

Who owns/operates it? HKZ 1-4 is owned by Vattenfall, BASF and Allianz and operated by Vattenfall.

How is Allianz involved? In its first direct investment in an offshore wind farm project, Allianz has acquired a c.25% stake in HKZ 1-4, its first equity renewables investment in the Netherlands.

He Dreiht, Germany

What is it? A 960MW wind farm expected to start operations end of 2025, He Dreiht means 'it spins' in the local dialect. Upon completion it will be one of the largest offshore wind farms in Germany, with 64 15MW turbines (Vestas V236-15), enough to power 1.1 million households with clean energy.

Where is it? In the German North Sea, 90km/56 miles northwest of the island of Borkum in Lower Saxony and around 110km/68 miles west of Helgoland.

Who owns/operates it? EnBW (50.1%) and a consortium of Allianz, AIP and NBIM (49.9%).

How is Allianz involved? In its first direct investment in an offshore wind farm project in Germany, and its second in offshore wind, Allianz has acquired a 16.6% stake in He Dreiht. Allianz Commercial is also a participating insurer on the project, providing coverage for Construction All Risks (CAR).

Photo: EnBW / Rolf Otzipka

Revolution Wind 1, USA

Photo: Ørsted

What is it? A wind farm providing 304MW of clean wind power to Connecticut and 400MW to Rhode Island. It will help the two states meet their climate goals of 100% renewables in Rhode Island by 2033 (the most ambitious clean energy goal in the US) and 100% electricity sourced from zero-carbon resources by 2040 for Connecticut.

Where is it? 25km/15 miles off the Rhode Island coast, 51km/32 miles off the Connecticut coast and 19km/12 miles southwest of Martha's Vineyard.

Who owns/operates it? Ørsted and Eversource in a 50:50 partnership.

How is Allianz involved? Allianz Commercial is lead insurer for the wind farm for Construction All Risks (CAR).

Dogger Bank Wind Farm, UK

Photo: Jan de Nul

Where is it? On an isolated sandbank in the North Sea, located between 125km and 290km (78 to 180 miles) off the Yorkshire Coast in northern England.

What is it? A wind farm being built in three phases – A, B and C – that will have an installed capacity of 3.6GW when completed in 2026, enough to supply 5% of UK electricity demand. Power will be generated by 277 GE Haliade-X turbines (13MW and 14MW), with first power expected in 2023 and 2024 for Dogger Bank A and B and turbine installation for Dogger Bank C starting in 2025. A fourth phase of development, Dogger Bank D, has been proposed that could bring capacity to over 5GW.

Who owns/operates it? Dogger Bank Wind Farm is a joint venture partnership between SSE Renewables (40%), Equinor (40%) and Vårgrønn (20%). It will be operated by Equinor on completion.

How is Allianz involved? Allianz Commercial is lead insurer for the Construction All Risks (CAR) on Dogger Bank A, B and C.

Hywind Scotland, UK

Photo: Equinor

What is it? The world's first commercial wind farm to use floating turbines, in operation since 2017. Hywind Scotland generates enough electricity to power 35,000 UK homes using five 6MW floating turbines with a spar-buoy design at water depths of 90 to 120 meters/295-394ft. The Siemens Wind Power SWT-6.0-154 turbines are anchored to the seabed with mooring lines and anchors, in much the way a floating spar platform is moored.

Where is it? In the North Sea, 29km/18 miles from Peterhead in Aberdeenshire, Scotland.

Who owns/operates it? It is operated by Hywind, a joint venture of owners Equinor and Masdar.

How is Allianz involved? Allianz Commercial is on board as lead insurer for the Operational All Risks (OAR).

NeuConnect, UK and Germany

Where is it? NeuConnect links the Isle of Grain, southeast England, with Wilhelmshaven, a town on the Jade Bight of Germany's North Sea coast.

What is it? The first direct power link between Germany and the UK, NeuConnect will allow up to 1.4GW of electricity to flow in either direction along 725km (450 miles) of land and undersea cables through British, Dutch and German waters. The interconnector – high-voltage cables that allow electricity to be transported between national grids – will help to boost energy security and resilience while also helping to integrate renewable energy sources in both countries. It is currently the single largest German-British infrastructure project ever undertaken, at a cost of €2.8bn ($3bn), and scheduled to come into operation in 2028.

Who owns/operates it? Meridiam, Allianz, Kansai Electric Power and TEPCO.

How is Allianz involved? As well as being an investor, Allianz is lead insurer for the Onshore Construction All Risks (CAR) and co-lead for the Offshore Construction All Risks (CAR).

Photo: Cadeler A/S

East Anglia THREE, UK

Where is it? 69km/43 miles off the coast of Suffolk in eastern England.

What is it? Part of the East Anglia Hub, East Anglia THREE will cover an area over 300km^2/186 square miles in the North Sea, making it the world's second largest offshore wind farm. With a total capacity of 1.4GW, the wind farm will generate enough green electricity to power the equivalent of more than one million homes using 95 Siemens Gamesa 14.7MW turbines when it comes into operation in 2026.

Who owns/operates it? ScottishPower Renewables (Iberdrola).

How is Allianz involved? Allianz Commercial is lead insurer for the Construction All Risks (CAR).

Jeonnam 1, South Korea

Where is it? In the Yellow Sea, off the coast of South Jeolla, a province in the southwestern tip of mainland South Korea.

What is it? Phase 1 of a wind farm with 99MW capacity – enough to power 70,000 households for a year – that will contribute to South Korea's offshore wind target of 12GW by 2030. Currently under construction, phase 1 is expected to enter commercial operation early 2025. Phases 2 and 3 are currently under development.

Who owns/operates it? Jeonnam 1 is a joint venture between SK E&S and CI III Fund, which is managed by Copenhagen Infrastructure Partners (CIP).

How is Allianz involved? Allianz Commercial is a lead insurer for Construction All Risks (CAR).

Photo for illustration purposes only

Allianz Risk Consulting solutions

Allianz Commercial has a market-leading position in supporting global offshore wind projects, underpinned by a global team of in-house experts, technical excellence, and a customer-focused approach.

Allianz risk consultants around the world help clients overcome the rapid changes taking place in the offshore wind risk landscape, providing comprehensive risk-monitoring solutions and delivering tailor-made coverage. They aim to continually collaborate on a range of loss-control services, including:

- **Risk workshops** with clients' technical project teams and third-party experts to develop credible loss scenarios.
- **Pre-risk evaluations** to identify, analyze and minimize risks associated with complex designs and engineering aspects.
- **Risk dialogue** with clients on emerging risks and lessons learned.
- **On-site surveys and field assessments** of critical assets and construction sites by risk engineers to ascertain areas for risk-quality monitoring and potential improvement.

Widescale deployment and the barriers to development

Supply chain challenges, bottlenecks, spiraling costs, and shortages of skills, components and vessels need to be overcome if the global rollout of offshore wind is to keep pace with carbon-reduction targets.

Given the extent of its potential and with so many installations being made in 2023, the deployment of offshore wind at scale is a hugely exciting prospect for the energy transition going forward.

“The industry is on the verge of commercialization of leading-edge technologies like floating offshore wind,” says **Adam Reed, Global Leader – Offshore Renewables and Upstream Energy at Allianz Commercial.** “The existing expertise associated with fixed-bottom turbines and offshore oil and gas is poised to pivot to new territories as impending carbon targets galvanize international action to get cleaner, more secure, sources of power online. As well as propelling the world towards a low-carbon future, the expansion of offshore wind across the world also has the potential to create millions of skilled jobs.”

But all is not plain sailing for developers, despite the global drive to decarbonize. In recent weeks, high-profile offshore wind projects in the US and Europe have been halted, mainly on the grounds of spiraling costs. In addition, turbine manufacturers have suffered losses running into billions. The situation is the result of cost increases due to inflation and rising interest rates, as well as structural supply shortages and strained supply chains.

These developments have led to calls from industry stakeholders for policymakers to adapt the regulatory framework to such new market realities to enable more investment certainty for manufacturers and developers.

The sector faces challenges ahead if the promise of offshore wind is to be realized in time to meet targets. “In spite of the growing demand for renewables, the energy sector confronts a series of pressures that could impede the progress of wide-scale rollout,” says **Harald Dimpflmaier, a Chief Underwriter in the Natural Resources and Construction team at Allianz Commercial.** “The energy transition needs to be fast-tracked by all stakeholders – financial institutions, corporates, and governments – and the particular difficulties currently confronting offshore wind highlight the need to invest in secure supply chains for the sector, or future growth could be hampered by bottlenecks and further inflationary pressures.”

A mammoth task ahead

Supply chain disruption, rising project and component costs, and the six to 12 years it can take to complete an offshore wind project are all bringing pressure to bear on global deployment.

“The scale and scope of the required rollout is epic,” says Reed. “It encompasses the expansion of manufacturing capacity, port facilities and infrastructure, specialist vessels and machinery, and the training of skilled staff right along the supply chain. The commodities required will include huge volumes of steel, which has been subject to severe price fluctuations in recent years, and rare earth elements, the mining and processing of which is presently dominated by China.”

Major players team up

Knowledge sharing and joint ventures are being explored by major companies in the energy space to promote development and share resources on offshore technology and infrastructure. Spanish infrastructure and energy conglomerate Acciona has partnered with Danish power business Acciona and Ørsted[20] to jointly develop solutions addressing the challenge of manufacturing large-scale foundations for offshore wind farms; Ocean Winds, a joint venture between Portuguese energy giant EDP and French utility company Engie[21], has made an application to develop offshore wind farms off the coast of Victoria in Australia; and Spanish sustainable infrastructure operator Ferrovial and German energy company RWE[22] have teamed up to develop, construct and operate floating offshore wind farms off the Spanish coast.

Other key components in offshore wind are also heavily reliant on China, including nacelles (China produces around 60% of onshore and offshore nacelles)[23], gearboxes, generators, castings, towers and flanges. Analysis by the Global Wind Energy Council (GWEC) reveals that shortages for key components and nacelles (the heart of a turbine that houses key mechanical and electrical equipment) might develop in the US and Europe from the middle of this decade as a result of some governments' reshoring initiatives to strengthen local industries.

A lack of investment could also affect the supply of specialist installation vessels towards the end of the decade. As governments attempt to diversify and strengthen their supply chains, including decoupling from China, there could be unintended consequences in the form of bottlenecks and higher costs, potentially delaying or even derailing the global energy transition, warns GWEC.[24]

Lengthy planning and permitting processes

The labyrinthine planning and permitting processes associated with offshore wind are also a challenge to its rollout. The industry faces regulatory and administrative hurdles, with consents required for construction, grid connection, and the transport of certain components. It also has to contend with legal challenges.

The European Commission's proposed Net Zero Industry Act promises to lower the administrative burden for net-zero manufacturing projects by streamlining administrative and permitting processes. In the UK, the government is seeking legislation to deliver an Offshore Wind Environmental Improvement Package that will help reduce offshore wind consenting time from up to four years to one, while the One-Stop-Shop approach is established in mature markets in Europe, including the UK, the Netherlands and Denmark. It uses a single national point of contact to create a streamlined, transparent and centralized permitting process.

If key barriers to deployment are not addressed, the Energy Transitions Commission (ETC) estimates the world could miss out on up to 3,500TWh of clean electricity generation from wind and solar in 2030. An ETC report claims simple measures to streamline planning and permitting could reduce offshore wind project timelines from 12 years to 5.5 years.[25]

Connecting to the grid

Even where permits are granted, developers sometimes have to wait up to 10 or even 15 years for a grid connection as legacy infrastructure struggles to meet rocketing demand. Such delays could hamper worldwide efforts to meet emissions-reduction deadlines, warn industry experts, who say a more streamlined approaches to permitting processes is needed to reduce bottlenecks.

Many offshore wind projects around the world are stuck in queues for grid connections, with the renewables industry stressing the need for more investment to expand and modernize existing grids that were built for a world powered by fossil fuels. The sometimes remote or inhospitable locations of wind farms and the variability of the power generated call for new technological solutions and infrastructure. At least $21.4trn will need to be invested in the electricity grid by 2050 if it is to support the world's net-zero pathway, according to a report from BloombergNEF, of which $17.3trn is required to expand the grid for new production and usage.[26]

The International Energy Agency (IEA) has highlighted the need for a fundamental transformation of power systems, including much higher levels of digitalization from generation to end use. It reckons global annual investment in grids will need to more than double from approximately $330bn per year to $750bn by 2030,[27] with three quarters allocated to the distribution grids to expand and strengthen digital technologies.

Multi-purpose wind farms and next-generation connectivity

The offshore wind industry is looking beyond point-to-point connections to a wider infrastructure that will expand international connectivity, support multiple uses, including green hydrogen production, and optimize economies of scale using 'energy islands'.

In Europe, individual offshore wind farms usually are connected to the mainland of their host country by subsea cables called interconnectors. But novel approaches to offshore electricity transmission and infrastructure are emerging. Hybrid wind farms can transmit power not only to shore but also between nations and each other, using multi-purpose interconnectors to create meshed offshore transmission grids. By facilitating the transmission and sharing of energy, they will help to mitigate the intermittent nature of wind power.

Energy islands could be a stepping stone to achieving these meshed grids. Whether the islands are fabricated or naturally occurring, they can serve as electricity hubs for multiple wind farms but also have the added potential to produce green hydrogen from seawater and house battery storage facilities.

Several projects are already at different stages of planning and development. Allianz has recently provided support for a feasibility study with Copenhagen Infrastructure Partners (CIP) looking into artificial energy islands in the German North Sea. The projects are at an early stage but Allianz is keen to explore their potential as part of its net-zero transition plan.

Other European projects in the pipeline include two energy islands planned by Denmark – one on the existing Baltic island of Bornholm, which will connect to both Denmark and Germany, and the other on an artificial island that will be built in the North Sea. Belgium will begin construction on an energy island in 2024 that will connect to Denmark's North Sea energy island and possibly to the UK via a Belgium-UK interconnector. Off the coast of England at Dogger Bank, the North Sea Wind Power Hub, led by a consortium, is a proposed transnational project that will potentially connect the UK, Denmark, the Netherlands, Germany, Belgium and Norway.

More countries want to combine transmission assets with offshore wind farms since these offshore hybrids save money and space and enhance energy flows between countries, according to WindEurope and Hitachi. Their report calls for cross-border and cross-sector cooperation to capture the full societal, environmental, economic and technical value of meshed offshore grids.[28]

Energy islands could serve as multi-purpose hubs for several wind farms
Photo: CIP

Hydrogen and Power-to-X

The world's first offshore green hydrogen production platform was inaugurated in France in 2022. Most hydrogen is produced using natural gas or methane, but hydrogen that is produced offshore using renewable power and desalinated seawater has a low or zero-carbon footprint. This green hydrogen is produced by electrolysis, which separates water into hydrogen and oxygen. The resulting gas can be converted into carbon-neutral fuels – the 'X' in what's often called Power-to-X – which can be stored or transported for conversion to electricity.

Multi-purpose wind farms could maximize space and infrastructure to produce green hydrogen, which is regarded as a promising fuel in the energy transition because it produces only water vapor when burned. It could be particularly useful for decarbonizing hard-to-abate sectors like heavy industry, transport, steel production, and mining. Green hydrogen's potential is being explored by governments around the world that are investing in offshore wind (both fixed-bottom and floating), including France, Germany, the Netherlands, the UK and China.

"We have seen interest in green hydrogen projects increasing," says **Adam Reed, Global Leader – Offshore Renewables and Upstream Energy at Allianz Commercial.** "Allianz has deployed capacity for the construction of one of the world's biggest renewable energy hubs, which will produce, store, and deliver hydrogen in the US. That particular plant is onshore, but we are also keen to support the expansion of more green hydrogen facilities on multi-purpose platforms offshore, where the power of strong, consistent winds and economies of scale can be maximized."

"Allianz has deployed capacity for the construction of one of the world's biggest renewable energy hubs, which will produce, store, and deliver hydrogen in the US

Floating offshore wind comes of age

The commercial deployment of floating wind turbines is one of the most exciting developments in the offshore space and is seen by many as the key to meeting future net-zero commitments.

Conventional fixed-bottom offshore wind turbines are generally suitable for waters up to 60m deep (197 feet). But around the world, 80% of offshore wind blows over seawaters that are deeper than that and further away from shore. This means fixed turbines are either impossible to install or not economically viable.

"In the past, water depth has limited the extent of offshore wind deployment, but the rapid advance of floating offshore wind [FOW] technologies is driving huge change in this area," says **Adam Reed, Global Leader – Offshore Renewables and Upstream Energy at Allianz Commercial.** "So-called 'floating' offshore wind turbines are in fact anchored or moored to the seabed. They allow power to be generated over deeper water with higher, more consistent wind speeds. Their commercial deployment opens up huge potential for offshore wind to develop beyond the historic offshore hub of the North Sea to the Pacific, the Atlantic, the Mediterranean and elsewhere. Countries beyond Europe are exploring the feasibility of floating offshore wind, including South Korea, Japan, China, Taiwan, Australia, and now, of course, the US, as part of the Biden-Harris investment drive in renewables. It is also being considered for its potential in converting seawater into green hydrogen for export."

A recent Floating Offshore Wind Report from TGS | 4C Offshore forecasts that 12.4GW of potential floating wind capacity will be operational or under construction globally by 2030, rising to 39GW by 2035.[29]

The UK, Norway, Portugal, China and Japan are currently the top five markets in total net floating wind installations, according to the GWEC, but by the end of 2030, the top five floating markets are likely to be the UK, South Korea, China, Portugal and Norway. Between them, France and China have 300MW of floating projects in pre-construction and set for construction late 2023 or 2024.[30]

By 2050, 15% of all offshore wind installed capacity will come from FOW, according to the risk management and assurance firm DNV. This would require 20,000 turbines to be installed globally, each mounted on a floating unit weighing 5,000 tonnes and secured with so many mooring lines that if they were tied end to end they would encircle the globe twice.[31]

The biggest FOW project in the world is Hywind Tampen in the Norwegian North Sea, with a capacity of 88MW. Currently under construction, it will be the first floating offshore wind farm to power oil and gas platforms, providing 35% of the electricity demand of the Snorre and Gullfaks oil and gas fields and cutting their CO_2 emissions by about 200,000 tonnes per year. Other similar projects are now underway, indicating that FOW could be a useful route to reducing carbon emissions in oil and gas production.

At present the costs of FOW are higher than conventional offshore wind, but they are falling and should continue to do so with the industrialization of the sector. The turbines used are essentially the same as those used for conventional offshore wind, but the foundations they sit on are different.

There is not yet a consensus on the particular foundation model that should be used *[see graphic]* with a number being explored by developers. This poses a challenge in terms of widescale rollout of FOW and also in terms of risk.

"A lack of standardization will impact the time needed to repair or replace parts, or whole structures, which could impact delay in start-up or business interruption coverage," says Reed.

Floating offshore wind: four possible solutions

There are many different designs in development for floating offshore wind foundations, with the following four approaches emerging most strongly. The first three are loosely moored to the seabed, while the tension leg platform is more firmly attached to the seabed and more stable. The viability of other novel approaches are also being explored.

1. Barge (water depth +30m)
2. Semi-submersible (water depth +40m)
3. Single point anchorage, or SPAR (water depth +100m)
4. Tension leg platform (water depth +50m)

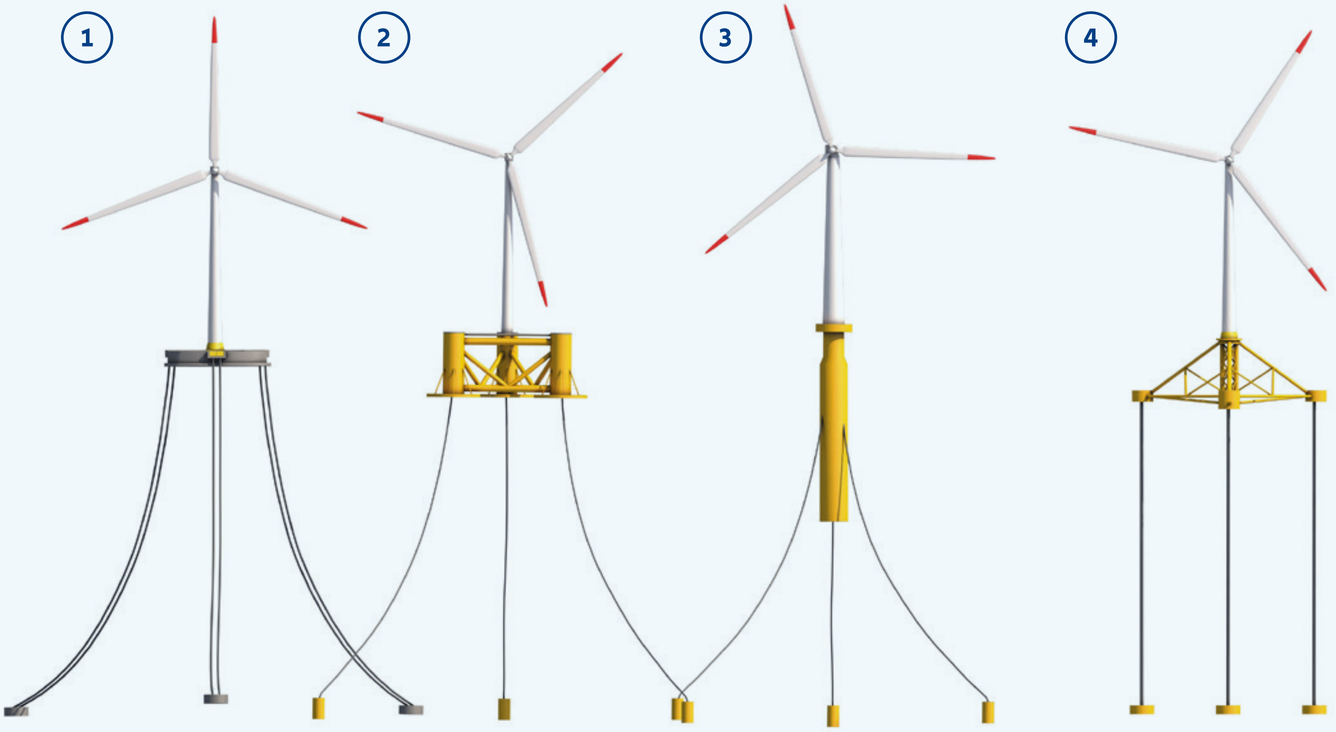


Photo: WindEurope / Adobe Stock

Offshore wind: risks, challenges and mitigation

While the promise of offshore wind as a viable source of clean power is undeniable, rapid growth carries risks for operators and insurers. Where do the challenges lie and what can the sector do to identify and tackle them?

Both the energy sector and the insurance industry have considerable expertise when it comes to the perils of offshore wind activities. There is a precedent and historic data to draw on when assessing the risks of hazardous marine environments, extreme weather, and the attendant risks of humidity, corrosion, oxidation and saltwater.

"The lessons learned from past losses are essential for the industry to improve and continue to grow more sustainably," says **Blanca Berruguete, Global Industry Solutions Director for Construction at Allianz Commercial.** "While the growth of offshore wind has been impressive, it has been accompanied by rapid advances in the technology used, which has introduced new risks across the supply chain."

Dr Wei Zhang, Senior Risk Consultant, Natural Resources and Construction, at Allianz Commercial, says there is a lack of technical and technological maturity in many of the newer aspects of operation and construction: "In particular, this is a concern with the evolving design of turbines, different foundation types, fire protection, and new cabling systems and cable protection required. Linked to this is the issue of quality overall, which extends beyond the turbines and cabling to the wider infrastructure, the quality of installation, and the expertise of all contractors involved.

"Offshore wind farms are highly complex projects requiring many different areas of expertise. It is important the technology is understood and that the risks are assessed across the whole marine spread. Interface management and communication between all the various project parties is a critical success factor."

Dr Zhang advises that risk identification of any project should include installation methods, independent verification/certification processes, quality control, safety procedures, and structural health monitoring.

"Each offshore wind project is unique and the associated risks are evolving with future projects that are increasingly bigger and more complex," says Dr Zhang. "These challenges can only be tackled effectively and efficiently through collaborative efforts between the owners, insurers and key stakeholders."

Bigger turbines, bigger risks

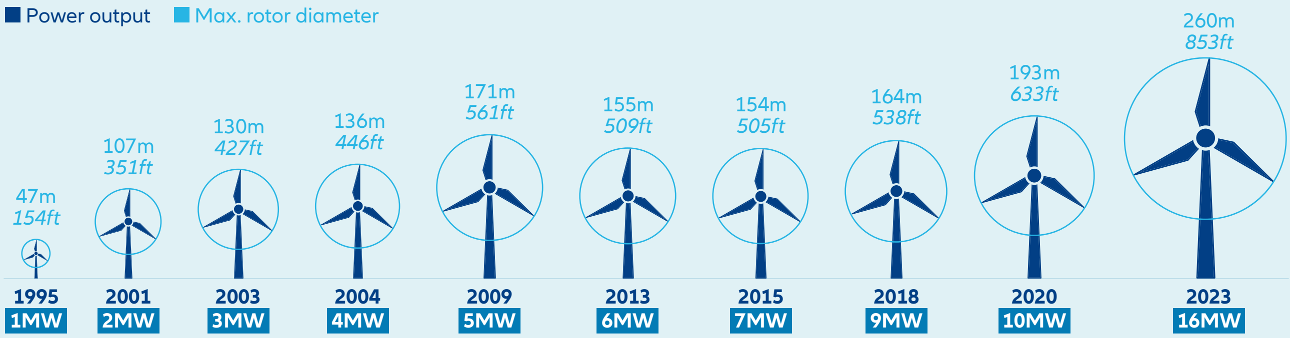
The increasing size of wind turbines is perhaps the most striking change the industry has seen in recent years. In the last 20 years they have almost quadrupled in height, from around 70m/230ft to around 260m/853ft in the case of GE's Haliade-X 13MW turbine – nearly three times taller than the Statue of Liberty.

"We are quite used to wind turbines with capacities of 8MW or 9MW, but now we're seeing newer models reaching 14MW to 18MW," says Dr Zhang. "A project in Australia is even planning to use 20MW turbines.[32] Inevitably, with the increase in size comes a corresponding increase in risk. Although turbines are engineered to work within certain conditions, there is a lack of real-world data on both performance and the long-term impacts on these larger turbines and their associated infrastructure, especially cables *[see graphic]*, and their maintenance requirements."

Allianz's experience of wind turbine losses shows that they mostly relate to rotor blades, main bearings, gearboxes and generators.

The evolution of wind turbines

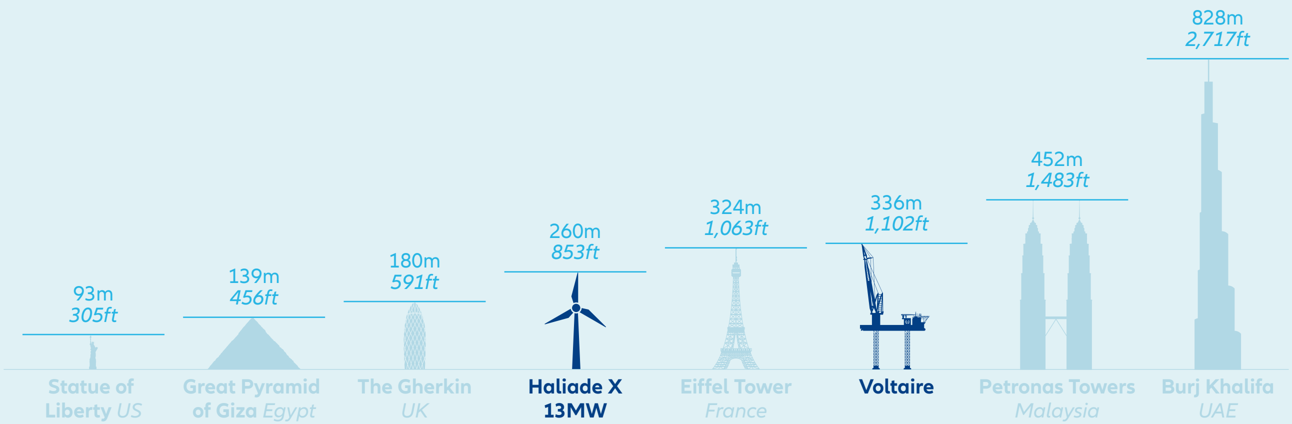
The rotor diameter of wind turbines has increased around fivefold in the past 30 years. In July 2023, Mingyang Smart Energy announced its MySE 16-260 turbine was operating at full capacity in China. With a rotor diameter of 260m (853ft) – as long as the Haliade-X is high – it lays claim to being the world's largest offshore wind turbine. Earlier this year, the company unveiled plans for an even larger turbine, with a capacity of 18MW or more and a rotor diameter of over 280m (919ft).



Sources: Allianz, DNV GL, Clarksons, Offshorewind.biz. Data as of September 2023

The monumental size of Haliade-X

In August 2023, the installation of 277 wind turbines began at Dogger Bank, the world's largest offshore wind farm, off the coast of north-east England in the North Sea. One single rotation of the immense GE Haliade-X 13MW turbine can power a UK household for two days. The turbines will be transported and installed using the biggest jack-up vessel ever built, Voltaire. Measuring 336m (1,102ft) at its highest point, Voltaire is 12m, or 39ft, taller than the Eiffel Tower.



"Even after the requisite testing period for a new technology, there can be serial damages that come to light much further down the line, typically affecting the main bearing, gearbox or generator, or one particular component of a turbine," says Dr Zhang. "This often comes down to the same root cause and can eventually be found to be a systematic fault with the design or manufacturing process. But it may take a while to identify this root cause."

As turbine blades and towers have increased in size, so, too, have their components, as well as the vessels and equipment required to install them. Cranes, jack-up vessels, monopiles and jackets *(see graphic)* are all getting bigger and will need to withstand installation and operation in deeper waters and more hazardous conditions.

Floating offshore presents a mixed risk picture

The expected expansion of floating offshore wind is partly dependent on a consensus being reached about the most suitable foundation models. "There are a few main types being tested at the moment, so until there is consistency, there remains a need for transparency and heightened risk management," says **Harald Dimpflmaier, a Chief Underwriter in the Natural Resources and Construction team at Allianz Commercial.** "The lack of standardization is an issue when it comes to considering the time needed to repair or replace parts or whole structures, which could impact delay in start-up and business interruption coverages. Certain foundation designs and very large floating structures require specific port infrastructure or a large footprint for them to be built and therefore also repaired. The number of facilities at the moment is limited, and there will be utilization of these for new-build projects, meaning existing offshore fields will have to compete for scarce port resources.

Top risks and losses in offshore wind

- Lack of technical maturity and data available on new or unproven technologies.
- Bigger turbines, cranes, vessels, and components create correspondingly bigger exposures.
- Damage to cables is the top cause of insurance claims. Wind turbine losses mostly relate to rotor blades, main bearings, gearboxes and generators.
- Natural catastrophe exposure and higher wind speeds could pose risks as the sector expands into new territories.
- The speed of build-out is creating supply-chain pressures on infrastructure, materials, components, and vessels.
- Access to expertise and specialist technical staff could be a challenge.
- Vessel collision with turbines and offshore infrastructure can also result in significant losses.

"The numerous foundation and floater concepts being considered also use different materials, such as metal versus concrete, for example. Both would have their own requirements, in terms of manufacturing facilities, logistics and installation, and perhaps also environmental implications."

In other respects, floating offshore wind turbines can reduce construction risk as they can be assembled in the relatively safe environment of a dry dock or near shore, Berruguete points out. "They are then towed out to sea by tugboats and installed on 'floating' platforms, which means there is less need for specialist heavy-lifting equipment. They can even be towed back to port for repairs. Fixed offshore wind is constructed largely at the offshore site and requires more specialist and expensive vessels, such as jack-up vessels, which sit on the seabed.

"As FOW projects are installed further out to sea than conventional wind farms, they are less likely to come up against resistance from coastal communities because noise and visual pollution are less of a concern."

However, the location of FOW development in new ocean areas not accessible to conventional fixed-bottom turbines could introduce risks concerning the biodiversity of deeper waters further out to sea. Large FOW farms are likely to create a wake that can modify the local oceanography. An increase in turbulence caused by wind and currents circulating around several turbines can create localized changes in ecosystems so it is important that particular attention is paid to the choice of locations for future FOW farms in relation to this.

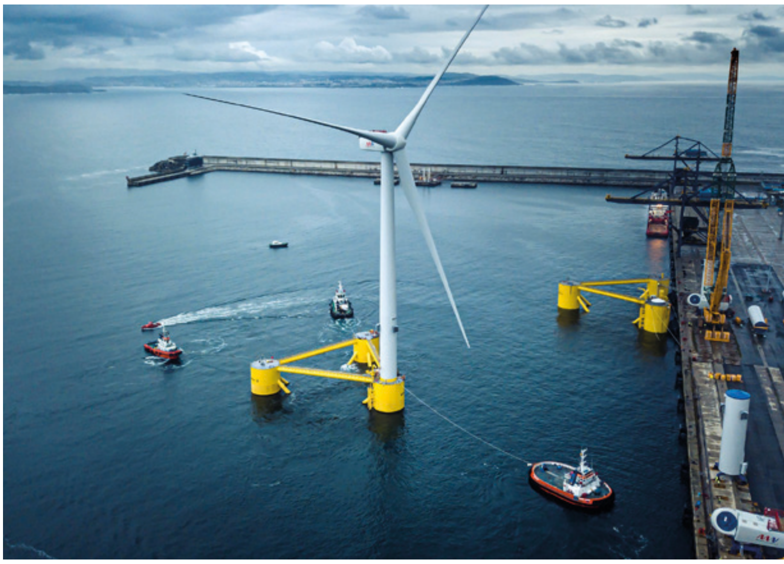


Photo: Principle Power

Damage to cables top cause of loss

Based on Allianz's own experience in one of its largest wind farm insurance markets, across the Germany and Central and Eastern Europe region, 53% of offshore wind claims by value over six years related to cable damages. From the loss of entire cables during transport to the bending of cables during installation, cable losses have incurred multi-million-dollar losses in offshore wind.

While technology risk is a driver of these losses, they tend to be aggravated by complex logistics, such as the availability of vessels, and the need to wait for favorable weather conditions in order to make repairs.

Damage can occur because of human error during manufacturing or cable laying, or from fishing nets, anchor drag, or dredging. Natural causes like shifting sediment or rock fall and severe storms can also cause damage.

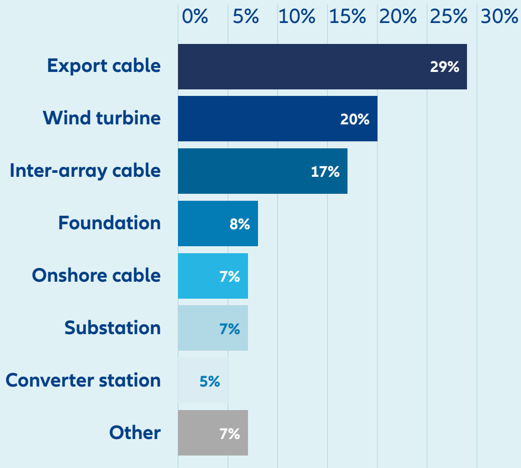
As wind farms get bigger, with more and longer cables, the probability of damage increases, while constructing wind farms in deeper waters further offshore can make the logistics of installation and repairs more difficult.

"The cables used in offshore wind, whether they're inter-array cables or export cables, operate in an inherently risky environment," says Dr Zhang. "As well as having to withstand natural hazards, they are exposed to a dynamic environment, and anything dynamic carries added risk because it causes more strain. With floating offshore wind farms, the dynamic cables are longer than with fixed-bottom turbines and more exposed to the stresses of the ocean environment. Another complication is that any damage to cables, such as a problem with insulation stemming from the manufacturing process, might not become apparent for several years."

The consequences of a cable failure can be considerable, with lost power generation revenue and lengthy as well as costly repairs and replacements. If an export cable is damaged, it can put a whole network of turbines out of commission.

Top causes of claims

Over half of offshore wind losses by value are related to cable damages (inter-array cable, export cable and onshore cable) according to Allianz Commercial claims data across Germany and Central and Eastern Europe. Wind turbine losses mostly relate to rotor blades, main bearings, gearboxes and generators.



Source: Allianz Commercial. Based on 126 claims across Allianz Commercial's offshore wind portfolio in Germany and Central and Eastern Europe from 2014 to 2020 and 100% claims amount.

"With cabling, quality of service is vital," says Dimpflmaier. "Contractors need to provide assurance they have the required expertise to remedy incidents and that they can source replacement components swiftly in order to avoid losses incurred during downtime. As insurers, when we underwrite subsea cabling work, in addition to technologies used, we will ask for details on the scale, scope and timetable of a project. We will enquire about contractors and how they will service repairs, how the client will manage the interface with them, what types of cabling will be used, what kind of vessels will be used, and how often qualified risk engineers will make site visits to oversee proceedings."

Harsh environments and natural catastrophe

The offshore sector in Europe has significant expertise in managing operations in hazardous marine environments. But as offshore wind expands around the world, there will be new developments further from shore in territories prone to different types of weather system and natural catastrophe, notably Asia and the US. There is limited relevant data available for insurers to model cat exposure, which makes risk assessment and aggregation challenging.

“Most of the development so far has been in the North Sea, where you can get very high wind speeds in Scotland, for example, but on the East Coast of the US and, in particular, Taiwan, the wind speeds and wave action will be much more significant,” says Dimpflmaier. “It remains to be seen whether climate change will heighten this risk in the future, although we know that rising sea surface temperatures can intensify the strength of hurricanes. Up to now, fortunately, we have seen very few losses connected to natural catastrophe events, but this could change as developments gather pace in the US and Asia, which have more significant nat-cat exposure.”

Photo: Ørsted

Dr Zhang emphasizes that wind turbines are engineered to withstand most nat-cat events: “For example, they respond to wind speeds and stop operating if necessary. However, extreme weather conditions such as winter storms, hurricanes and typhoons could still test the limits of turbine design. In addition, extreme weather and natural catastrophe could pose more of a risk to offshore installation and service activities. There is always a limited window of opportunity with offshore wind for installation and repairs, as daylight, weather conditions, wind speed, wave height and currents are all critical factors.”

The speed of build-out

The steep growth of offshore wind and its expansion into new territories will require significant build-outs of both infrastructure and supply chains, with existing factories and facilities already running at high capacity.

“These bottlenecks could be exacerbated in any territories with specific local requirements including local content requirements, which stipulate a minimum amount of investment or portion of the total spend needs to be in the host country,” says Berruguete. “This could limit developers’ choice of where to procure from, with knock-on pressure on factories, particularly if they are newer and less experienced in producing components.” Developers also have to work around local planning rules and requirements concerning the financial capacity of tenderers and their experience.

“The carbon targets that have been set by the world for 2030 are very ambitious,” says Dr Zhang. “They will require more skilled and upskilled technicians to be trained and in the workforce. Access to the right expertise could be a challenge. In addition, contractors will be racing to introduce innovations to save time and costs, possibly introducing risk potential. Given the difficulties in manufacturing all this highly advanced technological kit, there will need to be a focus on quality to avoid issues of both delay and the production of components with inherent workmanship issues that could lead to defects.”

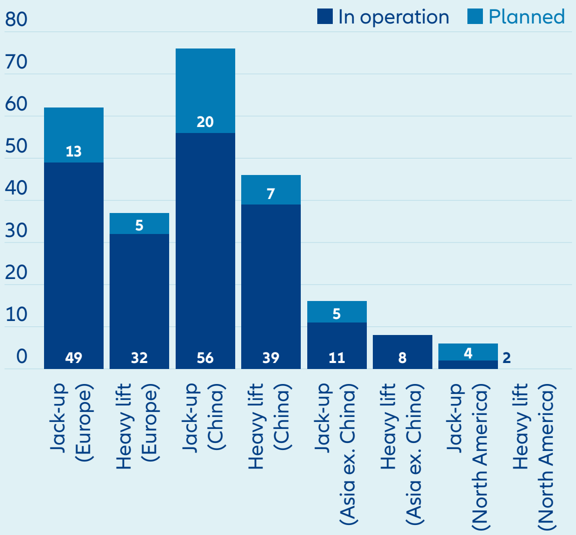
It is vital that focus is also maintained on vessel suitability, the fastening of cargo, voyage plans, analysis of meteorological and oceanographic conditions at the site of operation, weather forecasting, operational limits including contingency planning such as for storm preparedness, and any lifting equipment being used.

As well as ensuring contractor expertise, it is important to undertake third-party verification from qualified SOMWS (Society of Marine Warranty Surveyors) surveyors utilizing a standardized Scope of Work from the Joint Natural Resources Committee, which provides a vital extra set of 'eyes and ears' for all parties when in the field.

Availability of vessels and port facilities

Another pressing problem is the availability of vessels, which are already in high demand. "We need a bigger fleet globally, not just installation vessels but other support vessels, such as jack-up vessels," says **Adam Reed, Global Leader – Offshore Renewables and Upstream Energy at Allianz Commercial.** "The build-out calls for more and bigger cranes, more foundations, monopiles, jackets, larger components and molds. This will all impact heavily on industry logistics and resources."

Number of wind turbine installation vessels in 2023



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

There could be a shortage of wind turbine installation vessels in Europe by the end of this decade unless adequate investments are made before 2027, while the US will struggle to meet its offshore wind target unless it acts to build new vessels, according to the GWEC. It does not expect supply constraints in China.

As demand is likely to outstrip supply, this will present a challenge for developers not only in securing a vessel when needed, but also in having a contingency in the case of issues with their current vessel. "We have already seen new-build vessels experience problems during construction and need to be replaced," says Reed. "As more projects come to market needing these large vessels, it is unlikely that substitute vessels will be available, which could result in significant delays."

Research from Clarksons suggests that $20bn of investment is needed globally to build 200 new ships if the renewables sector is to meet its 2030 targets for offshore wind.[33] Key undersupplied vessels include cable-lay vessels, construction support offshore vessels, foundation and wind turbine installation vessels.

Most of the sector's specialist vessels are currently deployed in Europe, so if an operator in Asia or the US has a problem on its offshore site, mobilizing a vessel from the other side of the world will be an expensive and costly undertaking, leading to potentially long delays as well as longer and more exposed transits. Delivering any repair or replacement elements will be more challenging.

Vessel collision with turbines and offshore infrastructure can also cause significant insurance losses, with an uptick in incidents seen in recent years, adds Dr Zhang, "although this so far has typically involved smaller vessels and is often the result of human error. Again, any incident in a more hazardous environment and further from land will be harder to rectify. Vessel hire can cost hundreds of thousands of dollars a day."

There have also been incidents involving larger vessels. In 2022, drifting bulk carrier **Julietta D**[34] collided with an offshore wind turbine foundation and transformer station in the Hollandse Kust Zuid wind farm, having previously collided with the tanker **Pechora Star** after its anchor gave way in a storm. With 2,500 wind turbines due to be installed on the North Sea before 2030, the risk of a ship to turbine collision is estimated at 1.5 to 2.5 times a year, according to the Maritime Research Institute Netherlands (MARIN).[35]

In the US, a 100-year-old federal law framework called the Jones Act adds another layer of complexity to offshore wind build-outs. The framework stipulates that only ships built, owned, and operated by US citizens or permanent residents can move cargo between US ports. As so many important offshore-wind components are currently only manufactured outside the US, this has led some companies to introduce challenging workarounds, such as ship-to-ship transfers from a cargo barge on to an installation vessel, which introduces risk factors the sector has not had to contend with previously. During the Atlantic hurricane season, these could be exacerbated by East Coast windstorm perils.

The US administration is aiming to build five to six wind turbine installation vessels to meet President Biden's offshore wind target of 30GW by 2030. The first of these Jones Act-compliant vessels, the **Charybdis**, is expected to undergo sea trials in 2024.

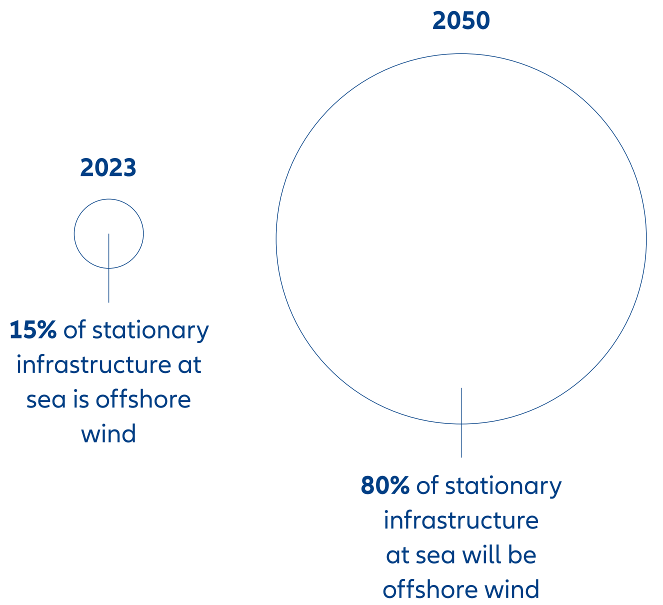
Around the world, ports will have to accommodate this increase in vessel numbers and larger turbines, requiring investment in port infrastructure and expansion. Ports will need to expand their land, reinforce their quays, enhance their deep-sea berths, and carry out other civil works, says WindEurope. This means ports will need to invest €6.5bn ($6.9bn) by 2030 to support such an expansion in Europe alone.[36]

Navigating issues around ESG

Concerns about offshore wind's impacts on biodiversity, the use of rare materials, and the various industries of the 'blue' economy highlight the need for sensitive development as the sector expands.

Ocean-linked sectors are estimated to contribute $1.5trn to the global economy. The 'blue' economy encompasses a range of industries, including the shipping, fishing, aquaculture, and tourism sectors, as well as renewable energy, and supports around 31 million jobs worldwide.[37]

Demand for ocean space will grow fivefold by 2050, according to a report from DNV.[38] Much of this demand globally is likely to be close to shore, heightening the need for co-existence planning. The report foresees offshore wind accounting for 80% of stationary infrastructure at sea by 2050, increasing from 15% today.



"With so many different interests at play on our seas, concerns have been raised about environmental stewardship and the importance of co-existence between various industries and coastal communities," says **Funke Adeosun, Global Transition Solutions Director at Allianz Commercial.** "To deliver net zero, we need to rapidly transition from high-carbon energy sources to low-carbon technologies such as wind power, but to do this responsibly, we must have the right policy environment to back the scale and speed needed to meet this ambition.

"It is important that measures are taken to minimize the environmental impact of wind energy infrastructure builds throughout the life cycle of projects. Also, project owners should have adequate levels of engagement with stakeholders and communities who may be affected. On the social side, they need to ensure they create quality green energy job opportunities in these locations."

Sourcing raw materials

Offshore wind assets rely on rare earth elements and metals like copper and lithium, some of which are sourced from a limited number of countries. The mining of these materials has raised environmental, social, and governance (ESG) concerns around human rights, corruption, emissions, and biodiversity. These issues could result in scrutiny from investors and the public, possibly leading to production disruptions and resistance to mining investments, warns the International Energy Agency (IEA).[39] This may in turn limit the supply of crucial minerals and metals, potentially derailing clean energy transitions. If businesses fail to manage these risks, they could be exposed to ESG-related regulatory, ethical and reputational criticisms.

The impacts on marine biodiversity

Biodiversity is an area of potential concern as offshore wind expands around the world. Larger wind farms can create turbulence and currents that could modify the local oceanography. Certain risks to marine wildlife are acknowledged, including the risk of collision with turbines or vessels, displacement due to disturbance (including noise), habitat loss or degradation, barrier effects (affecting migration or breeding patterns, for example), and indirect effects on the ecosystem, such as changes in the predator-prey dynamic. Researchers are also investigating the effects of power cables and electromagnetic frequencies (EMF) on marine life.

Offshore wind turbines have also been shown to increase biodiversity in some cases, by introducing new habitats for wildlife to exploit. A study conducted in the Irish Sea in the UK recently showed lobsters favored living in areas of 'scour protection' – the boulders placed around a turbine's foundations – which were functioning as an artificial reef.[40] Developers and conservation experts are exploring design features that could reduce environmental impact or promote biodiversity, including:

- A typhoon-resistant fish-farming jacket to be installed by Mingyang Smart Energy on a turbine in the South China Sea, providing a farming environment for 15,000 groupers (fishing is usually restricted around wind farms).
- The deployment of 3D-printed reefs by Ørsted and WWF Denmark at the Anholt Offshore Wind Farm in the Kattegat area of the North Sea, where overfishing, oxygen depletion, and habitat loss have led to a decline in the cod population, with knock-on effects for the ecosystem.
- Research in the Netherlands into whether painting a single turbine rotor black can reduce bird fatalities. An earlier study in Norway showed a reduction of 70%.[41] Ornithologists have also suggested painting turbines with black and white stripes could make them even more conspicuous to seabirds.[42]

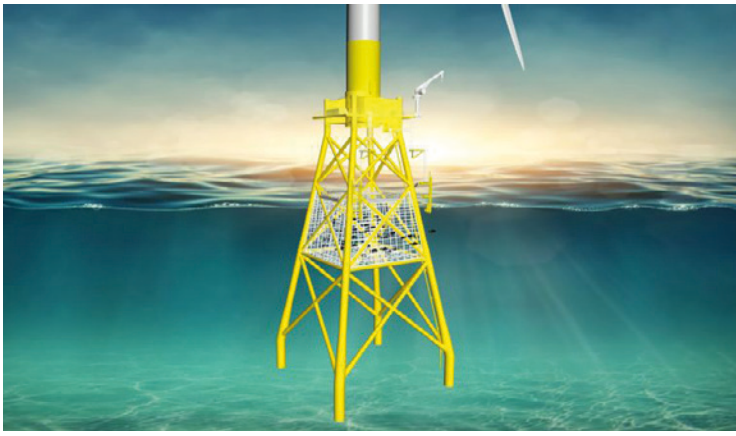
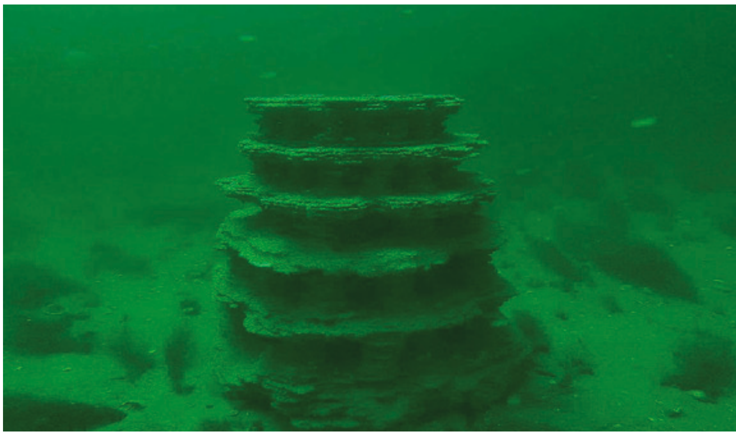


Image: Mingyang Smart Energy

Photo: Ørsted



A turbine can double up as a fish farm (top) and artificial reefs being installed at a wind farm in the North Sea (above).
Photo: Ørsted

Future-gazing: tech innovations that break the mold

In a fast-moving sector undergoing rapid change, pilot projects, concepts, and prototype technologies are pushing the boundaries of design, giving us a glimpse of what could be on stream in years to come.

Trailblazers rise to the drones challenge

A German research project is inviting drone operators to showcase their disruptive approaches to the challenges of logistics and operations and maintenance in offshore wind.

Whether it's air taxis being developed by Volocopter for the Paris Olympics in 2024, or the Sabrewing cargo vehicle that can carry almost 376kg/829lbs of payload, drones are breaking new ground in their capabilities and use cases.

For the offshore wind sector, the potential efficiencies drones represent have given rise to the Upcoming Drones Windfarm (UDW) research program, a federal-funded project conducted by the German energy company EnBW Energie Baden-Württemberg AG and the German Aerospace Center (DLR). Its goal is to identify the conditions and future actions necessary for drone operations to transport materials and, ultimately, passengers to offshore wind turbines. As part of this, the UDW project has invited drone manufacturers and providers to showcase their technologies in an Offshore Drone Challenge, with the winners to be chosen by a jury of industry experts including **Michele Williams, Global Head of Risk Consulting at Allianz Commercial.**

As much as a third of operational costs on a wind farm relate to logistics, according to **Marcus Ihle, in charge of Innovation and Conception, Renewable Energy, at EnBW.** "At the beginning of this research project, we asked ourselves, what if we could fly our engineers to work and deliver tools and components to the top of a turbine tower? How much smarter could we become with our operations and maintenance?"


Image: EnBW

Drones cost about one tenth of the operational cost of helicopters, says Ihle. "If we combined the use of drones with digitalization and artificial intelligence, we could reduce the human interface with turbines. That means we could cut craning hours, reduce the need for accommodation vessels, and cut the cost of chartering ships. We would also reduce our reliance on daylight, wave height and weather conditions, allowing us to optimize maintenance and reduce downtime."

The use case for participants in the challenge includes completing flight tasks for the transportation of materials *[see graphic]*.

Participants will need to demonstrate solutions to many challenges, explains Ihle. "If we're delivering heavy hydraulic equipment to tighten bolts, for example, we need to ensure the integrity and functions of a landing pad on a platform that may only be 15 meters in diameter. We also need to establish the technical interfaces that allow communication between the hardware in the drones and turbines, as well as the 'IT handshake', which alerts a turbine that a drone is approaching. As the turbines will probably be at least 100km from land, what provisions will be made for landing en route if it is ever needed? What form will the container for the payload take? We also need to ensure there will be stable connectivity between all concerned."

Beyond the drones and the technology, the UDW points to the importance of establishing regulatory frameworks and standardizing safety assessments and requirements going forward. “There will be many stakeholders involved, operating in multiple domains,” says Ihle. “You might have a wind farm in the Baltic Sea, but airspace is in Sweden.”

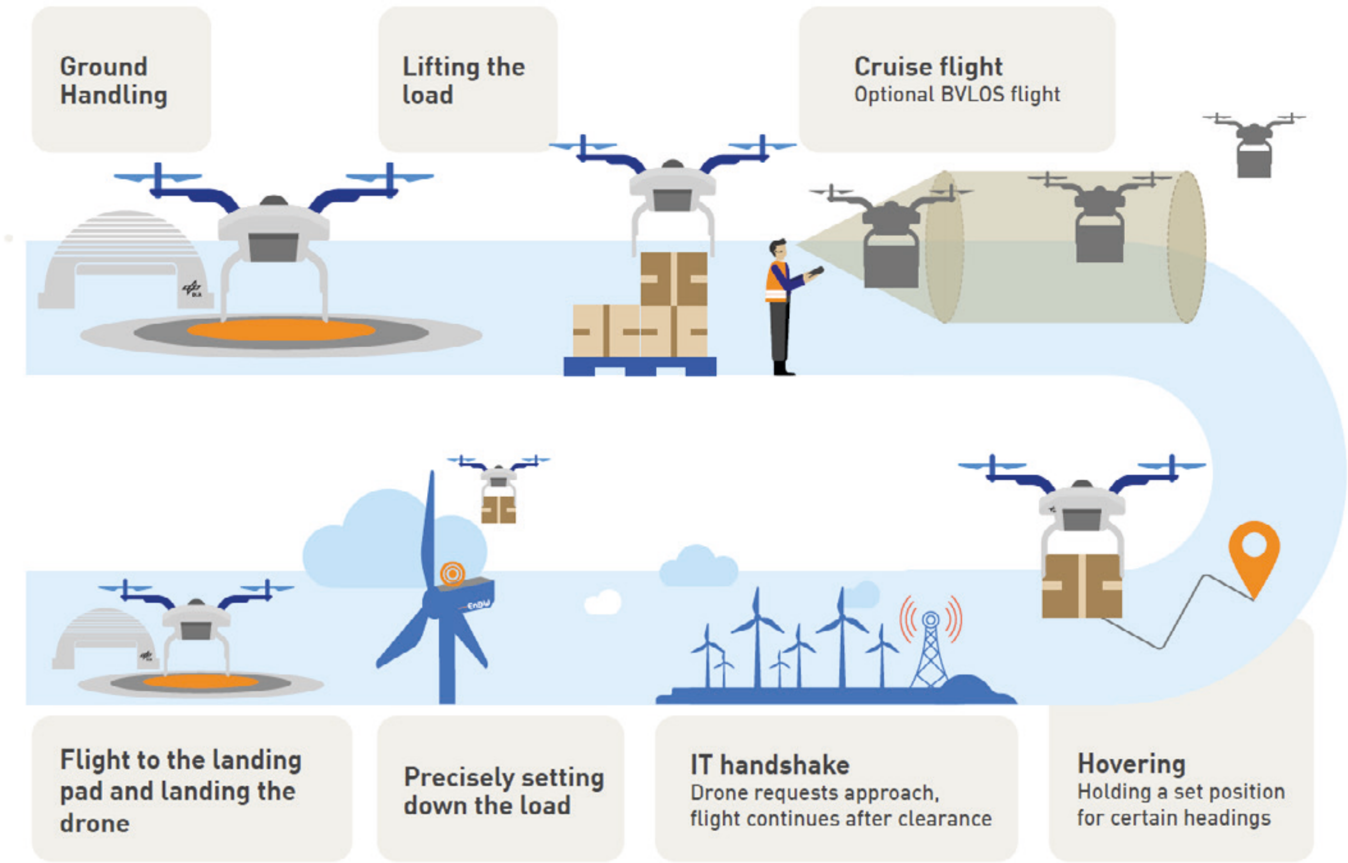
A robust business case for any new technology is a prerequisite, stresses Ihle, but also important is the timing. “Wind farms are typically planned and built over six to eight years, but with so many net-zero targets being set for 2030, we are running to tight deadlines.”

Successful participants in the challenge will demonstrate their solutions for transporting heavy equipment to wind farms in the summer of 2024. The challenge will take place at the DLR National Experimental Test Center for Unmanned Aircraft Systems.

↘ Find out more about the Upcoming Drones Windfarm project.

Offshore Drone Challenge

Innovators will be tested on seven key functions as part of the challenge set by EnBW Energie Baden-Württemberg AG and the German Aerospace Center (DLR).



Graphic: EnBW

Image: Modvion

Turbine towers made of wood

Danish turbine manufacturer Vestas has invested in a Swedish wood-technology start-up, Modvion,[43] which produces wind turbine towers made of laminated veneer lumber or LVL. Towers are usually constructed from steel and represent the most carbon-heavy component of a turbine. Modvion's towers are modular, lighter than steel, and can be transported by trucks. They are joined together with glue rather than the thousands of bolts on a steel structure that require regular inspections. The first towers have been manufactured for onshore use, but Modvion claims the technology could be used offshore with some minor adaptations. The company's first commercial installation is being built in Sweden – a 105m LVL tower that will be paired with a 2MW Vestas turbine.

Image: SeaTwirl

Twirl power

Swedish firm SeaTwirl[45] has the green light to test a floating vertical-axis wind turbine (VAWT) off the coast of Norway. The S2x has a tower connected to an underwater structure that consists of a floating component and a keel to help maintain stability, similar to on a sailboat. Most floating turbines are horizontal-axis, but a VAWT has a lower center of gravity with moving parts and electrical systems that are close to the water's surface and therefore more accessible for maintenance. VAWTs are also subject to fewer spacing constraints than conventional turbines.

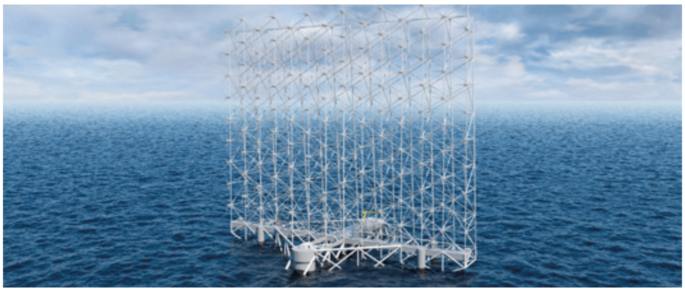


Image: Wind Catching Systems

More rotors, less space

The Windcatcher is a floating multi-rotor design concept for deeper waters from Norwegian developer Wind Catching Systems that has attracted $10mn investment from General Motors.[44] By using multiple turbines on a single floating platform, the Windcatcher technology maximizes power production per structure and reduces acreage use by 80%. Five units could produce the same amount of electricity as 25 conventional turbines and one unit could power 80,000 households. A self-contained maintenance system eliminates the need for specialized vessels to support offshore maintenance.

Image: World Wide Wind

Moving in different directions

Norwegian company World Wide Wind (WWW)[46] has created a novel design for floating offshore wind that uses two counter-rotating turbines within the same tilting mast. The CRVT, or counter-rotating vertical axis turbine, uses the same principles as sailboats by placing the heaviest part at the lowest point. It can scale up to deliver 40MW, enabling higher energy density than conventional turbines, says WWW. The low speed of the rotor blade's wing tip prevents bird strikes and the design allows for use of recyclable materials.

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