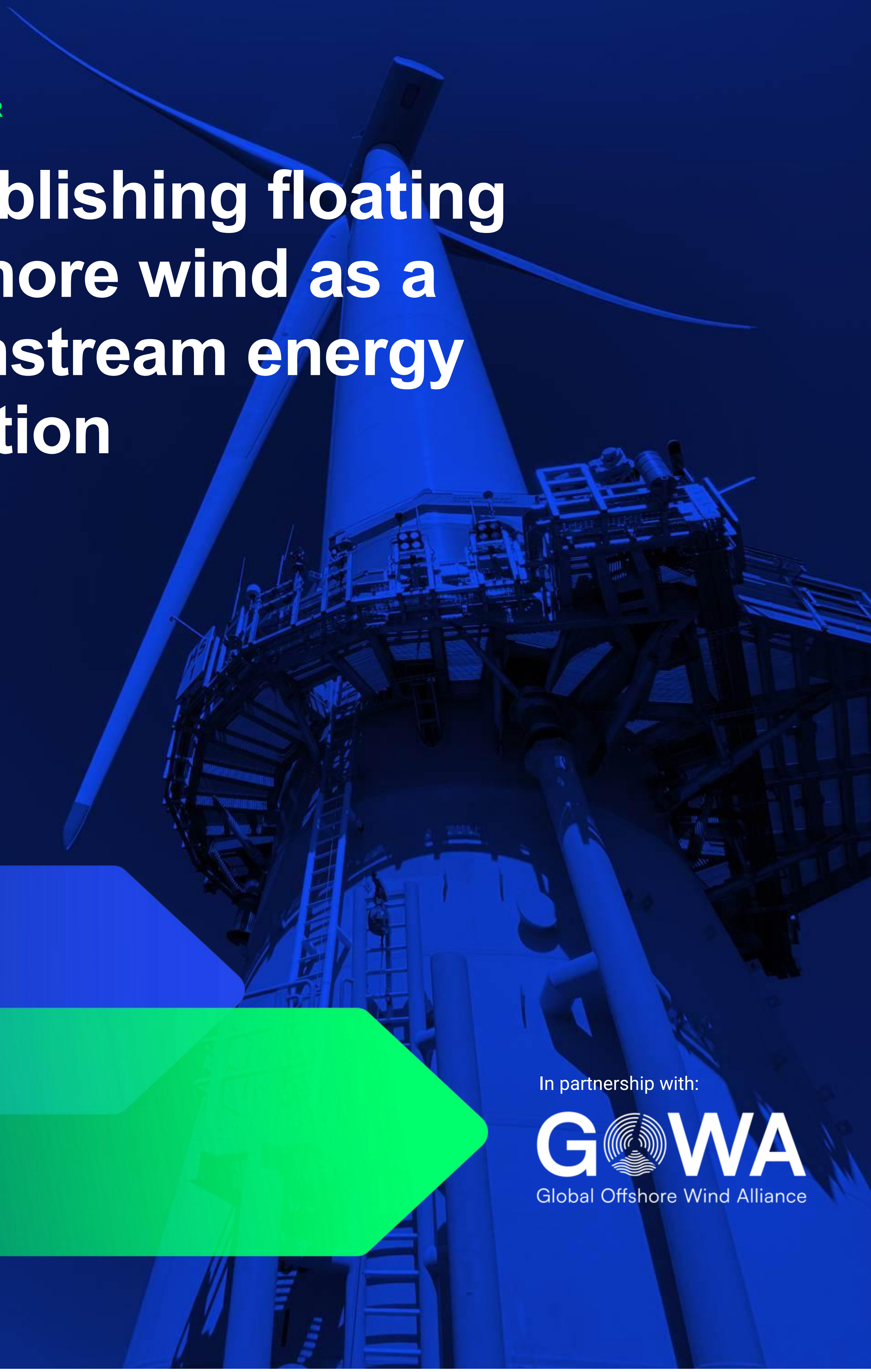
CARBON TRUST | OFFSHORE WIND

WHITEPAPER

Establishing floating offshore wind as a mainstream energy solution

February 2026



In partnership with:

GOWA
Global Offshore Wind Alliance

Acknowledgments

The Carbon Trust prepared this whitepaper through an impartial analysis of primary and secondary sources, complemented by valuable industry input.

The Carbon Trust would like to thank all those who contributed their time and expertise to the peer review of this whitepaper, including the GOWA co-founders and selected experts from across the global offshore wind community.

For the avoidance of doubt, this report expresses the independent views of the authors.

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Who we are

The Carbon Trust

Our mission is to accelerate the move to a decarbonised future.

We have been climate pioneers for more than 20 years, partnering with leading businesses, governments and financial institutions globally.

From strategic planning and target setting to activation and communication - we are your expert guide to turn your climate ambition into impact.

We are one global network of 350 experts with offices in the UK, the Netherlands, South Africa, Singapore and Mexico. To date, we have helped set 200+ science-based targets and guided 3,000+ organisations in 70 countries on their route to Net Zero.

GOWA
Global Offshore Wind Alliance

Global Offshore Wind Alliance

The Global Offshore Wind Alliance (GOWA) is a multi-stakeholder alliance that unites governments, industry leaders, civil society, and international organisations to raise ambition and accelerate the deployment of offshore wind worldwide.

GOWA was founded by the Government of Denmark, the International Renewable Energy Agency (IRENA), and the Global Wind Energy Council (GWEC).

GOWA is supported by the Ocean Resilience and Climate Alliance (ORCA), a philanthropic initiative that seeks to identify and fund ocean-climate solutions across mitigation, sequestration, adaptation, and resilience.

Foreword

Amisha Patel
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Floating offshore wind (FLOW) is no longer a question of technical feasibility. According to GWEC, with over ~278 MW of floating capacity now operational across more than 15 projects globally, the technology has demonstrated real-world viability and readiness for broader deployment. Progress now depends on building a strong and predictable project pipeline that can attract investment and drive economies of scale, enabling scalable commercial deployment.

This whitepaper provides an independent, evidence-based assessment of where the FLOW sector stands today. It explores the structural barriers holding FLOW back, and most importantly, the practical steps required to move forward. The whitepaper draws on lessons from the commercialisation of other renewable technologies and translates them into a clear framework for action, tailored to the unique characteristics of FLOW.

Around the world, governments are grappling with the same reality: electricity demand is rising rapidly, the pressure to decarbonise is intensifying, and delay is no longer an option in the shift to secure, renewable and affordable energy. For many countries with large coastlines, particularly those with deep waters, limited land availability, or heavy reliance on imported fuels, FLOW is the only scalable pathway for secure domestic renewable energy aligned with net zero targets.

Yet despite more than a decade of demonstration projects and a growing global pipeline, FLOW remains stuck in a pre-commercial holding pattern. Costs remain high in part due to the small scale of early projects, where mobilisation and demobilisation costs have a disproportionate impact on project economics. With the technology now proven, the focus must shift to enabling larger-scale developments that can deliver commercially viable business cases.

The Global Offshore Wind Alliance (GOWA) commissioned the Carbon Trust to develop this whitepaper to explain the opportunities and challenges facing FLOW and outline the pathway towards commercialisation. The Carbon Trust brings deep insight into this analysis, drawing on its long-standing leadership in offshore wind (OSW), built over more than a decade of work with governments, developers, supply chain actors, and innovators to accelerate deployment, reduce technology risk, and shape effective policy frameworks across both fixed- and floating-wind.

GOWA was established to raise ambition for OSW and accelerate deployment by facilitating international cooperation. The Alliance unites governments, industry, civil society and international organisations to turn ambition into delivery. As OSW expands beyond established regions and into emerging markets, the need for coordination has never been greater. The success of FLOW depends on a global approach including shared learning across regions, aligned policy signals, coordinated supply-chain planning, and early action by first-mover governments to de-risk investment and unlock scale.

The intent is not to prescribe a single pathway, nor to suggest that FLOW should replace fixed-bottom OSW. The two technologies are complementary, and both are essential to meeting global energy and climate goals. Treating FLOW as simply an extension of existing OSW policy risks repeating past mistakes, including applying mechanisms designed for mature technologies to a technology that still requires targeted support, tailored market design, and deliberate coordination.

This white paper is designed to support GOWA members and the wider global OSW network in exactly that task: informing bilateral and multilateral discussions, shaping policy interventions, and underpinning a new phase of international and regional cooperation on FLOW. It's also intended to contribute directly to the development Global Cooperation on Floating Offshore Wind - an ambition to be led by GOWA to align governments around shared ambition, coordinated action, and collective delivery.

This work has been made possible through the collaboration and engagement of a wide range of partners. GOWA is grateful to the Ocean Renewable Capital Alliance (ORCA) for its continued support in enabling independent, evidence-based analysis to inform global OSW acceleration. We also thank GOWA's co-founders the Government of Denmark, the International Renewable Energy Agency (IRENA), and the Global Wind Energy Council (GWEC) for their strategic guidance. We further acknowledge the valuable inputs and constructive challenge provided by members of the GWEC Floating Offshore Wind Accelerator Taskforce, whose industry perspectives have helped ground this work in the practical realities of delivering FLOW at scale.

The next few years will be decisive, and without intervention, FLOW risks remaining perpetually "over the horizon", promising, but unrealised. With coordinated action, it can become a cornerstone of a secure, affordable, and resilient clean energy system.

Photo of the WindFloat Atlantic project courtesy of Principle Power and Ocean Winds

Executive summary

Global electricity demand is expected to double by 2050, and offshore wind (OSW) will play a critical role in meeting this demand. However, fixed-bottom OSW alone cannot unlock the scale or geographic diversity required to meet this target and achieve global decarbonisation goals. With 70% of OSW resources located in deeper waters, floating offshore wind (FLOW) is critical to expanding renewable energy, strengthening energy security, and supporting economic transitions.

FLOW has moved beyond demonstration, with national targets exceeding 40 GW and major projects advancing. Yet progress is uncertain. Rising costs, inconsistent policy signals, supply chain constraints, and high perceived risk have slowed momentum, leaving the global pipeline far short of what is needed. Even under a high-growth scenario, FLOW would reach only 260 GW by 2050, well below the pace required to align with global climate goals. Coordinated action is essential to move beyond business-as-usual and unlock FLOW's economic, industrial, and energy security benefits and establish FLOW as a mainstream global energy solution.

This whitepaper identifies four levers for commercialisation - economies of scale, attractive policy landscapes, learning-by-doing and targeted R&D. While all four are necessary, **policy must come first**. Clear, stable targets, predictable auction schedules, and tailored revenue mechanisms are essential to unlock investment, build supply-chain capacity and enable repetition and volume required for commercial scale.

The FLOW industry is ready: the technology is proven, early projects demonstrate strong performance, and global developers and suppliers stand prepared to invest. Yet the **industry is at a stalemate**: developers need clearer policy, suppliers need confidence in future demand, and governments want to see cost reduction before providing stronger support.

What is needed now is a coherent international commitment to create favourable market conditions. Over the next few years, governments must move beyond ambition toward coordinated, durable policy action that treats FLOW as a distinct technology.

1. Introduction

Global electricity demand is expected to double by 2050,[1] driven by increased access, system electrification and the growth of data-intensive sectors. At the same time, amid geopolitical volatility, government leaders are increasingly wary of dependence on imported fossil fuels and the long-term environmental impacts of traditional energy generation.

Offshore wind (OSW) is one of the few renewable technologies that can meet this demand at scale, providing significant opportunities for cost reduction through industrialisation and proximity to major coastal demand centres. For these reasons, OSW is set to play a critical role in the future energy mix. IRENA estimates that 2,465 GW of OSW will be needed by 2050 to meet this additional electricity demand and achieve decarbonisation.[2]

Offshore wind development must scale rapidly to support a decarbonised future

OSW offers clear advantages and must be considered as part of the global renewable energy mix:

- **Energy security:** Countries with limited fossil fuel resources rely heavily on energy imports, leaving them exposed to geopolitical risks and supply-chain instability. Expanding OSW deployment helps to diversify energy production and strengthen domestic capacity, thereby reducing dependence on foreign energy and the associated economic volatility. For a country like Japan, which imported 87% of its energy in 2023, the cost benefits of OSW could be substantial; estimates suggest that 1 GW of OSW could cut Japan's annual fossil-fuel import bill by more than USD 300 million.[3]
- **Grid system value:** OSW offers a more consistent profile than onshore wind or solar PV, lowering dependence on additional storage infrastructure and improving grid reliability. Its proximity to demand centres, given that 15% of the global population lives within 10 km of the coast and most major industrial clusters are located along the coast, means transmission distances and system losses compared to inland generation are reduced.[4] It has baseload characteristics and provides an ideal complement to the overall energy mix. A diversified energy mix can reduce system operating costs by lowering exposure to fuel volatility, enhancing system flexibility, and reducing reliance on high-cost peaking generation.[5]
- **Cost competitiveness:** Fixed-bottom OSW remains cost-competitive in relation to other non-renewable sources. This is despite cost increases driven by supply chain disruptions, higher financing costs and policy uncertainty.
- **Growing the blue economy**: OSW development unlocks significant blue economy opportunities by enabling the efficient use of the seabed for clean electricity generation. It also leverages port and shipyard capabilities, creating skilled maritime jobs.

[1] Enerdata, Energy & emissions projections 2050, Final consumption, accessed December 2025 - Link

[2] IRENA (2023), World Energy Transitions Outlook - Link. IRENA is currently in the process of updating this figure.

[3] McKinsey (2020), Japan offshore wind: The ideal moment to build a vibrant industry – Link

[4] Cosby, A.G., Lebakula, V., Smith, C.N. et al. (2024), Accelerating growth of human coastal populations at the global and continent levels: 2000–2018 - Link. Over 1 billion people were found to live within 10km of water.

[5] Ikevuje et al (2024), Optimizing the energy mix: strategies for reducing energy dependence - Link

As of 2025, 83 GW of OSW has been installed worldwide, with an additional 48 GW under construction.[6] GWEC forecasts that with an ambitious 30 GW annual build-out, 350 GW of OSW will be deployed by 2034. Yet, even if this pace continues through to 2050, global OSW capacity would reach just over 880 GW, far short of IRENA's estimate of 2,465 GW by 2050. Closing this gap would require an annual build-out of 95 GW of new OSW per year until 2050, more than three times the projected installation rate.

Fixed-bottom OSW alone cannot deliver the scale, geographic reach or long-term pipeline required to close this gap. The sector must expand beyond fixed-bottom installations and accelerate the deployment of floating offshore wind (FLOW).

Floating wind is an essential part of the technology mix

FLOW is expected to play a central role in enabling a just transition, unlocking new regions of OSW potential and delivering economic growth. It is a **necessary complement** that broadens the overall offshore wind portfolio, and unlocks several additional benefits:

- **Higher capacity factors:** Deep-water sites suitable for FLOW are typically much farther offshore. On average, these sites offer stronger, more consistent wind speeds and achieve capacity factors above 60%, resulting in higher electricity yield per unit of installed capacity.[7]
- **Unlocks additional resources:** Deeper waters hold the majority of the world's OSW potential; 70% of the technically available resource lies in waters suited to FLOW.[8]
- **A just transition and economic revitalisation**: For regions facing the decline of fossil fuel activity, FLOW provides a practical route to diversifying the economy whilst safeguarding industrial capabilities and retaining industrial skills. FLOW can leverage existing offshore oil and gas (O&G) expertise and infrastructure, preserving high-value jobs and reducing capital costs.
- **Economic potential:** FLOW's long-term economic potential is substantial, though the rate at which benefits materialise will depend on a country's industrial base, investment appetite, policy environment and supply chain maturity. The United Kingdom estimates that achieving 24 GW of installed FLOW capacity by 2050 could create approximately 97,000 new jobs.[9]

The scale and nature of these benefits will depend on the country's pathway to FLOW. More mature OSW markets, such as the United Kingdom and the People's Republic of China, can leverage their experience to expand domestic supply chains and secure additional economic benefits. Established industrial economies with limited OSW deployment but strong maritime or manufacturing bases can capture substantial value by supporting early deployment of FLOW. Meanwhile, emerging markets with limited existing capabilities can attract investment and build a new industry from the ground up.

How these opportunities are realised depends not only on technology potential and existing capabilities, but also on a government's strategic priorities and interventions. The choice between leading early deployments or acting as a fast follower can shape how the industry evolves globally.

[6] GWEC (2025). Global offshore wind report - Link

[7] American offshore wind academy (2025), Beyond the horizon: The future of offshore wind is floating - Link

[8] ESMAP, World Bank (2025) - Link

[9] RenewableUK (2025), Floating wind: anchoring the next generation offshore - Link

The global potential of FLOW

Achieving a successful **global** energy transition will require developing OSW in markets where deployment is currently limited, expanding into new regions where it is non-existent and, in many cases, where fixed-bottom technology is not feasible. The FLOW industry will be inherently global, and coordinated international action will be crucial to achieving its full potential.

Figure 1 illustrates the scale of global FLOW technical potential. For countries with steep continental shelves, limited land availability and rapidly growing electricity demand, such as Japan (where 94% of offshore technical potential is in FLOW suitable waters), South Korea (88%) and Chinese Taipei (86%), FLOW may be the only scalable, domestic renewable energy source. This underscores the critical role of FLOW in unlocking new renewable resources and supporting the long-term growth of OSW.

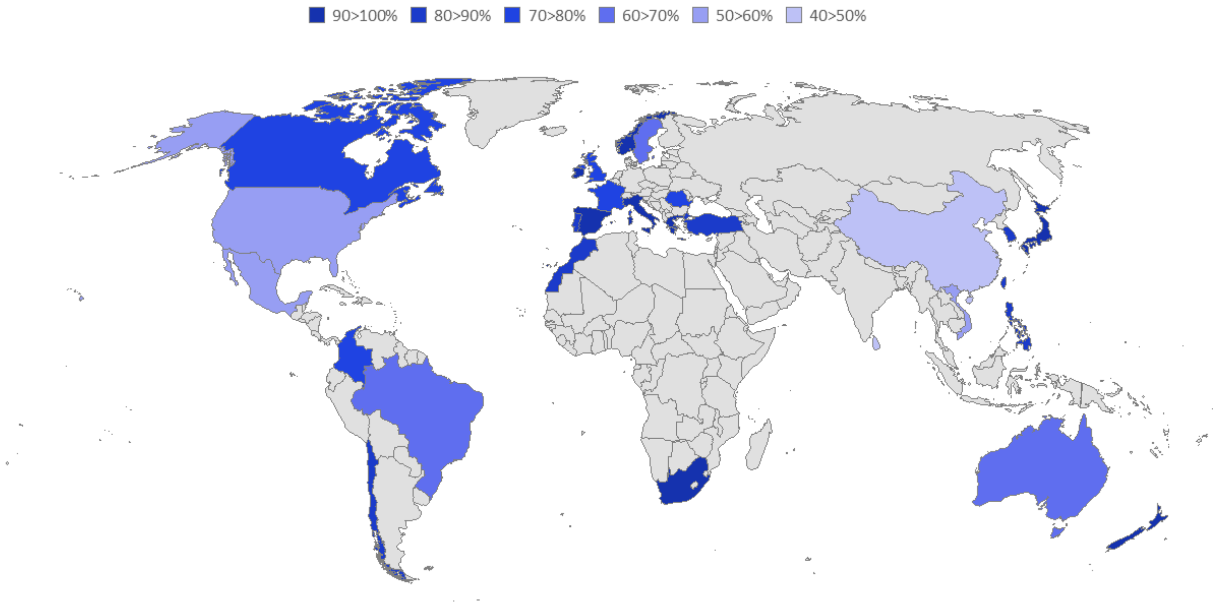

Figure 1. Global countries with floating resources as a percentage of their total offshore technical capacity. Source: World Bank ESMAP.[10]

FLOW is transitioning to commercial deployment, but progress remains uncertain

The FLOW industry has transitioned from demonstration to a global development pipeline of hundreds of gigawatts, underpinned by increasing government ambition and private-sector investment. Globally, national FLOW targets now exceed 40 GW,[11] and several FLOW-specific leasing rounds are advancing in the United Kingdom, Norway, France, China, South Korea, the Philippines, Australia, and the United States. Scotland alone holds 24 GW of seabed option agreements suited to FLOW development. Alongside several smaller projects currently in development, major commercial-scale projects are

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[10] Assessed countries are shown in blue, with the proportion of their FLOW technical potential relative to total potential indicated by shading. Countries were evaluated based on whether they have an existing FLOW pipeline, are actively engaging in FLOW market discussions, or have FLOW potential identified through the World Bank roadmap or other sources. Countries shown in grey were not assessed.

[11] GOWA and EMBER (2025), Offshore wind targets underpin acceleration to 2030 and beyond – Link

progressing, including the 560 MW GreenVolt project in the United Kingdom and the 750 MW awarded through France's large-scale FLOW tenders, AO5 and AO6.

Despite this progress, momentum is stalling. Confidence in the global pipeline is weakening, and slow advancement in several markets is generating uncertainty about the industry's ability to scale. Persistent delays risk locking the sector into a business-as-usual trajectory, which risks abandoned seabed leases, stranded assets and underutilised supply chains.

Securing final investment decisions for projects in development will be essential to restoring market confidence and realising the industry's potential. The critical question now is whether these projects can be delivered. This whitepaper explores the solutions required to turn this potential into reality.

Accelerating FLOW deployment is a necessity

GWEC estimates that 19 GW of FLOW could be realised by 2034, with an annual installed capacity of 5.7 GW achieved in 2034.[12] To better understand the long-term outlook, we analysed the existing project pipeline, national FLOW targets, World Bank growth scenarios and current momentum of global FLOW markets. The assessment produced two distinct scenarios for 2050, illustrated in Figure 2.

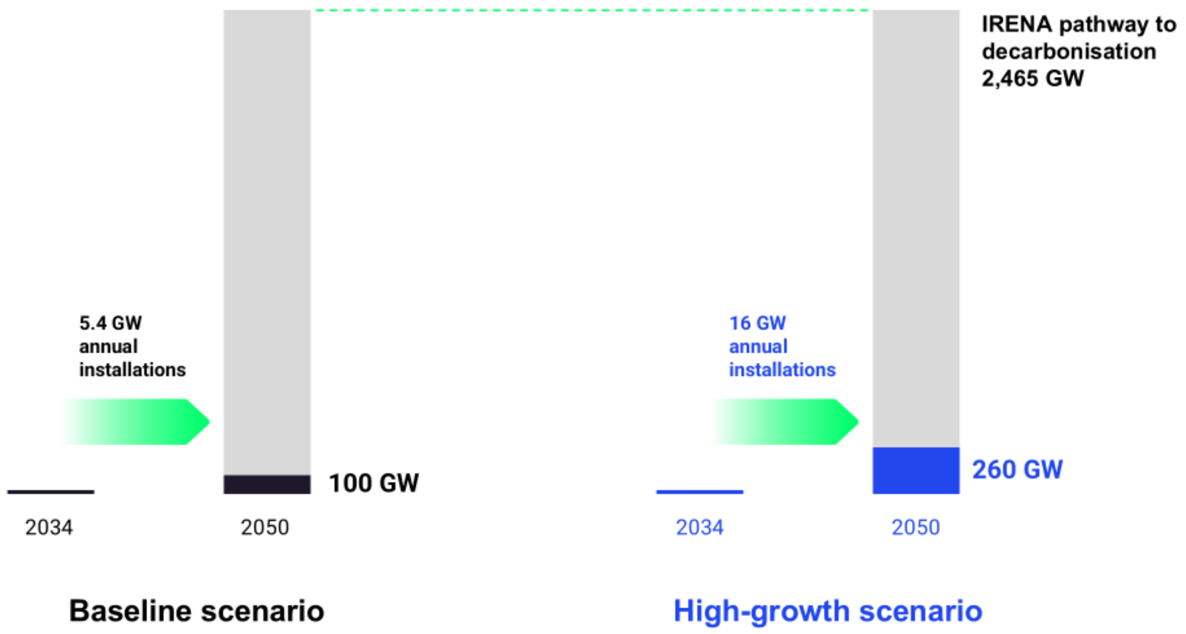

Figure 2: 2050 baseline and high growth scenarios as a percentage of IRENA's 2050 target.

- In a **baseline scenario, FLOW reaches 100 GW** of installed capacity by 2050. This outcome assumes only 17 countries will actively participate in the FLOW industry due to stalled progress. Following GWEC's baseline of 19 GW in 2034, achieving the low-growth scenario of 100 GW by 2050 requires a feasible annual installation rate of 5.4 GW from 2035 to 2050.
- A **high-growth scenario is more optimistic, projecting FLOW to reach 260 GW** of installed capacity by 2050. This assumes that all countries with FLOW targets will meet them, even if their targets are delayed, and that 24 countries are actively participating in FLOW. Following

[12] GWEC (2025), Global Offshore Wind Report 2025 - Link

GWEC's baseline of 19 GW of FLOW in 2034, achieving the high-growth scenario would require a much steeper annual installation rate of 16 GW from 2035 to 2050.

These projections reflect a business-as-usual trajectory that significantly underdelivers on FLOW's potential. Even in the high-growth scenario, annual FLOW installations average 16 GW, far below the 95 GW per year required to close the gap to align with IRENA's decarbonisation pathway. Failing to close this gap would result in ongoing dependence on energy imports and a loss of the economic and strategic benefits that OSW can deliver. Expecting fixed-bottom OSW to fill the remaining gap is unrealistic, particularly since regions where renewable energy is most urgently needed are constrained by deep waters.

This makes it even more critical to break away from business-as-usual and create favourable market conditions to unlock FLOW's potential. With all renewable technologies currently facing headwinds, **decisive action is essential** to accelerate the deployment of FLOW and secure its role as a critical part of the global energy mix.


Photo of Hywind Scotland courtesy of Alistair Morris

2. FLOW industry progress and challenges

Despite early enthusiasm for FLOW, progress has been slow. Figure 3 illustrates the cumulative capacity trajectory for fixed-bottom and FLOW projects over their first two decades of deployment, respectively. During the first decade, both technologies achieved comparable installed capacity. However, in the second decade, fixed-bottom projects demonstrated steady, year-on-year growth, whilst additions to FLOW capacity have lagged.

By 2030, we anticipate reaching a significant FLOW milestone of more than 2 GW of installed capacity, driven by projects such as GreenVolt (560 MW) in the United Kingdom and Firefly (750 MW) in South Korea. However, if project milestones are missed, the industry risks falling even further behind the growth trajectory of fixed-bottom wind and could start to lose momentum.

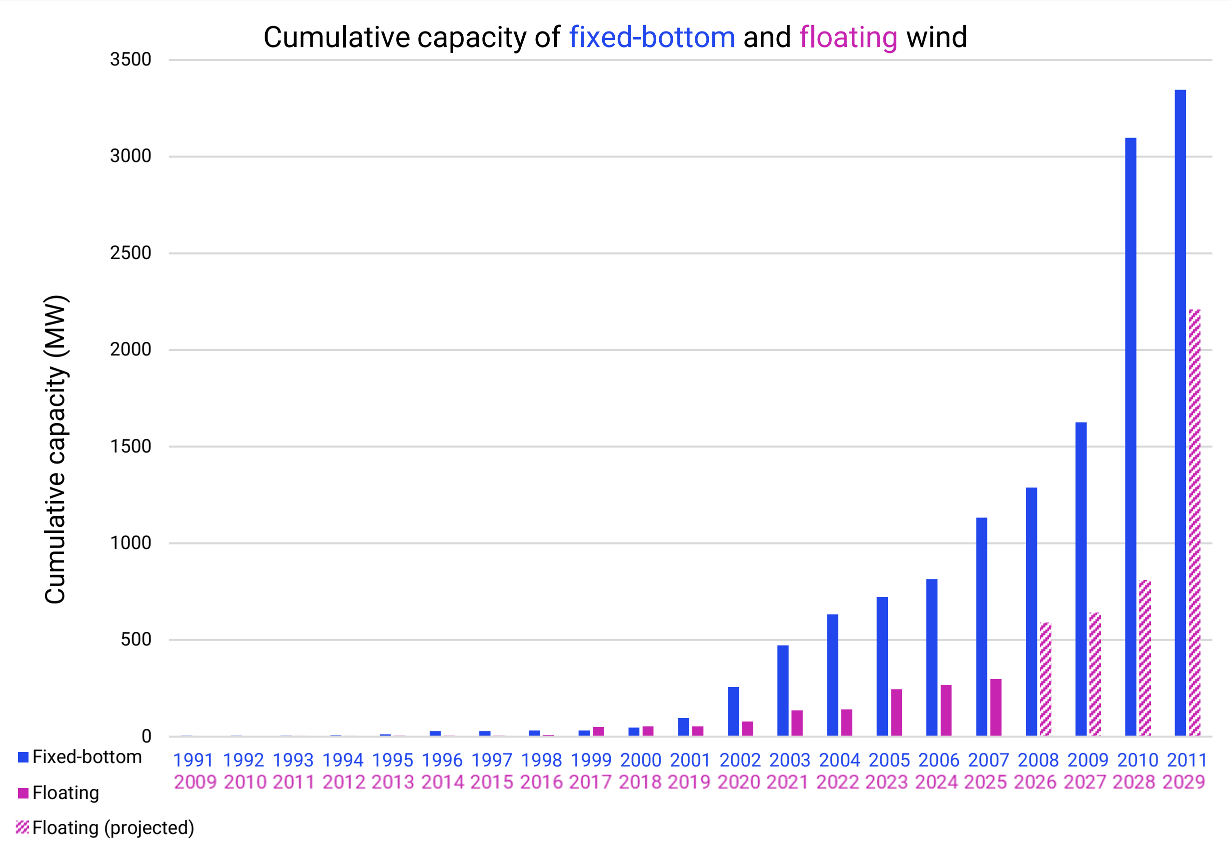

Figure 3: Cumulative capacity for fixed-bottom and floating wind. Data source: 4COffshore.[13]

To understand why FLOW has been slow to progress, it is essential to recognise how broader OSW challenges are shaping the environment into which FLOW is emerging. Over the past few years, the OSW industry in general (fixed-bottom) has faced:

- **Rising costs and affordability constraints:** Higher inflation and interest rates have undermined project economics, affecting raw material and labour costs, supply chain bottlenecks and increased premiums. This increase in costs has contributed to failed auctions and missed

[13] The first fixed-bottom OSW farm is considered as Vindeby in 1991, which used 0.45 MW turbines. The first deployment of 2 MW fixed-bottom turbines occurred in 2000 at the Blyth OSW farm. The first FLOW deployment is considered as the Hywind Demo in 2009. FLOW projects deploying turbines smaller than 2 MW are excluded.

financial investment decisions (FIDs), most notably Hornsea 4, creating gaps in project delivery and the supply chain pipeline.

- **Inflexible auction design:** Auction frameworks historically rewarded optimistic bidding rather than robust delivery planning. Fragile business cases, impacted by rising costs, and inflexible supply chain contracts, have struggled to absorb major shocks. Where governments have been slow to adjust auction parameters to reflect market conditions, developer participation has declined.[14]
- **Grid, planning and permitting delays**: Project and grid planning processes have not kept pace with government targets or leasing rounds, delaying projects and raising questions about the credibility of future pipelines.
- **Supply-demand imbalances**: Short-term disruptions in pipelines, due to failed auctions or missed FIDs, and longer-term uncertainty over auction pipeline, have weakened supplier confidence, increased costs and reduced willingness to invest in new capacity.

As a consequence, shareholder pressure has pushed developers to refocus on viable projects in mature markets. The previously abundant development pipeline has tightened, and only projects with strong, defensible business cases are progressing. This has slowed the globalisation of OSW and reduced geographic diversity at a time when major expansion is required. International geopolitical uncertainty further exacerbates this trend, increasing required investment-return premiums and elevating supply chain risk.

These converging industry-wide challenges define the landscape in which the FLOW industry is attempting to commercialise. These challenges have created a market environment in which financing is more difficult to secure, supply chains are more fragmented, and developers are more risk averse. FLOW is now on the brink of commercialisation but requires a step change in scale, industrialisation, and policy clarity to unlock its full potential.

Against this backdrop, some of the most pressing challenges for FLOW are:

Sustained high costs driven by short-term economic volatility

FLOW remains significantly more expensive than fixed-bottom OSW because it is still in the early stages of commercialisation and requires additional engineering to manage the dynamic behaviour of the floating substructures. These technical demands are further compounded by short-term economic volatility, preventing FLOW from achieving the scale-driven cost reductions observed in fixed-bottom technologies, which were achieved during a period of relative economic stability, low inflation, and fixed compensation schemes (for example, through feed-in-Tariffs and Renewable Obligation Certificates).

As a consequence, FLOW projects face high upfront costs, reflected in the United Kingdom's recent Contracts for Difference (CfD) Allocation Round 7, where two early-stage 100 MW FLOW projects

[14] Notable fixed-bottom examples include the Netherlands Nederwiek 1-A site, Germany's N-10.1 and N-10.2, Denmark's 6 GW North Sea auction and the UK's AR5, all of which saw no bids due to misaligned auction conditions. The governments are now responding to this by reevaluating the auction conditions.

cleared at £216.49/MWh.[15] These small awards do not yet capture the efficiencies expected at commercial scale.

Despite high current costs, FLOW has significant potential for cost reduction, particularly through modularised and industrialised production, as discussed in the next section. DNV estimates that the levelised cost of energy (LCOE) could drop by 59% by 2060, bringing costs to approximately USD 100/MWh, competitive with other generation sources.[16]

Inconsistent policy signals and a lack of long-term visibility

A lack of clear, long-term FLOW-specific policy has constrained the industry's ability to prepare for commercial-scale projects. Wider political volatility, ranging from uncertainty over energy security priorities to changing trade restrictions, has destabilised supply chains and increased costs. A notable example is the United States, where the Biden administration's 2022 target of 15 GW of FLOW by 2030 was deprioritised when the Trump administration assumed office in early 2025. Developers withdrew quickly, demonstrating how fragile emerging markets can be in the absence of policy continuity.

Developers and suppliers seeking investment in challenging market conditions will now rely, more than ever, on governments to establish durable, credible policy frameworks that signal a long-term commitment to FLOW. Encouragingly, some markets are already providing clearer signals such as Japan's renewed 15 GW target for 2040 and FLOW-specific leasing activity including The Crown Estate's Celtic Sea leases (4.5 GW), France's AO9 (up to 2 GW), and Norway's Utsira Nord (up to 1 GW). However, in markets where the FLOW pipeline remains unclear, momentum and investor confidence continue to decline. The actions governments will take over the next few years will determine whether countries capture FLOW's industrial and economic benefits or risk losing investment to faster-moving peers.

FLOW supply chain constraints and commercial immaturity

Inconsistent policy signals and limited long-term visibility have held back the development of a ready and resilient supply chain. As a result, key players such as port authorities, foundation manufacturers and turbine suppliers have been unable to commit to the capital-intensive investments required for commercial-scale delivery and cost-effective supply. Developers and governments, however, require confidence that components will be available at scale and at competitive prices, creating a stalemate that hinders progress. The consequences are limited capacity, higher prices, and delayed deployment timelines.

The industry must move from bespoke fabrication to repeatable, industrialised production, delivered through coordinated early commitments and project visibility. Mitigation rests on coordinated, early commitments that unlock industrialisation. FLOW's global footprint necessitates an internationalised supply chain, supported by modular designs. Industrialisation concepts such as Stiesdal's 5×1 philosophy (1 GW from one port in one season at one floater per week for <€1m/MW) demonstrate what is possible if firm, credible pipelines replace today's uncertainty. With appropriate policy certainty and pipeline visibility, the supply chain can realise these industrial concepts.

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[15] Department for Energy Security and Net Zero (2026), Record breaking auction for OSW secured to take back control of Britain's energy - Link. The blended fixed-bottom CfD price was awarded at £91.20/MWh. For reference, the cost of a new gas fired power station is estimated at £147/MWh.

[16] DNV (2025), Global Energy Transition Outlook 2025 - Link

FLOW's perceived risk profile has remained high

Several small array projects have been successfully deployed, demonstrating strong performance with high capacity factors, validating the fundamental engineering concept. Nevertheless, real risks remain, primarily around engineering optimisation and scaling the technology rather than fundamental feasibility. These include manufacturing large numbers of substructures in parallel, integrating increasingly large turbines, and industrialising the logistics that underpin production processes.

Despite the proven technical foundations, FLOW continues to be viewed as high-risk. Limited progress at scale has reinforced this perception, particularly in markets where policy and regulatory frameworks are unstable or inconsistent. Uncertain development pipelines, shifting auction schedules, and fragmented policy signals amplify perceived risk, with a disproportionate impact on the emerging FLOW industry. These perceptions do not reflect engineering viability but rather the sector's lack of scale and visibility.

De-risking FLOW is critical to delivering successful commercial-scale projects. Together, real and perceived risks contribute to a high overall risk profile for FLOW, resulting in a higher cost of capital, increased debt premiums, and reduced investor appetite. Distinguishing between real and perceived risks is an essential first step toward lowering financing costs, strengthening investor confidence, and beginning to de-risk the technology.

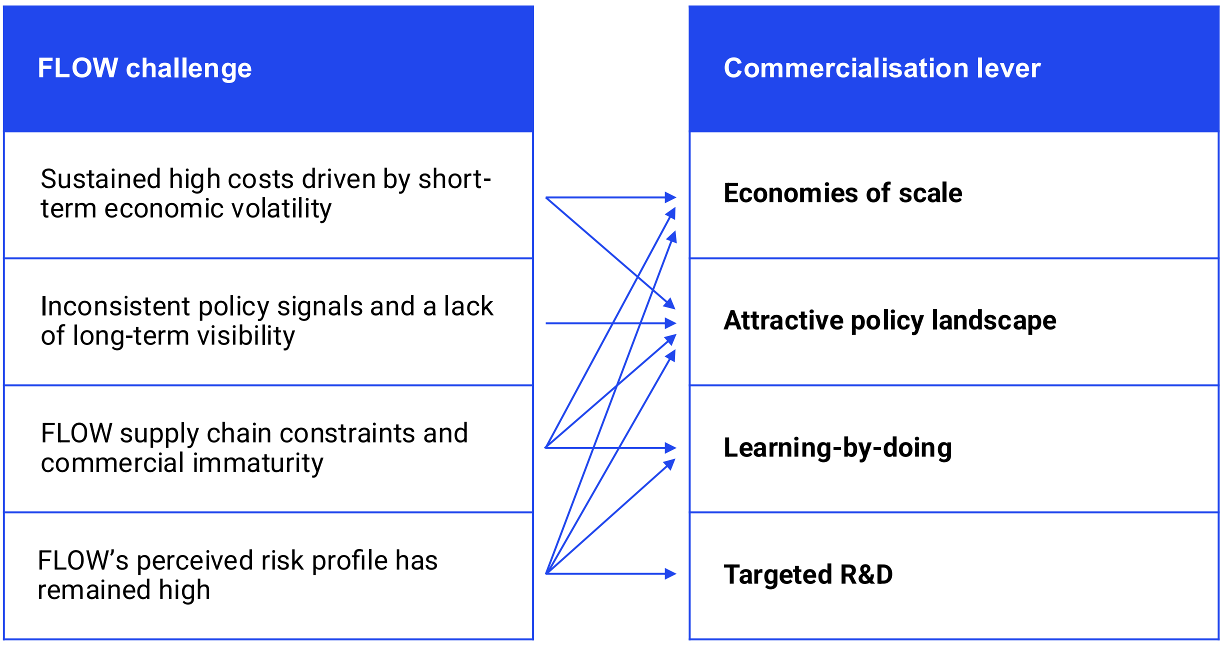
Photo of Kincardine courtesy of Arturo Andersen

3. Drivers to unlock commercialisation

Commercialisation marks the point at which FLOW becomes a scalable, commercially viable and widely deployable technology, which can attract project financing and sustained investment into the industry. With the industry at risk of losing momentum and further undermining investor confidence, identifying the key levers to shift behaviour toward achieving commercialisation status is essential. Rather than simply accepting that “it will take time”, the industry must actively create the conditions for success.

The commercialisation journeys of fixed-bottom OSW, onshore wind, and solar PV show how scepticism and early setbacks were overcome through a combination of economies of scale, learning-by-doing, attractive policy landscapes and targeted research and demonstration (R&D). We outline how these common levers can help overcome four major challenges for FLOW, described in section 2, and discuss their relevance and applicability in detail below.

Figure 4: Common commercialisation levers and their applicability to FLOW



Economies of scale

Significant cost reductions and efficiency gains emerge as production volume increases, which are necessary to enable the scale required for commercialisation. At the project level, producing more units spreads fixed costs over a larger base and improves process efficiency. At the market level, scaling up also creates opportunities for greater coordination across design, procurement, and installation activities, thereby reducing costs and improving operational efficiency.

FLOW deployment has been too limited and too dispersed to realise economies of scale. Figure 5 illustrates the rapid scale of fixed-bottom OSW: by 2002, Denmark’s Horns Rev 1 had already deployed 80 turbines, enabling meaningful economies of scale only a decade into the industry’s development. In contrast, more than ten years into the development of FLOW, the industry has yet to achieve the repetition and volume required for true economies of scale. The largest installed FLOW project, Hywind Tampen, only has 11 turbines.

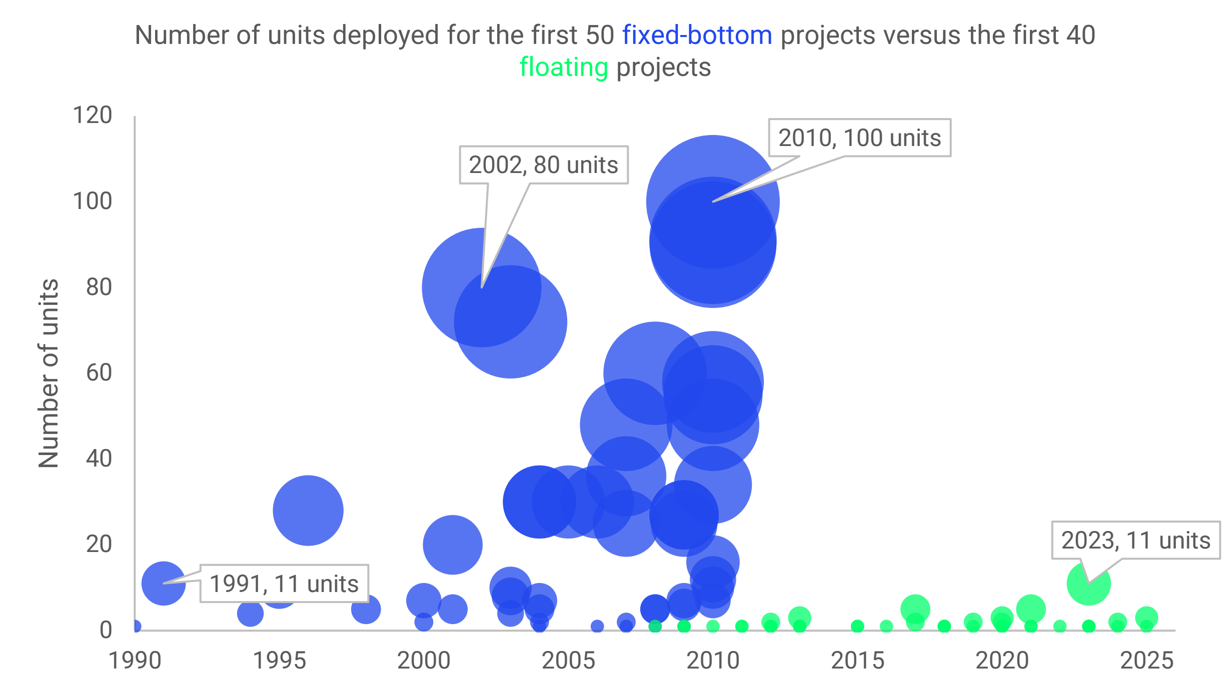


Figure 5: The comparison of the number of units deployed for the first 50 fixed-bottom wind and the first 40 floating wind projects. Data source: 4COffshore.

FLOW has a major opportunity to unlock economies of scale through serialised, modular production of substructures, without the need for site-specific customisation, and by building a global supply chain. Achieving this next phase of scale, through replicability and volume, will be a critical driver of FLOW's commercialisation. To achieve this, governments must create the enabling conditions for developers to build larger projects and ensure they are properly supported with attractive market conditions. This depends on a visible and sufficient pipeline of projects, created through an attractive policy landscape.

Attractive policy landscape: stable signals, visible pipelines and secure revenue

An attractive policy landscape, built on clear, predictable structures, is essential to reach commercialisation. Experience across other renewable sectors shows that commercialisation requires stability, visibility, and revenue certainty. Denmark's onshore wind industry scaled through guaranteed remuneration, national targets and municipal planning mandates, all of which de-risked early investment and enabled supply chain growth before transitioning to competitive tenders.

To create a supportive environment for FLOW, governments must implement mutually reinforcing policies that support the industry, supply chain and supporting infrastructure. At its core, this means:

1. Providing clear targets and consistent auction schedules.
2. Backing targets up with stable, proportionate revenue mechanisms.

Fixed-bottom OSW followed this trajectory: early deployment was supported by Feed in Tariffs (FiTs) and Renewable Obligation Certificates (ROCs), before moving to competitive tenders as scale and repeatability increased. As discussed in section 2, auction systems have recently come under pressure when governments failed to adjust to market conditions. Even mature fixed-bottom markets have been affected, with the Netherlands and Germany currently reforming their auction mechanisms and adopting CfDs after years of zero subsidies, recognising that revenue certainty is critical.

Is it also essential to acknowledge that, although OSW targets are often discussed collectively, fixed-bottom and FLOW are distinct and complementary technologies. Applying the same policy instruments to both risks overlooking FLOW's unique cost base, scale requirements, and level of technical maturity. Tailored policy support is essential if governments are to unlock FLOW's long-term value.

Predictability, through clear targets, stable revenue streams and regular auction cycles, remains essential. These elements, together, reduce investor risk, lower financing costs, and create the market visibility needed to unlock capital for high-cost commercial projects. FLOW's success will therefore depend on policy frameworks that provide technology-specific signals and the revenue certainty required to attract investment and allow the supply chain to commit to long-term growth.

Learning-by-doing

Learning-by-doing is an important lever for technology commercialisation. As projects are repeatedly deployed, developers, manufacturers and suppliers refine designs, improve processes and reduce errors, creating a reinforcing cycle of efficiency gains, cost reductions, and improved reliability. The extent of learning-by-doing varies across industries. In fixed-bottom OSW, learning-by-doing played a major role in reducing installation times and standardising processes, thereby enabling industry scale-up.[17] In Solar PV, by contrast, its impact was smaller, reflecting the simpler installation processes.[18]

For FLOW, meaningful learning-by-doing has not yet occurred. Projects have been too small, too infrequent and too geographically dispersed for industry-wide learning to accumulate. Existing projects have provided valuable technical insights for fabrication and installation, but not at the scale required to build confidence in commercial-scale projects. Long gaps between deployments disrupt learning continuity; in the United Kingdom, for example, the last FLOW project was delivered in 2019, and the next will begin construction almost a decade later. Without repeated, high-volume fabrication and deployment, the step-change required for commercialisation cannot occur.

FLOW's global nature adds complexity. Unlike fixed-bottom OSW, which benefited from concentrated activity around the North Sea basin, FLOW will develop across diverse markets, making it harder for lessons from one region to transfer to another. As a result, relying on business-as-usual or waiting for the first flagship commercial projects to succeed will not automatically generate the learnings and knowledge sharing the industry needs. Instead, deliberate, structured dissemination through alliances such as GOWA, government forums, and joint industry projects is essential to advance the industry.

Ultimately, FLOW requires learning-by-doing, and unlocking it depends on **predictable, regular project pipelines**. Without a steady flow of projects, learning dissipates, but with a continuous pipeline, it compounds. Predictable pipelines are the decisive enabler of FLOW's transition to a fully commercial, globally scalable industry.

Targeted R&D

All industries require R&D to develop scalable technologies and achieve commercialisation. Early-stage R&D is needed to achieve initial cost reduction and to demonstrate proof of concept. It is cited as the

[17] Carbon Trust (2020), Policy, innovation and cost reduction in UK OSW - Link

[18] Kavlak et al. (2018) Evaluating the Causes of Cost Reduction in Photovoltaic Modules – Link

primary driver of cost reduction for the first two decades of Solar PV.[18] In FLOW, this foundational phase of R&D is largely complete, with fundamental engineering concepts established and validated.

Existing industry R&D initiatives have demonstrated a strong willingness to absorb risk and stimulate private investment, meaning **R&D is no longer the primary barrier to commercialisation for FLOW**.[19] Ongoing innovation remains essential to stay competitive and respond to evolving market conditions, but its impact depends on being targeted and focused. R&D efforts must address commercial-scale barriers, avoid duplication and concentrate resources where they will deliver the greatest benefit. Pressing R&D challenges for FLOW include:

- Development of FLOW-specific wind turbine generators for global markets
- Major component exchange solutions
- Dynamic export and inter-array cable qualification and industrialisation
- FLOW-anchors and mooring systems (shared anchors; fibre ropes).

Innovation and iteration can continue as the sector grows. Success doesn't require perfection on the first attempt; the industry will refine, optimise, and de-risk the technology as it grows.

Assessing the levers: why policy must come first

The challenges discussed in section 2 (FLOW industry progress and challenges) have resulted in significant uncertainty of the global pipeline for FLOW. Amongst the commercialisation levers discussed in this section, establishing an **attractive policy landscape** is the most influential and impactful for FLOW**.** Establishing a landscape that provides a visible long-term pipeline and revenue certainty will also unlock **economies of scale** and **learning-by-doing,** which are key drivers of commercialisation.

Many countries have significant untapped potential for FLOW, including several emerging markets that lack an established OSW framework. These markets will need to work harder to create an attractive policy landscape for FLOW and to ensure successful frameworks for permitting, grid connection, and leasing. They also depend on progress in leading markets - the United Kingdom, France, China, Norway, Japan and South Korea - to reduce risk and clarify viable pathways.

The performance of early commercial projects will play a pivotal role in shaping market confidence and demonstrating commercial viability. Success will create reinforcing cycles of confidence, reduce perceived risks and establish a strong foundation from which all markets can progress. However, without deliberate intervention, their success alone will not guarantee industry-wide learning. FLOW's global nature necessitates unified commitment and international collaboration.

The industry is ready. Investors, suppliers, and developers are poised, but they need greater certainty to make this step change happen and to secure the multilateral financing support required to close the risk gap for existing projects, thereby unlocking a vast new source of secure, affordable renewable energy. Whilst the characteristics of an "attractive policy landscape" will vary by market, its core components are consistency, a visible pipeline, and secure, proportionate remuneration aligned with local conditions.

[19] Examples of R&D initiatives include Japan's Floating Offshore Wind Technology Research Association (FLOWRA), the Department for Business, Energy & Industrial Strategy's Floating Offshore Wind Demonstration programme in the United Kingdom, Norway's Ministry of Climate and Environment's recent FLOW innovation competition, the United States Department of Energy and Innovation Fund Denmark funding competition and others.

4. Actionable recommendations

The FLOW industry is at a stalemate. To take the next step to commercial scale, the supply chain requires a more secure pipeline; developers need more auctions with improved terms; and governments need to see cost reduction before they are willing to provide greater certainty.

To move beyond business-as-usual, the **industry must shift from ambition to coordinated action.** Now is the time to agree on a structured approach that will drive the scale up of FLOW, achieve global commercialisation, meet 2050 climate targets and unlock opportunities for emerging markets.

FLOW will always be complementary to fixed-bottom wind, and addressing the shared challenges of policy instability, supply chain constraints and investor confidence will support progress and cost reduction across both technologies. Yet FLOW faces heightened economic and political volatility, making it harder to scale supply chains and advance project development.

Considering the challenges outlined in section 2 (FLOW industry progress and challenges), the most impactful lever for commercialisation is establishing an **attractive policy landscape** that provides pipeline certainty and signals long-term commitment to the industry. The priority actions listed below reflect the need for more coordinated and durable policies.

Priority actions:

1. **Governments should commit to international cooperation, recognising that coordinated action is essential for FLOW's success.** The recent pledge by European nations to deploy 300 GW of offshore wind in the North Sea by 2050 shows collective ambition and has been widely welcomed by industry for its clarity and scale of ambition. As first-mover countries set the foundations for FLOW, collaborative action can create a more coherent and internationally aligned FLOW market that streamlines lessons and accelerates progress. Governments should commit to signing GOWA's proposed FLOW Global Cooperation Charter, which will reinforce shared objectives and send a clear, unified signal of long-term policy alignment and collective ambition.

2. **Governments should provide clear targets and consistent auction schedules.** As discussed throughout this whitepaper, predictable, long-term signals are essential for developers, suppliers and investors to commit to FLOW at scale. Without this predictability, the supply chain cannot plan capacity, developers cannot build bankable pipelines, and investors cannot price risk with confidence. Governments must work to establish appropriate national targets with frequent auctions and transparent timelines, aligned with grid and permitting readiness, to help restore credibility, reduce perceived risk, and send a powerful signal that FLOW's growth is intentional.

3. **Governments should treat FLOW as a distinct technology from fixed-bottom OSW when developing policy.** Although OSW targets are often grouped, the two technologies are at different maturity levels and must be treated separately, at least in the medium term. FLOW needs dedicated targets, tailored incentives and auction structures that reflect its currently higher costs and complexity. Governments could conduct exercises to develop realistic roadmaps, bringing predictability to pipelines and aligning with grid and permitting agencies. France's AO6 auctions illustrated this approach with a floating-specific auction, located at favourable sites, and backed by clear government commitments on future auction design, industrial investment and the development of a FLOW-ready supply chain.

4. **Governments should focus their efforts on de-risking FLOW projects.** Despite proven technology, FLOW is still perceived as high-risk. Governments should consider how to absorb some upfront risk, rather than leaving this entirely to project developers or lenders. There are several ways to do this in

practice, including policies that provide a clear pipeline and targeted support for essential FLOW infrastructure. Coordinated public investment in ports and related facilities demonstrates how practical infrastructure development can materially de-risk FLOW, as seen in France's investments in Brest and Leucate. Governments can also play a more direct role by providing equity participation or complementary public financing to catalyse critical supply chain investments.

5. **Governments should prioritise project deliverability.** Demonstrating successful delivery of FLOW projects will strengthen industry confidence, so governments must prioritise project deliverability by ensuring the right conditions are in place for success. Developers have already proven their capability in the fixed-bottom industry, but they require strong, well-structured business cases to deliver FLOW at scale. Governments therefore need to ensure that projects are attractive, technically feasible and supported by clear development pathways. By working closely with industry to identify barriers, governments can create the optimal conditions required for reliable, investable project delivery.

6. **Industry associations, in collaboration with OEMs, supply chain actors, and developers, should work with governments to adopt a regional approach to supply chain development.** The wide geographic spread of countries developing FLOW creates an opportunity to coordinate and map the supply chain at the regional level rather than on a project-by-project basis, helping shape new models for cross-border cooperation. A recent example is the FLOW Ports Alliance amongst the commercial ports of Brest in France, Shannon Foynes Port in Ireland, and Associated British Ports, which aims to collaborate on port design, standardisation, and best operational practices. This model could be adopted across other areas of the FLOW supply chain, driving coordinated cross-border development.

7. **International finance actors (DFIs/MDBs) should provide innovative financing mechanisms to hedge investor risk.** The cost of capital for FLOW remains high, particularly in emerging markets, and greater risk-sharing is essential to create a stable investment environment and attract private capital. Multilateral Development Banks and Development Finance Institutions can share risk through concessional loans, guarantees, and risk-sharing tools, as well as targeted technical assistance for policy development, PPA design, and planning, seen in the Philippines. Strong support and innovative financing for early-stage projects will be critical, especially in markets without established OSW sectors.

8. **Industry and government should use public-private partnerships (PPPs) to facilitate learning by doing.** The UK's 2019 OSW Sector Deal demonstrates how structured collaboration between government and industry can establish shared long-term commitments for sector development. Developing FLOW-specific PPPs would provide the policy stability and investment certainty required to unlock supply chain commercialisation and achieve cost reductions through economies of scale and learning-by-doing. This will transition FLOW from a perceived risk to a real opportunity.

Global collaboration is needed to move beyond a business-as-usual approach and drive strategic change to ensure FLOW's success

If continuing with business-as-usual, FLOW risks losing all momentum. Countries risk missing out on significant economic growth and energy-security benefits, and net zero targets will become unattainable by 2050. The next three to four years are key to driving this success.

This whitepaper calls for action to advance FLOW, urging governments, especially those with emerging or active project pipelines, to work together to accelerate sector development. This coordination would complement and support industry-led efforts to advance supply-chain strategies across regions. Leveraging GOWA's convening power to disseminate lessons from early market advancement will help move FLOW from perception of risk to reality of opportunity.

Photo of Hywind Scotland courtesy of Alistair Morris

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