National Audit Office

REPORT

Decarbonising the power sector

Department for Energy Security & Net Zero

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National Audit Office

Decarbonising the power sector

Department for Energy Security & Net Zero

Report by the Comptroller and Auditor General

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Gareth Davies
Comptroller and Auditor General
National Audit Office

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Key facts

13%

of 2021 UK greenhouse gas emissions were from electricity generation, representing 54 million tonnes of carbon dioxide equivalent ($MtCO_2e$)

2035

year by which the government intends all electricity to be from low-carbon sources, subject to security of supply

40% to 60%

increase in demand for electricity by 2035 as estimated by the government in its 2021 Net Zero Strategy

£280bn to £400bn

cost to decarbonise the power sector as estimated by the government in its 2021 Net Zero Strategy

73%	reduction in emissions from the power sector between 1990 and 2021
Approximately 41%	of electricity in 2021 was produced from natural gas, which will need to be largely phased out or adapted with carbon capture to achieve decarbonisation
Up to 24GW[1]	the government's ambition for nuclear capacity by 2050. The Department for Energy Security & Net Zero (DESNZ) expects all current stations to have retired by 2050. A new station, Hinkley Point C, is currently being built, and DESNZ confirmed an investment decision for a new station at Sizewell C in November 2022[2]
Up to 50GW	the government's ambition for offshore wind capacity by 2030. This would mean overseeing the deployment of three times as much offshore wind capacity in eight years as in the last two decades
Up to £62 million a day	constraint costs since 2018, where electricity generators are paid to constrain their output
Seven	teams (directorates) across three top-level groups in DESNZ responsible for decarbonising the power sector

Notes

1 A watt is a unit of power and there are 1 billion watts in 1 gigawatt (GW).

2 On 7 February 2023, the government announced that the Department for Business, Energy & Industrial Strategy (BEIS) would close, and its responsibilities would transfer to new departments, including the Department for Energy Security & Net Zero (DESNZ). References to DESNZ that relate to events prior to this date therefore refer to BEIS.

Summary

Introduction

1 In 2019, the government set a target to achieve net zero greenhouse gas emissions by 2050. This will require changes across society, from the way people heat their homes to the way they travel. Decarbonising electricity generation is fundamental to the government's net zero strategy because many sectors of the economy, such as transport and heating in buildings, are likely to switch to using electricity instead of fossil fuels such as natural gas. In 2021, the government set an ambition that by 2035 all electricity should be generated using clean sources, subject to security of supply, while meeting an expected increase in electricity demand of up to 60%. This means phasing out polluting types of electricity generation, such as gas-fired power stations and replacing them with a new mix of zero and low-carbon generation, including wind, solar and nuclear power.

2 Switching to clean electricity generation has increasingly become part of the government's plan to ensure there is an affordable and secure domestic energy supply in response to the disruption to international gas supplies that has followed Russia's invasion of Ukraine. In April 2022, the government published the British Energy Security Strategy.[1] This emphasised how accelerating progress towards a decarbonised power sector would, over time, enable a secure supply of electricity and affordable bills. The strategy set out increased government ambitions for transitioning to zero and low-carbon electricity generation during the 2020s, including increased ambitions for offshore wind and nuclear power.

3 In February 2023, the government established the Department for Energy Security & Net Zero (DESNZ), which has overall responsibility for ensuring the government achieves its power sector ambitions.[2] Government has overseen a 73% reduction in this sector's emissions since 1990, although in 2021 greenhouse gas emissions from electricity generation still represented 13% of total UK emissions. DESNZ is developing its plan to achieve the remaining emissions reductions, through a combination of changes across the power system. These include: increasing the amount of electricity generated by clean energy sources; developing the networks that transmit electricity from where it is generated to where it is used; establishing new market arrangements for buying and selling electricity; and encouraging consumers to use electricity in different ways so demand is more synchronised with patterns of supply. DESNZ is also establishing new governance structures and processes to enable it to oversee progress towards its ambitions.

1 Department for Business, Energy & Industrial Strategy, *British Energy Security Strategy*, 7 April 2022.
2 On 7 February 2023, the government announced that the Department for Business, Energy & Industrial Strategy (BEIS) would close, and its responsibilities would transfer to new departments, including the Department for Energy Security & Net Zero (DESNZ). References to DESNZ that relate to events prior to this date therefore refer to BEIS.

Purpose of this report

4 This report sets out the main challenges that DESNZ faces to decarbonise power. We have assessed the progress DESNZ has made since it set the ambition to decarbonise power by 2035 and examined how well it is set up to oversee future progress. We use offshore wind and nuclear power as examples of zero and low-carbon generation to illustrate some of our points. We recognise that DESNZ has made less progress since 2021 with establishing its long-term delivery plan than it intended because it needed to shift focus to respond to short-term challenges on energy supply and the cost of consumer bills. This report is therefore an early assessment in which we set out potential risks DESNZ needs to manage and make recommendations aimed at supporting DESNZ as it develops its plan. In the future we will assess government's progress with achieving power sector decarbonisation, how well it is managing the risks highlighted in this report, and the value for money of its interventions.

5 This report does not consider the response by DESNZ to recent energy supply and affordability challenges. In February 2023 we published *Energy bills support*.[3]

Key findings

Government faces challenges to decarbonise power

6 Transitioning to a secure, affordable and decarbonised supply of power by 2035 requires a step-change in both private investment and the pace at which new generating capacity is built. In its Net Zero Strategy, the government estimated that £280 billion to £400 billion of public and private investment in new generating capacity will be needed by 2037 to decarbonise the power sector. These costs represent the construction costs for power generation only, and do not include the costs for all aspects of decarbonising the power sector, such as network construction or research and innovation on technologies. Total costs will depend on factors including the location of new generation, the impact of any reforms to the electricity market and the effect of efforts to align consumer demand with supply. DESNZ has set stretching ambitions for the expansion of offshore wind, solar and nuclear power, which require much faster deployment rates than have been achieved before. For example, to achieve its ambition for 50 gigawatts (GW) of offshore wind by 2030, it needs to oversee the deployment of three times as much offshore wind capacity in eight years as in the last two decades (paragraphs 1.8, 1.14 to 1.17 and Figures 2 and 6).

3 Comptroller and Auditor General, *Energy bills support*, Session 2022-23, HC 1025, National Audit Office, February 2023.

7 **The power system needs to modernise to accommodate different kinds of electricity generation**. Renewables have different characteristics from the fossil fuel power sources they are set to replace. Wind and solar can only generate power when the wind is blowing or the sun is shining so generation cannot be controlled, unlike gas-fired power stations that can be turned on or off quickly to meet changes in demand. Renewables also have a very different economic model from gas-fired power stations, because once built they have relatively low running costs. These lower costs are not currently reflected in the price consumers pay for electricity because current market arrangements for buying and selling electricity were largely developed when gas and coal were the dominant fuels. DESNZ is working on ways to reform the electricity market and is encouraging consumers to use electricity more flexibly so that demand is more aligned to the intermittent nature of renewables, for example through its Smart Metering Implementation Programme (paragraphs 1.11 to 1.13, 1.16 and Figure 9).

8 **Decarbonising power requires government to increase its planning and coordination of the power system.** Expanding generation while modernising the power system entails several separate but linked changes that rely on a range of public and private sector organisations. Industry stakeholders are increasingly concerned about the lack of a government delivery plan that brings different aspects of power together. The Climate Change Committee recommended in its 2022 Progress Report to Parliament that DESNZ should publish an overarching delivery plan or strategy for decarbonising power.[4] Stakeholders we spoke to said there needs to be a delivery plan that recognises the time required to decarbonise all aspects of the power sector, including expanding generation and developing technologies ahead of 2035 (paragraphs 2.5, 2.8, 2.11 to 2.12 and Figures 4 and 5).

9 **DESNZ has not yet established a delivery plan to decarbonise power because it has prioritised responding to recent energy sector challenges.** In April 2021, DESNZ created an energy portfolio office, which is responsible for creating a delivery plan for power decarbonisation and coordinating the work of the DESNZ directorates responsible for different energy programmes including renewables, nuclear power and networks. DESNZ planned internally to prepare a first draft of its delivery plan with key decision points, risks, mitigations and interdependencies by October 2022, in support of a vision of how a fully decarbonised power sector will be achieved by 2035. During 2022, DESNZ prioritised developing and implementing responses to recent record-high energy bills and it therefore scaled back its work on coordinating long-term power sector decarbonisation. It told us it still has more work to do to develop a delivery plan (paragraphs 2.2 to 2.4).

4 Climate Change Committee, *Progress in reducing emissions, 2022 Report to Parliament*, June 2022.

Risks to DESNZ that stem from a lack of planning

10 **The lack of a delivery plan means DESNZ cannot be confident its ambition to decarbonise power by 2035 is achievable.** Many of the changes necessary to achieve decarbonisation rely on technologies that are not yet available or not yet ready to scale up to the level needed. A key example is technology to enable the power system to meet demand at times when there is little wind power. DESNZ is supporting the private sector to develop a range of solutions to this issue, such as hydrogen power and energy storage. However, it has not established a 'critical path' to 2035 to understand when it will need to make decisions about which technologies to adopt and roll out to stay on track. For example, DESNZ considers that achieving decarbonisation by 2035 requires new generation, including wind, solar and nuclear, to deploy at, or close to, the maximum level which is technically feasible in that time. However, there are several significant challenges, such as securing investment and identifying locations. Establishing an overall delivery plan would help DESNZ understand the resilience of its plans to setbacks and identify in advance the alternative pathways that it could take if required (paragraphs 1.13, 2.3, 2.4, 2.6, 2.9, 2.15 and Figures 7 and 8).

11 **There is a risk that without a delivery plan, decarbonising power while maintaining security of supply will cost consumers more.** There will be ways of sequencing the different changes required to decarbonise power that help to avoid unnecessary costs. For example, ensuring network capacity keeps pace with expanding generating capacity could avoid the risk of paying wind farms to shut down. If generators cannot access the grid, generation exceeds network capacity, or generation exceeds demand, then costs arise to consumers as generators are paid to constrain their output. While these 'constraint costs' typically vary (between £0 and £62 million a day since 2018), the annual total costs have recently increased, alongside the growth in offshore wind capacity. A clear delivery plan could also increase the confidence of investors to fund new infrastructure, which could reduce their costs of capital. In the past we have highlighted how a lack of clarity and changes in policy direction from government can affect investor confidence, increasing their required rate of return, and ultimately increasing costs for energy consumers (paragraphs 2.7, 2.11 to 2.13 and Figure 12).

12 **Without a delivery plan DESNZ cannot fully understand when costs could be highest and the potential effect on taxpayers and consumers.** Over time a decarbonised power system should have lower operational costs because it is typically more energy efficient. However, substantial upfront investment is required. The Climate Change Committee, which advises government on progress against its climate targets, has predicted that the capital investment required for building infrastructure to decarbonise power will increase in the 2020s, but should be in decline from 2035 onwards as the required build-rate falls and the costs of these technologies decreases. Typically, the costs to build, maintain and operate the power system are passed on to consumers' bills, which have recently reached record-highs because of global fuel prices (paragraphs 1.3, 1.15, 1.16, 2.16 to 2.18 and Figure 10).

13 DESNZ has more to do to manage portfolio performance, costs and risks of transitioning to a decarbonised, secure and affordable power system. While DESNZ has been reporting internally on its progress to decarbonise the power sector, it has not yet established a set of system-wide measures to track progress and costs, which could enable it to identify when it is off-track against expectations. It is also developing its end-to-end portfolio risk management framework. Risk management processes exist for programmes within the portfolio, and some significant risks are escalated for review by the energy portfolio office, energy board or net zero boards. However, not all risks are aggregated across the portfolio and there is no portfolio-wide view of the top risks to decarbonising the power sector (paragraphs 2.17 and 2.24 to 2.27).

Risks for DESNZ to manage when implementing its delivery plan

14 The ability of DESNZ to respond to changes in the external environment depends on the quality of its power sector insights and the extent to which it can operate and manage resources in an agile way. While DESNZ needs a delivery plan, it will need to remain flexible because new technologies could emerge that alter the most cost-effective pathway towards a decarbonised power system. There is also uncertainty about whether existing technologies can be deployed at the speed required to achieve the 2035 ambition. DESNZ has a model of future power generation it can use when considering which pathway might be optimal and making choices such as investing in more generating capacity or investing in energy storage. However, this model is only updated annually and therefore can quickly become out of date. Recent volatility in gas prices, for example, reduces the accuracy and usefulness of the model for policy decisions. DESNZ plans to increase its capacity and capability to manage progress towards decarbonisation and has set up a resourcing group to help move resources between DESNZ and other public bodies to prioritise activities and fill net zero roles (paragraphs 1.8, 2.6, 2.8, 2.20 to 2.22, 2.29 and 2.32).

15 The government intends to create a new organisation to coordinate the power system but has not clarified what its roles and responsibilities will be. DESNZ intends that the Future System Operator will advise government on policy decisions that balance decarbonisation with maintaining a secure supply of electricity and ensuring the system runs efficiently. This might include, for example, advice on the best location to build new wind farms. Government's ambition is for the Future System Operator to be established in 2024. DESNZ has not yet set out how it would work with the Future System Operator, and the extent to which the new organisation assumes responsibility for some coordinating activities (paragraph 2.28).

Conclusion

16 Decarbonising power is the backbone of the government's plan to achieve net zero. Although power sector emissions have reduced significantly over the past three decades, DESNZ cannot be complacent about the challenges involved in decarbonising further while continuing to ensure a secure supply that meets the predicted electricity demand increases. This will require substantial investment in new capacity, alongside system-wide modernisation, and needs a joined-up approach to ensure changes happen in sequence and with coherence. The longer DESNZ goes without a critical path bringing together different aspects of power decarbonisation, the higher the risk that it does not achieve its ambitions, or it does so at greater than necessary cost to taxpayers and consumers. While the recent energy crisis has understandably delayed DESNZ's progress in establishing a longer-term delivery plan for decarbonising power by 2035 it has reinforced the importance of ensuring that plan is resilient to external shocks.

Recommendations

17 In developing its delivery plan for power decarbonisation, DESNZ should:

a **establish how it will ensure the system is resilient to prolonged periods of low generation from renewables**. This should include considering the potential costs and benefits of maintaining some carbon-emitting power generation (such as unabated gas), while still achieving net zero across the economy;

b **within 12 months, review plans for achieving its ambitions for offshore wind and nuclear power expansion**. Where DESNZ determines that these ambitions are unattainable it should develop alternative options that enable it to achieve its broader power sector ambitions, such as investing in demand-side flexibility; and

c **ensure it has understood the main links between different aspects of decarbonisation and sets out in advance how these will be managed**. This should include how to determine the best sequencing of changes and investment, such as ensuring how network capacity keeps pace with expanding generation.

18 In developing arrangements to oversee progress against its plan, DESNZ should:

d **review the capability of its modelling to refine and update the most cost-effective system-wide approach to achieving net zero, including power sector decarbonisation**. It should consider, for example, the location of new generation, the impact of revisions to market arrangements and the potential role for greater demand-side flexibility. Where it identifies gaps in its modelling DESNZ should consider alternative sources of information to enable it to identify and respond to significant changes which might affect the most cost-effective pathway towards decarbonisation;

e **establish a set of clear measures of overall progress, and some interim milestones towards power sector decarbonisation**. It should report progress against these measures and milestones annually to Parliament, along with an explanation as to how this performance information has been used to determine any significant changes to its overall plan; and

f **establish arrangements to understand and respond to system-wide risks and opportunities, to ensure its plan is resilient to setbacks, disruption and future uncertainty**. This will involve having an overview of the cumulative demands on, for example, workforce, materials and investment across the system.

Part One

Background and challenges to decarbonising the power sector

Background to decarbonising the power sector

Net zero ambitions

1.1 In June 2019, Parliament passed legislation committing it to achieving net zero greenhouse gas emissions by 2050 (**Figure 1** on pages 14 and 15). This means reducing emissions substantially from current levels, so that the greenhouse gases the UK still emits in 2050 will be equal to or less than what is removed from the atmosphere by either the natural environment or carbon capture technologies.

1.2 In October 2021, the government published its *Net Zero Strategy* setting out its long-term plan for transitioning to a net zero economy.[5] It included an expectation that all electricity will come from low-carbon sources by 2035, subject to security of supply. This is subject to there being sufficient zero and low-carbon electricity generation to supply an expected 40% to 60% increase in electricity demand as more modes of transport and heating switch to electricity from fossil fuels.

1.3 Since Autumn 2021, energy bills have increased significantly to record-high levels due to various factors including an increased global demand for gas following the pandemic. In February 2022, Russia's invasion of Ukraine also resulted in an increased risk of gas supply shortfalls in the European market. In response, in April 2022 the government published its *British Energy Security Strategy*.[6] This reiterated its commitment to decarbonise the electricity system by 2035 and emphasised that doing so would also bring benefits of energy security and more affordable bills. In the strategy the government set out ambitions for low and zero-carbon electricity generation (**Figure 2** on page 16), of up to:

- 70 gigawatts (GW) of solar by 2035;[7]
- 50GW of offshore wind by 2030 (up from 40GW in the 2021 Net Zero Strategy);

5 Department for Business, Energy & Industrial Strategy, *Net Zero Strategy: Build Back Greener*, 19 October 2021.
6 Department for Business, Energy & Industrial Strategy, *British Energy Security Strategy*, 7 April 2022.
7 A watt is a unit of power and there are 1 billion watts in 1 gigawatt (GW).

- 24GW of nuclear by 2050; and
- 10GW of low-carbon hydrogen by 2030 (up from 5GW in the 2021 *UK Hydrogen Strategy*[8]).

Greenhouse gas emissions from electricity generation

1.4 Between 1990 and 2021, annual greenhouse gas emissions from electricity generation decreased by 73% from 203 million tonnes of carbon dioxide equivalent ($MtCO_2e$) to just over 54 $MtCO_2e$ (**Figure 3** on pages 18 and 19).[9] This was due to a reduction in burning coal and oil to generate electricity: in 1990 these accounted for 76% of electricity generation but that had decreased to approximately 4% in 2021. Emissions declined every year from 2012 to 2020 as coal was almost entirely phased out and replaced by less-polluting natural gas and renewables, such as wind and solar. Greater energy efficiency has also reduced total electricity demand. Despite these reductions, electricity generation is still a substantial source of emissions and represented 13% of total UK emissions in 2021, making it the fourth most-polluting sector after surface transport, industry and buildings.

1.5 Electricity demand is forecast to increase significantly as a result of the efforts to achieve net zero. This is because some major sources of emissions, particularly transport and heating in buildings, are expected to decarbonise by switching from fossil fuels to electricity. The Net Zero Strategy assumes an increase in electricity generation from 320TWh in 2019 to between 460TWh and 510TWh by 2035 (an increase of up to approximately 60%).[10] The Net Zero Strategy assumes electricity generation may have more than doubled from 2019 levels by 2050, to between 610TWh and 690TWh.

Roles and responsibilities in decarbonising the power sector

1.6 The Department for Energy Security & Net Zero (DESNZ) has overall responsibility for ensuring the government achieves its power sector ambitions.[11] It is supported by the Department for Environment, Food & Rural Affairs (Defra), the Department for Transport, the Department for Levelling Up, Housing & Communities (DLUHC), and HM Treasury. A range of other organisations in the public sector, such as Ofgem and the Ministry of Defence, and the private sector, also play a role (**Figure 4** on pages 20 and 21).

8 Department for Business, Energy & Industrial Strategy, *UK Hydrogen Strategy*, 17 August 2021.
9 Greenhouse gas emissions from electricity generation increased by 9% from 49.5 million tonnes of carbon dioxide equivalent ($MtCO_2e$) in 2020 to 54.1 $MtCO_2e$ in 2021. The Climate Change Committee ascribes this to low windspeed, less sunshine and nuclear power station outages, and compensating fossil fuel generation and imports.
10 A terawatt-hour (TWh) is a unit of power representing 10^{12} watt-hours. A watt-hour is a measure of electrical energy equivalent to one watt for one hour.
11 On 7 February 2023, the government announced that the Department for Business, Energy & Industrial Strategy (BEIS) would close, and its responsibilities would transfer to new departments, including the Department for Energy Security & Net Zero (DESNZ). References to DESNZ that relate to events prior to this date therefore refer to BEIS.

Figure 1

Timeline of key net zero and power system legislation, policies and targets, 2013 to 2022

In the past decade, the government has produced a large number of key documents and targets relating to energy, and the net zero system as a whole

2013

Aug 2013
Offshore Wind Industrial Strategy
Sets out the development of the value chain for offshore wind, and support for developers.

Oct 2013
Long-term Nuclear Energy Strategy
Sets out a vision for the UK nuclear power sector.

UK Solar PV Strategy
Sets out plans to make solar panels affordable to a variety of users.

Dec 2013
Energy Act 2013
Introduces the capacity market and Contracts for Difference.

2017

Oct 2017
The Clean Growth Strategy
Sets out proposals and policies for meeting carbon budgets.

Nov 2017
Industrial Strategy
Sets out support for innovation for low-carbon technologies.

2019

Jun 2019
Net Zero Legislation
Parliament passed legislation to achieve net zero greenhouse gas emissions by 2050.

2020

Jan 2020
UK National Energy and Climate Plan
Sets out integrated climate and energy objectives, targets, policies and measures.

Nov 2020
The Ten Point Plan for a Green Industrial Revolution
Sets out the approach to support green jobs, and accelerate the path to net zero.

Dec 2020
Modelling 2050: Electricity System Analysis
Sets out indicative low-cost power generation mixes.

Energy White Paper
Sets out how the UK will clean up its energy system and reach net zero emissions by 2050.

2021

Jul 2021
Smart Systems and Flexibility Plan
Sets out policy for transitioning to a smart, flexible, decarbonised energy system.

Aug 2021
UK Hydrogen Strategy
Sets out ambitions for increasing UK hydrogen supply.

Oct 2021
Net Zero Strategy
Sets out policies and proposals for decarbonising all sectors of the economy to meet net zero by 2050, including the ambition to decarbonise the power sector by 2035.

HM Treasury Net Zero Review
Potential cost exposure of businesses and households to the transition to net zero.

Oct 2021
Towards Fusion Energy
Sets out research ambitions for nuclear fusion reactors with a prototype being built at Culham, Oxfordshire.

2022

Apr 2022
British Energy Security Strategy
Sets out how Great Britain will accelerate homegrown power for greater energy independence.

Carbon Capture, Usage and Storage (CCUS): Investor Roadmap
Outlines opportunities to invest in CCUS in the UK.

Sep 2022
Energy net exporter target
Government announced that it wanted the UK to become an energy net exporter by 2040.

Energy specific policy

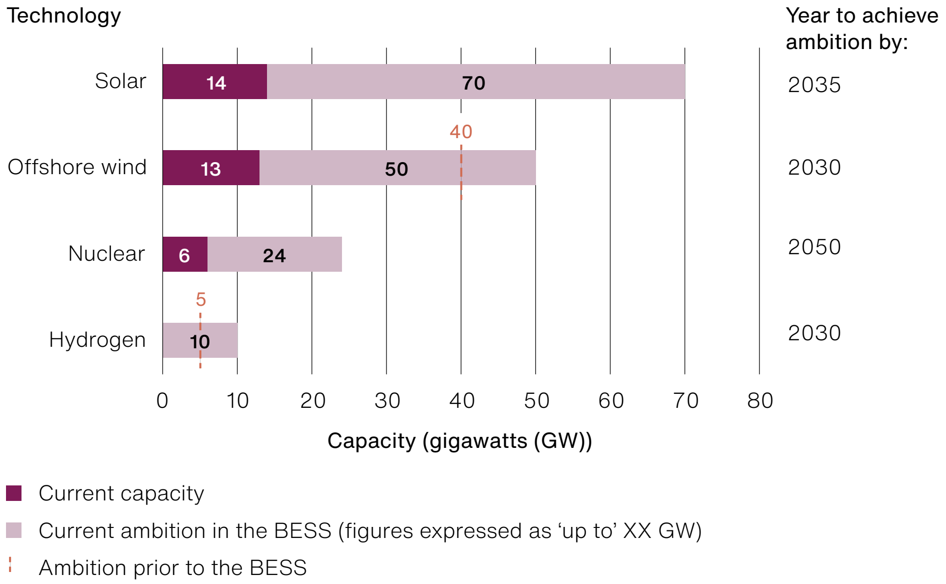
Whole net zero system policy

Source: National Audit Office analysis of published documentation

Figure 2

Current generating capacity and ambitions by technology, February 2023

The ambitions, as set out in the British Energy Security Strategy (BESS), will require a large increase in capacity across solar, offshore wind, nuclear and hydrogen



Notes

1 The figure includes the ambitions prior to the BESS for offshore wind and hydrogen. Government did not publish similar ambitions for nuclear or solar prior to the ambitions set out in the BESS.

2 The most recent published capacity values are used for 'current capacity': Solar is from September 2022; Offshore wind is from January 2023; Nuclear is from February 2023; and Hydrogen is from April 2022. Current capacity figures are rounded to the nearest whole number.

Source: National Audit Office analysis of published data and the British Energy Security Strategy. Available at: www.gov.uk/government/publications/british-energy-security-strategy/

Challenges to decarbonising the power sector

1.7 Cost-effectively decarbonising the power sector by 2035, while ensuring security of supply, will require system-wide changes (**Figure 5** on page 22). These include a substantial expansion of zero and low-carbon generation, such as wind farms and nuclear power stations, and reinforcing of the networks that transmit and distribute electricity. As more electricity is generated from intermittent renewable sources, this will have a knock-on impact on how the system operates, including the markets for buying and selling electricity, and how consumers use electricity.

Expanding generation

1.8 To achieve its ambitions for increasing zero and low-carbon generation as stated in the British Energy Security Strategy, in addition to expansions in onshore wind and solar capacity, DESNZ must oversee much faster deployment of offshore wind and nuclear power than has previously been achieved. Achieving DESNZ's ambition of up to 50GW of offshore wind by 2030 requires more than 37GW to be deployed in eight years. By comparison, as of January 2023, 12.6GW has been deployed since the first offshore wind farm started operating in 2000. DESNZ is internally monitoring more than 80GW of offshore wind capacity in various stages of development. As of January 2023, this includes approximately 27GW either securing planning permission or investment, or under construction (**Figure 6** on page 23), and around 40GW in pre-planning. The British Energy Security Strategy states that the development and deployment of offshore wind farms takes up to 13 years. DESNZ intends to reduce the time it takes for an offshore wind farm to become operational by cutting processing time by more than half, including achieving planning consent in one year rather than four.

1.9 DESNZ has an ambition for up to 24GW of nuclear power by 2050 and to make progress on up to eight more reactors by 2030. DESNZ expects to achieve these ambitions through a combination of large-scale new nuclear projects, like Hinkley Point C, and through supporting the development of small and advanced modular reactors (so-called SMRs and AMRs). In 2021, nuclear power stations generated approximately 19% of UK electricity. The UK currently has five nuclear stations, all but one of these is expected to be retired by 2028 as they reach the end of their useful economic life. This leaves only Sizewell B (1.2GW) operating from the current fleet, currently due to retire in 2035. A new 3.2GW station, Hinkley Point C, is currently being built, and DESNZ confirmed development consent for a new 3.2GW station at Sizewell C in July 2022 and a £679 million government investment in the project in November 2022.[12] This leaves a gap of nearly 18GW for the government to achieve its 2050 ambition of up to 24GW. Only one project (3.2GW at Hinkley Point C) has entered construction in the past 20 years.

1.10 For both offshore wind and nuclear power there are significant delivery risks that DESNZ needs to overcome to achieve the rapid increase in speed of deployment required to achieve its ambitions. For both technologies it is in the process of establishing plans and delivery arrangements (**Figures 7 and 8** on pages 24 and 25).

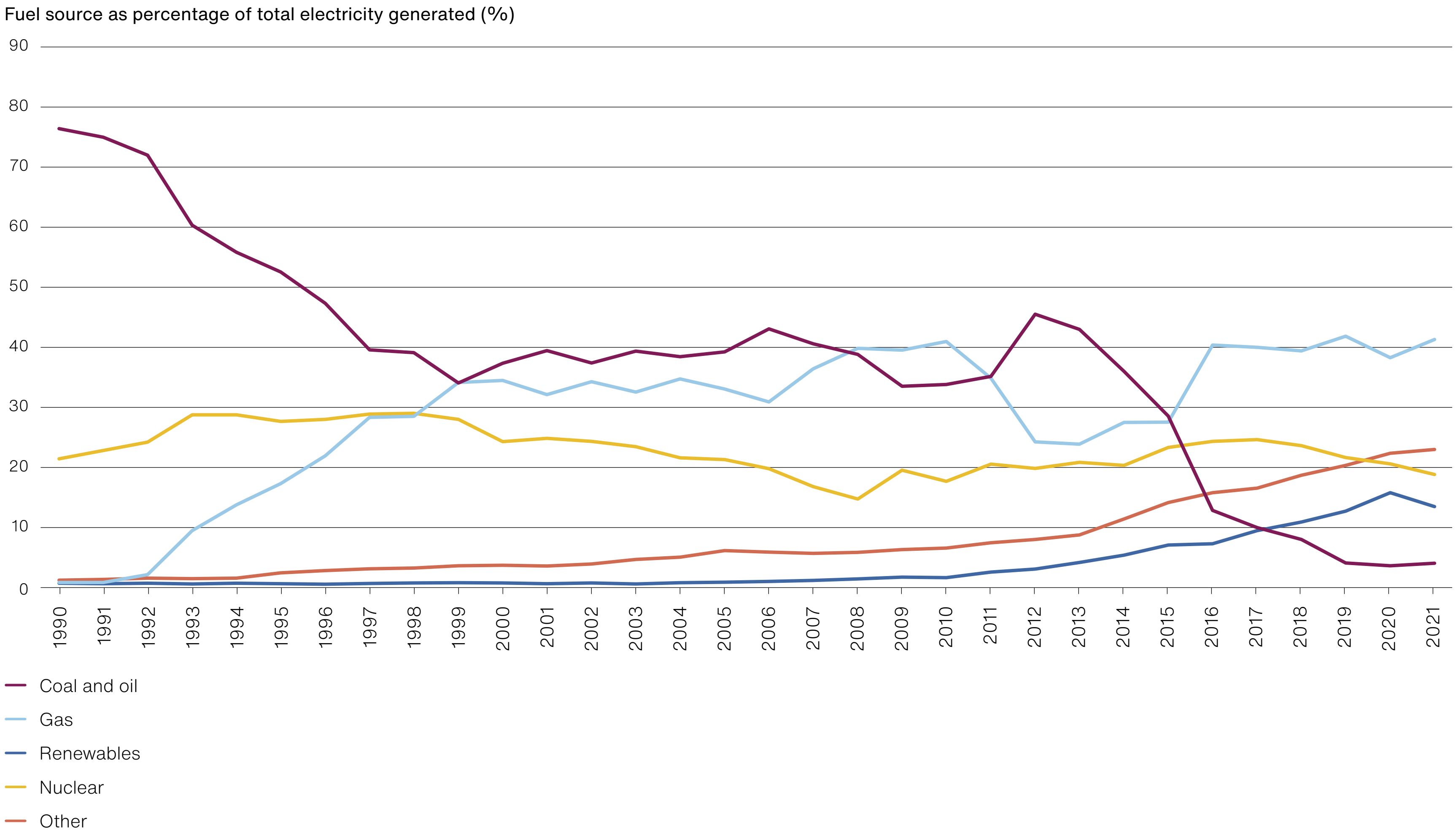
12 The £679 million government investment, to be matched by the developer EDF, is intended to support the project's development. The investment also allows for China General Nuclear's exit from the project, including buy-out costs.

Figure 3

Electricity generation and greenhouse gas emissions, 1990 to 2021

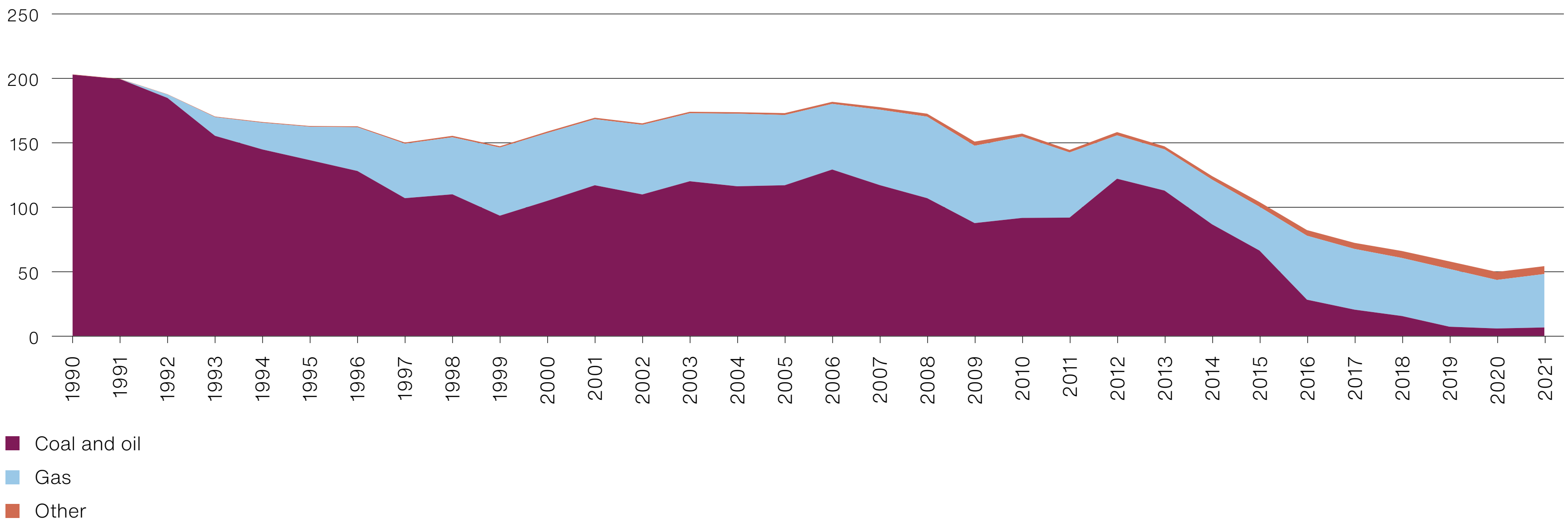
Electricity supply greenhouse gas emissions in 2021 had reduced by 73% from 1990 levels because of a move away from burning coal and oil for power

Proportion of electricity generated over time, by fuel type



UK carbon emissions from electricity generation over time, by fuel type

UK territorial carbon dioxide emissions from electricity generation ($MtCO_2e$)



Notes

1 For the ‘proportion of electricity generated over time, by fuel type’ graph, the category ‘Other’ includes: coke oven gas, blast furnace gas, waste products from chemical processes, refuse derived fuels and other renewable sources. The category ‘Renewables’ includes wind, solar and natural flow tidal.

2 For the ‘UK carbon emissions from electricity generation over time, by fuel type’ graph, the category ‘Other’ includes the remaining solid fuels and emissions. The published data did not provide any further breakdown of what these include.

Source: National Audit Office analysis of published data from the Department for Energy Security & Net Zero

Figure 4

Roles and responsibilities of a range of organisations related to the power sector

A large number of public and private sector organisations contribute to decarbonising electricity supply

Organisation type/organisation(s)	Role in decarbonising electricity supply
Central government departments	
Department for Energy Security & Net Zero	Responsible for developing and implementing policies to achieve net zero in the power sector and developing policy for innovation.
HM Treasury	Responsible for allocating budgets to government departments.
Department for Environment, Food & Rural Affairs (Defra)	A priority outcome for Defra is protecting and improving the environment. Inputs into how power-generating activities (for example, offshore wind) impact the environment, such as biodiversity.
Department for Transport	Has a priority outcome to tackle climate change and improve air quality by decarbonising transport. This could affect overall electricity demand, and advances in new technologies could be relevant for the power sector.
Department for Levelling Up, Housing & Communities	Responsible for reforming the planning system, which impacts decisions relating to the development of power-generating infrastructure.
Department for Business & Trade	Responsible for encouraging foreign investment and export trade. The Net Zero Strategy emphasises the need for private investment both from within the UK and abroad.
Ministry of Defence	Ensures interference caused by offshore wind farms on military radar is mitigated.
Other central government organisations	
Ofgem	Protects the interests of consumers relating to gas conveyed through pipes and electricity conveyed by transmission or distribution systems.
The Crown Estate and Crown Estate Scotland[4]	Manage the UK's seabed and approximately half of the foreshore. Responsible for permitting the installation of renewable technologies in these locations.
North Sea Transition Authority	Regulates and influences the oil, gas and carbon storage industries including approving and issuing storage permits.
UK Research and Innovation (UKRI)	Invests in national and international research and innovation across multiple disciplines and sectors. This includes funding research into experimental low-carbon technologies.
Low Carbon Contracts Company	Manages Contracts for Difference (CfD) with low-carbon electricity generators under the CfD scheme.
Planning Inspectorate	Purpose includes dealing with planning appeals, national infrastructure planning applications (such as for power-generating stations) and examining local plans.
Local government	
Local authorities	Responsible for decisions on planning proposals including power-generating infrastructure.

Figure 4 *continued*

Roles and responsibilities of a range of organisations related to the power sector

Organisation type/organisation(s)	Role in decarbonising electricity supply
Private sector	
National Grid	Investing in the electricity transmission network to connect and transport electricity from generators to consumers. Owns the National Grid Electricity System Operator (ESO), which is responsible for matching electricity supply and demand to keep them in balance at all times; loss of balance can cause power cuts.
Transmission system operators	Manage the networks that carry large amounts of electricity across the country at high voltage.
Distribution system operators	Distribution networks take electricity from the transmission networks and distribute it locally at lower voltages.

Notes

1 This figure sets out examples of organisations involved in decarbonising the power sector, and some of their respective roles and responsibilities.

2 'Priority outcomes' are set out in government departments' Outcome Delivery Plans.

3 The organisations related to the power sector differ across the United Kingdom. The roles of the devolved administrations and organisations in Scotland, Wales and Northern Ireland are not all listed here.

4 The Crown Estate was established by an Act of Parliament as a commercial business that returns its profit to HM Treasury. Crown Estate Scotland operates under the Scottish Crown Estate Act 2019 and returns revenue profit to the Scottish Consolidated Fund.

Source: National Audit Office analysis of published documentation

Expanding and reinforcing networks

1.11 To accommodate more geographically dispersed electricity generation, and greater flows of electricity as demand increases, networks that transmit electricity from generating sources to homes and businesses will need to expand. For example, in *Electricity networks*, we reported that network companies have a crucial role to play to support carbon emissions reductions in the energy sector and the wider economy.[13] Growth in the overall demand for electricity, and displacement of carbon-emitting fuels by renewables, mean that new investment is needed to expand and upgrade electricity networks.

13 Comptroller and Auditor General, *Electricity networks*, Session 2019-20, HC 42, National Audit Office, January 2020.

Figure 5

The energy system in Great Britain and actions to decarbonise

Decarbonising the power sector will require system-wide changes across five key aspects: electricity generation, networks, markets, consumer demand and innovation

Energy generation produces energy as electricity and gas.

To decarbonise further: Increasing the amount of electricity produced through zero and low-carbon generating technologies to reduce reliance on power from fossil fuels.

Example of government action: Ambition to increase offshore wind generation to 50 gigawatts (GW).

Energy transmission and distribution networks transmit energy as electricity and gas from the generating source to the consumer.

To decarbonise further: Networks will need to expand to accommodate more geographically disperse electricity generation, and greater flows of electricity as demand increases.

Example of government action: Ofgem, the energy sector regulator, is seeking to ensure electricity network companies transform to support a low-cost, low-carbon energy system in the way that it sets the rules for networks' allowed costs, targets and performance.

Energy suppliers buy energy on the wholesale market to sell to consumers.

To decarbonise further: The current market arrangements do not incentivise zero and low-carbon investment in the most effective way, particularly for flexible technologies that respond to peaks in demand.

Example of government action: Undertaking a review of electricity market arrangements (REMA).

Energy consumers buy energy from suppliers.

To decarbonise further: Reducing peaks in demand by encouraging consumers to be more efficient and flexible in when and how they use electricity.

Example of government action: The Smart Metering Implementation Programme.

Research and innovation into new technologies and approaches.

To decarbonise further: Finding new and better ways to decarbonise power, such as developing new ways of generating and storing energy.

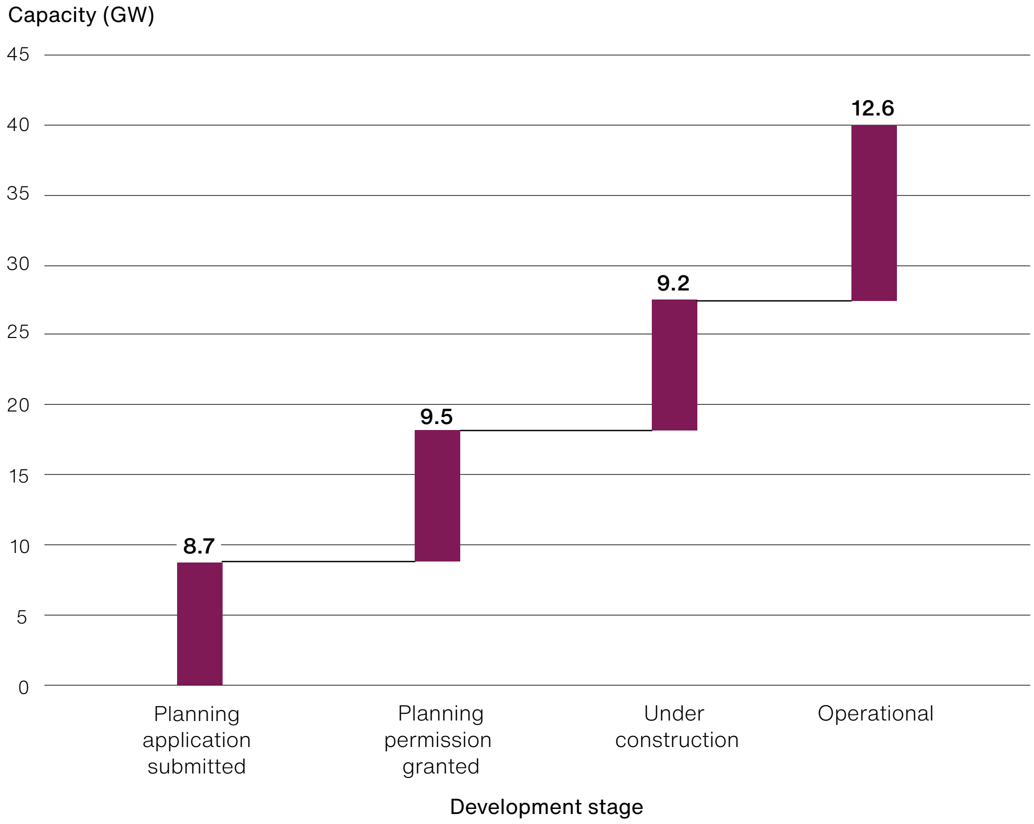
Example of government action: Published its Net Zero Research and Innovation Framework in 2021.

Source: National Audit Office review of published documentation

Figure 6

Offshore wind projects in the pipeline from planning application submitted to operational, as at January 2023

The Department for Energy Security & Net Zero (DESNZ) is tracking a pipeline of offshore wind projects, 12.6 gigawatts (GW) of which is already operational



Notes

1 Applications that have been rejected, withdrawn or abandoned have been excluded from this analysis, as have sites that have been decommissioned. Where applications have been revised and re-submitted, the original application has been excluded (to avoid double counting).

2 This figure includes projects in the Renewable Energy Planning Database that have submitted a planning application. DESNZ is internally monitoring more than 40GW of other projects in its pipeline, of which most are still to submit a planning application.

Source: National Audit Office analysis of the Department for Energy Security & Net Zero's (DESNZ's) documentation, and the Renewable Energy Planning Database published by DESNZ. Available at: www.gov.uk/government/collections/renewable-energy-planning-data

Figure 7

Examples of delivery risks for offshore wind and the Department for Energy Security & Net Zero's (DESNZ's) planned approach

DESNZ faces risks to delivering its ambition of up to 50 gigawatts (GW) of offshore wind power by 2030

Delivery risks

Financing: New offshore wind farms are currently supported through the government's Contracts for Difference (CfD) scheme. DESNZ has already made changes to the scheme in 2021 as CfDs incentivised the production of electricity even during periods of oversupply, leading to constraint costs. CfDs may need to be adapted again in the future when renewables form a greater proportion of the generating mix.

Workforce/supply chain: The Offshore Wind Industry Council published its Offshore Wind Skills Intelligence Report in 2022, stating that the number of employees working in UK offshore wind at the end of 2021 was just over 31,000 and forecast that this would increase to more than 97,000 by 2030. It highlighted skills gaps and shortages to address now and in the future, including in electrical engineering, data science and analysis, and consenting. These risks are exacerbated as other countries in Europe are also seeking to decarbonise their power sectors in response to the recent energy crisis and will require similar capacity and capability.

Site availability: There are limited sites suitable for power infrastructure, and these sites are often also suitable for other projects. For example, marine locations might be suitable for offshore wind and carbon storage, be earmarked as Marine Protected Areas, or be prime fishing grounds; all of which can lead to tensions. DESNZ, the Department for Environment, Food & Rural Affairs (Defra) and other departments are currently working to accelerate offshore wind deployment while simultaneously protecting and improving the environment. In addition, the Ministry of Defence must ensure that wind farms do not cause an unacceptable reduction in the performance capabilities of defence radars.

DESNZ's planned approach

DESNZ is mitigating these and other delivery risks through a suite of measures. For example, to tackle delivery risks and barriers to deployment, DESNZ appointed an Offshore Wind Industry Champion and established the Offshore Wind Acceleration Taskforce (OWAT) to bring industry experts together to work with government (including Ofgem) and National Grid. DESNZ is also continuing to keep the CfD scheme under review to ensure it continues to deliver secure, affordable low-carbon electricity generation, while minimising costs to consumers. The government has set up the Green Jobs Delivery Group, which focuses on workforce actions required across industry and government to help deliver green jobs and skills commitments.

Source: National Audit Office analysis of documentation from the Department for Energy Security & Net Zero

Figure 8

Examples of delivery risks for nuclear power and the Department for Energy Security & Net Zero's (DESNZ's) planned approach

DESNZ faces risks to delivering its ambition of up to 24 gigawatts (GW) of nuclear power by 2050

Delivery risks

Financing: Large-scale nuclear power stations require significant capital investment and can take a long time to provide investors with returns because of the length of time of construction. This can make it challenging to secure private investment, without providing government support. Hinkley Point C will be funded through a Contract for Difference (CfD). To fund a proposed nuclear station at Sizewell C, DESNZ is planning to use its Regulated Asset Base (RAB) model. Under this model, a company will receive a licence from Ofgem to charge a regulated price to consumers towards the cost of the station's construction. This will enable investors to share some of the project's construction and operating risks with consumers, lowering the cost of capital. DESNZ does not have a plan for how it will finance any large-scale nuclear stations after Sizewell C.

Technology: Hinkley Point C and Sizewell C would use the same reactor type, the European pressurised water reactor. There have been delays and cost overruns in projects to build this reactor type in other countries. Reactor types that do not already have regulatory approval would need to meet the requirements of the Generic Design Assessment to ensure high safety, security, environment and waste management standards. This process can take several years. Both small and advanced modular reactors (so-called SMRs and AMRs) are in the very early stages of development in the UK. This means their costs and benefits remain uncertain.

Project developers and site availability: It is not clear who would be able to fund and deliver large-scale nuclear in the future as organisations other than EDF that were planning to finance nuclear projects have withdrawn in recent years. There are eight sites in the UK that are licensed for large nuclear stations.

DESNZ's planned approach

DESNZ is setting up Great British Nuclear (GBN) in early 2023 to develop a pipeline of new stations and progress them through the development process. A team in DESNZ has been scoping and designing this new government arm's-length body since May 2022. DESNZ intends GBN to 'kickstart' the UK's nuclear industry and create a market beyond a single supplier by providing more opportunities for industry to build and invest in. It also hopes to reduce the cost and time it takes to build nuclear stations through learning and replication. DESNZ is also supporting SMRs and AMRs between 2022-23 and 2024-25 through its £120 million Future Nuclear Enabling Fund, by providing grants intended to help develop nuclear projects and reduce project risks, ahead of government selecting the next nuclear projects between 2025 and 2030.

Source: National Audit Office analysis of documentation from the Department for Energy Security & Net Zero

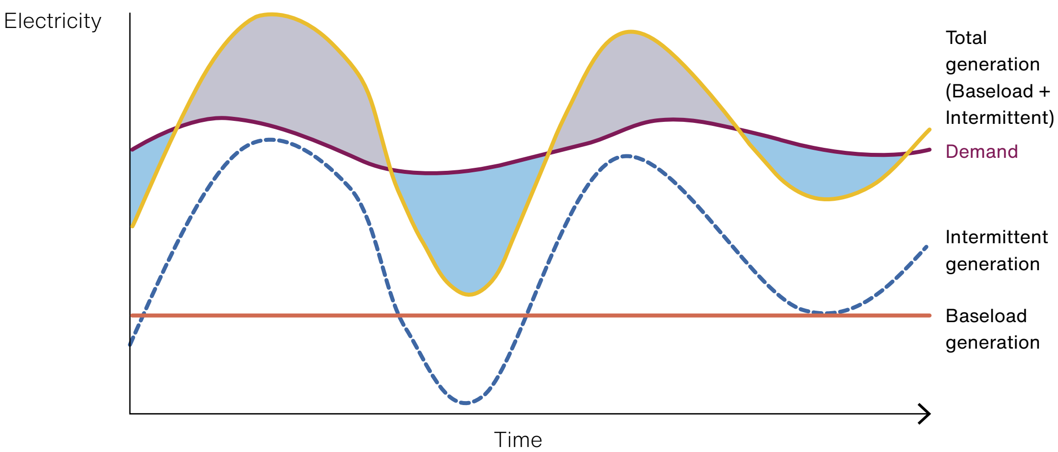
Changing how the system operates

1.12 Increasing the proportion of electricity generated by renewable technologies will have a profound impact on how the system operates. This is because renewables have different characteristics from the technologies they are replacing, particularly gas-fired power stations. Renewables are intermittent: they only produce electricity in certain conditions, such as wind and solar which generate when it is windy or sunny (see **Figure 9**). Gas-fired power stations are flexible: they can produce energy quickly on demand and currently provide most of the flexibility that ensures peaks in demand are met. Gas-fired power stations produced approximately 41% of the UK's electricity in 2021 but the government has set an ambition to reduce gas consumption by 40% by 2030 in its British Energy Security Strategy, and would need to phase out unabated gas-fired generation altogether to decarbonise power fully by 2035.

Figure 9

Illustration of types of electricity generation and fluctuations over time

Electricity generation in a predominantly renewables-based system fluctuates, meaning that at times additional flexible electricity generating sources are required to match demand



- The supply deficit – when intermittent and baseload generation combined is below the level of demand at any given time
- The supply surplus – when intermittent and baseload generation combined is above the level of demand at any given time

Note

1 Intermittent renewables, such as wind and solar, have peaks and troughs of generation linked to the amount of sun and wind. Baseload power, such as from nuclear power stations, provides a continuous flow of electricity when operating. When baseload and intermittent generation combined is below the level of demand at any given time (represented by the blue shaded area), additional flexible energy generation sources are required to ensure supply matches demand.

Source: National Audit Office analysis of published documentation

1.13 The potential solutions to managing with more intermittent generation could come from:

- **flexible technologies:** there are some technologies that provide flexibility and are potentially zero or low-carbon, such as burning hydrogen and using carbon capture with natural gas-fired power stations. In 2020, the system had a maximum of around 10GW of low-carbon flexible technologies.[14] DESNZ considers that by 2030 it may need around 30GW to cost-effectively integrate high levels of renewables. In the British Energy Security Strategy, DESNZ sets out its intentions for flexible technologies, including up to 10GW of low-carbon hydrogen production capacity by 2030, subject to affordability and value for money. DESNZ expects at least 5GW of this to be green hydrogen, that is produced using electrolysis powered by renewable energy. Producing zero and low-carbon hydrogen could be an enabler for hydrogen-powered electricity generation. DESNZ has also indicated that it could need more than 10GW of gas with carbon capture, utilisation and storage by 2035 to meet the Sixth Carbon Budget;[15]

- **innovating to benefit from new technologies:** some of the technologies that the UK is likely to rely on in future (such as hydrogen, and carbon capture, utilisation and storage) are nascent and untested at scale. In its 2021 *Net Zero Research and Innovation Framework*, the government set out the importance of also developing renewable, bioenergy and nuclear power (small and advanced modular reactors); and of energy system integration and flexibility;[16]

- **modernising markets:** current market arrangements for buying and selling electricity were largely developed when gas and coal were the dominant fuels. The wholesale price of electricity is set by the cost of whichever type of power, from whichever source, most recently met the peak demand for energy. The price is constantly updated and is normally set by the price of gas. Russia's invasion of Ukraine led to global gas supply and price shocks in international energy markets, resulting in energy price inflation in the UK. In addition, the current market is not set up to incentivise zero and low-carbon investment in the most effective way. These issues are the subject of the government's current review of energy market arrangements (REMA). This will look to identify reforms needed to encourage investment in generating technologies, including developing markets that incentivise investment in flexible technologies that may only operate for limited periods. DESNZ consulted on REMA between July and October 2022 and is currently analysing feedback; and

14 In 2020, there was around 10GW of flexibility on the system comprising 5GW from interconnection, 4GW from storage, and 1GW from industrial and commercial demand-side response. Imported electricity (such as through interconnectors) does not contribute to carbon emission calculations in the destination country, regardless of how it is generated, and is therefore classed as zero-carbon.

15 The government has set the Sixth Carbon Budget, the volume of greenhouse gases the UK can emit during the period 2033–2037, at 965 $MtCO_2e$. This is in line with the Climate Change Committee's recommendation for this period.

16 Department for Business, Energy & Industrial Strategy, *Net Zero Research and Innovation Framework,* 19 October 2021.

- **demand flexibility:** encouraging households and businesses to be more efficient and flexible in how and when they use electricity might have the potential to reduce peaks in demand, and hence the maximum generating and network capacity that is required. Consumers can benefit from energy efficiency in buildings, variable time-of-use tariffs, and understanding how their behaviour drives costs through smart meters. In 2021, DESNZ and Ofgem, the energy regulator for Great Britain, published their *Smart Systems and Flexibility Plan*, which sets out their vision, analysis and work programme for delivering a smart and flexible electricity system.[17] This included programmes such as the Smart Metering Implementation Programme, alongside actions to remove barriers and reform markets to value flexibility.

Financing power sector decarbonisation

1.14 In its 2021 Net Zero Strategy, DESNZ estimated that £280 billion to £400 billion of public and private investment in generating capacity and flexible assets will be required by 2037 to achieve power sector decarbonisation. This cost range is based on two possible pathways to net zero (one with higher demand levels, and one with lower demand) identified using DESNZ modelling, which relies on, and is sensitive to, a wide range of assumptions such as the costs and characteristics of generating technologies. These costs represent the construction costs for power generation only, and do not include the costs for all aspects of decarbonising the power sector, such as network construction or research and innovation on technologies.

1.15 The Climate Change Committee (CCC), which advises the government on progress towards net zero, estimates that £233 billion of additional capital investment into electricity supply, compared to a no-action counterfactual, will be required between 2021 and 2037. This includes upfront costs for building capital-intensive low-carbon generating capacity such as wind farms. It estimates that capital investment in generating capacity should decline from 2035 onwards as the required build rate begins to fall and costs of low-carbon technologies decrease. The CCC's Balanced Pathway model also estimates £48 billion of additional capital investment in wider infrastructure will be required between 2021 and 2037. This is mostly for electricity transmission and distribution networks, but it also includes investment in the wider economy such as for industrial carbon capture, utilisation and storage. The CCC's cost estimates are also produced using a DESNZ model, but are based on different baselines and the CCC model has additional assumptions and inputs relating to demand, flexibility, capacity ranges, costs and carbon values.[18]

17 Department for Business, Energy & Industrial Strategy and Ofgem, *Transitioning to a net zero energy system: smart systems and flexibility plan 2021*, July 2021.

18 The Climate Change Committee's (CCC's) figure of £233 billion is not directly comparable with the Department for Energy Security & Net Zero's (DESNZ's) estimation of £280 billion to £400 billion, as the DESNZ model is looking at the extra investment needed in power generation, whereas CCC's figures represent the difference in capital spending to meet net zero, compared with a baseline where no additional efforts are made to meet net zero, but the power sector still ensures security of supply and attempts to minimise costs to customers.

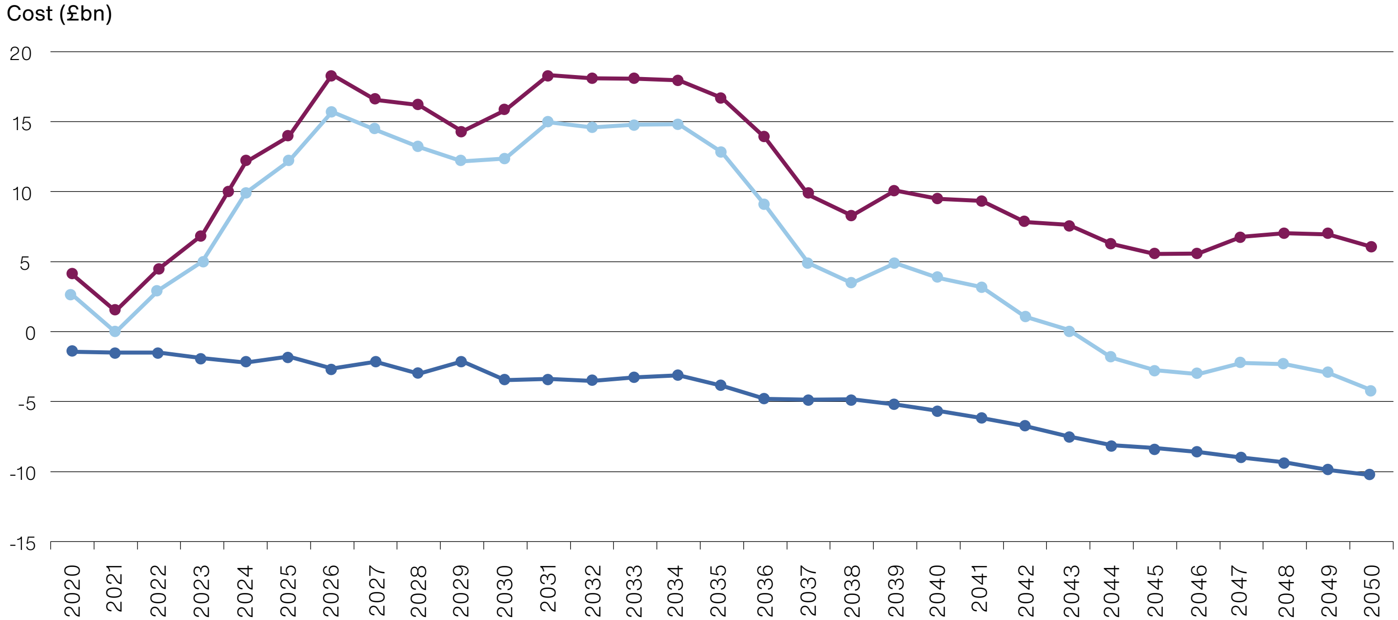
1.16 Large upfront capital costs are likely to be offset over time by operational savings from an increasingly low-carbon system, which is typically more energy efficient. For example, renewables have a very different economic model from gas-fired power stations, because once built they have relatively low running costs. The CCC estimates that the system they have modelled for complete decarbonisation of the electricity sector by 2035 will reduce operating costs by £10 billion a year relative to a high-carbon alternative (see **Figure 10** overleaf).

1.17 Different paths to power sector decarbonisation could have very different total costs depending on factors such as the location of new generation, the impact of any reforms to the electricity market and the effect of efforts to align consumer demand with supply. For example, DESNZ modelling shows that if system flexibility can be improved through electricity storage, demand-side response and interconnectors, this would require building less generating capacity and could save £6 billion to £10 billion a year in 2050 (2012 prices, undiscounted).

Figure 10

Capital investment costs and operational cost savings of electricity supply, 2020 to 2050

From 2044 onwards, the annual operational cost savings are projected to more than offset the annual additional capital investment required for electricity generation



	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Electricity supply CAPEX (£bn)	4	1	4	7	12	14	18	17	16	14	16	18	18	18	18	17
Electricity supply OPEX (£bn)	-1	-1	-2	-2	-2	-2	-3	-2	-3	-2	-3	-3	-4	-3	-3	-4
Total costs (net £bn)	**3**	**0**	**3**	**5**	**10**	**12**	**16**	**14**	**13**	**12**	**12**	**15**	**15**	**15**	**15**	**13**

	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Electricity supply CAPEX (£bn)	14	10	8	10	9	9	8	8	6	6	6	7	7	7	6
Electricity supply OPEX (£bn)	-5	-5	-5	-5	-6	-6	-7	-7	-8	-8	-9	-9	-9	-10	-10
Total costs (net £bn)	**9**	**5**	**3**	**5**	**4**	**3**	**1**	**0**	**-2**	**-3**	**-3**	**-2**	**-2**	**-3**	**-4**

Notes

1 This is based on the Climate Change Committee's (CCC's) Balanced Pathway model. It presents a three-year rolling average of in-year costs. The costs are presented in real 2019 values.

2 Electricity supply CAPEX is defined by the CCC as the additional capital investment required for "the upfront cost of building capital-intensive low-carbon capacity such as wind farms, as well as the need to at least double the size of the electricity sector by 2050. The investment is considerably larger than for gas-fired power plants and confers later savings in fuel use." These capital costs do not include the wider infrastructure investment that is required to enable the Balanced Pathway, such as investment in transmission and distribution networks or the development of Carbon Capture and Storage infrastructure. They also exclude network balancing costs (for example, storage and frequency management), which are estimated to be around £1 billion per year.

3 Electricity supply OPEX is defined by the CCC as "additional costs or saving of running low-carbon solutions once they have been deployed relative to the cost of the high-carbon option they replace."

4 Figures in the table are rounded to the nearest whole number. They may not sum due to rounding.

Source: National Audit Office analysis of the Climate Change Committee's Balanced Pathway data in its *Sixth Carbon Budget Report*. Available at: www.theccc.org.uk/publication/sixth-carbon-budget/

Part Two

Developing and implementing a delivery plan to decarbonise the power sector

2.1 The Department for Energy Security & Net Zero (DESNZ) and other government organisations involved in decarbonising power have a series of actions under way aimed at contributing towards government's ambition to decarbonise power by 2035.[19] However, DESNZ currently lacks an overarching delivery plan that brings these together. This part of the report sets out:

- progress DESNZ has made to date in developing a delivery plan and arrangements for overseeing its implementation;
- why a delivery plan for decarbonising power is important to mitigate value-for-money risks; and
- the risks DESNZ needs to manage in overseeing the progress towards its ambition.

Progress DESNZ has made with developing a delivery plan

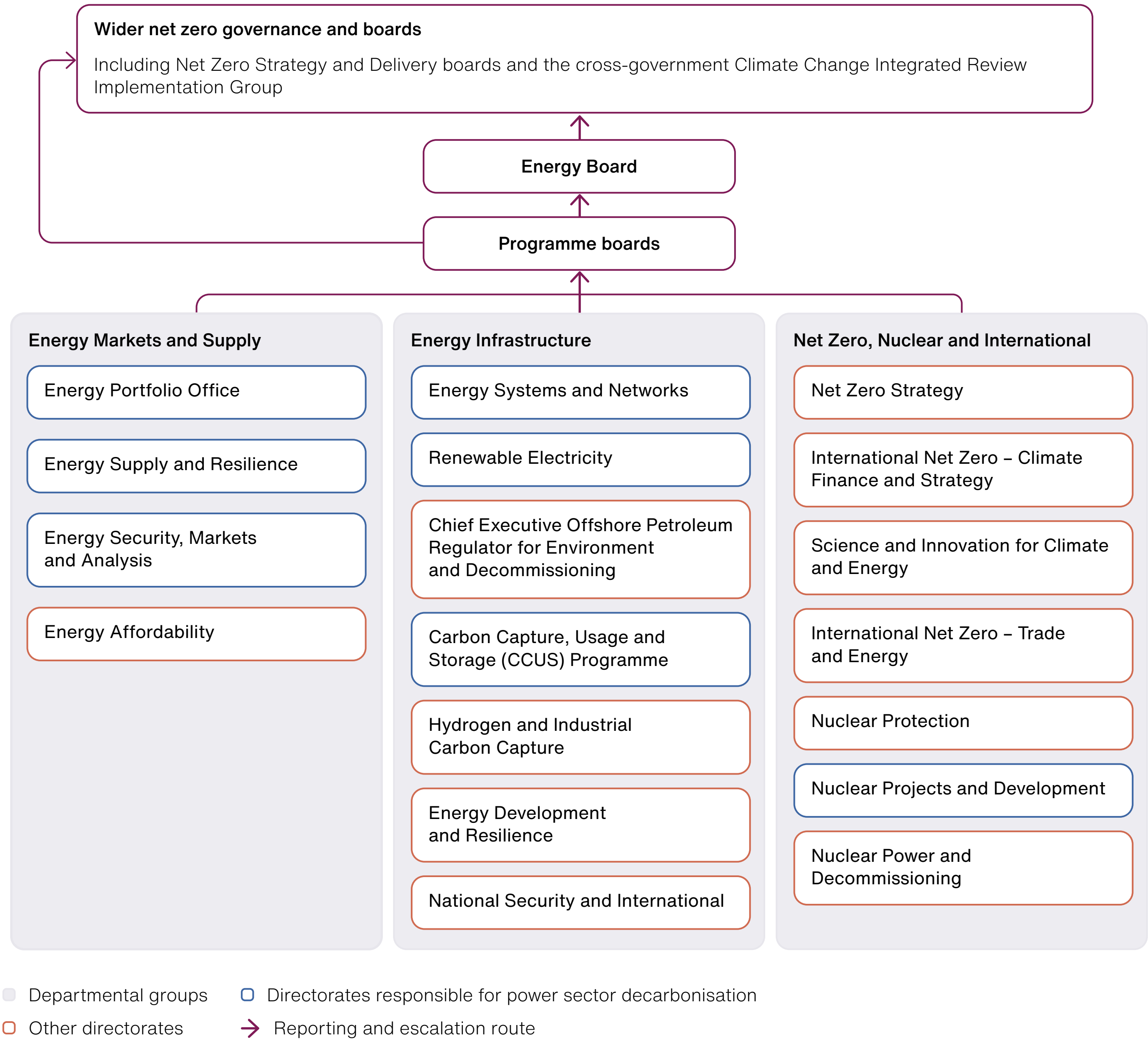
2.2 Since 2021, DESNZ has sought to improve its coordination of activities in pursuit of power sector decarbonisation. The teams responsible for decarbonising the power sector sit in seven directorates across three director general-led groups (**Figure 11** overleaf). In April 2021, DESNZ set up an energy board to provide oversight and assurance of the whole energy portfolio and escalate key risks to the net zero strategy and delivery boards. Each directorate provides a representative to sit on the energy board. Also in April 2021, DESNZ created an energy portfolio office. It created this to provide an overview of the sector, lead and oversee plans for power sector decarbonisation including coordinating work for DESNZ directorates, and act as secretariat to the energy board by providing progress updates, monitoring and risk information.

19 On 7 February 2023, the government announced that the Department for Business, Energy & Industrial Strategy (BEIS) would close, and its responsibilities would transfer to new departments, including the Department for Energy Security & Net Zero (DESNZ). References to DESNZ that relate to events prior to this date therefore refer to BEIS.

Figure 11

Power sector governance in the Department for Energy Security & Net Zero (DESNZ)

Since October 2022 the teams responsible for decarbonising the power sector sit in seven directorates across three departmental groups



Notes

1 See Figure 6 in our 2020 Achieving Net Zero report for more detail on the cross-government net zero governance arrangements. Available at: www.nao.org.uk/reports/achieving-net-zero/

2 DESNZ is made up of four departmental groups. Teams in three of these groups are responsible for decarbonising the power sector.

3 The Net Zero Strategy, and Science and Innovation for Climate and Energy directorates support the power sector but are not directly responsible for decarbonising the power sector.

Source: National Audit Office analysis of the Department for Energy Security & Net Zero's documentation

2.3 In February 2022, the energy board approved a proposal from the energy portfolio office to produce a plan for decarbonising the power sector. DESNZ felt this was necessary to provide a clear vision of how it will achieve power sector decarbonisation, and identify key decision points, risks, mitigations and interdependencies along a critical path.

2.4 However, recent energy sector crises mean DESNZ has made less progress on establishing its delivery plan than it initially envisaged. While prioritising rapid work on support to consumers through the Energy Price Guarantee and the Energy Bill Relief schemes, DESNZ scaled back its work on coordinating long-term power decarbonisation. For example, DESNZ planned internally to prepare a first draft of its delivery plan by October 2022. It told us it still has more work to do to develop a delivery plan.

2.5 Industry stakeholders are increasingly concerned about the lack of a government delivery plan that brings different aspects of power together. The Climate Change Committee recommended in its *2022 Progress Report to Parliament* that DESNZ should publish an overarching delivery plan or strategy for decarbonising power.[20] Stakeholders we spoke to said there needs to be a delivery plan that recognises the time required to decarbonise all aspects of the power sector, including expanding generation and developing technologies ahead of 2035. In addition, a net zero review, published by former energy minister Chris Skidmore in January 2023, noted the need for long-term certainty on policies and support available to unlock investments, and that the absence of this certainty has been a clear barrier to action for businesses and individuals.[21] The review also stated that the UK must demonstrate that its ambitions are being matched by credible delivery plans if it is to show the international community that the UK is serious about its leadership role in the net zero transition.

Risks DESNZ can mitigate by developing a delivery plan

Providing a clear vision

2.6 We expect government programmes to have a clear vision of objectives and an articulation of what success will look like. This is important for effective oversight, assessment of progress and value for money, early identification of problems, and to provide certainty to stakeholders. In decarbonising power there is some unavoidable uncertainty, which means it is not yet possible for DESNZ to define precisely what the decarbonised power system should look like. This is because some technologies are nascent or untested at scale, and others may emerge. As technologies develop, such as new ways to store energy, the most cost-effective pathway towards decarbonisation might change. There is also uncertainty as to how costs of existing technologies will change, and how receptive consumers will be to new ways of flexibly using power. DESNZ therefore needs to devise a delivery plan that both provides sufficient support for technologies that it may come to rely on, and also retains enough flexibility to take advantage of new options as they emerge.

20 Climate Change Committee, *2022 Progress Report to Parliament,* 29 June 2022.
21 Rt Hon Chris Skidmore MP, *Mission Zero: Independent Review of Net Zero*, 13 January 2022.

2.7 A clear delivery plan could help to minimise investors' cost of capital, which would reduce the costs of decarbonisation. In the past we have reported on how policy inconsistency and a lack of a long-term vision may have reduced investor confidence.[22] This can increase the rate of return investors seek and may ultimately increase costs to consumers. DESNZ is hoping that its review of electricity market arrangements (REMA) will provide some of this confidence by providing, for example, signals for investing in electricity generation.

2.8 A delivery plan could also reduce some uncertainties about what a decarbonised power system will look like. In particular, how government envisages the power system operating with more intermittent renewable generation (and less natural gas). Stakeholders we spoke to emphasised the time that could be required to develop solutions in advance of 2035 for reasons including:

- developing markets that incentivise investment in technologies that may only operate for limited periods (which could mean they charge a high price for the energy they generate to compensate for downtime and to cover ongoing costs);
- ensuring sufficient time to test emerging technologies at scale. For example, the UK has virtually no low-carbon hydrogen in the system. There are also concerns regarding bioenergy with carbon capture and storage (BECCS), and stakeholders questioned whether government truly understands the balance of carbon savings against emissions; and
- progressing legislation, for example to enable commercial frameworks that allow carbon capture, utilisation and storage to deploy.

2.9 DESNZ does not yet have a plan for how it will ensure flexible technologies develop quickly enough. DESNZ told us it has chosen not to target a particular generating mix, rather it will develop a range of flexible zero and low-carbon technologies. The government intends to enable this by investing in research and development, and then implementing market arrangements that facilitate competition to ensure the most appropriate mix is achieved. Its approach involves:

- the Net Zero Innovation Portfolio, a £1 billion grant fund running from 2021 to 2025, which aims to accelerate commercialisation of low-carbon technologies, systems and business models in power, buildings and industry;
- the *Net Zero Research and Innovation Framework* and roadmaps, which set out policy and funding available for flexible technologies; and
- consultations with industry on future market arrangements, and drawing on responses to determine future market arrangements, investment incentives and other support.

22 Comptroller and Auditor General, *Controlling the consumer-funded costs of energy policies: The Levy Control Framework*, Session 2016-17, HC 725, National Audit Office, October 2016, paragraphs 3.27 and 3.28.

2.10 The government's ambition is to decarbonise the power sector by 2035, subject to security of supply. However, DESNZ has not defined security of supply, including what residual emissions from fossil fuels it may tolerate if electricity from renewable sources is insufficient to meet demand. It may be, for example, that costs could be significantly lower if power sector emissions reduce to a level that can be offset in other sectors. This could be consistent with net zero overall, but retain system flexibility through limited use of, for example, unabated gas-fired power rather than developing new technologies.

Sequencing and managing links

2.11 The power system has a varied range of market arrangements for different aspects, and organisations with different roles and responsibilities. However, these are also interdependent. To achieve power decarbonisation cost-effectively, changes to different aspects of the power system must be aligned and sequenced effectively, to avoid one aspect being a constraint on another, or changes that are contradictory.

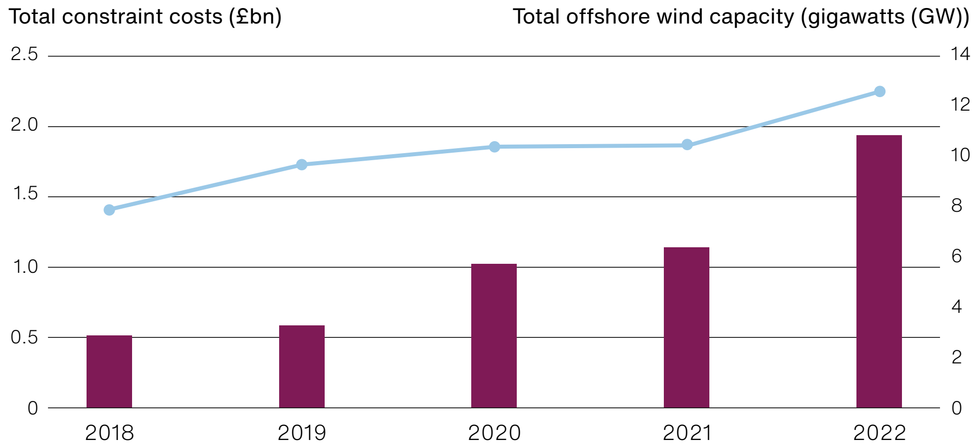
2.12 The effects of poor sequencing are already visible in the relationship between new generating capacity and expansion of electricity networks that connect them to the grid. If generators cannot access the grid, generation exceeds network capacity, or generation exceeds demand, then costs arise to consumers as generators are paid to constrain their output. While constraint costs typically vary (between £0 and £62 million a day since 2018), total annual costs have recently increased, alongside growth in offshore wind capacity (**Figure 12** overleaf). These costs could increase further if network capacity does not keep pace with electricity generation expansion.

2.13 A delivery plan to decarbonise power would help to identify where there are links between different aspects of decarbonisation and set out in advance how those links should be managed. This is what we expect when any department is planning a portfolio which spreads across multiple projects and programmes. We expect departments to have a good understanding of how activities interrelate and how a change in one part of the portfolio affects the whole portfolio in order that the department can act and stay aligned with objectives. For power sector decarbonisation, this would help to prevent bottlenecks in delivery and ensure that activities are given sufficient time to be completed in time for when they are needed.

Figure 12

Transmission constraint costs and offshore wind capacity, 2018 to 2022

Transmission constraints and offshore wind generation capacity have both increased year-on-year since 2018



	2018	2019	2020	2021	2022
Total constraint costs (£bn)	0.51	0.59	1.02	1.14	1.94
Total offshore wind capacity (GW)	7.9	9.7	10.4	10.5	12.6

Notes

1 This figure is illustrative of the challenges which can be seen with increasing generation. National Grid Electricity System Operator (ESO) states constraint costs are likely to increase as significant quantities of new generation capacity are connected. We have not undertaken statistical analysis to show correlation or causation between increasing offshore wind capacity and transmission constraint costs.

2 Constraint costs are impacted by wholesale energy prices; for example, as energy prices increase, the amount paid to generators to constrain their output will increase. We have not accounted for the effect of energy prices on constraint costs; however, it is likely that the increase in constraint costs between 2021 and 2022 is in part due to the increase in wholesale energy prices.

3 Constraint costs are payments to generators to control the electricity that they produce. If generators cannot access the grid, generation exceeds network capacity, or generation exceeds demand, then costs arise to consumers as generators are paid to constrain their output.
For example, there are physical limits on the electricity network surrounding the maximum load that the grid can safely distribute, otherwise the grid would overheat and overload. National Grid ESO assert that it balances the short-term costs of constraint payments against the costs of investing in expanding and reinforcing the grid to find the best value for money for consumers.

4 Constraint costs include: 'reducing the largest loss cost', which can include reducing generation in certain geographical areas while increasing output in other areas since power generators can be geographically distant from demand; 'inertia costs', which enable generating sources to synchronise their output to keep generation stable since turbines will carry on spinning even if the generator has lost power; 'voltage constraints', which ensure that voltage is output at the correct level; and 'thermal constraints', which prevent the circuits in one region from being overloaded by excess energy being transferred from another region.

5 The figure shows all offshore wind farms which are operational at the end of each year. For example, the total offshore wind capacity shown for 2018 includes all offshore wind farms that were operational at the end of December 2018.

Source: National Audit Office analysis of National Grid Electricity System Operator (ESO) Constraint Breakdown Costs and Volumes and the Department for Energy Security & Net Zero's Renewable Energy Planning Database. Available at: https://data.nationalgrideso.com/balancing/constraint-breakdown and www.gov.uk/government/publications/renewable-energy-planning- database-monthly-extract

Ensuring realism and resilience

2.14 When launching any programme, we would expect departments to:

- set realistic targets to manage stakeholder expectations, reduce optimism bias and manage the risk of headline targets driving decisions that reduce benefits overall; and
- ensure plans are resilient to manage risks and help government cope better with future emergency responses, as well as anticipate, withstand and recover from setbacks, without making unaffordable demands of the taxpayer.

2.15 DESNZ considers that achieving its 2035 ambition requires all currently known technologies, including offshore wind and nuclear power, to deploy at or close to the maximum level technically feasible in that time. This approach does not build resilience into the portfolio to take account of potential setbacks, disruption and future uncertainty. DESNZ would need to find alternative ways of achieving its ambition if the deployment of offshore wind or nuclear power began to fall short. This might require, for example, further investment in innovative technologies such as energy storage or greater reliance on reductions in demand. Optimism bias is a concept that is well-recognised in government. HM Treasury has published guidance aimed at redressing the tendency for project appraisers to be overly optimistic, by adjusting estimates of costs and benefits using data from previous or similar projects. Establishing an overall delivery plan is an opportunity for DESNZ to test the resilience of its approach, challenge any potential optimism bias, and identify alternative pathways to deploy if its current approach proves unfeasible.

Cumulative costs and affordability

2.16 For any project or programme, we would expect departments to be clear on the overall budget and how it will be paid for. This should include understanding the key drivers of the overall cost and managing them more closely where necessary. It also provides a baseline against which to measure whether actual costs differ from forecasts and to assess whether a more cost-effective alternative emerges. A detailed cost estimate can also improve understanding and planning for the timing of costs (for example, if costs are likely to be higher sooner due to upfront investments needed).

2.17 Since privatisation in the 1980s and 1990s, the power sector has largely relied on private investment for building and renewing infrastructure. The cost of maintaining and renewing the system tends to fall to consumer bills rather than taxation.

2.18 While DESNZ has estimated what decarbonising the power sector will cost, it has not yet assessed when there may be periods of higher spending and how this will be paid for, particularly if consumer bills remain high due to wholesale prices. The British Energy Security Strategy highlights the importance of energy that is secure, clean and affordable. DESNZ intends to achieve secure and clean energy in the most cost-effective way, and so there is uncertainty in how much achieving these objectives will cost and it will depend on future policy arrangements. It noted that cost-effectiveness must consider the costs to decarbonising the whole economy and not just the power sector. For example, it told us a more expensive power system could lead to a lower cost for decarbonising the economy overall.

Overseeing progress against the delivery plan

2.19 Once DESNZ has developed a delivery plan, it needs to ensure appropriate oversight arrangements are in place to implement it flexibly, efficiently and in the most cost-effective way.

Being able to respond to new information

2.20 Given uncertainties as to the best pathway to decarbonise power, DESNZ needs to ensure its plan can be flexible to new information and that it can take decisions as uncertainties reduce. Without this flexibility there is a risk of missing opportunities to incorporate new technologies that are more cost-effective and offer better value for money, or to respond to new information that emerges from deploying existing technologies. Past experience has shown that assumptions about technologies can prove to be incorrect. For example, the average lifetime cost of an offshore wind turbine has fallen faster than DESNZ predicted.

2.21 DESNZ has two models to help it anticipate a range of possible future scenarios and adapt its plans in response to new information and developments:

- The **Dynamic Dispatch Model (DDM)** is a power sector simulation model developed by DESNZ; it simulates how the electricity demand in Great Britain can be met from 2010 to 2050. The scenarios it produces are indicative as government does not stipulate how the power sector needs to evolve to reach net zero.

- **UK TIMES**, developed by University College London (UCL) and DESNZ, models the whole energy system for the UK and enables assessment of the most cost-effective route to decarbonising across different sectors.

2.22 DESNZ updates the models and their underpinning assumptions as more is learnt about emerging low-carbon technologies; DDM is updated once a year, UK TIMES is continuously being updated. However, since DDM is only updated annually, there is a risk that its results could quickly become out of date if external conditions change. Economic conditions, such as increasing interest rates, could mean that investors' required rate of return on projects, such as offshore wind farms, could be higher than the DDM currently estimates.

2.23 DESNZ also sponsored the Energy Systems Catapult, set up by government to accelerate transformation of the UK's energy system, to develop a 'digital twin' demonstrator for the energy system.[23] This is a virtual model which replicates the power system, allowing users to test different interventions and how they impact the wider energy system.

2.24 We would expect DESNZ to monitor system-wide progress against its ambitions and targets to understand where progress may be off track, and where it may need to allocate and reallocate resources between different activities. DESNZ currently tracks progress at the portfolio level through the energy board. Each of the directorates provides monthly updates to the board, including on how well programmes are delivering against their milestones and intended benefits. However, complete information on progress is only collected for some programmes related to the power sector, such as offshore wind and Sizewell C. It does not currently include, for example, detailed information on progress with networks or Hinkley Point C. DESNZ is planning to continue expanding its monitoring to encompass all the policies set out in the British Energy Security Strategy.

2.25 We would also expect DESNZ to have processes to monitor spend against expectations. Modelling, assessing and managing costs is important, particularly given recent inflation, energy and macroeconomic policy and political turmoil impacting on investor confidence. We found that DESNZ is not tracking total costs incurred and whether these are in line with its expectations for the overall costs to decarbonise. Without cost data, it is more challenging to consider trade-offs and assess pathways to decarbonise that offer superior value for money, and to take decisions to change course in response.

Portfolio risk management

2.26 We would expect DESNZ to:

- monitor and manage risks, with a clear escalation path from project to portfolio level including responsibilities for mitigation and communication at each level;
- assess portfolio risks against its risk appetite and tolerance (and those of other relevant organisations) and manage accordingly; and
- use risk information to inform decision-making, including through reporting risks to critical stakeholders.

23 The Energy Systems Catapult was set up by Innovate UK, the UK's national innovation agency (part of UK Research and Innovation, which is a non-departmental public body of the Department for Science, Innovation & Technology).

2.27 DESNZ is developing and maturing its end-to-end portfolio risk management framework. Risk management processes exist for each programme within the portfolio, and information on each project's most significant risks (that satisfy certain criteria) is escalated for review by the energy portfolio office. Risks can also be escalated for discussion at directorate or group level through other channels, such as via the energy board or net zero boards. For example, if there are too few nuclear technicians to meet the required build rate, the nuclear projects and development directorate is responsible for escalating the risk within DESNZ and proposing possible solutions. However, not all risks are aggregated across the portfolio and there is no portfolio-wide view of the top risks to decarbonising the power sector.

The role of the Future System Operator

2.28 DESNZ plans to establish a Future System Operator (FSO) in 2024 to increase coordination across the power sector. The FSO will have a key role in advising government to inform key policy decisions and facilitating net zero while maintaining security of supply, and an efficient, coordinated and economical system. This might include, for example, advice on the best location to build new wind farms. DESNZ expects the FSO will be an independent organisation that will take on all the main existing Electricity System Operator (ESO) roles and the longer-term roles of the Gas System Operator (GSO), with the aim of enabling more coordinated, strategic and whole-system planning. Creating it requires primary legislation, which DESNZ introduced through the Energy Bill in July 2022.[24] DESNZ has not yet set out how it will work with the FSO and the extent to which the FSO will assume responsibility for some of the coordinating activities envisaged for the energy portfolio office (see paragraph 2.2).

Capacity and capability

2.29 DESNZ will need to ensure it has sufficient capacity and capability to deliver progress against its delivery plan and respond to changes in the external environment. Our 2017 report *Capability in the civil service* highlighted several examples of how capability shortfalls led to problems in projects and programmes.[25]

2.30 DESNZ told us that the recent energy crisis had made it hard to reach complement on long-term activities as hiring staff for short-term activities was prioritised. For example, in February 2023 there were around 75 roles being recruited to the seven directorates working across power sector decarbonisation, as they aimed to grow to meet DESNZ's increased ambitions. In addition, the Government Internal Audit Agency noted that over 2021-22, DESNZ was shifting towards doing more delivery work, compared to policy. This was adding to the pressures on its capability and capacity.

24 As at February 2023, the Energy Bill is progressing through Parliamentary stages and will become an Act subject to Parliamentary approval.
25 Comptroller and Auditor General, *Capability in the civil service*, Session 2016-17, HC 919, National Audit Office, March 2017.

2.31 There are also potential capacity gaps in other government organisations that could hamper progress. For example, DESNZ and other stakeholders told us the Planning Inspectorate, which is responsible for considering wind farm applications and recommending to its Secretary of State whether they should proceed, has capacity constraints that can delay its engagement with applications, increasing the time for projects to come online. This problem may be exacerbated as the number of wind farm applications increases.

2.32 DESNZ directorates can report and escalate issues with resourcing through the governance structures (including the net zero boards). To meet demands within DESNZ, the permanent secretary has the power to move resources between groups, and director generals can move resources between directorates within their group (see Figure 11 on page 32). To prioritise and move resources between DESNZ and other public bodies, it has set up a Resourcing Group to ensure net zero roles can be filled with the right funding and skills, and partner organisations will be requested to contribute to energy priorities with resources. In addition, DESNZ will deprioritise projects where necessary to release resources, and plans to write to partner organisations requesting they release resources to work on high-priority projects.

Appendix One

Our evidence base

1 Our independent conclusions on how the government is managing power sector decarbonisation were reached following our analysis of evidence collected primarily between November 2021 and November 2022.

Qualitative analysis

Interviews with departmental officials and other public sector bodies

2 To understand the steps taken by the Department for Energy Security & Net Zero (DESNZ) to realise its vision for decarbonising the power sector, we conducted 26 interviews with relevant officials within the department. This included teams responsible for:

- energy portfolio;
- nuclear;
- finance and governance;
- delivery and reporting;
- energy security, networks and markets;
- carbon capture, usage and storage; and
- renewable energy and clean growth.

3 These meetings covered:

- understanding the overall vision that DESNZ has for power sector decarbonisation;
- assessing DESNZ's understanding of the interdependencies in decarbonising the power sector;
- understanding the optimisation approach for generation mix that DESNZ has to lower costs and maintain security of supply;
- critical success factors;
- understanding the nature of the targets, ambitions and the definition of security of supply;
- understanding the governance of DESNZ to deliver power sector decarbonisation;
- understanding DESNZ's approach to risk management; and
- understanding the challenges in developing electricity generating technologies.

4 Each interview was tailored to the responsibilities of each team, for example, the questions for the nuclear team were relevant to their particular policy areas.

5 We also met with officials from five other public sector bodies (Ofgem, Low Carbon Contracts Company, National Infrastructure Commission, HM Treasury and the Climate Change Committee) to inform our study approach and understand their perspectives on power sector decarbonisation. These meetings covered:

- understanding whether government is doing everything that it needs to do to achieve power sector decarbonisation;
- understanding the Contracts for Difference scheme;
- understanding the role of regulators; and
- understanding the interdependencies involved.

6 Interviews covered these themes:

- Does government have a clear vision for a decarbonised power sector?
- Does government understand what is required to achieve a resilient and decarbonised power sector?
- Does government recognise, and is it managing, risks to resilience and affordability in a decarbonised power sector?

7 Interviews primarily took place between November 2021 and November 2022. These interviews were carried out online and typically lasted for one hour with detailed notes being taken.

Analytical approach

8 The notes of these interviews were analysed and common themes were identified to inform our conclusions.

Interviews with wider stakeholders

9 To inform our study approach and capture a range of views and perspectives on the effectiveness of current structures and plans, we interviewed:

- industry experts and associations;
- academics and research institutes; and
- transmission and distribution system operators.

10 We conducted interviews with 18 wider stakeholders chosen because of their broad range of perspectives. The approach to each interview was tailored based on the stakeholder. Stakeholders interviewed:

- Providence Policy
- E3G
- UK Energy Research Centre
- Green Alliance
- University of Cambridge Energy Policy Research Group
- Tony Blair Institute
- Energy UK
- Energy Systems Catapult
- Renewable UK
- Hydrogen UK
- The Association for Renewable Energy & Clean Technology
- Volker Beckers
- University College London
- National Grid Electricity System Operator (ESO)
- RSPB UK
- Nuclear Industry Association
- Energy Networks Association
- Imperial College London.

11 These interviews discussed the following themes:

- Does government have a clear vision for a decarbonised power sector?
- Does government understand what is required to achieve a resilient and decarbonised power sector?
- Does government recognise, and is it managing, risks to resilience and affordability in a decarbonised power sector?

12 Interviews primarily took place between November 2021 and October 2022. These interviews were carried out online and typically lasted for one hour with detailed notes being taken.

Analytical approach

13 Notes of these interviews were analysed and common themes were identified.

Document review

14 We reviewed more than 200 departmental documents in order to understand the plan for power sector decarbonisation, and DESNZ's activities and progress. This included a review of:

- modelling of power sector and net zero scenarios;
- board meeting minutes and papers;
- internal management information systems;
- internal progress reporting;
- published strategies and reports; and
- external research reports.

15 Our review was carried out between January and October 2022. Documents reviewed primarily covered the period between August 2013 and October 2022.

Analytical approach

16 We assessed each document in a matrix to identify themes. This matrix considered plans for energy technologies, and for managing the power sector decarbonisation portfolio as a whole.

17 The following questions were considered for each document relating to energy technologies:

- Learning from experience: Has government evaluated the policies it has implemented to date to inform its approach? What do stakeholders think has worked well/not so well?
- Objectives: Does DESNZ have clear objectives (for example, the amount of new capacity required) including interim milestones against which to measure progress?
- Clarity of plan: Does DESNZ have a clear plan for achieving its objectives (roles and responsibilities, accountability structures and governance arrangements, skills and capacity)?
- Monitoring progress: Does DESNZ have information to monitor progress towards its objectives, including leading measures that give early warning signs of progress falling below expectations?
- Costs: Does DESNZ have clear cost estimates, how it will be financed by both public and private sectors, and any differential impacts?
- Managing risks: Does government have structures and processes in place to identify and manage emerging and existing delivery risks?
- Delivery variation: Does DESNZ have mechanisms in place to review its ambitions in response to changes in the delivery environment (for example, new technologies, market reforms, barriers to progress)?

18 The following questions were considered for each document relating to the portfolio:

- Purpose: Does government have a clear and consistent understanding of the power sector's objectives, alongside clear accountability for achieving its objectives?
- Information: Does government collect and structure information in a way to help understand performance at an individual programme, and at the overarching power sector level, to inform any necessary changes?
- Planning: Does government have a clear understanding of the funding and capability that is needed and available to deliver power sector decarbonisation?
- Governance: Does government have a centralised function that can provide the overarching governance and assurance required for the portfolio to be managed as a whole?
- Alignment: Does government understand how activities interrelate across the power sector, and how change impacts the whole portfolio?
- Risk: Does government have a view of risk across the whole of the power sector portfolio?

Quantitative analysis

19 We used datasets from DESNZ and the Digest of UK Energy Statistics to understand the historical supply of electricity. We analysed the generation of electricity and emissions by power source. These data were analysed to assess the current level of progress towards decarbonising the power sector, and to identify high-level generation mix changes.

20 In addition, we analysed projected data for the costs involved in power sector decarbonisation against the potential future cost savings for a decarbonised power system. We also used National Grid ESO data to assess transmission constraint costs.

21 We also used DESNZ's Renewable Energy Planning Database to assess how many gigawatts of offshore wind were in each stage of development, and to determine when these wind farms became operational.

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