CARBON TRUST

Offshore Wind in China
Sharing the UK's policy experience

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Contents

Introduction ... 3
Overview of China's current policy status ... 4
Renewable Energy Law ... 4
First concession round ... 6
Government coordination ... 7
Feed-in Tariffs ... 8
UK policy and implications for China ... 10
Incentive mechanisms ... 10
Offshore Wind Capital Grants Scheme ... 11
Renewables Obligation ... 16
Feed-in Tariffs with Contracts for Difference ... 22
Sites ... 26
Location and zone selection ... 28
Relaxing constraints in zones ... 30
Site selection ... 34
Planning for demonstrations and the grid ... 36
Planning for demonstrations ... 36
Planning for the grid ... 37
Technology and supply chain development ... 40
Summary ... 41
Works Cited ... 42

Introduction

Energy, and electricity in particular, is a highly policy dependent market, strongly shaped by regulation, incentives, and public goals. A successful offshore wind market therefore relies on strong and consistent government support. Such support is important for renewables as a whole but it is particularly important for offshore wind, given the relative risks and high costs involved. Offshore wind development requires both significant capital and technical resources, and in order to mobilise these two key ingredients investors must have confidence in the long term support of the sector by government. Without this, offshore wind will remain unnecessarily expensive or will not be developed at all (World Bank, 2008). According to analysis undertaken by the World Resources Institute, industry scale-up correlates with support policies with at least a three year time horizon, often with accompanying government commitment to the wind industry and ambitious targets for deployment (WRI, 2012).

The UK's offshore wind industry has enjoyed over a decade of support, meaning its policies and programmes have been operating for long enough to reap the benefits of hindsight. Lessons from the UK can now be drawn upon by other countries that are seeking to support their own offshore wind industry. With China's ambitious offshore wind deployment targets, it makes sense to review the benefits and limitations of the UK's experience as China designs its own policies and programmes to support the industry.

This document sets the scene by reviewing China's current policy status, regulatory framework, and incentive mechanisms. These illustrate the base case upon which subsequent options and recommendations are built. Following that, the UK's experience is outlined. It is organised according to our understanding of China's priorities. Incentive mechanisms are explored in depth, with the UK's three biggest policies and programmes described in detail, along with insight into how each apply to China. Information on offshore wind zoning, site selection and leasing regimes are subsequently described, and are supplemented with lessons learnt and insights for China. Finally, the UK's experience with technology and supply chain development is outlined, though these are considered to be areas of particular strength for China, so they are afforded less detail.

Overall, this paper delivers insights into the policies and programmes that have supported the UK's offshore wind industry, how they could be improved, and elements that China may choose to borrow from the UK's experience when formulating its own policy priorities and activities programme.

Overview of China's current policy status

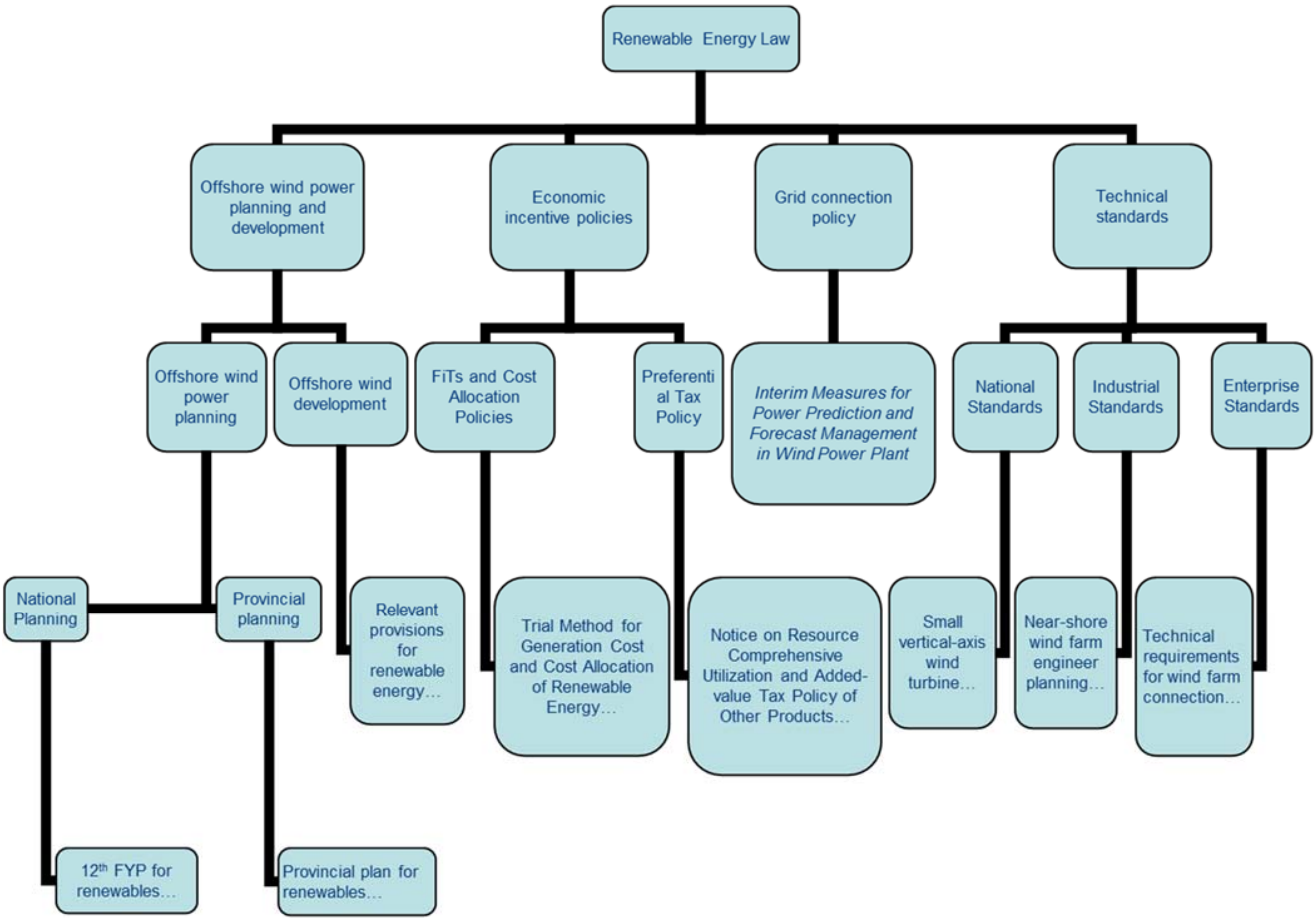
China has set clear and ambitious deployment goals for offshore wind and sees the technology as a critical component of its renewable energy technology portfolio. While Chinese onshore wind and solar deployment are scaling up extremely quickly and are roughly in line with national targets, offshore wind has experienced technical and financial setbacks that threaten the country's deployment ambitions.

This section briefly outlines the major components of China's offshore wind support landscape. It includes a high-level description of its Renewable Energy Law; information on China's first offshore wind concessional round; issues facing government coordination; and challenges in determining an appropriate feed-in tariff.

Renewable Energy Law

In order to promote the development of the offshore wind power industry, China has established a basic offshore wind power policy system. Based on the Renewable Energy Law (REL), the system consists of offshore wind power planning and development, economic incentive policies, grid connection policy, and technical standards, as shown in Figure 1. The system is expected to evolve over time to provide comprehensive regulatory support for the industry.

Figure 1: Influence of China's Renewable Energy Law on offshore wind power



Source: CWEA (2013)

Among the regulations included in the REL are a number of progressive policies to encourage investment in the industry. These include national targets, consenting policy, economic incentives, and grid connection policy.

National targets:

- Deployment – the government has set a target of 5 GW by 2015; 30 GW by 2030.
- Industry – power companies with capacity greater than 5 GW must produce 3% of electricity from non-hydro renewables by 2010 and 8% by 2020 (Ma & Weekes, 2010). Since most power generators in China are large state-owned enterprises with a capacity of more than 5 GW, this impacts the quantity of electricity produced from renewables significantly.
- R&D – targets have also been put in place to encourage increased innovative activity, including a target for R&D expenditure to account for 2.5% of GDP. During the 11th Five Year Plan period an estimated 15.3% of government stimulus funding was directed towards innovation, energy conservation, ecological improvements and industrial restructuring; and in 2010 the government invested US$1.3 billion in clean energy R&D, including wind (WRI, 2012).

Economic incentives:

- Price – the REL establishes a feed-in tariff (FIT) for the price of electricity based on the region and type of energy. For onshore wind, the NDRC established four FITs in 2009 for four groups of regions (NDRC, 2009). Group I, with the richest wind resource, is CNY 0.51 /kWh; Group II 0.54; Group III 0.58; and Group IV 0.61. However, crucially, fixed FITs for offshore wind are yet to be announced, with FITs for early offshore projects determined either by consenting or bidding.
- Renewable Energy Development Fund – this compensates grid companies for the increased costs of purchasing power from renewable sources (Out-Law, 2013).
- Preferential Tax Policy - investments in renewable energy benefit from favourable treatment both in terms of obligations for value added tax (VAT) and enterprise income tax (EIT). Since 2009, VAT for wind power has been reduced from 17% to 8.5% and income tax has been reduced from 33% to 15% (Xiliang et al., 2012).

Consenting policy:

- Planning – the REL attempts to streamline planning on a nationwide basis to ensure more co-ordination between central and provincial governments. After problems in the first concession round this now includes clear guidance on the roles of the respective government departments involved in offshore development.

Grid connection policy:

- Connection – companies must connect wind farms to the grid, and grid operators have a legal requirement to source a proportion of their energy from renewable sources. Furthermore, developers are not allowed to begin construction until they have obtained grid connection approval.
- Power Purchase Agreement – grid operators must purchase all renewable energy generated by licensed companies.

- **Power generation predictions** - in order to improve wind power connection, the REL requires all connected wind farms to set up a wind power prediction and report system.

The REL did not move deployment forward significantly in itself, but introducing medium and long-term renewable energy targets improved investor certainty in the market and illustrated the importance that the government placed on offshore wind power (WRI, 2012). However, the first round of concession tenders has experienced significant problems, in part due to misaligned government coordination between government departments and the absence of a sustainable and long-term feed-in tariff.

First concession round

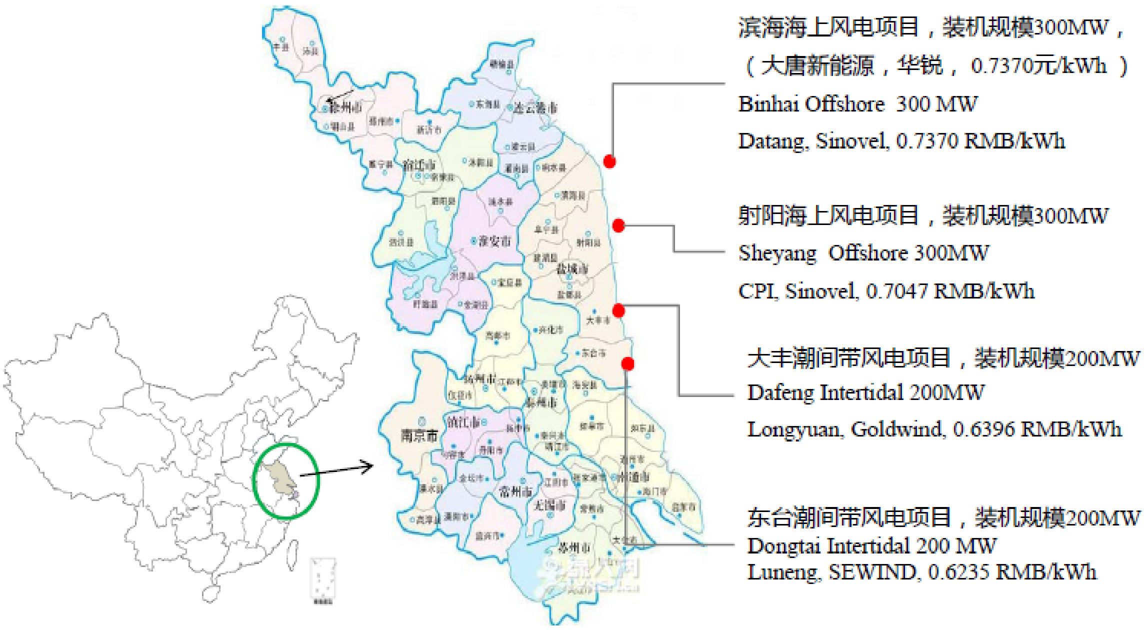
China's first round of concession bidding started in September 2010. Project developers were selected through an evaluation process that looked at the bid's tariff, construction design, technological capacity, and performance record (Ma & Weekes, 2010), although low electricity price and high equipment localisation appear to have been the prevailing factors in determining the winning bidder (Hong & Moller, 2012). Four projects totalling 1 GW power capacity were selected in four subsidiary counties of Yancheng city, Jiangsu, two of which were offshore and two of which were intertidal (see Table 1 and Figure 2).

Table 1: First concession round project details

Project	Capacity (MW)	Developer	Feed-in-Tariff (CNY per KWh)	Construction started
Jiangsu Binhai Offshore Wind Farm	300	China Datang Corporation Renewable Power Company	0.7370	Sept 2013
Jiangsu Sheyang Offshore Wind Farm	300	China Power Investment Corporation	0.7047	Expected 2013
Jiangsu Dongtai Intertidal Wind Farm	200	Shandong Luneng Group	0.6235	Sept 2013
Jiangsu Dafeng Intertidal Wind Farm	200	China Longyuan Power Group	0.6396	Sept 2013

Source: CWEA; www.4coffshore.com.

Figure 2: Location of first round concession projects in Jiangsu province



Source: CWEA (2013).

Government coordination

These projects were originally expected to be built within four years, but construction only commenced for three of the projects in September 2013 (Binhai, Dongtai, and Dafeng). Construction was expected to start in Sheyang in the final quarter of 2013, though as of January 2014 its status remains 'in development' as it continues to await permitting (4coffshore, 2013) (Pengfei, 2014). This delay was in part caused by a lack of coordination and conflict between various government departments, particularly the National Energy Administration (NEA) and the State Oceanic Administration (SOA). While the SOA wants wind farms to be built as far as possible from the shore, saving space for fishing, transportation and many other uses, the NEA wants the opposite, reducing the costs and technical challenges of installing wind farms further from shore. Indeed, while the NEA has a commitment to develop offshore wind farms in China, the SOA has no such mandate (Quartz & Co., 2013). Poor coordination has led to certain areas being designated for both offshore wind development and other activities, with developers having to relocate to new sites having incurred the costs for planning the original farm's development (EE News, 2012). For example:

- The Sheyang project, being developed by China Power Investment Corporation, was stuck in the project design phase due to the conflict of military use of the area (Xinhuanet, 2013);
- The Dongtai project, being developed by Shandong Luneng Group, experienced a 10km relocation further offshore to make way for a wildlife conservation area, and only applied to the NEA for project approval in Nov 2012, a year and a half later than planned;
- The projects at Binhai and Dafeng, owned respectively by China Datang Corporation and China Longyuan Power Group, didn't apply to NEA for project approval until 2013.

In order to resolve this conflict, in 2010 the NEA and SOA jointly released a new set of regulations and frameworks for offshore wind projects, delegating responsibility for selecting developer bids and agreeing FIT rates to the NEA, and responsibility for site approval to the SOA. The regulations also specified that future concession projects should be located at least 10km from shore and in 10m water depth if the tidal flat is more than 10km wide, and should avoid areas designated for commercial uses (e.g. fishing, tourism, military). This level of clarity over which offshore sites are licensed for development should ease the overall process and encourage developers to enter the market. The first four concession projects have since undergone a new round of environmental evaluation and cable routing (Innovation Norway, 2013), with construction having recently got underway in three sites (Binhai, Dafeng, and Dongtai) and being expected to commence in Sheyang in the final quarter of 2013.

Feed-in Tariffs

The other major obstacle making developers reluctant to start construction is the overly low feed-in-tariffs. Prior to this first concession round the government had removed a regulation stipulating that the highest and lowest bids would be eliminated from the tender, which had been used to good effect in the early onshore concession rounds. The danger of selecting bids based on price is that it tends to produce extremely low bids. In order to win the concession project, some bidders intentionally underestimate operating costs to get a lower price compared to other bidders. This created a race-to-the-bottom bidding war to win the concession projects, with developers entering bids with low and unprofitable FITs.

One interpretation might be that power companies were keen to impress local and central government with their progress towards developing clean energy sources (Innovation Norway, 2013), while another might suggest that this was in order to gain first-mover advantage over other developers hoping to engage with the offshore industry (Quartz & Co., 2013). However, once such a bid is selected, it proves economically impossible to construct and operate the offshore wind farm, with developers failing to meet the build-out price stated in their concession tender and construction stalling as a result of their inability to make commercial returns against such a low FIT (Hong & Moller, 2012).

It is unsurprising that developers are unable to make a profit given that the offshore FITs were only ~30% higher than the FITs established for onshore wind power, despite offshore projects typically costing 2-3 times more than those onshore. To help the developers of the first concession round to recoup the substantial investments in their respective projects, the NEA has allowed the four developers to apply for new feed-in-tariffs. For example, China Datang has applied for an increase of FIT from CNY 0.737 to 0.860 per kWh (Takung, 2013). Yet even this revised FIT is below the CNY 1.0/kWh thought to be necessary for developers to make an 8% internal rate of return (IRR) (Wind Power Monthly, 2013).

However, it should be acknowledged that due to the immaturity of the offshore wind industry in China and the lack of commercial projects in operation, it is still unclear what level of FIT would be most appropriate. The industry has much to learn before it can confidently establish a long-term incentive mechanism. Indeed, the onshore wind industry went through five rounds of concession bidding before NDRC established the benchmark FITs, and offshore wind has only been through one round so far. Thus, in the absence of a FIT, the Chinese government are likely to go through more rounds of concession tendering. The second round, with a total capacity of 2 GW, was originally planned to commence in 2011 but was postponed in line with the delays to the first concession round. With the first round projects now all approved and on track to begin construction towards the end of 2013, it is anticipated that the second round of concession tenders will open soon, likely in 2014. These 'pilot' projects will provide an opportunity for developers to gain experience in constructing offshore wind farms and provide a testing ground for various offshore wind technologies that can be deployed in China. Experience gained from these projects will help to identify key challenges and understand an appropriate level for a long-term and sustainable FIT (Quartz & Co., 2013).

China's offshore wind industry has also recently been boosted by the announcement in February 2013 that offshore wind has been given priority status by the NDRC. This affirms the government's commitment to supporting the sector and should result in preferential policies and incentive mechanisms for the industry, as well as better access to funding and faster consenting approval. With equipment manufacturing also explicitly identified in the priority list, the entire offshore wind supply chain can expect to benefit (Quartz & Co., 2013). Importantly, increased support is also expected to result in more favourable FITs to project developers.

UK policy and implications for China

Incentive mechanisms

Providing financial incentives for offshore wind developers is considered to be necessary to stimulate the development of this renewable resource, which is at an earlier stage of technology development and more costly than more mature renewable and non-renewable electricity generating technologies.

Most countries have used feed-in tariffs to stimulate the growth of renewables. The UK has used three major mechanisms to support offshore wind, and has deployed them at different times to achieve different results. The incentives that have or will be used are:

- Offshore Wind Capital Grants Scheme
- Renewables Obligation
- Contracts for Difference

The Offshore Wind Capital Grants Scheme was designed to stimulate an initial pipeline of project proposals that would be used by the government to gather data on sites and project costs, and to inform the design of future incentive cost structures and cost levels.

The Renewables Obligation pushed electricity suppliers to source low carbon electricity and also provided financial incentives for different types of renewable energy, including offshore wind.

Contracts for Difference is meant to give project developers a level of long-term financial support so that they can have confidence in the economic viability of their projects following the cessation of the Renewables Obligation for offshore wind in March, 2017.

Together, these incentives have been designed to carve a path for offshore wind from a position of weak data, high costs, and high risks, to one that enjoys richer data, longer term certainty, lower risk, and more investible offshore wind development opportunities.

Opportunities for China

- Develop an **offshore wind capital grants scheme**. This should:
  - The scheme should have a data-sharing clause to improve the government's awareness of the commercial realities of developing offshore wind in Chinese waters.
  - The scheme should support R&D and technology testing, which will improve domestic capacity, support 'learning by doing,' and encourage the development of a domestic offshore wind supply chain. The scale should be large enough to motivate a broad group of developers in order to increase the likelihood that ambitious targets will be met and ultimately reduce costs.
  - The scheme could be flexible, in that grants could be repaid by developers if they choose to accept future financial support from government.
- Develop an **on-going price support mechanism**
  - This mechanism should seek to balance developer incentives with government costs to ensure value for money for electricity consumers and tax payers.
  - Market-based instruments whose price support levels automatically adjust depending on the level of deployment could be considered since they reduce the need for cost data collection by reacting to the difference between targeted and actual deployment. The UK's Renewables Obligation was originally designed to be a dynamic instrument, where support levels would rise as actual deployment fell below the target and fall as deployment approached the target. While such mechanisms suffer from complexity and price support uncertainty, which threaten investor confidence, these issues may be countered by making appropriate tweaks to the system, and by the presence of China's centrally controlled wholesale electricity price.
  - Feed-in tariff instruments are well-understood, straightforward, and have successfully supported other renewable energy technologies in China and elsewhere. Such mechanisms are effective if priced correctly, but limited data availability and developers' over-eagerness to win contracts is clouding the price discovery process in China. A capital grants scheme could be used to improve data collection.

Offshore Wind Capital Grants Scheme

Purpose

This scheme was developed in 2001 and designed to kick-start offshore wind project development when there was little certainty about the actual costs of commercial-scale offshore wind power. The scheme was partly used to allow the government to gather information about development costs and have an opportunity to design future incentive regimes with more information.

It was also recognised that offshore wind was expected to play an important part in the UK's overall renewable energy strategy, with a very significant proportion of its low carbon electricity coming from offshore wind. Given the government's requirements on energy utilities to source a growing percentage of their electricity from renewable sources (described below under the

Renewables Obligation), industry believed that some capital grant funding would be needed to catalyse the offshore wind sector, whose growth was critical for the utilities to meet their future renewables obligation.

Early development of offshore wind would also:

- deliver an early contribution to the Renewables Obligation and emission reductions;
- underpin development of the industry and the equipment supply chains;
- provide a learning experience which can improve confidence and help reduce future costs;
- enable future projects to proceed without the need for grant support.

Other aims of the Scheme included:

- maximising value for money for the public expenditure involved;
- providing a fair, transparent and auditable process;
- compliance with legal requirements including state aid rules;
- minimising the burden on applicants and grant recipients;
- maximising uptake of the funding available while avoiding overspends (DTI, 2003).

Funding

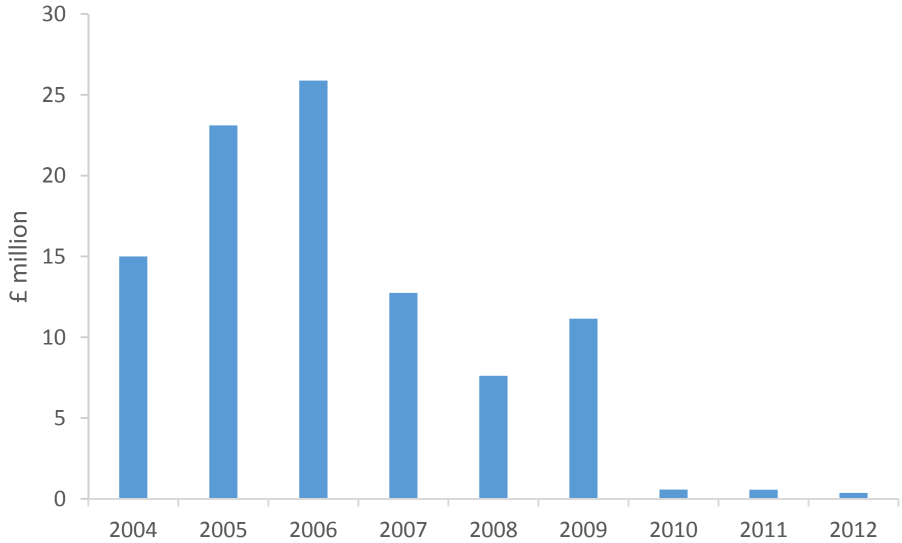
The Scheme's budget was initially set at £64 million and provided by the Department of Trade and Industry (DTI, replaced in 2007 by the Department for Business, Enterprise and Regulatory Reform and the Department for Innovation, Universities and Skills). The budget was earmarked to support Round 1[1] and Round 2 projects, but in 2003 the DTI dedicated another £28 million to the programme and expanded the scope of the Scheme to include some Round 3 projects as well.

In the same year, a further £10 million was committed to the Scheme through the New Opportunities Fund, a publically administered fund whose money is sourced from the National Lottery. Some additional funding was provided in later years, with the total available funding reaching £107 million altogether.

[1] See 'Location and zone selection' (page 26) for a description of the UK's offshore leasing 'Rounds'.

The disbursement schedule was as follows (excluding the £10 million from the New Opportunities Fund):

Figure 3: Offshore Wind Capital Grant Scheme spending, 2002-2012



Note: Based on 2008 disbursement information. Source: (UK Parliament, 2008)

Projects could receive public funding of up to 40% of eligible costs per project. Initial disbursements totalling 75% of the awarded grant sum were made following construction and commissioning of a project. The balance of expenditure was made over the following 3-year period.

Qualifying criteria and eligibility

To qualify for funding, project proposals had to satisfy some essential qualifying criteria. The criteria required that, as far as possible:

- successful proposals were moved from planning to operation as quickly and efficiently as possible;
- low carbon electricity generated was made available to UK electricity suppliers for a minimum of 10 years so that they could comply with their Renewables Obligation;
- a diversity of companies were supported such that a range of capabilities and supply chains were developed in the UK;
- a range of commercial and technical approaches were supported to achieve an element of testing through the Scheme.

There were various rules around the nature of consortia that were proposing collaborative agreements, mainly to ensure that:

- the group had clearly defined leadership to whom grant funding would be delivered;
- the ownership rights and income splits over the completed projects were legally sound;
- all applicants and each partner in any consortium passed financial viability tests;
- public sector organisations were excluded from the granting process.

Rules around project eligibility were also described, and required that:

- project proponents make proposals for a specific location in UK territorial waters;
- project proponents have a lease from the Crown Estate either in their possession or in active negotiation;
- the project be for no less than 20MW;
- the project be connected to a local distribution network or the National Grid;
- the project be commissioned within three years of the competition round closing date under which the proposal was submitted;
- an independent consultant be commissioned to review evidence and confirm that in their opinion, the stated efficiencies, availability, annual output, capital cost, and operating cost can be achieved; and,
- various government Acts be recognised and adhered to.

Information gathering for future use

As mentioned, the Offshore Wind Capital Grants Scheme was not only used as a mechanism to accelerate deployment, but it was also used by the government as a tool to gather data on project costs, wind speed information, technical barriers and opportunities, different commercial arrangements, the effectiveness of consortia building, and expected project timelines. This information was later factored in to the government's assessment of what would make a suitable feed-in tariff.

In order to ensure that the valuable data submitted by project developers could be used in this way, the DTI included an information-sharing clause in the Scheme's design. Developers that accepted grant funding also gave the DTI the right to publish the:

- identity of applicants (including consortium or joint venture membership where relevant);
- project location and capacity;
- expected annual output;
- number and size of turbines;
- estimated investment cost;
- grant requested;
- total public support from all sources;
- proposed commissioning date;
- project description (including any key technical features);
- list of compliant bids;
- list of successful bids

Lessons learnt and insights for China

China might consider its own offshore wind capital grants scheme. The UK government effectively used its Offshore Wind Capital Grants programme to facilitate data gathering and price discovery for offshore wind. China has tried to use the bidding prices on its four concession projects to enable price discovery, but since Chinese developers were eager to gain first mover advantage and win initial contracts, they underestimated their required FIT level and are now having to renegotiate FITs with the NEA. These unexpected underestimates limited the value of this price discovery process. A capital scheme may still be useful so that the government can get more data, and developers can test different designs and themselves better understand the true cost of offshore wind deployment.

The UK's scheme could be used as a model since it is broadly considered to have been a success. Nearly all of the funding was granted, with some exceptions[2].

More interestingly, a National Audit Office report shows that by 2009 £85.6 million of the Scheme had been granted to the private sector to accelerate the deployment of offshore wind, but a significant amount – nearly £50 million of capital plus interest – was voluntarily paid back to government in order for developers to access the increased financial incentives that became available under the Renewables Obligation (NAO, 2010). This shows that investments made through capital grants schemes can serve their initial purpose and, through follow-on legislation or programme development, potentially be recouped by government by offering other creative incentives that are linked to previous funding support.

After a decade of administration the scheme amounted to over £100 million – nearly four times larger than initially envisioned by the DTI in 2001 – and enabled progress against its main objectives. Likewise, a Chinese Offshore Wind Capital Grants programme could also be used to help motivate domestic R&D so that innovative technologies could be developed and tested, leading to lower deployment costs of higher turbine efficiencies. A grant scheme could also be used to help develop the offshore wind supply chain in China, as it was in the UK.

Despite the fact that the scheme ended up being much larger than originally envisaged, it has nevertheless been criticised for being too small and failing to catalyse the industry as quickly and broadly as it might have had it been larger (Szarka, et al., 2012). China may want to reflect on the size of any grant scheme it may wish to establish, especially given its very ambitious deployment targets.

Innovation, technology testing and deployment can be materially accelerated when there is more money available for developers. Achieving China's extraordinary deployment ambitions might mean that more companies need to be significantly involved in the early days of deployment so that China's domestic capacity grows many prongs in terms of corporate learning and supply chain development. This may mean grant money needs to be spread out across many companies, rather than just a handful of the most ambitious or most established ones, and consequently the amount of money available needs to be large so that it can have a material impact on a wider array of projects.

[2] Following the cancellation of a large offshore wind project that had won grant finance under the Scheme, the Department for Business, Enterprise and Regulatory Reform reallocated some funding to support grants for offshore wind turbine manufacturing component suppliers. Roughly £3 million was clawed back during the governments drive for public savings in 2010 by "reducing the scope" of the Grant programme.

Renewables Obligation

Purpose

The Renewables Obligation (RO) has three functions. It is a financial incentive mechanism for renewable electricity generators, as well as both an obligation and incentive for electricity suppliers to increase the proportion of renewables in their electricity mix. It is the main support mechanism for large renewable energy projects in the UK, including offshore wind. The RO came into effect in 2002 in England, Scotland and Wales, and in 2005 in Northern Ireland. The scheme will no longer apply to offshore wind projects that come online after March 2017, and will be replaced by a contracts-for-difference feed-in tariff.

How it works

A system involving Renewables Obligation Certificates (ROCs) was invented to operate the RO. A ROC is a green certificate that represents a quantity of renewable energy, measured in megawatt-hours. Companies that generate eligible renewable electricity are awarded ROCs from the Office of Gas and Electricity Markets (Ofgem) for every megawatt-hour of electricity they produce. Electricity suppliers buy ROCs from independent generators and are also awarded ROCs when they generate their own eligible renewable electricity. They must forfeit ROCs to Ofgem at the end of the year to meet their RO.

For each financial year (April to March), electricity suppliers are required to produce evidence of their compliance with the RO by presenting sufficient ROCs to Ofgem by September. In 2012-2013, suppliers in England, Wales and Scotland were required to present Ofgem with 15.8 ROCs for every 100MWh they supplied (representing a 15.8% renewable energy mix). This is an increase over 2011-2012 when they were required to present 12.4 ROCs per 100 MWh supplied (or a 12.4% renewable energy mix). The figure for Northern Ireland is lower (Ofgem, 2013).

If suppliers are unable to produce enough ROCs to cover their RO, they need to pay into a 'buy-out' fund, which is administered by Ofgem. The buy-out fund is used as a mechanism to further incentivise the accumulation of ROCs by electricity suppliers. Once a year, the proceeds in the buy-out fund are paid back to suppliers in proportion to the number of ROCs they presented. For example, if a company presented Ofgem with 5% of all of the ROCs submitted in that period, the company would receive 5% of the total funds that defaulting supply companies paid into the buy-out fund.

The value of a ROC is therefore partly determined by the buy-out price, which is set by Ofgem, and partly determined by the size of the buy-out fund and the proportion of ROCs a company presents to Ofgem. The figures since the introduction of the RO are shown in Table 2, below. It shows that it is increasingly costly for electricity suppliers to fail to meet their RO, and increasingly attractive for suppliers to overachieve their renewable energy content. It also shows that the growth rate of required renewable electricity content is accelerating, especially over the last few years.

Table 2: Renewable Obligation requirements and prices, 2002-2014

Obligation period (April 1 to 31 March)	% of supply	Buy-out Price (£/MWh)	Effective price per unit (p/kWh)
2002-2003	3.0	£30.00	0.09
2003-2004	4.3	£30.51	0.13
2004-2005	4.9	£31.9	0.15
2005-2006	5.5	£32.33	0.18
2006-2007	6.7	£33.24	0.22
2007-2008	7.9	£34.30	0.29
2008-2009	9.1	£35.76	0.33
2009-2010	9.7	£37.19	0.36
2010-2011	11.1	£36.99	0.41
2011-2012	12.4	£38.69	0.48
2012-2013	15.8	£40.71	0.64
2013-2014	20.6	£42.02	0.87

ROCs are traded entirely separately to the purchase of the electricity itself (which is done through the wholesale electricity market) and can essentially be seen as a price support mechanism whereby a premium is passed on to the renewable energy generators. Generators of renewable energy can either sell ROCs directly to suppliers or auction them online. One online auctioning platform called e-ROC operates by connecting small energy generators to suppliers. Between 2002 and 2010 ROCs were auctioned on a quarterly basis on e-ROC, and prices typically ranged between £40-53/ROC (reflecting the buy-out price plus the expected buy-out fund differential). Since September 2010 the auction has been held monthly, and prices have fluctuated between ~£40-£51/ROC (eROC, 2014).

The RO was originally designed to pull through the lowest cost technologies sequentially, with each renewable energy technology receiving the same level of support per MWh generated (despite less mature technologies having higher costs). This had the effect of limiting the amount of investment into less mature technologies, such as offshore wind, and effectively supporting only the least expensive renewable option.

Since onshore wind was the least expensive renewable option at the time, it meant that onshore wind became a very popular project option. But other obstacles, like community resistance to onshore wind power and other planning constraints, prevented rapid deployment of onshore wind. Consequently, projects were stalled and it was recognised that the overall renewable electricity targets would not be met using this "one size fits all" support mechanism.

To compensate for this, the scheme was changed so that different renewable energy technologies received different levels of support through the ROC scheme. This differentiation aimed to give more financial support to early-stage renewable technologies so that there is more incentive to develop them, and less financial support to relatively mature and less expensive renewable technologies that need less support to be competitive. Smaller systems that do not enjoy economies of scale tend to get more support than larger systems.

Offshore wind has enjoyed higher levels of support than most other renewable technologies because of its relative immaturity and because it is expected to contribute very significantly to the UK's future low carbon electricity mix, but it still suffers from lower than expected deployment levels.

Technologies were initially divided into four different bands:

Table 3: Initial ROC bands for four technology groups

Technology band	ROCs/MWh	Technology examples
Established	0.5	Sewage gas
Reference	1	Hydroelectric, onshore wind, standard gasification, energy from waste with CHP
Post-demonstration	1.5	Dedicated biomass, co-firing with energy crops with CHP
Emerging	2	Offshore wind, geothermal, tidal stream, wave

Policymakers recognised a risk in this approach since the RO bands were not periodically adjusted to reflect changing technology costs and market conditions, and since ROCs themselves fluctuated in value. The ROC value is driven by the amount of renewables deployed, which is in turn subject to market risk (principally the cost of deploying the renewable capacity) and political risk (for instance the rate at which renewables are given planning permission).

To manage that risk the government introduced a 'guaranteed headroom' mechanism in 2009. Under the headroom mechanism, once the RO target has been reached it is continually readjusted to stay a set level above capacity until a cap is reached. Once this headroom mechanism is activated, the ROC value becomes fixed for any given level of banding. The RO then acts more like a feed-in tariff. Since the RO target was never reached, this mechanism was never triggered, but represented an added layer of complexity to the system that confused investors and raised uncertainty about the long-term stability of the scheme.

The ROC system was reviewed again in 2013 and produced a ROC schedule up to 2016-17 that, for the first time, sharpened the granularity of the ROCs. So rather than grouping technologies in wider bands of full or half ROCs, as had previously been the case, the schedule has been fine-tuned to include even smaller fractions of a ROC.

Table 4, below, shows a sample of different technologies and their support levels. As can be seen, technologies that are more novel or have a smaller capacity tend to receive more support, and that support may diminish over time. Note that offshore wind received 1.5 ROCs/MWh prior to a 2009 review, but that was increased to 2 ROCs thereafter because of its importance in meeting the 2020 renewable targets, and because its deployment has been slower than expected.

Table 4: Revised ROC schedule for selected renewable energy technologies

Technology	2013-14	2013-14	2014-15	2015-16	2016-17
Anaerobic digestion (<500kW)	4	4	4	4	4
			Further reviewed from 2014-15		
Anaerobic digestion (>5MW)	2	2	2	1.9	1.8
Dedicated biomass	1.5	1.5	1.5	1.5	1.4
Geothermal	2	2	2	1.9	1.8
Landfill gas (open sites)					
Onshore wind (>5MW)	1	0.9	0.9	0.9	0.9
Offshore wind	2	2	2	1.9	1.8
Hydro (250kW-1MW)	2	2	2	2	2
			Further reviewed from 2014-15		
Hydro (>5MW)	1	0.7	0.7	0.7	0.7
Solar PV (>5MW)	2	Subject to consultation			
Tidal stream and Wave	2	5 to a 30MW project cap. 2 ROCs above the cap.			

Source: (DTI, 2013)

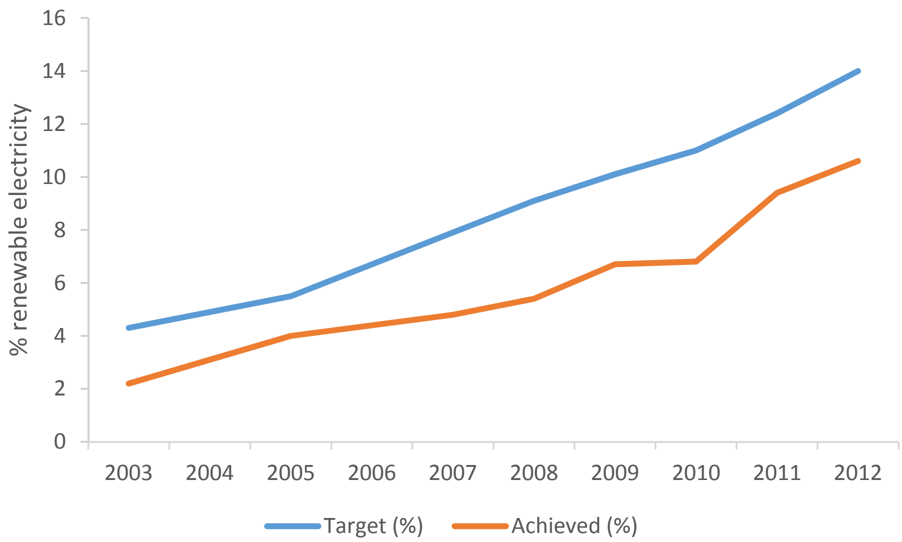
Electricity generators that want to participate in the RO system must register on Ofgem's Renewables and CHP Register in order to receive ROCs for the electricity they produce from eligible sources. Electricity suppliers must also sign up to the Register in order to comply with the RO and to receive ROCs for eligible electricity they produce.

Lessons learnt and insights for China

A market-based incentive mechanism like the RO is an option that may be worth exploring in China. One of the biggest economic challenges facing Chinese offshore wind policy is gathering enough data to determine what FIT level(s) would be sufficient to encourage offshore wind development in a way that balances government costs and developer incentives. As such, developing a market-based mechanism whose incentive level automatically adjusts in response to actual deployment could be a way to circumvent the needs for a rich dataset and the maintenance of deep technical and economic knowledge within government.

If China is interested in a mechanism like the RO it could learn from some of the limitations it faced in the UK. While the Renewables Obligation has been somewhat successful it could be argued that the level of support was not strong enough. In terms of results, the actual level of renewable electricity production has hovered around only two-thirds of targeted levels, as shown in Figure 4 below.

Figure 4: Targeted vs achieved renewable electricity



Sources: (HM Government, 2009a); (HM Government, 2009b)

This suggests that the RO's targets were set too low and failed to provide an adequate incentive level for utilities to demand low carbon electricity and/or for developers to supply it. Looking at the UK's current trajectory and pipeline of renewable electricity projects, it will be a challenge for the UK to achieve the c.30% renewable electricity required to meet renewable energy targets by 2020.

Separately, the RO scheme suffers from a fundamental design flaw that has failed to manage one element of price risk. This failure stems from the fact that ROCs are subsidy payments received by electricity generators that are added on top of the wholesale electricity price. The value of the ROC plus the wholesale electricity price is supposed to adequately compensate for more expensive renewable generation, but since the wholesale electricity price fluctuates, there is uncertainty about the final price electricity generators will receive per MWh of electricity supplied.

This uncertainty was recognised when the scheme was being developed, but some stakeholders felt that since utilities (who in the UK also tend to be major renewable electricity project developers) supposedly have better information about likely future energy prices than any other stakeholders, they should shoulder the risk that wholesale electricity price volatility creates in the RO scheme.

Utilities disagreed. They were afraid that factors beyond their control (e.g. the unexpectedly rapid commercialisation of shale gas) could depress wholesale electricity prices, which, even with the ROC price support, would fail to provide an overall level of compensation necessary to make renewable projects economically viable. This risk arguably limited investment.

While this issue was problematic in the UK, where wholesale electricity prices are determined by the market and fluctuate according to supply and demand, in China the wholesale electricity price is set by the National Development and Reform Commission (NDRC) (Vrije Universiteit Brussel, 2013). Since wholesale electricity price changes may be more predictable, an incentive mechanism that adds revenues on top of such an electricity price may represent less risk to Chinese developers and investors. Investment risk due to price volatility has been criticised as one of the biggest limitations of the RO in the UK, and this fundamental difference in China's electricity pricing model may go some way to ameliorating this risk.

An additional design flaw stemmed from the fact that ROCs were exchanged between Ofgem and utilities, rather than directly between Ofgem and renewable electricity generators. While most renewable electricity projects were built by utilities in the UK, some independent companies also participated in the scheme and built large projects, including offshore wind. Analysis showed that when independent suppliers negotiated Power Purchase Agreements with utilities, utilities would use their market power and the aforementioned wholesale electricity price risk to force suppliers to accept discounted prices for their electricity. Historically as little as 70% of the ROC value was passed through to independent generators (Carbon Trust, 2008).

Through a simple design tweak, China could overcome this problem. ROCs could be given directly to developers rather than being mediated by utilities.

The RO's biggest issues revolved around certainty. Renewable energy generators wanted to have long-term certainty over the value of ROCs for different renewable technologies in order to create a predictable investment environment for projects that often take many years to develop.

To improve certainty for investors, the government released the proposed ROC ratio for public consultation one year earlier than expected. In its decision on price support, the government maintained significant support for offshore wind until 2017, which was recommended by industry but not necessarily expected (DECC, 2012).

China could learn from this experience by setting ROC ratios far in advance. If China followed the original intention of the RO and let the value of ROCs change according to the level of actual deployment versus targeted deployment, then it could confidently set the ROC ratios in advance. It would provide a level of quantitative certainty to investors, whilst letting prices adjust automatically according to market conditions. While there would be a degree of arbitrariness in setting the ROC ratios in advance, at least developers would know what to expect and they could generate their own risk-reward calculations using predictable numbers.

Readers might wonder why this RO was kept in place at all in the UK and not simply replaced with a feed-in tariff, since so many of the adjustments and tweaks to the RO system were made to try to manage the risks and uncertainties that a feed-in tariff mechanism solves by design. The reason is that stakeholders insisted that scrapping the RO and replacing it with a feed-in tariff would itself create uncertainty in the market, raise risks, have a knock-on effect in investor confidence and ultimately raise the cost of finance. Upon reflection, it could be argued that an early overhaul of the support regime would have been preferable rather than adding layers of complexity to the RO, which itself created uncertainty in the market.

The take-away message for China, which is evident across all of these lessons, is that predictability and certainty underpin investment decisions. When faced with risks whose level are difficult to anticipate, lenders will raise the cost of finance and make projects unnecessarily (and perhaps prohibitively) expensive. The ultimate consequence of uncertainty is simply that targets will be missed.

Indeed, uncertainty about the future price support regime that will come into place after the RO is phased out in 2017 is having some unintended consequences. The forward guidance on ROCs has given developers the incentive to accelerate projects so that they come online before the March 2017 deadline, after which the ROC regime will no longer apply to offshore wind. Simultaneously, developers are halting investment in projects that will not be ready in time for the 2017 deadline. They are waiting until there is further clarity on the government's new Contracts-for-Difference Feed-in Tariff mechanism, which is due to affect offshore wind in March 2017. Developers rank the new subsidy mechanism as the third biggest risk to offshore wind development in the UK, following cuts to offshore wind subsidies (biggest risk) and the continuing Eurozone crisis (second biggest risk). Until developers are confident in that mechanism and a strong price signal, they remain reluctant to invest in new projects (Freshfields Bruckhaus Deringer, 2013).

Feed-in Tariffs with Contracts for Difference

Purpose

A Feed-in Tariff with Contract for Difference (FiT CfD) is a long-term contract between an electricity generator and a contract counterparty. The contract enables the generator to stabilise its revenues at a pre-agreed level (the strike price) for the duration of the contract (DECC, 2011).

The Department of Energy and Climate Change describes the Contracts for Difference (CfD) scheme as a mechanism that is "designed to give investors the confidence and certainty they need to invest in low carbon electricity generation, helping the UK electricity sector to attract greater investment in low-carbon generation, and subsequently reducing the UK's carbon emissions." (DECC, 2013)

It is also meant to protect consumers from unnecessarily high electricity prices. Unlike other support schemes, the FiT CfD helps avoid the risk of a developer achieving windfall profits should the market price of electricity rise above their long-term costs of production. One-way mechanisms like the Renewable Obligation or regular feed-in tariffs may potentially give generators windfall profits if electricity prices are very high. But the FiT CfD is a two-way mechanism that opens up the possibility of generators paying consumers should the electricity price exceed the strike price.

CfD is one element in a broader set of Electricity Market Reform rules that the UK government is developing to prepare itself for the future, where electricity markets will have to operate differently than they do now. In essence, the need for reform is driven by the fact that the cost structure of renewable electricity is fundamentality different to that of non-renewable electricity. This is because renewable electricity costs are almost entirely upfront capital costs, with no ongoing fuel costs, whereas non-renewable electricity costs are heavily determined by fuel costs.

The electricity market was designed to operate under the assumption that each MWh of electricity has a fuel cost (which significantly determines the price of electricity), but with an increasing volume of fuel-free renewables, the electricity market has to be reformed since the price signal for electricity will no longer be driven by fuel costs. If electricity prices aren't driven by fuel costs, then investors need to have some kind of mechanism that lets them know how they will be compensated for their investments. They need to have confidence that their renewable electricity investments will get reasonable returns over time. Investors in non-renewable electricity infrastructure also want confidence that their investments won't be stranded in the future, and will also be adequately compensated for the peak-load and critical system balancing role that their infrastructure will play.

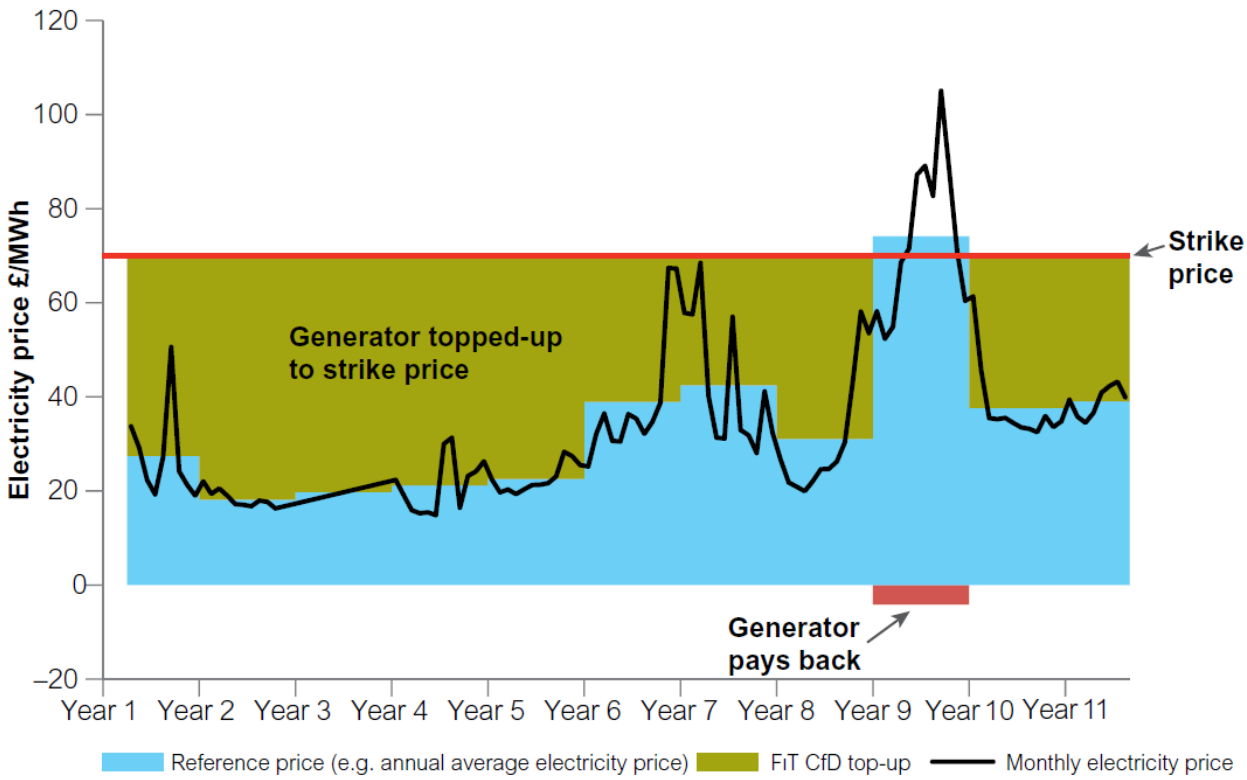
How it works

FiT CfDs are awarded to generators for 15 years, compared to a contract tenure of 20 years under the RO scheme. Until 31st March 2017, developers can choose to be supported by either the RO or the FiT CfD mechanism, though since the latter is still under consultation and final development the RO remains the only genuine support mechanism available to developers at this time.

FiTs with CfDs work by stabilising the prices received by low carbon generation, reducing the risks they face and making sure that large-scale renewable technologies receive a price for its power that makes investment economically viable. As mentioned, CfDs also control costs to consumers by capping the price that consumers pay for low carbon electricity – if electricity prices are high, generators must pay money back to consumers.

They do this by paying the generator the difference between a measure of the cost of investing in a particular low-carbon technology (the 'strike price') and a measure of the average market price for electricity (the 'reference price') (see Figure 5). The generator participates in the electricity market, including selling its power, in the normal way (DECC, 2013).

Figure 5: Illustration of baseload Feed-in Tariff with Contract for Difference



Source: (DECC, 2011)

The financial flows work as follows:

1. Generators sell electricity to electricity suppliers at the wholesale electricity price.
2. If the wholesale electricity price is lower than the strike price, the government pays generators the difference between the two (the "FiT CfD top-up").
3. If the wholesale electricity price is higher than the strike price, the generator pays back the difference between the two. These back-payments are then passed on to consumers.

Money for the FiT CfD top-up is sourced from a levy on consumers' electricity bills, which is pooled by government and used to fund various low carbon electricity support mechanisms, including the standard feed-in tariff for small producers, the FiT CfD, and the Renewable Obligation.

The strike price applies to offshore wind as well as a series of other renewables that were previously eligible for finance under the RO. It differs between technologies and depends on the deployment costs, maturity of the technology, and investor risk, as shown in Table 5. The strike price is critical for developers since it allows them to determine the financial viability of their projects, and is also critical for the government, which wants to find a balance between providing an appropriate incentive level whilst maintaining good value for money for consumers, who ultimately foot the bill.

At a time of increasing energy costs in the UK and high political sensitivity surrounding costs of living, the government is especially conscious of controlling low carbon electricity levies on consumers. As such, they have developed a system to control costs called the Levy Control Framework (LCF).

In 2011/12 the LCF was £1.8 billion. It is scheduled to reach £7.6 billion (in 2011/12 prices) by 2020/21. Contracts for Difference are forecast to cost £2.354 billion (in 2011/12 prices) in 2020/21.

A summary of the upper limit on spend through the LCF is shown in Table 5, below, as well as a draft strike price for offshore wind and a sample of other technologies. Note the relatively generous draft strike price given for offshore wind, as well as the high deployment expectations by 2020. Also note the considerable degree of uncertainty associated with future deployment, especially for offshore wind.

Table 5: Levy Control Framework and strike price for selected technologies, 2014-2021

	Levy Control Framework – Upper Limits on Spend (£m) (2011/12 prices)						
Technology	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
	3,300	4,300	4,900	5,600	6,450	7,000	7,600
	Draft Strike prices (£/MWh) (2012 prices)						
	2014-15	2015-16	2016-17	2017-18	2018-19	Potential Deployment by 2020 (GW)	
Anaerobic Digestion	145	145	145	140	135	~0.2	
Biomass conversion	105	105	105	105	105	1.2 – 4	
Geothermal	125	120	120	120	120	<0.1	
Hydro	95	95	95	95	95	~1.7	
Onshore wind	100	100	100	95	95	9 – 12	
Offshore wind	155	155	150	140	135	8 – 16	
Large solar PV	125	125	120	115	110	2.4 – 3.2	
Tidal stream & wave	305	305	305	305	305	~0.1	

Source: (HM Government, 2013)

The first round of projects eligible for the scheme will be granted through allocation on a first-come-first-served (FCFS) basis. Eligible FCFS bids will be awarded FiT CfDs in order of receipt of their bid. Bids will be awarded until half of the FiT CfD budget for any delivery year is committed.

After that, the FiT CfDs will switch to allocation rounds for all delivery years. Allocation rounds will define a window of application, within which all bids will be considered equally (but not sequentially as with FCFS).

Initially the allocation rounds may be unconstrained but, subject to the remaining headroom in the FiT CfD budget and more generally the LCF, the rounds move to a competitive process where generators will state the strike price they are willing to accept in return for the CfD. The government will award the lowest strike price bids FiT CfD to the limit of the annual round.

There are certain conditions that bid winners must meet or they risk losing the FiT CfD. These include achieving 'financial close' i.e. funding to build the generating capacity within one year of the FiT CfD being awarded and bringing generation on stream by a certain time ('backstop'). These conditions are to make sure that FiT CfDs are not tied up in projects that end up not delivering anything.

Lessons learnt and insights for China

In theory, the FiT CfD mechanism is an improvement over the RO, which it is replacing, since it provides certainty over the per-MWh payment project developers will receive. This enables them to understand the economic viability of their projects, reduces project risk, and ultimately reduces the cost of finance.

Mechanisms like FiT CfD are increasingly being experimented with internationally, and lessons could be applied in China. The UK's version aims to minimise many elements of uncertainty that the RO did not adequately address, but these elements of uncertainty may not be as material in China due to other contextual differences between China and the UK. Nevertheless, any mechanism that improves investor confidence is good, and it is additionally beneficial if it can be designed in a way that limits a government's exposure to costs.

The Levy Control Framework's upper limit on spend will likely lead to less deployment than would be the case in the absence of a spending cap. However, the need for financial limits is understandable from a political perspective since it protects consumers from increasing energy costs.

The scheme has gone through many iterations and has been tweaked many times through rounds of public consultation and feedback, and the government seems committed to designing a programme that will minimise risk and uncertainty for investors while balancing costs to consumers. Implementing something similar in China would fail to overcome the difficulty that the NEA is facing with regards to price discovery for a FIT, but developing a support system like this after rolling out programmes like the Offshore Wind Capital Grants Scheme, which would help with data collection and price discovery, could be a sensible way forward.

Determining a single FIT level can be challenging for the government since they do not have the technical and commercial information that project proponents have. Determining several FIT levels based on different characteristics may be even more of a challenge.

To avoid a repeat of developers underestimating the costs of deployment, China could require an independent third-party assessment of developers' plans by an accredited engineering firm. The UK's FiT CfD scheme requires this type of third-party assessment during project submission.

To improve data collection, China could develop deeper in-house government expertise by creating a government-supported knowledgeable body that understands the costs of offshore wind and can build offshore wind costing models. The UK's Crown Estate up-skilled its human resource when offshore wind emerged as a technology that it would need to administer.

The UK government is eager to avoid post-implementation changes to the scheme in order to raise investor confidence, and as such is still undergoing revisions. But this should be an area of policy for China to watch as details emerge over time.

The ultimate effectiveness of the FiT CfD scheme at spurring deployment remains to be seen.

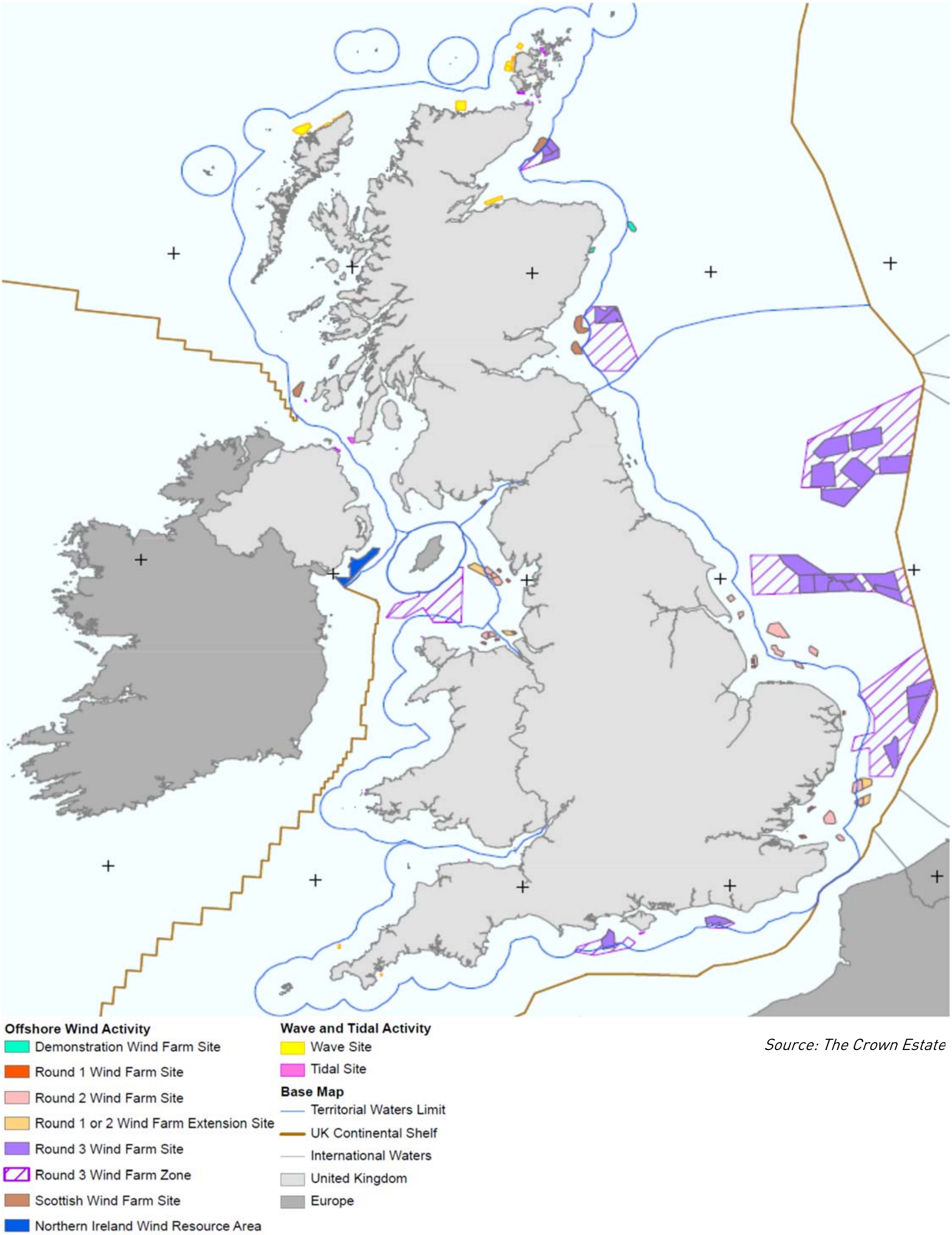
Sites

Selecting the location of an offshore wind development is the most critical consideration that influences a site's power production over time and determines costs related to installation, operations, maintenance and decommissioning. The UK has used a consultative but centralised approach to develop zones in which most of the required permitting and consent issues have been agreed between relevant parties beforehand. This prevents developers from having to go through lengthy and arduous approvals processes with many stakeholders who have competing interests in using the sea. It also means that investors have greater confidence in project proposals, since they are less likely to be delayed due to siting conflicts, which reduces the cost of finance.

Opportunities for China

- Location and zone selection
  - Entrust a centralised government body with the responsibility of designating zones in which offshore wind developments can be built (e.g. a joint task force between the NEA, the SOA and perhaps provincial governments). The body should negotiate pre-approval from stakeholders with competing interests in the sea, including conservation, fisheries, shipping routes, and military, to streamline the permitting process for developers.
  - Zones could be used as tools to help China administer differentiated feed-in tariff rates, which could be based on sea depth, distance from shore, and wind speed.
  - Recognise that wind speed is the most critical determinant in the long-term productivity of an offshore array, so investment in detailed wind speed mapping likely offers good value for money and can help with zone prioritisation.
- Relaxing constraints in zones
  - Relaxing constraints can significantly reduce deployment costs. Wind speed maps can help the government determine which areas are worth prioritising when negotiating with stakeholders to relax constraints.
- Site selection
  - Leave specific site selection up to developers, since they are better equipped to determine the commercial realities of developing a specific site, but facilitate the process by pre-approving development zones in coordination with other stakeholders.
  - Invest in and deploy the most sophisticated wind speed monitoring technology.
  - Consider having developers' site-specific plans audited or reviewed by third party independent engineering firms to ensure that maximum value is wrought from zones.

Figure 6: UK Offshore Renewable Energy sites

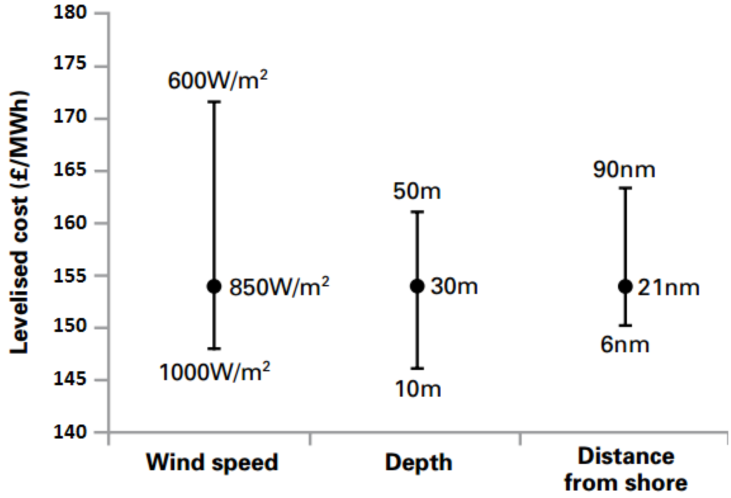


Source: The Crown Estate

Location and zone selection

Selecting the location of offshore wind farms is one of their most critical components. Figure 7 shows the importance of location as it relates to the main revenue and cost drivers.

Figure 7: Variation in levelised cost with wind speed, depth and distance from shore.



Note: Ranges show the impact of flexing wind power, depth and distance from shore while keeping the other variables constant at the values used to calculate the mid-point levelised cost.

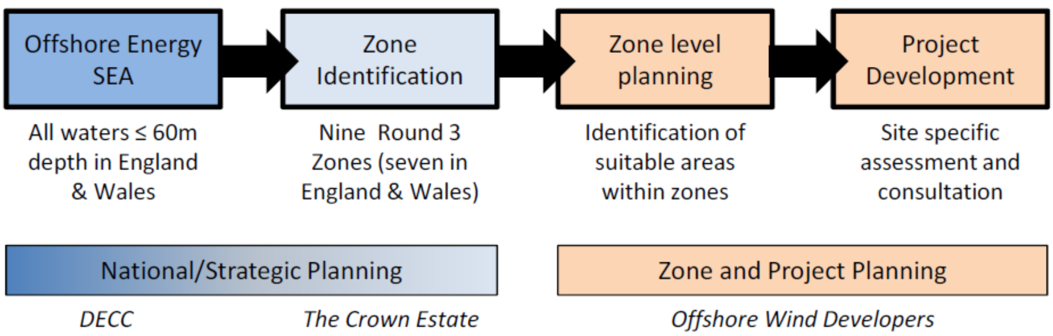
Source: BCG, Carbon Trust analysis

As can be seen, locations with the highest wind speed are the most important determinant of power production and revenue.

Selecting a location for offshore wind arrays relies on government approvals, which are influenced by competing uses of the sea's area. Indeed, constraints on deployment areas can significantly restrict available offshore wind deployment areas and may rule out the most productive (windiest) or least cost (shallow or near-shore) opportunities for development. In the UK, location selection was done in a series of stages that identified deployment zones and came to leasing terms through a series of offshore leasing 'rounds'.

In the UK, the Department for Energy and Climate Change and the Crown Estate are jointly responsible for determining "zones" that are open for construction, as shown in Figure 8, and developers are responsible for identifying which areas within each zone are suitable for construction, and which specific sites in those areas are best suited for project development.

Figure 8: Responsibilities for planning, zoning, and site selection

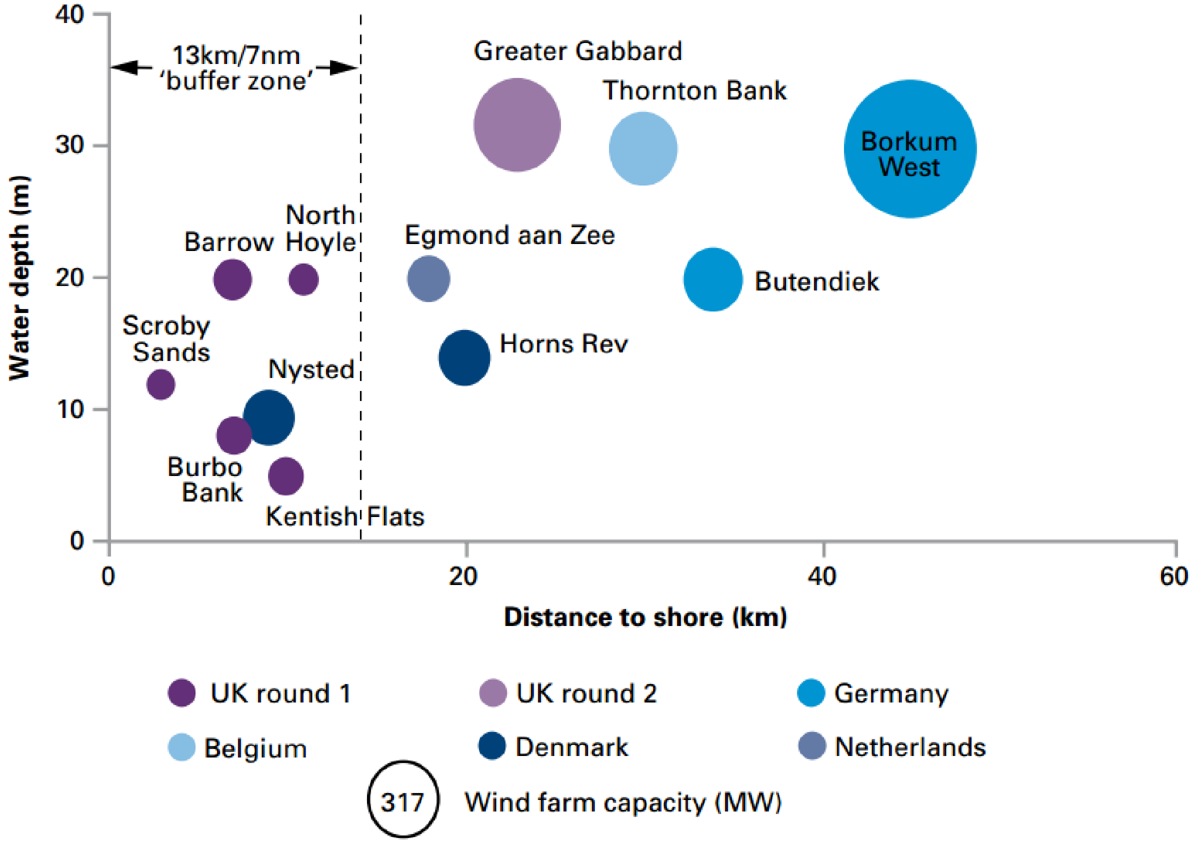


Source: The Crown Estate (2012)

After an initial 4MW test site at Blyth in 2000, the UK commenced offshore wind farm development with 'Round 1' of site leases. Five pilot sites, as shown in Figure 6, were developed from 2003 to 2008 with a total capacity of 390MW. The UK's 'Round 2' of site leases consists of a further 8GW of sites, mostly off the East Coast plus some significant developments in the North West and in the Thames Estuary (also shown in Figure 6).

Figure 9 shows the distribution of the main sites developed to date across different depths and distances from shore. The UK Round 1 and 2 sites are distributed within 12 nautical miles (nm) of shore at depths of up to 20m (Barrow and North Hoyle are the deepest) and there are some under construction at depths of up to 35m (Thornton Bank and Greater Gabbard).

Figure 9: Distribution of developed UK sites with depth and distance to shore.



Source: BCG, Carbon Trust analysis

In December 2007 the government announced a Strategic Environmental Assessment of the UK's marine estate to review whether enough seabed can be made available for a total of 33GW of offshore wind power capacity, more than enough for the 29GW potentially required to meet the EU 2020 renewable energy targets. In June 2008 the Crown Estate announced a 'Round 3' leasing process to provide the additional 25GW beyond the currently planned Rounds 1 and 2 of 8GW. Locations are shown in Figure 6.

The first stage of zone three selection involved a national selection of large areas of UK seabed which are suitable for developing offshore wind farms. This stage was critical since zone selection is a major determinant of the ultimate costs and profitability of offshore arrays.

Lessons learnt and insights for China

Investing in detailed wind speed mapping and sea floor mapping could help the government determine which areas are most appropriate for offshore wind development. It is recognised that China's offshore area is much vaster than the UK's, so to manage this task, the government could pre-select preferred deployment areas based on rough offshore information and more detailed onshore considerations like grid interconnection capability and the locations of electricity demand centres. These pre-selected areas could also be used to coordinate with the SOA, military, and other users of offshore areas so that site selection could be more targeted and avoid conflict with other offshore uses.

This zoning approach was effective in the UK because it overcame one of the biggest barriers that developers would have to face, namely coordinating with other users of the seabed and sea area to negotiate areas in which offshore wind could be built.

In China, broad development 'zones' have been selected, but once developers have won a bid they have to obtain permits for their specific construction site from the SEA, SOA, Marine Transport Administration, NEA, and other government departments. Only after these negotiations can they start construction. This process been very costly in terms of time, and many current users of the sea are understandably reluctant to forfeit any authority they have over it. Further detailing the exact sea areas in which developers can build and pre-approving construction in them by streamlining national government stakeholders could be an effective approach to manage these challenges in China.

Additionally, creating zones that incrementally open up more and more challenging areas of the sea could be a way of encouraging incremental learning and technology development, and could also be an approach to rolling out tiered FIT levels, should the government maintain its interest in such an approach. Specific zoning that corresponds to differentiated FIT levels requires a significant amount of data, however, which is a challenge given the relative immaturity of the offshore wind market and limited wind speed and sea bed mapping.

Relaxing constraints in zones

When carrying out the Strategic Environmental Assessment, the government had options concerning competing uses of the sea area. The Carbon Trust analysed the impact of recognising different competing uses of the sea area, and classified them into 'hard constraints' and 'soft constraints'.

Hard constraints would likely prove more difficult to relax, and included things like:

- Dredging (existing, application and option areas)
- Oil & gas surface infrastructure 6nm buffer
- International Maritime Organisation (IMO) routing
- Maritime Coastguard Agency (MCA) Offshore Renewable Energy Installations (OREI) guidance – sites not recommended
- MoD Practice & Exercise Areas (PEXA) ranked as danger areas

Soft constraints would likely be less difficult to relax, and included things like:

- Terrestrial and maritime Special Areas of Conservation (SACs) and Special Protection Areas (SPAs).
- Offshore SACs (possible and draft)
- Potential SACs and SPAs where indicative boundary data available
- MoD PEXA exercise areas
- MCA OREI guidance – site potential assessment
- Civil Aviation Radar – 140m blade tip height

The impact on the levelised cost of energy (LCOE) when these constraints are lifted is shown in Figure 10. The fewer constraints that are maintained, the lower the LCOE for offshore wind.

Applying all current constraints would restrict most development to what are predicted to be the most expensive site types, north of the Dogger Bank. The current capex of these sites is estimated at £3.1m/MW, 40% higher than Round 2 sites. In addition, the risk of these sites would be significantly higher because deep-water, further-from-shore technology is not yet commercial and in the short-to-medium term would carry a technology risk premium. Furthermore, any maintenance or failures would lead to longer downtime without on-site communities of operations & maintenance personnel. Current constraints would therefore limit development to sites with such high costs.

Relaxing both shipping and MoD soft constraints would increase the area available in the attractive near shore sites to up to 50GW, but most of this would be within the near-shore buffer zone. In addition, development may be further constrained by a lack of grid connection options in Scotland as well as unforeseen constraints such as MoD radar concerns, unsuitable seabed geology and local environmental issues.

Around 13GW would still therefore need to be built on Dogger Bank. It was determined that in order to locate 29GW (the deployment that was envisaged to meet the UK's 2020 renewable electricity target) on the most economically attractive sites (near-shore, shallow and mid-distance, mid-depth sites), the seaward buffer zone would need to be reduced in some places and some constraints currently considered 'hard' would need to be relaxed, especially the 6nm exclusion zone in place around oil and gas installations.

Fully relaxing all constraints would allow the 29GW deployment cost to fall from £75bn to £59bn, representing an enormous saving simply through efficiently locating arrays.

Figure 10: Levelised costs of energy under different constraints scenarios.

Source: BCG, Carbon Trust analysis

DECC completed its first Offshore Energy Strategic Environmental Assessment in 2009, and its second in 2011. These assessments concluded that up to 33GW of offshore wind development could take place within the UK Renewable Energy Zone and English and Welsh Territorial Waters up to a depth of 60m, provided that some areas were avoided (e.g. shipping lanes), and that projects included any necessary measures to mitigate likely significant adverse impacts on the environment and other users of the sea.

The Crown Estate, which grants leases for the use of the UK seabed for offshore renewable energy construction, designed the Round 3 zones. In 2008 and 2009, using the information which was available, the Crown Estate identified large areas of seabed around the UK which are the most suitable for offshore wind development. In 2009 The Crown Estate ran a competitive tender process and awarded these Round 3 zones to different offshore wind developers. In parallel, The Crown Estate undertook a Habitats Regulations Assessment (also known as Appropriate Assessment) in relation to the Round 3 tender programme. This was required under the UK Habitats Regulations, which are derived from the European Habitats Directive and Birds Directive.

The second stage in the process of deciding where to locate offshore wind farms within the Round 3 zones – the 'zone and project planning stage – is the responsibility of the offshore wind developer who has the rights for the zone. Offshore wind developers can look for wind farm projects within the boundary of their Round 3 zone. They are currently undertaking survey work and studies to help them understand the most appropriate locations for offshore wind farm projects within the zone. They will take into consideration engineering, economics and environmental factors when deciding on the locations of wind farms.

When they have made the decision on the best location for a project, they undertake an Environmental Impact Assessment and detailed consultation on the proposal for the wind farm. Then they will submit an application for development consent to the National Infrastructure Directorate within the Planning Inspectorate (PINS). Based on all the evidence, including information from stakeholders, PINS will carefully weigh up the benefits of the project against the environmental impacts, and will make a recommendation to the Department for Energy and Climate Change (DECC) about the project. The final decision on whether or not to grant development consent for the project will be made by the DECC Secretary of State (The Crown Estate, 2012).

Lessons learnt and insights for China

The NEA and the SOA might consider coordinating to determine whether any of the constraints that are created by competing users of the sea could be relaxed. Relaxing constraints enormously reduced offshore wind deployment costs by opening up more economically viable areas of the sea, and enabled the technology to be more cost-competitive than it otherwise would have been.

Additionally, dedicating efforts to relaxing constraints necessarily requires interaction and coordination among the various parties that use the sea. This could be an opportunity to negotiate specific zones that are available for offshore wind development, effectively streamlining the negotiation and permitting burden that is currently borne by developers.

Finally, it is worth noting that opening up dedicated, pre-authorised development zones does not exempt developers in the UK from submitting their specific plans for environmental impact assessment and other planning consents. While the Crown Estate may classify zones as buildable, the construction methods, wind farm layout, total capacity, onshore interconnection details, and other characteristics still need to be approved by other authorities. For example, the UK's Infrastructure Planning Commission still retains a role in approving major infrastructure project like offshore wind, and local authorities are extensively consulted throughout the process. Building wind farms in pre-approved zones is a necessary, but not sufficient, condition to move forward with offshore wind construction in the UK.

China may likewise deign to adopt a similar approach to planning, where specific offshore zones are pre-approved using a streamlined and coordinated approach that seeks to relax constraints and reduce costs, but where other considerations beyond the wind farm's specific offshore location require additional approvals.

Site selection

Once zones have been defined by the government, developers engage in careful site selection to determine the financial feasibility of their projects. Note that since the Crown Estate has outlined the zones in which offshore turbines can be built, they have effectively controlled for all other potential uses of that sea area. Consequently, developers do not have to engage with any other agencies (e.g. the Ministry of Defence, the Department of Environment, Food and Rural Affairs, Department of Transport's Maritime and Coastguard Agency, etc.). In this way, the Crown Estate's centralised government authority over the seabed is highly useful for developers since it streamlines the approvals process considerably.

Site selection is especially reliant on high quality wind speed data, since it is the biggest determinant to the long-term profitability of a project. Significant amount of innovation has been put into lowering the cost of gathering site specific data while improving accuracy.

Figure 11: Meteorological mast

Traditional meteorological masts (met masts) are fixed to the seafloor and require expensive jack-up barges to install (see Figure 11). This installation procedure makes them sensitive to weather conditions and increases the complexity of the activity. They are only capable of measuring wind speeds and directions at a single point in a site, and tend to be restricted to measurement altitude of about 100m above sea level. Overall, fixed met masts tend to cost between £7-17m, and require 12-18 months to deploy.

Innovation in this area has been a priority in the UK, since developers understand how critical high quality wind speed data is to the long-term performance of an offshore wind array. An innovative technology that is now being tested and deployed consists of a floating platform supporting LiDAR equipment that can remotely sense wind speeds using a laser (see Figure 12). The technology allows for wind speed measurement at various altitudes simultaneously (currently up to 300m), which has multiple technical benefits, including gaining more insight into the likely differential stresses on turbine blades and the optimum altitude of the nacelle. The floating LiDAR platforms can be towed to a site and anchored, which enables very fast deployment (days rather than 12-18 months) and significantly reduces the complexity of installation. Moreover, the platform can be towed and placed at different parts of a site to gather multiple data points, rather than being fixed to the seafloor. Overall, floating LiDAR platforms can bring wind speed measurement costs down to roughly £0.5m while increasing the accuracy of wind speed readings.

High quality data about specific site characteristics not only improve the confidence in the long-term performance of a site for project developers, but crucially, also bolster the confidence of lenders and investors in the projects, which can significantly reduce the cost of finance. Developing technologies that enable high quality site selection therefore has near-term benefits from lower costs of capital, as well as long term benefits from more productive and profitable installations that maximise the use of the sea.

Lessons learnt and insights for China

The biggest lesson from site selection is that wind speeds are the largest determinant of an offshore wind array's long-term productivity. Detailed wind speed studies should therefore be encouraged so that developers optimally site their turbines, and R&D efforts in this field are recommended since new technologies that increase the accuracy of wind speed data will likely yield high returns on investment.

In the UK, it is ultimately up to the developer to select sites within pre-approved zones and determine the costs of development. But again, the UK's experience of having a centralised government body (the Crown Estate) negotiate with other agencies to offer pre-approved zones has been very helpful in terms of streamlining developers' permitting and approvals processes. It is recommended that China explore this type of institutional coordination, or that some combination of government agencies manage this process.

Separately, to provide a higher degree of certainty both to investors and to the government, site-specific plans could be audited or reviewed by third-party independent engineering firms to ensure that the information provided by developers is reasonable. This should help to ensure that the maximum value is wrought from zones, which are space-limited and must be used efficiently to get full value for money from investments and ensure the offshore resource is used most effectively.

Planning for demonstrations and the grid

Opportunities for China

- Demonstration projects
  - Act early and recognise the lead-times required to mainstream demonstration technologies so that deployment cost reductions can be realised before major scale-up takes place.
  - Extend the consenting envelope to allow new technologies to be tested on the edge of approved wind farms.
  - Collaborate internationally on demonstration and technology development.
- Grid planning
  - Develop offshore wind projects and grid reinforcement upgrades simultaneously to minimise delays connecting to the grid.

Planning for demonstrations

Demonstration projects are an essential step in the technology development process. They allow for new technologies and processes to be trialled, enable new entrants to test and prove their designs, and can contribute to data gathering, help to reduce costs, and improve installation efficiencies.

In the UK, developers have found that demonstrations tend to be most efficiently rolled out when they are deployed at the edge of a wind farm that has already received approval. Site conditions tend to be well known and environmental studies are already complete and approved, which helps developers manage costs, and installation vessels and other onshore and offshore infrastructure are already being utilised, which delivers economies of scale. Also, siting demonstration turbines at the edge of approved sites reduces the risk that they will negatively impact upon the rest of the array.

But one of the biggest constraints that has been faced in the UK is the approvals process required for these demonstrations, and the risk that the entire wind farm might be jeopardised by the addition of a demonstration activity.

Since the specific designs of demonstration projects often take shape after the rest of the farm has been designed and approved, a fresh round of permitting and approvals must be sought by developers to deploy perhaps only one turbine. These time costs and delays in approvals can mean that developers have to forfeit the economies of scale and possible efficiencies, meaning that demonstrations either become very expensive, or are not pursued at all.

Additionally, lengthy lead times for demonstration projects mean that, in order for them to have material effect on cost, especially when deployment ambitions are high, they have to be supported early.

In the UK, decisions for Round 3 technology selection need to be finalised by the middle of 2014 for deployment in 2015-16. Since technologies must be successfully tested for at least two years before they can be integrated into a commercial project, it is clear that early demonstrations are important. Figure 13 illustrates the example of offshore wind foundation demonstrations for Round 3 wind projects in the UK.

Figure 13: Lead times for demonstration projects

Lessons learnt and insights for China

China's offshore wind deployment targets are very ambitious, and the compressed timelines in which the country aims to achieve its offshore capacity make it all the more the important that it invest in technology and process demonstrations early. The earlier lower-cost innovations can be demonstrated, the earlier they will be able to be included at the technology decision stage.

China should consider mechanisms that accelerate the approval process for demonstrations. Since developers tend to deploy demonstrations at the edge of offshore wind arrays, China may consider allowing for special exemptions for these areas, or consider extending the consenting envelope to allow new technologies to be tested.

The UK does not have an enviable track record on this front – indeed, the duration of planning consent can be 27-36 months to approve greenfield sites, compared to only 3 months in Norway. To change consents (for example, for larger rotors), timelines can stretch from 9-24 months. These delays are costly, stifle innovation and limit the degree to which developers can deploy the most up-to-date technologies.

Additionally, elements of many of the technology developments that domestic offshore wind companies are eager to test and demonstrate may have already been tried elsewhere in the world, given the relative maturity of the offshore wind industry in other countries. China could benefit from collaborative partnerships and sharing demonstration data to accelerate the industry as a whole and reduce costs all over the world.

Planning for the grid

The UK's electricity grid infrastructure is old. While it has been upgraded over time and delivers power extremely reliably, it suffers from north-south capacity constraints and limitations on where new high-voltage current can be interconnected. When new, large-scale power generation is to be brought into the grid, it usually needs to undergo upgrades to be able to handle the additional power, and usually follows an 'invest then connect' approach.

Following this approach, developers apply for connection to the transmission network, and the transmission licensee (National Grid or Scottish Power) makes an assessment of the transmission network reinforcement required to connect the new generation. The developer must then wait for these network reinforcements to be completed by the transmission licensee before it can connect to the network. This delay can be of an indeterminate period, depending on how quickly the transmission licensee acts and the speed with which planning approval can be secured, resulting in additional costs and uncertainty for the developer.

For example, onshore wind developers in Scotland have in some cases waited more than five years before they could connect because the network reinforcements triggered by their applications have resulted in lengthy planning processes.

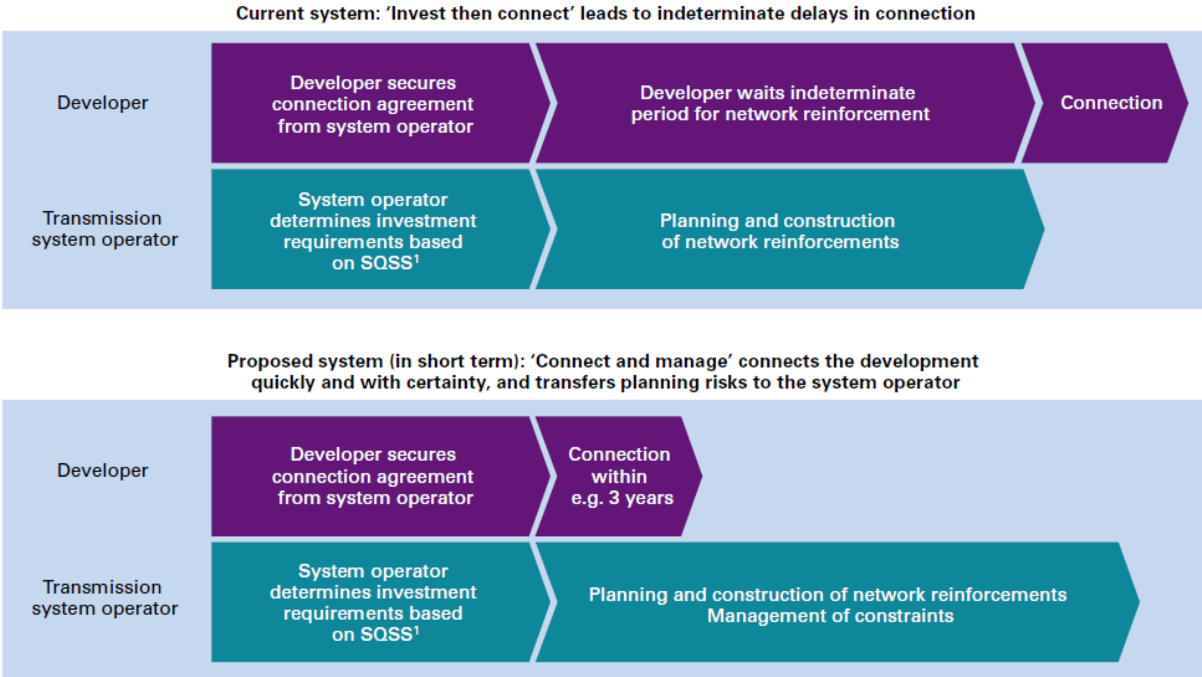
An alternative approach, at least in the short term, is known as 'connect and manage', in which the developer is provided access to the grid transmission network before potential required reinforcement is completed. As shown in Figure 14, it would reduce the delays in connecting new wind generation and would provide certainty for developers, thereby improving the financial viability of projects.

Such a system would however lead to higher constraint costs in parts of the network with limited transmission capacity and substantial renewable generation (such as Scotland). In these regions a high degree of sharing of transmission capacity will be required until new transmission capacity is constructed, with the implication that thermal generation may need to be constrained at certain times to enable the network to accommodate wind generation.

'Connect and manage' would also have the effect of removing some of the impact that transmission constraints have on the site choices made by developers. Under the current system, developers are incentivised to build in regions where grid constraints are low so as to ensure faster grid connection, which may not be the most efficient locations for generation.

In the medium term, 'connect and manage' should be augmented or replaced by more efficient methods of allocating transmission capacity, and of assigning the value of this capacity to generators. Two possible options are auctioning of transmission access rights, and secondary trading of short- and long-term rights. However development and implementation of such a mechanism will take a number of years, and in the interim 'connect and manage' is the most effective means of connecting new wind generation to the network without incurring significant delays.

Figure 14: Different approaches to grid connection



Lessons learnt and insights for China

In China, grid capacity does not seem to be as great an issue as it is for the UK. Newer, higher capacity grid infrastructure already exists, especially around large urban centres where most offshore wind capacity is likely to be installed. Moreover, China does not seem to suffer from the same planning constraints and delays that are often experienced in the UK. As such this potential challenge seems less material for China than it has been in the UK.

It is recognised, however, that many gigawatts of onshore wind capacity have been built but remain unconnected to China's grid. This raises the possibility that a similar degree of misaligned planning may be possible for China's offshore wind resources as well. While the onshore grid connection challenges revolved around difficulties developing high voltage transmission infrastructure over vast distances, rather than on more localised grid capacity constraints and interconnection issues, the principle of planning coordination remains the same.

Overall, ensuring that planned offshore capacity is matched with other enabling infrastructure development like high-capacity grids is important. The greater the extent to which offshore developments and grid reinforcements can be designed and built simultaneously, the better will be China's position.

Technology and supply chain development

The capability of a country's commercial stakeholders to deliver offshore wind technologies at scale relies on the development of a robust supply chain. To deliver it cost effectively requires investment in technology development and innovation. As the offshore wind market has matured in the UK, significant effort has been put into both technology and supply chain development. Based on past experience in other renewable energy technologies, each are considered to be strengths in China.

Opportunities for China

- Apply a similar industrial strategy to offshore wind that was used for the solar PV and onshore wind industries in China. Technology development and targeted support for the domestic supply chain significantly reduced costs on both of those industries and allowed for China to build dozens of gigawatts of capacity in a very short time.
- Leverage expertise from other relevant industries with transferable experience, like oil and gas, onshore wind, shipping, aerospace and marine engineering.

New and more efficient technologies are being developed, tested and deployed all along the offshore wind supply chain. The capacity of turbines is increasing, which means that blades are longer and heavier, posing challenges for materials scientists. Innovators are aiming to reduce blade weight while increasing strength and resistance to the ever greater sheer forces and variable loads that are amplified with blade length. Using innovative materials may also help buffer offshore wind turbines from the price variability of widely used materials like steel, whose historic price fluctuations have been a significant driver of increasing offshore wind costs. Lightweighting components through innovative materials development not only diversifies inputs and strengthens performance, it also lightens the load on towers and especially foundations, enabling tested foundation designs to be used for higher capacity turbines, or making new foundation designs viable more generally.

The particularly high cost of unscheduled maintenance in an offshore environment means that direct drive gearboxes hold promise for O&M cost reductions since they would reduce the reliance on an historically weak part of wind turbine design. Electricity transmission line losses are also a significant operating cost, especially as wind farms are built further from shore. Ensuring that electricity losses are reduced by implementing HVDC transmission cables is sensible, but is currently relatively expensive.

Overall, there are many technology options to reduce costs and improve performance, and targeted innovation spending is required to move those options from R&D to commercial deployment.

The UK has used industry collaboration to accelerate cost reductions, through programmes such as the Carbon Trust's Offshore Wind Accelerator programme, and has recently launched a centre of excellence called the Offshore Renewable Energy Catapult. Both initiatives aim to reduce the costs of offshore wind by supporting technology development and demonstration, leveraging the power of partnership and collaboration to accelerate these cost reductions.

In terms of supporting supply chain development, one of the key elements revolves around improving certainty in the industry that there will continue to be demand for the technologies. Investors and developers need to be quite certain that offshore wind will remain a government priority, since it requires government support to be commercial viable at this stage. Only if they have that certainty will they be comfortable making the large upfront capital investments in new factories, ports, bespoke installation vessels and equipment. These assets have long lifespans and are only economically viable if they will be used for a long time.

While the UK's targets have remained fairly consistent over time, trust in their realism and the government's genuine commitment to offshore wind has wavered. A lack of certainty has led to halting progress in terms of supply chain development in the UK.

Technology cost reductions and supply chain development have historically been strengths of China. Both its domestic onshore wind and solar PV capabilities were supported by a sophisticated industrial development strategy that has paid dividends. Chinese innovation and scale drastically reduced the costs of solar PV, and an integrated approach to onshore wind has made it the world leader. It is realistic to believe that a similar approach could yield strong results in offshore wind as well.

Summary

China has committed to lead the world in offshore wind deployment. Like any country striving to launch a nascent industry it is encountering some obstacles. Determining balanced economic incentives is challenging when so few benchmark projects have been deployed. Improving industry and government coordination can be difficult in the early stages. Good site selection can be challenged by competing uses of the sea, and planning for demonstrations and grid development must be coordinated with foresight.

The UK has encountered many similar issues while supporting its own domestic offshore wind market, and has learned valuable lessons that can help to overcome some of the barriers China is facing. It is also recognised that China's context and stakeholders are different, and that the global offshore wind market has matured since the UK first started significantly supporting the industry over a decade ago. The contextual characteristics and technology advances may work to favour China's ambitious deployment targets.

The opportunities for China that are profiled in this report are meant to serve as options based on the experience of the UK, and must be considered in light of local circumstances and the rapidly evolving international offshore wind market. They are, however, based on over ten years of deliberative action, iteration, intensive industrial input and engagement, and a government that puts significant stake in ensuring value for money. For those reasons, the UK's experience is thought to be among the world's most developed for offshore wind. It is hoped that it provides valuable insights for China and helps to accelerate deployment and industry-wide cost reductions, ultimately leading to more affordable low carbon renewable energy, enhanced energy security, and a reduction in greenhouse gas emissions.

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