Designing an effective offshore wind market:

Six policy pillars for success

CARBON TRUST | OFFSHORE WIND | Net Zero INTELLIGENCE UNIT

CONTENTS

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About this report

For many countries, offshore wind will hold the key to energy security and a cost-effective Net Zero transition. This report is the first in a series by the Carbon Trust, aiming to help policymakers design effective offshore wind markets. This report introduces six policy areas which are fundamental for approaching offshore wind development at a whole systems level. Upcoming reports in the series will analyse the impact of specific interventions within these policy pillars, within both maturing and emerging offshore wind markets.

This report is based on the Carbon Trust's experience providing policy advice to governments in the UK, US, Colombia, Japan, Vietnam, the Philippines, Ireland and others. It also draws on insights and experience gained through over a decade of leading collaborative research, development and demonstration programmes, which have reduced costs and risks throughout the offshore wind supply chain.

This is a collaborative report written by the Carbon Trust's offshore wind experts and Net Zero Intelligence Unit. Additional thanks to Helen Andrews-Tipper, Juan Quiroga, Ainslie Macleod, Annie Osborne and Kieran Hymers.

Who we are

The Carbon Trust is a global network of more than 400 experts with offices in the UK, the Netherlands, South Africa, China, Singapore and Mexico. Climate pioneers for more than 20 years, we work at the forefront of the global offshore wind industry, collaborating with governments, developers and innovators to make fixed and floating offshore wind a viable commercial energy generation solution.

The Net Zero Intelligence Unit provides experience-led insights to accelerate global progress towards Net Zero. The Unit is a dedicated team focussed on raising ambition, awareness and action on Net Zero by drawing on the Carbon Trust's 20 years' experience of working with businesses, governments and financial institutions globally.

Introduction

The promise of several million green jobs and a reliable energy source that could, with the right enabling policy, reduce exposure to volatile fossil fuel prices, has placed offshore wind high on policy agendas worldwide. As well as supporting green growth and energy security, for many countries, deploying offshore wind will play a critical role in delivering on Net Zero targets. In a Net Zero world, wind and solar will make up almost 70% of global electricity generation by 2050[1]. The International Renewable Energy Agency (IRENA), predicts that 2,000 GW of global offshore wind capacity will be needed to limit global warming to 1.5C[2]. To stay on track, this means deploying 380 GW by 2030, enough to power up to 300 million homes. Fortunately, falling costs make offshore wind an increasingly attractive part of the renewable energy mix.

However, the current rate of deployment suggests these targets will not be met. At the end of 2022, total global offshore wind capacity stood at 64.3 GW. A total of 269 GW is expected to be operational by 2030[3]. Combined, government targets are almost aligned with IRENA's Net Zero pathway, amounting to around 370 GW by 2031[4]. However, meeting these targets will require coordinated efforts by a number of stakeholders. In addition to the developers responsible for constructing and operating wind farms, turbine and component suppliers, financiers, academic researchers, policymakers and others perform essential roles in the offshore wind ecosystem. Government intervention is critical for creating a healthy foundation to enable offshore wind expansion: the success and cost reductions achieved in offshore wind to date are in large part due to well-structured policy interventions.

Maturing and emerging offshore wind markets

High rates of offshore wind development at an increasingly low cost are now observed in the UK and other parts of Europe. These markets were early adopters and are now leaders in offshore wind, together accounting for almost 47% of global capacity by the end of 2022. Here, specific targets for renewables and wind energy expansion following international agreements to reduce greenhouse gas emissions, and well-structured policies, forged a dedicated offshore wind industry. Subsequent policies to drive down costs and encourage competition led to bigger and more efficient turbines, economies of scale and industry-wide collaboration.

In recent years, China has rapidly become a leader in offshore wind and many other new markets are making quick progress, including the US, Japan and Taiwan. Many other regions possess huge offshore wind potential but – to varying degrees – still require the essential regulatory, technical and infrastructural building blocks to kick-start market development. Commercial-scale projects are expected to start in Vietnam, the Philippines and India within the next few years and, although at an earlier stage, the Caribbean region has a technical potential capacity of 751 GW[5] matched with a significant need for low-cost energy and economic diversification. Mature markets have accumulated lessons in successful offshore wind development over 30 years; emerging offshore wind markets must now apply these learnings in a fraction of the time.

[1] Net Zero by 2050 – Analysis - IEA

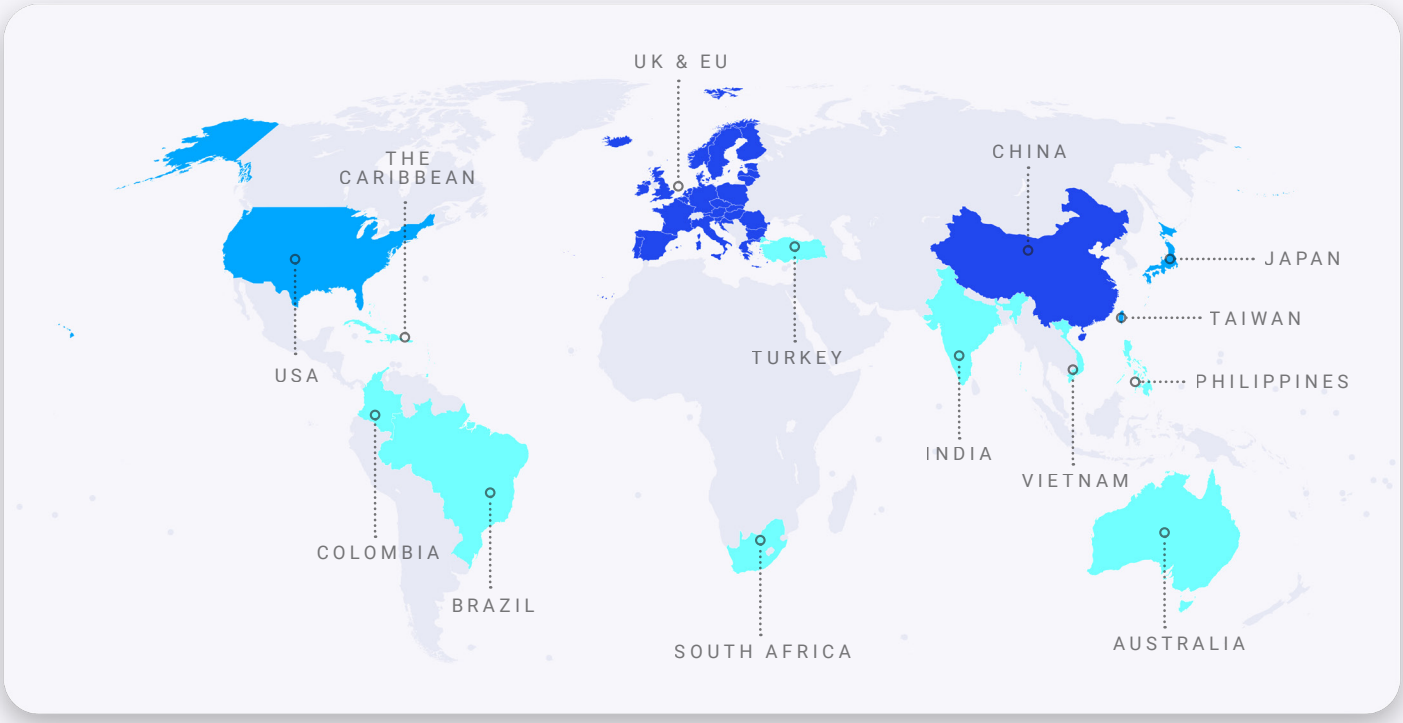
[2] Offshore renewables: An action agenda for deployment (A contribution to the G20 Presidency) (irena.org)

[3] Global Offshore Wind Farms Database | 4C Offshore

[4] GWECs Global Offshore Wind Report 2022 - Global Wind Energy Council

[5] Offshore Wind Technical Potential | Analysis and Maps | ESMAP

An illustration of global offshore wind markets



NB: This is not an exhaustive list of global offshore wind markets. A large number of countries worldwide are exploring and advancing offshore wind development.

- Maturing offshore wind markets
- Emerging offshore wind markets with commercial scale projects
- Emerging offshore wind markets with no current commercial scale projects

Six pillars of effective offshore wind policy

Technical potential is only one condition for offshore wind success. Governments should approach market development at a whole systems level. While local context is crucial, best practice in any market involves addressing the following key areas at the right time and with the right set of stakeholders:

1 Market scale and visibility	2 Site development	3 Grid integration
4 Incentive mechanisms	5 Supply chain development	6 Innovation support

The following section highlights specific interventions within each policy pillar which have helped to accelerate offshore wind deployment in maturing markets.

1. MARKET SCALE AND VISIBILITY

Clarity and certainty around a government's long-term commitment to offshore wind is vital for industry confidence.

Japan's offshore wind market had a slow start. Initially, attractive Feed-in Tariffs (FiT) allowed developers to sell renewable electricity to the grid, but this was not enough to spur development. After the government introduced targets and sent other strong market signals, developers were encouraged to invest. In recent years, the Japanese government has strengthened the regulatory environment for offshore wind. The 2018 Offshore Wind Promotion Bill introduced a competitive bid process for offshore wind sites, and extended leases to 30 years which aligns with the average lifetime of an offshore wind farm. Since then, the Japanese government has announced increasingly ambitious renewable energy targets, including technology-specific targets for offshore wind. The government also published a 2020 Vision for Offshore Wind Power Industry setting out 10-year plans for designating areas of seabed for offshore wind development.

These combined interventions have motivated developers by clarifying the long-term opportunities for entering the Japanese market. As of 2023 Japan has over 50 GW of offshore wind in early planning stages. By 2050, it is estimated that 63 GW of installed offshore wind capacity will generate 30,000 jobs and 940.9 billion yen[6].

> **Targets and other strong market signals can encourage investment.**

2. SITE DEVELOPMENT

Effective marine spatial planning and site allocation processes are crucial for reducing risk and delay.

Site development encompasses multiple stages of offshore wind market creation. Marine spatial planning involves identifying potential zones for offshore wind development considering environmental conditions and existing marine uses. Geophysical, meteorological and other environmental surveys are undertaken to confirm suitability. This is followed by the leasing, permitting and consenting processes.

Two different models for site development have helped accelerate deployment in mature markets. The centralised model seen in Denmark and the Netherlands involves governments conducting site surveys and acquiring relevant permits, before auctioning specific sites for developers to build in. This can reduce the risks for developers in pre-development stages. In contrast, the UK and US have opted for a decentralised model, whereby governments auction wide sections of seabed, and developers bear responsibility for most site development activities. Both France and Germany have recently transitioned to more centralised models. This increases upfront costs for governments, but leads to greater competition, due to a larger number of informed bidders at auction stage. Governments can then recover costs incurred for site assessments through subsidy reductions.

[6] Skills development recommendations for the Japanese offshore wind market | The Carbon Trust

France's 2023 Acceleration Bill will also streamline site development, by identifying zones for accelerated permitting and holding public consultations for whole areas rather than individual projects. Securing consent and permits remains a significant bottleneck even in mature markets. It is one of the most time-consuming stages of offshore wind development, taking three to five years on average. The challenge for governments is making consenting processes as efficient as possible while mitigating potential impacts of development on marine biodiversity and other marine users.

Consenting is one of the most time-consuming stages of offshore wind development.

3. GRID CONNECTION

Inadequate grid infrastructure prevents countries from using and transporting the renewable electricity they produce.

As well as facing long queues to connect to the power grid, once connected, wind farms often need to be deliberately curtailed (switched off) to prevent them from generating high volumes of electricity that could overwhelm the grid. Curtailment also prevents wind farm operators from selling the energy they generate. Governments, developers and power grid owners should therefore plan how and where electricity will be transported before projects commence. In Europe, wind farms in the North Sea are usually connected to the closest point on the shore, also known as point-to-point connection. However electricity demand is often concentrated elsewhere. This puts pressure on the onshore transmission grid which transports the electricity, especially as renewables are often deployed faster than transmission grids can be upgraded to accommodate them. As a solution, European governments are exploring meshed offshore grids. These connect clusters of wind farms to offshore energy hubs which, in turn, connect to multiple countries. Meshed grids[7] could ease strain on onshore grids and transport electricity to land more efficiently, while minimising cost and environmental impact by using a smaller number of cables. This requires high voltage direct current (HVDC) cables which transport large amounts of electricity over long distances with minimal power losses.

Stakeholders should plan how and where electricity will be transported before projects commence.

4. INCENTIVE MECHANISMS

Incentives help to stimulate offshore wind markets by reducing risks and costs for developers and investors, but must be tailored to current government priorities.

More generous incentives, including grants and fixed remuneration, are likely to be needed in markets where offshore wind has not yet been deployed and project delivery risks may be considered higher. When markets are sufficiently mature, governments can

[7] PROMOTioN - Home (promotion-offshore.net)

introduce competitive auctions, in which companies bid for government contracts and associated subsidies.

In the UK, Renewable Obligation Certificates (ROCs) helped to kick start the market. ROCs were issued to developers per MwH of renewable energy produced and could be sold on to energy suppliers to meet renewable electricity procurement quotas. This generous and stable income stream drove early investor confidence. As cost-reduction became a priority, a competitive auction scheme called Contracts for Difference (CfDs) has now replaced the Renewables Obligation. Under CfDs, developers receive a 15-year fixed 'strike' price for energy generated and win contracts by proposing the lowest strike price. This intense competition encouraged suppliers and developers to streamline operations and reduce costs. By 2020, the price of offshore wind in the UK was a third of what it had been a decade earlier[8] and offshore wind supplied 13% of the UK's electricity[9]. Size and efficiency of turbines also improved, as guaranteed returns on investment allowed developers to build wind farms of unprecedented scale.

Although competitive auctions can deliver substantial cost reductions, they must also be designed to ensure the deliverability of projects and not to invite such low bids that projects become economically viable. Policymakers should ensure their priorities are clear when designing incentives. For instance, although cost reduction was once the UK's primary goal, focus has now shifted towards speed of delivery, commercialising floating wind and other innovative solutions and strengthening local supply chains.

> **Incentive design should reflect a government's priorities, like cost reduction or strengthening local supply chains.**

5. SUPPLY CHAIN DEVELOPMENT

As well as direct investment, market scale, visibility and incentive mechanisms can grow local capacity.

Policymakers can help build capacity to supply the products and services required for offshore wind farms. Supply chain support can include investing in local port infrastructure, reducing barriers to entry for companies or developing skills and workforces. Although many maturing markets have relied on global supply chains to reduce cost and speed up deployment, governments are increasingly looking to build local supply chains to strengthen energy security and domestic economies.

Ireland plans to develop 5 GW of offshore wind by 2030. However, without further supply chain support, the socioeconomic benefits of this development will largely be felt outside of Ireland. The Carbon Trust advised the Irish government on the support needed. A key recommendation was to address Ireland's skills shortage in a cost-effective way, partly through specialist marine apprenticeship schemes[10].

A sufficient pipeline of projects can also give suppliers the confidence to invest in local facilities. Policies driving market visibility and incentive mechanisms can also be designed to stimulate supply chains. As such, the Carbon Trust recommended that the Irish government make supply chain plans a mandatory part of auction bids.

[8] Policy, innovation and cost reduction in UK offshore wind | The Carbon Trust
[9] Module [1]: Offshore Wind in the UK - The History of Offshore Wind in the UK (Offshore Wind Industry Council)
[10] Harnessing our potential: investment and jobs in Ireland's offshore wind industry | The Carbon Trust

> **Global supply chains can accelerate deployment at lower costs, while local supply chains can strengthen energy security and domestic economies.**

6. INNOVATION SUPPORT

Policy can ensure that early-stage technologies carrying higher short-term risks and costs are nurtured, for long-term benefit of the industry.

Innovation is vital, both for reducing costs and designing new offshore wind technologies that can withstand deeper waters, more extreme weather and other emerging challenges. Collaboration between government and industry can help direct R&D efforts to areas of highest impact. New technologies progress through multiple stages before commercial application, and each stage merits different levels of government support. Early-stage technologies with lower chances of reaching the market will require more government involvement, through direct grant funding for academic research. In later R&D stages, industry-led collaborative initiatives are effective for targeting technological improvements. These allow costs and risks to be shared between public and private sectors. Joint industry projects and similar initiatives ensure that research is tailored to the needs of the industry and promotes industry-wide knowledge sharing to advance innovation.In the UK, for instance, the Carbon Trust's Offshore Wind Accelerator helped reduce the cost of offshore wind energy by 15% in its first decade[11].

Following R&D, technologies must be tested and demonstrated at scale. These stages are essential to reduce risk, but dedicated offshore test sites are costly. Demonstrating novel technologies alongside commercial wind farms is a cost-effective solution that also facilitates permitting and grid connection. However, specific policies must be designed to encourage this, especially in markets using price-driven auctions, as new technologies will bring higher costs and risks.

> **Innovation is vital for reducing costs and building offshore wind in challenging environments.**

[11] Ten years of accelerating innovation | The Carbon Trust

Snapshot: Progress in emerging offshore wind markets

This section analyses current progress across the six policy pillars in three emerging offshore wind markets where the Carbon Trust has provided support.

PHILLIPINES

Policymakers must consider how all parts of the system come together, balancing a desire for rapid offshore wind expansion with adequate planning.

Market scale and visibility:

Site development:

Grid connection:

Incentive mechanisms:

Supply chain development:

Innovation support:

Key challenges and opportunities:

Market scale and visibility

The Philippines Government Department of Energy (DoE) has awarded over 60+ service contracts to developers. Setting clear targets for fixed and floating offshore wind development, as well as outlining the overarching development model, could help solidify ambitions and timelines.

Site development

The DoE is overseeing a marine spatial planning exercise to identify optimal offshore wind development zones. Developers with service contracts are expected to start amassing data on wind speeds, soil type and water depth. This will be essential to price offshore wind.

Grid connection

Grid connection is one of the biggest barriers to offshore wind development. The complicated grid ownership structure does not encourage upgrades, so regulation will likely be needed. Small, flexible grids would be more suitable than a unified meshed grid across the thousands of islands.

Supply chain development

The government is keen to include offshore wind within its Green Energy Auction programme, but auctioning offshore wind prematurely could lead to an uncompetitive market and no development. The Global Wind Energy Council stresses that no successful European or Asian offshore wind market began with auctions.

[12] A-vision-for-industry-development-Mark-Hutchinson-GWEC.pdf (worldbank.org)

UNITED STATES

Collaboration between states, faster consenting process and supply chain investment will be crucial for meeting the US' ambitious offshore wind goals.

Market Scale and Visibility:

Site Development:

Grid Connection:

Incentive Mechanisms:

Supply Chain Development:

Innovation Support:

Key challenges and opportunities:

Market Scale and Visibility

Offshore wind farms have been commissioned on the East coast, while West-coast states are still in leasing and permitting stages. Consenting processes are a bottleneck throughout the country, and each state possesses unique challenges and opportunities. California's waters require floating wind technology. In Maine, ensuring offshore wind can co-exist with the established fishing industry is a top priority.

Grid Connection

There is a need to upgrade and expand the transmission and grid infrastructure. Initiatives such as the Department of Energy's Building a Better Grid aims to support better planning and coordinated transmission solutions. States are starting to coordinate, but more needs to be done to implement suggested improvements.

Supply Chain Development

Supply chain investment is needed to deliver on the national 30 GW by 2030 offshore wind target and capture associated economic rewards. Current and planned port and vessel infrastructure would only support up to 14 GW of capacity, and global supply chains are already reaching capacity supporting European demand. State and national supply chain investment needs to be coordinated and supported by strong policies to develop the workforce and ensure community benefits.

COLOMBIA

Although a nascent market, Colombia looks set to be a first mover and leader in Latin American offshore wind.

Market Scale and Visibility:

Site Development:

Grid Connection:

Incentive Mechanisms:

Supply Chain Development:

Innovation Support:

Key challenges and opportunities:

Market Scale and Visibility

The Colombian government released a roadmap for Offshore Wind in 2022, commissioned by the World Bank. This demonstrated a commitment to diversifying the country's energy mix. It estimated that the country had the potential to install 50 GW of offshore wind capacity and announced that site leasing would start in 2023.

Site Development

Colombia plans to award its first offshore wind permits in 2023, for sites in the Central Caribbean. A 2022 resolution clarified the tender criteria, which require developers to carry out feasibility studies and obtain licenses, then commission wind farms within 10 years of winning a bid.

Grid Connection

Grid infrastructure is a key development area for Colombia. Investment in grid upgrades will be needed to progress towards 50 GW of offshore wind capacity. To address this, the government has conducted pre-feasibility studies identifying where bottlenecks are expected, to highlight where investment would be most beneficial.

Supply Chain Development

The country has been successfully implementing a package of tax benefits for Non-Conventional Renewable Energies. These include income tax deduction, accelerated depreciation, VAT exclusion and tariff exemption. Also, dedicated renewable energy auctions have been carried out, enabling 3 GW of investment in solar and wind, and this may include offshore wind in future rounds.

This report is the first in a series aiming to help policymakers design effective offshore wind markets. Further editions will focus on specific interventions within the six policy areas introduced in this report, with learnings for maturing and emerging offshore wind markets. All reports will be available on the Carbon Trust website.