United Kingdom 2024

Energy Policy Review

International Energy Agency

INTERNATIONAL ENERGY AGENCY

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Executive summary

The United Kingdom's energy transition is poised for its next phase

The IEA peer review of the United Kingdom (UK) took place over 20-24 November 2023. The review came at a timely moment, as the United Kingdom is in the process of reviewing its energy transition strategy to align with industrial and energy security goals.

The United Kingdom was one of the first major economies to legally establish a net zero target in 2019. It was also an early mover in setting legally binding carbon budgets and carbon pricing as well as creating an independent body, the Climate Change Committee, with statutory authority to track the government's progress toward its climate targets.

The United Kingdom met its first three carbon budgets (2008-12, 2013-17 and 2018-22). Greenhouse gas (GHG) emissions in 2023 are estimated to be 53% lower than in 1990. Most GHG emissions reductions came from a decline in coal use and an increase in renewable electricity generation.

The United Kingdom has committed to lowering emissions by 68% from 1990 levels by 2030 as part of strengthening its Nationally Determined Contribution to the United Nations Framework Convention on Climate Change. It will, therefore, need to not only maintain but to accelerate action to reach the target. Continuing to meet carbon budgets will become harder, as the abatement challenge increases, requiring more policy action to support investment across more sectors.

The government has a long list of targets and policies to support energy-related climate change strategies. Since the IEA's last review, the UK government has set out the wider context of its strategic priorities for the energy sector in several papers, including: the Energy White Paper (2020), the Ten Point Plan for a Green Industrial Revolution (2020), the Net Zero Strategy (2021), the British Energy Security Strategy (2022), Powering Up Britain (2023), Powering Up Britain: Energy Security Plan (2023), and Powering Up Britain: The Net Zero Growth Plan (2023). Such long-term planning is helpful to provide investment signals and determine the expectations of various parts of the energy system. Equally important is ensuring a stable and predictable policy environment. Looking ahead, the shift from strategy setting to implementation will need to happen quickly, as investments toward 2030 and 2050 targets are needed right away.

The electricity system will need to accommodate sizeable new growth in clean electricity

The UK electricity sector has undergone major changes in recent years, with a sizeable reduction in coal power generation and rapid deployment of renewable energy sources. The government has ambitions to fully decarbonise the power sector by 2035 (subject to security of supply), deploy up to 50 gigawatts (GW) of offshore wind by 2030, increase solar capacity by 70 GW by 2035 and realise up to 24 GW of nuclear power by 2050.

Historically, coal power was the main source of electricity generation in the United Kingdom, but since the IEA's last review (2019), most of the United Kingdom's coal-fired power plants have closed in line with plans to phase out coal-fired generation by October 2024.

In addition, nuclear's share in electricity generation has also been declining to around 15% of generation. However, the UK government has committed to ensuring that nuclear continues to play an important role in the energy mix and is taking steps to revitalise its nuclear industry.

The reduction of electricity generation from coal and nuclear has been compensated by increased electricity generation from natural gas and large-scale deployment of renewables. Renewables have risen to reach 42% of the electricity mix in 2022, with renewable generation growing more than threefold since 2012, led by wind.

In the coming years, the United Kingdom will need to ensure the continued buildout of low-emissions generation to displace unabated gas, replace nuclear closures and keep up with load growth driven by electrification. Moreover, the energy transition will necessitate an unprecedented buildout of grid infrastructure.

The government's Contracts for Difference scheme has been a notable success story in driving the renewables boom. The government is also working to remove barriers to renewables development and reduce the time it takes to get planning consents for renewables projects. A massive buildout of grid infrastructure and rapid growth in grid connections will be critical priority areas to support the energy transition.

Energy efficiency upgrades and electrification of heating will be crucial to decarbonising UK buildings

The UK buildings sector, with a stock that is among the oldest in Europe, accounts for over a quarter of the United Kingdom's energy emissions. The IEA urges the government to keep a sustained focus on energy efficiency upgrades of the

existing building stock and a rapid turnover of fossil fuel heating systems toward electricity as priority areas that can show fast results.

Toward this end, the United Kingdom has already laid out strategies and put in place policies, underpinned by financial support, to decarbonise the buildings sector, including phasing out fossil fuel boilers. Still, ambitious targets will need significantly more policy focus to be achieved, and the government should avoid frequently changing timelines and targets and strive for maximum ambition.

A major impediment to the electrification of buildings is the cost of electricity relative to fossil fuel alternatives, which poses challenges for affordable fuel switching. Efforts to rebalance costs between electricity and natural gas are, therefore, strongly encouraged.

UK transport sector strategies are comprehensive and should be implemented and sustained

Transport is the United Kingdom's largest emitting sector, responsible for over one-third of domestic energy-related emissions. Its accelerated decarbonisation is central to delivering overall climate commitments. Toward this end, the United Kingdom has laid out roadmaps and strategy documents to clarify its approach, which involve plans across modes of transport.

The government has implemented strong policies to increase uptake of zero emissions vehicles (ZEVs) to facilitate decarbonisation of the light vehicle fleet. For example, regulations to deliver the world-leading ZEV mandate entered into force in January 2024. Complementary efforts to use other tools – including fuel efficiency targets, biofuels mandates, and the promotion of public and active transport – will help support more rapid decarbonisation of road transport.

Industrial decarbonisation will hinge on technology development, supported by infrastructure

The industry sector is an important part of the UK economy, accounting for around a fifth of UK energy consumption and 14% of emissions. Government efforts on industrial decarbonisation should be oriented toward the near-term goal of optimising energy efficiency gains, combined with sustained efforts to enable investment in deep decarbonisation.

Electrification can be supported by efforts to redistribute costs from electricity to natural gas as well as reforms to improve grid connections.

Commercialisation and adoption of new technologies, including carbon capture, utilisation and storage (CCUS) and hydrogen, will also be critical to industrial decarbonisation. The United Kingdom's cluster approach to CCUS, which

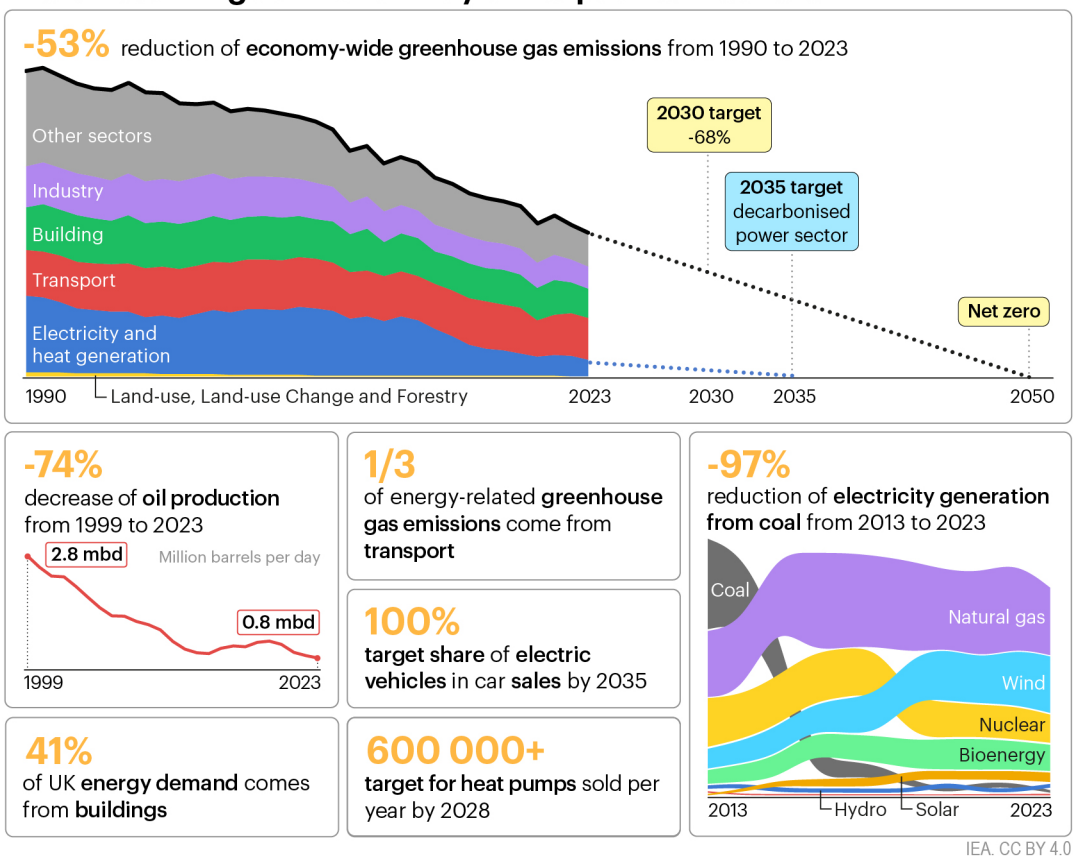
leverages regional industrial advantages and ensures broad geographic coverage, is a good one in principle. In the future, low-carbon hydrogen is expected to play a more prominent role in the industry sector, and industry will be a key driver of hydrogen development in the United Kingdom.

The UK oil and gas sector will need to prepare for declining production profiles and energy transitions

The United Kingdom is also an historically important oil and gas producer, which has underpinned domestic energy security and supported strong economic activity and quality jobs. Offshore oil and gas production in the United Kingdom is on a long-term declining trend despite additional production from new fields and incremental projects in existing fields. As in all oil- and gas-producing countries, the United Kingdom will need to assess the longer term role of upstream production in a net zero future.

Given the economic significance of the United Kingdom's oil and gas industry in the overall economy, the government will also need to be mindful of economic challenges to revenues and jobs that the energy transition might bring. In this regard, the clean energy economy can offer considerable opportunities for creating new jobs and industries.

The United Kingdom is halfway on its path to Net Zero



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1. Climate and energy policy

In the past decade, the United Kingdom energy mix has changed significantly, with an overall reduction in energy production, supply and consumption. Compared to other IEA countries, domestic energy production covers a significant share of total energy supply (TES) (68% in 2022).

Domestic oil and gas production accounts for a large portion of UK supply (75% for oil and 54% for gas); the rest is imported. Other sources of energy production are less significant, with coal production falling by 96% from 2012 to 2022. Nuclear has also declined, while renewables have increased considerably, especially in recent years (Figure 1.1).

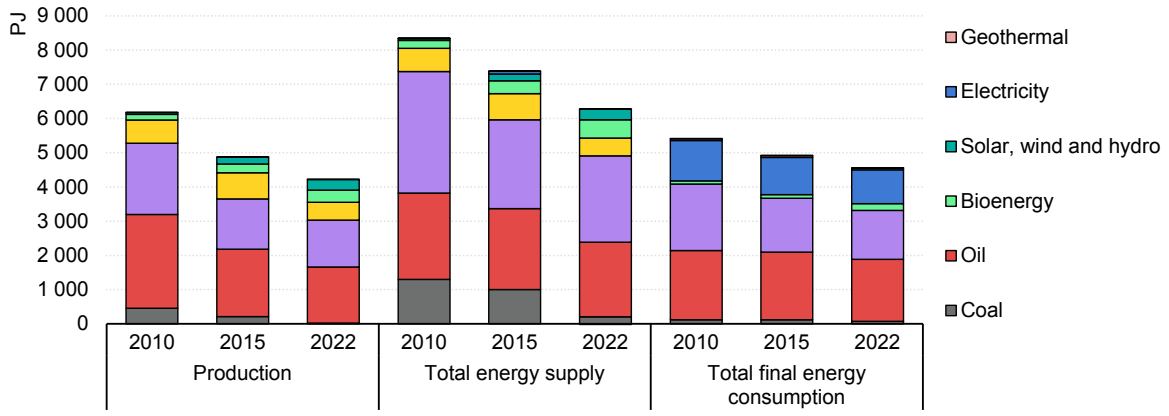
Despite the recent increase in renewable energy supply, the United Kingdom's TES still relies heavily on fossil fuels, which accounted for 77% in 2022, down from 87% in 2010. Most energy is used directly (such as oil in transport and gas for heating), but some energy sources in TES are used for transformation processes such as electricity, heat generation and oil refining.

The electricity mix has changed significantly in recent years, with a sharp drop in coal generation and increased generation from wind, bioenergy and solar photovoltaics (PV). The district heating fuel mix has also experienced a shift away from coal, mainly due to a shift towards natural gas and bioenergy (Figure 1.2).

The buildings sector is responsible for the highest share of energy demand (41% in 2022), followed by transport (35%) and industry (24%) (Figure 1.3). Energy demand has recently increased for buildings but has been declining for industry and transport.

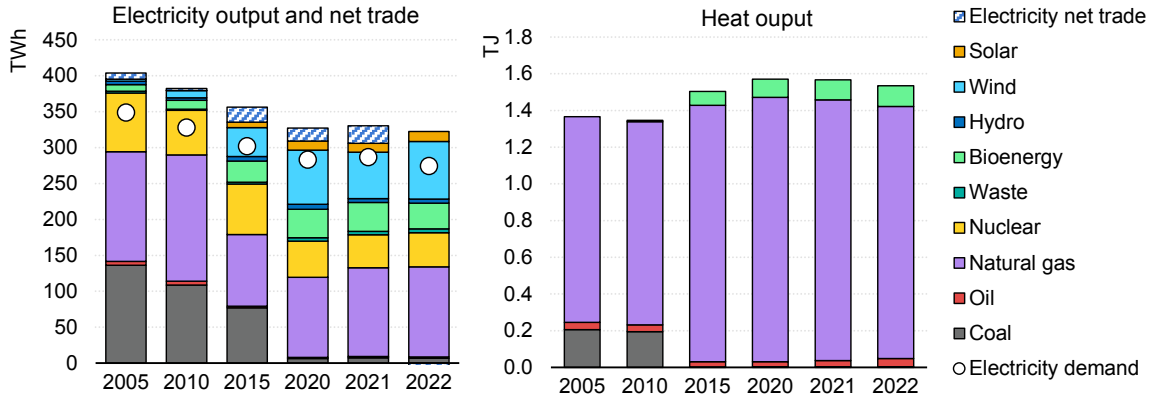
The United Kingdom's building sector relies on a diversified energy mix, mostly from gas, oil and electricity. The transport sector is dominated by oil (92% of energy demand in 2022, mostly diesel and gasoline in road transport). The United Kingdom's industrial sector has a diverse energy mix, with a notably high share of natural gas and electricity (Figure 1.3).

Figure 1.1 Energy production, total energy supply and total final energy consumption by fuel in the United Kingdom, 2010-2022



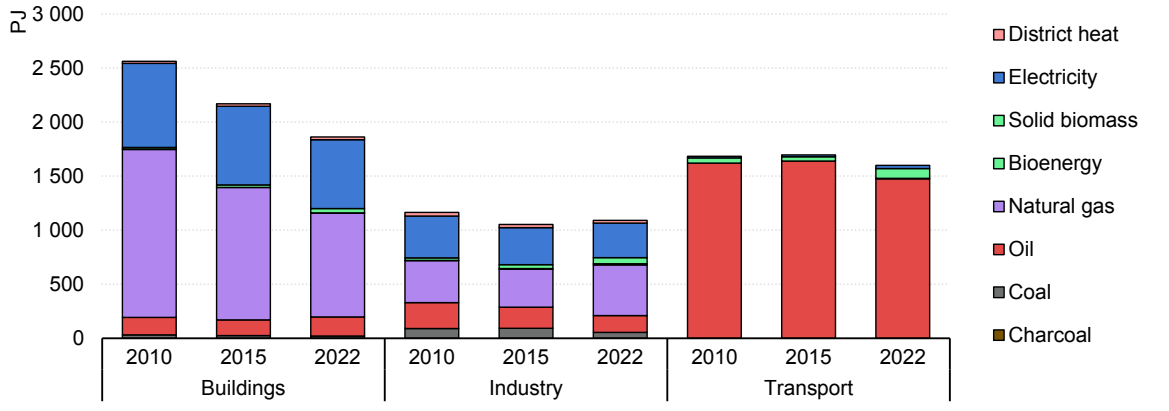
Source: IEA (2024), World Energy Balances (database).

Figure 1.2 Electricity and heat supply by fuel in the United Kingdom, 2005-2022



Source: IEA (2024), Electricity Information (database).

Figure 1.3 Energy demand by sector and fuel in the United Kingdom, 2010-2022



Source: IEA (2024), World Energy Balances (database).

Institutional overview

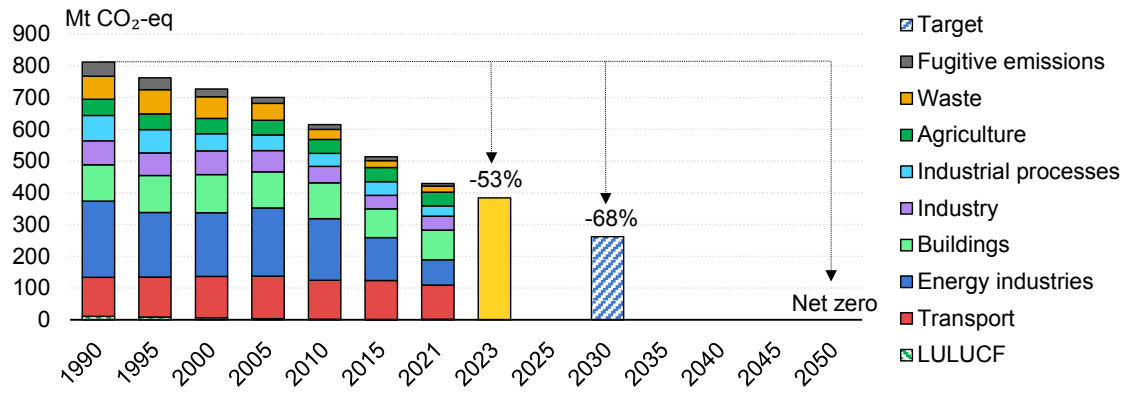
UK energy security and net zero policies cover areas where power is devolved to Scotland, Wales and Northern Ireland and areas where power is reserved (within the Northern Ireland settlement) and so remains with the UK government.

The Secretary of State for Energy Security and Net Zero is under a UK-wide duty to ensure that the United Kingdom achieves net zero emissions by 2050. Scotland, Wales and Northern Ireland have separately legislated for their own, similar targets.

Climate change targets

In June 2019, the UK government legislated a net zero emissions target, becoming the first major economy to set a legally binding target for net zero. In December 2020, it strengthened its Nationally Determined Contribution to the United Nations Framework Convention on Climate Change to reduce economy-wide GHG emissions by at least 68% by 2030, compared to 1990 levels. According to the latest data, in 2023, the United Kingdom reduced its emissions by 53% compared to 1990 levels (Figure 1.4).

Figure 1.4 Greenhouse gas emissions by sector in the United Kingdom, 1990-2023, and 2030 and 2050 targets



Notes: Mt CO_2-eq = million tonnes carbon dioxide equivalent; LULUCF = land use, land-use change and forestry. Data for 2022 are from UK national statistics.

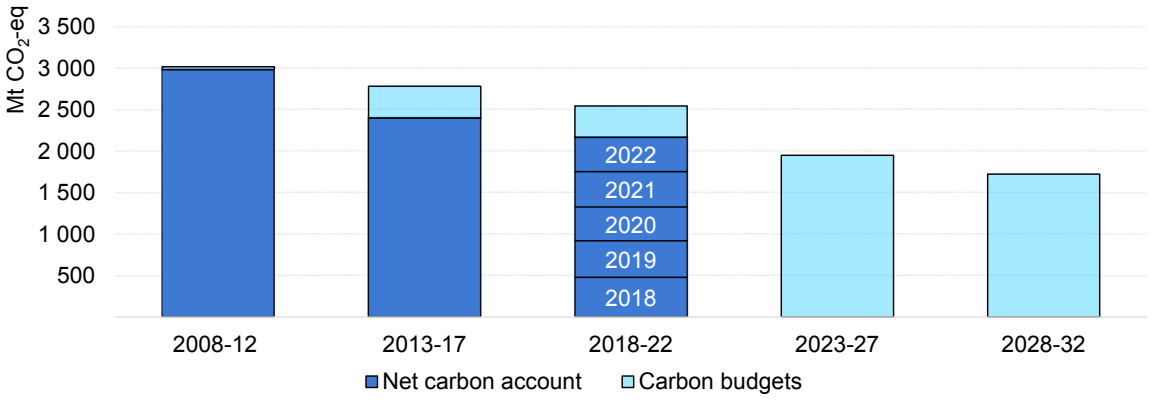
Sources: IEA analysis based on data from UNFCCC (2023), Greenhouse gas inventory data.

To keep the United Kingdom on a pathway to achieving the 2050 target, the government sets legally binding, 5-year caps on emissions – carbon budgets – 12 years in advance and publishes a report setting out proposals and policies for meeting the budgets. Six carbon budgets have been set to date, covering 2008-37.

The United Kingdom met its first three carbon budgets (2008-12, 2013-17 and 2018-22) (Figure 1.5). Most GHG emissions reductions came from a decline in coal use and an increase in renewables for electricity generation (under energy industries in Figure 1.4). The United Kingdom's Sixth Carbon Budget put into law a target to reduce GHG emissions to 965 Mt CO_2-eq between 2033 and 2037 – meaning emissions will be approximately 77% lower (including international aviation and shipping) in 2035 than in 1990.

The Climate Change Act 2008 established the Climate Change Committee as an independent, statutory body to advise the government on emissions targets and report to parliament on progress made in reducing GHG emissions as well as preparing for and adapting to the impacts of climate change.

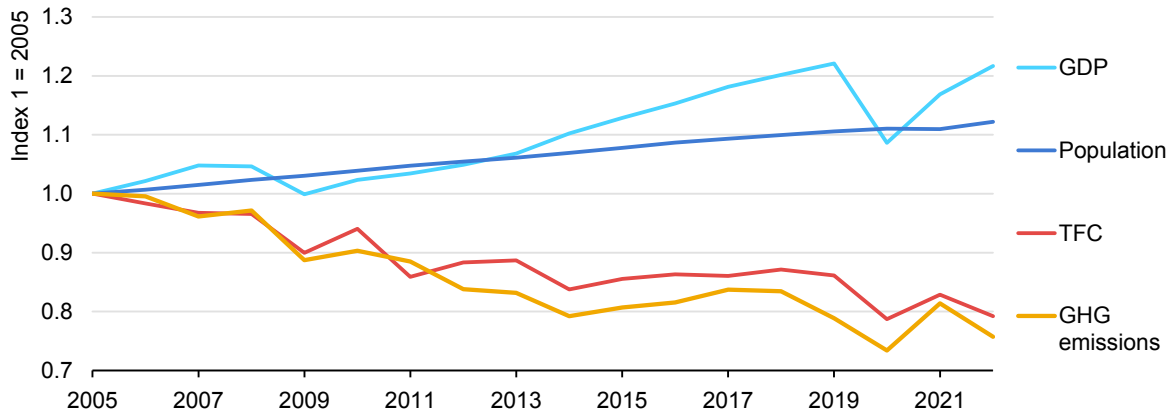
Figure 1.5 Carbon budgets and net carbon accounts



Sources: IEA analysis based on data from UK Government (2023) Carbon Budgets; Office for National Statistics (2024), UK Environmental Accounts: 2023.

The United Kingdom's gross domestic product (GDP) has been growing since 2005, with only a slight decline in 2009 due to the financial crisis and in 2020 from the impacts of Covid-19 (Figure 1.6). Population has been gradually increasing, from 65 million in 2015 to 68 million in 2022. Despite overall economic and population growth, emissions have been steadily falling.

Figure 1.6 Trends of GDP, population, total final consumption and greenhouse gas emissions, 2005-2022



Source: IEA (2024), World Energy Balances (database).

Energy transitions policy overview

Since the IEA's last in-depth review, the UK government has set out the wider context of its strategic priorities for the energy sector in several papers, including the Energy White Paper (2020), the Ten Point Plan for a Green Industrial Revolution (2020), the Net Zero Strategy (2021), the British Energy Security Strategy (2022), the Energy Security Plan (2023) and Powering Up Britain: The Net Zero Growth Plan (2023). These publications detail government aims of:

- reaching net zero targets
- driving economic growth
- reducing dependence on imported fossil fuels for heating and power
- enhancing energy security
- promoting infrastructure investment
- creating green jobs
- levelling up the country
- protecting and improving the environment
- ensuring bills are affordable.

The government has a long list of targets and policies to support energy-related climate change policies. It also constantly reviews targets, with the last update provided in March 2023 under the Carbon Budget Delivery Plan. The Delivery Plan is a dynamic long-term plan for a transition that will take place over the next 16 years, setting the country on course to reach net zero by 2050. This set out a package of quantified and unquantified proposals and policies, and associated timescales and delivery risks, that enable Carbon Budget 4 (2023-27) through Carbon 6 (2033-2037) to be met.

The Plan's key policies include:

- Fully decarbonising the electricity system by 2035, subject to security of supply.
- An offshore wind ambition of up to 50 GW by 2030 – including up to 5 GW of innovative floating offshore wind.
- Looking to increase the United Kingdom's current 15 GW of solar capacity to 70 GW by 2035; consulting on simplifying planning for rooftop solar in commercial settings; and ensuring efficient, timely network connections to enable deployment.
- Deploying up to 24 GW of nuclear power by 2050 to support renewable sources.
- Delivering up to 10 GW of low-carbon hydrogen production capacity by 2030. At least half of this will come from electrolytic hydrogen, drawing on the scale-up of offshore wind and other renewables and new nuclear.
- Launching Track-2 of the CCUS Cluster Sequencing Process on a pathway to storing at least an additional 10 million tonnes per annum of CO_2 by 2030.

Energy Act 2023

In October 2023, the UK government passed the Energy Act 2023, a sweeping new piece of legislation that is designed to accelerate energy transition efforts and ensure energy affordability and security. Among other measures, the law updates the energy regulator, Ofgem's, mandate to consider net zero targets as part of its operations and decisions. It also includes a new licensing framework for CO_2 transport and storage and a hydrogen grid conversion trial, and introduces a new tendering process for onshore electricity networks. Additionally, the law includes actions to incentivise the uptake of heat pumps, increase the rollout of smart meters and boost demand for smart appliances.

A notable development in the Energy Act 2023 is the establishment of a Future System Operator (FSO), which will assume all responsibilities of the electricity system operator, along with long-term planning, forecasting and market strategy functions of the natural gas system operator. In the future, the FSO will oversee strategic planning for the hydrogen system as well. The goal of the FSO is to take a holistic system approach to planning, markets, energy security and resilience to ensure that the regulatory model for the energy sector is fit for purpose in an increasingly transforming landscape. The first whole system Central Strategic Network Plan is due in 2026. The FSO will also hold advisory responsibilities to offer recommendations and analysis to the regulator and the government. Over time, its oversight could extend to areas such as heating and CCUS. The government is in the process of establishing the National Energy System Operator toward this end.

Investment and financing

Since 2010, the United Kingdom has made nearly GBP 200 billion of public and private investment in low-carbon energy sectors. The Net Zero Strategy estimates that through the late 2020s and 2030s, an additional GBP 50-60 billion in capital investments will be needed annually to meet net zero and energy security targets.

The United Kingdom has recently made significant steps to support investment through public funding. It committed GBP 30 billion of domestic investment for the green industrial revolution in Spending Review 2021, as well as GBP 6 billion for energy efficiency at the Autumn Statement 2022 and up to GBP 20 billion for CCUS announced in the Spring Budget 2023. According to the BloombergNEF Energy Transition Investment Trends 2024 report, total public and private investment in UK low-carbon sectors reached GBP 60 billion in 2023, up 84% from 2022.

The 2023 Green Finance Strategy sets out actions to mobilise private investment toward energy security and net zero ambitions. Annual investment in low-carbon sectors has been more than doubling in real terms over the past five years. Through 2021 and 2022, over GBP 50 billion of new investments were delivered in low-carbon sectors in the United Kingdom.

The public financing landscape in the United Kingdom is underpinned by key institutions, such as the UK Infrastructure Bank, the British Business Bank, UK Research and Innovation, and UK Export Finance. The government also supports local authorities to attract private investment through the work of local net zero hubs and the UK Infrastructure Bank, as well as the promotion of programmes such as the Local Investment in Natural Capital programme and investment zones.

Throughout 2023, the government developed and published a series of net zero investment roadmaps that articulate investment needs by sector and summarise relevant government policy and opportunities to support investment decisions. So far, the government has published a roadmap on offshore wind, nuclear power and heat pumps, and updated roadmaps on CCUS and hydrogen.

The government also established the Net Zero Council, a new partnership to work with key leaders across business and finance to support the net zero target.

Energy and environmental taxation

The Climate Change Levy was introduced in 2001 and taxes the supply of non-domestic energy in the United Kingdom with the aim of reducing emissions through energy efficiency and encouraging the switch to cleaner fuels. Climate Change Levy rates on gas and other taxable commodities have been rising since

2019/20, while rates on liquefied petroleum gas (LPG) have been frozen since 2019/20, and rates for electricity were reduced in 2019/20 and 2020/21 and have been frozen since.

Carbon price support is a tax on fossil fuels used for electricity generation in Great Britain (GB)[1], with rates based on the carbon content of the fuels (gas, oil, LPG and solid fuels). It was introduced in 2013 to top up a low EU Emissions Trading System carbon price and has contributed to coal-based generation falling from more than a fifth in 2015 to just 2.2% in 2022. It has been frozen at the equivalent of GBP 18 per tonne of carbon dioxide (t CO_2) since 2016.

Fuel duties are levied on purchases of petrol, diesel and a variety of other hydrocarbon fuels. A value-added tax (VAT) applies to the price of fuel inclusive of any fuel duty that applies. Over the 2011-22 period, petrol and diesel attracted a duty rate of 57.95 pence per litre (ppl). The rate was temporarily cut to 52.95 ppl for 12 months in March 2022. This cut was subsequently extended for another 12 months in March 2023 and is due to expire in March 2024. Biofuels attract the same rate of fuel duty as their fossil fuel equivalents.

Carbon pricing

The United Kingdom currently applies a carbon price to approximately 25% of its territorial emissions via the UK Emissions Trading Scheme (UK ETS), a cap-and-trade scheme covering the power, heavy industry and aviation sectors. Energy producers using fossil fuels also pay the carbon price support of GBP 18/t CO_2-eq. From January 2024, the trajectory for the emissions cap by sectors within the UK ETS will be aligned with the overall trajectory to reach net zero by 2050. The UK ETS carbon price is determined by the market. It averaged GBP 74 for the power sector and GBP 56 for energy-intensive industry in 2023.

The UK ETS allocates a proportion of allowances for free to some participants to reduce their exposure to the carbon price so as to mitigate the risk of carbon leakage. Free allowances are issued using a formula based on historic emissions, carbon leakage risk and carbon efficiency compared to a benchmark. The government is in the process of reviewing the free allocation framework and has also announced it would implement a Carbon Border Adjustment Mechanism in 2027 to reduce the risk of carbon leakage.

In its 2023 government response, the UK ETS Authority decided to reduce the annual emissions cap to approximately 49.3 Mt CO_2-eq in 2030 and reduce the overall Phase 1 cap to 936 Mt CO_2-eq. This is a roughly 30% reduction in the total cap over the first phase.

[1] Great Britain refers to the geographic area that includes England, Scotland and Wales.

Energy price support

Due to high retail energy prices brought on by the global energy crisis, the UK government supplemented existing regulatory arrangements for retail price caps (which limit the amount that suppliers can charge for electricity and gas) with direct financial support for households. The Energy Bill Support Scheme gave every household a GBP 400 discount on their energy bills for the winter 2022-23, which ended in March 2023. The department will continue to support households with their bills through the relaunched "It All Adds Up" campaign, which offers advice on simple low- or no-cost actions that households can take to reduce their energy use and lower energy bills.

Energy security

The United Kingdom stopped importing Russian gas in April 2022.

Spells of cold weather in the winter of 2022-23 demonstrated the resilience of the United Kingdom's energy supply. The gas system was well-supplied at all times and the market responded effectively to increased demand when necessary. Electricity supply margins were generally robust throughout winter, with high wind generation allowing the United Kingdom to regularly export excess power to Europe. Reciprocal imports were available to support GB peak supply on days with lower winds.

The National Grid Electricity System Operator was able to successfully balance the system throughout winter using available operational tools, including the Demand Flexibility Service, which provided incentives for households and business customers to reduce electricity usage in peak periods. Similarly, National Gas Transmission implemented a series of reforms to its Demand Side Response Scheme in the winter, designed to incentivise industry, shippers and consumers to participate in the scheme.

Electricity and gas margins in the winter of 2023-24 have also been sufficient.

Energy sector employment

The energy transition is expected to lead to a major opportunity for UK jobs, notably in clean energy sectors and their supply chains. At the same time, the fossil fuel sector may face some disruptions. The government's Ten Point Plan for a Green Industrial Revolution estimated that it would support up to 250 000 green jobs by 2030, while the government set an ambition to create 2 million green jobs by 2030. The government-commissioned, independent Green Jobs Taskforce was set up to bring together industry, unions, academia and the skills sector to offer advice to the government on how to realise its ambition.

Critical minerals

The United Kingdom published its first ever Critical Minerals Strategy in July 2022, which aims to improve the security of supply of critical minerals. Since the strategy's publication, the government has been engaging with industry and international partners to deliver on the stated ambitions. In light of a rapidly changing global landscape, reflected by the government's Integrated Review Refresh 2023, the Critical Minerals Refresh (March 2023) reinforces the strategy and sets out a renewed approach to delivering resilient critical mineral supply chains for 2023 and onwards.

Under the January 2022 UK Criticality Assessment of Technology Critical Minerals and Metals, 26 candidate materials were assessed for their potential criticality to the UK economy in terms of their global supply risk and the UK economic vulnerability to such a disruption. Eighteen of the these have a "high" potential criticality rating based on these criteria and constitute the UK Critical Minerals List 2021.

Analysis of UK sectoral exposure to critical minerals supply chains is a rapidly developing part of the government's approach to critical minerals more broadly. Beyond *ad hoc* analyses on the impact of supply disruptions of critical minerals, the United Kingdom has several programmes of work to improve the transparency of UK supply chains and the role of critical minerals in the UK energy system.

Assessment

The United Kingdom was the first G7/G20 economy to legally establish a net zero target, positioning the country as a global leader on climate change mitigation and setting the stage for other countries to follow suit. Moreover, the United Kingdom was also an early mover in setting legally binding carbon budgets and establishing carbon pricing. It was also one of the first countries to create an independent and statutory body, the Climate Change Committee, with authority to track the government's progress in line with UK climate targets and advise the government on carbon budget levels as well as emissions reduction and adaptation strategies. All these actions represent best practices for institutional arrangements to address climate change, and the IEA commends the United Kingdom for its leadership and foresight on climate change.

To underpin its net zero target, the United Kingdom has issued a number of policy planning and strategy documents that include sectoral roadmaps. Such long-term planning is helpful to provide investment signals and determine the expectations of various parts of the energy system. The volume of policy and strategy documents is extensive and the frequency of their issuance high, which can create some uncertainty for the energy sector and investors regarding the current state of play. Streamlining and clarifying the active set of policy documents would help

toward this end. Moreover, the shift from strategy setting to implementation will need to happen quickly, as investments toward 2030 and 2050 targets are needed right away.

On the pathway to net zero, the United Kingdom sets out carbon budgets for 5-year increments 12 years in advance. So far, the government has laid out six carbon budgets. The process of establishing five-year budgets many years in advance is a good one that offers long-term predictability to companies and stakeholders on the expected emissions trajectory; the five-year intervals offer appropriate clarity on signposts, and the regular updates to budgets allow sufficient scope for course correction.

To date, the United Kingdom has made steady progress in lowering GHG emissions, successfully meeting its first three carbon budgets. GHG emissions in 2023 were 53% lower than in 1990, the baseline year for the country's climate targets – the first major economy to halve emissions. Under its updated Nationally Determined Contribution, the United Kingdom has committed to lowering emissions by 68% from 1990 levels by 2030, so it will need to not only maintain but accelerate action to reach the target. Continuing to meet these carbon budgets will become harder, as the abatement challenge increases, requiring more policy action to support investment across more sectors.

The electricity sector, which previously accounted for more than a third of the country's energy-related GHG emissions, now accounts for less than one-fifth, with large emissions reductions mainly driven by the closure of a large portion of the country's coal-fired generation capacity. In its place, the country has seen strong growth in renewable generation, led by wind. In the coming years, the United Kingdom will need to ensure the continued buildout of low-emissions generation to displace remaining coal and unabated gas, replace nuclear closures and keep up with load growth driven by electrification. Growth in wind (offshore and onshore), solar PV and nuclear (large-scale and small modular reactors) will all be required, and government support mechanisms should be sustained to ensure this outcome. Moreover, the energy transition will necessitate a massive buildout of grid infrastructure. Demand-side electrification and distributed resources also represent an untapped opportunity and challenge to optimise the electricity grid and reduce emissions.

In other sectors, more work is needed to accelerate emissions reductions in line with climate targets. The transport sector accounts for over one-third of energy-related GHG emissions and remains heavily dependent on oil as a fuel source (92% of the sector's total final energy consumption). The government has implemented strong policies across ZEVs to facilitate decarbonisation of the light vehicle fleet (see Chapter 4). However, it could also employ a variety of other tools at its disposal – including fuel efficiency targets, biofuels mandates, and the

promotion of public transit and active transport – to encourage more rapid decarbonisation of road transport. Moreover, the government should also promote technology development and deployment for low-emissions options to decarbonise heavy transport, including heavy-duty road transport, aviation and shipping, all of which are sizeable sectors in the United Kingdom. Strategies in place are comprehensive and should be implemented and sustained, including appropriate and sustained levels of financial support.

Buildings is another sector in which the United Kingdom should increase decarbonisation results. The sector accounts for 41% of the country's energy consumption and 24% of energy emissions. The United Kingdom already has a number of policies in place to support emissions reductions in the buildings sector (see Chapter 3). The IEA encourages a sustained focus on energy efficiency upgrades of the existing building stock (with a focus on low-income households) and a rapid turnover of fossil fuel heating systems toward electricity as priority areas that can show fast results and where upfront costs can be recovered in terms of energy and emissions savings.

The industry sector is also one with relatively high levels of energy intensity and emissions (see Chapter 5). Here, too, government efforts should be oriented toward the near-term goal of optimising energy efficiency gains combined with sustained efforts to enable investment in deep decarbonisation. Industry would benefit from clarity on future decarbonisation options across hydrogen, CCUS and electrification.

More broadly, the United Kingdom should also avoid an outsized focus on long-term technology development at the expense of near-term emissions reduction gains from actions such as energy efficiency improvements in buildings.

Under the comprehensive Energy Act 2023, the United Kingdom has committed to establish an FSO that will bring together system planning across the electricity, gas and hydrogen sectors and CCUS toward a more holistic approach. The FSO is a significant shift in governance structures that recognises the growing interconnectivity across energy sectors and the need for the government to work with an independent body to drive the transition. The IEA further urges the United Kingdom to ensure sufficient regulatory powers and institutional capacity across all relevant sectors under the new FSO. The FSO will provide spatial planning in 2026; however, the industry is seeking clarity now. Where possible, the United Kingdom should expedite spatial planning outcomes to mobilise investments. The FSO will also offer an important example for other countries looking into new, fit-for-purpose regulatory models.

The United Kingdom is also an historically important oil and gas producer, which has underpinned domestic energy security and supported strong economic activity and quality jobs. As the United Kingdom and the rest of the world look toward a

net zero future, the government should regularly and systematically evaluate whether future bid rounds for oil and gas align with net zero goals.

The United Kingdom has taken several steps to reflect climate change incentives in its taxation system. The Climate Change Levy and the Carbon Price Support have been in place for many years, along with the application of an ETS (previously the EU ETS, since 2021 the UK ETS) on energy sectors. The actions are welcome and should be sustained and expanded. In particular, the UK government should not only continue to monitor the levels of carbon and climate taxation and steadily increase rates to reflect the need for higher levels of emissions reductions needed to meet climate targets, but also aim to align allowance prices with those in the EU ETS. The government should also continually assess the level of free allowances allocated to industry to determine whether they can be wound down faster, and consider directing ETS revenues toward industrial decarbonisation options. Moreover, the government should also evaluate opportunities to introduce a carbon or environmental lens into its fuel duties to drive more behavioural change toward cleaner transport options.

Relatedly, the energy transition is necessary and will cost. The United Kingdom should consider how to fund this transition, noting tensions and potential unintended consequences. For example, providing short-term bill relief across gas and electricity could signal against fuel switching by households and industry. Similarly, applying the aforementioned levies to electricity to fund decarbonisation activities could deter electrification incentives in other sectors, notably industry and buildings.

Across energy sectors, low-carbon energy infrastructure will take time to build. The United Kingdom should focus its efforts on providing strategic direction and prioritisation, including technology choice and locational signals. Industry needs clarity on infrastructure buildout to facilitate immediate investment by the private sector.

Likewise, the development of a green taxonomy would further clarify the technological options that can be applied to meet targets and support green financing solutions. The government is currently consulting on a UK Green Taxonomy, which will help toward this end.

On energy security, the United Kingdom has long-established and well-functioning frameworks in place across the energy system. The recent energy crisis resulting from the Russian Federation’s (hereafter “Russia”) invasion of Ukraine demonstrated the resilience of UK energy supplies. The United Kingdom is notably well-connected with energy systems in continental Europe, offering supply diversity and optionality, bolstering energy security across Europe. Looking ahead, as the energy system undergoes profound transformation, the United Kingdom should continue to monitor the adequacy and resilience of its energy

infrastructure, particularly for natural gas and electricity but also for CCUS and hydrogen, to ensure that supply tracks with changing demand. Likewise, the United Kingdom should adequately prepare for increased risks and vulnerabilities facing its energy infrastructure due to a changing climate. Moreover, as the energy system becomes increasingly digitalised, the UK government should likewise ensure cyber protections across all energy infrastructure; government efforts to date in this area have been strong.

Moreover, transitioning to a clean energy system will require exponential growth in the deployment of clean energy technologies, and rapid deployment of these will depend on the availability of critical minerals. The United Kingdom should continue to support global efforts to diversify supply sources, tapping into domestic opportunities where available and economically feasible. Moreover, the government should also continue to scale up the recycling of crucial raw materials for low-carbon technologies and ensure these are extracted in responsible ways. It is, therefore, important to clarify the United Kingdom's own needs and the part it can play in developing resilient supply chains globally. The UK Critical Minerals Strategy is a big step forward, as the government has deployed funding to support the development of UK domestic supply chains, forge new partnerships with key countries, and bolster research and development (R&D) and development assistance. The 2023 Maximising Resources, Minimising Waste programme is another step forward to address waste management and recycling.

Similarly, the energy transition will necessitate major growth in skills and the workforce to underpin the vast buildout and maintenance of infrastructure. This represents an enormous job creation opportunity for the United Kingdom, but the government should ensure that skills shortages do not become an impediment to energy transition investments. There is already some evidence of shortages, such as in the energy efficiency and heating sectors. Therefore, all energy transition policies should be accompanied by holistic planning to addresses the full supply chain and skills requirements, including long-term commitments to training. Ensuring sufficient skills and capacity likewise also applies to government institutions, regulators and system operators.

Key recommendations

The government of the United Kingdom should:

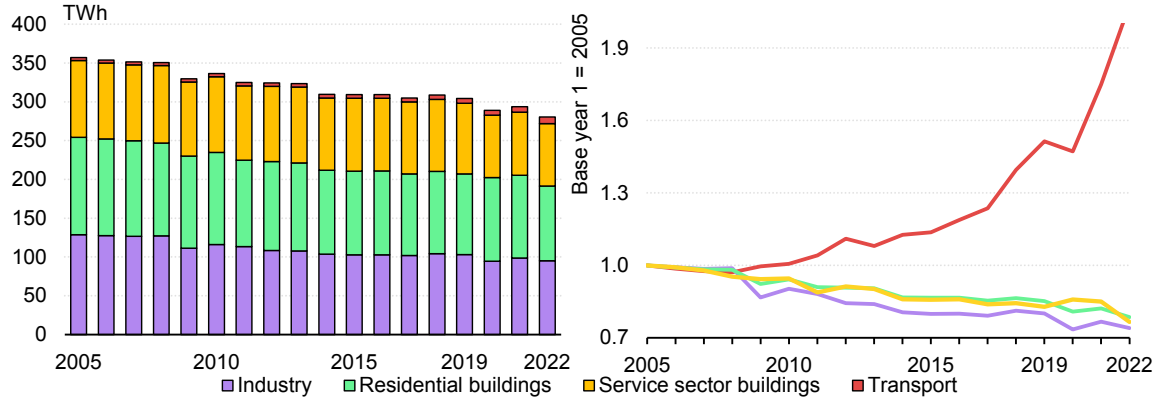
- Consolidate policy, strategy and development plans across sectors to provide simple, clear investment signals to industry. Accelerate actions needed to implement strategies, including clarity on technology pathways.
- Prioritise planning reforms to kickstart the major infrastructure buildout required to meet carbon budgets, including clarifying locations, business models and transition strategies across sectors.

- Monitor the cost of the transition and its funding base, ensuring that existing and future policies do not lead to unintended outcomes across competing decarbonisation priorities. Continuously assess impacts on vulnerable consumers.
- Ensure that policy and regulatory frameworks are consistent and provide the necessary signals to support investments in supply chains and skills at the scale needed for the energy transition.
- Pursue a balanced approach in establishing the Future System Operator to facilitate the timely delivery of net zero emissions. Expedite the delivery of spatial planning due in 2026.

2. Electricity

The United Kingdom's electricity sector is undergoing major changes, with falling demand, a sizeable reduction in coal power generation and rapid deployment of renewable energy sources. From 2005, UK electricity demand has gradually declined from a peak of 357 TWh in 2005 to a record low of 279 TWh in 2022 (Figure 2.1). However, the share of each sector in total electricity demand has remained roughly constant. In 2022, the industry sector accounted for one-third of electricity demand while the buildings sector was responsible for 63% (34% in residential buildings and 29% in service sector buildings). Electricity demand from transport is low but has significantly increased since 2005.

Figure 2.1 Electricity demand by sector and sectoral trends in the United Kingdom, 2005-2022



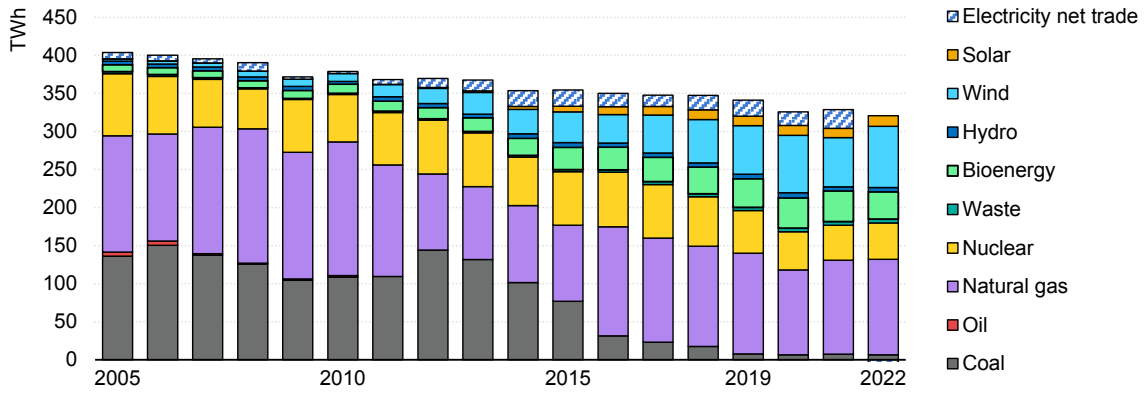
Source: IEA (2024), Electricity Information (database).

Historically, coal power was the main source of electricity generation, accounting for 40% in 2012. Since then, coal-fired generation has plunged, falling to 2.2% in 2022 (Figure 2.2). Since the last IEA review, most UK coal-fired power plants have closed in line with plans to phase out coal-fired generation by October 2024. This led to a significant overall decline of GHG emissions from electricity and heat production from 205 Mt CO_2-eq in 2005 to 69 Mt CO_2-eq in 2022. The main mechanism to meet the coal closure requirement is a new emissions intensity limit in the capacity market, previously due to take effect from 1 October 2025, brought forward by a year.

In addition, nuclear's share in electricity generation has also been declining. Nuclear generation represented 14.8% of total generation in 2022, lower than its peak of 21.5% in 2016, with three nuclear plants closing as they came to the end

of their operational life. However, the UK government has committed to ensuring that nuclear continues to play an important role in the energy mix and is taking steps to revitalise the UK nuclear industry.

Figure 2.2 Electricity generation by source and net trade in the United Kingdom, 2005-2022



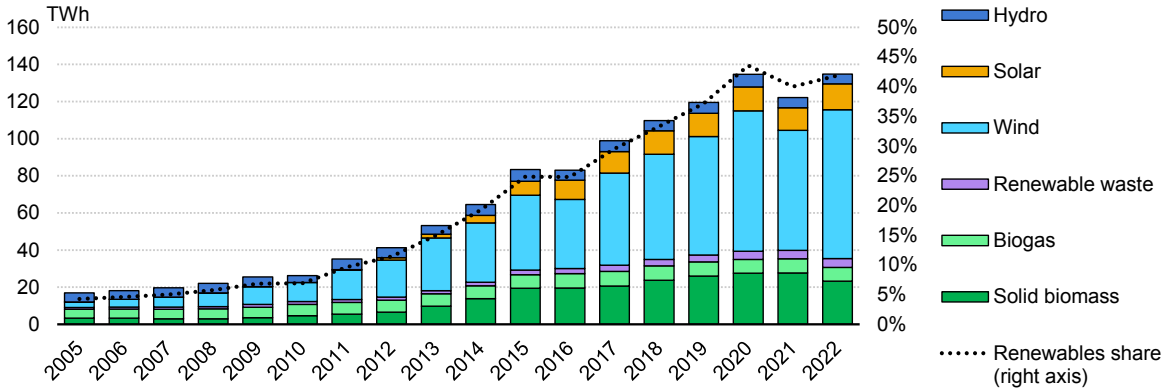
Source: IEA (2024), Electricity Information (database).

Renewables

The reduction of electricity generation from coal and nuclear has been compensated by increased electricity generation from natural gas and large-scale deployment of renewables. Renewables rose to 42% of the mix in 2022, with renewable generation growing more than threefold since 2012 (Figure 2.3). Wind energy has been the largest contributor and currently accounts for 25% of UK electricity generation. The other renewable sources of electricity are bioenergy at 11%, solar at 4% and hydro at 2%.

Installed renewable capacity has increased by 33% with respect to 2017 (Table 2.1), driven by the Contracts for Difference (CfD) scheme. Capacity connected to the distribution network increased significantly from 2017 to 2022, with the distribution network's share rising from 29.9% to 34.4%.

Figure 2.3 Electricity generation from renewables and their share in electricity generation in the United Kingdom, 2005-2022



Source: IEA (2024), Electricity Information (database).

Table 2.1 Cumulative installed capacity of electricity generation by source in the United Kingdom

Primary fuel (GW)	2017	2022	Difference
Coal	14.1	4.8	-9.3
Oil	1.4	1.4	-0.1
Gas	36.0	35.9	-0.1
Nuclear	8.9	5.9	-3.0
Hydro	1.8	1.8	0.0
Onshore wind	12.6	14.8	+2.2
Offshore wind	7.0	13.9	+6.9
Solar	12.8	14.7	+1.9
Wave and tidal stream	0.0	0.0	0.0
Bioenergy	5.4	7.5	+2.0
Other fuels	0.8	1.0	0.1
Total renewables	40.3	53.5	13.2
Total installed capacity	**100.9**	**101.7**	**+0.74**

Source: IEA analysis based on UK Government (2024), Energy Trends: UK renewables.

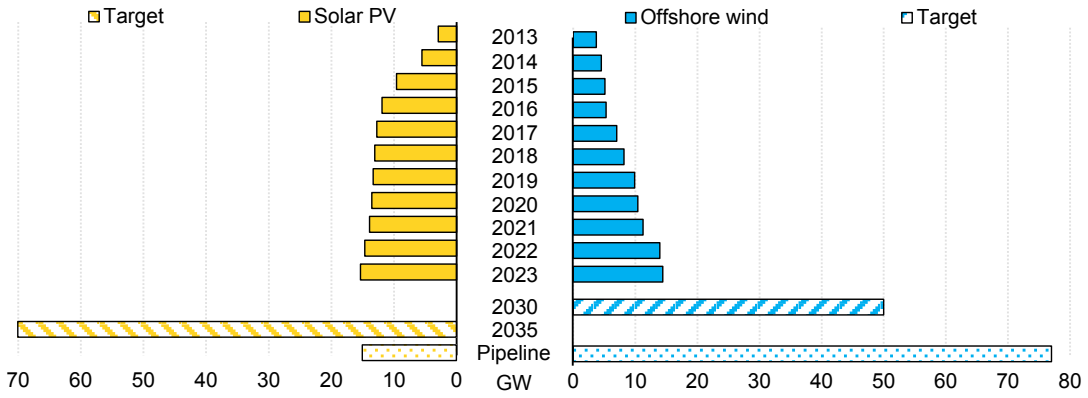
In 2023, the United Kingdom surpassed 15 GW of installed onshore wind capacity, the most of any renewable technology. Onshore wind is one of the cheapest forms of electricity generation in the United Kingdom, with costs falling by around 50% since 2013.

The United Kingdom is a world leader in offshore wind, with over 14 GW of capacity installed – the largest in Europe. It also has around 77 GW of offshore projects in the pipeline now, of which 25 GW are floating offshore wind.

The British Energy Security Strategy and Powering Up Britain documents included ambitions to deploy 50 GW of offshore wind capacity by 2030 (more than 3 times today's capacity), including up to 5 GW of floating offshore capacity, and 70 GW of solar capacity by 2035 (more than quadruple today's levels).

Solar PV accounted for 27% of installed UK renewable capacity in 2022 at over 15 GW, along with a pipeline of over 15 GW. To support growth, in May 2023, the government set up a joint government-industry taskforce, covering both ground-mounted and rooftop solar, to bring together key players to drive forward the actions needed to realise the 70 GW ambition.

Figure 2.4 Solar and offshore wind installed capacity, targets and projects in the pipeline in the United Kingdom, 2013-2035



Note: 2023 refers to Q2 data; offshore wind includes both seabed and floating; onshore wind is excluded as it does not have a target.

Source: IEA analysis based on UK Government (2024), Energy Trends: UK renewables.

Biomass accounted for 14% of renewable generation capacity and 11% of UK electricity supply in 2022. In August 2023, the government published the Biomass Strategy, which sets out the government's view on the role that biomass can play in reaching net zero, and policy action to enable growth in the sector.

The CfD scheme is the government's main mechanism for supporting new low-carbon electricity generation projects. Contracts, which are offered through auctions, guarantee a set price per megawatt hour (MWh) of electricity for 15 years, indexed to inflation. CfD auctions have so far awarded contracts totalling over 30 GW of new low-carbon electricity capacity across all technologies, including around 20 GW of offshore wind. The fourth allocation round in 2022 awarded contracts to almost 11 GW of new capacity to be added to the grid from

2023 onwards. The fifth round in 2023 marked the first after a move to annual auctions. It has contracted a total of 3.7 GW of renewable electricity to date.

The government is working to remove barriers to renewable development and reduce the time it takes to get planning consent while continuing to maintain environmental protections. This includes progressing work to simplify planning arrangements, driving forward actions to deliver the skills needed to deploy wind and solar at scale, addressing any potential supply chain constraints, and ensuring that network infrastructure can support mass deployment.

To further accelerate the deployment of rooftop solar, the government recently consulted on changes to permitted development rights to simplify planning processes for commercial rooftop installations.

Nuclear

There are currently five nuclear power plants with a total of nine reactors operating across England and Scotland. Sizewell B is the only existing plant that is expected to continue generation past the end of the decade, with a capacity of 1.2 GW. The 2022 British Energy Security Strategy established the government's ambition for up to 24 GW of nuclear by 2050, around 25% of the projected electricity demand for 2050.

The Hinkley Point C (HPC) nuclear project is the first in the pipeline of new nuclear projects towards achieving the government's nuclear target. The first two reactors are expected to be operational in June 2027 and June 2028, respectively, with a total capacity of 3.2 GW (or generating around 7% of Great Britain's current demand). The government signed a CfD for HPC that fixes the cost of electricity produced by the power station. In January 2024, EDF announced a cost overrun at HPC, from GBP 25-26 billion to GBP 31-35 billion.

Sizewell C in Suffolk is the sister project to HPC and would also have a total capacity of 3.2 GW. The UK government became a co-shareholder in the project with EDF in November 2022, through an historic investment of GBP 700 million. The government has since become the majority shareholder in the project, having made a total investment of GBP 2.5 billion available to support the project's development to the point of final investment decision (FID).

In September 2023, the government and Sizewell C Company launched an equity-raising process for the project, backed by the Regulated Asset Base model for nuclear, established by the Nuclear Energy (Financing) Act 2022 as an option for all new nuclear projects, to increase private sector participation and lower project financing costs. The Sizewell C equity-raising process is ongoing; subject to the outcome of this process and wider approvals, the government is targeting FID for later in 2024.

Great British Nuclear (GBN) is a new arm's-length body responsible for helping to deliver new nuclear projects, backed with necessary funding. In 2023, GBN launched a Technology Selection Process for Small Modular Reactors (SMRs), with the aim of identifying those technologies best able to reach a project FID by the end of 2029 and deliver projects in the mid-2030s. In October 2023, six technology vendors were down-selected and announced. The ambition is to announce in 2024 which of the six companies the government will support.

In January 2024, the UK government published the Civil Nuclear Roadmap to 2050, which reconfirms the government's ambition to deploy up to 24 GW of nuclear power by 2050 and defines commitments towards achieving this in partnership with industry. The roadmap sets a rolling deployment goal of committing 3-7 GW every 5 years from 2030; commits to exploring another large-scale project following, and subject to, an FID on Sizewell C before the end of the current parliament; and sets out the need for all technologies (SMRs, advanced modular reactors and GW power stations).

Industry structure and network operations

The Department for Energy Security and Net Zero (DESNZ) sets the overall direction for electricity policy in the United Kingdom.

The Office of Gas and Electricity Markets (Ofgem) is the main regulator of gas and electricity networks in Great Britain. It regulates network companies and is responsible for decisions on price controls and enforcement. Ofgem is independent of the government and accountable to the UK Parliament.

Electricity network companies are privately owned entities, regulated by Ofgem, who build, own and operate the electricity networks across Great Britain. They are responsible for the day-to-day maintenance and operation of the physical electricity network, in co-ordination with system operators.

Transmission system

The United Kingdom has four transmission owners, with National Grid covering England and Wales, Scottish & Southern Electricity Networks and SP Energy Networks covering Scotland, and Northern Ireland Electricity Networks covering Northern Ireland.

The transmission network for Great Britain is currently planned by the Electricity Systems Operator (ESO), part of National Grid Group. The ESO has responsibility for identifying future capacity constraints on the system and making recommendations for network capacity construction where necessary. The delivery of the network is then undertaken by the incumbent transmission owners. The ESO's activities in network planning are regulated by Ofgem. The ESO is

responsible for the day-to-day balancing of the transmission network across Britain. It also publishes the Electricity Ten Year Statement that outlines the needs of the National Energy System Operator (NESO) over the next 10-20 years. The latest Electricity Ten Year Statement was published in 2023.

The Holistic Network Design, published in July 2022 by National Grid Electricity System Operator, provides a high level of detail on the scale of transmission infrastructure required to connect 23 GW of offshore wind. The Holistic Network Design outlines the need for offshore network investments of GBP 32 billion and an additional GBP 21.7 billion across 94 onshore projects. The Transitional Centralised Strategic Network Plan will identify additional infrastructure required to connect approximately 21 GW of offshore wind.

The UK government is establishing the NESO, using powers vested in the Energy Act 2023. NESO will take on responsibilities across electricity, gas and hydrogen. It will have an enhanced strategic and whole-system approach to operating and planning the energy sector, and advising the government to inform policy decisions, with objectives to drive progress towards net zero while maintaining energy security and minimising costs for consumers. Work is ongoing to prepare for the creation of NESO, which the government aims to be operational in 2024, dependent on a number of factors, including agreeing on timelines with key parties.

Interconnections

Historically, the United Kingdom has been a net electricity importer, with a peak of 9 260 gigawatt hours (GWh) imported in Q2 2023. The United Kingdom's total net imports peaked in Q3 2021 at 7 648 GWh. As of February 2024, it had nine operational interconnectors with a total installed capacity of 9.8 GW, connecting the United Kingdom to Belgium, Denmark, France, Ireland, the Netherlands and Norway. Interconnector development in Great Britain is developer-led and regulated by Ofgem. As with the transmission network, the ESO oversees system management, including capacity allocation and congestion management.

The United Kingdom became a net exporter of electricity for the first time in 2022, with net exports of 5 TWh, mainly due to outages at French nuclear plants. The United Kingdom reverted to being a net importer of electricity in Q1 2023.

Distribution system

In England and Wales, the 12 distribution licence areas are operated by 6 distribution network operators. The Scottish and Northern Irish transmission owners also operate the distribution networks in those regions.

Grid connections

Contractual arrangements for connecting to the higher voltage transmission network are managed by the ESO. These connections are typically for large solar farms, offshore wind farms and battery storage projects, as well as onshore wind, nuclear power stations, interconnectors, very large industrial demand and a comparatively small number of non-renewable projects. Meanwhile, distribution network operators are responsible for providing connections to the lower voltage distribution network. Applications range from large demand connections such as data centres to smaller scale generation projects such as solar farms and individual connection upgrades for domestic properties, such as for heat pumps and EV charging points.

In recent years, the volume of applications has surged, causing constraints on the network and increasing the size of the contracted queue (the pipeline of customers holding agreements for connection in the future), with new applicants routinely receiving transmission connection dates in the late 2030s. Moreover, many projects in the queue do not come to fruition, blocking more viable projects due to the current "first-come, first-served" approach to queue management. The ESO is leading reforms to remove stalled projects from the queue and introduce a "first-ready, first-connected" model, which will allow projects that are ready to connect to do so earlier. Similar reforms have been (or are being) introduced at the distribution level.

The government and Ofgem published the Connections Action Plan in November 2023, to reduce connection timescales. The Plan aims for transmission connection delays of no more than six months for net zero aligned projects, down from the current average of five years. It also aims to ensure that a significant majority of applicants receive their requested connection dates, up from 14% at present.

Once generation and demand projects are connected, they pay ongoing system charges to cover the costs incurred by the network companies in building and operating the networks. Ofgem approves the design of these network tariffs.

Grid planning reforms

The instrumental role for the electricity sector in meeting net zero targets means that grids will be critical to the transition. In Great Britain, the government estimates that around four times as much new transmission network will be needed by 2030 as was built since 1990. To support government efforts on facilitating a grid buildout, the government appointed the United Kingdom's Electricity Networks Commissioner, Nick Winser CBE, to make recommendations on how to cut the current 14-year timeline for transmission network delivery in half.

The government's response to the Electricity Network Commissioner's report was issued in November 2023, under the Transmission Acceleration Action Plan. The Plan is divided into eight action areas: 1) strategic spatial planning; 2) design standards; 3) regulatory approval; 4) planning approval; 5) supply chain and skills; 6) communities and engagement; 7) outage planning; and 8) end-to-end process. The holistic approach is meant to cover the entire infrastructure planning process, across all locations (including land and sea). In 2024, the government will commission the ESO, in advance of becoming NESO, to develop the first Strategic Spatial Energy Plan. The first iteration of the Strategic Spatial Energy Plan will cover associated infrastructure for power generation, including offshore generation in Great British waters, and hydrogen assets. NESO will also produce a Centralised Strategic Network Plan that will identify network needs and will be informed by the Strategic Spatial Energy Plan. In terms of regulatory approvals, the centralised network plans will inform Ofgem as it carries out a streamlined regulatory approval process, previously carried out by Ofgem on a case-by-case basis.

In terms of planning approvals, the government concurrently issued updated national policy statements for energy infrastructure in England and Wales that designate large electricity grid projects with "critical national priority" status. This will facilitate project approvals. The government also published a response to its consultation on community benefits for electricity network infrastructure. The proposed approach and next steps outlined include an electricity bill discount for properties closest to transmission infrastructure and a wider community benefit for the local community. The government will publish initial voluntary guidance on wider benefits in 2024.

Market operation

The current GB market design is based on bilateral contracting between generators and suppliers. The ESO acts as a "residual" balancer.

Wholesale market

Suppliers purchase electricity from generators at a wholesale price. In Great Britain, national pricing is applied so that at any given moment, there is a single price for wholesale electricity across the country.

The GB wholesale market is marked by relatively low levels of liquidity. Ofgem is planning to publish a new call for input on power market liquidity to obtain industry views on whether liquidity is sufficient and explore if any intervention is warranted.

In August 2023, Ofgem introduced new rules to prevent generators from artificially inflating energy prices and forcing up household bills. The changes are aimed at generators attempting to make excessive profits through the balancing mechanism.

The government's ongoing Review of Electricity Market Arrangements is considering options for reform to all non-retail electricity markets and policies to improve investment signals for generation or consumption assets. These include wholesale markets, the balancing mechanism and ancillary services, as well as related policies, such as the capacity market and CfDs.

Capacity market

The capacity market is meant to ensure the security of electricity supply by offering generation capacity incentives to participate in the system when needed. In particular, it ensures sufficient supply during periods of system stress such as cold winter days. It allows eligible generators to bid in competitive auctions for capacity. Successful bids receive payments to keep capacity in the system. There are two auctions per year, one to secure capacity four years out and one for year-ahead delivery.

All types of technologies can participate in the capacity market (including wind, solar, storage) as long as they do not receive other forms of support (e.g. CfDs). There has been around 21 GW of nameplate renewable capacity that participated in capacity market auctions to date. Renewable capacity is heavily "de-rated" in the capacity market to account for its lack of guaranteed availability when needed.

Retail market

The domestic retail electricity market has seen considerable consolidation since the summer of 2021 due to supplier exits. There have also been low levels of switching, with only 143 000 electricity switches by household consumers in June 2023, representing 0.5% of all households (down from 2.1% in March 2021). The period of low switching levels is primarily attributable to the lack of price competition below the level of the standard variable tariff (see below).

Customers in the retail market can opt for fixed tariffs or a standard variable tariff. Currently, most consumers choose the standard variable tariffs that are capped by Ofgem's default tariff cap, which sets a maximum price that suppliers can charge. High prices over the past two years have made it difficult for suppliers to offer attractive and competitive fixed tariffs.

Some suppliers offer more innovative products, such as time-of-use tariffs. Many of these products are focused on consumers who have EVs and are often bundled with smart chargers.

The increasing uptake of elective half-hourly settlement and implementation of market-wide half-hourly settlement, enabled by the rollout of smart meters, will see load profiling largely replaced by accurate consumption data. This will mean that

suppliers are incentivised to encourage their customers to change their consumption patterns and strengthen suppliers' incentives to offer new products, such as time-of-use tariffs.

Due to higher wholesale prices, direct fuel costs have increased in recent years, accounting for a larger share of consumer electricity bills. There are several non-energy costs included in a typical electricity bill, such as policy costs, administrative costs and costs to transport energy to customers, with the main non-energy cost for network charges. There is also an allowance to cover policy costs for environmental and social schemes, such as the Warm Home Discount, Renewable Obligations, CfDs, capacity markets, Energy Company Obligations, feed-in tariffs, smart meter costs and energy-intensive industry exemptions.

Electrification policies

Though electricity demand has been declining over the last decade, expected increased electrification in the heat and transport sectors, as well as in industrial uses, could drive an increase in electricity demand of up to 60% by 2035.

There are various targets to incentivise electrification in other energy sectors. The government has committed to all new cars and vans being zero emissions at the tailpipe by 2035 and to end the sale of all new non-zero emission road vehicles by 2040 (see Chapter 4). The government also aims for 600 000 heat pump installations annually by 2028 (see Chapter 3) and offers incentives to companies to promote fuel switching (including electrification) in industry (see Chapter 5).

The government recognises several barriers to fuel switching to electricity, notably that electricity is currently significantly more expensive than natural gas. To begin addressing these challenges, the government launched a call for evidence on fuel switching to electrification in July 2023.

Consumer subsidies and support schemes

In winter 2022, the government introduced measures to support households with high energy bills. This included the Energy Price Guarantee, which ensured that a typical household paid an average of GBP 2 500 a year on its energy bills over the winter.

The Energy Bills Discount Scheme provides all eligible businesses and other non-household energy users with a discount on high energy bills for 12 months from 1 April 2023 until 31 March 2024. It also provides businesses in sectors with particularly high levels of energy use and trade intensity with a higher level of support.

The Warm Home Discount provides GBP 150 off winter electricity bills for low-income households at risk of fuel poverty. The money is provided as a

one-off discount on the electricity bill. If more suitable, customers may be able to get the discount on their gas bills instead, if their supplier provides them with both gas and electricity. The scheme is funded by participating energy suppliers.

The Winter Fuel Payment is an annual, tax-free payment to over 11 million pensioners of GBP 250-600 in the winter.

Cold weather payments help toward the additional costs of heating a home during periods of unseasonably cold or severe weather. A payment of GBP 25 a week is automatically made when the average temperature reaches, or is forecast to reach, 0°C or below for seven consecutive days between 1 November and 31 March each year. The scheme is targeted at those most vulnerable to the cold, including older and disabled people.

For industry, the British Industry Supercharger will be implemented from April 2024 and will reduce industrial electricity prices for eligible energy-intensive industries.

System flexibility

As variable renewable energy is set to play a greater role in the electricity system over time, the need for system flexibility will likewise grow. The 2021 Smart Systems and Flexibility Plan estimated that by 2030 Great Britain will need about 30 GW of short-term storage, interconnection capacity and demand side response; triple the 2021 levels.

Recent market reforms to support system flexibility include work by the Open Networks project to standardise the approach to procuring flexibility across distribution networks and developing "primacy" rules to increase co-ordination between local and national markets.

The ESO is continuing to introduce reforms to balancing services to support system flexibility, including the rollout of new frequency response services, the pathfinder projects (which have already announced market solutions for stability and reactive power procurement) and developing additional reserve markets. Ofgem published a decision on the future of local energy institutions and governance in November 2023 – one of the intentions is to assign a market facilitation function to a single entity to deliver more joined-up flexibility markets. Finally, in October 2023, Ofgem took the decision to approve a code modification which will allow virtual lead parties (for example, aggregators) to access the wholesale market of Great Britain, opening up further revenue streams for providers of flexibility.

Alongside Powering Up Britain, the government published a response to the July 2022 consultation on Delivering a Smart and Secure Electricity System. It set out a multi-year programme to support competitive and well-functioning markets in energy smart appliances and demand side response services, which will facilitate

shifting electricity demand. The proposals include establishing a licensing regime for providers of demand side response for domestic and small business customers to ensure there are sufficient protections in place for both consumers and the electricity system. Regulations will also establish technical interoperability, grid stability, data privacy and cybersecurity requirements for energy smart appliances, like smart heat pumps and smart private EV charging points. The government plans to implement these policies over the mid- to late 2020s.

Electricity storage

Today, there is 6.4 GW of electricity storage operational in Great Britain, comprised of 2.8 GW of pumped hydro storage and 3.6 GW of newer, grid-scale battery storage. Total battery capacity is expected to increase to more than 12 GW by 2026.

Storage assets receive compensation through participation and stacking revenues across a range of electricity markets and services, including the wholesale market, the balancing mechanism, ancillary services, local flexibility markets and the capacity market.

The government has recently published a consultation on a proposed support arrangement intended to enable investment in long duration electricity storage assets such as additional pumped hydro storage. This will use a cap and floor mechanism, similar to what has been successfully used for electricity interconnector investments.

Demand side response

Over the past few years, the UK government has advanced and supported reforms across the suite of market mechanisms to remove barriers to the participation of demand side response. This includes lowering participation thresholds, moving markets closer to real time and opening access to the balancing mechanism.

In the autumn of 2022, the National Grid ESO launched its new Demand Flexibility Service as an additional tool to manage the electricity system over the winter. It gave the ESO the option to pay consumers – via their energy supplier or an approved third-party intermediary – to lower their demand in tight supply periods. The scheme incentivised 1.6 million households and businesses to lower their electricity demand when required, saving over 3 300 MWh of electricity during the 2022/23 winter period. Following approval by Ofgem, the ESO has reintroduced the scheme for winter 2023/24, giving more households and businesses the opportunity to take part.

Smart meters

Great Britain introduced a legally binding installation "Targets Framework" over 2022-25 which imposes fixed annual minimum installation targets on energy suppliers for electricity and gas smart meters. The "Targets Framework" builds on the previous smart metering policy framework, which was in place from 2013 to 2021 and required energy suppliers to take all reasonable steps to replace traditional meters with smart meters.

To support the deployment of smart meters, the UK government established the Smart Metering Implementation Programme to drive an industry-led rollout of electricity and gas meters to households and small enterprises. The Northern Ireland Executive is currently developing a plan for smart electricity meters in Northern Ireland. Smart meters remain voluntary, and consumers can refuse installation.

At the end of September 2023, there were almost 34 million smart and advanced meters in Great Britain homes and small businesses. In total, 59% of meters were smart.

An independent review of energy supplier evidence on the impacts of the smart metering rollout on household energy use published in June 2023 found that smart meters contribute to an approximate 3% reduction in energy consumption. Energy service companies and aggregators can access smart meter and smart grid data to tailor advice to consumers on energy savings.

Energy data and digitalisation

The 2021 Energy Digitalisation Strategy and the 2022 joint response to the Energy Digitalisation Taskforce set out the need for greater digitalisation of the energy system. Improved access to high-quality data and dynamic digital tools will be necessary to manage the growing complexity of the system, ensure informed network planning and maximise the benefits of decarbonisation.

The government, Ofgem and Innovate UK committed to improving asset visibility, examining the feasibility of a sector-wide data-sharing infrastructure (a "digital spine"), and exploring approaches to enable consumers to confidently share their personal energy data.

Electricity security

The National Emergency Plan outlines the roles and responsibilities for electricity emergency management. DESNZ is responsible for developing, reviewing, updating and testing the emergency procedures outlined in the plan, while implementation of most procedures and processes is the responsibility of the electricity industry.

For balancing issues, National Grid ESO has a wide range of tools at its disposal. Pre-emergency measures have historically been effective for balancing margins and avoiding customer impacts. Electricity margin notices are formal requests to the market to bring forward additional capacity. Should the situation escalate, the system operator has contracts in place with generators and large energy users to provide temporary extra power or reduce demand.

The capacity market plays an important role in ensuring security of electricity supply. It provides capacity providers with steady, monthly payments to ensure there is enough capacity to meet demand, and issues penalties if providers fail to deliver the agreed volume of energy when it is needed. The capacity market is based on an enduring reliability standard for the GB electricity market set in 2013, equivalent to a loss of load expectation of three hours per year, a level similar to a number of European countries.

In addition to processes such as the capacity market, the ESO also publishes a series of documents designed to provide information to industry participants on the upcoming summer/winter. The main Winter Outlook Report is published in early October each year with an early view published in June (alongside a review of the previous winter). The Summer Outlook Report is published in April. Furthermore, the Risk Preparedness Plan for Electricity Sector in Great Britain sets out a common framework to prevent, prepare and manage electricity crises.

DESNZ work to increase the cyber resilience of the energy sector primarily falls under Pillar 2 of the National Cyber Strategy 2022. In line with the Strategy, the government has set targets for Critical National Infrastructure cyber resilience, focused on private sector critical infrastructure.

Assessment

The United Kingdom has set an ambitious target to decarbonise its power sector by 2035, subject to security of supply. It has already made notable progress toward the target, including by shuttering most coal-fired generation and setting a target to phase out remaining capacity by October 2024. Unabated natural gas-fired generation is expected to remain in the system for longer, particularly to meet peak demand, while low-carbon flexible technologies are developing.

The United Kingdom recognises the key role of nuclear energy, which the IEA believes is a central pillar on the path to net zero. Not only will nuclear lower emissions and reduce reliance on imported fossil fuels, but it can also help support a clean power system dominated by wind and solar. However, given the age of the United Kingdom’s nuclear industry, only one existing plant is expected to be operational past the end of the decade. This means that achieving the goal of

sourcing up to a quarter of generation from nuclear by 2050 will require the buildout of new nuclear capacity, which has been beset by cost overruns and delays.

Still, the UK government's efforts to revitalise the sector are welcome developments in a context where many other advanced economies have allowed their nuclear industries to decline. In particular, the United Kingdom's Regulated Asset Base model offers an innovative financing mechanism with appropriate risk allocation for new nuclear projects (including Sizewell C) and can help mobilise more private investment in the sector. The UK government's efforts to support SMRs through the GBN body will also help unlock the technology and expand nuclear's role in the future energy mix, given lower capital costs and more manageable safety characteristics. To realise this potential, the government should continue to develop and implement clear financing frameworks for large-scale, third-generation reactors and SMRs that support public-private partnerships. It should also ensure GBN receives the necessary funding to deliver on short-, medium- and long-term nuclear deployment objectives.

At present, the timeline and the combination of technologies that will be called upon to meet the up to 24 GW nuclear target by 2050 are unclear. The government's recently issued roadmap will clarify the planned pathway. The government should ensure clear milestones for nuclear project deployment and delineate the roles and responsibilities of public and private stakeholders toward these milestones. It should also align nuclear plans with supply chain capabilities, workforce development and the availability of nuclear fuel supply, especially for advanced reactors such as SMRs. As part of this, the government should allocate sufficient resources to ensure its nuclear regulators (the Office of Nuclear Regulation and environmental agencies) are supported with sufficient funding to develop timely and appropriate licensing and permitting regimes for advanced reactors, such as SMRs, and support international collaboration between nuclear regulators.

The UK government should also continue working with all involved parties to clarify conditions for the transfer of long-term liabilities for the defueling and decommissioning of the existing nuclear fleet and to identify a suitable site for its geological disposal facility.

As in most IEA countries, an expansion of renewable energy is a central pillar to decarbonising the power sector. The United Kingdom has been an early leader in offshore wind deployment, whose capacity has almost quadrupled in the past decade from 3.7 GW to 14.4 GW. Looking ahead, the United Kingdom has ambitions to deploy up to 50 GW of wind capacity by 2030 and up to 70 GW of solar by 2035, more than tripling and quadrupling today's respective capacities, respectively.

The government should utilise renewable energies as broadly as possible in terms of geography and technology. A physical balance must be established between the regions across the country and associated interconnectors to guarantee security of supply.

The government's main tool for incentivising investments in renewable energy capacity has been the CfD scheme. CfDs, which help bridge the gap between market prices and the prices needed by project developers to recover costs, have proven effective for expanding UK renewable electricity capacity. The scheme has awarded contracts to around 30 GW of new renewable capacity across all technologies, including around 20 GW of offshore wind.

The absence of any contracted capacity for offshore wind in the most recent (fifth) CfD auction can be partly attributed to the strike price, which was not updated to reflect recent tight supply chains and inflation that the industry has been facing. The government should, therefore, ensure that future auctions thoroughly assess the competitiveness of the strike price relative to global market conditions to support robust capacity allocations that track with targets. Revisions to the terms for the sixth auction round are a welcome step in this regard.

Starting with the fifth auction, the CfD allocation rounds have been held annually. The IEA commends these annual allocation rounds, which will provide better predictability on the offshore auctions against 2030 targets. Furthermore, the government is considering the possibility of introducing valuing factors other than just price in the allocation of CfDs. These could address other deployment challenges for offshore wind and encourage a steady offshore wind rollout.

Beyond the CfD scheme, the government has significant work to do to streamline permitting processes, which is a significant inhibitor to project build. In addition, work is needed to bolster renewables sector skills and manufacturing capacity. Recent moves by National Grid to fast-track connections for up to 20 GW of renewables projects will also help expedite the expansion of renewable energy capacity, along with battery storage projects. Upcoming network plans should aim to provide tangible actions to further assist with fast-tracking grid connections and addressing local opposition.

The ESO published a Holistic Network Design that provides guidance on the level of transmission infrastructure needed to connect the large volumes of offshore wind that will come online. The IEA commends the United Kingdom's efforts to plan ahead for growth in the sector to avoid transmission bottlenecks from slowing down the deployment of offshore wind.

Nonetheless, transmission planning and the time to realisation of infrastructure across the electricity system can be lengthy. The United Kingdom should explore options to expedite permitting, including implementing recent recommendations

from the Electricity Networks Commissioner, focused on halving the time it takes to build new grid infrastructure (from 14 years to 7). Toward this end, the government's response to the review and planned reforms such as the Connection Action Plan and Transmission Acceleration Action Plan are much-needed developments and will help facilitate and accelerate necessary grid expansions and connections. Grids remain a considerable bottleneck in the United Kingdom's net zero trajectory and much more rapid expansion and connection are needed to stay on track toward climate targets.

Moreover, a current focus on transmission grid expansion should be accompanied with due consideration for the expansion and upgrade of the distribution grid to accommodate growing behind-the-meter generation and flexibility resources (such as EVs). In particular, the government should plan ahead for the massive growth of solar PV and the impact of homes that export their residual renewable electricity to the distribution grid.

The establishment of the National Energy System Operator under the Energy Act 2023 should facilitate a more holistic approach to system planning, which will be needed in a context of transformations across the energy system, especially the outsized role that electricity is expected to play in the coming years. The government should ensure that ramping up the operation of the FSO does not impede immediate actions needed to support electricity grid expansion, including the implementation of recently announced grid plans.

The government has taken recent steps toward market reform to assess and address potential impediments to efficient market operation. This includes the call for input on market liquidity, Ofgem rules to prevent generators from artificially inflating prices through the balancing mechanism and the findings from the ongoing Review of Electricity Market Arrangements. The government should likewise study the impact of recent developments in the retail sector, notably the high level of supplier exits and related low levels of customer switching, with an eye to ensuring the most competitive prices for end-users.

Like all countries with expanding shares of wind and solar, the United Kingdom will need to pay more attention to system flexibility to ensure stability and reliability through the transition to a decarbonised system. Toward this end, the United Kingdom has a number of regulatory efforts underway, including the 2021 Smart Systems and Flexibility Plan and the Energy Digitalisation Strategy, and proposed market reforms for load controllers and energy smart appliances under the Smart Secure Electricity System Programme.

The United Kingdom has also made inroads on expanding the role of electricity storage, which is poised for more rapid growth in the coming years and will be instrumental in bolstering electricity system flexibility. The ability for storage to participate in a range of electricity markets and services (including the capacity

market) has helped support its uptake and should be continued. A planned policy framework to enable storage investments is also a welcome development.

The UK government has also taken actions in recent years to increase the role of consumers in the operation of the electricity system. Beyond strong growth in distributed generation in recent years, the government has moved forward reforms that should produce results on increasing demand side response, and it has supported industry-led innovation such as the new Demand Flexibility Service. The accelerated rollout of smart meters to customers will also help, and the government should monitor progress toward the targets of 74.5% and 68.7% coverage in homes and small businesses, respectively, by the end of 2025. Facilitating access to consumption data and fostering growth in energy service offerings will also help lower consumption and increase demand flexibility.

Given the expected growth in electricity demand across sectors, from buildings to transport and industry, the IEA commends the United Kingdom's strategy to promote electrification as a key tool to achieve decarbonisation. The government and system operator will need to duly plan for the expansion of generation capacity to meet demand, along with accompanying transmission upgrades. Moreover, the government has rightly recognised that a notable barrier to electrification are the policy costs placed on electricity consumption relative to fossil fuels. The IEA supports government efforts to investigate fuel switching to electrification and urges a reassessment of energy taxation to increase price incentives for switching to electricity (while also maintaining incentives for energy efficiency and flexible/smart operations).

The United Kingdom is well-integrated with neighbouring European countries through a robust network of interconnections. The government's target to expand interconnection capacity to at least 18 GW by 2030 will further bolster system flexibility, which will be needed as more wind and solar capacity are added to the system. In addition to point-to-point interconnectors, the government should continue to support multi-purpose interconnectors (offshore wind farms combined with interconnectors). As UK offshore wind capacity grows, the country is poised to become a net exporter of clean electricity, supporting emissions reductions and energy security in the rest of Europe.

The United Kingdom has a well-defined system in place to manage electricity security. The National Emergency Plan outlines clear roles and responsibilities for emergency system management. Moreover, National Grid ESO has a variety of tools to manage tight market situations that also mitigate risks of outages, including electricity margin notices and contracts with large consumers and generators. Winter and summer outlooks prepared by the ESO also help with planning.

The capacity market, underpinned by a reliability standard, is one of the main tools to ensure electricity supply adequacy. The government should regularly monitor its efficacy and cost-effectiveness and ensure that it does not unintentionally subsidise fossil generation at the expense of new clean energy investments.

Recommendations

The government of the United Kingdom should:

- Accelerate the deployment and optimisation of electricity grid infrastructure – at both the transmission and distribution levels – to integrate large volumes of renewables and flexible resources and accommodate greater complexity and potential at the distribution level.
- Develop a roadmap that clearly lays out the pathway for fossil electricity generation to be replaced by low-carbon options, including large-scale generation and flexibility resources, such as storage and demand response, toward the goal of a decarbonised electricity system by 2035.
- Develop indicators to monitor progress toward the long-term objective of deploying up to 24 GW of nuclear capacity by 2050 and a framework to ensure timely updates to the Civil Nuclear Roadmap to 2050 as milestones are reached.
- Develop and implement innovative financing frameworks for large-scale and small modular reactors and ensure Great British Nuclear has the required financial resources to drive the delivery of new nuclear projects.
- Ensure a robust methodology around future Contracts for Difference auctions to support strong capacity additions that track with renewables targets.
- Undertake energy price reforms to redistribute policy costs away from electricity to motivate increased electrification.

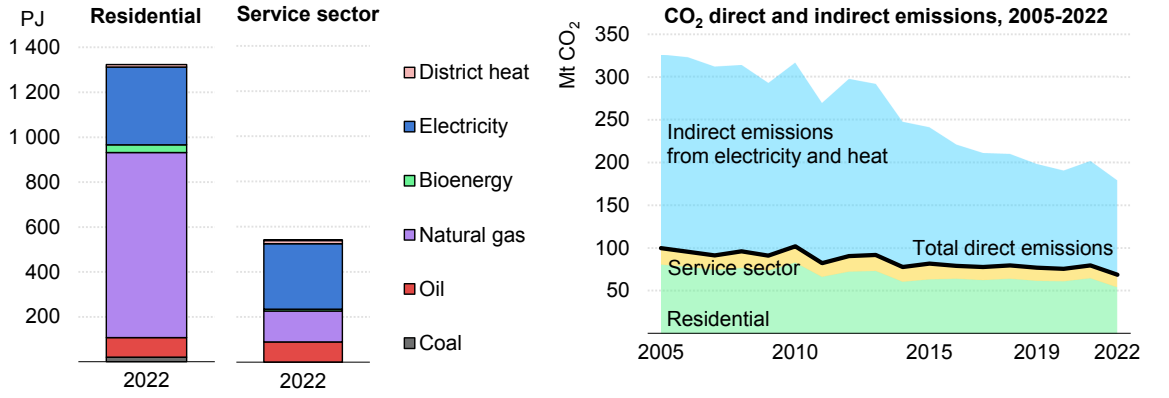
3. Buildings

In 2022, the buildings sector accounted for 41% of total final energy consumption (TFEC), with residential buildings accounting for 29% and service sector buildings for 12%. TFEC of buildings has decreased from 2 565 PJ in 2010 to 1 866 PJ in 2022 (Figure 3.1).

In 2022, natural gas covered the largest part of energy consumption in residential buildings (62%), followed by electricity (26%), oil (7%) and bioenergy (3%). In the service sector, the largest two sources of energy were electricity (54%) and natural gas (25%), followed by oil (16%) (Figure 3.1).

Direct emissions from the buildings sector accounted for 22% of total energy-related emissions. Thanks to the reduction of natural gas in residential buildings (from 67% in 2005 to 62% in 2022) and an overall reduction of energy demand by the sector, direct CO_2 emissions from buildings decreased from 100 Mt CO_2 in 2005 to 69 Mt CO_2 in 2022. Indirect emissions from the use of electricity and heat in the sector have been falling thanks to the decarbonisation of electricity generation (see Chapter 2) and amounted to 42 Mt CO_2-eq in 2022.

Figure 3.1 Total final energy consumption, 2022, and greenhouse gas emissions, 2005-2022, from buildings in the United Kingdom



Sources: IEA (2024), World Energy Balances (database); IEA (2024), Greenhouse Gas Emissions from Energy (database).

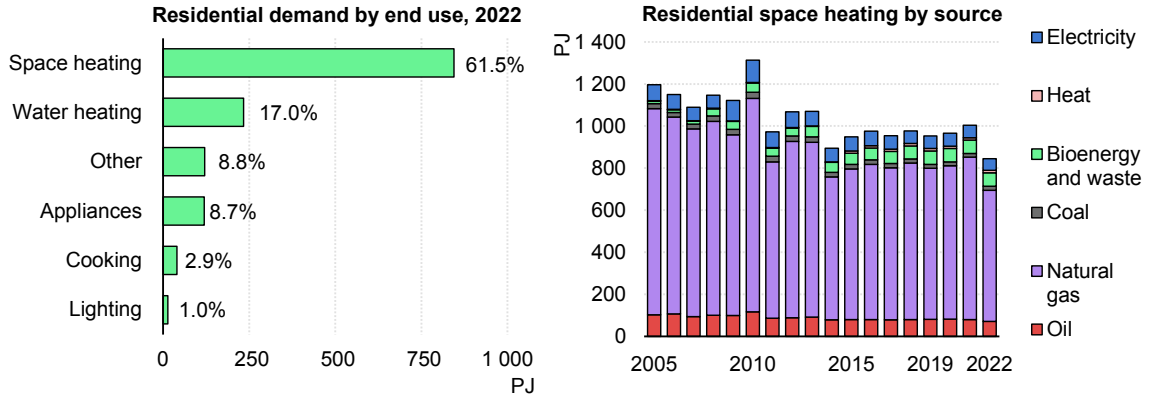
As part of the United Kingdom's climate target of at least a 68% reduction in GHGs from 1990 levels by 2030 under the Paris Agreement, the buildings sector is accountable for 66 Mt CO_2-eq of emissions reductions. The sector will also form an important part of the target to achieve net zero emissions by 2050.

The United Kingdom's building stock of roughly 30 million buildings is among the oldest in Europe and accounts for around 17% of the country's GHG emissions. Around 85% of homes rely on gas heating, one of the highest proportions globally, while around 20% or more may be unsuitable for heat pumps.

The building stock has seen significant improvement in energy efficiency in recent decades, with progress driven by cavity wall insulation, boiler upgrades from standard to condensing combi and full double glazing.

Most energy demand in residential buildings is from space heating (62% in 2022), which is largely covered by natural gas (74%), followed by oil (8.5%), bioenergy and waste (7.6%) and electricity (6.6%) (Figure 3.2).

Figure 3.2 Residential demand in the United Kingdom by end-use, 2022, and residential space heating by source, 2005-2022



Source: IEA (2024), Energy End-uses and Efficiency Indicators (database).

Strategies and targets

The government's 2021 Heat and Buildings Strategy lays out planned actions to lower GHG emissions from the buildings sector both in the near and long terms. It covers measures such as energy efficiency upgrades to existing homes, supply chains and employment, as well as phasing out fossil fuels and exploring the role of hydrogen in heating.

Concurrently, the 2021 Net Zero Strategy includes a Heat and Buildings chapter, which outlines focus areas for investment and support to households to lower energy bills and improve thermal comfort. Measures include phasing out the installation of new and replacing all existing natural gas boilers in line with their natural replacement cycle as well as making heat pumps more cost-competitive (lowering costs by at least 25-50% by 2025 and reaching parity with gas boilers

by 2030) and expanding their production. It also calls for putting in place hydrogen-ready boilers with an eye to net zero emissions by 2050.

In the 2022 Autumn Statement, the government stated an ambition to lower final energy consumption from buildings and industry by 15% by 2030 relative to 2021 levels.

Most recently, driven by cost-of-living considerations, in September 2023, the government announced that it would give households more time to phase out gas boilers in favour of heat pumps, and noted that it would offer exemptions to around a fifth of UK households for the 2035 phase-out. It also cancelled plans to require landlords to upgrade the energy efficiency of their properties.

Building standards and certifications

An energy performance certificate (EPC) is required any time a building is built, sold or rented. It must include information on a property's energy use and typical energy costs as well as recommendations for energy savings. An EPC, which is valid for ten years, assigns a building a rating from A (most efficient) to G (least efficient) based on the structure and materials of the building and its services (heating, ventilation, lighting, etc.).

The 2017 Clean Growth Strategy called for as many homes as possible to achieve an EPC rating of C (see the section below on certifications) by 2035 where it is cost-effective, affordable and practical. To date, around 47% of houses in England have achieved the EPC C level, up from just 10% in 2010.

Around 58% of homes in England with an EPC still fall below C ratings. Owner-occupied homes hold poorer ratings, with around 56% rated as D or worse. The 2018 minimum energy efficiency standard required all rental properties to meet an EPC E rating or higher by 2020 (with exemptions where costs were too high). The government consulted on setting a minimum energy efficiency standard trajectory of EPC B, where cost-effective, by 2030 for rented commercial buildings in England and Wales. This included an interim EPC milestone in 2027. The Net Zero Strategy also announced plans to consult on regulating the commercial owner-occupied building stock. The government also consulted in 2020 on raising standards for privately rented homes to EPC B and C, but in September 2023 the prime minister announced the government would not be introducing standards above those currently required. There are no proposals for standards for owner-occupied homes.

As highlighted in the Powering Up Britain document, the government is currently working on proposals for improving EPC metrics and intends to consult on these in the coming months, considering published proposals from the Climate Change

Committee. The government also has a continuing programme of user research to improve the way in which information is presented on EPCs.

The government is also reviewing the building physics model and methodology underpinning EPCs to make it fit for purpose to support net zero. The Department for Energy Security and Net Zero published the public consultation on the new building physics model, the Home Energy Model, in December 2023. The government aims to consult on the Home Energy Model methodology for producing EPCs in 2024.

The Future Homes Standard, which will be in place in 2025, will require newly built homes to be future-proofed with low-carbon heating and advanced energy efficiency solutions that will amount to 75-80% fewer emissions compared to homes under the previous standard.

The government is also considering setting a long-term regulatory standard for social housing, subject to consultation.

Funding and support programmes

During the current parliament, the government is investing GBP 6.6 billion in lowering emissions and improving the energy efficiency in buildings and reducing reliance on fossil fuels for heating. An additional GBP 6 billion in new government funding is planned over the period 2025-28. The long-term funding plan is designed to support an expansion of supply chains and scaling up of local capacities.

A number of programmes help support these goals, including:

- The GBP 450 million Boiler Upgrade Scheme provides GBP 7 500 (increased by 50% in September 2023) in grants to households to switch from fossil fuel boilers to heat pumps, along with incentives to heat pump manufacturers and GBP 60 million for heat pump innovation. The scheme has been extended to 2028, with its budget tripled to GBP 1.5 billion over 3 years.
- The "Help to Heat" schemes offer grants that support upgrades to over half a million homes in the coming years through the Social Housing Decarbonisation, Home Upgrade Grant Schemes and Energy Company Obligation Scheme.
- The Home Upgrade Grant and Social Housing Decarbonisation Fund support energy efficiency improvements to social and private homes. GBP 778 million of government funding was allocated for Wave 2.1 in March 2023, which is expected to generate energy performance improvements in around 90 000 social homes. A Wave 2.2 competition closed in January 2024 that will allocate up to GBP 80 million.

- GBP 630 million of government funding was allocated for the second phase of the Home Upgrade Grant in March 2023 to support low-income, off-gas grid households across England.
- The Sustainable Warmth competition, which ran from 2021 to 2023, awarded GBP 439 in funds to local authorities for upgrades to up to 30 000 low-income households. Meanwhile, the GBP 1 billion Great British Insulation Scheme, launched in July 2023, supports around 30 000 of the least energy efficient homes (EPC D-G) through March 2026 to save GBP 300-400 each year.
- The Energy Company Obligation (ECO) scheme requires energy suppliers to install energy efficiency and cleaner heating solutions in primarily low-income and vulnerable homes. To accelerate efforts to meet fuel poverty targets, the government committed to a four-year, GBP 4 billion extension and expansion of ECO with ECO4. The ECO4 grant programme is focused on providing support to low-income and vulnerable households, with around 800 000 energy efficiency measures to be implemented in around 450 000 homes.
- The GBP 1.425 billion Public Sector Decarbonisation Scheme aims to lower direct emissions from public sector buildings by 75% by 2037.
- The government is also running a neighbourhood trial of hydrogen for heating to take decisions in 2026 on the role of hydrogen in decarbonising heating. It will assess evidence from its wider research programme, the neighbourhood trial and similar schemes across Europe to inform its decisions.

The government is also exploring options to address distortions in fuel prices to ensure that low-carbon technologies are equivalent in cost to fossil fuel boilers. It accepted a recommendation in the 2022 Independent Review of Net Zero to commit to outlining a clear approach to rebalancing gas and electricity pricing by the end of 2023/24 and make significant progress toward shifting relative prices by the end of 2024.

Campaigns

In response to the global energy crisis in 2023, the government launched the GBP 18 million "It All Adds Up" campaign, which provides advice to households on lowering energy consumption and energy bills by applying measures with low or no costs, as well as recommendations for longer term actions to improve energy efficiency. The campaign, through partners and advertising, directs households to a website that groups tips and advice in one place. Recommendations include measures such as reducing boiler temperatures and unplugging appliances, with potential cost savings for each action.

The government also launched the Energy Efficient Home campaign in October 2023, promoting both heat pumps and energy efficiency measures. The campaign aims to educate and enable homeowners, inspiring them to self-identify energy efficient changes they can make to their homes.

Appliances, equipment, lighting

To support the achievement of its Carbon Budget and net zero by 2050 targets, the government released its Energy-related Products Policy Framework in November 2021, which laid out plans for appliances and equipment. Proposals include strengthening the minimum energy performance standards for space heating equipment as well as improving energy labelling to make it easier to understand energy efficiency savings.

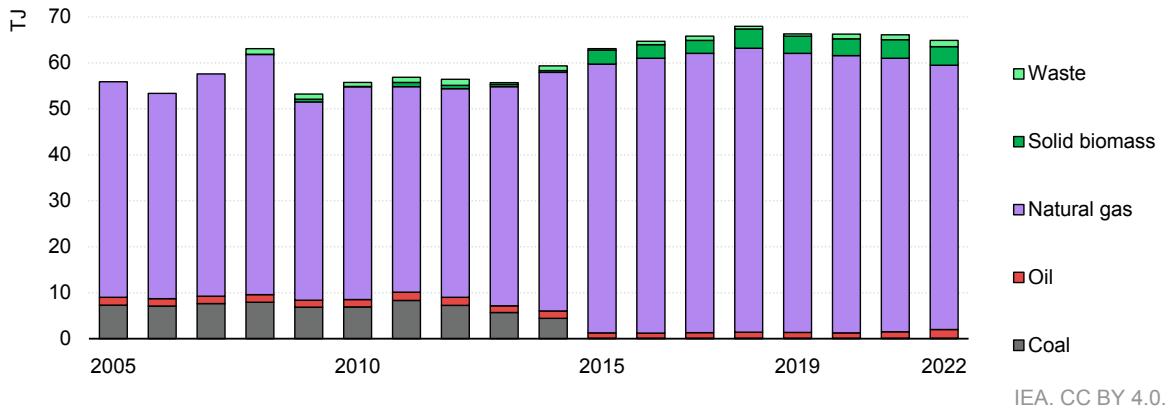
Following the United Kingdom's departure from the European Union, new EU Ecodesign and Energy Labelling regulations do not automatically apply in Great Britain. In their place, the UK government sets regulatory standards and product design specifications on energy-related products in the United Kingdom. A 2021 policy study underpins the government's efforts in this regard.

District heating

Natural gas is the main source for district heat generation, with its share increasing by about 36% from 2011 to 2022. The shift in the energy mix for district heat generation over the past decades, moving from coal to solid biomass, reflects a transition towards more environmentally friendly and sustainable energy sources (Figure 3.3). However, biomass alone may not be sufficient to completely replace coal, and natural gas is filling the gap left by coal in district heat generation.

Though district heating currently makes up a small portion of heat supply for buildings in the United Kingdom (3%), the development of heat networks is an important component in the government's plan to reach net zero emissions by 2050, as laid out in the Heat and Buildings Strategy. Notably, the relatively high degree of urban density makes the United Kingdom suitable for the development of such networks.

Figure 3.3 District heating supply by source and carbon intensity in the United Kingdom, 2005-2022



IEA. CC BY 4.0.

Source: IEA (2024), World Energy Balances (database).

A 2021 assessment of the district heating potential in the United Kingdom identified economic potential of around 95 TWh per year, which is considered the maximum level that could be achieved. The 2023 Net Zero Strategy noted that district heating could supply up to 20% of national heating demand by 2050. The Heat Networks Industry Council estimates that delivering this level would require GBP 60-80 billion by 2050 from both public and private sources.

Under the GBP 338 million Heat Network Transformation Programme, the government, in collaboration with industry and local administrations, has been offering funding for heat network development. The GBP 270 million Green Heat Network Fund, which replaced the Heat Networks Investment Project, offers funding for low-carbon district heating options such as heat pumps, energy from waste, geothermal and recovered heat. The programme also includes the GBP 5 million heat training grant for worker training courses on either heat pumps or heat networks.

Regulation for heat networks is expected to be in place in 2024 under the Energy Act 2023, with Ofgem appointed as the regulator. The regulations will include a licensing regime for building networks as well as consumer protections and authority to impose carbon emissions limits.

Assessment

The United Kingdom's building stock accounts for a large share (41%) of the country's energy consumption, led by residential buildings, with natural gas accounting for nearly a third of residential energy demand. Notably, the UK building stock of roughly 30 million buildings is among the oldest in Europe and direct emissions from the sector account for around 27% of the country's GHG emissions (34% including electricity used in the sector). As such, the United Kingdom should prioritise energy savings and GHG reduction efforts in the buildings sector, where a more concerted focus on energy efficiency and electrification of heating can lead to significant benefits based on existing technologies. Importantly, energy efficiency upgrades to buildings yield the dual benefits of addressing emissions and lowering energy bills.

Toward this end, the United Kingdom has already laid out strategies and put in place policies, underpinned by financial support, to decarbonise the buildings sector. In particular, both the 2021 Heat and Buildings Strategy and the Net Zero Strategy outline a number of measures that will support the government's goals, including energy efficiency upgrades to existing homes and phasing out the installation of new and replacing all existing natural gas boilers. The documents also include efforts to explore the role of hydrogen in heating. The government should prioritise green financing options and their accessibility, which would significantly help mobilise investment and consumer uptake in the sector.

The inclusion of specific targets and timelines (even if not binding) in the strategies, such as the installation of over 600 000 heat pumps per year by 2028, are welcome developments, as they provide industry with relevant signposts and guidance to inform investment decisions on infrastructure, manufacturing and technology development. However, the targets are ambitious relative to the current state of the market and significantly more policy focus is needed for them to be realised. Due consideration should also be given to the possible impacts on the distribution grid.

As evidenced across Europe since 2022, despite strong interest in the replacement of fossil fuel boilers with heat pumps, motivated by generous levels of government support, limited supply of both equipment and workers can significantly slow down deployment and drive up costs. Similarly, the skills and supply chain constraints in the United Kingdom remain a major bottleneck to energy efficiency and heating upgrades to homes. As such, the government should prioritise efforts to jumpstart the market, including through a stable policy environment over longer time horizons.

More recently, driven by cost-of-living considerations, in September 2023, the government announced that it would give some households more time to phase out gas boilers from an earlier deadline of 2035 and called for yet-to-be-clarified exemptions. It also cancelled plans to require landlords to upgrade the energy efficiency of their properties. While affordability issues should undoubtedly underpin all clean energy policy decisions, the government should avoid frequent changes to timelines and targets and strive for maximum ambition, especially in areas where technologies already exist and where upfront costs can easily be recovered through energy savings.

The government takes a technology-neutral approach to its decarbonisation strategy, which can lower the risks associated with picking losers and pay off in early stages of energy transitions when technological optionality is broad. However, in areas where technologies already exist at scale, the government should redirect efforts toward large-scale deployment of technologies that can realise immediate gains from emissions reductions. Notably, in heating for buildings, electrification has cost and technology-readiness advantages relative to alternatives, so government support measures should focus on accelerating its uptake in most buildings over efforts to test the use of hydrogen in home heating.

A major impediment to electrification of buildings is the cost of electricity relative to fossil fuel alternatives, which poses challenges for affordable fuel switching. Notably, electricity bills include additional charges for environmental and social schemes known as “green levies”, while far fewer of these are applied to gas bills. As a result, the government has committed to investigate options to redistribute

costs between electricity and natural gas. The IEA commends these efforts and encourages the rapid implementation of measures to rebalance prices.

The United Kingdom has a long-standing buildings certification system in place. The Future Homes Standard that is set to take effect in 2025 will help ensure the new building stock is built to advanced energy efficiency and low-carbon standards. Nonetheless, in the meanwhile, fossil fuel heating systems can still be installed in homes.

Moreover, in the United Kingdom, the existing building stock represents a far bigger challenge. Though the United Kingdom has made inroads in improving the energy performance of its buildings in the past decade, it still has significant room for improvement given that the average standard of homes in the United Kingdom is estimated to be in the high EPC D rating range. Setting a minimum energy efficiency standard for homeowners and landlords (to EPC C by 2030) should, therefore, be reconsidered, especially for rental properties, which fare even lower on energy performance. The current consultation on setting a minimum standard of EPC B by 2030 for commercial rentals is a step in the right direction.

Beyond this, the government could make greater efforts to ensure that low-cost recommendations for efficiency improvements as part of the EPC process are implemented, including offering targeted financial support where feasible and cost-effective. In addition, the government should seek to increase the coverage of the building stock with EPCs, including by leveraging information from smart meters to develop dynamic energy performance certificates.

The IEA also commends the government on its effort to develop a regulatory standard for social housing, and urges more urgent action to target energy savings (and consequently lower energy bills) to low-income households.

The United Kingdom offers several support programmes to households and businesses to improve the energy performance of buildings, including the Boiler Upgrade Scheme and the Great British Insulation Scheme. Given the outsized role that space heating plays in the energy consumption of the buildings sector, the focus on upgrading heating systems is a fitting choice. Green finance options would help motivate uptake (such as in Australia).

The UK government should also give due consideration to increasing the uptake of energy efficient appliances as well as mitigating the impact that increased space cooling will have on energy demand and emissions.

As in most other countries, low-income households face a disproportionate burden from energy bills, which account for up to 15% of the average disposable income of the bottom income decile. Moreover, low-income households tend to live in buildings with lower energy efficiency ratings. In recent years, the UK government

has increased its focus on reducing energy poverty, especially through the updated ECO scheme and the Social Housing Decarbonisation Fund. Such measures go a long way to lowering energy bills for the most vulnerable segments of the population that most need the help. The IEA encourages a continued and expanded focus on such initiatives.

Along these lines, the IEA discourages the government from applying blanket price supports, using instead targeted measures directed at low-income households. While the comprehensive price freeze that was put in place from October 2022 was an extraordinary response to the sudden and rapid run-up in energy prices stemming from Russia's invasion of Ukraine, it also serves the purpose of minimising incentives for energy efficiency measures on the part of consumers. The UK government can get ahead of future energy crises by prioritising near-term efforts to improve the energy efficiency of the existing building stock, thereby mitigating the need for expensive blanket subsidies to cover potential future energy price spikes.

The most recent energy crisis also highlighted the effectiveness of behaviour change and awareness-raising campaigns, as implemented across Europe in 2022. The UK government's "It All Adds Up" campaign offered advice to households on ways to lower energy consumption and energy bills through simple, low-cost measures. The programme's website is easy to follow and offers clear information on costs and savings from various measures. The IEA commends such efforts and urges the government to track its results and build upon its success, including drawing upon best practice from awareness campaigns in other parts of the world. In particular, the United Kingdom should align energy efficiency and net zero campaigns with the immediate health and well-being benefits they can bring to people's lives.

The United Kingdom's strategy to expand the role of district heating is welcome given the strong potential such networks can bring in terms of energy efficiency and GHG reductions, especially considering the United Kingdom's relatively high urban density. The upcoming regulatory framework, due in 2024, is an important first step, and could be accompanied by more financial support in the early years to help kickstart investments, including by expanding the Heat Network Transformation Programme and the Green Heat Network Fund. The United Kingdom should also investigate the use of non-fossil fuel sources for district heating, as over 90% of supply is currently fuelled by natural gas.

Overall, the United Kingdom has taken a number of steps within its strategy to decarbonise the buildings sector, setting clear targets and employing a combination of certifications, standards and financial support. Still, the scale of the challenge and the gap between the sector's energy performance today and net zero emissions by 2050 suggests that more action is needed to accelerate results.

The United Kingdom can build off existing programmes to expand their reach, especially considering the relatively quick pay-off from energy efficiency improvements in buildings compared to other, longer term technological solutions in other sectors. A more holistic approach to policy support for buildings would help toward this end.

Recommendations

The government of the United Kingdom should:

- Prioritise energy efficiency measures in existing buildings, both through buildings standards and renovation incentives.
- Consider a mandated phase-out date for fossil boilers to jump start investments in manufacturing, skills and supply chains.
- Rebalance the policy costs associated with electricity relative to natural gas to increase incentives for electrification.
- Expedite a decision on the technology-neutral approach to household heating before 2026; prioritise electrification as a more economic and ready-to-deploy solution compared to hydrogen.
- Ramp up public awareness campaigns around the broader energy transition as well as targeted campaigns on household energy savings to drive more rapid emissions reductions through behavioural changes.

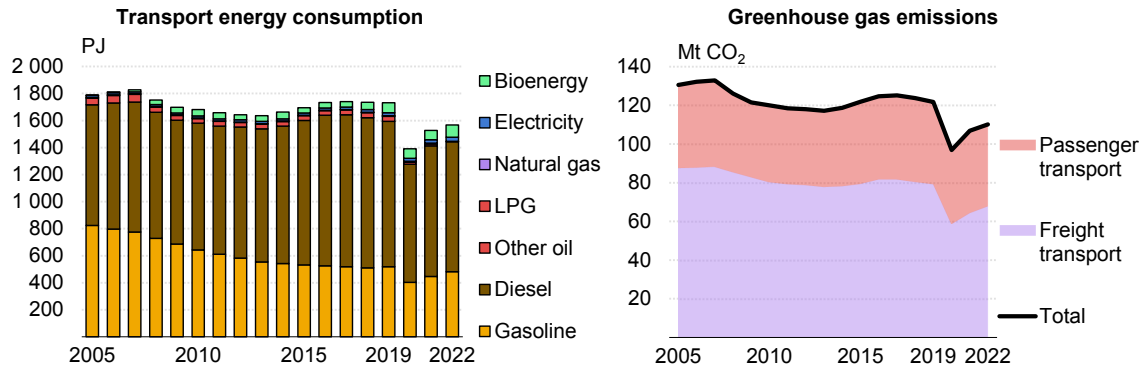
4. Transport

Transport is the United Kingdom's largest emitting sector, responsible for 36% of domestic energy-related emissions in 2022, and its accelerated decarbonisation is central to delivering overall climate commitments. Road vehicles account for over 90% of the transport sector's GHG emissions.

The transport sector is the primary user of petroleum products in the United Kingdom, accounting for almost three-quarters of oil product demand in 2022 and a fifth of total energy consumption. Transport energy demand and emissions reached a peak in 2017, then slowly decreased until 2019. After the 2020 dip due to the pandemic, energy demand and emissions from the sector remained well below 2019 levels in 2021 and 2022. Total energy demand in the transport sector is dominated by diesel (60%) and gasoline (30%), but in recent years the share of biofuels and biogas increased to 6% of transport energy demand in 2022 (Figure 4.1).

The UK government has set out a holistic, cross-modal approach to reducing transport emissions in recent policy documents and strategies and plans to regularly review progress to ensure its approach accounts for emerging evidence and technological developments while providing sufficient certainty to spur investments in line with targets.

Figure 4.1 Energy demand and emissions in transport by source in the United Kingdom, 2005-2022



Note: LPG = liquified petroleum gas.

Sources: IEA (2024), World Energy Balances (database).; IEA (2024), Greenhouse Gas Emissions from Energy (database).

Transport fuel taxation

For road transport, fuel duties are levied on sales of petrol, diesel and other hydrocarbon fuels, while a value-added tax applies to the price of fuel inclusive of any fuel duty that applies. From March 2011 to March 2022, petrol and diesel were subject to a duty rate of 57.95 ppl. The rate was temporarily cut for 12 months to 52.95 ppl from March 2022 to address cost-of-living impacts stemming from the energy crisis. The cut was subsequently extended for a further 12 months at Spring Budget 2023 and is currently planned to expire in March 2024. Biofuels and renewable fuels attract the same rates of fuel duty as their fossil fuel equivalents. Road fuel gases attract different rates (e.g. the rate for non-natural gases is GBP 0.2888 per kilogram).

Electric vehicles

The number of EVs (including battery electric vehicles and plug-in hybrids) in the United Kingdom has increased. At the end of 2023, there were 982 328 licensed zero-emission electric vehicles (ZEVs) in the United Kingdom, an increase of 67% compared to a year earlier. In 2023, 16.5% of all new cars sold were zero emission and ZEVs currently account for 3.1% of all road vehicles, compared to 1.7% at the end of 2022.

The Vehicle Emissions Trading Schemes Order 2023, which implements the ZEV mandate, establishes trading schemes that oblige manufacturers to sell an increasing share of ZEVs each year from 2024 until 2030, setting a pathway for the phase-out of all new fossil fuel cars and vans by 2035. The mandate sets a target of 80% of new cars and 70% of new vans to be zero emission by 2030.

Alongside the ZEV mandate, the government will continue to regulate exhaust CO_2 emissions from new conventional cars and vans.

The UK government has offered grants for over a decade to help offset the upfront costs of new ZEVs. Over GBP 1.6 billion in grants have been issued to support more than 500 000 ultra-low emissions EVs, of which 355 000 are ZEVs. Given its success, the grant was closed to new orders in June 2022 for plug-in cars. Grants will continue at least until financial year 2023/24 for taxis and motorcycles and until 2024/25 for vans, trucks and wheelchair accessible vehicles.

From 2025, zero emission cars, vans and motorcycles will have to pay the same vehicle excise duty rate as petrol and diesel vehicles. However, ZEVs will still have preferential first-year rates of vehicle excise duties compared to the most polluting vehicles. The vehicle excise duty expensive car supplement will only be applied to ZEVs registered on or after 1 April 2025, and will not be retrospectively applied to EVs registered before this date.

Favourable benefit-in-kind rates for company cars continue to drive ZEV uptake. Benefit-in-kind rates are 2% for EVs until 2025, after which they will increase by 1 percentage point each year until they reach 5% for battery EVs by April 2028. By contrast, the rate for petrol and diesel cars will increase by 1 percentage point in 2025-26 and then be maintained, with the most polluting cars subject to a rate of 37% by 2028.

The price of EVs in the United Kingdom continues to fall, with some models on the used market now similar in price to their petrol or diesel equivalents. Most drivers in the United Kingdom buy their car on the used market, so this will be an important source of affordable EVs.

Charging infrastructure

Overall, the ratio of EV charging stations to EVs has generally increased in parallel with the proportion of EVs in the national fleet. In 2022, there were around 19 chargers per EV on the road, above a general recommended number of 10 chargers per EV. An adequate distribution of chargers throughout the country has to also be ensured.

As of 1 January 2024, there were over 53 600 publicly available charging points, including more than 10 000 50-kilowatt or above devices – a 45% increase since January 2023. As of 1 July 2023, the government had funded the installation of 380 555 domestic charging devices since 2013 and a further 3 433 sockets under the new Electric Vehicle Chargepoint Grant launched in April 2022. As of July 2023, the government had also funded the installation of 46 172 charging points in workplace carparks since 2016.

In March 2022, the UK government published the EV Infrastructure Strategy, setting out its plan to deliver a charging network. The Strategy outlines an expectation to deploy a minimum of 300 000 public charging points by 2030.

The government is already supporting motorway service area (MSA) operators and the private sector to deliver ultra-rapid, open access charging points at every MSA. The government's Rapid Charging Fund will build on these early intervention projects and fund a portion of the cost of upgrading the electricity grid at strategic locations, where it is currently not commercially viable. The GBP 11 million National Highways Energy Storage Systems project will procure and install battery storage at MSA sites to support the installation of ultra-rapid EV chargers.

Outside of MSAs, the Local EV Infrastructure Fund will provide local authorities in England with funding to work with industry and transform the availability of charging for drivers without off-street parking. In March 2023, the government announced that an additional GBP 381 million would be made available to local

authorities over the next two financial years to accelerate the commercialisation of local charging infrastructure in rural areas.

The government has also introduced regulations to improve the consumer experience across the public charging network and enhance consumer confidence. The regulations, which came into force in November 2023, will ensure that pricing information and payment methods are simplified, charging points are reliable, and public charging point data are open and freely available.

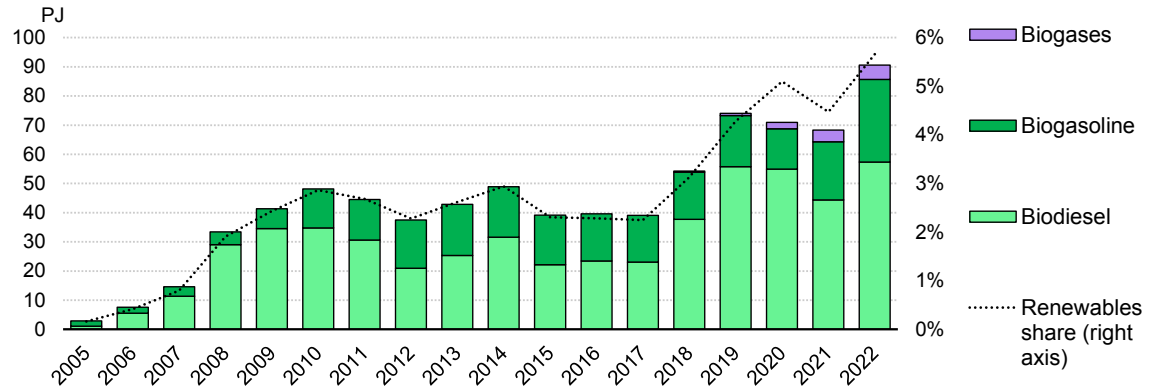
Legislation came into force in June 2022 requiring new or majorly renovated buildings with associated parking to have EV charging infrastructure installed. It is estimated that this will lead to the installation of up to 145 000 new charging points across England annually.

There are 8 publicly accessible hydrogen refuelling stations in the United Kingdom, with 4 more planned, serving a current fleet of approximately 265 vehicles. Future government support for additional hydrogen refuelling infrastructure will be linked to specific R&D programmes, which are expected to provide a base level of demand.

Renewable fuels

The share of renewable fuels in transport energy demand increased in the United Kingdom from less than 1% in 2007 to 5.7% in 2022 (in energy terms). Biodiesel accounted for 63% of renewable biofuels in 2022, biogasoline for 31%, biogases for 5% and a small fraction of bio-LPG completed the renewable energy used in the sector. Despite a decrease from 2019 to 2021, in 2022, renewables used in transport achieved a record high, thanks to a 62% increase in the use of biogasoline from 2019 to 2022, a 3% increase of biodiesel and a jumpstart in the use of biogases.

Figure 4.2 Renewable energy in transport in the United Kingdom, 2005-2022



Source: IEA (2024), World Energy Balances (database).

Low-carbon fuels, including renewable fuels such as biofuels and renewable fuels of non-biological origin, are expected to play an important role in decarbonising the transport sector alongside other key measures such as electrification. They contribute to about a third of carbon savings in the transport sector required under current legally binding carbon budgets. Currently, low-carbon fuels are mainly used in the road sector, supported by the Renewable Transport Fuel Obligation (RTFO). On the path to net zero, they will need to be expanded to other transport modes, such as aviation and maritime. A separate mandate for sustainable aviation fuels (SAF) is set to apply from 2025. And in the forthcoming Clean Maritime Plan refresh, the government expects to make a commitment on the steps needed to drive the uptake of low-carbon fuels in the domestic maritime sector.

Since 2008, the RTFO has driven the uptake of renewable fuels in road transport. It places a requirement to supply renewable fuels on fuel suppliers of more than 450 000 litres of fuel per year. Fuels supported under the RTFO include biofuels and other renewable fuels. Other renewable fuels include hydrogen produced from either renewable energy or biogas and synthetic fuels derived from renewable hydrogen and a CO_2 source. Generally, any renewable fuel can be supplied under the RTFO provided it meets minimum GHG savings thresholds and broader sustainability criteria.

For 2024, the RTFO's main obligation is currently set at 11.8%, while the development fuel obligation (targeting newer strategic fuels such as hydrogen and synthetic fuels) is set at 1%. These are set to increase to 14.6% and 2.8%, respectively, by 2032.

The RTFO operates as a certificate-trading scheme. Suppliers demonstrate compliance by redeeming certificates, which they either claim for supplying sustainable renewable fuel or purchase from other suppliers. Obligated suppliers can also choose to "buy-out" of their obligation by paying money to the government rather than redeeming certificates. The cost of doing so, which serves as a *de facto* price cap, is GBP 0.50 per litre for the main obligation and GBP 0.80 per litre for the development fuel obligation.

To support growth in the sector, the Department for Transport plans to publish a Low Carbon Fuels Strategy in 2024, which will lay out a vision for the deployment of low-carbon fuels across transport modes up to 2050. The Strategy will build on stakeholder engagement throughout 2022, including a call for evidence and workshops as well as research into feedstock availability and infrastructure mapping.

Public transport and active mobility

The UK government also plans to promote increased travel by walking and cycling with a vision that by 2030 half of all journeys in towns and cities will take place by foot or bicycle. The second statutory Cycling and Walking Investment Strategy sets out these objectives and the financial resources in place to achieve them, over the period 2021-25. The newly formed executive government agency, Active Travel England (housed under the Department of Transport), is improving the quality of active travel infrastructure and has a statutory consultee role within the planning system.

Given that 82% of UK emissions fall under the scope of local authorities, local and regional authorities are often best placed to take the decisions that will deliver the transport changes required. Therefore, the UK Department for Transport is focused on unlocking barriers through policy, regulation and guidance, as well as capacity building and strategic co-ordination across authorities.

The UK Department for Transport is also developing a nationwide connectivity metric that will inform decisions on transport infrastructure schemes and land use by highlighting the best-connected places by public transport, walking and cycling to the destinations people travel to for jobs and services. The aims are twofold: first, to guide new development to sustainable locations, minimising the carbon intensity of journeys and building to higher densities; second, to identify gaps in connectivity by these modes that can be remedied by introducing new services. The Levelling Up and Regeneration Act 2023 also requires local planning authorities to introduce infrastructure delivery strategies that lay out their priorities for infrastructure required to support new growth. By proactively planning, costing and identifying funding for sustainable modes of transport, local authorities will be able to ensure low-carbon forms of travel are available for those living and working in new developments and residents are able to easily access the services they need.

Heavy goods vehicles

In November 2021, the UK government confirmed its intention to end the sale of new non-zero emission heavy goods vehicles (HGVs) weighing less than or equal to 26 tonnes by 2035, with all new HGVs sold to be fully zero emission at the exhaust by 2040.

The Department for Transport is also working with industry stakeholders to develop a zero emission HGV and coach infrastructure strategy for publication in 2024. The strategy will set the strategic direction and outline the respective roles and responsibilities of both government and industry to ensure the delivery of the refuelling and recharging infrastructure required to meet the 2035 and 2040 end of sale dates for new non-zero emission HGVs.

The UK government's GBP 200 million zero emissions HGV and infrastructure demonstrators will showcase zero emission HGV technologies at scale, helping to identify barriers to the mass deployment of vehicles and installation of recharging and refuelling infrastructure.

Rail

The UK government has committed to deliver a net zero rail network by 2050, with an ambition to remove all diesel-only trains by 2040. To support delivery, the United Kingdom plans to electrify additional lines and deploy battery and hydrogen trains on some lines where it makes economic and operational sense. As part of the 2021 Integrated Rail Plan, the government already announced the electrification of several routes.

Since 2019, the government has provided around GBP 4.75 million in funding through Innovate UK, a national innovation agency, to support first-of-a-kind competitions in rail, including for hydrogen trials. Additional funding includes GBP 2.15 million for the Rail Network Enhancement Pipeline to help bridge the gap between technological innovation and operational application by supporting trials of the United Kingdom's first fast-charging battery-only train.

In recent years, the United Kingdom has experienced challenges to its high-speed rail ambitions. In particular, the High-Speed 2 project to link London and Birmingham, and then onwards to Manchester, has experienced cost overruns and delays since it was originally conceived in 2009. The government cancelled a line of the project going from the Midlands to Leeds in 2021. More recently, the government announced that Phase 2 of the project, connecting Birmingham to Manchester, will also be cancelled. Funding for High-Speed 2 beyond Birmingham is being redirected to other transport projects through Network North, including for new rail projects.

Aviation

In 2022, the UK Department for Transport published the Jet Zero Strategy, setting out the government's approach to achieving net zero by 2050 for UK aviation. The strategic framework sets out three guiding principles (international leadership, delivered in partnership and maximising opportunities) and six core policy measures (system efficiencies, SAF, zero emission flight, markets and removals, influencing consumers, and addressing non-CO_2).

The UK government is also investing significantly in R&D to support the delivery of the Jet Zero Strategy, including to support the commercialisation of SAFs, zero-carbon aircraft technology and airport preparedness for handling hydrogen.

This includes through the Aerospace Technology Institute Programme, which will receive GBP 685 million from the government over 2022-25, and a further GBP 975 million in 2025-30.

SAF is considered an instrumental technology for decarbonising the aviation sector. In the Jet Zero Strategy, the government estimated that SAF would contribute 17% of the emissions reduction needed to reach net zero for the aviation sector by 2050.

To help create the conditions for SAF uptake, the United Kingdom will introduce a SAF mandate from 2025 leading to at least 10% of UK jet fuel being sourced from sustainable feedstocks by 2030. The mandate will place an obligation on fuel suppliers to supply SAF, incentivising SAF that achieves the greatest GHG savings. The mandate will include stringent sustainability criteria to ensure fuel feedstocks do not drive wider environmental degradation (such as deforestation). Fuels supplied to meet the mandate will need to be waste-derived biofuels, recycled carbon fuels or power-to-liquid fuels.

The United Kingdom considers the SAF industry to be an important economic opportunity to create new industries, supply chains and jobs. To further support the development of a UK SAF industry, the government has allocated over GBP 135 million to 13 projects through the Advanced Fuels Fund to support first-of-a-kind SAF production plants to reach investment-ready stage and achieve commercial scale. The Advanced Fuel Fund will support private investment in UK SAF projects toward the aim of having at least five commercial SAF plants under construction by 2025. To provide greater certainty to investors, the government has committed to design and implement a revenue certainty mechanism for UK SAF production and will publish a consultation on options for this in spring 2024. The delivery plan sets out timelines for the implementation of such a mechanism by the end of 2026.

The UK government launched the UK SAF Clearing House in November 2023, which acts as a hub to support the testing of new, alternative aviation fuels against industry standards through co-ordination, advice and funding.

The United Kingdom also provided up to GBP 1 million to Virgin Atlantic and industry partners to help deliver the world's first transatlantic flight on a commercial airliner using 100% SAF in November 2023.

Maritime

The UK Department for Transport aims to publish a refreshed Clean Maritime Plan in 2024, building off the 2019 Plan. The refresh will include a range of policy proposals as well as decarbonisation goals for the domestic maritime sector,

developed using a new, purpose-built maritime emissions model that will provide an updated analysis of cost-effective and credible decarbonisation pathways for its sector and their feasibility.

The GBP 206 million UK Shipping Office for Reducing Emissions programme aims to accelerate the development and commercial deployment of the technologies required for maritime decarbonisation.

In July 2023, the UK ETS Authority published its response to the Developing the UK Emissions Trading Scheme consultation, setting out details of the future development of the UK ETS. The consultation response confirms the ETS Authority's plans to expand the UK ETS to the domestic maritime sector from 2026.

Hydrogen

Hydrogen is likely to play a key role in supporting the decarbonisation of industrial processes, power and some parts of transport, such as maritime and aviation (direct use or via SAFs).

In transport, the government expects battery electrification to remain the dominant zero emission technology for passenger cars and vans, and to increasingly dominate in new HGVs, buses and coaches. There may be some specific use cases where hydrogen offers advantages over batteries, such as where longer ranges are needed or in rural/remote locations, such as non-road mobile machinery or construction vehicles.

Low-carbon hydrogen-derived fuels like ammonia are likely to play a crucial role in the decarbonisation of the maritime sector. Analysis in DESNZ's Hydrogen Transport and Storage Networks Pathway estimates that by 2050 there could be 50-60 TWh of demand for hydrogen from UK domestic and international shipping. The government is supporting innovation through R&D funds such as the Clean Maritime Demonstration Competition and Zero Emission Vessels and Infrastructure competition.

Assessment

As the United Kingdom's largest emitting sector, the transport sector is one where accelerated emissions reductions are needed to meet climate targets. To this end, as in other sectors, the United Kingdom has laid out roadmaps and strategy documents to clarify its approach, which involve plans across modes of transport. The IEA commends the United Kingdom on its comprehensive approach to decarbonising the transport sector, which offers lessons to other countries looking to develop sectoral roadmaps.

Fuel duties are an important tool for the government to drive behavioural change among transport end-users toward decarbonisation objectives. The United Kingdom applies fuel duties and levies on transport fuels, but these taxes do not appear to be structured with a carbon-intensity lens, as is the case for natural gas and electricity (non-household supply), for example, where the Climate Change Levy applies. Meanwhile, the UK ETS currently applies to the power, heavy industry and aviation sectors, but not to other transport sectors, although the scheme will expand to cover maritime from 2026. Moreover, oil alternatives such as biofuels face the same fuel duty rate as oil products. The UK government should assess options to introduce a carbon component to its fuel taxation system to motivate shifts away from oil in transport. This could provide a dedicated revenue stream for energy savings programmes, especially for vulnerable consumers.

At the end of 2023, ZEVs accounted for around 3.1% of all road-using vehicles, compared to 1.7% at the end of 2022, and in total in 2023, 16.5% of all new cars sold were zero emission. The ZEV mandate is a welcome step, as it implements a trading system that encourages carmakers to gradually lower emissions from cars with flexible options. The mandate ensures that 80% of new cars and 70% of new vans sold by 2030 will be zero emissions, ramping up toward the target of 100% ZEV sales by 2035. The ZEV mandate is poised to be a net zero success story. The clarity to industry that the ZEV mandate brings is likely to mobilise new investment in manufacturing, which can offer lessons to other sectors too. Incentives for corporate fleet purchases of EVs are also driving uptake.

Moreover, the government also offered grants to consumers to offset the upfront costs of EVs. The grants for plug-in cars ended in June 2022, though remain for at least the next financial year for some other categories of vehicles, including battery electric vans and HGVs. In addition, from 2025, EVs will still have preferential first-year vehicle excise duty rates compared to the most polluting vehicles, while the favourable benefit-in-kind rate for EVs was extended to 2028. The United Kingdom’s efforts at adjusting subsidies for EVs with an eye to affordability (and to avoid subsidising high-income segments of the market) are appreciated. Nonetheless, the government should also track the uptake of EVs in the next few years without the subsidies and ensure that penetration still tracks with targets, as EVs will remain the dominant low-emissions technology for passenger cars and vans.

The UK government has also developed a robust strategy to buildout EV charging infrastructure, accompanied by financial support, that will help ensure that EV penetration is not slowed down by insufficient charging points. The National Infrastructure Commission stated that the United Kingdom is on track to meet the EV Infrastructure’s Strategy of 300 000 chargers, if 30% annual growth continues. Also, adequate distribution of reliable charging points throughout the country must be ensured, including in public spaces and less densely populated areas, to allow

for a strong increase in EV deployment that is not limited to houses with private parking or in high-income areas, and to provide confidence to drivers. In addition, the fast transition from internal combustion engines to EVs will have an impact on the distribution network and it should be considered with high priority and urgency in future market design and distribution network upgrades. Smart EV charging strategies can reduce the level of investment in electricity infrastructure needed to accommodate increased electricity demand while boosting electricity system flexibility and supporting higher integration of variable renewable generation.

The United Kingdom has rightly recognised the role that renewable fuels will play in decarbonising the transport sector. Not only will electrification be challenging and costly in some transport segments, but biofuels can continue to deliver significant results in the years until EVs make a deeper dent in passenger road transport. Toward this end, the United Kingdom has supported the uptake of renewable fuels since 2008 under the RTFO. Given the considerable carbon savings that are achieved from renewable fuels, the United Kingdom should be ambitious in its policy development on renewable fuels (especially in harder to decarbonise transport segments) under its forthcoming Low Carbon Fuels Strategy, including exploring options to maximise the role of biofuels based on existing transport infrastructure and vehicle models under the RTFO, with due consideration to sustainability criteria (including life cycle emissions).

The United Kingdom has also expanded public transport and increased transport choices, such as greater options to walk and cycle in urban areas, a central pillar of its transport sector strategy, one which the IEA heartily supports. Any effort to encourage public transport usage and active travel, which have considerable environmental and health co-benefits, will go a long way toward lowering emissions, especially in larger cities. Notably, London's Ultra Low Emission Zone has been particularly successful at reducing both congestion and emissions, and offers lessons to other cities. The UK government has fortified institutional capacity in government as well as co-operation with local governments to overcome barriers and improve outcomes. The tying of local government infrastructure planning to sustainable transport is also a welcome one that should produce results.

Transitioning the heavy-duty road transport system will also be an important pillar for decarbonising the transport sector, given that freight road transport accounts for around a third of transport energy demand. Moreover, even though HGVs represent around 1.5% of road vehicles in the United Kingdom, they account for 20% of road transport emissions. The government is working with industry to develop a zero emissions HGV and coach infrastructure strategy and supporting innovation in the area through Zero Emission HGV and Infrastructure demonstrators. The development of such plans is welcome, and the IEA urges the

government to quickly finalise policies and strategies to provide industry investment clarity as soon as possible.

Greater utilisation of available measures to decarbonise the HGV fleet in advance of the build-up to the ZEV mandate would also be merited. In this regard, the government should give some consideration to promoting greater use of low-carbon fuels for the HGV sector in the short term given the sizeable emissions reduction potential that it can offer. Such a measure can co-exist in the short term with the longer term drive towards a ZEV regime. This policy could have a regional focus to align with UK refinery infrastructure, which will face viability issues over the coming years.

In non-road transport segments, the United Kingdom has also made strides toward decarbonisation. Its plans for achieving net zero emissions in rail, centred on electrification and bolstered by financial support, has already yielded some results. The IEA encourages the United Kingdom to build off these successes and aim for electrifying more lines. At the same time, the development of high-speed rail has experienced cost overruns and delays. The government should strive to improve rail infrastructure planning toward increased efficiency, prioritising projects with the highest potential of motivating modal shifts from road transport.

In aviation, the Jet Zero Strategy sets out a clear framework underpinned by policy measures and R&D funding support. The IEA commends the United Kingdom on its focus on SAFs, which will help drive the growth of the sector and can position the United Kingdom as a leader in decarbonising air travel. However, the SAF industry is awaiting guidance on the final details of the planned mandate and revenue certainty mechanism.

In shipping, the government has also laid out a Clean Maritime Plan, which will be updated shortly, and set out updated decarbonisation pathways for the sector. The extension of the UK ETS to the domestic maritime sector is also a welcome one that will position the United Kingdom as a leader in this area.

Finally, hydrogen may play an important role in decarbonising the transport sector, especially heavy transport segments. In this regard, the UK Hydrogen Strategy, underpinned by government support for research and innovation (R&I), could help address the full range of the hydrogen supply chain.

Recommendations

The government of the United Kingdom should:

- Monitor the impact of the removal of electric vehicle purchase subsidies on new sales and reassess whether financial incentives are needed for longer; consider targeted support to low-income consumers.

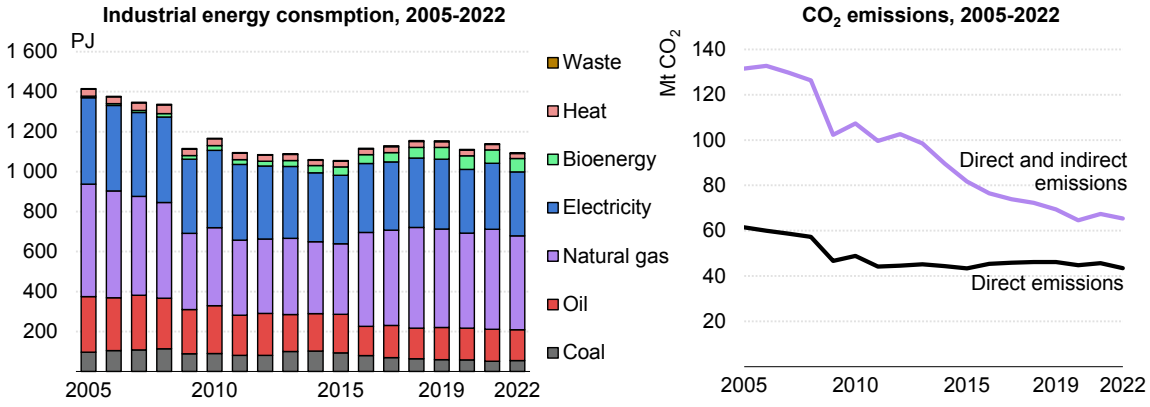
- Accelerate the deployment of a reliable and smart electric vehicle charging infrastructure to provide confidence to drivers and support electricity system flexibility.
- Prioritise the upgrading and utilisation of public transport, in conjunction with local authorities.
- In light of the longer lead-times for electrification, consider promoting the uptake of low-carbon fuels for heavy goods vehicles in the short term.
- Expedite the issuance of a sustainable aviation fuel mandate and its supporting details to jumpstart investments into fuel production.

5. Industry

The industry sector is an important part of the UK economy, accounting for GBP 200 billion in GDP annually and 2.4 million direct jobs (5 million across the value chain). Industry accounted for 24% of TFEC in 2022, and 62% of energy demand from industry comes from fossil fuels, mainly led by natural gas (Figure 5.1). Energy demand in the industry sector has declined significantly over the years, with a large drop from the recession caused by the financial crisis (2008-09). The government has set a target to reduce final energy consumption in industry and buildings by 15% by 2030 relative to 2021 levels.

From a CO_2 emissions perspective, direct emissions from the industry sector accounted for 14% of total UK energy-related emissions in 2022, with 45% of industry emissions concentrated in seven industrial clusters. When including indirect emissions[2] from electricity and heat used in the sector, the share of industrial emissions increases to 21%. Indirect emissions have significantly fallen thanks to the decarbonisation of electricity generation (see Chapter 2).

Figure 5.1 Energy demand and emissions from industry in the United Kingdom, 2005-2022



Sources: IEA (2024), World Energy Balances (database); IEA (2024), Greenhouse Gas Emissions from Energy (database).

[2] In order to reallocate emissions of the transformation to end-use sectors, the IEA has developed an internal methodology making use of the available data, which consisted in allocating emissions based on the total amount of electricity and heat consumed by each end-use sector.

Decarbonisation strategies

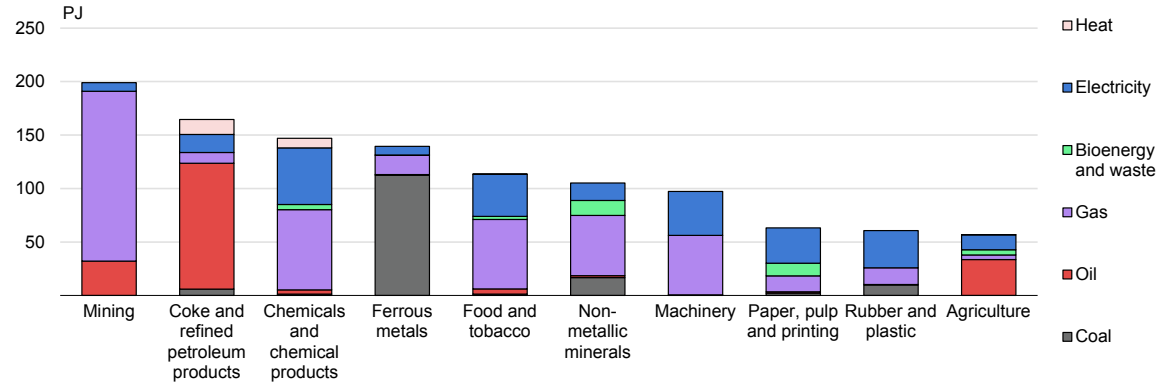
To underpin its net zero target, the United Kingdom has developed a number of supporting plans, including the Industrial Decarbonisation Strategy in 2021, which was the first of its kind to set out a pathway for achieving net zero emissions in industry. It includes a roadmap that outlines key technological signposts as well as policy actions on the path to net zero. The Strategy estimates that GHG emissions need to fall by at least two-thirds in the sector by 2035 and by at least 90% by 2050, including 3 Mt CO_2-eq through CCUS by 2030 (and 14 Mt CO_2-eq by 2050) and 20 TWh by switching to low-carbon fuels. It also notes that energy efficiency measures across industry could result in GHG reductions of 4 Mt CO_2-eq by 2050. The Strategy is due to be updated in 2026.

Policy measures outlined in the Industrial Decarbonisation Strategy include carbon pricing mechanisms, support to ensure competitiveness and prevent carbon leakage, demonstration and deployment funding to support technology development (including CCUS and hydrogen), infrastructure support, and demand-side mechanisms. The Strategy includes a commitment to track progress annually and update actions every five years.

More recently, the Powering Up Britain strategy from 2023 includes a chapter on the decarbonisation of industry. It notes that decarbonising the UK industrial sector has the potential to unlock GBP 19 billion in public and private investment across the United Kingdom. It includes commitments such as GBP 20 billion toward CCUS, and sets out actions needed for industry to reduce emissions, save on energy bills and connect to low-carbon infrastructure such as carbon capture technology. The Strategy also pledges the replacement of around 50 TWh of fossil fuels per year by 2035 with low-carbon alternatives in industry. Electrification of industry is expected to play an important part in meeting this ambition, as fuel switching has the potential to reduce annual industrial emissions by between 7 Mt CO_2-eq and 19 Mt CO_2-eq by 2050, contributing between 15% and 40% of the (necessary) carbon abatement in industry by 2050.

In line with the indicative pathway set out in the Net Zero Strategy, compared to 2021 emissions levels, GHG emissions in industry could, on average, fall by 15-25% over 2023-27, by 41-52% by 2030 and by 62-75% over 2033-37.

Figure 5.2 Industry sub-sector energy mix in the United Kingdom, 2021



Source: IEA (2024), Energy End-uses and Efficiency Indicators (database).

Carbon pricing

Energy-intensive industries are subject to the UK ETS, in which companies are required to secure sufficient emissions allowances to cover their annual GHG emissions. Industrial sectors that are considered at risk of carbon leakage receive some of their allowances free of charge.

Based on a recommendation from the Independent Review of Net Zero, the UK ETS Authority agreed in December 2023 to develop a long-term pathway for the ETS to net zero through 2050. Therefore, the ETS Authority will legislate to extend the ETS past 2030 up to at least 2050, aligning with net zero targets.

The UK government is also reviewing its approach to carbon leakage, on which it has undertaken consultations. As part of this, the government is reconsidering the free allocation of emissions allowances to industry under a review. The cap on the quantity of free allowances will be set at 40% of the overall cap.

In December 2023, the UK government also announced that it would implement a Carbon Border Adjustment Mechanism (CBAM) by 2027, one year after the EU CBAM is due to take effect. The CBAM will account for the CO_2 intensity of production as well as the carbon price applied in the country of production, though the specifics of the mechanism will be worked out based on consultations in 2024.

Programmes and support mechanisms

The Industrial Energy Transformation Fund offers grants to industrial sites with high energy consumption to implement energy efficiency measures as well as help lower costs and risks associated with investments in deeper decarbonisation technologies. In March 2023, the government announced a GBP 185 million extension to the Fund, subject to business case approval, bringing the programme's total budget to GBP 500 million.

The Recovery Loan Scheme supports access to finance for small and medium-sized enterprises by offering 70% government-backed guarantees on loans against the outstanding balance of a facility to support energy efficiency projects.

Companies can also take advantage of several capital allowances for energy efficiency investments. The Annual Investment Allowance lets businesses lower their profits by 100% of qualifying plant and machine expenditures in the year of investment, up to a cap of GBP 1 million. Companies could also claim 130% of capital allowances on qualifying plants and machinery under the "super-deduction" from April 2021 through March 2023. For qualifying expenditures on plant and machinery, companies could also claim a 50% first-year allowance until the end of March 2023.

The government also offers tax incentives to support emissions reduction efforts in industry. Climate change agreements are voluntary agreements between the government and 53 economic sectors of UK industry to lower energy consumption and emissions. It covers around 30% of industrial energy consumption. In return, eligible companies receive a discount on the Climate Change Levy. In March 2023, the government announced an extension of the scheme through December 2024 and published a consultation on proposed reforms for the extension and on any potential future scheme. The government's 2023 Autumn Statement introduced a new six-year Climate Change Agreement starting in 2025, offering companies around GBP 300 million in annual tax relief in exchange for adhering to agreed energy efficiency or carbon reduction targets. Alongside the Autumn Statement, an additional consultation was published detailing proposals for the six-year scheme (that closed in February 2024).

Moreover, eligible plant and machinery used in onsite renewable energy generation and storage, including rooftop solar panels and batteries, are exempt from business rates from April 2022 through March 2035.

Audits

The Energy Savings Opportunity Scheme for large businesses assesses their energy use every four years and provides tailored and cost-effective recommendations to save energy and achieve carbon and cost savings. The Scheme is currently being strengthened as outlined in the 2022 government response to the Energy Savings Opportunities Scheme consultation.

The government also promotes information and awareness-raising campaigns. In addition, the British Energy Security Strategy from 2022 aims to set up dedicated energy efficiency decarbonisation advice to small businesses.

Information campaigns

The government also promotes information and awareness-raising campaigns. The government offers 100 000 free copies of guidelines for the ISO 50005 energy management standard to help small and medium-sized enterprises develop cost-effective energy management solutions to lower their energy consumption, bills and emissions through a phased implementation approach.

In addition, the British Energy Security Strategy from 2022 confirms the aim to set up "a dedicated energy efficiency decarbonisation advice offering to small businesses".

Carbon capture, utilisation and storage

CCUS is one of the core strategies outlined in the Industrial Decarbonisation Strategy, including by putting in place funding mechanisms to support deployment. Toward this end, the United Kingdom has put in place an industrial CCUS cluster approach, leveraging the fact that many emissions-intensive facilities are located in concentrated geographical clusters and would be able to connect to a large-scale CO_2 storage site using shared infrastructure. The government estimates that the United Kingdom could potentially store around 78 billion tonnes of CO_2, one of the largest capacities in Europe.

The government has committed to deploy CCUS in at least two industrial clusters by the mid-2020s, and four by 2030 at the latest, with an aim to capture and store 20-30 Mt CO_2 per year by 2030. The first two clusters, HyNet and the East Coast Cluster, have already been launched and represent Track 1 of the sequencing process; Track 2 will include clusters planned for 2030.

To support investment in CCUS, in the first quarter of 2023, the government announced GBP 20 billion in capital funding for CCUS. In addition, it has launched a series of business models for CCUS deployment that address commercial barriers to investment through regulatory frameworks and capital and revenue funding. The Industrial Carbon Capture business model includes a capital grant offered through the GBP 1 billion CCUS Infrastructure Fund, along with revenue support through the GBP 140 million Industrial Decarbonisation and Hydrogen Revenue Support scheme.

Hydrogen

Low-carbon hydrogen is a leading option to decarbonise industrial processes that are harder or more expensive to electrify (see Chapter 6). By 2030, UK industry could use an additional 10-21 TWh of hydrogen as an industrial fuel. To stay on track for delivering Carbon Budget 6, hydrogen demand from industry may need to increase up to 45 TWh by 2035. By 2050, based on modelling, low-carbon

hydrogen fuel consumption in industrial sectors could range from 25 TWh (in clusters only) to 105 TWh (in a scenario with widespread national access).

Short-term, low-regret opportunities for hydrogen conversion include steam boilers and co-generation processes in sectors such as chemicals, refineries and paper. In the longer term, hydrogen is a leading option for decarbonising high-temperature direct firing. The government is supporting innovation and testing to bring high-temperature hydrogen technologies to maturity and commercial readiness.

Assessment

Energy demand and emissions from the United Kingdom's industry sector have fallen over the past decade. Nonetheless, the sector still accounts for around a fourth of energy consumption and 14% of energy-related CO_2 emissions (21% including emissions from heat and electricity used in the sector). Moreover, over half of industry energy demand comes from fossil fuels (mainly natural gas), suggesting that the sector requires more concerted efforts to accelerate emissions reductions.

The United Kingdom should be commended for developing the first comprehensive roadmap, including key technological and policy signposts, for reaching net zero emissions from industry under the 2021 Industrial Decarbonisation Strategy. Such a strategic document provides crucial signals to investors to undertake long-term decarbonisation planning. Moreover, the strategy includes a commitment to assess progress annually and update policy action every five years, which will help the government track developments and course correct, as needed. The United Kingdom should build off the strategy to develop roadmaps for specific industrial sectors (e.g. steel, cement) in co-ordination with the private sector, as some other countries have done (Canada, Finland and Sweden, for example).

The UK ETS is an important tool for industrial decarbonisation. To manage carbon leakage, industry receives free allocations of allowances. Upon completion of a review in July 2023, the government is in the process of revising the ETS to align the caps with carbon budgets and net zero targets. A review of free allocations is also underway to better target carbon leakage at the same time that other measures such as a CBAM are also planned for implementation. The ETS can be an effective tool for industrial decarbonisation and the IEA encourages the comprehensive review to balance price signals with carbon leakage. Notably, the UK market could see considerable benefits from linking to the EU ETS, which offers a larger, more liquid market and limits exposure to the EU CBAM for UK industry.

The government has also offered industry significant financial support to undertake decarbonisation efforts.

An important pillar in the decarbonisation of industry will be energy efficiency. Toward this end, the government's Industrial Energy Transformation Fund offers grants for the implementation of energy efficiency measures at industrial sites with high energy consumption, while the Recovery Loan Scheme helps small and medium-sized enterprises access financing to undertake energy efficiency projects. However, compared to the size of the industry sector, the level of support is relatively modest. The government should explore the success of such measures and their benefits in terms of emissions reductions and consider expanding the programmes accordingly. In addition, the government offers several tax incentives and capital allowances to industry to implement energy efficiency and emissions reduction measures. The recent extension of the Climate Change Agreements Scheme by two years and the Industrial Energy Transformation Fund to GBP 500 million are steps in the right direction. Longer term clarity on climate change agreements would further help, in line with the newly announced six-year Climate Change Agreement.

Energy audits can also be an effective way of identifying cost-effective energy-saving measures that companies can implement. In the United Kingdom, the Energy Savings Opportunity Scheme requires energy audits of large companies every four years and offers recommendations to save energy and lower emissions. The UK government, as part of efforts currently underway to strengthen the Energy Savings Opportunity Scheme, should assess ways to ensure that companies follow through with the audits' recommendations. Several countries, for example, include a requirement for a company to implement those measures with the lowest costs and greatest energy savings. Recommendations could also be tied to existing or future financial support programmes. The government should also explore options to encourage energy audits for small and medium-sized enterprises, building off the findings of the Pilot Energy Advice Service.

Beyond energy efficiency, deeper decarbonisation of the industry sector will hinge on technological solutions. To start, electrification of industrial processes will be an important tool to lower emissions. In addition to high upfront costs, the economics of electrification will hinge on the cost competitiveness of electricity relative to other energy sources, especially natural gas. The government should take the necessary steps to ensure that electricity does not face outsized costs, in particular from higher levels of taxation. Moreover, the government should also ensure that electrification is on a level playing field with subsidy-driven hydrogen. This would avoid skewing technology choice based on unequal incentives and could be achieved by developing a business model for industrial electrification, enabling technological neutrality by providing a level of support consistent with other options.

Another major impediment to electrification appears to be the lack of sufficient grid connections. The government should undertake holistic grid planning across the electricity sector, with an eye to expanded demand from industry, to ensure that infrastructure constraints do not get in the way of viable electrification projects moving forward. Clearer guidance on grid planning and timeframes for connections to the industrial sector would help toward this end, as would efforts to expedite grid expansions. The recently announced Connection Action Plan and Transmission Acceleration Action Plan are welcome steps in this direction.

CCUS is a key component of the United Kingdom's Net Zero Strategy, which includes the government's ambition to capture 20-30 Mt CO_2 by 2030. The United Kingdom's cluster approach to CCUS, which leverages regional industrial advantages and ensures a broad geographic coverage, is a good one in principle. More timely decision making should be prioritised, as should consistent funding, to expedite progress on projects and deliver the planned targets.

The 2023 announcement of GBP 20 billion in CCUS investments over the next two decades and "business models" for CCUS are welcome positive steps. As part of the industrial business model, the government should clarify the long-term, stable revenue stream for the CCUS value chain – including capture, transportation and storage – so that the industry can quickly ramp up investment and deliver the carbon savings needed to achieve net zero. This includes sustained high carbon prices as well as clear and consistent funding access. The government could also improve communication to industry, for example through one-stop shops and campaigns targeting the industrial sector.

Commercialisation and adoption of new technologies will be critical to industrial decarbonisation. The government should support the derisking of these new approaches by ensuring that sufficient support is available, particularly for first-of-a-kind commercial deployments.

In the future, low-carbon hydrogen is expected to play a more prominent role in the industry sector, and industry will be a key driver of hydrogen development in the United Kingdom. Toward this end, the United Kingdom's 2021 Hydrogen Strategy sets a clear pathway for hydrogen development and the role it can play in meeting net zero emissions, including in the industrial sector, where electrification may be more challenging than in other sectors. The United Kingdom is also developing a Low Carbon Hydrogen Standard to support industrial producers of hydrogen to decarbonise production. Such efforts will go a long way to support emissions reductions in industry domestically and offer lessons abroad. The government should clarify rules on "revenue stacking" and combining government support schemes, especially on the eligibility of low-carbon hydrogen business models for CCUS cluster funding, to effectively scale low-carbon hydrogen production.

More broadly, an energy hubs model, where low-carbon resources can be combined with existing infrastructure and industrial capabilities to more efficiently manage energy production, storage and transmission, can yield considerable benefits in the UK context, building off the existing cluster approach to planning for CCUS.

Recommendations

The government of the United Kingdom should:

- Support industrial electrification by accelerating grid expansions and grid connections, building on expected electricity planning reforms.
- Ensure longer term continuity of fiscal incentives for energy efficiency and industrial decarbonisation.
- Provide long-term policy clarity to the sector on Emissions Trading Scheme reforms, including free allocation of allowances and the Carbon Border Adjustment Mechanism.
- Ensure that technologies needed for decarbonisation of industry, such as electrification, carbon capture, utilisation and storage; and hydrogen, have appropriate infrastructure and stable, long-term revenue streams.

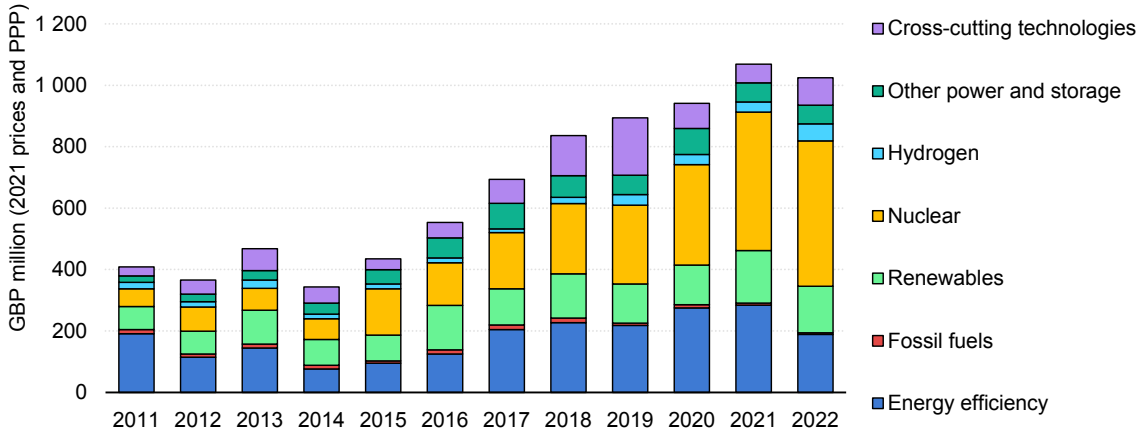
6. Energy research and innovation

The Powering up Britain: Net Zero Growth Plan and the UK Science and Technology Framework set out how R&I is a key enabler for net zero, to drive down the costs of technologies, processes and systems; explore new business models; financing; regulatory frameworks; and the role of consumers. A range of levers are needed to develop and test innovations and bring them to market at scale. This means government-funded R&I, appropriate policy and regulatory support, private sector innovation, investor funding, and academic research all have key roles to play.

Public energy-related R&D funding has steadily increased since 2014, reaching GBP 1.05 billion in 2022. This amounts to 0.042% of GDP, above the IEA average of 0.038%. The largest part of spending in 2022 went to research on nuclear energy (45%), energy efficiency (18%) and renewables (14%). A smaller portion of public R&D funding was allocated to cross-cutting technologies (8%), other power and storage (6%), hydrogen (5%), and carbon capture and storage (2%) (Figure 6.1).

In the future, the government expects a greater shift toward demonstration projects, as it has made major demonstration investments for 2022-25 to ensure that low-carbon technologies are scaled up and ready to support ambitious deployment targets throughout the 2030s and 2040s.

Figure 6.1 Energy-related R&D public expenditure in United Kingdom by sector, 2011-2022



Note: PPP = purchasing power parity.

Source: IEA (2024), Energy Technology RD&D Budgets (database).

Institutional responsibilities

The Energy Innovation Board was set up in November 2016 to provide an opportunity to collaborate at a strategic level across the UK public sector on energy innovation. In December 2020, it revised its Terms of Reference to encompass innovation-related to delivery of the United Kingdom's net zero ambition and was renamed the Net Zero Innovation Board (NZIB). The NZIB provides strategic oversight of public programmes on energy innovation, including assessing how government net zero-related R&I spending is performing and delivering against the challenges from the government's Net Zero Research & Innovation Framework.

The Innovation Delivery Board is a sub-group of the NZIB. It oversees progress and delivery of individual UK government-funded net zero R&I programmes and enhances collaboration and information-sharing among the respective programme leads.

Innovation policies and strategies

The United Kingdom's approach to net zero R&I is outlined in the UK Net Zero Research and Innovation Framework, published in October 2021. The framework's objective is to accelerate investment in research and investment toward net zero by identifying key R&I challenges and needs over the next five to ten years, set out timelines for priorities (in the short, medium and long terms), and provide a framework for future net zero R&D investment decisions. It makes clear that the government continues to be committed to increasing public spending on R&I to GBP 22 billion annually by 2026-27 (2.4% of GDP in 2027).

The government expects to invest approximately GBP 4.2 billion in net zero R&I between 2022 and 2025 and published its Net Zero Research and Innovation Delivery Plan related to this spending in March 2023. The intention is that the government's net zero R&I portfolio will regularly report progress against this Delivery Plan to the NZIB, to inform recommendations and decision making for future spending review rounds, and help develop future public spending priorities.

In 2021-22, the United Kingdom spent GBP 1.1 billion on energy innovation, from basic research to demonstration activities, the highest annual spend for more than 35 years. Total government expenditure on R&D across all sectors is expected to reach GBP 20 billion per year by 2024/25.

As part of this commitment, the UK government launched the GBP 1 billion Net Zero Innovation Portfolio. The portfolio supports innovation in priority areas under power, buildings, industry and disruptive innovations. It builds directly on the government's previous investments (GBP 505 million) in the Energy Innovation Portfolio. This is in addition to the net zero R&I delivered through other

departmental programmes and through UK Research & Innovation (UKRI). Further funding from Ofgem's GBP 450 million Strategic Innovation Fund (GBP 263 million during the current spending review period) is being invested in innovation related to energy networks.

The Green Finance Strategy, updated in 2023, sets out the full spectrum of commercialisation support available, including public R&I funding. This includes the role of public financing institutions such as the UK Infrastructure Bank and British Business Bank in supporting the commercialisation and scale-up of UK companies.

Energy innovation needs assessments take a whole-system view of the energy sector and provide evidence and analysis on the role of different technologies in the United Kingdom's future energy system; potential domestic and export growth opportunities; and where innovation support and investment for those technologies could deliver the greatest benefits. The United Kingdom is currently undertaking a refresh of its energy innovation needs assessment analysis to reflect updated net zero considerations.

The 2021 Innovation Strategy and the 2023 UK Science and Technology Framework set out the government's vision to make the United Kingdom a global hub for innovation by 2035. The government aims to boost private sector investment across the whole United Kingdom, creating suitable conditions for businesses to innovate and giving them the confidence to do so. UKRI is the country's national R&I agency that supports innovation across sectors, including the energy sector, offering a number of funding programmes aligned with net zero goals.

For example, UKRI's Investor Partnerships future economy programme (GBP 80 million over three years) aligns Innovate UK's grant funding with investor partners' funding and expertise. The programme's goal is to encourage R&D in micro, small and medium-sized enterprises by attracting capital toward them at an early stage. Innovate UK has also supported successful programmes, such as the Living Lab initiative that allows innovators to trial products or services in UK homes.

Monitoring and evaluation

Assessment of R&I progress includes reporting by departments and public sector spending bodies to the NZIB and Innovation Delivery Board on the programmes and initiatives covered by the current Net Zero Research and Innovation Delivery Plan for a strategic view on progress. This will be informed by project management information gathered by each department, such as key performance indicators and milestones agreed at programme inception. This will help to ensure that individual programmes have effective governance over delivery and will enable

the NZIB to consider and develop recommendations for future prioritisation and spending across the portfolio. Evaluation best practice is being considered by the Innovation Delivery Board, which will then in turn report on progress to the NZIB.

The Delivery Plan is a baseline from which to measure the progress and success of the government's net zero R&I portfolio over the next few years and help with future prioritisation and spending decisions, including those that can unlock private sector investment. An update is expected to be published by the end of the Spending Review period in 2025. This should be the start of a process of tracking the R&I needed to support the delivery of the United Kingdom's net zero target out to 2050. Subsequent plans, covering future Spending Review periods, will continue to improve reporting on the outcomes of programmes and will be based on the most up-to-date learning and achievements from the current portfolio.

International collaboration

The United Kingdom considers Mission Innovation to be the primary international forum to strengthen co-operation on clean technology development. The United Kingdom is co-lead for the Clean Hydrogen and Green Powered Future Missions and is a core member of the Zero Emission Shipping Mission. The United Kingdom has also associated to the Horizon Europe R&I funding programme. It additionally participates in around half of IEA Technology Collaboration Programmes and serves as a Steering Committee member and funder of the Clean Energy Ministerial Secretariat, and co-lead/participant in many Clean Energy Ministerial workstreams.

Hydrogen

The UK government considers hydrogen to be a critical component of its energy security and net zero plans, and expects hydrogen development to offer considerable economic opportunities in industrial regions.

The UK Hydrogen Strategy published in August 2021 outlines a comprehensive roadmap for the development of the wider hydrogen economy over the 2020s to deliver the government's 2030 ambition. The Strategy sets a target to deliver 5 gigawatts (GW) of hydrogen by 2030. The semi-annual UK Hydrogen Strategy Updates to the Market outline government progress against these ambitions. The British Energy Security Strategy doubled the target to 10 GW by 2030, with at least half coming from electrolytic hydrogen, and up to 1 GW of electrolytic hydrogen by 2025. The target will be subject to affordability and value for money, drawing on the scale-up of UK offshore wind and other renewables and new nuclear.

The Hydrogen Sector Development Action Plan (July 2022) sets out actions that the government and industry will take to maximise the economic benefits of the hydrogen economy. The Action Plan focuses actions for sector development on

investment, supply chains, jobs and skills, and trade and exports. The Hydrogen Investment Roadmap (April 2023) lays out investment opportunities across the hydrogen value chain – from production through transmission and storage to the range of potential end-uses, including industry, power, transport and heating.

The United Kingdom offers support to hydrogen production projects under the Net Zero Hydrogen Fund (up to GBP 240 million) and Hydrogen Production Business Model. A shortlist of 20 projects were invited to the due diligence stage, for a total capacity of 408 megawatts (MW). The United Kingdom announced funding for 11 of these projects in December 2023, for up to 125 MW of new hydrogen. In addition, the Low Carbon Hydrogen Supply 2 Fund has provided around GBP 60 million of support to innovation in hydrogen production methods, including funding ten ongoing demonstration projects.

To support the development of a hydrogen economy, the United Kingdom has put in place a Low Carbon Hydrogen Standard to help ensure that hydrogen production pathways align with GHG reduction targets. The Standard defines what constitutes "low-carbon hydrogen" at the point of production. It sets out a detailed methodology for calculating the emissions associated with hydrogen production and the requirements producers are expected to meet to prove that the hydrogen they produce is compliant. The government intends to update the Standard following regular reviews to ensure that the guidance remains fit-for-purpose and reflects emerging technological and policy developments globally.

The United Kingdom is also taking significant steps to support the deployment of electrolytic hydrogen production, with published aims of at least 5 GW of electrolytic hydrogen capacity by 2030, supported by hydrogen allocation rounds. An announcement was made in December 2023 regarding successful projects for the first electrolytic allocation round (HAR1), offering support from the GBP 240 million Net Zero Hydrogen Fund (capital funding) and from the Hydrogen Production Business Model (revenue support). The United Kingdom launched the second hydrogen allocation round (HAR2) in December 2023, which will support up to 750 MW of low-carbon hydrogen production (subject to affordability and value for money).

Carbon capture, utilisation and storage

CCUS is considered instrumental to meeting the United Kingdom's net zero ambitions across economic sectors, including for industrial decarbonisation, low-carbon power, engineered GHG removal technologies and delivering hydrogen ambitions.

The UK approach focuses on establishing CCUS "clusters", which take advantage of the fact that many emissions-intensive facilities are located in concentrated geographical areas and would be able to connect to a large-scale CO_2 storage

site using shared infrastructure. The 2020 Ten Point Plan for a Green Industrial Revolution included the aim to support CCUS in four industrial clusters by 2030, including at least one power plant equipped with carbon capture.

The 2021 Net Zero Strategy laid out the government's ambition to capture and store 20-30 Mt CO_2 per year by 2030.

Assessment

UK spending on energy-related R&I has been steadily increasing since 2014, reaching a record high in 2021 of around GBP 1.1 billion, or 0.046% of GDP, above the IEA average of 0.038%. In 2022, energy-related R&I spending slightly decreased to GBP 1.05 billion. In its Net Zero Research and Innovation Delivery Plan, the government expects to invest approximately GBP 4.2 billion in net zero R&I between 2022 and 2025, with regular reporting to inform decision making. The IEA commends the United Kingdom's systematic incorporation of energy technology into its net zero strategies, backed by financial resources. The efforts will position the United Kingdom well to push energy transitions faster and potentially capitalise economically on technology leadership.

R&I investment in the United Kingdom covers a wide range of technologies (with the largest share historically dedicated to nuclear), which has the advantage of providing a large portfolio of options to achieve energy and climate targets. However, the time to achieve net zero is limited and it would be beneficial to focus on a set of the most impactful net zero R&I initiatives and encourage private sector investment in the areas that have greater potential for supporting the net zero target. The current refresh of energy innovation needs assessment analysis is a welcome step in this direction.

Better alignment of programme resourcing and delivery with innovation cycles rather than spending review cycles would enable more responsive and impactful R&I programming. The government should develop market mechanisms to provide an ongoing base level of funding for energy R&I that would enable greater flexibility in programme delivery and provide clear long-term signals to support private sector investment in net zero innovation priorities.

Particular focus should be given to strengthening connections across phases of innovation and ensuring that supports are in place to scale and commercialise net zero technologies, building on existing work such as UKRI's Investor Partnerships Initiative. The government should ensure that emerging clean technology firms have viable instruments to grow, by facilitating their access to growth capital and project financing, particularly for first-of-a-kind commercial projects. This could be done by developing new tools or adapting existing ones, such as the UK Infrastructure Bank. The government could also use public procurement to develop lead markets for net zero-aligned products. This would provide investible

demand signals to support industrial decarbonisation (e.g. green steel and lower carbon cement and concrete) and the expansion of emerging sectors, such as GHG removal technologies.

Nuclear is an important technology in the United Kingdom's net zero strategy, with advanced nuclear reactors, including SMRs, expected to play a key role, notably in the power sector. Advanced nuclear technologies could also potentially help decarbonise hard-to-abate sectors, such as high-temperature heat for industry, district heating and hydrogen production. The United Kingdom has developed an ambitious innovation agenda for advanced nuclear technologies as outlined in its key documents, such as the 2021 Net Zero Strategy, the Ten Point Plan for a Green Industrial Revolution, Powering Up Britain, the British Energy Security Strategy and, more recently, the UK Civil Nuclear Roadmap to 2050. In addition to the UK Advanced Modular Reactor demonstrator programme, the government is working to clarify the contributions of advanced nuclear technologies to support decarbonisation in hard-to-abate sectors.

As international collaboration will be instrumental to unlocking and expanding the penetration of clean energy technologies, the United Kingdom has demonstrated leadership on energy innovation in international fora. This includes Mission Innovation, where the Unted Kingdom plays a leading role in multiple workstreams, alongside participation in around half of the IEA's Technology Collaboration Programmes, many Clean Energy Ministerial activities and several Nuclear Energy Agency working groups.

The UK government considers hydrogen to be a critical component in its energy security and net zero plans, and it expects hydrogen development to offer considerable economic opportunities in industrial regions.

The Net Zero Hydrogen Fund and Hydrogen Production Business Model provide support to hydrogen production projects. It is encouraging that a shortlist of 20 projects was invited to the due diligence stage. However, a tight schedule needs to be followed to deliver the 2025 and 2030 production targets.

The United Kingdom is investing to incentivise hydrogen demand across sectors, mainly relying on the UK ETS scheme to incentivise low-carbon hydrogen uptake in the industry, power and aviation sectors, and in due course domestic maritime transport. Carbon pricing should be combined with other policy instruments, such as mandates, quotas and hydrogen-specific requirements in public procurement, to help the industry derisk investment and improve the economic feasibility of low-emissions hydrogen. The IEA also recommends focusing investment and incentives on using low-emissions hydrogen to displace unabated fossil fuels in those sectors where other clean energy alternatives are limited or costly.

Recommendations

The government of the United Kingdom should:

- Ensure stable funding to match timelines for delivering effective programmes to unlock the most impactful net zero technologies, and to encourage private sector investment in these areas.
- Share and apply insights across the entire research and innovation portfolio, with a particular focus on bridging the gap toward later stages of the innovation cycle.
- Improve access to capital to accelerate the scale-up of emerging clean technology firms and ground-breaking commercial projects. Utilise government procurement to support industrial decarbonisation and the expansion of emerging sectors, such as greenhouse gas removal technologies.
- Clarify the contributions that advanced nuclear technologies are expected to play in support of nuclear targets and net zero ambitions, particularly in hard-to-abate sectors, building on the Civil Nuclear Roadmap to 2050.
- Provide a clear and stable framework for accelerating the commercialisation and market adoption of the most scalable demonstration projects for new, low-carbon hydrogen technologies across the value chain.

7. Oil and gas

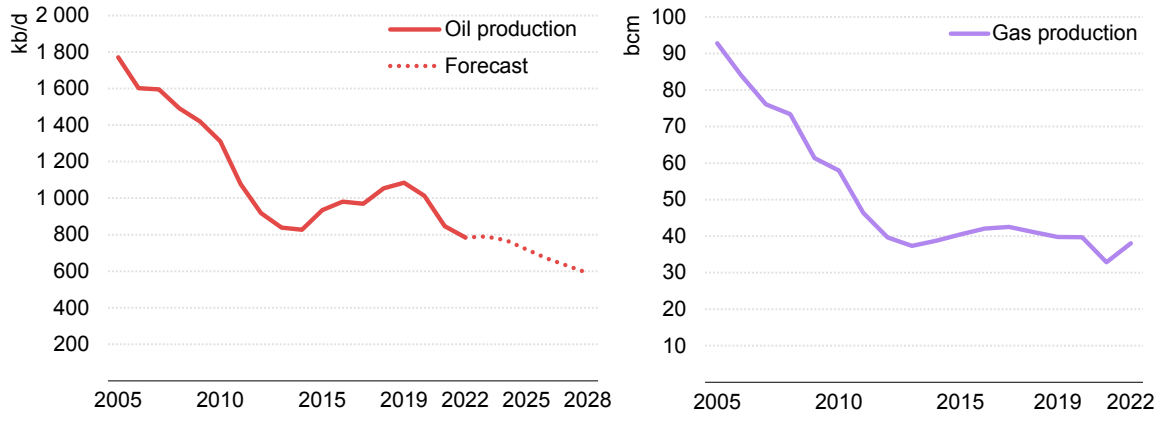
Upstream oil and gas

Oil and gas production

Offshore oil production in the United Kingdom has been on a long-term declining trend despite additional production from new fields and incremental projects in existing ones. With only a handful of large undeveloped discoveries under active consideration for development, the production decline is expected to continue, albeit at a slower rate, to 2050. With continuing production and very limited reserve replacement through commercial discoveries, oil reserves have continued to fall. The North Sea Transition Authority (NSTA) estimates that proven and probable UK Continental Shelf (UKCS) oil reserves at the end of 2022 will be 2.7 billion barrels of oil equivalent. IEA projections expect UK oil production to continue its decline until at least 2028 (Figure 7.1).

Like oil, offshore gas production in the United Kingdom is on a long-term declining trend. UK gas production peaked in 2000 and declined rapidly through to 2013. Production then plateaued until 2020 before a decline in 2021. This was subsequently followed by a recovery in 2022 as Covid measures eased (Figure 7.1). However, with few new gas developments under consideration and limited exploration prospects, rapid decline is now expected to 2050. The government's policy is to support maximising UK gas supply as the North Sea basin declines and minimising reliance on imports.

Figure 7.1 Oil and gas production and forecast in the United Kingdom, 2005-2028



Notes: kb/d = thousand barrels per day; bcm = billion cubic metres.
Sources: IEA (2024), World Energy Balances (database); IEA (2023), Oil 2023 (database).

Industry structure

The United Kingdom's oil and gas sector is dominated by production from offshore areas across the UKCS and almost 300 fields. Previously, the oil and gas majors dominated, but in recent years investment in the North Sea has seen increased activity by independents and private equity-backed players. However, a few large international majors still account for 35% of reserves and over 15% of all UK licensed acreage, which includes significant legacy acreage retained from earlier licensing rounds. Private equity-backed and independent companies are now one of the larger acreage holders, with over 50% of net acreage.

Overall, the oil and gas industry brings sizeable economic benefits to the United Kingdom, including on average GBP 16 billion to the UK economy annually (2018-22). The sector supported around 200 000 British jobs in 2021 (direct, indirect and induced), approximately 43% of which were based in Scotland, and is expected to pay around GBP 28 billion in tax revenue over the next five years.

Regulatory regime

Development proposals for oil and gas fields are dealt with by the NSTA and the Offshore Petroleum Regulator for Environment and Decommissioning (OPRED). Project proposals can cover a range of activities, including exploration and appraisal of potential sites; development of new fields to enable production; redevelopment or retrofitting of existing fields or infrastructure; restarting production from existing fields or infrastructure that have ceased operation; and decommissioning or repurposing existing infrastructure.

It typically takes around five years (or more), depending upon investor sentiment and field complexity, from the award of a licence to first production, and not all licences lead to production. There are several necessary consents after licensing and before production to ensure all developments meet the required safety and environmental standards. Development and initialisation of supporting infrastructure is required before first production. Legal challenges can also lead to project delays.

The government introduced the Climate Compatibility Checkpoint to ensure that the compatibility of new licensing with the United Kingdom's climate objectives is assessed before a decision to endorse a new licensing round is taken. The Checkpoint does not have a legislative basis, and is instead presented as an informative, data and narrative-based exercise designed to inform ministers on whether to endorse the NSTA in launching a new licensing round. The Checkpoint tests benchmark UK production emissions against other producers, and checks sector progress in delivering commitments in the North Sea Transition Deal.

Looking to the future, the Checkpoint considers forecasted supply and demand data to assess whether the United Kingdom is expected to remain a net importer of oil and gas.

The Offshore Petroleum Licensing Bill, currently progressing through parliament, includes two tests, which if passed will require the NSTA to run an annual process for new licences in the UKCS. The tests require that the United Kingdom be projected to remain a net importer of both oil and gas and that carbon emissions associated with UK gas is lower than imported liquefied natural gas (LNG).

The British Energy Security Strategy announced the Gas and Oil New Project Regulatory Accelerator, a cross-regulator project to cut approval times for licence and environmental consents to help bring forward production dates, subject to environmental considerations.

In November 2019, the government placed a moratorium on shale gas exploration in England and committed to not support hydraulic fracturing barring unequivocal evidence that it can be done safely. In late 2022, this position was briefly reviewed in light of high gas costs, but the government confirmed that it would continue to maintain the moratorium. There are no plans to develop any unconventional oil or gas in the United Kingdom.

The United Kingdom does not offer any subsidies for oil and gas production.

The 32nd Offshore Licensing Round was launched in July 2019. The NSTA offered for award 113 licence areas for oil and gas to 65 companies. The NSTA launched the 33rd offshore oil and gas licensing round in October 2022, receiving 115 bids from 76 different companies and awarded 51 licences in the first 2 traches.

Energy profits levy

The United Kingdom implemented a fiscal response to high oil and gas prices in 2022 by introducing the Energy Profits Levy (EPL) in May 2022, recognising that profit levels in the sector had increased significantly due to global circumstances, including Russia's invasion of Ukraine. The EPL is a temporary 35% surcharge on company profits, on top of the default 40% headline tax rate applied to profits from UK oil and gas production, bringing the overall combined tax rate to 75%, one of the highest rates globally. The Levy will remain in place until March 2028. However, if prices fall below historically normal levels over a sustained period, the tax rate for oil and gas companies will return to 40%.

The EPL includes an investment allowance, under which companies can claim around GBP 0.90 in tax relief for every GBP 1 they invest. This relief increases to GBP 1.09 for every GBP 1 invested in reducing GHG emissions from the production of oil and gas.

The Office for Budget Responsibility expects the EPL to raise nearly GBP 15 billion from 2022-23 to 2027-28 (on top of fiscal receipts of around GBP 13 billion from the permanent tax regime).

Decommissioning

The oil and gas sector will play an important role in the decommissioning of legacy oil and gas assets or repurposing them to support the delivery of new energy technologies. Owners of offshore oil and gas infrastructure, including wells, must fulfil their obligations to decommission in accordance with statutory requirements and remediate the marine environment consistent with government policy.

OPRED is responsible for regulating decommissioning activity, including ensuring compliance with the Petroleum Act 1998. Government policy for infrastructure is outlined in OPRED Guidance Notes, which explain that decommissioning must aim to achieve a clear seabed. Additional, specific requirements for wells are outlined in offshore production licences, requiring wells to be decommissioned in accordance with an approved specification.

The NSTA's Decommissioning Strategy sets out obligations, expectations and priorities for owners of redundant offshore oil and gas infrastructure to consider repurposing infrastructure once hydrocarbon production ends. The NSTA has also conducted analysis exploring possible pipelines suitable for repurposing. However, repurposing ultimately will depend on the market for possible alternative uses, such as CCUS or hydrogen.

Prior to planning for decommissioning, operators must evaluate the repurposing potential for assets. This is meant to be done during the late life operating phase, at least six years prior to the expected cessation of production.

Decarbonising oil and gas production

The NSTA expects the upstream oil and gas industry to reduce GHG emissions from all parts of upstream operations, as far as reasonable based on circumstances. Investments to decarbonise upstream production take many forms, such as improvements to increase operational efficiency (and reduce associated emissions), reduce flaring or venting of gases produced during production, and electrify offshore production platforms to reduce or remove dependencies on diesel or natural gas turbines that power offshore operations.

North Sea Transition Deal

In 2021, the UK government agreed the North Sea Transition Deal with industry. The deal supports workers, businesses and the supply chain through the energy transition by leveraging the industry's existing capabilities, infrastructure and

private investment potential to develop new and emerging technologies such as hydrogen, CCUS, offshore wind and decommissioning. Under the deal, industry has committed to take action to reduce emissions from oil and gas production by 10% by 2025, 25% by 2027 and 50% by 2030 (relative to 2018). Through the package of measures, the deal is expected to cut pollution by up to 60 million tonnes (Mt) by 2030, including 15 Mt from oil and gas production on the UKCS.

As part of monitoring progress toward the North Sea Transition Deal targets, the NSTA publishes an annual Emissions Monitoring Report that summarises current progress against targets and provides examples of emissions mitigation measures.

All installations involved in the production of hydrocarbons from the UK carbon sink are expected to have GHG emissions reduction action plans. The NSTA's Strategy outlines the expectation for flaring, venting and associated emissions to be at the lowest possible levels, with zero routine flaring and venting by 2030.

Workforce

The offshore oil and gas sector is a major employer, responsible for around 120 000 direct and indirect jobs in 2021. Research by Robert Gordon University reported that over 90% of the United Kingdom's oil and gas workforce have medium to high skills transferability and are well positioned to work in adjacent energy sectors. It also forecast that around 200 000 people will be required in 2030 to underpin the United Kingdom's offshore wind, hydrogen, CCUS, and oil and gas sectors.

The North Sea Transition Deal estimates that decarbonisation investment in the sector could support up to 40 000 direct and indirect jobs as part of efforts to decarbonise offshore oil and gas production. This includes opportunities for reskilling the existing oil and gas workforce along with new entrants to the sector. The deal commits the sector to creating an integrated people and skills plan, with measurable objectives, to support its transition and diversification.

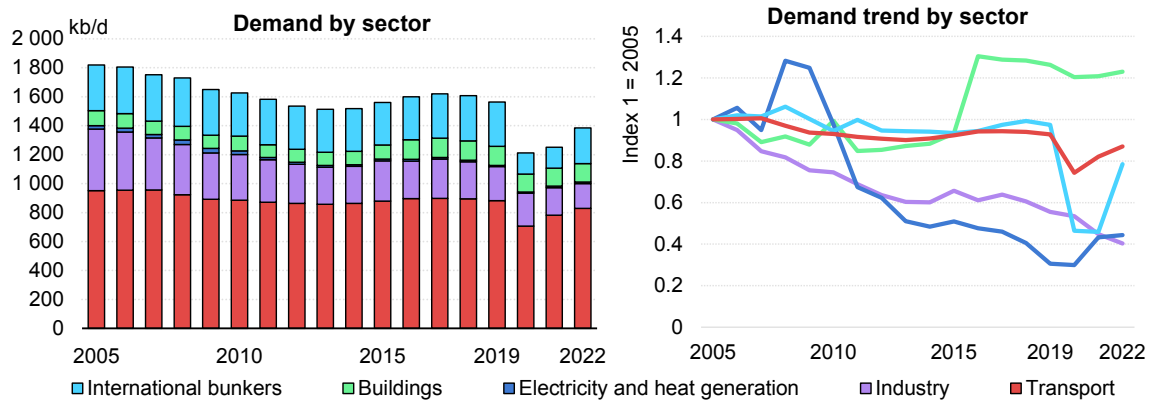
Oil

Oil products demand

Oil products are used primarily in transport, which in 2022 accounted for 60% of total oil products demand, followed by international bunkers (18%), industry (12%) and buildings (9%). In 2022, diesel accounted for - of total demand, followed by gasoline (20%) and jet kerosene (19%). Energy demand for oil products has declined over the years, from 1 819 kb/d in 2005 to 1 385 kb/d in 2022. Notably, in 2020, there was a sharp drop in demand for oil products, reaching its lowest

level at 1 212 kb/d. Despite the rebound in 2021 and 2022, oil demand has stayed well below its 2017 peak (Figure 7.2).

Figure 7.2 Oil products demand and trend by sector in the United Kingdom, 2005-2022

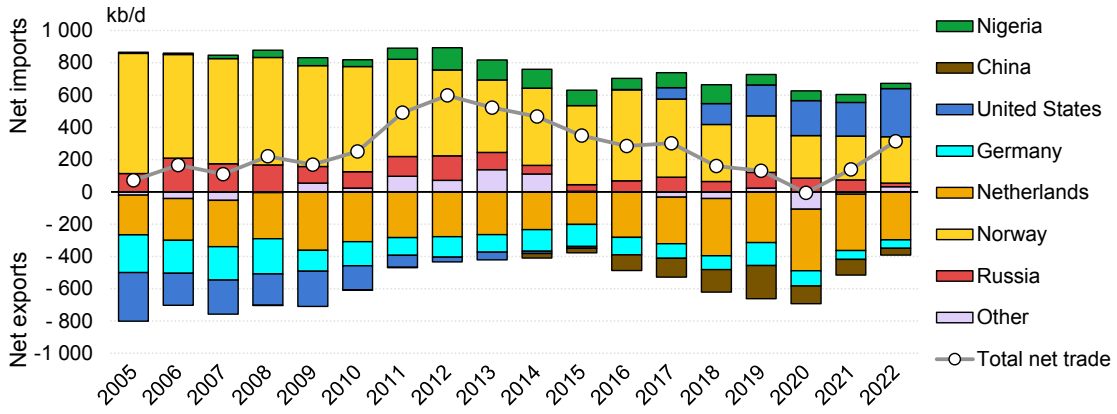


Source: IEA (2023), Oil Information (database).

Trade

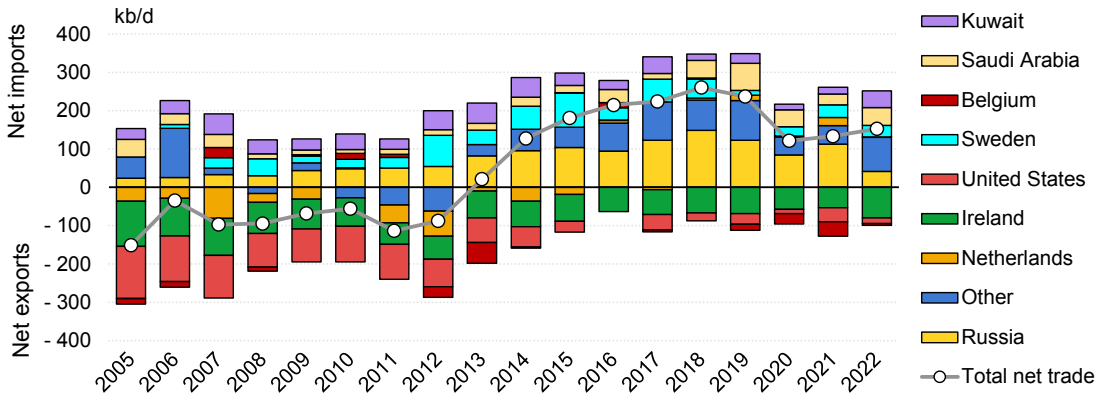
The United Kingdom is a net importer of both crude and oil products. In 2022, net imports of crude oil primarily came from Norway and the United States, while the main crude oil export destinations were the Netherlands and the People's Republic of China (Figure 7.3). In the same year, the primary countries for net imports of oil products were Russia, Sweden and Saudi Arabia, while the primary destinations for net exports were Ireland, the United States and Belgium (Figure 7.4).

Figure 7.3. United Kingdom's crude oil net trade by country, 2005-2022



Source: IEA (2023), Oil Information (database).

Figure 7.4 United Kingdom's oil products net trade by country, 2005-2022



Source: IEA (2023), Oil Information (database).

The UK government declared its intention to end oil imports from Russia shortly after Russia's invasion of Ukraine and worked with an industry taskforce to implement it. A statutory ban on the import of oil from Russia took effect in December 2022.

The United Kingdom is expected to increase net imports in future years as North Sea production decreases. While oil demand is projected to fall by an average of 1.6% per year over the next ten years, oil production is estimated to drop by an average of 5.8% annually, with increased imports filling the gap.

Infrastructure

The United Kingdom has an extensive network of oil pipelines, most of which carry refined products. There are six major refineries in the United Kingdom with three smaller refineries dedicated to specialised products. The six major oil refineries are all coastal and have a combined capacity of 1.3 million barrels per day (62 Mt per year). The United Kingdom also has 41 coastal terminals and 20 inland terminals that are used for petroleum products.

The planning and development of new oil (and gas) infrastructure in the United Kingdom is driven by the commercial decisions of independent energy companies. The government's role is to license and regulate the development of energy infrastructure while ensuring the United Kingdom remains an attractive place for private investment.

Industry structure

The downstream oil sector comprises over 200 companies involved in the refining, importing, distribution and marketing of petroleum products. The sector is

estimated to support the employment of over 100 000 people and contributes a significant amount to the Exchequer's total receipts through duty and tax payments.

Due to shifting market conditions and a longer term trend toward lower consumption, the UK sector has been facing a number of changes. These include fragmenting supply chains with major oil companies, which previously ran vertically integrated well-to-pump operations, divesting assets or outsourcing some operations. The sector is also facing relatively high utilisation rates and closures of capacity in the available infrastructure. For example, there are currently 6 UK oil refineries, down from a high of 19 in 1975, and the number of filling stations has declined from around 18 000 in 1990 to under 8 400 in 2023. The market expectation is that continued improvements in vehicle fleet efficiency and the development of EVs will continue to produce a long-term reduction in demand for transport fuels and change in the product mix. Global expansion of refining capacity also affects the UK and European fuel sector by reducing margins in the domestic and export markets.

Overall, for both wholesale and retail, the United Kingdom generally operates an open market with prices set by the market. There are some exceptions to this in the downstream sector, however.

The fuel retail market is highly competitive and fragmented between a wide variety of brands, owners and operators. Hypermarkets have a significant market share of fuel sales in the United Kingdom.

Retail competition

There are currently no regulations or controls on crude oil or oil product prices in the United Kingdom.

However, following the sharp rise in fuel prices following Russia's invasion of Ukraine in 2022, the Competition and Markets Authority (CMA) was asked to review and consider the health of competition in the road fuel market. The CMA reported in July 2022, and found that the retail market appeared relatively competitive, with some weaknesses in competition. The findings prompted the CMA to carry out a year-long market study to explore whether the retail fuel market has adversely affected consumer interests. Based on the findings from its July 2023 report, it recommended the government introduce a statutory open data scheme for transport fuel prices and an ongoing price monitoring function, which the government accepted. In the interim, the CMA has created a voluntary scheme for fuel retailers to share up-to-date road fuel prices daily.

Demand destruction policies

In 2023, the government committed to the transition to net zero, including phasing out the sale of internal combustion engines by 2035 (from the previous target of 2030). The Department for Transport has also consulted on a Zero Emissions Vehicle Mandate, which will set statutory targets for the share of ZEVs leading up to 2035.

The government also has a number of policies in place to promote the use of biofuels in transport to displace oil consumption (see Chapter 4).

The United Kingdom expects domestic demand for road fuels to fall over the next 10-20 years. UK refinery owners and operators are involved in significant industrial projects to capture carbon and produce hydrogen, with schemes set up for significant government investment in these industrial clusters.

In the heating sector, the government remains committed to transitioning to clean home heating, including through heat pumps. A recent announcement stated that homes will not have to switch before 2035 and the government will make exemptions and offer financial assistance through the Boiler Upgrade Scheme.

Oil security

The procedures to operate the United Kingdom's oil stockholding regime are well established. Since January 2021, the United Kingdom is no longer subject to a consumption-based obligation under the EU Directive, instead being bound only by the IEA requirement to hold 90 days of net imports. This change meant the UK obligation was reduced by around 60%, though actual stocks only dropped from around 15 Mt to an average of 9.5 Mt.

The United Kingdom manages its IEA obligation by directing large suppliers (refiners and importers who supply more than 50 000 tonnes to the UK market in a 12-month period) to hold stocks. Companies can either hold physical stocks in their own storage or purchase "tickets" to cover their obligation (contractual arrangements where a third party holds stocks on behalf of an obligated entity). In the event of a stock release, the government temporarily reduces the obligation on companies by the agreed amount to free up stocks to release to the global oil market.

The National Emergency Plan for Fuel (NEP-F) sets out the government's approach to maintaining the continuity of fuel supplies in Great Britain. The Plan is intended for use by the downstream oil supply industry, local resilience fora (in England and Wales) and regional resilience partnerships (in Scotland), and resilience planners for essential services. It specifies the role each should play to

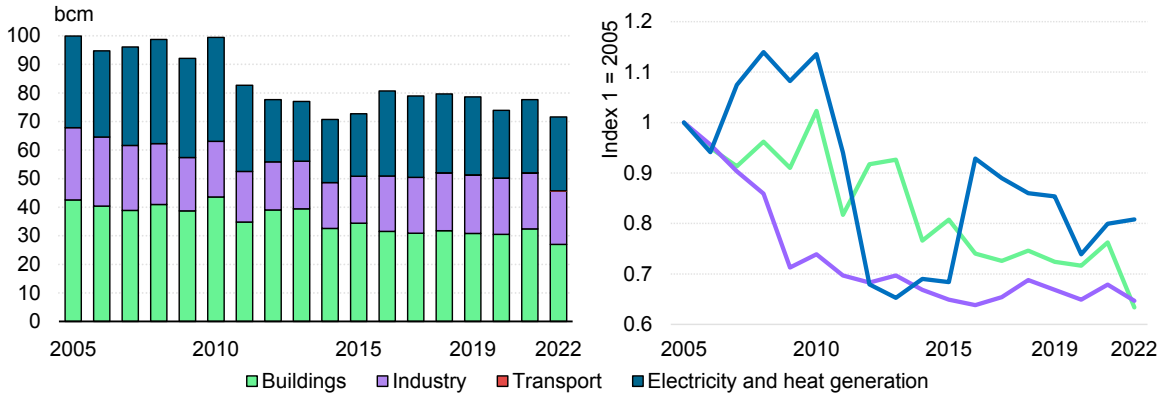
prepare for or respond to a fuel supply crisis, clarifies the government's approach, and sets the context for the level of fuel resilience appropriate to maintain essential services.

Natural gas

Natural gas demand

Natural gas is used in the United Kingdom for space heating in buildings (38% of total gas demand in 2022), electricity generation (36%) and industry (26%). Natural gas demand decreased in all sectors from 100 bcm in 2005 to 72 bcm in 2022 (Figure 7.5). Peak demand, which is heavily influenced by weather, reached 416 million cubic metres (mcm)/day in December 2022.

Figure 7.5 Natural gas demand by sector and its trend in the United Kingdom, 2005-2022



Source: IEA (2023), Natural Gas Information (database).

Under net zero scenarios, natural gas demand is expected to steadily decline through 2050, though in less ambitious scenarios it still plays an important role in the energy system, especially for home heating.

Trade

Disruption to global gas supply following Russia's invasion of Ukraine saw substantial shifts in UK trade patterns. Natural gas exports tripled in 2022 compared to 2021, reaching a record high (Figure 7.6). Total imports also reached a record high, up 10%, driven by a significant increase in LNG imports, up 74%.

Net imports of natural gas increased from 2005 to 2010 as production decreased, to then stabilise with annual fluctuations until 2022. The main source of natural gas imports is Norway, rising from 11.6 bcm in 2005 to 31 bcm in 2022. Imports

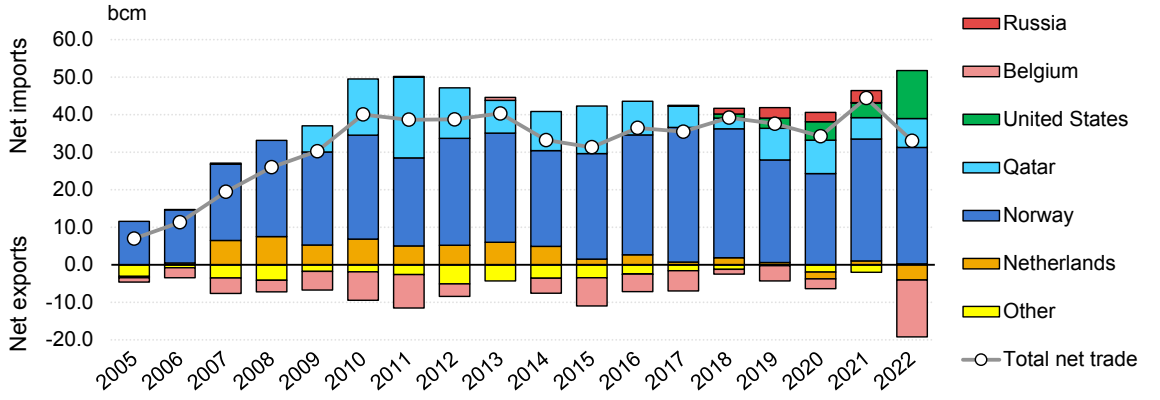
from the Netherlands were significant until 2014, when the country's gas production started to decline. Since 2009, the United Kingdom also imports LNG from Qatar, and since 2017 from the United States, which supplied a record high of 13 bcm of gas to the United Kingdom in 2022 (Figure 7.6). Belgium is the main country to which the United Kingdom exports gas, with a record high of 15 bcm in 2022.

The United Kingdom has the second-largest LNG regasification infrastructure in Europe (after Spain), which was utilised to support European efforts to shift away from Russian gas. The United Kingdom operated as a land bridge using interconnectors for exports to Belgium and the Netherlands.

LNG accounted for almost half of total imports in 2022, with imports from the United States overtaking those from Qatar for the first time. US LNG accounted for half of total LNG imports and 22% of total imports.

Under the Electricity System Operator's Future Energy Scenarios to 2050, UK gas exports will fall from 2025 based on increased LNG storage infrastructure in continental Europe. The United Kingdom will remain reliant on imports, likely supplied predominantly from Norway and continental Europe.

Figure 7.6 United Kingdom's natural gas supply by source, 2005-2022



Source: IEA (2023), Natural Gas Information (database).

Industry structure

The GB gas transmission and distribution systems are operated by independent private companies and are not subject to public ownership. The energy regulator, Ofgem, has an obligation to ensure any undertaking that owns a transmission/distribution system is certified as independent from generation and supply interests before being designated as a system operator.

National Gas Transmission (NGT) owns and operates the gas transmission network, known as the National Transmission System (NTS). The NTS transports gas to the distribution networks and large NTS consumers. NGT has the right to buy, sell and store gas only to keep the system in balance across Great Britain.

Users of the NTS can obtain commercial rights to transport gas on the NTS by buying capacity via a variety of competitive auctions or application processes.

In 2023, there were 20 gas distribution system operators (not including site-specific gas transporters); 8 regional, regulated monopolies, owned and managed by 4 companies after National Grid sold its majority stakes in distribution activities in 2016; and 15 smaller gas distribution system operators.

As gas network companies operate as natural monopolies, Ofgem sets price controls to ensure that infrastructure investment is delivered at a fair price for consumers.

The Energy Act 2023 calls for the creation of a FSO that brings together the planning for the electricity, natural gas and hydrogen systems, and potentially systems for new technologies, into a single institution (see Chapter 1). The government is in the process of establishing the NESO to fulfil this requirement.

Infrastructure

The United Kingdom benefits from diversity of gas supply sources, with a large share of direct flows coming from the Norwegian Continental Shelf. The country also has two bi-directional interconnectors with Belgium and the Netherlands.

The government is working with industry to increase LNG import capacity at the Grain and South Hook LNG terminals. The upgrade at Grain LNG is already underway and will increase the terminal's annual import capacity in 2025. South Hook LNG announced a final investment decision in November 2022 to increase terminal capacity. Once completed, the two projects will together increase the United Kingdom's LNG import capacity to around 59 bcm.

The United Kingdom currently has 8 gas storage facilities with a combined capacity of 3.13 bcm and a total maximum delivery capacity of around 130 mcm per day. The largest facility is Rough, operated by Centrica, which was re-opened in winter 2023/24, and increased the United Kingdom's gas storage capacity by approximately 50%. Centrica has announced additional capacity will be added ahead of the coming winter. There are an additional seven storage projects (for a total capacity of 8.7 bcm) that are planned but have not taken FIDs yet.

At the transmission level, the NGT and Ofgem have agreed a total expenditure allowance of approximately GBP 2 billion for the 2021-26 price control period. Most of the spending has been directed toward maintaining a safe and resilient transmission network.

At the distribution level, gas distribution networks and Ofgem have agreed on a total expenditure of GBP 9.7 billion over the 2021-26 price control period. Approximately GBP 4.1 billion of this will be repair expenditure, with GBP 1.9 billion capital expenditure and GBP 3.6 billion for operational expenditure.

Market overview

Wholesale market

The wholesale gas market has one price for gas irrespective of where the gas comes from, cleared at the National Balancing Point (NBP). Rising NBP prices have provided a strong incentive for gas flows from flexible sources, such as LNG, to the GB market.

Gas shippers play an important role in the GB wholesale gas markets as they are the only entities licenced to buy and sell gas. They also own all the gas in the network, contracting with gas transporters to carry the gas to where it is required. As of 2023, there were over 290 gas shippers licenced by Ofgem (though not all are active).

Retail market

As of 30 June 2023, there were approximately 24 million gas meters operated by large energy suppliers in households across the United Kingdom and around 0.8 million non-domestic gas metering points.

Energy retail suppliers in the United Kingdom buy electricity and gas in the wholesale market and sell it on to customers, the majority of whom (on average 70% of electricity customers and 80% of gas customers) buy both gas and electricity from the same supplier via a “dual fuel account.” The Default Tariff cap, set by Ofgem, limits the amount that suppliers can charge household customers on default tariffs.

The UK retail energy market is a liberalised, competitive marketplace with all types of customers able to switch supplier based on price and service. However, due to the recent gas-price crisis, competition and switching has been low in recent years, with few differentiated products, services and non-variable tariffs available to the household sector. In the non-household market, a majority of contracts are fixed-rate, historically ranging from one to five years.

Following a period of large amounts of market entry, the domestic retail gas market has seen considerable consolidation since the summer of 2021, due to supplier exits.

Gas pricing

Domestic customers can opt for a fixed tariff, where the rate is set by the supplier, or a standard variable tariff, which is capped by Ofgem's default tariff cap. With fixed tariffs, suppliers can structure and pass on costs to customers as they chose. With standard variable tariffs capped by the Default Tariff cap, Ofgem sets the maximum price that suppliers can charge per unit of energy for each element of the cap. Ofgem's sets a new cap level each quarter.

Wholesale prices have increased in recent years, driven by a combination of external factors, including increasing demand, following recovery from Covid-19 and Russia's invasion of Ukraine. As a result, direct fuel costs have increased, making up a larger proportion of a typical consumer's gas bill (around 60% in Q4 2023, up from around 40-50% historically).

In response to unprecedented rapid and significant energy bill increases, the government stepped in to provide temporary support for energy consumers. For domestic consumers, the Energy Bills Support Scheme provided a GBP 400 rebate on electricity bills over the period October 2022-March 2023. This was in addition to the Energy Price Guarantee, which runs from October 2022 to April 2024, that capped the maximum unit cost of electricity and gas. For non-domestic consumers, the Energy Bill Relief Scheme initially provided a discount on electricity and gas unit rates; it has since been succeeded by the Energy Bills Discount Scheme, which provides all eligible businesses with a baseline discount on high energy bills for 12 months from April 2023 through March 2024.

The government also offers the Warm Home Discount, Winter Fuel Payment and Cold Weather Payment to eligible low-income and vulnerable households.

Natural gas in the clean energy transition

Though overall natural gas demand will decline on the pathway to net zero, peak demand is expected to stay high during the transition. This means that the gas system will need to change to maintain resilience against increasingly dynamic and unpredictable requirements. Even when net zero targets in 2050 are met, the United Kingdom expects to still need some gas for use in buildings, industry and power generation (when combined with CCUS and balancing residual emissions by removal technologies).

In power generation, although Britain's electricity market is highly diversified, unabated gas generation currently accounts for nearly 40% of generation (2022). Looking ahead, gas will be used less frequently in the future as low-carbon alternatives play a greater role.

Direct use of natural gas in UK homes will also decline. Other low-carbon technologies, such as heat pumps, will reduce the demand for gas, alongside more energy efficiency measures in households. Increasing volumes of domestically produced biomethane will also be injected into the gas grid (see below) and hydrogen has the potential to form an increasing part of the energy mix.

Biomethane

The recently published Biomass Strategy notes that biomethane is expected to play an important role in the United Kingdom's net zero target by 2050.

The Green Gas Support Scheme (GGSS) provides tariff support for biomethane produced via anaerobic digestion and injected into the gas grid. Producers receive tariff payments for a 15-year lifetime. The GGSS launched in November 2021 and is currently open for applications until 30 November 2025. The government estimates that from 2029/30 to 2040/41, the GGSS could deliver annual generation of 2.8 TWh of renewable heat, enough to heat around 200 000 homes annually.

The government outlined its support for biomethane in the Energy Security Plan in March 2023, where it committed to consult on introducing a policy framework for biomethane to follow the GGSS once it is closed to new applications.

Natural gas security

The United Kingdom's approach to natural gas security is outlined in the National Preventive Action Plan: Gas published in July 2023. The National Emergency Plan-Downstream Gas and Electricity sets out long-established response plans for government and key industry stakeholders in the event of a gas or electricity supply emergency.

The GB gas system is very resilient to supply shocks, in part due to diverse supplies from the UKCS, Norwegian Continental Shelf, interconnectors to continental Europe and deliveries of LNG. NGT as the system operator has a wide range of tools available, which have historically been effective in managing periods of tight margins.

In the unlikely event that these are insufficient to meet demand, a network gas supply emergency can be called by the network emergency co-ordinator, an

independent body responsible for co-ordinating the actions of network transporters in a gas supply emergency. In the event of a network gas supply emergency in which all initial tools have been exhausted, the network emergency co-ordinator can implement load shedding to balance the gas system, where large industrial customers are instructed to stop or reduce their gas consumption.

The United Kingdom's gas market and storage has operated successfully when needed, helping to meet demand caused by cold weather spells. However, as part of broader measures to enhance gas system resilience, the government will consider the future role that storage, along with other sources of flexibility, can play in the longer term, aligning with future plans for hydrogen and CO_2 storage. The government issued an updated assessment of UK gas storage needs in December 2023, which will be followed by a call for evidence to delve into the three flexibility options (storage, LNG and interconnectors) in greater detail.

On gas demand, NGT as the system operator implemented a series of reforms to its existing Demand Side Response Scheme for winter 2022-23. The government is working with NGT to increase the available volumes for industrial demand reduction for winter 2023-24 and investigate options for participation of households and smaller businesses.

Assessment

Upstream oil and gas

The United Kingdom has long-standing experience with upstream oil and gas production across the UKCS in the North Sea. As such, the government has a robust regulatory regime that has driven investment in the sector for decades. The permitting system is transparent and seemingly effective, covering the full range of site development, from exploration to decommissioning. Moreover, the government's recent efforts to accelerate and streamline permitting will be a welcome development for the industry in light of relatively long project timelines (five years or more) at present (though timelines are also influenced by factors beyond permitting, such as economic variables and field complexity).

As in all oil- and gas-producing countries, the United Kingdom will need to assess the longer term role of upstream production in a net zero future. Given the maturity of UK oil and gas assets, with declining production profiles, new production will mainly limit the reduction in UK supply. Therefore, it is possible that the sector will see a natural decline that aligns with net zero targets and waning global demand. However, the government should assess whether future licensing rounds with longer term start dates will be compatible with net zero pathways and whether it clouds net zero messaging. The Climate Compatibility Checkpoint is a good step in this direction and bolstering its statutory standing should be considered.

In the lead up to net zero emissions, the UK upstream sector is also a contributor to overall GHG emissions in the country (2.5%). Though the government has expectations for industry to pursue a number of decarbonisation measures and requires companies to have GHG emissions reduction plans in place as part of the licensing regime, the government can consider the viability of imposing regulatory requirements on facilities to ensure a minimum level of effort across operations.

Regarding the decommissioning of legacy oil and gas assets, the government has a robust regulatory regime in place. It should continually track the financial viability of producing companies to undertake decommissioning activities in light of a recent shift in upstream ownership away from oil and gas majors to private equity-backed players.

Given the economic significance of the UK oil and gas industry in the overall economy, the government will also need to be mindful of the economic disruptions to revenues and jobs that the energy transition will bring. Toward this end, the UK government reached an agreement with the industry under the North Sea Transition Deal that includes commitments from the government and/or oil and gas companies to collectively invest up to GBP 16 billion by 2030 to support local economic diversification and jobs, including in areas such as upstream decarbonisation, CCUS and hydrogen. The deal includes emissions reduction commitments from the industry from 2025 to 2030 and tracks progress toward targets. The IEA lauds the government's efforts to work in partnership with the oil and gas industry to ensure a smooth transition, notably for workers and communities in the North Sea region. The deal is comprehensive and well-considered and can be effective at both lowering emissions in the sector and managing disruptions and capitalising on opportunities facing the sector, especially if planned financial and regulatory support is realised as planned.

Technology will undoubtedly play an outsized role in decarbonising upstream oil and gas production. In addition to company efforts across a range of technology areas, the government has placed a high priority on innovation in the sector, notably for CCUS and hydrogen. The United Kingdom's success in offshore wind can also be tapped to power upstream operations.

Oil

The United Kingdom currently has diverse supplies of both crude and refined products. Though it will face declining domestic crude production in the coming years, the United Kingdom will not materially impact its security of supply, as most crude production is exported. Rather, the United Kingdom's refining sector plays a greater role in domestic supply.

The United Kingdom has a liberalised market for oil, with a large number of retail outlets. Nonetheless, the government should closely monitor the recent evolution of the sector – based on changing ownership structures, declining numbers of refineries and fuelling stations – to ensure that retail markets remain competitive and pricing fair to consumers. The 2023 results of the Competition and Markets Authority study into retail competition is a good first step. The IEA welcomes the government's intent to bring forward in 2024 a mechanism that will provide consumers with more visibility on local pricing at forecourts.

The UK government has taken a number of steps to lower oil demand and associated emissions from oil consumption, which have borne results in terms of declining demand over the past decade. The transport sector is the main focus of policies, accounting for the bulk (63%) of oil demand. In this regard, the United Kingdom has a number of measures, including a ZEV mandate to phase out new sales of internal combustion engines by 2035, a Renewable Transport Fuel Obligation to increase penetration of biofuels in transport. Beyond transport, the government has also put in support mechanisms to encourage switching of fossil fuel heating system with heat pumps. The policy focus on transport is a welcome one and should be sustained and expanded to realise more rapid reductions in oil consumption in line with climate targets.

Still, during the transition to net zero emissions, oil will play a significant role in certain harder to decarbonise transport segments. In the coming years, the expected overall decline in oil demand based on the energy transition should be regularly and thoroughly assessed against oil import options to ensure sufficient supply and supporting infrastructure to sectors that still need it on the pathway to net zero emissions.

In particular, the six major UK refineries have a combined capacity roughly equivalent to current domestic demand. Declining road fuel demand due to net zero policies combined with increased competition from refineries in Asia, the Middle East and Africa will continue to challenge domestic refining margins. Unless refineries find new business opportunities (such as in SAFs), their commercial viability might be endangered. As certain regions are heavily dependent on a single refinery, potential closures might have a negative impact on regional security of supply. As such, the resilience of the downstream oil sector should be monitored and preserved through the energy transition. Inter-governmental alignment and clear signals from the government on the future role of the downstream sector could help provide guidance to the industry.

The United Kingdom, as a member of the IEA, has consistently met its obligation of holding 90 days of net oil imports. In addition, it has maintained the EU requirement of holding at least - of its stocks as oil products. The United Kingdom should be commended for continuing to hold oil product stocks,

as these could prove more useful in a supply disruption. Nevertheless, despite large capacities at import terminals and a robust infrastructure for transporting oil, UK industry has low forward cover for some oil products from operational stocks. Furthermore, the United Kingdom's emergency stocks are currently not considered to be a tool to mitigate domestic supply disruptions. Consequently, the United Kingdom should consider additional, product-based, stockholding arrangements, to prepare for the likely closure of additional refineries and the evolution of the UK domestic liquid fuels market, within the context of the transition to net zero.

Natural gas

Similar to oil, UK natural gas production has been on a declining trend, with imports increasingly required to fill the gap over domestic demand. The United Kingdom will need to monitor its import options to ensure sufficient supply to meet demand in the coming years, especially given considerable uncertainty regarding the trajectory of gas demand reduction based on various scenarios.

Natural gas supply disruptions based on Russia's invasion of Ukraine had significant impacts on UK supply, too, even though the country's direct imports of natural gas from Russia were minimal before the invasion. The United Kingdom is well-integrated into the European natural gas market, with the second-largest LNG import infrastructure in Europe, thereby playing a critical role in helping Europe shift away from Russian supplies. A combination of pipelines and regasification capacity offers the United Kingdom considerable optionality for supply sources, with the bulk coming from Norway, and the United States becoming a bigger supplier of LNG since 2022. Upgrades to LNG terminal capacity will further support this trend. Looking ahead, the United Kingdom should continue to co-ordinate its natural gas supply and trade flows with that of continental Europe to ensure security of supply across the continent.

With the reopening of the Rough storage facility, the United Kingdom has expanded its gas storage capacity, which played an important role in ensuring security of gas supplies in the winter of 2022-23. In this regard, the UK government's decision to welcome the reopening of Rough was a good one. Still, the United Kingdom's total storage capacity remains low by European standards. Given that storage will continue to support natural gas security of supply in the years to come, the government should co-ordinate with industry to explore options for a further expansion of storage capacity.

The United Kingdom's natural gas industry has a clear regulatory framework, including as it relates to cost recovery for network infrastructure investment. As the energy transition gains speed in the coming years, gas transmission requirements will need to be considered in parallel with infrastructure to support

other fuels, including biomethane and hydrogen. Moreover, the interconnectedness of the gas and electricity systems will also increase. The United Kingdom's decision to establish an FSO that brings together the planning for the electricity, natural gas and hydrogen systems is, therefore, a welcome one that should help increase the efficiency of infrastructure investments and align regulatory settings across sectors to support the energy transition. However, the FSO should have equivalent expertise in gas market specificities as in electricity to facilitate a joined-up approach across the energy system. Moreover, the creation of the FSO should not slow down the implementation of needed regulatory and policy changes to advance net zero objectives.

The United Kingdom's gas market is liberalised. Wholesale markets have a high degree of liquidity and retail markets have generally been competitive, with customers able to switch suppliers based on price and service. Nonetheless, based on the recent energy crisis, competition and switching rates have fallen and supplier exits have increased. Ofgem's recent reform efforts to improve the suppliers' resilience are welcome developments. However, ongoing challenges related to supplier switching and price competition should be further investigated, and additional remedial measures taken as necessary.

In response to the unprecedented surge in natural gas prices following Russia's invasion of Ukraine, the UK government put in place a number of measures to protect both households and industry from the impacts with significant energy support schemes that provided discounts on energy bills for all energy consumers. As these temporary interventions have since concluded, the government is continuing to provide a range of support for households in most need and is set to provide GBP 104 billion cost-of-living support over 2022-25, which is one the largest support packages in Europe. The government also put in place subsidies to encourage households to switch to heat pumps. Nonetheless, the United Kingdom has not experienced structural demand destruction for natural gas to the extent that many other European countries have seen. In light of continued gas security concerns amid Russia's ongoing war in Ukraine, the government should explore additional steps to support customers in lowering their consumption of natural gas, especially in winter. Energy efficiency upgrades to homes is a good area to direct efforts in this regard (see the section on "Buildings").

Moreover, the energy transition will require longer term reductions in natural gas demand, so measures taken today based on high prices can have lasting benefits.

Unabated natural gas today play's a significant role in the United Kingdom's energy system, notably in the power, industry and buildings sector. The United Kingdom expects a gradual phase-down of gas across these sectors. Clean sources such as renewables and nuclear will wind down gas-fired

generation's role in the power system, aside from a back-up role to support security of supply. In industry, natural gas will need to be replaced with technological alternatives, including electricity and hydrogen. And in buildings, electricity will be the main tool to decarbonise, though biomethane will play a growing role as well. Natural gas is expected to remain a mainstay in the power and industry sectors in a net zero world (albeit in smaller volumes), supported by CCUS. The UK government should track progress in all these sectors and ensure that the declines in natural gas consumption track well with the country's net zero trajectory. Moreover, the UK government should clarify the role that natural gas is expected play across energy sectors, considering a wide variance across demand forecasts based on scenarios. Notably in electricity, longer term system and infrastructure planning should reflect this role in light of the target to decarbonise electricity, subject to security of supply, by 2035.

Recommendations

Upstream oil and gas

- Consider bolstering the Climate Compatibility Checkpoint's legal standing to formalise the review of future licensing rounds against net zero goals.

Oil

- Give clear signals regarding the planned future of the downstream oil sector and align visions across all relevant government entities.
- Conduct a study on the regional supply impacts of refinery closures to develop a better understanding of the future downstream resiliency needs.
- Assess the adequacy of current oil stock levels as part of the ongoing review of stocks, as commercial stocks appear to be low by international standards.

Natural gas

- Study the energy security benefits of adding natural gas storage capacity, particularly strategic storage to enhance gas supply resilience.
- Ensure an integrated gas and electricity systems approach, covering generation, storage and grid management, to optimise capacity and flexibility.
- Clarify the role of natural gas in a planned decarbonised power system by 2035, especially as a flexibility resource to complement significantly higher shares of variable renewables.

Annexes

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Abbreviations and acronyms

CBAM	Carbon Border Adjustment Mechanism
CCUS	carbon capture, utilisation and storage
CfD	Contracts for Difference
CMA	Competition and Markets Authority
ECO	Energy Company Obligation
EPC	energy performance certificate
EPL	Energy Profits Levy
ESO	Electricity Systems Operator
ETS	Emissions Trading Scheme
EV	electric vehicle
FID	final investment decision
FSO	future system operator
GB	Great Britain
GBN	Great British Nuclear
GBP	British pound sterling (currency)
GDP	gross domestic product
GGSS	Green Gas Support Scheme
GHG	greenhouse gas
HGV	heavy goods vehicle
HPC	Hinkley Point C
IEA	International Energy Agency
LNG	liquefied natural gas
LPG	liquefied petroleum gas
LULUCF	land use, land-use change and forestry
MSA	motorway service area
NBP	National Balancing Point
NESO	National Energy System Operator
NGT	National Gas Transmission
NTS	National Transmission System
NSTA	North Sea Transition Authority
NZIB	Net Zero Innovation Board
Ofgem	Office of Gas and Electricity Markets
OPRED	Offshore Petroleum Regulator Transport Fuel Obligation
ppl	pence per litre
PV	photovoltaic
R&D	research and development

R&I	research and innovation
RTFO	Renewable Transport Fuel Obligation
SAF	sustainable aviation fuel
SMR	small modular reactor
TES	total energy supply
TFEC	total final energy consumption
UK	United Kingdom
UKCS	UK Continental Shelf
UKRI	UK Research & Innovation
VAT	value-added tax
ZEV	zero emissions vehicle

Units of measure

bcm	billion cubic metre
GW	gigawatt
GWh	gigawatt hour
mcm	million cubic metre
Mt	million tonne
Mt CO_2-eq	million tonne of carbon dioxide equivalent
MW	megawatt
MWh	megawatt hour
PJ	petajoule
t CO_2	tonne of carbon dioxide
TJ	terajoule
TWh	terawatt hour

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Energy Policy Review

Government action plays a pivotal role in ensuring secure and sustainable energy transitions and combatting the climate crisis. Energy policy is critical not just for the energy sector but also for meeting environmental, economic and social goals. Governments need to respond to their country's specific needs, adapt to regional contexts and help address global challenges. In this context, the International Energy Agency (IEA) conducts Energy Policy Reviews to support governments in developing more impactful energy and climate policies.

This *Energy Policy Review* was prepared in partnership between the Government of the United Kingdom and the IEA. It draws on the IEA's extensive knowledge and the inputs of expert peers from IEA member countries to assess the United Kingdom's most pressing energy sector challenges and provide recommendations on how to address them, backed by international best practices. The report also highlights areas where United Kingdom's leadership can serve as an example in promoting secure clean energy transitions. It also promotes the exchange of best practices among countries to foster learning, build consensus and strengthen political will for a sustainable and affordable clean energy future.