Floating offshore wind

The quest for scale

Harvesting wind in previously inaccessible seabed areas has many advantages, but there are some obstacles that need to be overcome before we can deploy floating offshore wind at scale. One of the main challenges is the lack of standardisation in emerging technologies. Additionally, significant investment in port infrastructure is required to make deployment feasible.

Executive summary

Fixed-bottom turbines currently dominate the global offshore wind market, but their limitations in deep waters make floating alternatives attractive to scale up offshore wind deployment.

Floating wind, forecasted to reach more than 25 GW by the mid 2030s, offers numerous advantages, including access to higher wind speeds further out at sea, expanded seabed areas, and reduced environmental impact during installation and operation.

Key players, such as the UK, the US and China, and numerous European countries, are making significant allocations for floating offshore wind projects. But despite the potential, the mass roll-out of floating wind turbine faces technical challenges. These include a lack of standardisation in the emerging technologies around foundation design, as well as supply chain constraints, leading to a relatively high levelised cost of energy.

Overcoming these barriers requires substantial investment, port infrastructure development and policy support. As countries race to achieve their energy transition goals, floating offshore wind is likely to be a crucial technology for renewable energy production, but realising its potential will require careful planning and a mix of innovation and co-operation.

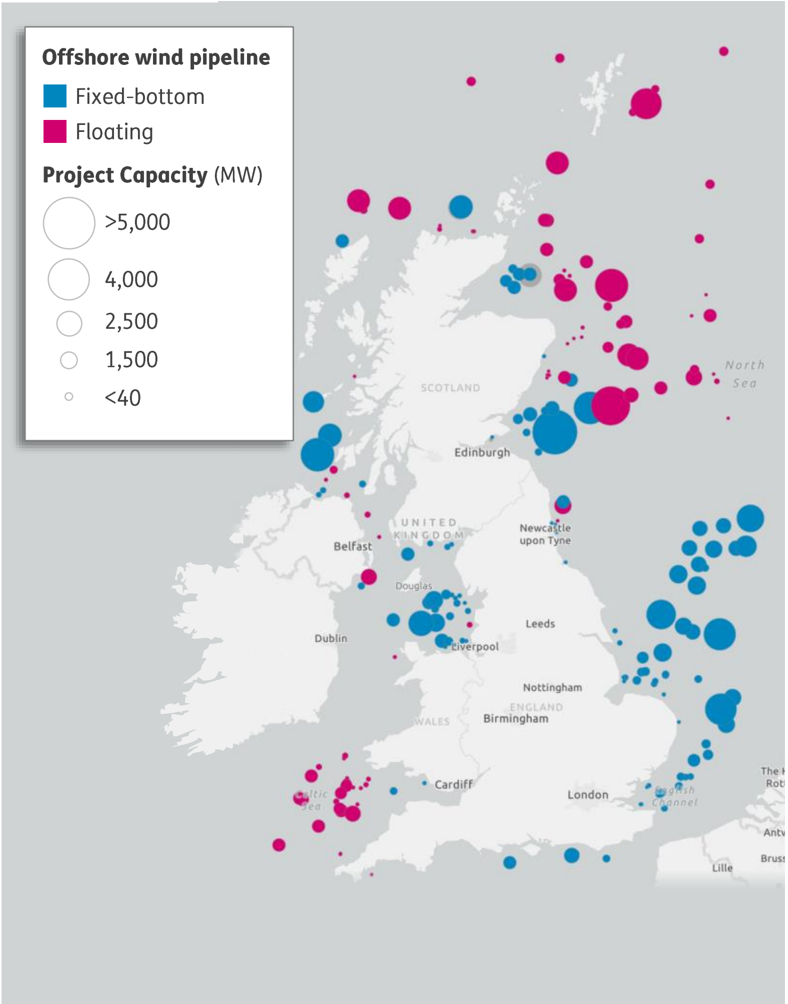
Floating offshore wind: the quest for scale

Fixed-bottom offshore wind farms – wind farms with foundations built into the seabed – constitute more than 99% of today's commissioned capacity of offshore wind. But such technologies are limited to water depths below 60 meters, after which pile installation, flange design and welding for plates thicker than 120mm become challenging. This is a significant limitation, particularly for those numerous countries that have very limited shallow waters near their coastline.

However, floating offshore wind – wind turbines with floating foundations anchored to the seabed – is forecasted to reach over 25 GW by the middle of the next decade (from negligible levels today), driven by recent and forthcoming allocations in countries such as the UK, the US, China, Japan, South Korea, France, Norway, Portugal and Spain.

The UK is projected to be the market leader in 2035 with around 8GW of total capacity, followed by the US with close to 5 GW. The figure to the right shows developers' early-stage interest in projects in the UK's seabed, split between fixed-bottom and floating offshore wind.

***Figure 1:** Baringa's map of UK offshore wind early-stage interest in projects from developers, fixed-bottom and floating*

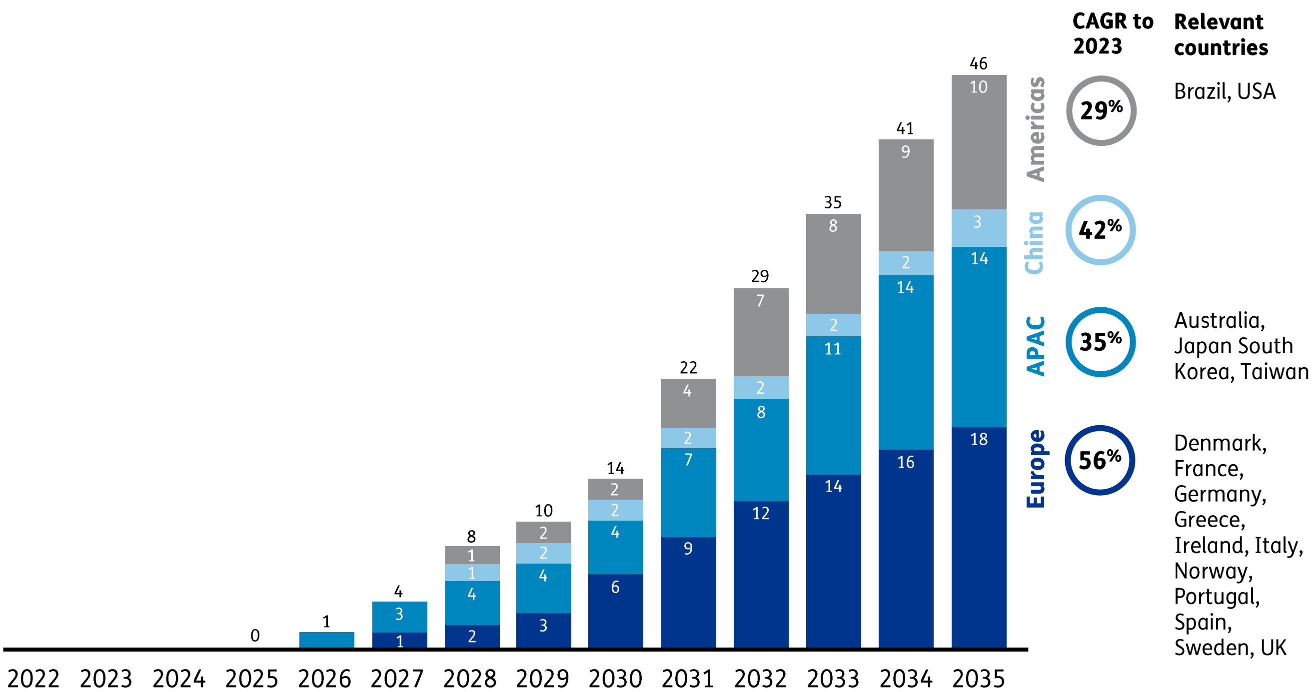


- **UK Key Floating Allocations:** In January 2022, Crown Estate Scotland awarded almost 28 GW of offshore capacity in the ScotWind leasing round, with the majority of the 20 chosen projects being floating wind farms, equal to around 17 GW. In March 2023, it also selected 13 projects with 5.5 GW total capacity in the Innovation and Targeted Oil & Gas (INTOG) round. Meanwhile, The Crown Estate is preparing to formally launch the leasing round for the first commercial-scale floating wind farms in the Celtic Sea later this year, delivering up to 4.5 GW capacity.

- **US Key Floating Allocations:** In December 2022, the US awarded five lease areas off the coast of California, the first US leases for floating offshore wind, with a capacity of 5-8 GW depending on technical design. The US has also identified two draft Wind Energy Areas (WEAs) offshore southern Oregon, with a lease round due to take place in 2024, allocating 2.6GW of floating wind technologies.

- **Other European countries** such as Portugal, Spain and Italy are also expected to hold their first floating offshore wind auctions in 2024.
- **Colombia** has also announced it will award its first offshore wind permits in 2024, both for fixed-bottom and floating, officially kicking off offshore wind in Latin America.

***Figure 2:** Estimate of cumulative floating offshore wind capacity entering construction, by region (GW)*



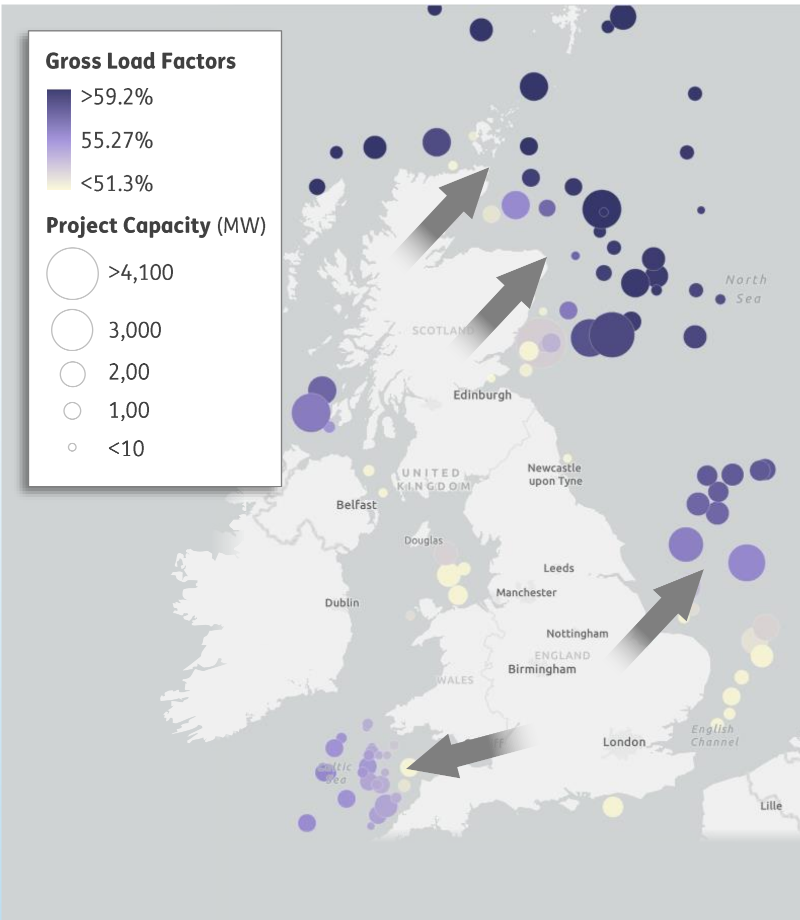
Floating offers strong benefits

Floating offshore wind provides various advantages compared to fixed bottom.

Floating wind farms can access higher wind speeds and avoid potential constraints. Wind speeds tend to be higher, the further from shore (as illustrated in the map to the right for GB), where water depth is also typically greater, allowing for greater load factors and annual energy production.

In addition, moving further away from shore typically offers greater optionality relating to environmental impacts or shipping and fishing areas.

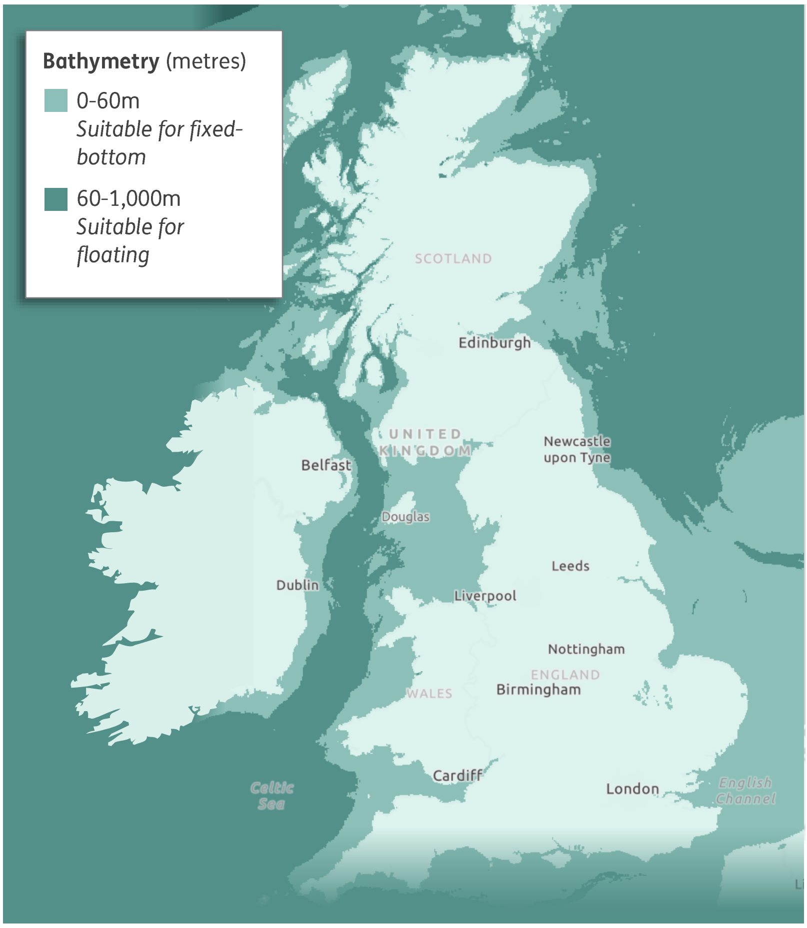
Figure 3: *Baringa's map of offshore wind gross load factors (does not include TLM, curtailment, wake effects), Source: Renewables. Ninja*



Floating offshore wind allows for development across a significantly wider seabed area. In more advanced offshore wind markets such as the UK, floating technology unlocks new seabed areas for offshore wind deployment, as illustrated in Figure 4, which shows the country's sea bathymetry (map of sea depth). A World Bank sponsored study suggests that more than 70% of global technical potential for offshore wind is in waters over 50 metres deep, and hence is likely to require floating wind. Indeed, some countries, including many in the Asia-Pacific region and the Mediterranean basin, have steep underwater features, meaning that floating offshore wind is the only offshore technology which can be deployed at scale.

Moreover, floating offshore wind farms are also able to support the decarbonisation of the offshore oil and gas sector by accessing these deeper sea areas. Currently, 5 GW of floating offshore wind capacity from the INTOG auction is intended to power UK offshore oil and gas platforms in the North Sea, reducing or eliminating the need to use gas for electricity generation on those platforms.

***Figure 4:** Baringa's map of UK offshore wind Bathymetry and thresholds for fixed-bottom and floating wind, bathymetry from GEBCO 2022*



- **Installation is less invasive for local wildlife than fixed bottom.** Indeed, drag anchors, SEPLA anchors, and other anchoring solutions make the installation process less invasive for fish and marine mammals as noise is minimised, compared to piling installation. The majority of fabrication and assembly can be done in port, before the structure is then towed offshore, without requiring expensive and scarce installations vessels used for fixed offshore wind farms.
- **Finally, floating structures have historically been used in the oil and gas sector**, providing direct knowledge of foundation technologies, project management, vessel operations, cabling, balance-of-plant, operations and maintenance, as well as in the workforce and its transferable skills. There are already direct cross-overs with electrification projects being developed in the North Sea, through Scotland's INTOG but also Equinor's Hywind Tampen in Norway, the world's largest offshore wind farm of 88 MW that became fully operational in August 2023 and will supply nearby oil and gas platforms.

Why it hasn't scaled yet

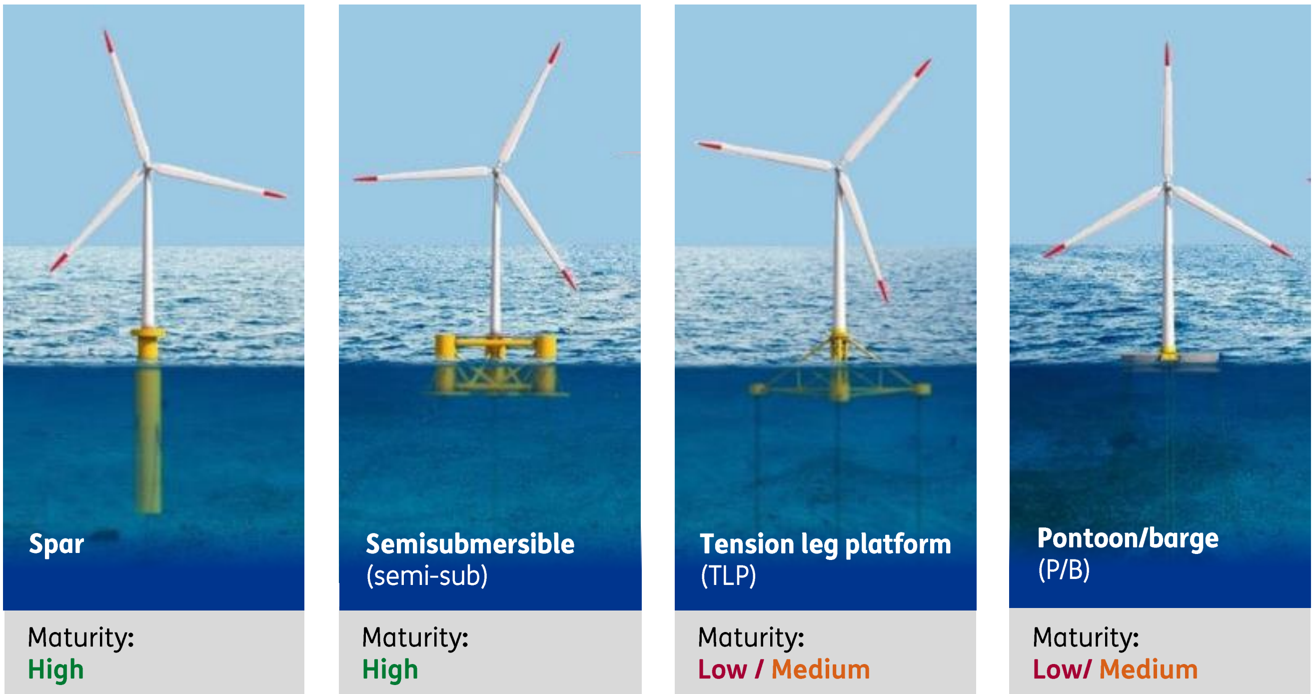
Despite the benefits and opportunities of floating wind, significant barriers to deployment remain. Key issues are the **lack of standardisation of floating foundations** due to the limited number of commercial scale projects to date, **supply chain constraints** for key components and services, and the **higher levelised cost of electricity** for floating wind.

Today, the 14 fully commissioned floating wind farms globally have an average capacity of 15MW, with the biggest ones being the Hywind Tampen in Norway (88 MW), Kincardine in Scotland (48 MW), WindFloat Atlantic in Portugal (25 MW) and Hywind Scotland (30 MW). Notably, China has begun construction of a 1GW project Hainan province.

With every development being unique in terms of water depth, seabed type and environmental conditions, **foundation technology standardisation and selection is a challenge for developers**. This has knock-on impacts for port operators, who are unable to coalesce around a consistent standard for port facilities such as water depth at portside, laydown areas, and wet storage areas.

The four main structure types are spar buoy, semi-submersible platform, tension leg platform and barge.

Figure 5: *Floating offshore wind foundation designs (this image was adapted from Wind Europe).*



- **Spar** is the simplest concept, achieving inherent stability although at a high weight, and also requires complex manufacturing at a high cost. However, it requires much deeper waters and is therefore not suitable for many locations.

- **Semi-sub** is the most popular concept. It is overall lower risk and benefits from a broader weather window for installation and slightly lower weight than Spar, although it requires dry dock for its complex fabrication.

- **TLP** has attractive dynamics, however it is not deployed widely. It offers high stability while being a simple and light structure. However, it is unstable during assembly and requires a special installation vessel, making it the most expensive design type, although at almost half the weight of Spar.

- **Barge** is the shallowest foundation type, able to accommodate various seabed conditions and is buildable in steel, concrete or hybrid, offering flexibility. It is however highly complex, demanding a more robust mooring system.

The Spar and Semi-sub technologies are getting closer to readiness for full-scale deployments. In Europe, about 85% of projects in the pipeline are currently aiming to use semi-sub technology.

Across the offshore wind value chain, the tight supply chain could result in long timelines for delivery and risk meeting the ambitious targets set by different countries, such as the UK's 5 GW by 2030 and the US' 15 GW by 2035. Based on a survey undertaken by Baringa, the supply chain constraints are mostly concentrated on the floating foundations, export cables, port infrastructure and vessel availability. Foundation constraints are mostly driven by the uncertainty of design and preferred materials for the foundation and a limited supplier base with most only operating at the pilot-scale thus far.

Constraints around export cables, particularly in the UK, arise due to competition from grid upgrades and other interconnectors, as well as a lack of technicians for installation and testing.

Meanwhile, port infrastructure requires significant investment, as well as collaboration between developers on upgrading ports, which can be tricky given the competitive nature of subsidy allocations and wider market uncertainty. Also, ports are not generally optimised in terms of location, infrastructure, water depth, available space for fabrication, and storage, to support developing floating offshore wind at scale.

Finally, installation and operations and maintenance vessel availability can also prove challenging, as the final assembly (with the turbine installed on the substructure) can only be towed at 3-3.5 knots, involving a much higher weather window risk.

The novel nature of floating foundation technologies inevitably makes it higher cost than fixed bottom equivalents. As a result, floating offshore wind farms are expected to need higher level of subsidies for a number of years to allow the technology to scale and become more competitive – although it remains unclear if or when true cost parity with fixed bottom wind will be achieved.

State sponsorship

Governments have followed different approaches when it comes to budgeting for auctions and providing overall funding for support.

Norway's government enterprise, Enova, provided a technology development grant of $2.1m to Wind Catching Systems, which is developing a floating multi-turbine structure named the Windcatcher to support its design, construction and testing.

Support also takes the form of government grants or loans, with France having secured €2bn to support the construction and operation of the first commercial-scale FOFW farm in France; Sud Bretagne. Meanwhile, some countries allocate large sums to the development and commercialisation of technology, with Spain pledging to invest at least €200m in FOFW R&D and innovation, as part of its plan to promote offshore technologies.

In the UK, the recent CfD allocation round 5 showed a lack of participation of offshore wind across fixed bottom and floating, largely linked to the combination of a challenging macro-economic environment, with a price cap on those technologies. The price cap was since increased significantly for both fixed bottom and floating offshore wind in AR6, which, together with the new pot structure, will likely result in a more favourable outcome for offshore wind projects.

Moving forwards, significant investment is needed to develop the necessary roadmap for port infrastructure and supply chain in order to support industrial-scale floating offshore wind. In many countries this is likely to require government support, in the form of grants, direct investments, loan / revenue guarantees, or similar models.

To be deployed at scale, offshore wind must overcome these barriers

The design of floating foundations is perhaps the most challenging obstacle. There is a trade-off between the competition required to spur innovation and the benefits of a uniform design. Given the implications of foundation design on supply chain investments and requirements, it is important that the industry quickly aligns on a set of preferred technologies.

The scale required for future floating offshore wind development will also involve substantial requirements for supply chain upgrades across its different components. Taking the example of ports, WindEurope estimates that Europe must invest €6.5bn by 2030 to support offshore wind development.

The UK's Floating Wind Offshore Wind Taskforce also published a report with an estimated need for £4bn investment in ports to ensure the country's readiness for mass floating wind deployment by the end of this decade. A total of 11 ports would likely need to be upgraded, with a minimum of three-to-five ports needed in Scotland to install turbines onto the floating bases, and a further two ports needed to service the Celtic Sea sector. Currently, the Port of Nigg in Scotland and Port Talbot in Wales are well positioned for floating foundation deployment. Similarly, the US is projecting a need for £8bn investment in ports alone to establish a supply chain by 2030.

Such infrastructure development presents a significant coordination problem as forward visibility around project pipelines are needed to make private investors comfortable, while significant floating offshore wind deployment cannot take place at scale without infrastructure investment. There is a clear role for policy support in this area and governments around the world are considering ways to stimulate the supply chain through new criteria in competitive allocations, grants, and tax credits such as the IRA in the US.

Support for the technology

Cost parity between fixed and floating offshore wind has drawn significant attention in the effort to deploy floating assets. Due to the expected evolution of key cost components, combined with significant supply chain tightness and a lower scale of deployment, we expect floating offshore wind to remain at a premium against fixed bottom until the late 2030s. However, a number of countries have introduced ring-fenced support for the technology as part of revenue support schemes and targeted CAPEX grants, which allow for initial deployment in spite of the cost premium.

As countries are racing to meet their energy transition goals, they will be faced with a choice of ensuring renewables deployment at scale or falling behind their decarbonisation objectives. Offshore wind is a key technology which allows the scaling of renewables, and countries pushing their decarbonisation agenda will need to find a way to scale deployment in the coming decades. In light of this, floating offshore wind appears an obvious technology to deploy because it unlocks new production areas in established and new offshore wind markets.

Supply chain development will also provide local energy-related jobs, as countries seek to transition away from fossil fuel and transition their workforce towards other sectors. There are therefore broader social considerations which may be accounted for in the development of floating offshore wind, which may well justify a premium against fixed bottom in the coming years.

If you're interested in hearing more, please get in touch with one of our experts:

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