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SCOTLAND

THE FUTURE OF OFFSHORE WIND ENERGY:

HOW IT IS TAKING SHAPE IN SCOTLAND

Introduction

Offshore wind power is vital for enabling the energy transition. If net zero is to be achieved by 2050, the Global Wind Energy Council forecasts that offshore wind will need to account for around 25% of total power production worldwide. This will mean increasing the current global capacity of around 30GW to 450GW by 2030, and then more than doubling to the hugely significant 1,150GW by 2050.

Much of the vast offshore wind resources available remain untapped. Harnessing the strong and consistent winds over open waters will lead to higher energy yields and reduce visual impacts compared to onshore installations. The offshore wind industry has made significant progress in recent years and this upward trajectory looks only set to continue.

"Wind is one of the strongest renewables technologies most countries are focusing their efforts and investments. In 2015, onshore and offshore wind technologies were responsible for barely 4% of the total global power generation. By this year, it has reached 8%. And by 2035, it is expected to have a share of 15%," says Barbara Monterrubio, managing analyst of energy at GlobalData.

"There have been massive technology advances over the last decades having pushed offshore wind generation further. It's moved into deeper waters. Then there's the improved offshore technology and infrastructure, as well as taller turbines. All these factors are leading to more efficient installations.

8%

The share of global power generation that onshore and offshore wind technologies reached in 2023.

15%

The share of global power generation that onshore and offshore wind technologies are projected to reach by 2035.

"On the road to net zero, wind technology developments are key for reaching decarbonisation targets in the power sector. Also, wind installations help support other technological developments – such as green hydrogen production.

"All this combined with other technologies such as AI – used in robotics, smart monitoring, and predictive maintenance – would give a huge boost to wind power to meet increasing demand."

Scotland's ambitions

In Scotland, the rapidly growing offshore wind power sector is well placed to capitalise on such potential with more than 462,000km^2 of marine environment available and some 790 islands. This provides ample scope for expanding the possibilities of future energy production.

Offshore wind is integral to Scotland's ambitions to reach net zero by 2045, five years ahead of most other nations. Innovative projects and continued investment could see an additional 28GW of offshore wind power capacity added by 2033, comprising a mix of floating and fixed wind farms, generating clean electricity and creating employment opportunities in coastal communities.

"Offshore wind is vitally important in terms of job creation and energy security. It's essential to produce substantially more electricity for what we'll need in the future," explains David Rennie, head of low-carbon energy at Scottish Enterprise.

One key initiative is the **ScotWind** leasing round, which closed in January 2022. The round made vast areas of Scottish waters available for competitive bidding to developers for creating innovative offshore wind projects. This large-scale program is intended to significantly increase Scotland's renewable energy capacity, attracting private investment, fostering innovation, and creating jobs. Each bidder was also required to submit a Supply Chain Development Statement to indicate what they intend to purchase in Scotland – helping to grow the Scottish supply chain.

"This is a game-changer – because the leasing round was probably bigger and contained more licences than the industry likely expected," adds Rennie. "The plans there are significant and challenging, but also come with huge opportunities."

So far, the scheme has resulted in 20 projects being approved, with each initial option lasting for ten years – yet the lease will be considerably longer. Through these 20 projects, it is projected that ScotWind will raise a total of £28.8bn of investment for the country, which equates to £1bn of investment for each gigawatt of energy generated.

The expansion of offshore wind power also aligns with Scotland's commitment to sustainable growth, technological innovation, and international leadership in renewable energy – as demonstrated by hosting COP26 in Glasgow in 2021.

Furthermore, Scotland's rich history of oil & gas extraction in the North Sea provides a unique advantage in its pursuit of offshore wind opportunities. The decades of experience developed in this sector have created a robust engineering talent pool and a wealth of expertise that can be applied to developing and growing the offshore wind industry. Furthermore, Scotland's world-class universities and internationally respected institutes ensure that the next generation of engineering talent has the platform to grow and flourish.

The well-established supply chains, network of skilled professionals, and culture of innovation provide a clear pathway for Scotland to build its clean energy future on the foundations of its industrial heritage.

How Scotland leads in offshore wind

Scotland has set an ambitious target to significantly expand its offshore wind capacity, solidifying its commitment to renewable energy and combating climate change. With a goal of achieving 11GW of offshore wind capacity by 2030, Scotland is already setting about establishing itself as a global leader in this sector.

This ambition is already well underway with the construction of the **Seagreen Offshore Wind Farm** that upon completion will generate 1.1GW of power and stand as Scotland's largest wind farm and be the world's deepest. The £3bn project, which is jointly funded by TotalEnergies and SSE Renewables, is composed of 114 separate wind turbines, some of which will stand up to 280m from the sea surface and will combine to displace around two million tonnes of CO_2 a year.

But by 2030, the capacity of Seagreen will be surpassed by the **Berwick Bank** project. Located 40km off the coast of East Lothian, Berwick Bank turbines will produce an expected 4.1GW of power – contributing more than a third to Scotland's 11GW target.

Scotland is also pressing ahead with the development of floating offshore wind farms, which are not fixed to the seabed and can therefore operate in deeper waters. With the technology believed to hold the potential to double the capacity of fixed wind farms, Scotland's status as a leading developer of the technology offers major environmental, economic, and industrial gains.

This has already been shown through the development of the 30MW **Hywind Scotland pilot park**, which is the world's first floating wind farm – 29km off the coast of Peterhead. The project has been operating since 2017 and has set the highest average capacity factor of all UK offshore farms each year since.

11GW

The offshore wind capacity goal that Scotland aims to achieve by 2030.

4.1GW

The amount of power Berwick Bank project is expected to produce by 2030, more than a third of Scotland's 11GW target.

#1

Hywind Scotland was the first commercial floating wind farm in the world.

But the prospect of floating wind farms making a major contribution to renewable generation is made clearer with the **MarramWind** project off the north-east coast of Scotland. When complete, it will deliver up to 3GW of energy in waters as deep as 100m. Furthermore, 14 out of the 20 projects approved through the ScotWind leasing round are using floating turbines, with the remaining six using fixed turbines.

"Increasingly we're going to decarbonise and electrify our networks and our vehicles. Therefore, we're going to need huge amounts of electricity to do that. We're also going to need electricity to produce clean hydrogen," says Rennie.

"For a number of the ScotWind projects, there are questions about getting a grid connection. Some will and some may not. If they can't, the only way they can proceed is to produce hydrogen, and transport either back to shore or store it in some way."

Another significant step is the launch of the **Innovation and Targeted Oil & Gas (INTOG) leasing program**, which is designed to play a pivotal role in both the production of electricity and the decarbonisation of the North Sea oil & gas sector.

Operated by Crown Estate Scotland, the scheme enables developers to apply for seabed rights to provide renewable wind energy directly to existing O&G infrastructure or to carry out innovative projects that produce 100MW of energy or less.

Designed to help achieve the aims of the North Sea Transition Sector Deal, INTOG has already resulted in the approval of 13 separate projects in the North Sea that are expected to provide 5GW of renewable power to the oil & gas industry and a further 499MW through innovative projects.

"Both initiatives are hugely important. They are very much a sign of our ambition and confidence in offshore wind," comments Rennie. "Scotland has both the waters and the supply chain in order to meet this. In a global sense, it puts us up there."

Rennie explains that there is very much a focus in both initiatives on using the Scottish and UK supply chain for materials and components for ScotWind and INTOG developers.

"Developers have made a commitment, wherever possible, to use Scottish and UK content. And they have to set out plans to do that," he says. "Our job as Scottish Enterprise is to work with developers to set out what the plans are for procurement and what is their demand plan. Then work with the supply chain at the same time to see how they can match up with the demand."

Data analysis

The number of offshore wind farms needed in Scotland

Scotland currently has 1.9GW of offshore wind capacity in operation, with an ambition to add a further 27.6GW by 2034. This would require 2.3GW of extra capacity each year. However, the country is on track to produce an average of 4.6GW extra capacity a year across 41 different projects – far surpassing current targets.

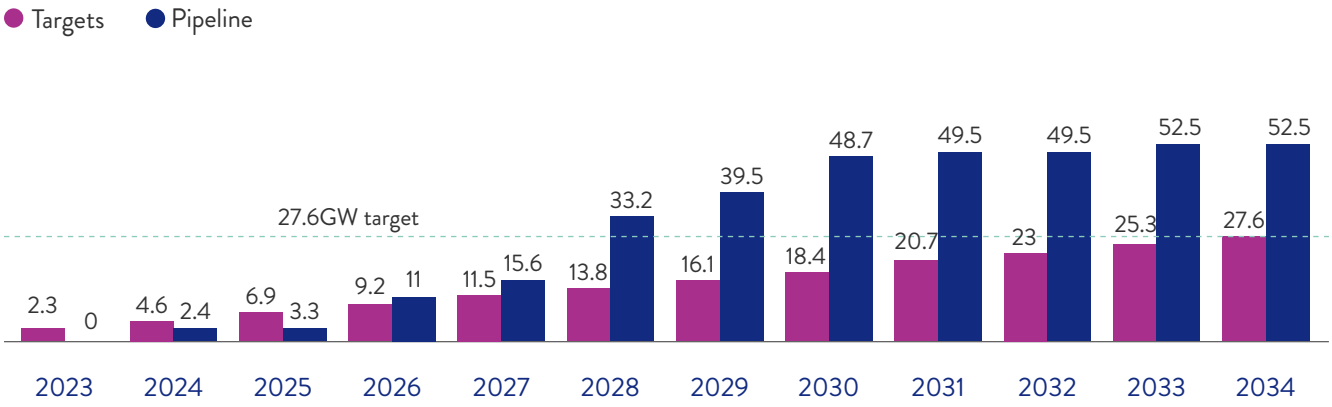
27.6GW

The extra offshore wind capacity Scotland is planning by 2034.

Scotland could meet offshore wind targets as early as 2028 if pipeline projects are approved

An extra 2.3GW of offshore wind capacity is needed a year to hit the 2034 target of 27.6GW. Scotland is on track to double this, with an average of 4.6GW a year in the pipeline.

Total capacity of pipeline offshore wind projects in Scotland, by year online



Source: GlobalData
Note: Year online is estimate

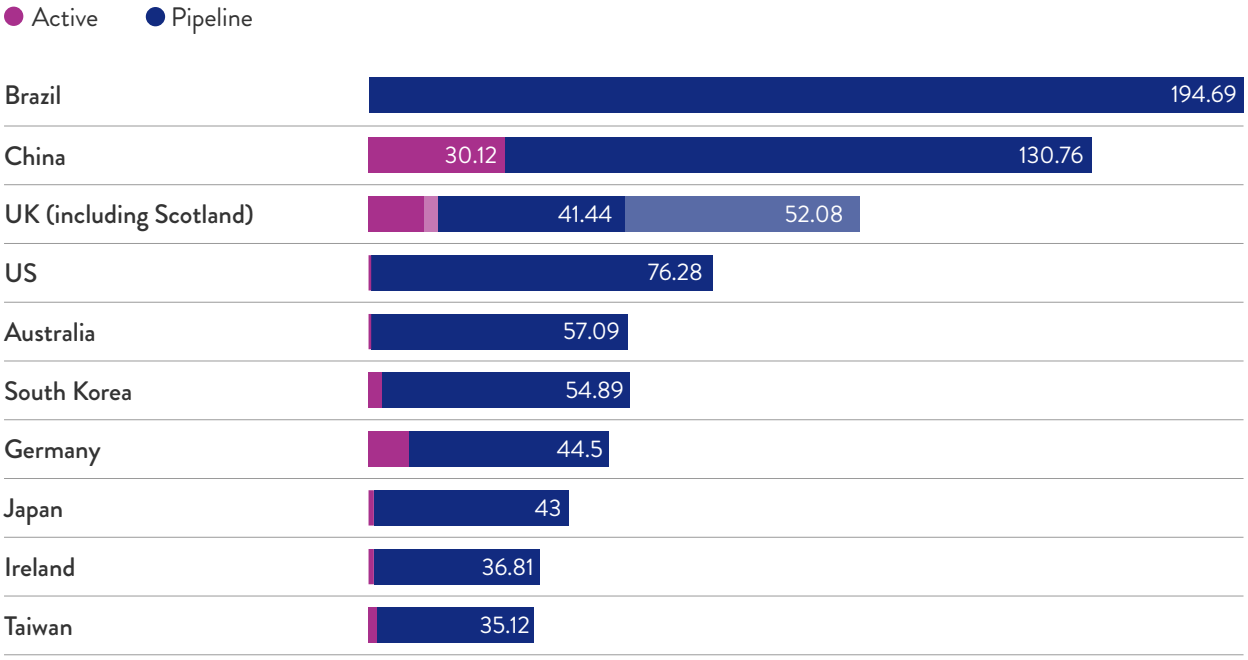
Data analysis

How does Scotland compare?

Overall, the UK has the third largest offshore pipeline in the world, with 93.5GW of capacity currently being planned. Scotland forms a significant majority of this with 52GW in the pipeline. On its own, Scotland's offshore pipeline would outrank the rest of the UK combined. Key to enabling such ambitious projects has been the drive and investment from the Scottish Government, alongside trusted industry partners and private investors.

Scotland is a world leader with its active and pipeline of offshore wind projects

Countries by active and pipeline offshore wind capacity (GW)



Source: GlobalData

Data analysis

Who are the biggest players?

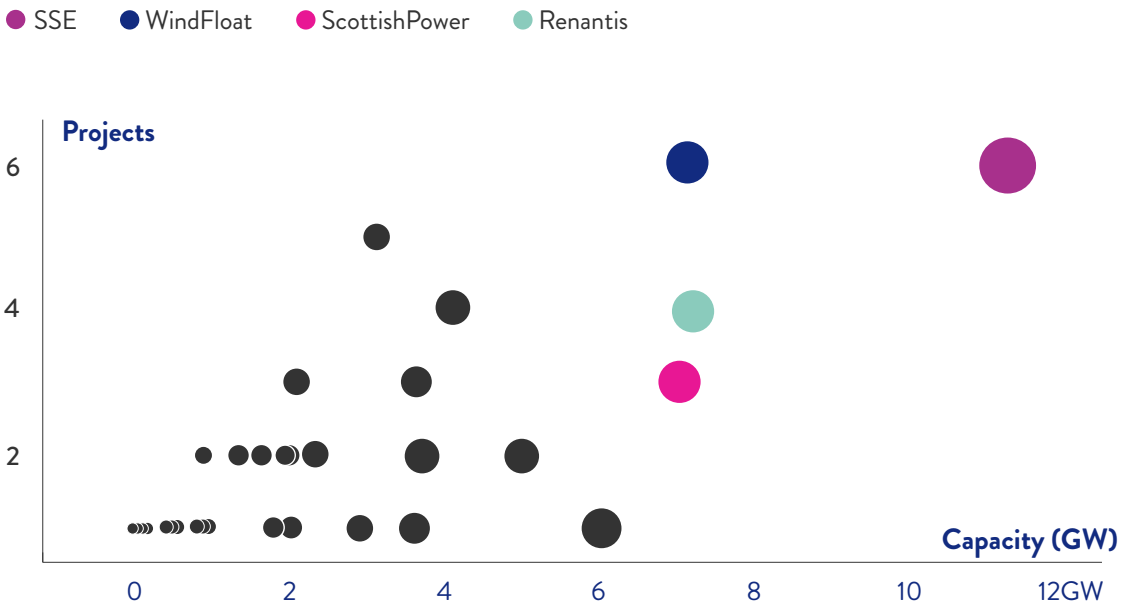
SSE is the biggest player by some margin, planning nearly 12GW across six projects. WindFloat, ScottishPower and Renantis are also significant players.

12GW

The capacity that SSE is planning across six projects.

SSE, WindFloat, ScottishPower, and Renantis are the biggest players in Scottish offshore wind

Offshore wind companies in Scotland, by number and capacity of pipeline projects



Source: GlobalData
Note: Many projects are collaborations between multiple companies. The chart is not representative of the total number of projects or total capacity.

Scotland's ambitions

Wind turbines are getting bigger. This growth in both size and power represents a major advancement towards improved efficiency and higher energy production. The enlargement of turbine designs relies on the most efficient materials, advanced aerodynamics, and engineering innovation to capture greater volumes of wind energy. Consequently, the deployment of fewer of these larger turbines can achieve the same energy generation capacity as their smaller counterparts. However, the continued growth of turbines presents challenges for the supply chain.

Nevertheless, advances in technologies represent a major step forward to not only minimise the visual impact of offshore wind farms on the marine landscape but also optimise ocean space utilisation. Additionally, larger turbines often entail reduced operational and maintenance costs per unit of energy yielded.

Furthermore, the adoption of floating wind turbines marks a pioneering advance in offshore renewable energy technology, especially in deeper waters. These innovative structures extend the possibilities of harnessing wind energy in locations previously deemed inaccessible.

Deeper waters offer stronger and more consistent wind flow, resulting in increased energy production potential. This advancement expands the geographical scope for offshore wind energy projects, enabling nations with deeper territorial waters to tap into their offshore wind potential.

Innovations in technology and predictive maintenance are optimising offshore wind assets. Advanced technologies such as sensors, data analytics, and predictive algorithms allow offshore wind operators to foresee potential equipment issues and maintenance requirements with precision. This intelligence minimises downtime, increases uptime, prolongs the lifespan of assets, and can result in significant cost reductions.

And advances look only set to continue in Scotland with the **Floating Offshore Wind Centre of Excellence** established by ORE Catapult, bringing together government, academia, and the industry in a triple helix approach to further capabilities. In fact, the ORE Catapult's founding focus in 2013 was to be the UK's leading centre for accelerating offshore wind innovations, covering R&D, testing, and growing the supply chain.

Scotland's ambitions

Establishing offshore wind as a major source of energy generation comes with significant challenges.

The provision of grid connections for emerging offshore wind farms, for example, poses significant challenges that demand innovative solutions. One prominent challenge lies in the remote locations of these farms, often distant from existing onshore grids. This requires the construction of extensive subsea cables and transmission infrastructure, resulting in substantial upfront costs and technical complexities.

However, these challenges can be overcome through strategic planning and technology integration. Shared grid infrastructure among neighbouring wind farms can optimise resource utilisation and bring down costs. Moreover, advances in high-voltage direct current (HVDC) technology enable efficient long-distance transmission, minimising energy losses.

Collaboration between governments, energy companies, and grid operators is crucial in overcoming such challenges. Regulatory frameworks that prioritise offshore wind integration and incentivise grid expansion can prove highly effective. Additionally, ongoing research and innovation in energy storage solutions will help alleviate strain on grids during peak demand.

Hydrogen and battery storage solutions also promise to play a critical role in addressing the challenge of curtailed wind energy, where excess wind power often goes to waste due to grid limitations. Both technologies offer efficient ways to store and release surplus energy, enhancing grid flexibility and reducing waste.

By integrating hydrogen and battery storage, the issue of curtailed wind energy can be addressed. These technologies not only optimise renewable energy utilisation but also enhance grid stability and resilience. As the world moves towards greater renewable integration, hydrogen and battery storage become crucial in unlocking the full potential of wind energy while ensuring a reliable and sustainable power supply.

What the future of offshore wind could look like

The future of offshore wind in Scotland holds immense promise, marked by a combination of innovation, challenges, and a solid commitment to sustainable energy solutions. As the nation seeks to achieve its ambitious goal of 11GW of offshore wind capacity by 2030, several key trends and developments are shaping the path forward.

One pressing challenge in the offshore wind sector is the eventual decommissioning of existing wind farms as they reach the end of their operational life. Typically, wind farms have an operational life of 25 years. Therefore, many of the newer wind farms built recently will need either decommissioning or renewing before net zero arrives.

Scotland is already developing expertise in decommissioning onshore wind farms. **ScottishPower Renewables' Hagshaw Hill** was Scotland's first commercial wind farm but is now in the decommissioning process of old assets and replacing them with new turbines. This expertise will be in increasing demand as ageing assets need upgrading or taking down across Scotland.

25

The number of years a wind farm is typically operational.

35%

The possible savings made in embodied carbon by using recycled materials to manufacture new turbines, according to Zero Waste Scotland.

However, this challenge is also an opportunity to embrace the principles of the circular economy. By applying strategies that prioritise the reuse, recycling, and repurposing of materials, Scotland can minimise waste and environmental impact. Decommissioned turbines, for instance, can be disassembled, and components can be refurbished or used in other industries. This approach not only mitigates the environmental impact but also feeds into the circular economy by reducing the need for raw materials and lowering overall costs. According to Zero Waste Scotland, using recycled materials to manufacture new turbines could result in 35% savings of embodied carbon.

"At the moment, there is a focus in Scotland on development. But in time, there will be opportunities for the supply chain. Because if you put it up and install it, you can take it down," says Rennie.

"What I think we'll see over the next maybe five to ten years is more and more companies focused on both onshore and offshore decommissioning.

"Over a 25-year period, a lot of the spend on offshore wind is operations and maintenance. So, building that supply chain for day-to-day maintenance is really important and part of that is decommissioning. That's a big opportunity for Scotland."

Increasing efficiency and new technologies

Efficiency gains in turbine technology remain a driving force in the evolution of offshore wind. Continued research and development (R&D) are resulting in larger, more efficient turbines that can produce more energy from the same amount of wind. This increase in efficiency not only enhances energy generation but also contributes to a more cost-effective energy solution. As turbine design and manufacturing processes improve, Scotland's offshore wind farms will become even more competitive in the global renewable energy landscape.

Another exciting development on the horizon is the concept of energy islands. These are large-scale offshore hubs that integrate renewable energy sources, including offshore wind, with energy storage solutions and potentially even interconnections to neighbouring countries. Energy islands can serve as major power generation centres and distribution points, ensuring a stable supply of clean energy while also reducing the strain on existing land-based infrastructure. This innovative approach aligns with Scotland's commitment to fully utilise its abundant natural resources for maximum benefit.

"There are many projects and new technologies still in R&D but have proved very promising, from bladeless wind turbines to wind vibration membranes to capture wind power," adds Monterrubio. "Wind energy technologies have been in constant evolution to capture more power."

Unlike traditional turbines with rotating blades, bladeless designs use innovative mechanisms such as oscillating poles or airfoils to capture the wind's kinetic energy. This concept aims to reduce maintenance costs, noise, and bird collisions associated with traditional turbines. However, bladeless turbines could be used in more built-up areas and are unlikely to challenge the dominance of three-bladed turbines in offshore environments.

As new technologies emerge, collaboration among industry, academia, and government will prove vital. Initiatives that encourage knowledge-sharing, cross-disciplinary research, and innovation are essential to driving progress in offshore wind technology and its associated sectors. Scotland's favourable policy framework and commitment to supporting research and development provide an effective environment for such collaborations to flourish.

Business opportunities in offshore wind

Scotland's ambitious renewable energy goals present abundant opportunities for wind energy suppliers and companies to contribute significantly to the nation's sustainable future. With commitments to achieve net zero by 2045 and generate 50% of its energy from renewables by 2030, Scotland offers a major opportunity for innovation and growth in the wind energy sector.

The economic potential is equally compelling. The growth of wind energy projects stimulates job creation across various sectors, from manufacturing and construction to research and development. This, in turn, bolsters local economies and fosters skills development.

Crucially, Rennie estimates that if all the ScotWind and INTOG projects come online and scale up according to plans, the value of all the required components, structures, and materials – such as nacelles, foundations, towers, routers, cables, substations – could exceed £80bn.

"There's a lot of different opportunities for the supply chain, our job is to promote that opportunity," he adds.

As Scotland envisions a greener future, wind energy suppliers and companies have a huge opportunity to not only position themselves as key players in a fast-growing market but also to contribute to a more sustainable and resilient energy landscape. All of this will contribute to advancing Scotland's global leadership in offshore wind energy and making a substantial contribution towards meeting its net zero ambitions.

50%

The share of energy that Scotland aims to generate from renewables by 2030.

£80bn+

The value of all the required components, structures, and materials for the ScotWind and INTOG projects if all scale up according to the plans.

For more information about Scotland's offshore wind sector, visit the SDI website. Or to get in touch about investing in Scotland's offshore wind sector, click here.