TONY BLAIR INSTITUTE FOR GLOBAL CHANGE

An Efficient Energy Transition: Lessons From the UK's Offshore Wind Rollout

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Executive Summary

- The UK's legally binding target of net-zero emissions by 2050 will require the most significant overhaul in energy technologies since the Industrial Revolution. A challenge of this scale requires a clear vision and a credible delivery plan.
- There is now increasing clarity in respect of this vision. Interim targets for 2030 and 2035 set a feasible pathway to 2050. Sector-specific targets – such as the complete decarbonisation of power by 2035 – are being set, and the technologies required to reduce emissions are well understood.
- But the credibility of the plans and the answer to the question "Will policies and markets deliver the technology deployment?" are much less clear. The focus must therefore shift to formulating a credible plan to deliver the green-technology revolution that is central to reaching net zero.
- The task ahead is daunting. By 2030 we need to be fitting 1 million heat pumps to homes each year and have 10 million battery electric vehicles (BEVs) on the road. We must have installed 40 gigawatts (GW) of offshore-wind power capacity and 30 terawatt hours (TWh) of low-carbon hydrogen. We will need to be cultivating 115 kilohectares (kha) of energy crops and sequestering 10 megatonnes (Mt) of carbon dioxide each year.
- To achieve these goals, we will have to learn the lessons of past policy interventions. Reflection and learning are essential if we are to succeed. The UK has a unique opportunity to do this thanks to the impressive rollout of offshore wind in North Sea waters over the past 20 years. The sector has grown at an unprecedented rate, and the UK is second only to China in installed capacity. The result is a technology that is much further along the development timeline than other low-carbon technologies required for net zero. This gives us a critical opportunity to identify lessons that can be applied to other technologies required for net zero to increase the chances of delivering them at the scale and pace required to hit the targets above.
- We identify eight lessons from the rollout of offshore wind that the UK government should apply to other net-zero technologies:

1 Long-term political commitment is crucial to drive low-cost deployment and domestic benefits.

Offshore wind has benefitted from consistent political support, which has fostered confidence across industry to invest in related research and development (R&D), supply chains and skills. Certainty is crucial to a realistic deployment pathway for other low-carbon technologies.

2 Tackling the cost of capital should be a central objective of policy.

The cost of capital is a critical determinant of the overall project cost for new technologies owing to the risks associated with early deployment. By reducing investor risk, and therefore the cost of capital, a Contract for Difference (CfD) – the government's main mechanism to support large-scale renewable projects – can deliver a reduction of between 10 and 21 per cent on overall project costs. This focus on cost of capital has been hugely successful with offshore wind and there is evidence that it has had a strong influence on global deployment. A similar approach should be followed with other early-stage technologies to ensure an affordable transition for consumers both in the UK and globally.

3 Adapting support to the maturity of the technology.

Offshore wind has benefitted from the right support at the right time, whether that was early-stage development funding, supply-chain investment or more recently the CfD. This shows the importance of targeted support to technologies at different stages in the development timeline. If technologies are eligible for a CfD but consistently fail to win a contract, as has happened with wave and geothermal power, government should consider whether this is the right type of support, or whether the technology should be pursued at all.

4 Design markets around desired long-term outcomes.

To date, government has followed an approach of increasingly complex market intervention in an attempt to shoehorn low-carbon technologies into a market designed around fossil-fuel technologies. Now that there is clarity on the type of technology that will dominate the future electricity system, government must initiate a comprehensive market-reform process to ensure that incentives across the system are aligned to deliver a flexible, net-zero, cost-effective system by 2035.

5 A healthy pipeline is key for competition and supply-chain development.

By offering a reliable revenue stream and a stable timeline of auctions, the CfD has created sustained investor interest in the UK renewables market. This has manifested as a strong pipeline of offshore-wind projects bidding into each auction, creating intense competition between developers on cost. A strong pipeline also delivers line of sight, making it crucial to the development of a sustainable supply chain, which means jobs and wider domestic economic benefits for the UK.

6 Partnership between industry and government can deliver sustained investment.

Offshore wind has profited from a close relationship between industry and government through partnerships such as the Offshore Wind Industry Council and the Offshore Wind Sector Deal. Such partnerships are crucial in forming open channels of dialogue between industry and government, allowing the articulation of a joint vision and a means of tackling barriers to deployment.

7 Strategic systems thinking is required for an efficient transition.

To date, each new wind farm in the North Sea has received a point-to-point connection with the onshore electricity grid, disrupting local communities on the east coast. The government is now considering an offshore transmission system to reduce costs and limit the need for onshore infrastructure. Other system efficiencies include enabling an active demand side (for example, EV owners selling power back to the grid) to reduce the overall amount of new-build electricity capacity, and the reuse of oil and gas assets for carbon capture, utilisation and storage (CCUS). The government must think strategically to ensure an efficient and politically feasible transition to net zero.

8 **A clear strategy is needed for securing domestic benefits.**

While the rollout of offshore wind is a policy success story, the government has failed to capitalise on the domestic economic opportunities of being an early mover. If UK electricity consumers are expected to pay a premium to commercialise nascent technologies, then they should also expect the government to secure long-term social and economic benefits for the UK. The failure to capitalise on that opportunity with offshore wind is now being rectified through the Offshore Wind Sector Deal and CfD contract terms, but the government must take care to analyse and capitalise on domestic opportunities from other net-zero technologies.

The decarbonisation of the UK economy is accelerating. But we do not have time to repeat the policy mistakes of the past. Crucially:

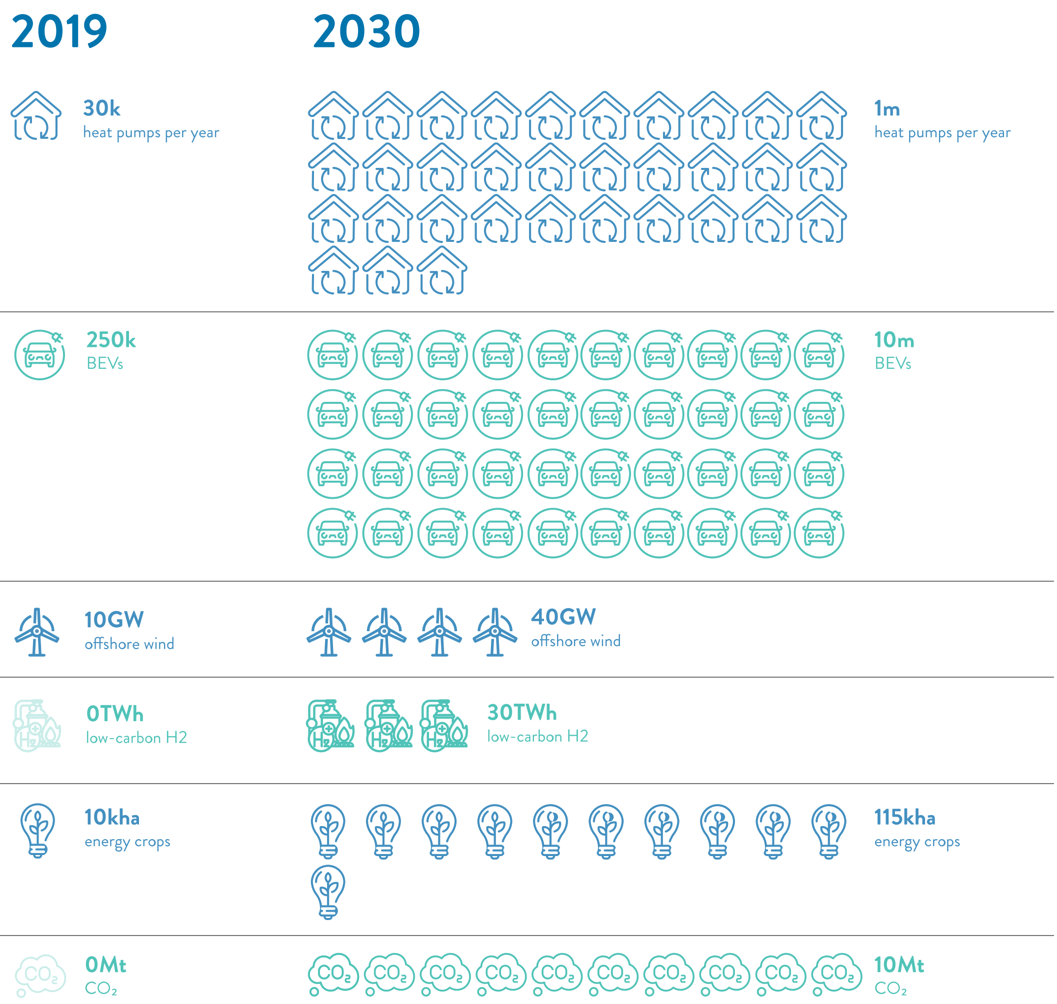
1. Upscaling UK offshore-wind generation will be a huge challenge. Applying the eight lessons identified in this paper will unlock barriers to deployment and allow the UK to meet and surge beyond 40GW of offshore wind.
2. Applying these lessons to other sectors of the economy will facilitate the rapid deployment of the novel technologies required for net zero.

Introduction

The Need to Scale Up Technology Deployment

- The 2020s is the decade that will determine whether the UK reaches net-zero emissions by 2050. Modelling from the Office for Budget Responsibility (OBR) has shown that early action drives the most economic route to net zero, allowing markets to deliver cost-effective solutions and limiting inefficient government intervention in the 2030s and 2040s. [1] The high-level ambition is in place: the UK's 2030 target for an emissions reduction of 68 per cent from 1990 is net-zero consistent.
- Technology deployment and behaviour change are the two key elements of delivering net zero. Behaviour change – explored in our recent paper – has consistently been downplayed by the government. And technology deployment, while consistently talked up in principle, is not happening at the scale required.
- Unquestionably, the level of deployment required is unprecedented and eye-watering. Figure 1 provides an idea of the scale-up of low-carbon technologies needed to meet the 2030 target. This is extremely challenging, but offshore wind's meteoric rise from 1 per cent of UK electricity generation to 13 per cent in ten years provides key learnings that can be applied to rapid deployment of other key net-zero technologies.
- This paper provides a critical assessment of the rollout of offshore wind in the UK and considers how the lessons learned can be applied to other technologies to ensure an efficient, timely transition to a net-zero UK economy.

Figure 1 – The scale of the UK's 2030 targets for low-carbon technologies

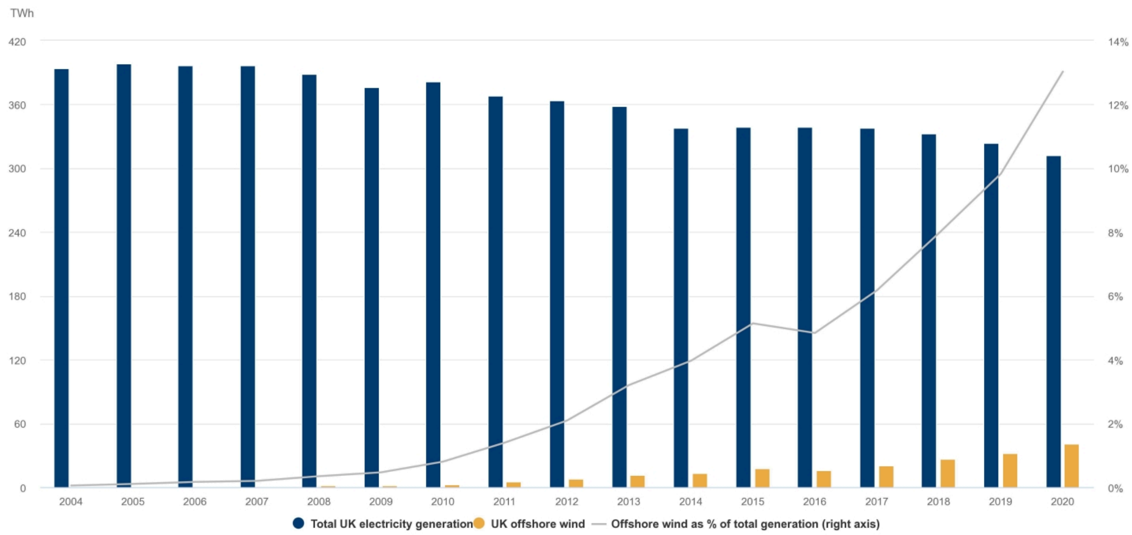


Source: Committee on Climate Change, Sixth Carbon Budget. Link.

The Rapid Rise of UK Offshore Wind

The deployment of offshore wind has been a major UK success story over the past 20 years. The sector has expanded from two small turbines off the coast of Northumberland at the turn of the millennium to over 2000 turbines dotted along the UK continental shelf, with new projects growing in number and turbine size. The share of offshore wind in total electricity generation has steadily increased, hitting 13 per cent in 2020.

Figure 2 – UK offshore-wind generation as a proportion of total electricity generation, 2004-2020



Source: BEIS, UK Energy in Brief 2021 Dataset. Link.

The rollout can be viewed in five distinct phases, which show different stages of development and increasing speeds of deployment.

1. 2000 to 2004: Rate of deployment = 25MW/year, UK = 100 per cent of global capacity

The first five-year interval was characteristic of the early phase of a technology development timeline with a focus on R&D and demonstration. In 2000 a pilot project consisting of two 2MW turbines was installed off the coast of Blyth in Northumberland. They were the biggest wind turbines in the world at the time but pale in comparison to the latest models.

In brief: Britain's renewables support schemes

Non-Fossil Fuel Obligation (NFFO): An obligation placed on suppliers to secure specified amounts of new generating capacity from non-fossil sources.

- Opened: 1990. Closed to new generating capacity: 1998.

Renewables Obligation (RO): An obligation placed on suppliers to source an increasing proportion of electricity from renewable sources. At the start of the RO in 2002, suppliers were obligated to source 3 per cent of their electricity from renewables. This has risen to at least 25 per cent in recent years.

Opened: 2002. Closed to new generating capacity: 2017.

Contracts for Difference (CfD): A government-backed contract that provides low-carbon generators with a guaranteed strike price, thereby insulating that generator from market volatility and reducing the cost of capital. Contracts are allocated through a competitive auction process.

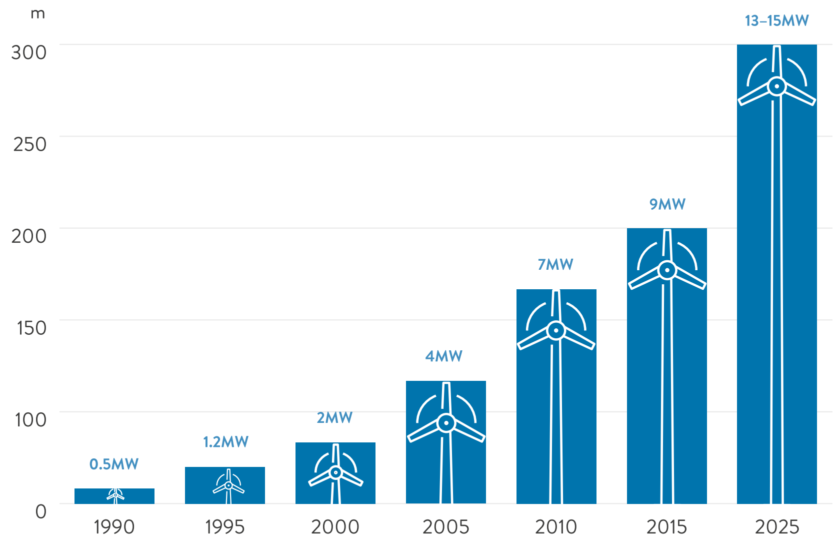
Opened: 2014. Still in operation. The fourth allocation round is currently under way.

Two further projects were commissioned during the period, both consisting of 30 2MW turbines giving a total UK installed capacity of 124MW at the end of 2004 – just 1 per cent of today's installed capacity. The latter two projects were the first to be supported by the Renewables Obligation (RO) – the first major UK government policy to support large-scale renewable electricity projects.

2. 2005 to 2009: Rate of deployment = 123MW/year, UK = 44 per cent of global capacity

The second phase was characterised by early commercialisation with five projects totalling 604MW of installed capacity, roughly five times the deployment rate of the first phase. There was also evidence of technological advancement with the demonstration of two 5MW turbines in 2007. These models were more than double the capacity of the earliest turbines and signalled the start of what would become an intense rivalry between turbine manufacturers to produce larger and more efficient turbines.

Figure 3 – How the offshore-wind industry has grown



Source: TBI graphic, data from Bloomberg New Energy Finance.

3. 2010 to 2014: Rate of deployment = 671MW/year, UK = 51 per cent of global capacity

The third phase of offshore-wind deployment in the UK was defined by rapid commercialisation and technological advancement. Thirteen projects totalling 3.3GW of capacity were installed in this five-year period – another five-fold increase in deployment rate and 27 times the rate of the first phase. The majority of the turbines installed during the period continued to be at the smaller end of Figure 3, around 3MW in capacity. However, prototypes of larger turbines were once again piloted ensuring the continued development of the technology.

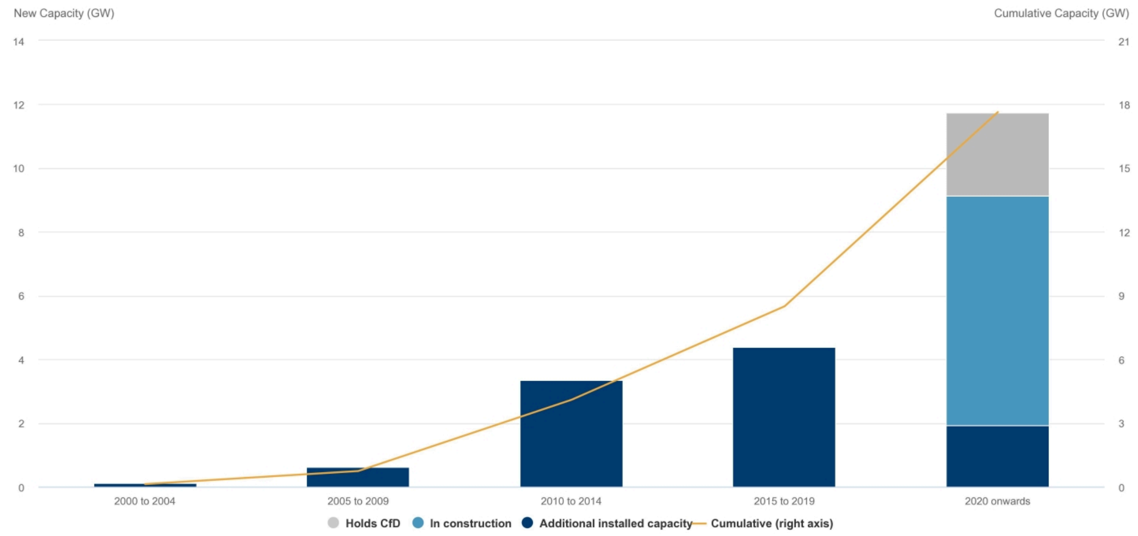
Again, all projects in this period were underpinned by the RO, but the increased deployment rate can in part be explained by a 2009 reform to the mechanism that introduced banding to RO technologies to adjust the balance of support provided to technologies according to their maturity. This banding effectively doubled the subsidy for electricity produced by offshore wind turbines, making the technology a more enticing investment proposition.

4. 2015 to 2019: Rate of deployment = 881MW/year, UK = 30 per cent of global capacity

The next five-year period saw a further increase in the rate of deployment, although the pace of growth moderated. Thirteen new projects were commissioned with a combined capacity of 4.4GW. There was a step-change in technology with most projects using 6 to 8MW turbines, double the typical capacity of previous models.

But while deployment continued to grow, the rate of increase slowed because of the transition from the previous subsidy mechanism (the RO) to the new Contracts for Difference (CfD) scheme. There was an overlap between the two: the RO remained open to offshore-wind developers until 2017 while the first CfD auction took place in 2014. This overlap was generally agreed to be a good means of transitioning between the two schemes but deployment initially stuttered, perhaps because developers had to determine which scheme offered better value.

Figure 4 – UK offshore-wind capacity, 2000–2020 and beyond



Source: The Crown Estate, Offshore Wind Operational Report. Link.

5. 2020 onwards: required rate of deployment = 3GW/year

The most recent phase of offshore-wind deployment was the first post-RO period. Only two projects have been commissioned in the two years since the turn of the decade, mainly due to disruption caused by the Covid-19 pandemic. However, these projects are impressive in size, totalling 1.9GW and continuing the trend towards larger turbines (7MW) seen in the previous period.

There is a further 9.8GW of capacity in the pipeline with 7.2GW under construction and 2.6GW holding CfD contracts in the pre-construction phase. However, only 5.5GW of that pipeline is expected to be operational by 2024. Combined with the capacity already installed since 2020, this totals 7.4GW capacity for this five-year period and an average deployment rate of 1.5GW/year, which is a long way short of the 3GW/year required to meet the government's offshore-wind target of 40GW by 2030.

The fourth round of the CfD scheme is currently open to applicants and there are hopes that it will bring forward up to 8GW of offshore-wind capacity. And last week's government announcement of a shift from two-yearly to annual CfD auctions is a crucial step in keeping alive the chances of meeting the target of 40GW by 2030.

Further positive news in the past month came from Crown Estate Scotland's announcement of the outcome of its latest round of seabed leasing. The results of the auction far surpassed expectations, with 17 projects totalling up to 24.8GW winning contracts. This provides a much-needed boost to the offshore wind pipeline beyond 2030.

Performance

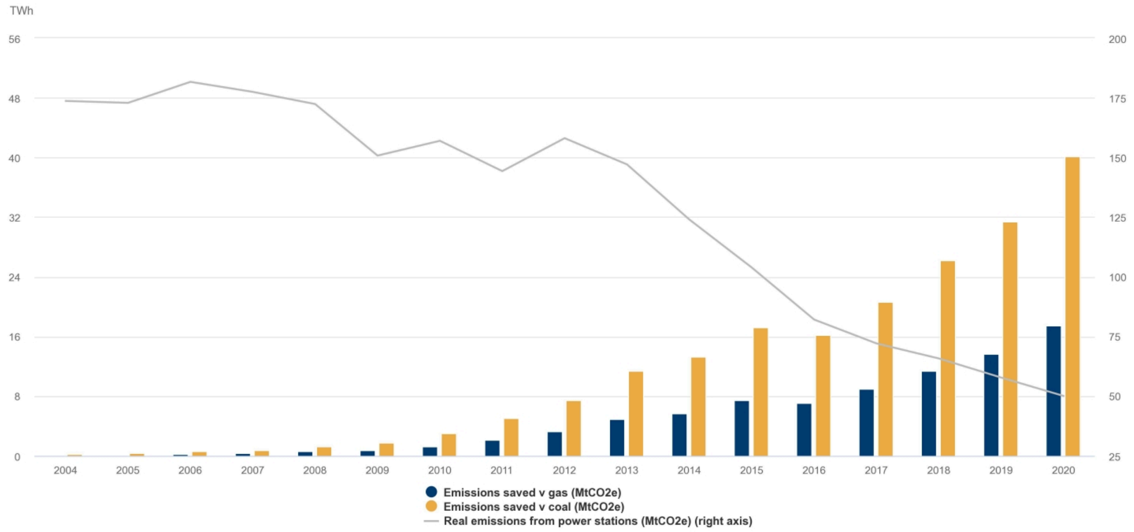
How can we assess the UK's offshore-wind deployment to date? We estimate how much progress has been made in three key areas.

1. **Emissions reduction:** the purpose of the UK's pursuit of offshore wind is to reduce power-sector emissions and ensure a sustainable future, but how effective has offshore wind been in achieving this?
2. **Technology-cost reduction:** while cutting emissions is key, it cannot be done at any cost. Reducing the cost of offshore wind is crucial to make the net-zero transition affordable for consumers and to accelerate deployment both in UK waters and internationally. How has the UK performed in this area?
3. **Domestic economic benefits:** the influx of offshore-wind investment should deliver economic benefits to people living in the UK. Has the UK maximised the domestic economic benefits on offer?

Emissions Reduction

Reducing carbon dioxide emissions was the main reason for the UK's move to deploy offshore wind. How far have emissions fallen? To calculate the environmental benefits from offshore wind, it makes sense to compare its life-cycle emissions with those from fossil-fuel energy counterfactuals. Research has shown that the life-cycle emissions – that is, the emissions produced through the entire life-cycle of a technology, from raw mineral extraction through to final disposal – of offshore wind are 11gCO2e/kWh, equal to 2.5 per cent and 1.1 per cent of the life-cycle emissions of natural gas and coal plants respectively. [2]

Figure 5 – Annual emissions from UK power stations, and emissions saved from replacing gas and coal with offshore wind, 2004–2020



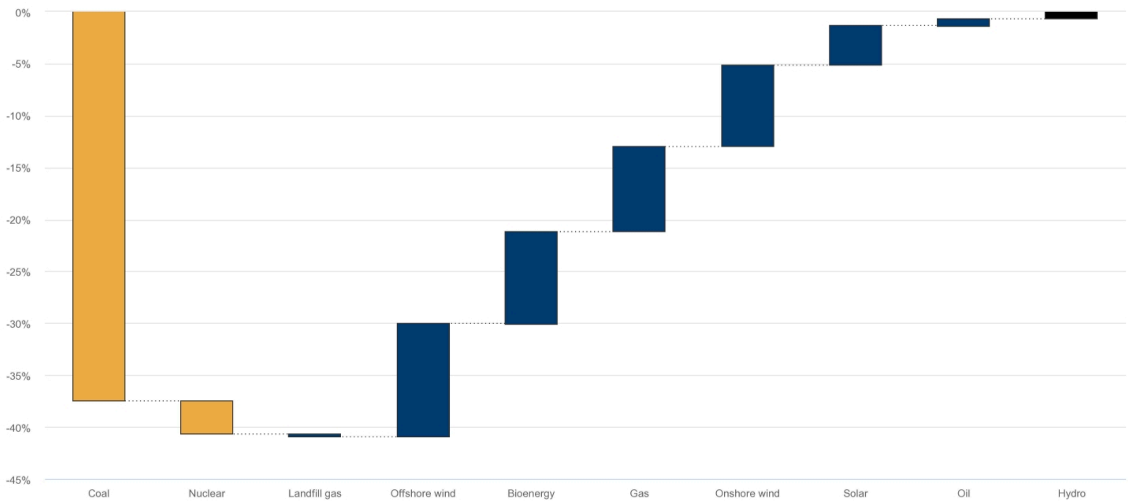
Source: BEIS, UK Energy in Brief 2021 Dataset. Link.

Using real offshore-wind generation data since 2004, we can estimate the annual emissions savings achieved against the counterfactuals of that generation coming from gas or coal. The chart above shows a clear relationship between the increase in offshore-wind generation and the decline in overall UK power-sector emissions. But to estimate the true level of emissions saving from offshore wind, it is important to understand the change in the UK electricity mix.

Since 2012, the share of coal has declined from 39 per cent to less than 2 per cent. Figure 6 shows that this shortfall in coal generation has been offset by a range of technologies, most notably offshore wind, bioenergy, gas, and onshore wind.

We can therefore assume that offshore-wind generation has predominantly replaced coal generation and driven total emissions savings of around 180 million tonnes of CO_2 equivalent ($MtCO_2e$) since 2012. In other words, emissions from the UK's electricity mix in 2020 were 45 per cent lower than a counterfactual mix with no offshore-wind generation displacing coal. There is an argument that gas would have been used to displace coal in the absence of offshore wind and that such an estimate is excessive. In that scenario, offshore wind has generated emissions savings of 76 $MtCO_2e$ since 2012, and 26 per cent lower emissions in 2020. In reality, the truth is likely to be somewhere between these two estimates; regardless, the contribution of wind power to UK decarbonisation has already been substantial.

Figure 6 – The contribution of different technologies to replacing coal in the UK electricity system



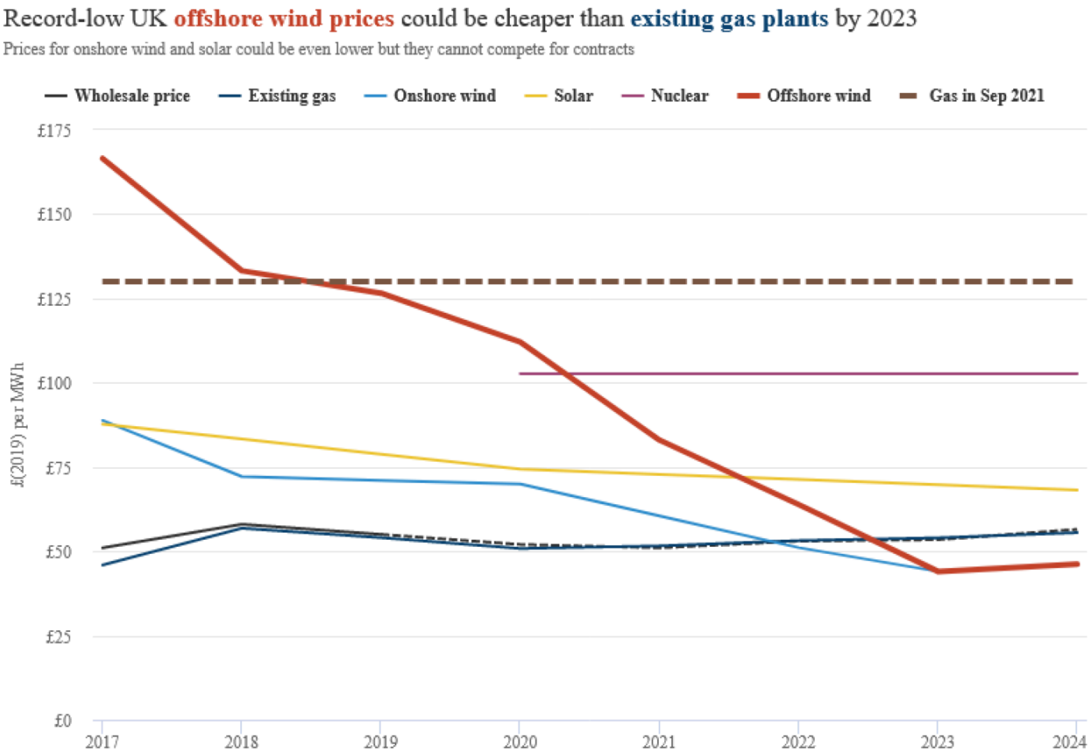
Source: BEIS, UK Energy in Brief 2021 Dataset. Link.

Cost Reduction

The most impressive element of the UK's experience with offshore wind has been the dramatic cost reductions seen since the introduction of the CfD scheme in 2014. Analysis from Carbon Brief (below) has shown that costs have fallen from £167/megawatt hour (MWh) for projects coming online in 2017 to £44/MWh for projects in 2023 – a cost reduction of 74 per cent over six years.

Costs are now so low that it is cheaper to build and run new offshore-wind farms than to simply continue operating existing gas power stations. Furthermore, contracts for the latest offshore-wind farms due to come online between 2023 and 2025 were secured at a price level below the government's own wholesale price projections, meaning that these projects are expected to save consumers money over their lifetime. When those projects become operational, and if power prices change in line with government forecasts, consumers can expect savings of £250 million per year. With current wholesale energy price levels so high due to the gas price crisis, the consumer savings will be much more.

Figure 7 – Cost per MWh of different technologies, 2017–2024



Source: Carbon Brief, Analysis: Record-low price for UK offshore wind cheaper than existing gas plants by 2023. Link.

The pace of decline in offshore-wind costs has far surpassed even the most optimistic projections from the start of the last decade. In 2011, the UK government set a target price of £100/MWh by 2020. In 2012, the Crown Estate produced four scenarios for cost reduction by 2020, ranging from £89 to £115/MWh. In fact, the price had fallen to around half those levels by 2020. The UK's performance in reducing the cost of offshore wind is therefore a remarkable success story, and its outsize role in global deployment to date has undoubtedly helped to cut the costs of the technology, thereby accelerating global deployment.

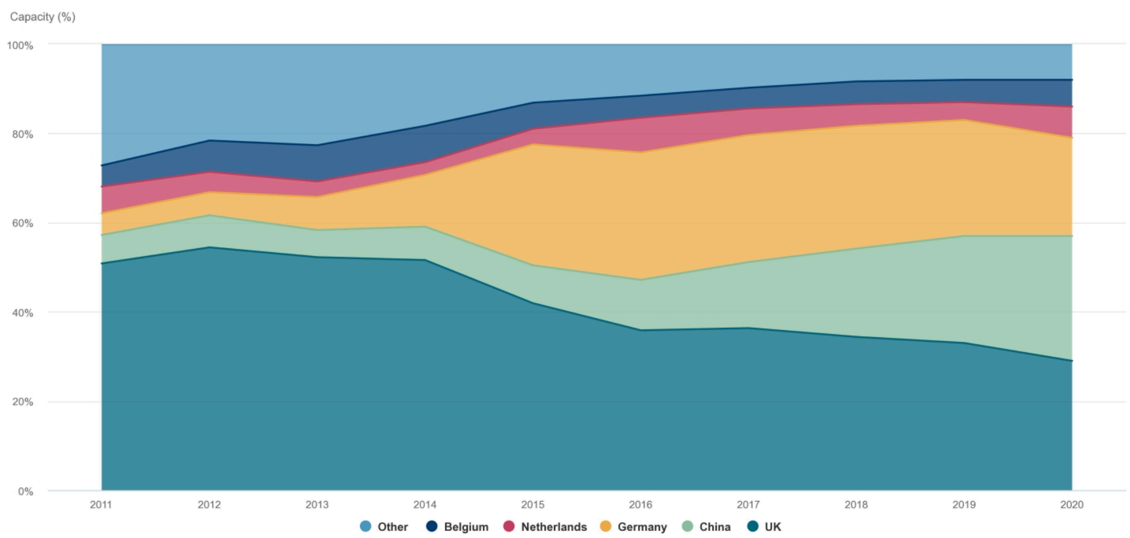
Domestic Economic Benefits

One of the criticisms of the UK offshore-wind sector to date has been its failure to maximise the potential economic benefits to local communities and the UK as a whole. The domestic content of early projects was estimated at around 32 per cent, [3] a surprisingly low level given the UK's position as global leader in deployment. Fundamentally, domestic content has suffered from the government's decision to prioritise cost reduction above all else. Intense competition among developers to reduce cost led to the importing of cheap parts and labour from abroad. This caused frustration in local communities as UK manufacturers and workers were overlooked, but it was likely to have contributed to the accelerated decline in costs.

But things have improved in recent years. Domestic content in the latest projects is closer to 50 per cent and the industry has set a target of 60 per cent by 2030. [4] At these levels, the UK offshore-wind market is expected to deliver £2.6 billion in Gross Value Added and 21,000 jobs per annum by 2050 [5]. As the global market expands, the key challenge for the UK supply chain is to remain competitive so that it is able to capitalise on the significant commercial opportunities abroad.

The chart below shows the relative share of global offshore-wind capacity over the past decade. At the start of the decade the UK was clearly the dominant market force with over half of all installed capacity. However, there has been a steady decline in the UK's global share as other markets have expanded, including Germany and more recently China. While the UK's dominance is waning, this is a positive sign of the growing export opportunities for UK suppliers as global offshore-wind capacity surges to over 234GW by 2030, up from 54GW today. [6]

Figure 8 – Cumulative offshore-wind capacity by country, 2011–2020



Source: Global Wind Energy Council, Annual Reports from 2012-2021. Link.

Eight Key Lessons From the UK's Experience With Offshore Wind

Lesson 1: Long-term political commitment is crucial to drive low-cost deployment and domestic benefits

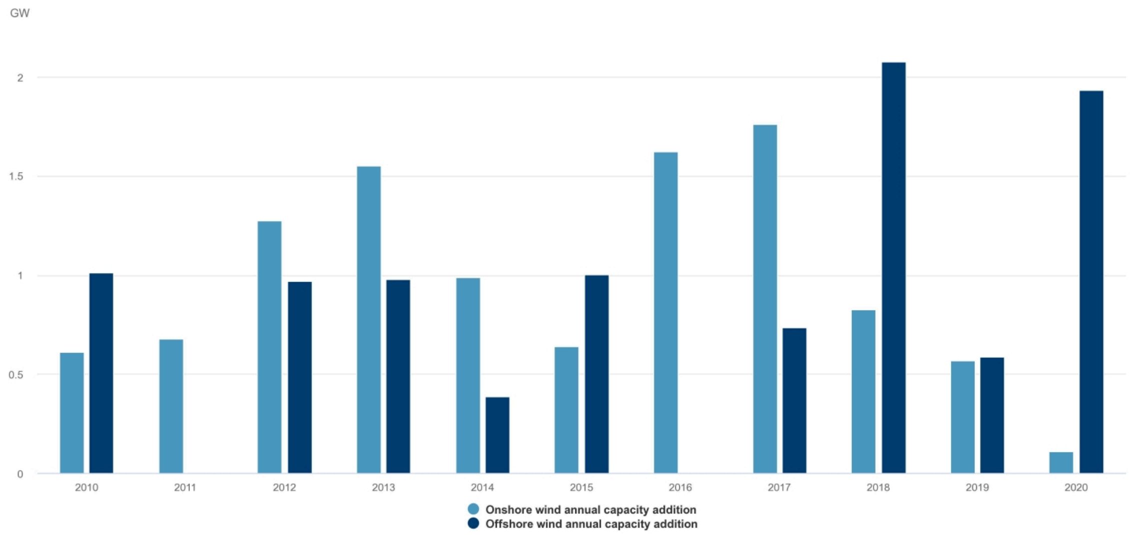
The nature of delivering net zero – a multi-decade, cross-economy endeavour dependent on large and sustained levels of investment – means that cross-party, enduring political commitment is essential to foster new technologies.

The UK has seen cross-party support for climate targets and the Climate Change Act. But only a limited number of areas have seen broad-based support for individual technologies.

Offshore wind was identified in the early 2000s as a strategically important technology with significant UK opportunities. As a result, the Labour government committed to high levels of deployment. This was followed by sustained support from both the Coalition and, since 2015, the Conservative governments of Theresa May and Boris Johnson. That support has manifested in policies such as the CfD, which provides the certainty that developers need to develop a project pipeline and deliver the investment needed to build large projects. Crucially, it has also enabled the development of a skilled supply chain and the ability to deliver sustained cost reduction.

But that consistency of policy support has not been replicated elsewhere. Take the respective rollouts of onshore and offshore wind. The chart below shows that both technologies experienced a drop-off in deployment after 2013, triggered by the closure of the RO scheme. The introduction of the CfD scheme in 2015 was followed by a return to high levels of deployment but onshore wind dropped off again after 2017 following the government's decision to effectively ban the technology. [7]

Figure 9: Wind-deployment rates (GW), 2010–2020

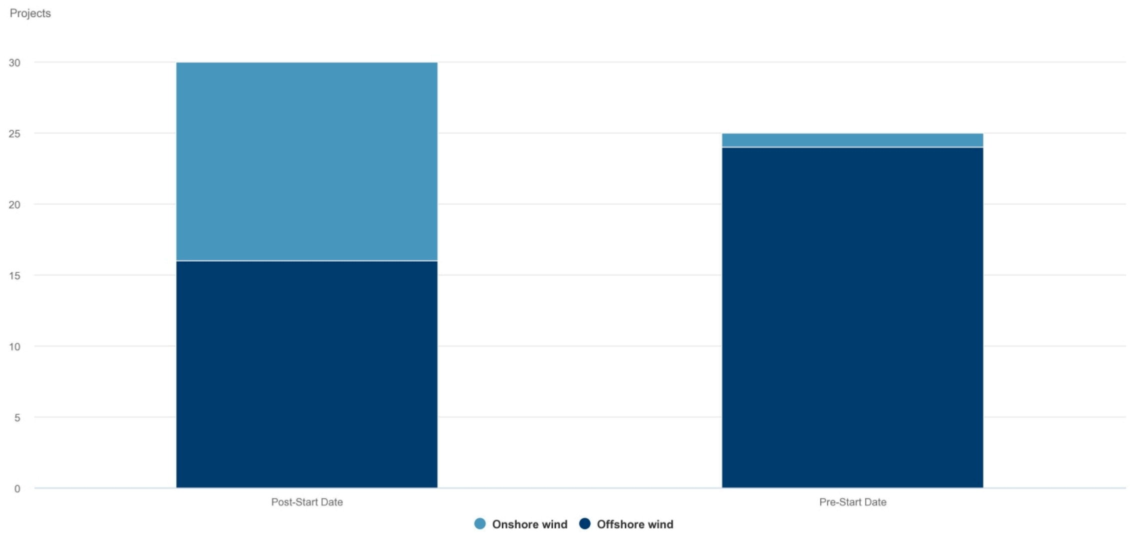


Source: BEIS, Digest of UK Energy Statistics 2021 (DUKES 5.12). Link.

Onshore wind will be able to access government subsidy again in the ongoing fourth allocation round of the CfD from 2021 but the inconsistency in government support has created a deployment gap at a time where the UK needs to rapidly increase low-carbon generation capacity. This type of wavering political support is a recipe for failing to meet the government's deployment and emission targets.

Blowing hot and cold on onshore wind has real, long-term impacts – as Figure 10 shows, offshore and onshore wind have a similar number of CfD projects in operation (left), but there are far more offshore-wind projects in the pipeline (right). This is clear evidence of the impact that political will can have on project pipelines, with the onshore-wind CfD pipeline having collapsed due to the lack of a supportive policy framework.

Figure 10 – CFD portfolios in offshore and onshore wind, by contract stage



Source: LCCC, Portfolio Dashboard – CfD portfolio by contract stage. Link.

Similarly, support for the deployment of nuclear power has been inconsistent. When Hinkley Point C comes online later this decade, it will be the first new nuclear power station for 30 years. That has meant cost-reduction opportunities from fleet deployment have not been delivered and Britain has never built a sustainable domestic nuclear supply chain. In fact, offshore wind can be viewed as the exception rather than the rule: it is the only low-carbon power technology that has received consistent political support.

We see similar problems in other technologies required to reach net zero. In home-energy efficiency, insulation deployment levels have varied hugely as funding has been cut. In heating, low-carbon alternatives have so far failed to deliver significant market share as support has changed over time. And on carbon capture and storage, a decade or more has been lost as a result of government decisions to introduce and later remove support.

Looking ahead, we know that the technologies required for net zero can be broadly split into three groups: those that will clearly play a core role; those that are needed to support the core technologies; and those that have potential to play a key role if the technology improves and/or costs fall. This categorisation can help guide the level of political commitment that should be applied to different technologies.

For example, we know that offshore-wind capacity will need to increase at least four-fold to meet the government's stated target, [8] and possibly up to ten-fold to deliver a net-zero power system by 2035. [9] And to decarbonise buildings, annual heat-pump installations will need to jump from 35,000 today to 600,000 by 2028 to meet the government's target, or one million by 2030 to meet the Committee on Climate Change (CCC)'s recommendation. There is no room for hesitancy. Technologies such as these will be core to the transition to net zero, and sustained political commitment is the only option.

Sustained political support will also be critical in achieving these levels of deployment in a cost-efficient way. It will give investors and developers confidence in their future pipeline, which in turn will deliver strong inward investment in technology development and supply chains. That inward investment will drive cost reductions and create local jobs, meaning that reliable government support feeds all the way through to delivering objectives on cost reduction and domestic content.

Lesson 2: Tackling the cost of capital should be a central objective of policy

Investment is core to meeting the challenge of net zero. The CCC estimates that £1.4 trillion of investment is needed over the next 30 years to deliver net zero. But the real cost depends greatly on the cost of capital for that investment.

There are two elements to the cost of capital. One is the risk-free interest rate on government bonds that anchors interest rates across the economy. The other is the risk premium associated with investment projects. Risk-free interest rates, as represented by the interest rates on long term government bonds, are at unprecedented lows. This represents a big opportunity to finance highly capital-intensive projects like renewables much more cheaply than would have been the case at most other points in recent history. We should take advantage of this now because if rates begin to rise, it will create a headwind against green investment.

Meanwhile policy can act to reduce the project risk, further lowering the cost of capital. Offshore wind provides a fitting example of how policy design can reduce the cost of capital and therefore the cost of the net-zero transition. In the early 2000s, the design of the RO meant that it left significant risk with project developers, which translated into high debt cost and, therefore, higher overall project costs. But the CfD, by providing a stable power price, slashed the cost of capital. Arup estimates that a CfD can lower the weighted average cost of capital (WACC) of an onshore-wind project to the point where the levelised cost of energy (LCOE) falls by £6–£12/MWh [10], which equates to a total project cost saving of between 10 and 21 per cent.

In the power sector, a drop of one percentage point in the WACC is equivalent to a reduction in LCOE of around 6 per cent. In our homes, using an illustrative example of a £10,000 heat pump and a loan repayment period of 10 years, the cost to the consumer at a 10 per cent rate of interest would be around £15,500, but just £10,510 if the cost of finance is 1 per cent.

When we look at the other technologies which are needed to deliver net zero – heat pumps, battery storage, nuclear power stations, CCUS, low-carbon hydrogen and so on – stable investment regimes do not yet exist. Delivering them will be crucial to cutting the overall costs of the transition.

Lesson 3: Adapting support to the maturity of the technology

Recognising that different types of government support are needed at different points in a technology-development timeline is key to the successful and cost-effective rollout of that technology. For example, novel technologies attempting to demonstrate their viability need different treatment to a fully proven technology that is being rolled out at commercial scale.

Offshore wind has benefitted from consistent access to subsidy, whether through the NFFO, the RO or the CfD scheme. This has allowed the industry to gain experience and demonstrate that key project risks (i.e. installation costs and timings, turbine availability and operating and maintenance costs) can be managed, thereby reducing the overall risk profile of offshore-wind farm projects. In turn, this has allowed for a reduction in the required returns demanded by providers of capital, further cutting the technology cost.

But we have seen other technologies struggle over the same period. Despite having access to all three CfD allocation rounds to date, technologies such as wave, tidal stream and geothermal have failed to secure a single contract. This raises the question of whether the CfD is the right support framework for these technologies, or whether a different approach is required. It is important that the success of offshore wind does not diminish the opportunity for other technologies to experience similar price discovery through the CfD framework. So it is good to see that government has ringfenced parts of the CfD fourth allocation round budget for specific technologies, and it will be interesting to see the impact this has on technology cost.

Of course, it would not be prudent for government to attempt to support every technology to full commercial deployment – decisions need to be taken on which technologies are likely to be most cost-efficient in the round. To some, this may sound like "picking winners", but in reality, it is strategic decision-making off the back of robust analyses that consider things such as cost-reduction potential, system value and potential value to UK plc. Ultimately, government support should be conditional on cost reduction – if the technology cost does not fall, then support should be removed.

And it is crucial that the policy framework continues to evolve and adapt to the implications of these new technologies gaining increasing share and influence in the market. Insulating offshore-wind investors from market volatility has been an effective means of crowding in investment. But as the technology becomes more dominant in the market, it is important that investors and operators are increasingly exposed to market signals to ensure efficient operation of the system.

Lesson 4: Design markets around desired long-term outcomes

One of the key benefits of the net-zero target is that it provides a clear and measurable long-term goal – something quite rare in politics. And there is increasing clarity on the actions and technologies required to achieve that goal. The general direction of travel is now clear, and this clarity should enable a shift in government mindset from small-scale, ad-hoc interventions to fundamental reforms.

The development of offshore wind to date has essentially taken place in an insulated bubble, with investors and developers protected from price volatility and therefore given no incentive to respond to market signals. This has been an effective approach to growing a new industry by minimising investor risk, but problems are now arising as offshore-wind generation grows and becomes a major component of the system.

Price Cannibalisation: A Result of Deploying Renewables In a Market Designed Around Fossil Fuels

The UK's wholesale electricity market was designed around fossil-fuel technologies – which was a sensible approach given their dominance in electricity supply. Fuel cost (i.e. the price of gas) is the key driver of how much it costs to generate electricity from these technologies, and therefore it dictates the wholesale market price. This dynamic has worked effectively as long as most of our electricity has come from fossil fuels, but the influx of renewable technologies presents a new challenge.

Offshore wind is a technology with no fuel cost because wind is free. This means that when offshore wind is generating, the wholesale market price falls. That may sound promising in principle, but it becomes an issue as an increasing proportion of our electricity comes from offshore wind. The fact that the wholesale market price is almost entirely dictated by fuel cost means that the greater the share of offshore wind on the system, the more the wholesale market price tends toward zero – a phenomenon known as price cannibalisation.

In practice this means that offshore-wind developers' returns fall as more offshore wind joins the system. At present, most offshore-wind developers are protected from this phenomenon thanks to the revenue certainty delivered by CfD contracts. But this presents a real issue for developers when they come to the end of those contracts, and may result in offshore wind farms being decommissioned before the end of their working life due to an inability to recover remaining capital and ongoing operating costs.

The experience with offshore wind has highlighted that the technologies needed to power a net-zero system have different characteristics to the technologies that have been used in the past, and markets must be redesigned accordingly. The old approach has worked while new technologies have played a minor role, but as these technologies begin to dominate, government must shift its mindset from focusing on near-term deployment to developing a framework that will allow low-carbon technologies to grow to the levels we know are needed.

Lesson 5: A healthy pipeline is key for competition and supply-chain development

A healthy project pipeline is a fundamental element of the stable rollout of key net-zero technologies. It ensures competition between different developers – a key driver of price discovery – and it delivers forward certainty to supply chains, unlocking investment in manufacturing facilities and skills development.

Until now, offshore wind has benefitted from a healthy pipeline driven by sustained political will, constant access to subsidy and regular leasing of seabed through the Crown Estate. This combination of overarching government support, a credible business model and the availability of project sites creates an attractive investment landscape. There are challenges ahead in ensuring a sufficient pipeline for the next phase of offshore-wind power deployment towards the 40GW 2030 target, but following the same principles is a recipe for success.

On other technologies, a lack of clear project pipelines is undermining investment in supply chains and skills. On heat pumps, for example, the UK has ambitious targets for annual installations but ranks at the bottom of the European table for the rate of installations in 2020, with 60 times fewer heat pumps installed than Norway. [11] Added to that, government funding announced in the recent Heat and Buildings Strategy accounts for less than 7 per cent of what the government itself says is required for heat decarbonisation in the 2020s.

These inconsistencies deliver mixed messages to the market, disincentivising investment. Creating a coherent investment proposition will be the best way for government to build a healthy project pipeline, minimising the associated costs and maximising the associated domestic benefits.

Lesson 6: Partnership between industry and government can deliver sustained investment

The net-zero transition requires the proliferation of several new capital-intensive technologies in a timeframe that is narrowing with every year of delay, and a market that is designed around old technologies with low capex ratios. Combining the strengths of industry and government to identify and overcome barriers to deployment is the only way of ensuring success under these conditions.

Offshore wind has benefitted from consistent and productive collaboration between industry and government. Initiatives such as the Offshore Wind Industry Council (established in 2013) and the Offshore Wind Sector Deal (signed in 2019) provide a strong signal of government support and create a formal dialogue between industry and government. This facilitates better understanding of the challenges being faced by both parties and drives collaboration to overcome them, smoothing the deployment trajectory and delivering sustained investment.

Other technologies have struggled without consistent government partnership. CCUS has had a turbulent history in the UK where it has twice been on the cusp of deployment, only to lose the support of government at the last minute. A lack of early cross-departmental agreement on the budget, specifically from HM Treasury, was found to be a key factor in the failures, indicating the importance of ensuring alignment across government before entering a partnership with industry. [12, 13]

Had CCUS received the continuous support offered to offshore wind, the first projects would have already been deployed and the UK would have advanced down the cost curve. This would have increased the chances of early market capitalisation and the associated benefits for the UK. Every effort should be made to avoid a similar situation where trust between industry and government is damaged, and deployment set back as a result.

The government now seems to recognise the importance of industry partnerships, with new initiatives appearing such as the Nuclear Sector Deal, the CCUS Council and the Hydrogen Council. This is positive progress, but the durability of these partnerships is now key in driving continuous investment and the establishment of new partnerships, especially on heat pumps.

Lesson 7: Strategic systems thinking is required for an efficient transition

One of the failures of the offshore-wind rollout has been the short-sighted approach to grid infrastructure, with each new wind farm having an individual transmission connection onshore. This approach is costly and the numerous onshore connection points result in environmental issues and backlash from local communities on the east coast. [14]

With four to ten times more capacity expected to be deployed in the North Sea over the next 20 years, a new approach is needed. The government is now considering options for an integrated offshore transmission network that will reduce onshore connection points and increase flexibility by strengthening connections between the UK grid and the continent.

To date, the UK has successfully decarbonised primarily through a focus on reducing power-sector emissions by replacing coal with renewables. The next phase of decarbonisation will be much more complex, involving the interaction of different sectors (transport, power, heat, industry) and a doubling in electricity supply.

There will be opportunities to harness the interaction between sectors to drive efficiencies, such as EV batteries providing system flexibility, and excess renewable power being used to create hydrogen for industry. But capitalising on those opportunities will require comprehensive systems thinking. The opportunities and challenges need to be identified and embedded in future planning.

The key lesson for other technologies is to plan for desired long-term system outcomes rather than focusing on an individual technology and project basis.

Lesson 8: A clear strategy is needed for securing domestic economic benefits

The global transition to net zero will require more than $4 trillion of annual clean-energy investment by 2030 [15]. This presents a huge global export opportunity for countries able to capitalise on the relevant technologies. But competition will be intense and the countries that do best will be the ones that take a strategic approach to the markets they aim to enter, in the context of a well-designed industrial decarbonisation strategy. That requires a strategic assessment of domestic capabilities, possible productivity and economic benefits, and international competition to identify the technologies and markets in which a country may have a comparative advantage.

For example, considering the UK's global lead in the offshore-wind market, it might make sense to build domestic capabilities and skills that can be exported abroad to a growing market. The UK has performed poorly in this area to date, prioritising lowest cost and importing from abroad over building domestic capabilities. But efforts are now underway to rectify that, and the experience with offshore wind provides a valuable lesson for the early development of other technologies.

Floating offshore wind (FOW) presents a significant future export opportunity for the UK. FOW technology is very similar to conventional offshore wind except that the requirement for fixed seabed foundations is removed, allowing projects to access deeper waters. This technological innovation means that FOW has a much higher resource potential than conventional offshore wind, which is restricted to shallow water sites.

The World Bank estimates the global FOW technical resource to be over twice the size of conventional offshore wind. [16] And the UK currently leads the world in terms of FOW capacity in the pipeline – seabed leasing contracts with the potential to produce up to 12.5GW were awarded in the recent Crown Estate Scotland leasing round. This recalls the early days of conventional offshore-wind deployment and offers an opportunity for the UK to apply the lessons learned and maximise the domestic economic benefits from this new technology.

However, not every technology presents an exciting international market opportunity. The UK's relatively low heat-pump installation rate and capabilities suggests a limited global opportunity. But there are still local supply-chain and employment opportunities on offer with a rollout of more than 20 million heat pumps, and the government should plan to maximise them. In general, the strategic UK industrial opportunity lies not in the production of turbines and heat pumps, but in the know-how and services to integrate these technologies into an efficient, flexible system.

The UK government made an initial assessment of the role that some technologies would play in the UK's future energy system through the Energy Innovation Needs Assessments, [17] but a much more comprehensive piece of work is needed to identify international and local opportunities from the net-zero transition and develop deployment strategies to reflect them.

Conclusion

The deployment of offshore wind in the UK is rightly heralded as one of the homegrown success stories of the past decade. But that success was no accident. Nor was it the result of laissez-faire economics. Careful, sustained and appropriately designed policy support, and coordination with industry, were critical.

That is not to say that the rollout has been faultless. The deployment of offshore wind offers several lessons, both in terms of good practice and areas for improvement.

The current energy crisis only intensifies the need for a rapid transition away from fossil fuels. This transition *can* be achieved on time and at reasonable cost, but we must learn the lessons of Britain's success in wind power.

1. A huge challenge lies ahead in upscaling UK offshore-wind generation. Applying the eight lessons identified in this paper will unlock barriers to deployment and allow the UK to meet and move beyond the target of 40GW by 2030.
2. Broader application of these lessons to other sectors of the economy will facilitate the rapid deployment of the novel technologies required for net zero.

Charts created with Highcharts unless otherwise credited.

Footnotes

1. ^ OBR. Fiscal risks report, 2021. Available here.
2. ^ NREL. Wind LCA Harmonization. Available here.
3. ^ ORE Catapult. The Economic Value of Offshore Wind. Available here.
4. ^ BEIS. Offshore Wind Sector Deal. Available here.
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7. ^ The construction period for offshore wind is longer than for onshore wind, so there is a lag between offshore and onshore commissioning.
8. ^ The UK government has set a target to deploy 40GW of offshore wind by 2030.
9. ^ Imperial College. UK offshore wind target must be at least doubled to deliver net-zero electricity. Available here.
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16. ^ World Bank. Technical Potential – Offshore Wind. Available here.
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