KPMG

Hindsight is 2050 vision

Learning the lessons from the UK's experience to guide how we decarbonise the global power sector

sse

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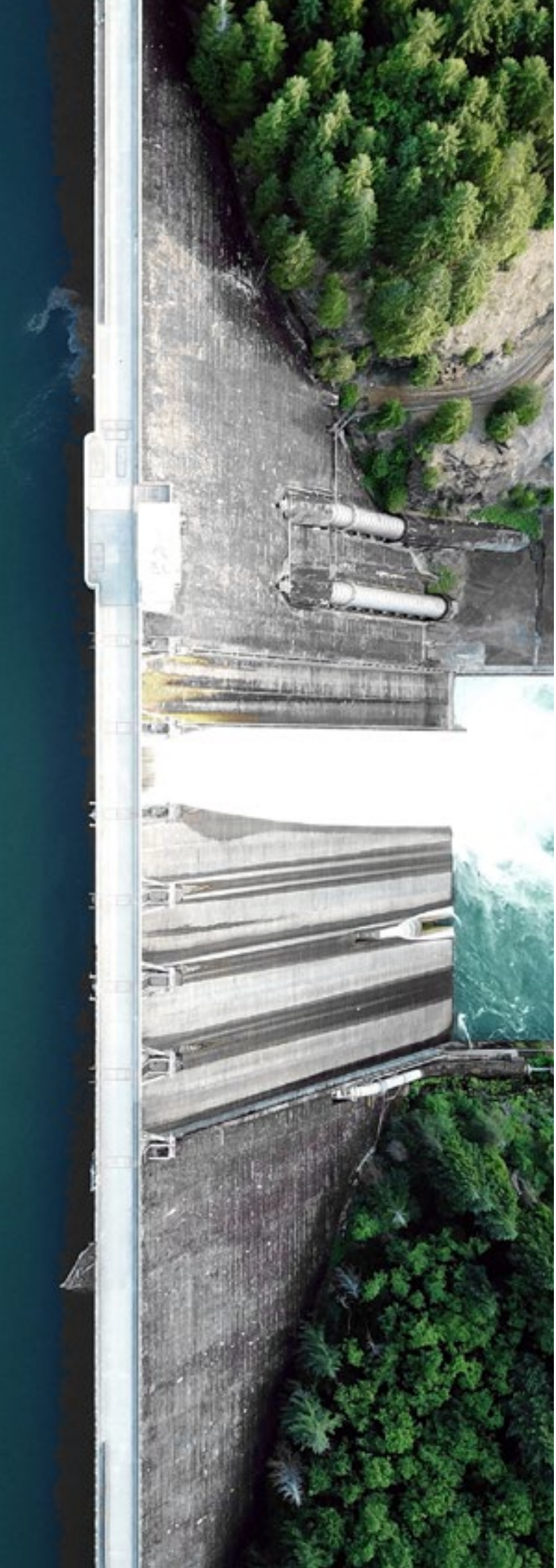
Purpose

This report, co-authored by KPMG, a leading professional services firm, and leading low-carbon energy company SSE plc, sets out what lessons we can learn from the UK's success in decarbonising the power sector to guide how we rapidly reduce emissions in the power sectors across the globe.

As the UK prepares to host the critical COP26 UN climate summit in Glasgow, it is vital that the UK sets an example for the rest of the world. To aid those efforts, this report looks back at progress made by the UK in decarbonising power generation since the passage of the Climate Change Act in 2008.

Based on the UK's experience, the report seeks to identify lessons learned from the UK's experience and draws upon other international case studies to assess what works and what doesn't. Taking these key lessons, the report identifies a set of key principles that can help inform the approach taken by other countries as they develop their national plans ahead of COP26.



Contents

Forewords

As a leading low-carbon electricity company, we are proud to be working with the UK Government as a Principal Partner of COP26 to support a successful summit in Glasgow in November 2021.

With a heritage in renewable electricity dating back nearly 80 years to when our hydro-electric stations brought the first electricity to the north of Scotland, we know the value that sustainable, low-carbon electricity can bring to communities, the economy and the environment. We also know that low-carbon electricity is one of the most powerful tools countries can bring to bear in the battle to tackle climate change.

This year more than ever, countries around the world are facing tough decisions not only on how to bounce back from the economic impacts of coronavirus, but on how to balance this economic imperative with the need to take climate action. Too often, these options are viewed as mutually exclusive. Our experience in the UK shows that this does not have to be the case and that by creating the conditions for investment in low-carbon technologies, governments around the world can deliver the energy transition we need without sacrificing jobs and economic prosperity.

We have been at the forefront of efforts to decarbonise the UK power system for many years. Last year, emissions from our generating portfolio were the lowest since records began and we are now leading the construction of more offshore wind than any other company on the planet. We are building the network infrastructure that will be needed to connect rapidly growing renewable capacity and support up to a trebling of electricity demand as net zero power helps other parts of the economy to decarbonise. And we are developing the flexible solutions that will be required to help balance a renewables-led system, from 'nature's battery' in the form of hydro pumped storage to hydrogen and carbon capture technology. In doing so, we are regenerating communities and micro economies, creating jobs and building supply chains.

But we have only been able to do so because the UK has established the right long-term signals and policy frameworks to underpin significant investment. While there are major challenges ahead, we believe the experience of the UK to date offers a valuable guide for how we need to approach the international power sector decarbonisation challenge. Through this report we hope to share our experiences in the UK and help support others as we seek collectively to decarbonise the global economy by 2050.

Martin Pibworth
Group Energy and Commercial Director, SSE plc

Around 70% of the world's economy is now signed up to net zero targets. We expect more countries to follow suit ahead of COP26 in November. The focus now needs to shift to implementation and delivery of the emissions reduction targets countries have set.

The UK has, in many respects, lead the way when it comes to making progress on power sector decarbonisation, as is now halfway to net zero. Having been heavily involved myself in the design of the Electricity Market Reforms under the Coalition Government, I look back with a lot of pride on how far we have come since the Climate Change Act was passed in 2008. But there are many challenges ahead as we seek to decarbonise other sectors of the economy, like transport, industry and heating.

With most of the world's economy now signed up to net zero, it is essential that we seek to share best practice and lessons learned and build our understanding of how to achieve net zero at least cost, whilst maintaining security of supply. I hope that this report provides a useful contribution to this debate in the run up to COP26.

Simon Virley CB
Vice Chair and Head of Energy and Natural Resources, KPMG

Executive summary

The challenge of limiting global warming to 1.5°C will require a collaborative international effort; but this collaboration at a global level must be underpinned by rapid progress by individual countries to cut emissions over the next decade and establish a credible path to reaching net zero emissions.

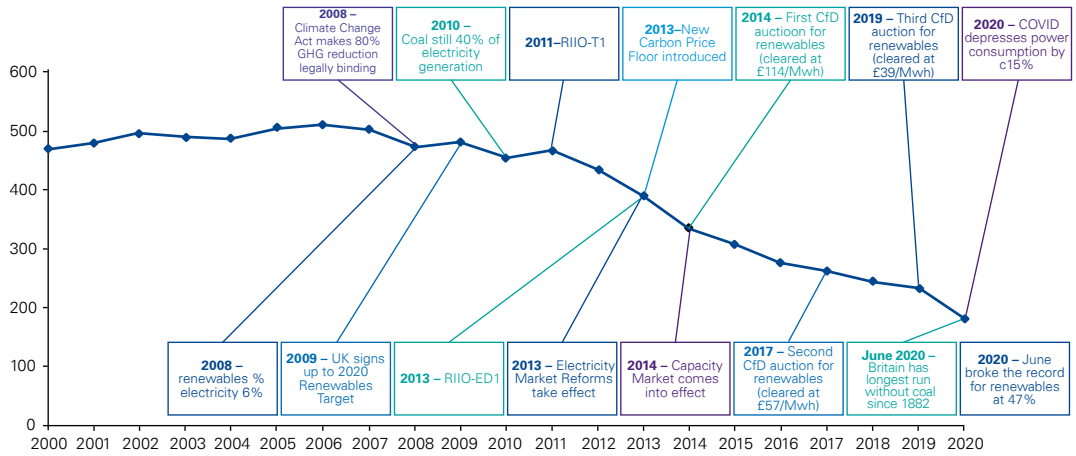
This bottom-up approach is at the heart of the Paris Agreement and only works if all countries play their part in tackling the climate crisis. Much of the progress made to date has focused on decarbonising the power sector given its historically large contribution to overall emissions and the significant potential for low-carbon electricity to enable decarbonisation of other critical emitting activities like travel, heating and industry.

The UK is sharing the COP Presidency with Italy and, as host of the critical summit in November this year, will need to demonstrate international leadership. This report critically appraises the UK's efforts to decarbonise the GB electricity market over the period since the passage of the Climate Change Act in 2008 to 2020, in order to derive the key lessons from that experience and, by combining those lessons with case studies from other countries, the 'key principles' that can form the basis of a decarbonisation blueprint for other nations to build from.

Leading the world on decarbonisation: assessing the UK's progress to date

The UK has shown that it is indeed possible to decarbonise the electricity sector at pace. It's efforts have been underpinned by some fundamental interventions, including the Electricity Market Reforms (EMR) and the RIIO network price control introduced by the national energy regulator, Ofgem. Reflecting on the UK's progress since, these reforms have been a considerable success, delivering on all of the key objectives set out by the Government and Ofgem at their introduction: namely, to decarbonise the power system, whilst maintaining security of supply, keeping energy bills down, securing the necessary investment from the private sector and creating green jobs.

gCO2 per MWh



Source: mygridgb.co.uk, National Grid ESO

What worked?

Ensuring Long term certainty	Costs were driven down through a well-designed policy instrument – the Contract for Difference (CfD) - which has helped lower the cost of capital for investors, plus a clear long-term policy framework, established by the legally-binding 5-year Carbon Budgets introduced by the 2008 Climate Change Act.
Incentivising investment in power networks	The creation of clear allowed returns for networks with the correct efficiency incentives saw the investment in network infrastructure increase since 2013. Electricity network companies have reduced the carbon footprint of their networks by 850,000 tCO2e between 2015 and 2017 and reduced power cuts by 11%.
Powering past coal	The clear commitment of the UK Government to carbon pricing and an Emissions Performance Standard (EPS), which effectively blocked new (unabated) coal-fired generation and helped the switch from coal to gas and to drive coal off the system.
Striving for balance across the "energy trilemma"	The Capacity Market has helped to ensure security of supply at limited costs to consumers.

What challenges have been encountered?

Public buy-in is paramount to deliver a just transition	Cost transparency and affordability need to be prioritised in a just transition especially as consumer behaviours will be key in decarbonising the remaining sectors of the economy
Market design needs to incentivise net zero at the lowest cost	As renewable penetration grows, implementing the right market framework to support the strategic investment needed in clean generation under increasingly low and volatile wholesale prices
Slow progress in decarbonisation of heat, transport, and industry	The UK's success in decarbonising power has yet to be replicated across other key emitting areas of its economy such as unlocking CCS and clean hydrogen in industrial clusters
Flexibility is key in a renewables-led system	There is a pressing need for lower-carbon flexible generation like batteries, hydro pumped storage and hydrogen along with demand side solutions to be brought forward.
Clear energy wide governance that oversees the whole system decarbonisation	Whole system decarbonisation in order to achieve carbon neutrality by 2050 will mean setting new accountabilities and responsibilities

Lessons from the UK's experience can help build a guide for how countries can tackle the climate crisis

While every country will be at a different stage on its journey and will face its own unique challenges, some challenges will be universal. Looking back on the UK's efforts to decarbonise the electricity market since 2008, this report assesses the successes and challenges the UK has encountered on its journey and the steps it will need to take on the road ahead. By combining those lessons with case studies from other countries, it identifies a set of core 'key principles' to guide the decisions countries will need to take in order to plot a deliverable pathway to a net zero power sector as part of efforts to limit global warming.

The Key Principles

1) Set legally binding, long-term targets backed by robust institutional structures

2) Strive for balance across the ever-present energy trilemma to retain a public mandate for decarbonisation

3) Decarbonise power first to unlock electrification of other sectors of the economy

4) Incentivise lowest cost investment in low carbon solutions including putting a clear price on carbon

5) Drive strategic investment that anticipates future system needs

By seeking to globalise these principles, we believe that COP26 offers a vital opportunity for the UK to work with other countries to accelerate our transition to a clean electricity system.

01 Leading the world on decarbonisation: assessing the UK's progress to date

Background

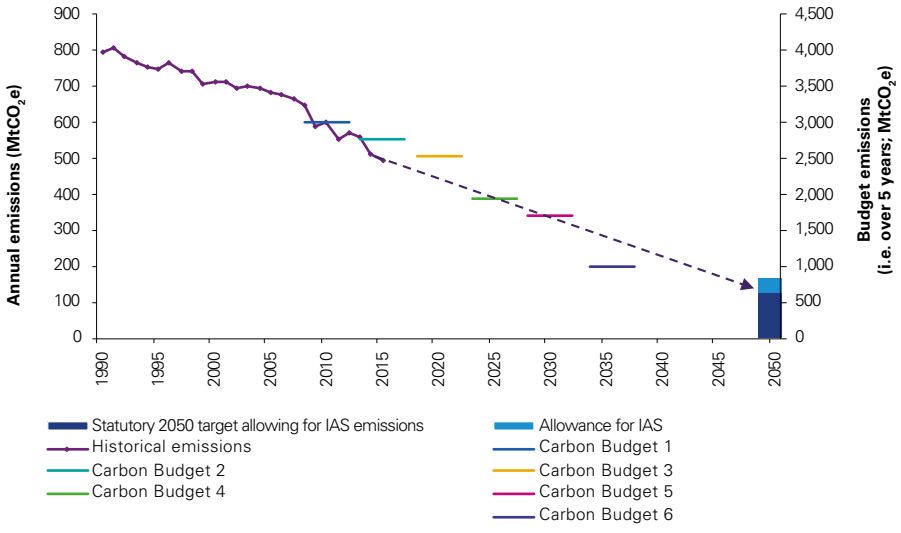
Having signed up to the Rio Convention in 1992 and the Kyoto Protocol in 1997, the UK has long-standing commitments to drive significant reductions in greenhouse gas (GHG) emissions. However, the passage of the Climate Change Act in November 2008 represented a major turning point, making the UK the first country to set a global, legally binding climate change mitigation target – committing to reduce its GHG emissions by 80% by 2050.

To ensure the UK Government was held to account, the Act established a governance framework built around 'Carbon Budgets', under which UK Government, on the advice of the independent Climate Change Committee (CCC), sets out and legislates for a series of five-year caps on GHG emissions to plot a clear pathway to the 2050 target.

In 2019, these targets were further strengthened when the UK became the first major economy to establish a legally binding target to achieve net zero emissions by 2050.

Progress

The Office for Economic Co-operation and Development (OECD) has cited the UK as the most successful major economy in the world at driving down emissions[1]. Despite delivering a reduction in GHG emissions of nearly 50% since 1990, the UK has continued to grow, with GDP increasing by over 75% over the same period[2].



Source: BEIS, CCC

1 https://data.oecd.org/air/air-and-ghg-emissions.htm

2 UK Government Energy White Paper 2020

This progress has been driven overwhelmingly by the UK's success in driving down the carbon intensity of the power sector in Great Britain, which has fallen from 481gCO2/kWh in 2010[3] to 181gCO2/kWh in 2020[4]. During April it recorded the lowest level in British history, registering 39gCO2/KWh during the 2021 Easter Bank Holiday[5].

Coal generation has almost been driven off the system, with a record-breaking 67 days without any coal-fired generation in 2020, the longest stretch since the 1880s[6]. Coal contributed more than 40% of generation back in 2012; by 2020, that had fallen to 2%[7]; and by 2024 there will be no unabated coal generation in the GB system.

At the same time, the UK has overseen a rapid acceleration in the deployment of renewables, primarily in onshore and offshore wind.

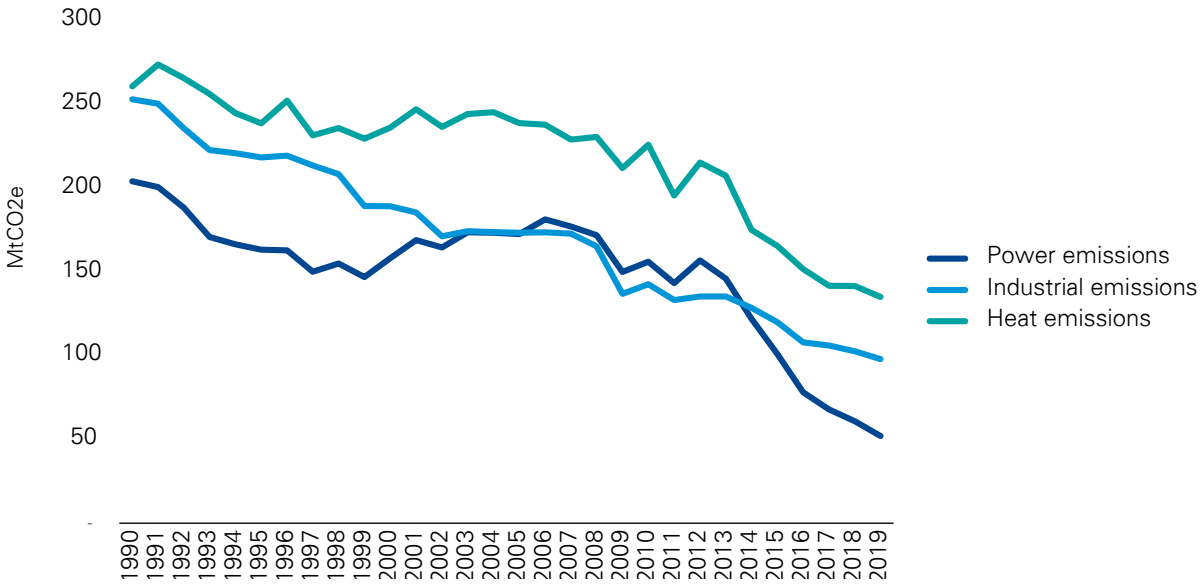
Renewables' share of power generation has risen from around 7% in 2010 to over 40% in 2020[8], beating what was then considered to be a highly ambitious target set back in 2010 of renewables accounting for a third of all power generation by 2020.

This transition is continuing, with UK Government recently establishing a target to deliver 40GW of offshore wind capacity by 2030 – enough to power every home in Great Britain.

These are challenging targets and it is clear that the UK still has a long way to go if it is to achieve net zero by 2050. In particular, limited progress has been made to date in tackling emissions from heat, transport and industry.

However, its progress in decarbonising the power sector has been rapid and leaves it well positioned to leverage this progress to decarbonise other sectors of the economy through electrification.

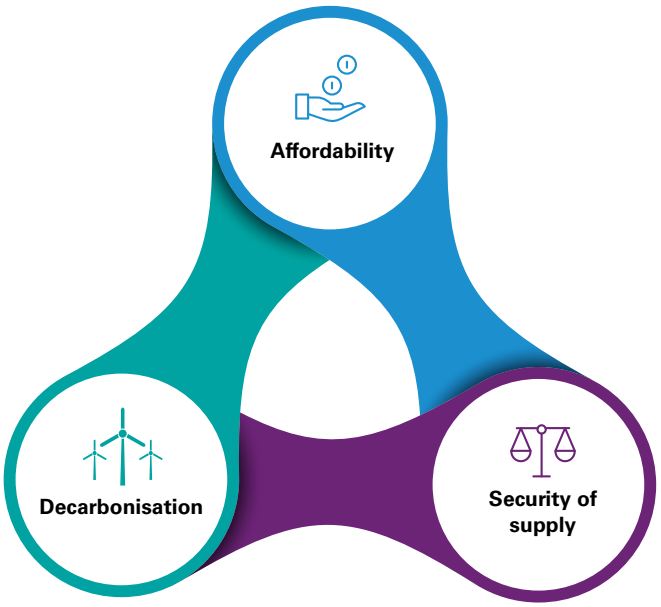
Carbon emissions from the power, heat and industry in the UK since 1990



3 UK Government Energy White Paper 2020
4 https://renews.biz/60488/uk-power-emissions-fall-to-record-low
5 https://www.bbc.co.uk/news/uk-56657299
6 https://www.ecotricity.co.uk/our-news/2020/
7 Elexon and National Grid
8 https://www.gov.uk/Government/statistics/uk-energy-in-brief-2020

The energy 'trilemma'

While the Climate Change Act placed decarbonisation firmly at the top of the policy agenda, in setting energy policy the UK Government has been mindful of the need to balance this with two other key factors comprising the so-called energy 'trilemma' – affordability and security of supply.



Fundamentally, the need to 'keep the lights on' has been viewed as non-negotiable, while the cost of energy to consumers has always been and remains a politically charged issue. In short, ensuring energy remains both reliable and affordable is pre-requisite to maintaining a mandate for decarbonisation.

What steps were taken?

With binding targets in place, the UK Government set about designing policy and regulatory frameworks that would attract sufficient private sector investment to deliver the new, low-carbon technology required while leveraging competitive pressure to drive down costs for consumers.

A key pillar of this was the Electricity Market Reform (EMR) programme, designed between 2010 and 2015.

This led to the Energy Act 2013, which introduced four key policy mechanisms:

1 Contracts for Difference (CfD)

- Provides long-term price stabilisation to low carbon generation plants
- This has supported a major investment in low carbon technologies, driving down costs, and increasing penetration and dramatically reducing the carbon intensity of GB power supply

2 Capacity Market (CM)

- Increased penetration of variable renewables and closure of older nuclear and coal plants, has caused challenges in ensuring security of supply
- The CM helps balance the system at times of stress, providing back-up generators and demand-side response (i.e. when demand outstrips supply or vice versa)

3 Carbon Price Floor

- Requires UK power generators to pay a minimum carbon price for the carbon they emit, which is currently set at £18 on top of the UK ETS
- Aimed to encourage coal to gas switching and reduce costs for low carbon generation

4 Emisions Performance Standard (EPS)

- Emissions Performance Standard (EPS), a regulatory limit on CO2 emmissions from new power stations
- Limit current set at 450gkWh, which effectively banned the building of new coal fired power stations in the GB market

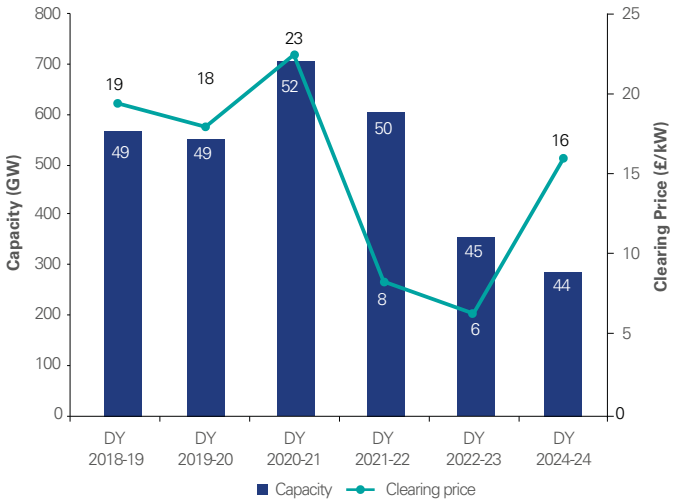
Deploying new renewable capacity: a new financing framework

The introduction of a robust, long-term financing framework to unlock significant investment in low-carbon generation has been a key pillar of the UK's success. The ground-breaking Contracts for Difference (CfD) scheme represented a key shift for the UK Government and legislation took almost four years to be passed. Under the scheme, developers are awarded 15-year contracts at a fixed £/MWh rate (or strike price), helping to reduce the cost of capital by providing long-term price certainty. When the wholesale price falls below the strike price, developers receive a top up funded through levies on electricity bills. When wholesale prices are higher than the strike price, developers pay back into the pot. In this way, the price risk for projects is reduced underpinning investment at a low cost of capital which lower costs for consumers.

The initial CfD contracts were awarded on a bilateral basis to introduce the mechanism to investors and work through any issues before introducing competitive auctions. The first bilateral prices were negotiated at relatively high prices in the region of £150/MWh, however with the first CfD auction in 2015 prices fell to £114/MWh, and, as competitive pressure increased, subsequent auctions in 2017 and 2019 delivered further significant price reductions. Offshore wind is now close to being deployed at a strike price below the prevailing wholesale price – making it effectively subsidy-free.

Ensuring security of supply: introduction of a capacity mechanism

The UK is one of many European countries, including Greece, Ireland, Italy, Spain, Sweden, France and Finland, to have implemented a form of capacity mechanism to guarantee security of supply as the power sector decarbonises. The UK introduced the Capacity Market (CM) in 2014 to ensure that sufficient firm, flexible power plant remains available to meet demand as more variable renewable generation is procured through the CfD mechanism. Successful bidders into each CM auction receive contracts that provide monthly payments in exchange for their availability in times of need.



Source: EMR Delivery Body

Clearing prices have been low throughout, clearing at £18/kW in the first auction in 2014 and £8/kW in 2017. The design of the scheme has evolved over time as the market has changed, including through enabling other technologies to participate, such as demand-side response, interconnectors, battery storage and small-scale flexible generation. While the policy was never intended to be a driver of decarbonisation – rather to ensure security of supply in a changing energy mix – the carbon intensity of the generation it procured has fallen over time.

Incentivising low-cost decarbonisation: carbon pricing

With the introduction of the European Union Emissions Trading Scheme (EU ETS) in 2005, the EU sought to correct the fundamental market failure to price in the carbon externality by requiring emitters from covered sectors to purchase allowances to cover their carbon emissions.

In 2011 the UK committed to going one step further by introducing a minimum floor price for carbon for electricity generation in Great Britain, introducing the Carbon Price Support (CPS) to top up the EU ETS. The original intent of the Carbon Price Floor (CPF) was to provide confidence to investors by setting a minimum carbon price, thus reducing the risks of investment in low-carbon infrastructure or activities.

The combination of the EU ETS and the CPS in the power sector has helped to accelerate coal-to-gas switching in the electricity system, driving significant emissions reductions by utilising underused gas capacity and ensuring the system calls upon lower-carbon generation options first. Coal-to-gas fuel switching was later replicated across the European Economic Area, as the EU ETS got to levels to drive coal-to-gas fuel switching since 2019.

Putting an end to new coal generation: capping emissions

In 2013 the UK introduced an Emissions Performance Standard (EPS) in the power sector, which eventually came into force in 2014. This set a specific regulatory limit on the amount of carbon a new fossil fuel plant is permitted to emit annually. The EPS was set at 450gCO2/kWh until the end of 2044 (for baseload generation).

In practice, this has meant giving plants a total tonnage allowance of CO2 within which they have to remain within each year and effectively put an end to the prospect of any new coal-fired power stations being built, while carbon price support and CfDs drove existing coal off the system. The combination of measures means that the UK has nearly removed coal completely from the power sector, ahead of a formal closure date that has been set for 2024.

Attracting sufficient investment in electricity networks: long-term regulatory model

Alongside actions to deploy more low-carbon generation, the UK has also taken steps to ensure sufficient investment is made across the transmission and distribution networks to connect and transport new electricity sources.

In 2009, the UK's energy regulator, Ofgem, identified a requirement for £32bn of investment in Britain's energy networks over ten years in order to ensure a secure and sustainable energy supply to consumers – effectively double the rate of investment seen in the preceding 20 years.

In 2010, Ofgem subsequently introduced an innovative new performance-based regulatory model, RIIO (Revenue = Incentives + Innovation + Outputs), with the aim of bringing forward that investment at a fair cost to consumers.Ofgem sought to deliver better results for consumers by introducing specific output incentives for network operators to improve reliability and drive innovation in grid infrastructure. By setting out long-term price controls alongside these incentives, it aimed to provide certainty and reduce risk for investors to deliver investment cost-effectively for customers.

Taking a strategic view: whole system thinking

In order to deliver on the 2020 decarbonisation target, the Government adopted a whole system approach with EMR being introduced as a package of reform supported by various other measures put forward by the industry and the regulator, Ofgem:

The Electricity Networks Strategy Group (ENSG)

The ENSG was a forum which brought together key stakeholders in electricity networks that work together to support the government in meeting the renewable electricity challenge. In 2012, ENSG pulled together the required plans for transmission network upgrades required to accommodate the new generation needed to meet the government's 2020 renewable energy target.

Electricity Balancing Significant Code Review (EBSCR)

In August 2012, Ofgem launched the EBSCR having expressed concerns that cash-out prices were not creating the correct signals for the market to balance, which, they argued, could increase the risks to future electricity security of supply with high levels of renewable energy and undermine balancing efficiency, in addition to unnecessarily increasing costs. As a package, the Electricity Balancing Significant Code Review (EBSCR) policies have been designed to improve incentives on market participants to balance their positions by strengthening the price signal for cash-out.

These reforms have become even more important given the move to net zero in 2019 as power sector decarbonisation is expected to be a catalyst for the decarbonisation of the rest of the UK economy. Based on estimated 2020 GHG emission figures, the UK is now halfway there.

02 Learning lessons: what worked?

Long-term certainty: lower risk means lower cost and more jobs

The return an investor requires is determined, to a major degree, by the perceived level of risk associated with their investment. Lower-risk projects can attract lower-cost financing, increasing their competitiveness which ramps up deployment and ultimately drives down prices.

By providing a clear, long-term trajectory underpinned by binding decarbonisation targets enshrined in legislation, including the net zero target, the UK has created a more stable, lower-risk environment for investors.

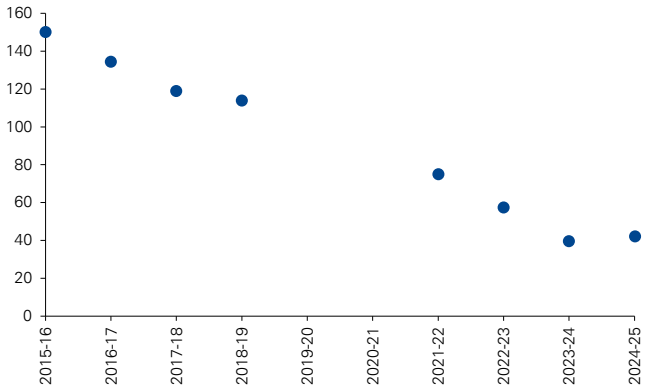
This robust legislative framework has been combined with long-term financing frameworks on the contractual side giving visibility and certainty over prices, this has served to reduce the cost of capital and increase investment flows into low-carbon technologies.

Nowhere has the benefit of this been evidenced more clearly than in the UK offshore wind sector, where costs have fallen to the point where new offshore wind farms could generate power much more cheaply than both new and existing gas power stations from 2023[10].

As deployment has accelerated, the global supply chain has matured and this, alongside innovation in technology, has driven significant cost reductions.

The long-term policy certainty in the UK has underpinned development of a significant low-carbon industry in the UK. By 2030, the low-carbon economy will support over 700,000 jobs in the UK[11], outstripping the total employment estimates for the oil and gas sector. The offshore wind sector alone currently employs over 25,000 full-time workers all over Great Britain and is expected to grow to over 60,000 this decade with the Government's increased 40GW ambition for 2030[12].

£/MWh 2012 Real



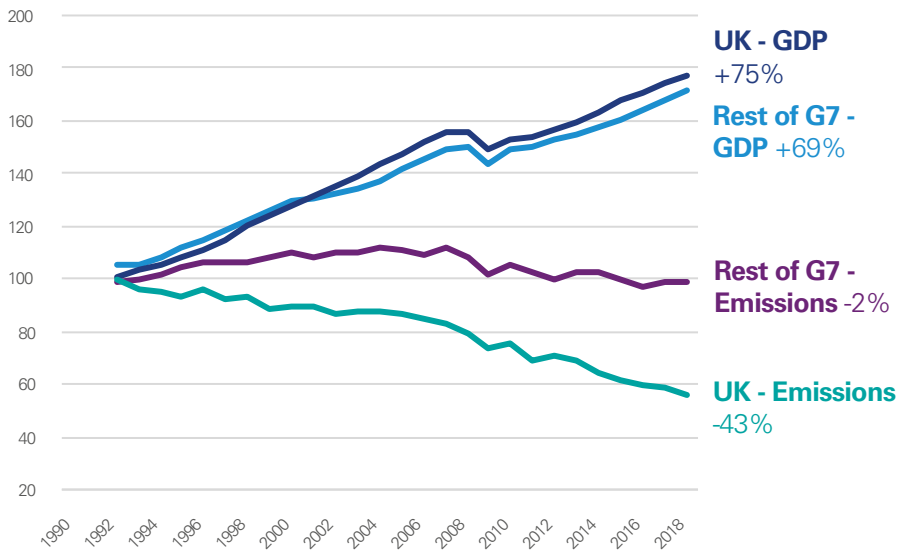
Source: GWEC Global Offshore Wind Market Report

Jobs are typically located away from traditional economic centres, supporting regional economies. The Humber region in the north east of England saw the creation of a Siemens factory dedicated to the manufacturing of wind turbines in Green Port Hull in 2015 creating over 1,000 new jobs in the city. More recently, GE announced its decision to invest in a new blade factory in Teesside, due to open in 2023, which could create up to 750 direct renewable energy jobs and up to 1,500 indirect jobs in the area. This new facility was underpinned by certainty of contract orders from the world's largest offshore wind farm at Dogger Bank, being built by SSE, Equinor and ENI.

10 BEIS, Cost of electricity generation, 2020
11 https://renews.biz/60898/england-to-benefit-from-plus1-million-low-carbon-jobs-by-2030
12 OWIC

Maintaining balance across the 'trilemma'

The UK is the most successful major economy at driving down emissions whilst continuing to grow (GBP, real terms)



Source: 2020 Energy White Paper

The UK's decarbonisation journey has not been at the expense of security or cost, with a focus throughout on balancing the energy trilemma. The UK has decarbonised its electricity system at almost twice the pace of any other of the world's 30 largest electricity systems major economy, during a period in which it has increased GDP by 75% - a faster rate than other G7 nations.

And despite overseeing a radical transformation of its power system, in which firmer and more flexible forms of generation were displaced by variable renewables, the UK has maintained security of supply. The implementation of mechanisms such as the Capacity Market has been critical to maintaining security of supply at a relatively low cost to consumers, making sure the lights have stayed on as the UK decarbonises.

Alongside delivering sufficient electricity generation, the GB market continues to have one of the most reliable energy networks system in the world, with 99.999984% reliability on the Transmission network[13]. Indeed, whilst there have been major system-related power cuts over this period in the US,

Texas case study

Energy system resilience during extreme weather events

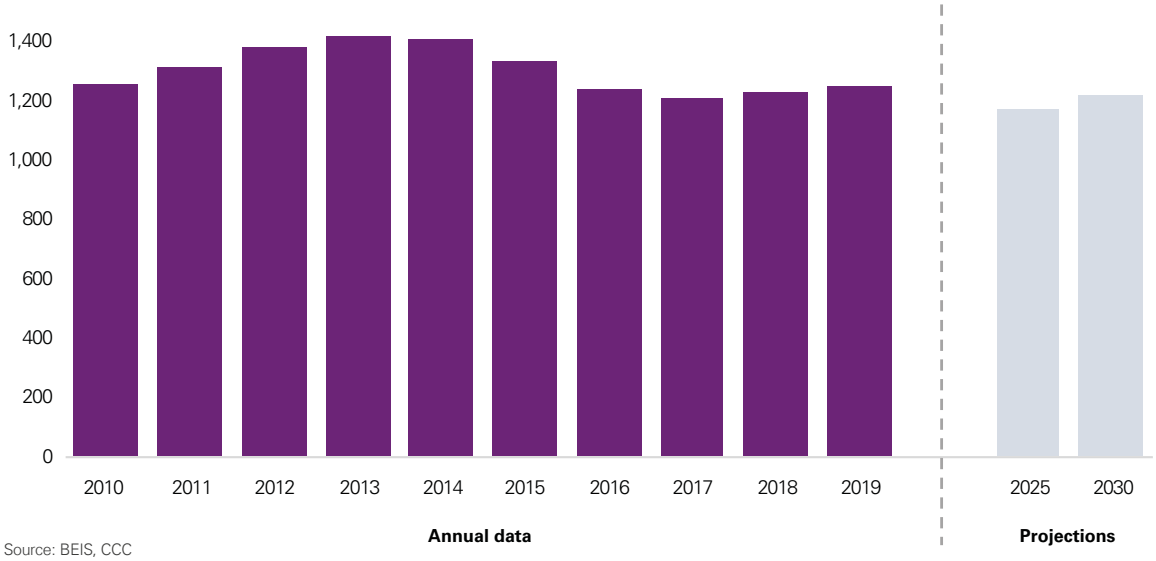
Texas provides a case study on the importance of whole system energy planning and capacity availability incentives for ensuring security of supply in periods of peak demand. Texas operates its electricity market under an energy-only market relying on scarcity pricing of up to $9,000/MWh during times of peak grid stress to incentivise power plant owners to invest in resources to cover those emergencies. Other markets have capacity markets to ensure sufficient generation is available to meet peaks in demand.

Capacity margins in Texas have been tightening for a number of years, with particular concern that margins would be exceeded during summer heatwaves. In the end, winter storms in February 2021 meant that, as demand soared and generation capacity went offline the system operator, the Electric Reliability Council of Texas (ERCOT), sought permission to deliver rolling outages in order to prevent widespread blackouts across the state to maintain the grid with peaks 10GW over previous winter, and above the 74.8GW summer peak.

In this case, **Texas lacked the capacity and resource adequacy tools** that other markets such as the GB use to secure resources to cover rare imbalances between electricity supply and demand, highlighting the importance of these mechanisms and the limitations of purely market-based signals for ensuring security of supply.

13 https://www.nationalgrideso.com

Average household dual fuel bill (£)



Source: BEIS, CCC

Australia, South Africa, Belgium and other countries, most power cuts in the UK are short-lived and due to exceptional weather events.

This has been supported by the regulated financing framework that has delivered record levels of investment in the energy networks, ensuring that the grid has been able to connect up and manage an increasing proportion of renewables.

As well as guaranteeing energy security, the UK has prioritised affordability. In GB, energy bills have remained relatively consistent in real terms over the past ten years despite the significant increase in low-carbon investments which are supported through charges on consumers. Although these policy costs have increased over time, they have been largely offset by reductions in other bill components and falling consumption due to energy efficiency.

Powering past coal

The UK's success in decarbonising its power sector has been thanks primarily to its progress in attracting investment into renewables deployment that has allows coal to be driven off the system.

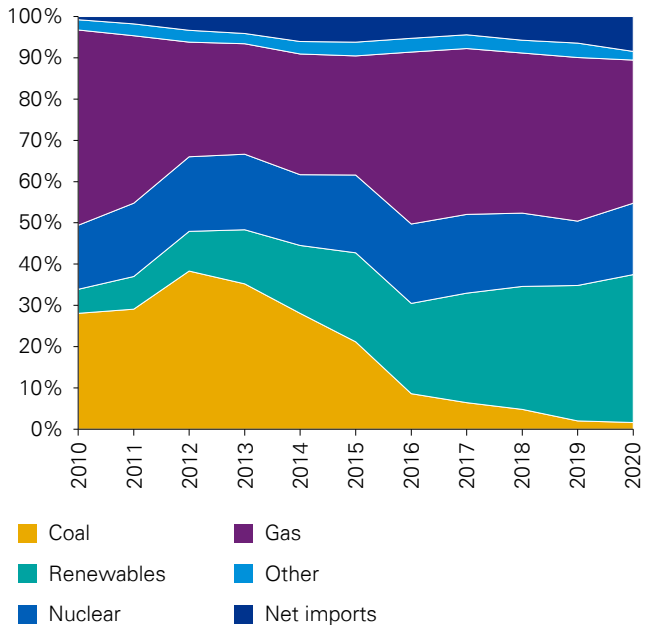
By implementing new policy and regulatory frameworks that provided certainty to investors in the form of CfDs for renewables and the RIIO price control for the networks to connect them, the UK was able to help reduce the cost of capital which in turn attracted more investment and drove down the price of renewables. As more renewables were built, coal was pushed down the merit order.

However, this was insufficient without a mechanism for driving coal-to-gas switching. Through the carbon price support (CPS) and the emissions performance standard, the UK addressed the market's failure to price in the impact of carbon emissions – respectively making existing coal uneconomic. and precluding new coal generation from being built

The role of carbon pricing has been indispensable in driving out carbon intensive energy sources and incentivising abatement technologies. The UK has taken a technology neutral approach that ensures that that carbon-intensive generation is replaced with the lowest-cost option, minimising costs to billpayers. The mechanism is now well understood by the market and continues to be an important driver of power sector decarbonisation.

As a consequence, coal's share of the GB generation mix went from around 40% in 2012 to almost zero by 2020, with legislation requiring any remaining coal to close by 2024. Indeed, 2019 and 2020 saw record numbers of coal free days in the energy mix.

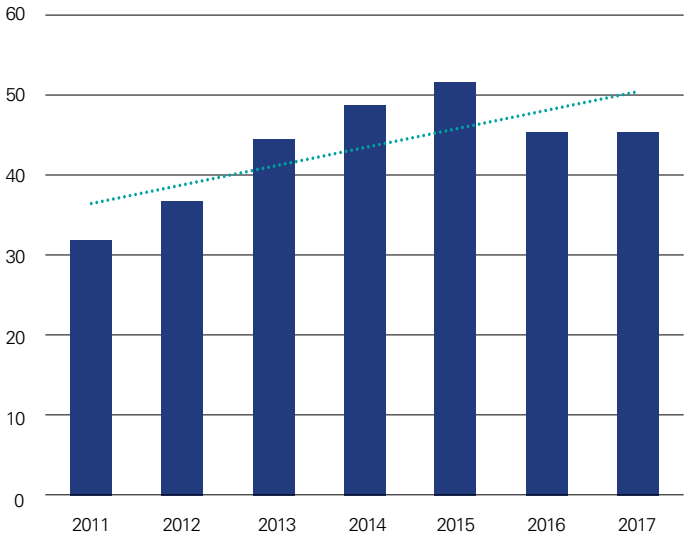
Power generation mix



Ramping up investment in networks

RIIO (Revenue = Incentives + Innovation + Outputs)
Investment per customer has increased by 30% since 2011

Total industry capex per customer (Real 2002/03 prices)

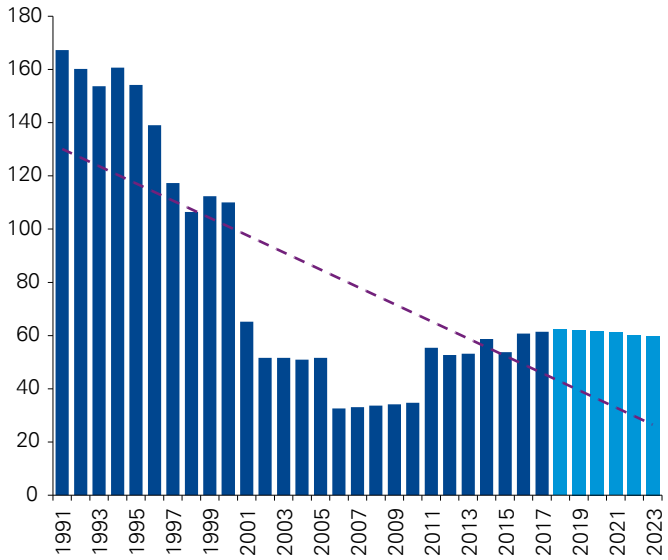


Source: Nera Economic Consulting

With over £9bn worth of savings to consumers delivered between 2011 and 2018[14], the regulated price control framework for UK energy networks has been successful in attracting significant investment in order to upgrade the network to meet growing demand, improve reliability and drive innovation in areas like embedded generation. Electricity network companies have reduced the carbon footprint of their networks by 850,000 tCO2e between 2015 and 2017 and reduced power cuts by 11%[15]. Average electricity distribution costs per consumer have also decreased the level of investment increasing as the low-carbon transition gathers pace.

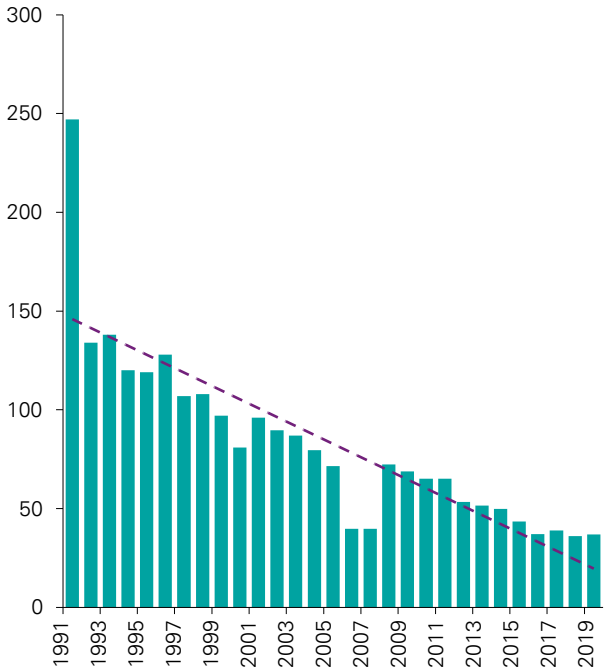
14 Energy Networks Association – April 2019
15 Reference?

Operating expenditure per customer (£m, Real 2016-17 prices)



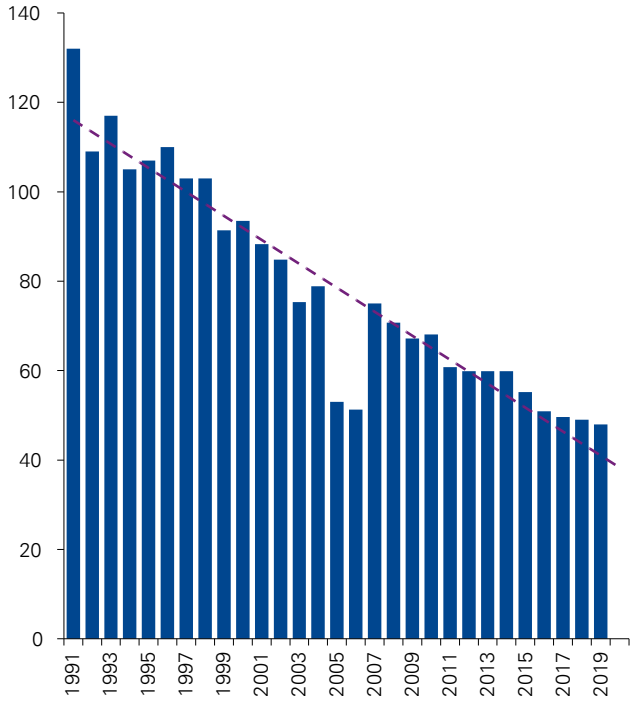
Source: Nera Economic Consulting

Number of customers interrupted per 100 customers per year



Source: Nera Economic Consulting

Average minutes lost per customer per year



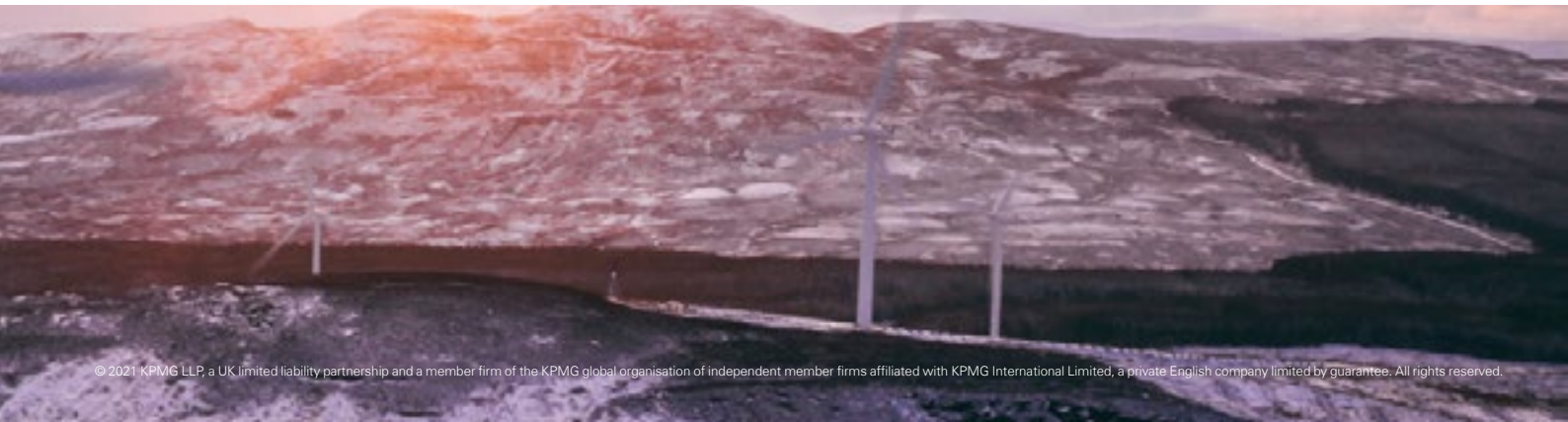
Source: Nera Economic Consulting

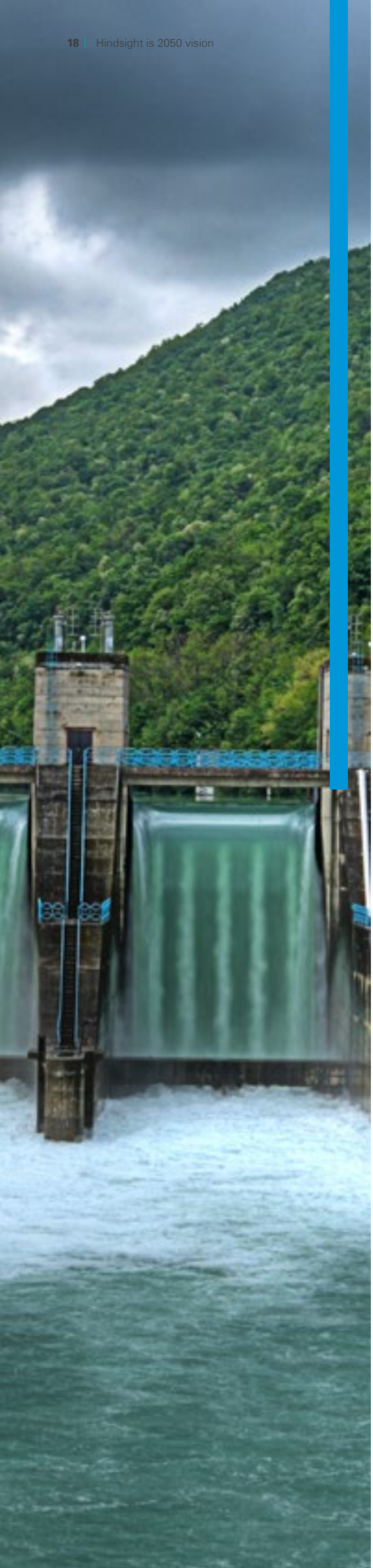
Clear climate governance and accountability

The Climate Change Committee (CCC) was established to advise the UK and devolved governments on emissions targets and to report to Parliament on progress made in reducing GHG emissions and preparing for and adapting to the impacts of climate change. In doing so, it provides independent advice on setting and meeting carbon budgets and preparing for climate change; monitors progress in reducing emissions and achieving carbon budgets and targets; conducts independent analysis into climate change science, economics and policy; and engages with a wide range of organisations and individuals to share evidence and analysis.

Setting up the Climate Change Committee (CCC) as an independent body to hold the Government accountable for delivering on the Climate Change Act of 2008 lay a strong foundation for good climate governance. The practice of setting out sequential carbon budgets, put forward by an impartial expert in the form of the CCC and legislated for by government, provides a clear roadmap to the end goal that gives confidence to investors and lends urgency and direction to domestic policy makers.

The clear and binding long-term legislative climate targets put in place by the UK led to development of the robust policy and regulatory mechanisms outlined above. These have been key enablers of the UK's rapid decarbonisation of its power sector, attracting the significant private investment into low-carbon technologies needed to deliver on political ambition.





03 What challenges have been encountered?

While the UK has undoubtedly made significant progress in decarbonising the power sector, there are a number of outstanding challenges that still need to be tackled to deliver a net zero power system quickly enough to support full decarbonisation of the wider economy by 2050.

Ensuring consumer buy-in to the Energy Transition

While public opinion is increasingly asking for more investment to tackle carbon emissions, the question of how the benefits are ultimately passed on to consumers, playing a more active role in the energy system than ever before, will be paramount. Whist energy bills have generally been flat through the last decade, there have been concerns about how you fund the necessary low-carbon investment in a fair way.

A sharp increase in energy prices in 2012 led to a public outcry with many commentators pointing to a rise in low-carbon policy costs as a key driver. This created meaningful political pressure that forced Government to seek ways to deliver immediate cost reductions and, in 2013, it announced plans to scale back targets under its flagship home energy efficiency scheme, the Energy Company Obligation (ECO). Agreement was reached at the same time with network operators to defer some costs, while the Government worked with suppliers to offer a one-off tax-funded rebate applied automatically to energy bills. Collectively these measures enabled government to announce a £50 per household saving but did not resolve political concerns, which eventually resulted in the imposition of a retail market price cap domestic electricity and gas in 2017.

The Government has also encountered similar pressure from Energy Intensive Industries (EIIs), who are more heavily impacted by levies on electricity bills with knock-on effects on their international competitiveness. Government responded in 2016 by initially allowing EIIs to apply for relief on costs already incurred, before implementing an EII exemption scheme from 2018. While this supports the most affected industries, it increases the proportion of policy costs being picked up by smaller businesses and households.

Similar concerns around the cost of the transition have been experienced by other countries internationally. The French Government's withdrawal of the increase in the carbon tax on fuel following months of the 'Yellow Vests' movement protests is an example of the importance of distributional impacts for public buy-in. Similarly, political differences plagued the implementation of carbon pricing in Australia, where a Carbon Tax covering electricity generation and industry was scrapped in 2014 after only two years of operation.

The question of how the transition to net zero is funded will be even more prominent moving forward. With the majority of low-carbon investment being funded directly through energy bills in GB, those on lower incomes pick up a proportionately higher share of the cost, while being less able to invest in energy efficiency measures to reduce what they pay. In addition, these policy costs are largely placed on electricity, making low carbon alternatives more expensive than fossil fuel options. The role of public finances versus energy bills as the right tool for financing net zero remains an area of policy debate.

Incentivising households to change behaviours and invest in decarbonising their homes will require a balanced approach across all relevant policy and regulatory levers. This will need to include support being provided to those on lower incomes and vulnerable households. Supporting direct consumer participation in the energy system will help drive down costs for individuals and for the wider system.

With the net zero transition driving radical change across the economy, broader distributional impacts beyond energy bills will also need to be considered, including those who lose jobs in current high-carbon industries. In a net zero world, jobs are likely to be in different areas of the country and require different skills. A joined-up approach across government, industry and civil society will be required. A relevant success story is in the offshore wind sector, where people previously employed in oil and gas industries are finding roles which can harness their transferable skills.

Decarbonising heat, transport and industry

The UK's success in decarbonising power has yet to be replicated across other key emitting areas of its economy such as heat, transport and heavy industry. With the carbon intensity of the UK's electricity tumbling, this presents an opportunity to leverage the progress that's been made on the supply side to tackle the more difficult challenge of delivering the required changes on the demand side.

Forecasts from the Climate Change Committee (CCC) suggest that electricity demand in the UK could double to meet net zero by 2050 due to increasing deployment of electric vehicles (EVs) and heat pumps, or even treble in a high-electrification scenario where significant volumes of electricity are used for hydrogen and synthetic fuel production.

The UK has taken initial steps towards increasing EV uptake by announcing an end date for the sale of Internal Combustion Engine (ICE) cars and vans from 2030, and is now focused on accelerating deployment of the necessary charging infrastructure, but there is still a long way to go. And despite some speculation over the future of conventional gas boilers, uptake of low carbon heating sources remains low.

As demand for these technologies increases, there will be a need for the UK's network infrastructure to be upgraded both to support huge rise in electricity demand and to increase flexibility to manage changing consumption patterns and more embedded storage (in the form of EVs) and generation.

The future of carbon pricing

The UK's approach to carbon pricing has been a key factor in its success in decarbonising electricity to date, supporting deployment of renewables and incentivising coal to gas switching. However, there is now less certainty on the future pathway for carbon prices across the economy.

In recent months, generators have faced significant uncertainty as a result of the UK no longer being party to the EU ETS following the UK's departure from the European Union. The UK remains committed to robust carbon pricing and has implemented its own UK Emissions Trading System (UK ETS), with the first auctions held in May 2021 and clearing at prices similar to the EU ETS, despite initial fears over pent up demand leading to inflated prices. The EU and the UK have agreed to give serious consideration to establishing a formal linkage between the two schemes as part of the EU-UK Trade and Cooperation agreement, which would mitigate initial uncertainty and provide price stability through a larger market, however at the time of writing a linking agreement has yet to be progressed.

At the same time, the success of carbon pricing in the electricity sector is yet to be replicated in other sector parts of the economy where markets are not pricing in the carbon impact of goods produced and consumed. Where this begins to touch more directly on consumers and international competitiveness, it will be less easy to implement and there may be better policy and regulatory options to achieve the same goal.

Wholesale market reform to ensure lowest-cost renewables

As observed in other countries, as renewables penetration grows, with more and more capacity generating at zero marginal cost, there is wholesale price cannibalisation (the so called the 'merit order' effect), with increasingly low and volatile wholesale prices. Current wholesale prices are set based on the marginal costs of the marginal generator (typically thermal plants). In a market which is dominated by low-carbon plant with marginal running costs close to zero, this could, at times, lead to prices which are insufficient to promote investment and keep plants operational.

At the same time, revenue stabilisation mechanisms in place in the UK (ie CfDs), while extremely successful in bringing forward investment, currently only focus on new plants, making contract-backed investments in new renewables more attractive than potentially more cost-effective investments to extend the operational life of existing assets. While more renewable projects will soon be developed on a merchant basis all over the world, the cannibalisation impact caused by a lack of demand and supply flexibility can become a threat to their ability to keep competing with government-backed contract plants.

Instances of negative prices have increased in most countries with high renewable penetration. Periods of lower prices are not uncommon and when passed on to consumers, will be a positive outcome of the energy transition. However, if wholesale prices decrease to unsustainably low levels for extended periods, the uncertainty and the impact on returns might lead existing plants to close earlier than would be economically efficient to do so, requiring more new low carbon generation driving the to meet the country's net zero target, rather than extend the life or repower an existing asset. It could also drive investors to seek to recoup the cost of the full lifetime of the asset over the initial 15-year contract, driving up the price of CfDs.

The UK Government recognised this issue in a recent call for evidence on future power market reforms. Implementing the right wholesale market framework that supports the most economically rational investments in renewables and creates a 'level playing field' for new and existing projects will be a key challenge in the early 2020s if the UK is to achieve net zero at least cost to consumers. Its successes to date show that the UK Government has been willing to make bold policy interventions where it identifies the need and it will need to be ready to act again.

Low carbon flexibility to ensure security of supply

Another impact of increasing renewables penetration is the need for increasing use of balancing services by the system operator in order to ensure supply continues to meet demand given the inherent variability of renewables.

Historically, unabated thermal generating plant, including that procured through the Capacity Market have provided the firm, flexible power needed to balance the system at times of high demand and low renewable output. As renewables have increased, the role of thermal generation has change too, moving from providing baseload power to responsive power to maintain energy security. This has helped reduce carbon emissions by minimising running hours but underlines the need for a capacity mechanism to maintain availability.

In order to achieve a net zero power sector in the 2030s, there is a pressing need for lower-carbon flexible generation solutions to be brought forward in order to decarbonise the last 10-30% emissions in the electricity system[16]. This will include the need to deploy firm power sources such as gas-fired generation with carbon capture and storage (CCS) and hydrogen power generation to help balance the variability of renewables but also to help underpin wider industrial decarbonisation.

A number of unsuccessful attempts have previously been made to bring forward the first scale power CCS project in the UK. The Government's focus is now on developing CCS alongside wider economic decarbonisation within industrial 'clusters', grouping together industrial emitters, electricity generation and heavy transport around ports in industrial regions. It has committed to delivering two operational industrial clusters by 2025, and two more by 2030, capturing annual volumes of at least 10mt of carbon.

Development of the industrial clusters will also create demand for hydrogen that can support investment in technologies like hydrogen electrolysers. As well as producing a clean fuel that can be used flexibly to generate power, or potentially to fuel heating and transport, electrolysers can ensure system operability with the ability to redirect excess supply of renewable energy towards the production of green hydrogen to be stored long-term in salt caverns.

Alongside CCS, long-term duration storage can play a vital role in smoothing peaks in supply with a recent Imperial College London study finding that 4.5GW of new long duration pumped hydro storage with 90GWh of storage could save up to £690m per year in energy system costs by 2050.[17] 75% of these cost savings are from avoided capex costs of additional low-carbon generation otherwise needed to meet security of supply and emissions targets.

It will also be vital to unlock the full value of demand-side flexibility, increasingly provided by households as we electrify heat and transport. There is a broad consensus on the role for electric vehicles and batteries as intra-day buffers, together with longer-duration storage including pumped hydro and hydrogen as multiple day through to inter-seasonal storage. However, these technologies face a similar challenge to other low-carbon infrastructure, with high upfront costs, long lead times backed by long lifetimes and uncertain revenues and so still need clearer market signals and support frameworks to be adopted at the scale needed.

16 Energy Transitions Commission (2021) - https://www.energy-transitions.org/publications/making-clean-electricity-possible/

17 Whole-System Value of Long-Duration Energy Storage in a Net-Zero Emission Energy System for Great Britain, Imperial College London – Feb 2021

Source: Arnold Schwarzenegger Institute

California case study

Managing California's renewable energy drive

The California power market offers a useful case study of rapid decarbonisation and the deployment of renewables, and indeed the potential for progress to be driven by sub-national actors. Consistent political support, particularly under the leadership of Governor Arnold Schwarzenegger who implemented ambitious solar and renewables targets in the mid-late 2000s, coupled with high levels of investment in technological innovation, means that it has led the way ahead of other states in the US, both in terms of speed of implementation and degree of renewables penetration. Highly ambitious local targets within its 50+ municipalities have also led to a strong appetite for direct procurement of renewable generation and storage, which means this trend is set to continue.

Geographically, California is well-placed to establish itself as a renewables leader. Strong wind speeds in many regions and high levels of solar radiation have helped to ensure significant renewable deployments and attract international investment in assets, which supported the large decreases in levelised costs. Although its coastline is unsuited for conventional, fixed-bottom offshore wind, it is looking to increase its wind capacity significantly via floating offshore wind as the technology matures. Unlike in many other regions, it is also effectively securing investment in flexibility to help manage its increasing renewables capacity and is now one of the biggest battery storage markets in the world, with several of the world's largest units in advanced stages of development.

Although the state has seen significant reductions in carbon intensity of its power system with significant renewables generation from this leading ambition, the changes to its generation mix have led to challenges which are likely to be faced by others.

Rapid deployment of solar generation (13GW) largely generating at the same time has led to a phenomenon known as the 'duck curve', where system demand is displaced by large volumes of distributed solar during the day. California represents the most pronounced example of this effect globally and managing this challenge currently requires high levels of spending on constraining generation and system services.

However, California has been successful in securing investment in flexibility and is now one of the biggest battery storage markets in the world, with several of the world's largest units in advanced stages of development. To provide flexibility over longer periods, the Californian Independent System Operator (CAISO) is looking at options to tender for hydro pumped storage capacity to provide longer duration storage to help manage increasing levels of variable renewables.

Bringing forward strategic investment

Achieving net zero will require a significant increase in electricity demand to support decarbonisation of heat and transport, as well as a greater degree of flexibility to accommodate increasing levels of distributed energy and storage.

As we have already seen over recent years, meeting this demand principally from renewable sources will require significant investment in transmission network infrastructure onshore to transport clean power to demand centres, as well as a coordinated offshore grid, while distribution networks will need to be reinforced and upgraded to become 'smart grids' capable of facilitating millions more electric vehicles and heat pumps, as well as distributed energy. While the current regulatory price control framework has proven effective in driving investment into energy networks, the transformative changes required in the coming years will require a different, more anticipatory approach that brings forward sufficient strategic investment to ensure future demand can be met.

Transmission

The UK's approach to transmission charging was not designed for a renewables-led energy system and will need reform to support delivery of net zero. There is an ongoing tension between, on the one hand, the regulator's approach to remove system cost inefficiencies by incentivising generation to locate near where demand occurs and, on the other hand, the tendency for renewable generation projects to be located away from demand centres due to the location of the required natural resources, particularly when geographically defined by seabed leases. Ofgem's current charging system means projects in the north of Scotland, for example, where natural renewable energy sources are plentiful, pay higher transmission charges than those in the south. This creates a distortive barrier to the investment that will be needed to deliver the required increase in renewables to meet net zero.

As seen in the most recent CfD auction rounds, offshore wind projects connecting to Scotland struggle to bid as competitively as English projects. Ensuring that locational signals promote the right level of investment where it is needed the most is key for the operability of the network; however, when it comes to renewable energy projects, geographic location is very often not flexible particularly in markets around north west Europe given generation is both determined and limited by seabed availability. A review of the current transmission charging methodology is therefore likely to be needed to deliver net zero cost-effectively.

Distribution

At the local level, a significant transformation is required in both the volume of electricity being consumed and the way in which it is supplied and consumed. With over 10 million EVs expected on UK roads by 2030, along with millions of heat pumps, the next decade will be critical for investment in reinforcing the reliability and flexibility of the distribution network as operators make the transition to more proactive distribution system operators, integrating and managing new electricity loads and embedded generation.

To ensure this strategic investment represents value for money for network customers and recognises local needs, it will require robust and data-driven evidence and a locally focused deployment approach. Without strategic investment and local coordination, network companies may ultimately struggle to keep pace with increasing electrification, resulting in an infrastructure gap and increased costs for consumers.

Strategic approach to planning

Given the scale of the challenges and transformation required to deliver net zero, a joined up and strategic approach to planning the future energy system will be vital.

An important example is that the current offshore marine planning and licensing regime is not fit for purpose for scaling up the levels of annual offshore wind deployment needed in UK waters to achieve net zero. The combination of the leasing tender regime, the marine planning regime and the transmission model is creating uncertainty and longer planning timelines for project developers. It is often described as creating a "race to the water", instead of promoting a coordinated approach.

The current point-to-point approach to connect offshore wind to the grid is another example of a model that is no longer fit for purpose in light of its increasingly central role in delivering net zero. This has been recognised through the UK Government and Ofgem led Offshore Transmission Network Review (OTNR), which seeks to better coordinate on and offshore network infrastructure delivery. A strategic

shift in delivering offshore transmission is essential to reach the UK's 2030 target of 40 GW by 2030, and the 100+GW identified as needed by 2050. Taking a more integrated approach to the UK's offshore grid could help save £6bn in connection costs by 2050 according to the ESO[18] and allow for greater efficiencies in project development, alongside reducing local environmental impacts. Integrating and sharing offshore infrastructure would not only reduce connection times for offshore wind but also help the UK maximise the use of the UK's offshore wind resource by enabling more projects to connect onshore and with neighbouring markets.

While the UK opted for a point-to-point model to offshore wind connections which has helped reduce costs to date, other markets like Denmark, Germany and the Netherlands, adopted a model of more centrally planned model to onshore energy from offshore wind to manage their available seabed, and are going a step further in considering creating offshore wind hubs with the support of the EU.

Germany case study

Non-financial barriers slowing Germany's renewables ambition

Onshore wind is seen as critical to achieving Germany's goal of reaching 65% renewables in power consumption by 2030, with 71GW expected to be installed - a rate of over 4GW per year. However, recent auction rounds have been under-subscribed by an average of around 55%, with only 1.4GW of new capacity installed in 2020.

This has been driven by issues with gaining permission for projects, lawsuits by environmental groups and local citizen movements which have dented investor confidence in onshore wind in Germany.

Parallels can be drawn with the GB energy market with consenting and permitting issues for offshore wind projects seen in recent years, which threaten to impede progress towards the UK Government's target of 40GW of offshore wind capacity by 2030. Competition in CfD auctions in the UK to date has continued to be high with all previous rounds oversubscribed; however, as seen in Germany non-financial barriers could cause projects to be delayed or cancelled, adding risk and cost to delivering on ambitious renewable energy targets.

Energy efficiency

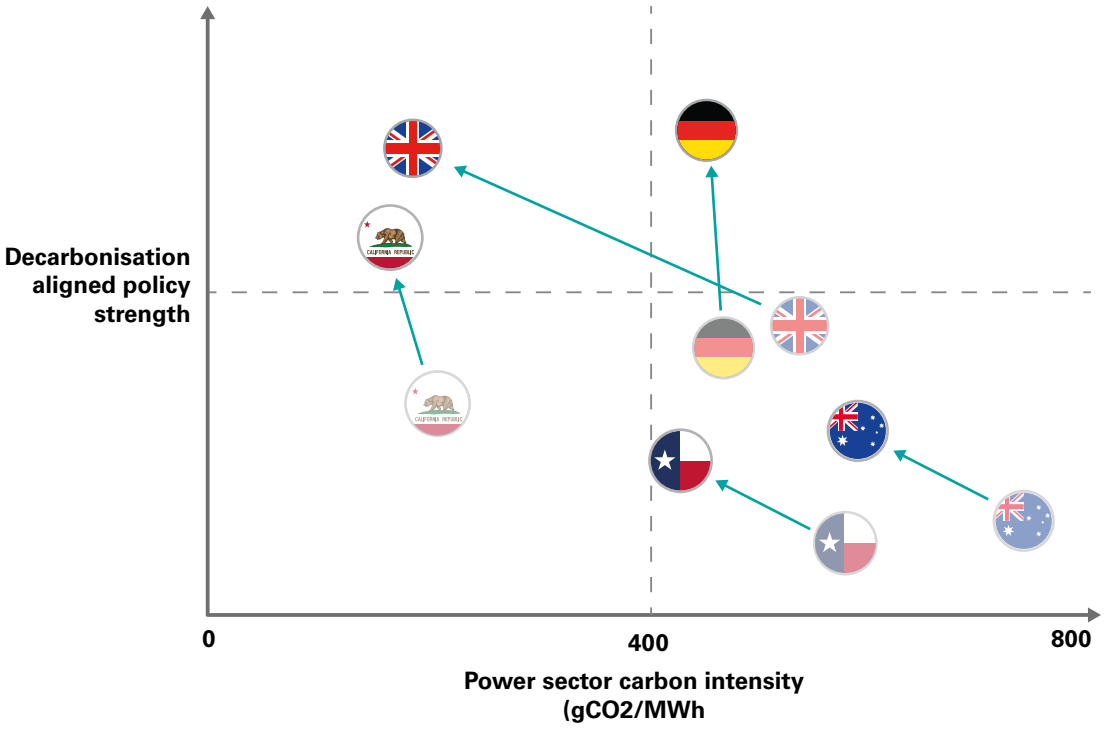
Despite having some of the least energy efficient housing stock in Europe[19], the UK has yet to deliver sufficient improvements in reducing demand. With almost all the heavy lifting on decarbonisation so far being done by the supply side, addressing demand remains a key outstanding challenge. Energy efficiency measures can form a cost-effective way to contribute towards meeting the UK's decarbonisation goals as well as delivering consumer savings on their energy bills. While some progress has been made through subsidised schemes targeted at delivering measures to qualifying fuel poor households, such as the Energy Company Obligation (ECO), driving uptake from 'able to pay' households has proven more challenging with schemes including the shelved Green Deal and more recently the Green Homes Grant failing to gain traction.

As the UK prepares for the next phase of policy development on the road to net zero, a number of both old and new challenges need to be explored further. Government has acknowledged these in its 2020 Energy White Paper however, more engagement and clarity on the mechanisms of their delivery, the market incentives and the legal and institutional design to deliver them are needed.

18 https://www.nationalgrideso.com/future-energy/projects/offshore-coordination-project

19 Energy efficiency: building towards net zero, Twenty-First Report of Session 2017–19, House of Commons, 2019

04 International comparison: How does the UK experience compare and what else can we learn:



Source:

UK

Over the past decade no major economy has decarbonised more rapidly than the UK. Long-term, binding targets joint with policy focused on the energy trilemma has ensured the UK has led the way on reducing the carbon intensity of its power sector. Prioritising consumer costs, decarbonisation as well as system security has ensured that progress, although rapid, has been sustainable and without detriment to UK citizens.

California

Only California rivals the UK in terms of power sector emissions, and similar to the UK, the state is often seen as a case study for others embarking on their own decarbonisation journey. A well suited climate for solar generation as well as long term commitments have catapulted California ahead of other states in terms of renewables penetration, however it's system operator is now struggling to keep pace with increasing grid stability issues and an overreliance on interconnections to markets with similar climactic conditions, leading to blackouts and increasing power prices.

Germany

Germany has seen a significant shift in decarbonisation policy compared to other markets considered in this study. However, in taking account of public opinion, particularly around nuclear, has slowed the pace of decarbonisation and led to higher consumer costs overall. A recent switch to a more centralised system balancing approach has, however, helped to reduce balancing costs and could be an important lesson for other nations.

Texas

As one of the few electricity markets without some form of capacity market, Texas has always experienced more volatile wholesale prices than in other markets. Critics question this approach in terms of system security and negative renewables press, especially during the recent blackouts in February 2021 that sent electricity prices soaring. On the other hand, the market signals it creates have supported increased investment in batteries and flexibility, which is currently a major challenge area for the UK.

Australia

The National Electricity Market (NEM) in Australia is another energy-only market, which uses a number of locational pricing mechanisms to provide strong market signals for generation as well as demand, flexibility and storage capacity. Despite this, Australia lags behind in terms of decarbonisation, with no federal renewable generation targets and a continued heavy reliance on coal.

These case studies demonstrate a number of key lessons learnt and alternative market models that the UK, and other nations, should consider as we look to build a power sector that best supports our net zero ambitions, whilst reducing the impact on consumers in terms of electricity cost and energy security. This will be essential if we are to address the challenges outlined above.

	Great Britain	Germany	California (Caiso)	Texas (Ercot)	Australia
Carbon pricing?	✓ ✓	✓ ✓	✗	✗	✗
Legislative economy-wide emissions reduction target?	✓ ✓ ✓	✓ ✓ ✓	✓ ✓ ✓	✗	✓
Renewables procurement mechanism offering fixed duration price stability?	✓ ✓ ✓	✓ ✓ ✓	✗	✗	✗
Capacity market?	✓ ✓ ✓	✓	✗	✗	✗
Long term investable framework for network investment?	✓ ✓	✓ ✓	✓	✓	✓ ✓
Integrated heat decarbonization polices?	✗	✓ ✓	✗	✗	✗
Integrated Industrial decarbonization polices?	✓ ✓	✗	✗	✗	✗
Co-ordinated offshore grid approach	✗	✓ ✓ ✓	✗	✗	✗

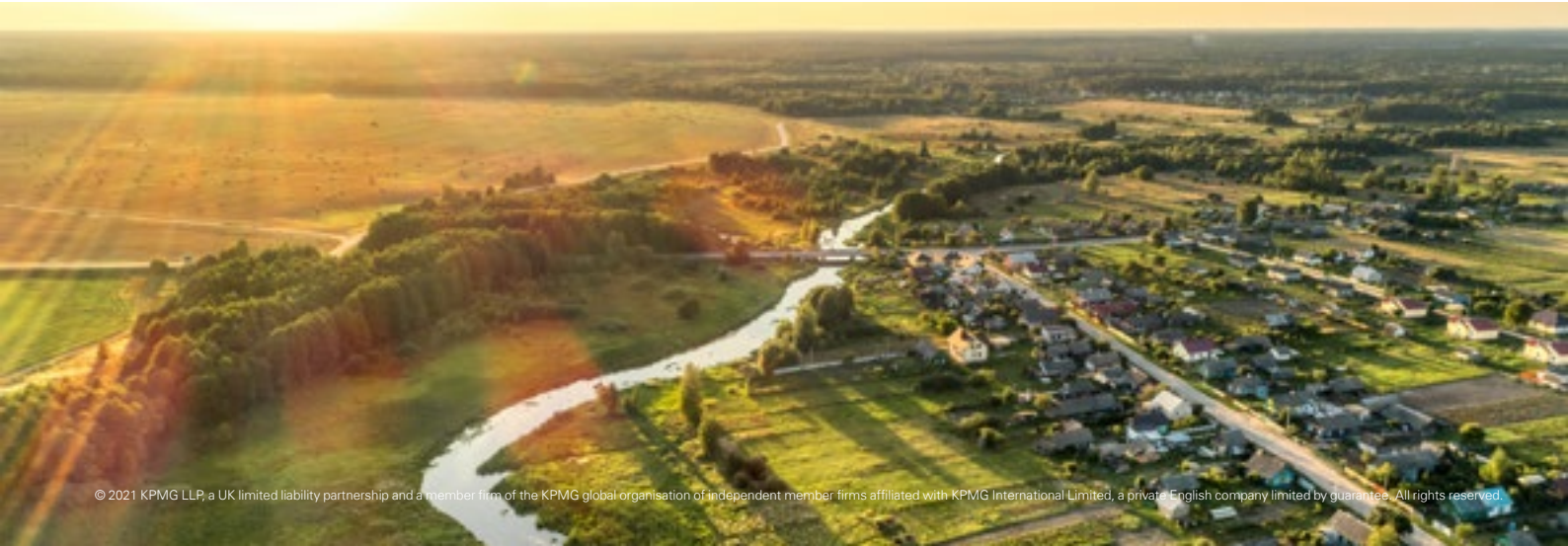
05 Bringing it together: what the UK has learned about how to decarbonise the power system

Success drivers	Related challenges	Key principles for global decarbonisation
Robust institutional structures and accountability	— Clearer accountability on strategic planning needed for net zero	Set legally binding, long-term targets backed by robust institutional structures
Legally binding, long-term decarbonisation targets	— Translating long-term targets into clear plans and policies need to deliver them	
Maintaining security of supply through a capacity mechanism	— Increasing balancing costs — Need to deliver low-carbon firm, flexible capacity	Maintain balance across the ever-present energy trilemma to retain a public mandate for decarbonisation
Keeping electricity affordable by driving wholesale price reductions and delivering a fair transition	— Regressive funding of policy costs through energy bills — Politicisation of policy costs — Limited progress of energy efficiency programmes	
Rapid decarbonisation of power through coal phase out and renewables deployment	— Slow progress in decarbonising other sectors — Limited impact on the demand side to date	Decarbonise power first to unlock electrification of other sectors
Robust carbon pricing	— Lack of long-term visibility due to no ETS linking	Incentivise lowest-cost investment in low-carbon solutions including by putting a clear price on carbon
Long-term financing frameworks	— Wholesale price cannibalisation requires market design reforms — Transmission charging reform to support (not undermine) investment — Further progress required on funding mechanisms for CCS, hydrogen and long-duration storage	
Stable and investable regulatory control regime to attract network investment	— Need to bring forward sufficient investment ahead of demand — DSO transition to enable electrification of sectors — Requirement for joined up planning and coordination	Drive strategic investment that anticipates future system needs

Five key principles for countries to establish a credible net zero pathway

There is clearly no exact formula that will determine whether an individual country is successful at reaching net zero. However, looking back at the UK's experience – both in terms of what has worked well and the challenges it has faced and will face in the future – five clear guiding principles can be drawn out that can help guide the global decarbonisation effort.

1	**Set binding, long-term targets backed by robust institutional structures**	Clear, long-term targets provide long-term certainty and investor confidence; in the UK, the Climate Change Act and five-year Carbon Budgets have provided an effective governance framework and ensured public accountability.
2	**Maintain balance across the ever-present energy trilemma to retain a public mandate for decarbonisation**	Reliability and affordability for consumers need to be considered continually on the journey to net zero in order to maintain a public mandate. Without policies in place to keep the lights on and without due consideration to the cost and distributional impact of the transition, it cannot succeed.
3	**Decarbonise power first to unlock electrification of other sectors of the economy**	Once the majority of electricity comes from clean sources, it provides a powerful tool with which to help decarbonise other sectors of the economy, such as transport, heat and industry; however, consumer engagement, incentives and regulatory interventions are required to build demand for low-carbon solutions.
4	**Incentivise lowest cost investment in low-carbon solutions including through putting a clear price on carbon**	Setting a robust carbon price with a clear, visible trajectory is the simplest way to incentivise the lowest-cost carbon abatement options, while stable long-term policy and regulatory frameworks encourage investment by helping to de-risk projects, lowering the cost of capital, in turn driving down technology costs and delivering at lower costs for consumers.
5	**Drive strategic investment that anticipates future system needs**	The transition to net zero will require rapid changes in the way and volumes in which energy is generated and consumed. This requires long-term planning and early, strategic investments in critical enabling infrastructure in networks and flexibility in particular, as well as the removal of structural barriers to renewables growth.



Contact us

Glenn Barber
Group Director of Corporate Affairs
glenn.barber@sse.com

Simon Virley CB
Vice Chair and Head of Energy and Natural Resources, KPMG in the UK
simon.virley@kpmg.co.uk

home.kpmg/uk

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