

March 2026

Supplementary analysis of the Seventh Carbon Budget

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Climate Change Committee

11 March 2026

This report is available online at: www.theccc.org.uk/publications.

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The Committee

The Climate Change Committee (CCC) is an independent, statutory body established under the Climate Change Act 2008. Our purpose is to advise the UK and devolved governments on emissions targets and to report to Parliament on progress made in reducing greenhouse gas emissions and preparing for and adapting to the impacts of climate change.

Members of the Committee include:



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Nigel Topping was appointed by the UK Prime Minister as UN Climate Change High Level Champion for COP26. In this role Nigel mobilised global private sector and local government to take bold action on climate change, launching the Race to Zero and Race to Resilience campaigns and, with Mark Carney, the Glasgow Financial Alliance for Net Zero.



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Keith Bell is a co-Director of the UK Energy Research Centre (UKERC), a Chartered Engineer and a Fellow of the Royal Society of Edinburgh. He has been at the University of Strathclyde since 2005, was appointed to the Scottish Power Chair in Smart Grids in 2013 and has been involved in energy system research in collaboration with many academic and industrial partners.



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Acknowledgements

The Committee would like to thank:

The team that prepared this report and its analysis. This was led by Emma Pinchbeck, James Richardson, Emily Nurse, Eoin Devane, Esther Harris, and Miranda Schroder; and included Rose Armitage, Owen Bellamy, Sandra Bogelein, Ari Briggart, Marta Calore, Rachel Carr-Whitworth, Victoria de la Cruz, Joshua Deru, Stephen Dillon, Kieron Driscoll, Jana Fakhreddine, Shane Fernando, Ruth Gregg, Rachel Hay, Luke Jones, Sam Karlake, Adam Khan, Shara Lewis-Campbell, Michael Lord, Grace Macready, Fatima Manji, Luke Maxfield, Moryse McInnis, Aaron McMahon, Leo Mercer, Sarah Nelson, Amarath Ou, Emma Patterson, Jessie Peramal, Simon Rayner, Viv Scott, Rachel Sewell, Bryony Sheridan, Jamie Tarlton, Seán Taylor, Indra Thillainathan, Emma Vause, Sophie Vipond, Scarlett Walker, Eveline White, Louis Worthington, and Fergal Wraith.

Our expert advisor on the role of households and the public in the Net Zero transition, Professor Rebecca Willis.

Executive Summary

Under a range of assumptions, the benefits of Net Zero consistently outweigh the costs. While achieving Net Zero requires investment, for every £1 spent there will be £2 to £4 in benefits. A decarbonised UK will provide greater energy security and be cheaper to operate and maintain than the system we have today. The cost of wasted energy will be halved.

Our Seventh Carbon Budget advice report estimated the additional cost of the Balanced Pathway – our pathway to Net Zero – would be around £4 billion per year on average between 2025 and 2050, relative to a baseline of no further emissions reductions from today. Since the advice report was published, there has been challenge around what these costs mean, and public misunderstanding of some of the assumptions made. This report builds on the findings of our Seventh Carbon Budget advice by assessing the full range of quantifiable costs and benefits in the Balanced Pathway. This is done in three parts:

Cost-benefit analysis

To support our assessment of investment and operating costs presented in the Seventh Carbon Budget advice, we now incorporate our assessment of co-impacts to fully appraise the value of the Net Zero transition. These include health benefits from improved air quality and active travel, warmer and less damp homes, and healthier eating habits. We also include benefits from avoided climate damages. This is in line with Government guidance set out in HM Treasury's Green Book and is the standard way of assessing the overall investment case for policies and programmes. Considering this range of costs and benefits, the Balanced Pathway delivers strong value for money, with a benefit-cost ratio between 2.1 and 4.4.

Sensitivity analysis

We test our conclusions from the Seventh Carbon Budget advice and cost-benefit analysis under a range of sensitivities to reflect uncertainties in modelling methodologies and assumptions. These include sensitivities on the choice of time period over which to appraise, the value of carbon emissions avoided, fossil fuel prices, and a range of technology unit costs. Under each of our sensitivities, upfront investment continues to generate operating cost savings that outweigh the additional costs by the Seventh Carbon Budget period (2038 to 2042). The benefits of Net Zero continue to exceed the costs by at least a factor of 1.8. The net additional cost of the Balanced Pathway is between 0% and 0.5% of GDP per year between 2025 and 2050, under each sensitivity.

This sensitivity analysis shows that an electrified energy system is both a more efficient and a more secure energy system. Energy losses in a Net Zero world are halved compared to the system today. When we model a 2022-equivalent fossil fuel price spike occurring once over the period (modelled as 2040), the average household energy bill increases by 59% in the high-carbon baseline, but by only 4% in the Balanced Pathway. When considering costs to households, businesses and the Exchequer, the total additional cost of a single fossil fuel shock of 2022 magnitude is likely to be as large as the total net additional cost of meeting the Balanced Pathway across every year to 2050.

Baseline and gross system costs

Any assessment of the costs of Net Zero needs to take account of the costs of the alternative. Our analysis compares the cost of a Net Zero economy to the cost that would otherwise need to be spent in an economy where we do not pursue Net Zero any further. We find that the gross system cost of the Balanced Pathway falls below the baseline cost from 2041, consistent with the finding in our Seventh Carbon Budget advice that upfront investment into low-carbon technologies generates operating cost savings.

Introduction

In February 2025, we published advice to the UK Government on the recommended level of the Seventh Carbon Budget.

This report complements our Seventh Carbon Budget advice by giving more detail about our assumptions and conclusions on costs and benefits. It also responds to requests from Parliamentarians and government officials to understand how different assumptions – and the latest available evidence on markets and technologies – might impact on our evidence.

This report interrogates our costing analysis by testing alternative assumptions and methodologies. This includes a full cost-benefit analysis, as well as further sensitivity analysis to test the underlying assumptions.

Estimating the cost of achieving Net Zero is technically complex, requiring the application of economic principles and modelling methodologies, supported by a wide range of underlying assumptions. Changing these methodologies and assumptions can have a material impact on the outputs. However, this costings analysis shows that regardless of the chosen methodologies and assumptions, achieving Net Zero brings a net benefit to society.

Our costing assessment for the Seventh Carbon Budget advice

Our advice on the recommended level of the budget is underpinned by detailed sectoral analysis. This sectoral analysis is then aggregated to produce the Balanced Pathway, our cost-effective, cross-economy pathway to Net Zero between 2025 and 2050. The purpose of the Balanced Pathway is to fulfil our obligation under the Climate Change Act 2008 to offer Government advice on the level of emissions reduction in the UK economy. The Balanced Pathway demonstrates that the proposed level for the Seventh Carbon Budget is cost-effective and feasible. The proposed level of the Seventh Carbon Budget is 535 MtCO_{2e}. It is now for the Government to propose a level for the Seventh Carbon Budget to Parliament, and for Parliament to approve or reject that level. This must take place by 30 June 2026.

Our costing of this pathway is carried out in line with principles in the UK Government's official guidance on cost-benefit analysis, the Green Book.¹ Our Seventh Carbon Budget advice report, methodology report, and associated data publications detail the key assumptions and evidence sources underpinning this advice. These reflect the best available evidence at the time of writing.

The costing assessment in the Seventh Carbon Budget advice report is broadly comprised of four parts:

- **Sector-level and whole-economy costs:** We calculate the additional investment and operating costs and cost savings of the Balanced Pathway for each sector, compared to a 'no further decarbonisation' baseline. These are the social costs and cost savings of market sector goods and services, such as the costs of electric cars compared to petrol or diesel cars, or the running costs of electricity compared to petrol or diesel.
- **Assessment of co-impacts:** We assess the value of wider costs and benefits in the Balanced Pathway, including improvements to health and wellbeing. We quantify these co-impacts where this can be done robustly.

- **Costs for households:** We consider how the whole-economy costs and cost savings translate for households by assessing annual household spending on home energy, transport, and food in 2025 and 2050, in line with our Balanced Pathway.
- **Uncertainty analysis:** We supplement our advice with uncertainty analysis, exploring the impact on emissions of uncertainties in key technology costs and future costs of oil, gas, electricity, and hydrogen.

Additional economic analysis in this report

This report builds on these findings by expanding our costing assessment in the Seventh Carbon Budget advice. It addresses the key areas where we can add to our advice for the benefit of the public debate.

The analysis in this report is structured across three chapters.

Chapter 1: Costs and benefits in the Balanced Pathway

Chapter 1 introduces additional cost-benefit analysis of the Balanced Pathway, carried out in line with Green Book guidance. This integrates a fuller range of the costs and benefits for the Net Zero transition. It expands our existing assessment of whole-economy costs and cost savings, and the value of co-impacts in the Balanced Pathway, bringing in analysis of additional co-impacts and the value of the greenhouse gas emissions avoided. We extend our analysis on the benefits from air quality to assess the impacts of a wider range of sectors.

We introduce further analysis on the range of costs and benefits in the cost-benefit analysis. This includes an estimate of savings in the cost of wasted energy across the energy system between 2025 and 2050, as the system becomes more electrified and more efficient.

Chapter 2: Sensitivities to costs and benefits

Chapter 2 tests our costing and energy security conclusions from the Seventh Carbon Budget advice, and our cost-benefit analysis conclusions in this report, by assessing 10 sensitivity scenarios. These include:

- Assessing a longer appraisal period to account for the costs and benefits of Net Zero which will accrue beyond the point at which Net Zero is reached in 2050.
- Adjusting the discount rate to reflect lower expectations of per capita consumption growth for the UK economy, which is a component of the Green Book discount rate.
- Applying a damage-based approach to the valuation of carbon emissions savings, which diverges from the approach recommended in the Green Book.
- Testing the impact of a single fossil fuel price spike between now and 2050 (modelled as occurring in 2040) at the levels experienced in the recent energy crisis following Russia's invasion of Ukraine.
- A range of scenarios varying the costs of key technologies deployed in the Balanced Pathway, including offshore wind, transmission networks, heat pumps, and electric vehicles.
- A scenario where the value of co-impacts is tempered by a rebound effect, whereby improved efficiency of electric vehicles results in increased levels of driving.

Chapter 3: Baseline and gross system costs

Chapter 3 provides further explanation of our baseline and offers more detail around how the costs of the whole system in the baseline compare to the costs of the whole system in the Balanced Pathway.

In the Seventh Carbon Budget advice report, we present our sector-level costs and cost savings, whole-economy costs and cost savings, and co-impacts relative to a baseline of no further decarbonisation. This allows us to assess the additional costs and benefits of achieving Net Zero compared to a scenario where the UK does not pursue Net Zero. This is essential to understanding the cost of Net Zero, as it reflects the difference between costs in a decarbonised UK and the costs that would be spent regardless of decarbonisation.

Chapter 1: Costs and benefits in the Balanced Pathway

This chapter expands our costing assessment in the Seventh Carbon Budget advice report by presenting a wider range of costs and benefits under the Balanced Pathway. We integrate our existing assessment on whole-economy costs and cost savings, and the value of co-impacts, with new analysis on the value of air quality improvements and the value of greenhouse gas emissions avoided.

Our key messages are:

- **When accounting for a full range of costs and benefits, the transition to Net Zero delivers strong net benefits.** When combining the expanded range of costs and benefits using a Green Book cost-benefit analysis approach, the Balanced Pathway demonstrates high value for money. For every pound spent on Net Zero, the benefits outweigh this by 2.2 to 4.1 times.
- **Energy losses in a Net Zero system are halved compared to the system today.** Low-carbon technologies are typically more efficient than high-carbon technologies and therefore require less energy input to meet the same level of demand. We estimate the value of energy losses in our system today and compare this to the value of energy losses in 2050 under the Balanced Pathway. Operating cost savings, from the use of more efficient technologies, is a significant benefit of the Balanced Pathway.
- **The value of health benefits from improved air quality could be higher than presented in our Seventh Carbon Budget advice.** Our Seventh Carbon Budget advice estimated the value of a range of co-impacts from the Balanced Pathway. These include improved air quality, better insulated homes, increased active travel, and healthier diets. Here, we expand our assessment of improved air quality to include the impact of aviation and land measures, which it wasn't possible for us to model at the time of our advice report. We find that the value of benefits from improved air quality are 20% higher in 2050 than presented in our advice report.
- **Avoiding climate damages is the most significant benefit of meeting Net Zero.** Climate change is here, now. Until the world reaches Net Zero CO₂ emissions, with deep reductions in other greenhouse gases, global temperatures will continue to rise. That will inevitably lead to increasingly extreme weather, including in the UK. We introduce new analysis of the value of carbon emissions savings in the Balanced Pathway. Using a range of Green Book-aligned carbon values, we estimate this saving is between £40 billion and £130 billion in 2050.

1.1 Approach

In this chapter, we assess a full range of costs and benefits in the Balanced Pathway using a cost-benefit analysis. This is the UK Government's standard method for economic appraisal, as set out in

the Green Book.² All costs and benefits in this analysis are additional, relative to a no further decarbonisation baseline.*

1.1.1 Approach to cost-benefit analysis

The purpose of an economic appraisal is to support objective, evidence-based decision-making by assessing the social value of a policy option. This involves identifying the full range of costs and benefits associated with the option and applying welfare-economic principles to determine its overall impact on society. Cost-benefit analysis is the recommended approach for appraisal, and its key principles include:

- **Cost streams:** identifying all relevant positive effects on society (social benefits) and negative effects on society (social costs) across a defined appraisal period, compared to a 'no action' counterfactual scenario.
- **Monetisation:** where possible, cost-benefit analysis encourages the conversion of costs and benefits into monetary equivalents. Some economic costs and benefits are priced by markets, and therefore straightforward to monetise. Other economic costs and benefits can be more challenging to monetise, as they are not exchanged at an agreed price. To convert the value of non-market goods and services into monetary terms, economists use a range of well-established methods of valuation. In this analysis, we monetise costs and benefits where possible and compare them. All costs and benefits are presented in 2023 real prices, consistent with those used in the Seventh Carbon Budget advice report.
- **Discounting:** this is the process of converting future costs and benefits into 'present value' terms, in order to reflect society's preference for incurring benefits sooner and incurring losses later. Discounting a stream of monetised costs and benefits will give more weight to costs and benefits in the near term, to reflect this preference.

A cost-benefit analysis is traditionally used to support the economic business case for policy options by the UK Government. Businesses often apply the same approach. Here, we use standard Government approaches to assess the economic case for the Balanced Pathway, considering three broad types of costs and benefits.[†] These are sector-level and whole-economy social costs and cost savings for market goods and services (Section 1.2), the value of co-impacts (Section 1.3) and the value of emissions savings (Section 1.4).

1.1.2 Appraisal period

The appraisal period is the defined time horizon over which costs and benefits are evaluated. The Green Book recommends the selection of an appraisal period that matches the whole lifetime of the proposal. For example, proposals involving infrastructure such as roads, railways, and new buildings would typically use a 60-year appraisal period, refurbishments of existing buildings a 30-year period, and administrative changes a 10-year period. The Green Book acknowledges that some proposals, including measures to reduce climate change risks, are likely to have significant costs and benefits beyond 60 years.

In our cost-benefit analysis, we apply an appraisal period of 26 years (2025 to 2050), which aligns with our Balanced Pathway modelling period in the Seventh Carbon Budget advice report. This is

* For more detail on the cost of our baseline scenario, see Section 3.1.

[†] When assessing policy options for large structural changes, the UK Government is likely to carry out a more detailed assessment than a cost-benefit analysis, including existing policies, multi-scenario modelling and consideration of risk. Our advice on the Seventh Carbon Budget already considers a range of factors, including economic, fiscal and social circumstances, and therefore accounts for large structural change under the Balanced Pathway.

likely to significantly underestimate the benefits of Net Zero, which will continue to deliver substantial value beyond 2050. We explore the impact of varying this appraisal period to more accurately reflect the expected duration over which these benefits will accrue in Section 2.2.2.

1.1.3 Discounting

In order to discount our stream of costs and benefits, we apply the Green Book's Social Time Preference Rate (STPR) as a default discount rate. This means that, for every year into the future that costs and benefits are incurred, their in-year values are discounted at an annual rate of 3.5% in real terms. To align with the Green Book supplementary guidance on emissions valuation, we also apply this rate to emissions savings. For health-related co-impacts, we apply the Green Book recommended lower discount rate of 1.5% in real terms.^{*,3}

HM Treasury has recently announced a review of the current approach to discounting, expected to be completed in March 2026.⁴ We explore the impact of applying an alternative discount rate as a sensitivity in Section 2.2.1.

1.2 Sector-level and whole-economy costs and cost savings

1.2.1 Approach to costings in the Seventh Carbon Budget advice

In the Seventh Carbon Budget advice report, we present the additional cost of the Balanced Pathway, relative to our baseline scenario of no further decarbonisation action in the UK. Our whole-economy costs and cost savings aggregate sector-level modelling of Green Book-aligned social costs and cost savings.[†] When combined, the whole-economy cost of the Balanced Pathway reflects the cost of the transition to the UK economy as a whole, rather than the cost experienced by specific individuals or groups. These are the social costs and cost savings associated with market goods and services.

- **Sector-level costs:** costs in the Balanced Pathway are calculated at sector-level and split into additional investment costs and cost savings (capex) and additional operating costs and cost savings (opex).
 - **Additional investment costs and cost savings (capex):** the in-year premium paid (or saving generated) for low-carbon assets (in our pathway) compared to the high-carbon alternative (in our baseline). For example, in the surface transport sector, additional investment costs include the net cost or cost saving of buying electric vehicles (EVs) compared to fossil fuel vehicles. They also include the cost of EV charge points, and the labour required to install them.
 - **Additional operating costs and cost savings (opex):** the additional ongoing expenses (or savings) incurred to maintain and run low-carbon assets compared to the high-carbon alternative, usually consisting of maintenance and fuel costs. For example, in

* The discount rate for health is lower than the STPR because it does not include the wealth effect: the idea that future income growth makes additional money less valuable. This reflects that improved health, in terms of years lived, does not become less valuable with more income.

† Social costs include the cost of raw materials, installation and labour required to build and operate assets. They do not include transfers, including taxes and subsidies.

the surface transport sector, additional operating costs include the difference between the electricity and maintenance costs for EVs, and the fuel and maintenance costs for fossil fuel vehicles.

- **Whole-economy costs:** sector-level costs are aggregated to estimate the additional cost of the Balanced Pathway to the UK economy as a whole. Costs that pass from one sector to another (for example, the cost of electricity purchased at sector-level, which is passed through to be spent on energy infrastructure) are only included once. This ensures there is no double counting in our aggregated costs.

For more detail on what was included in our whole-economy cost calculations, see Chapter 4 of the Seventh Carbon Budget advice report and Chapter 2 of the methodology report.

1.2.2 Whole-economy costs and cost savings in the Balanced Pathway

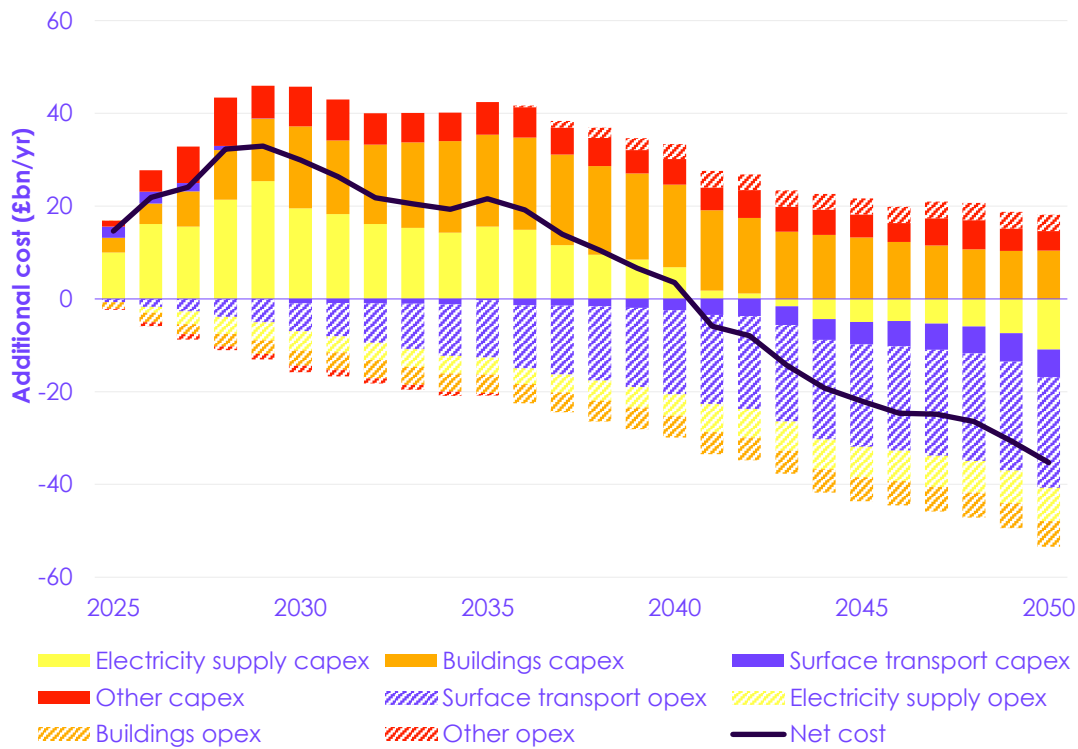
In our Seventh Carbon Budget advice, we find that annual operating cost savings in the Balanced Pathway exceed the in-year investment by the Seventh Carbon Budget Period (2038-2042). Given the balance between investment costs and operating savings, the net additional cost of the Balanced Pathway is around £4 billion per year on average, between 2025 and 2050 (Figure 1.1). This translates to around 0.2% of GDP, using Office for Budget Responsibility (OBR) estimates.⁵

- As a comparison, the OBR estimate that the cost of the energy bill support in 2022-23 following the fossil fuel price spike was £41.6 billion to the taxpayer alone.^{*6} When considering costs to households, businesses and the Exchequer, the total additional cost of a single fossil fuel shock of 2022 magnitude is likely to be as large as the total net additional cost of meeting the Balanced Pathway across every year to 2050 (see Chapter 2).
- Additional investment costs are frontloaded in the Balanced Pathway, peaking in 2029, and then falling towards 2050. Falling investment costs are in part driven by falling costs of low-carbon technologies, as markets begin to establish supply chains and benefit from learning-by-doing and economies of scale.
- Low-carbon technologies are typically more efficient than their high-carbon counterparts and therefore require less energy to meet the same level of demand (Box 1.1). This is a significant driver of operating cost savings, which grow towards 2050 as more low-carbon technologies are deployed.
- As presented in our Seventh Carbon Budget advice report, our headline conclusions on whole-economy costs are undiscounted.

We explore the potential impact of uncertainties in key areas of our sectoral costs on our overall costing conclusions in Chapter 2.

* This includes the cost of three schemes: the energy bills support scheme (EBSS), the energy price guarantee (EPG) and the energy bill relief scheme (EBRS) in the 2022-23 financial year.

Figure 1.1 Additional capital and operating costs in the Balanced Pathway, compared to the baseline



Description: Additional costs in the Balanced Pathway are front-loaded, peaking in 2029. Capital costs are offset by operating savings in later years, with the pathway becoming a net cost saving overall in 2041.

Source: CCC analysis.

Notes: (1) In-year costs are in 2023 prices. (2) Capex is additional capital expenditure and opex is additional operating expenditure. Both are relative to a baseline of 'no further decarbonisation' action. (3) The 'other' category includes fuel supply, aviation, shipping, agriculture, land use, industry, waste, engineered removals and F-gases. (4) Capex and opex are accounted in the years of construction and operation respectively, in line with Green Book practices. In this aggregation of costs, we adjust for double counting by removing the cost of electricity and low-carbon fuels from the sectors which produce them and maintaining this cost in sectors which consume them. There is more detail in Chapter 4 of the Seventh Carbon Budget advice report, and Chapter 2 of the methodology report.

Box 1.1 Efficiency gains in a low-carbon system

Chapter 10 of the Seventh Carbon Budget advice report provides an overview of how energy is supplied in the UK, converted into different forms, and distributed through end uses. Ultimately, input energy is either converted into useful energy or lost. Here, we use this energy system modelling to estimate the value of energy losses in today's system (2025) and in a fully decarbonised system (2050).

Primary energy is the energy that is supplied into the system (for example, as oil, gas, or renewable electricity), transformed, and converted into useful energy (Figure 1.2). At each stage, some energy is lost to surroundings (including through leaks, heat, and sound). By applying the cost of energy to the losses associated with each energy vector, we can estimate the value of total energy lost each year.*

- **Energy losses in today's system are valued at £60 billion per year.** In 2025, the energy system is dominated by oil and gas, which are used to power fossil fuel technologies such as gas boilers and petrol and diesel cars.
 - Around 1,900 TWh of primary energy input is required to generate a useful energy output of around 900 TWh. Due to inefficiencies of fossil fuel combustion, more than half of the energy inputted – around 1,000 TWh – is wasted rather than transformed into useful energy output.
 - The value of energy losses from primary energy to useful output is around £60 billion per year, which is equivalent to £2,000 per household. The majority of this is from inefficient conversion of oil and gas.
- **Energy losses in a Net Zero system are halved compared to today.** In 2050, the role of fossil fuels in the energy system is much more limited, and the system is dominated by electricity, largely generated by renewables. Losses in this system are valued at £30 billion per year. Since many of the electric technologies used tend to be more efficient and therefore waste less energy during conversion, considerably less primary energy is now needed to deliver the same energy service.
 - Losses from transformation of raw resources – such as gas or wind – to energy are reduced. The fuel efficiency of a typical combined-cycle gas power station is only 54%, meaning that around half of the energy content of the gas is lost.⁷ Renewable sources such as wind and solar do not face these economic losses.
 - When energy is delivered to end-users, electric appliances are generally more efficient than their fossil fuel counterparts, meaning that less energy is needed to deliver the same service. For example, EVs are around four times more efficient than a typical petrol car, so require roughly a quarter of the energy to travel a given distance.⁸ In buildings, heat pumps are around three-to-four times more efficient than gas boilers.⁹
 - Despite demand for useful energy growing between 2025 and 2050, the primary energy required to meet this demand falls to less than 1,300 TWh. Due to more efficient energy generation and conversion processes, useful energy obtained from this primary energy increases to around 1,000 TWh. This increases the useful output per unit of input by roughly two-thirds. Energy losses in 2050 are correspondingly lower than in 2025, at 500 TWh per year.[†]
 - In 2025, the majority of energy that is wasted is oil and gas. In 2050, energy losses are a mix of different energy types in the Net Zero system, some of which are more expensive per unit (for example, sustainable aviation fuel). Therefore, the cost per unit of energy lost is higher in 2050 than 2025.
- **Efficiency gains from moving from today's system to a Net Zero system are around £30 billion.** The transition to more efficient low-carbon technologies means that the value of energy wasted in the Net Zero system is £30 billion per year less than in today's system. This is equivalent to around £1,000 per household.

Source: CCC analysis

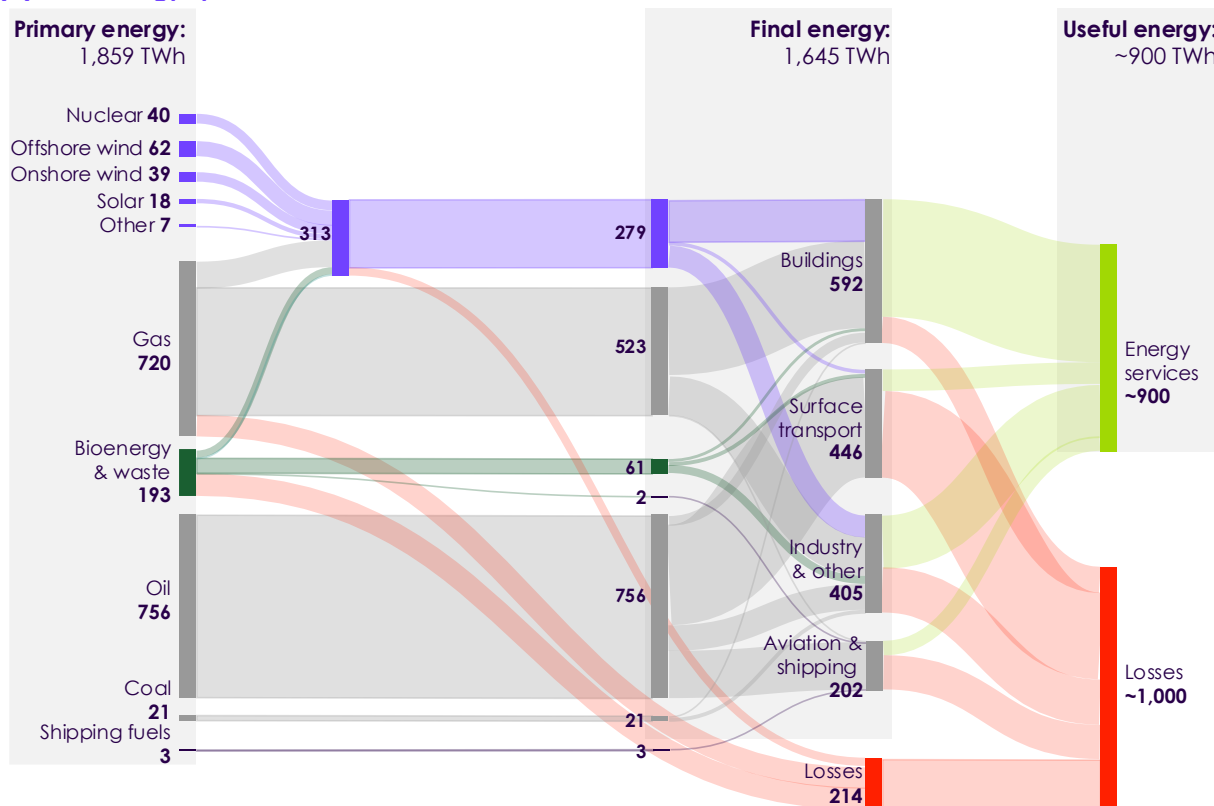
* Energy cost analysis uses long-run variable costs (LRVCs). These depend on energy type and year. They are calculated using the cost of energy generation, including capital and operating components. In this analysis we use the same LRVCs as in the Seventh Carbon Budget advice. For more detail on how they're calculated, see Chapter 1 of the methodology report.

† In 2050, buildings are predominantly heated using heat pumps, which extract around 200 TWh of ambient heat from air, ground and water. This is included in useful energy output, and not in primary energy.

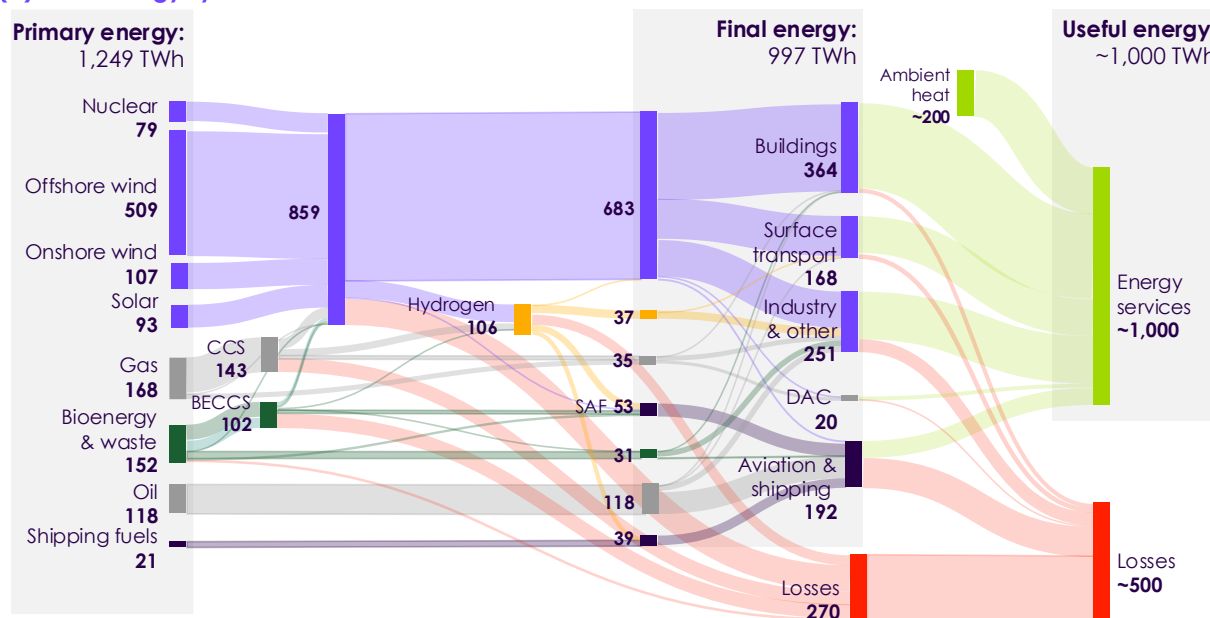
Figure 1.2 The transformation of the energy system in the Balanced Pathway from 2025 to 2050



(a) 2025 energy system



(b) 2050 energy system



Description: Flow diagrams visualising the energy system in 2025 and 2050. The major changes to the system include large scale electrification, a reduced role for oil and gas, and reduced energy losses.

Source: Department for Business, Energy and Industrial Strategy (2019) Experimental statistics on whole UK energy flow incorporating end use energy efficiency; CCC analysis (from Chapter 10 of the Seventh Carbon Budget advice report).

Notes: (1) Shipping fuels include ammonia, methanol, and synthetic methanol. (2) Useful energy and losses are illustrative estimates and have been rounded to the nearest 100 TWh. These are based on evidence on the relative efficiencies of the main technologies in use in each sector in 2025 and 2050. (3) Ambient heat refers to the energy extracted by heat pumps from air, ground, or water. (4) For simplicity, small flows of energy (<1 TWh) have been excluded.

1.3 The value of co-impacts

1.3.1 Approach to estimating the value of co-impacts

In our Seventh Carbon Budget advice, we assess the costs and benefits of wider impacts in the Balanced Pathway. For example, the shift from petrol and diesel vehicles to EVs reduces air pollution, which leads to benefits such as improved health outcomes. These benefits represent a value to society. Co-impacts are presented as a monetary value to society, quantified in line with Green Book appraisal principles.

- Our analysis for the Seventh Carbon Budget advice only includes co-impacts where there is sufficient evidence available, and where the impact is both feasible and material to model. As a result, it is not a comprehensive assessment of all co-impacts, but an estimate of the most significant and most well-evidenced co-impacts only.
- In this analysis, we expand our approach to valuing benefits from air quality improvements from aviation and land use measures (see Section 1.3.2).
- In the Seventh Carbon Budget advice, we present our assessment of co-impacts separately to our sector-level and whole-economy cost assessment. However, for the purpose of cost-benefit analysis, in this report we combine these, along with savings from emissions reductions, to present a full assessment of costs and benefits in the Balanced Pathway.

More detailed analysis on quantified co-impacts can be found in Chapter 8 of the Seventh Carbon Budget advice report and Chapter 3 of the methodology report.

1.3.2 Co-impacts in the Balanced Pathway

Quantified co-impacts in the Seventh Carbon Budget advice

Our Seventh Carbon Budget advice presents a range of positive co-impacts (benefits) and negative co-impacts (costs) in the Balanced Pathway. Positive co-impacts include improved health and wider outcomes, through improved air quality, better insulated homes, increased active travel, and healthier diets. For example, PM_{2.5} emissions from driving lead to impacts on people's health, such as increased respiratory issues and cardiovascular diseases. Negative co-impacts include additional time spent on public transport, and, if a rebound effect (increased driving as a result of lower driving costs of EVs) occurs, include increased costs of congestion. In our assessment, the positive co-impacts significantly outweigh the negative co-impacts.

Key quantified co-impacts include:

- **Cleaner air:** the shift to low-carbon heating, electric vehicles, and modal shift will improve air quality, with knock-on positive impacts such as improved health outcomes.
- **Warmer and less damp homes:** low-carbon heating and energy efficiency measures may also bring benefits such as improved thermal comfort and reduced fuel poverty, provided they are installed appropriately.
- **Modal shift and reduced driving:** provided there are improved public and active travel options, there will be more travel choice, with improved health outcomes from active

travel. Whether a rebound effect occurs affects the extent to which these potential impacts are realised (see Section 2.5).

- **Healthier diets:** a reduction in average meat and dairy consumption is compatible with a healthy and nutritionally-balanced diet and has the potential to bring positive health impacts. The extent of health benefits depends on what types of meat and dairy are replaced and what they are replaced with.

Expansion of air quality benefits

In our Seventh Carbon Budget analysis, improved air quality is one of the largest quantified co-impacts. This accounts for the impact of cleaner air in buildings and transport sectors: from the shift to low-carbon heating, and electric vehicles and modal shift.¹⁰

Since publication, we have expanded this assessment to further estimate the benefits associated with air quality improvements through emissions reduction in the aviation and land use sectors. These are estimated to increase air quality-related benefits from the Balanced Pathway by 20% in 2050.

- We follow the same methodology illustrated in Chapter 3 of our methodology report to estimate the air quality impact of aviation. We convert changes in PM_{2.5}, SO₂, and NO_x emissions related to measures in the Balanced Pathway into monetary values, to capture the positive impacts of improved air quality, in particular on health.^{11;12}
- For land use, we use the monetary values associated with air pollution reduction estimated in a land use valuation model produced by Eunomia.¹³ The avoided damage is due to changes in land cover, including improved air quality from increased tree cover, and reductions in agricultural ammonia emissions, which has positive impacts, in particular on health.
- We also expect significant health benefits associated with improved air quality from industrial decarbonisation. However, we have not been able to quantify these due to data limitations.
 - While national-level estimations are not available, a few studies have been developed for specific subsectors and locations. The Department for Energy Security and Net Zero (DESNZ) has carried out a feasibility study estimating the PM and NO_x reduction potential of non-road mobile machinery decarbonisation to be very high. Tata Steel expects the proposed electric furnace in Port Talbot to reduce dust emissions from site chimneys by 90%.^{14;15}
- There could also be additional benefits from improved indoor air quality, but we have not been able to quantify these (Box 1.2).

Box 1.2 Indoor air quality co-benefits

Improvements in indoor air quality are expected to lead to health benefits. These are not quantified in our Seventh Carbon Budget advice or this report, as indoor air quality is a complex phenomenon and published evidence is limited compared to outdoor air quality.

- People generally spend 80% to 90% of their lives indoors and are exposed to a wide range of emissions. This includes emissions from building materials and fabric, the use of gas and in some cases solid fuel cookers, boilers and stoves, and the use of products containing solvents and other compounds.^{16;17}
- In Chapter 7 of the Seventh Carbon Budget advice report, we illustrate that the buildings sector can almost completely decarbonise through electrification of heating and appliances. This will lead to emissions reductions from toxic pollutants such as PM_{2.5} and NO₂ and could significantly improve indoor air quality.
- Quantifying the impact of indoor air pollution requires estimation of three key dynamics of exposure:
 - Exposure indoors to pollution that has infiltrated from outdoors.
 - Exposure indoors to pollution that has both infiltrated from outdoors and been emitted or generated indoors.
 - Exposure indoors to pollution arising from indoor sources only.¹⁸
- Quantifying each dynamic carries uncertainties arising from limitations in measurement data, variability in building characteristics and occupant behaviour, and differences in pollutant types and chemical transformations indoors. These factors all complicate efforts to estimate health impacts reliably.^{19;20}
- In the absence of sufficient empirical epidemiological evidence on indoor air pollution, some US-based studies provide impact assessments for indoor pollutants. The US mortality burden associated with total indoor and outdoor PM_{2.5} exposure in the year 2012 ranged from ~230,000 to ~300,000 deaths. In the studies, indoor exposure to PM_{2.5} of outdoor origin is typically the largest total exposure, found to account for ~40% to 60% of total mortality.²¹

Co-impacts in the Balanced Pathway

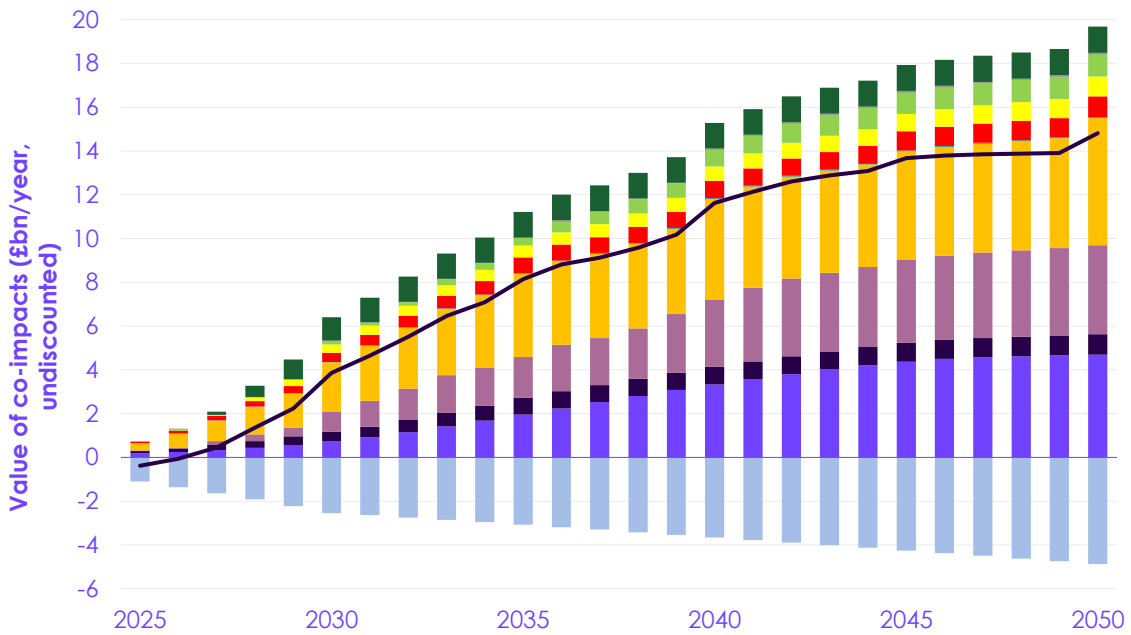
Expanding the analysis to include the impacts from aviation and land use on air quality benefits increases the overall benefits from improvements in air quality by 20% in 2050, compared to our Seventh Carbon Budget advice.

- Including these expanded air quality impacts from aviation and land use increases the total value of all quantified co-impacts in the Balanced Pathway by 7% in 2050, assuming no rebound effect (Figure 1.3). This is the central case that we use for the cost-benefit analysis presented in this chapter.
- There is uncertainty around the degree to which a rebound effect due to the lower cost of motoring for EVs will occur, but policies could be designed to minimise this. This is why we test sensitivities with and without this. In Section 2.5, we test a sensitivity where the rebound effect does occur.

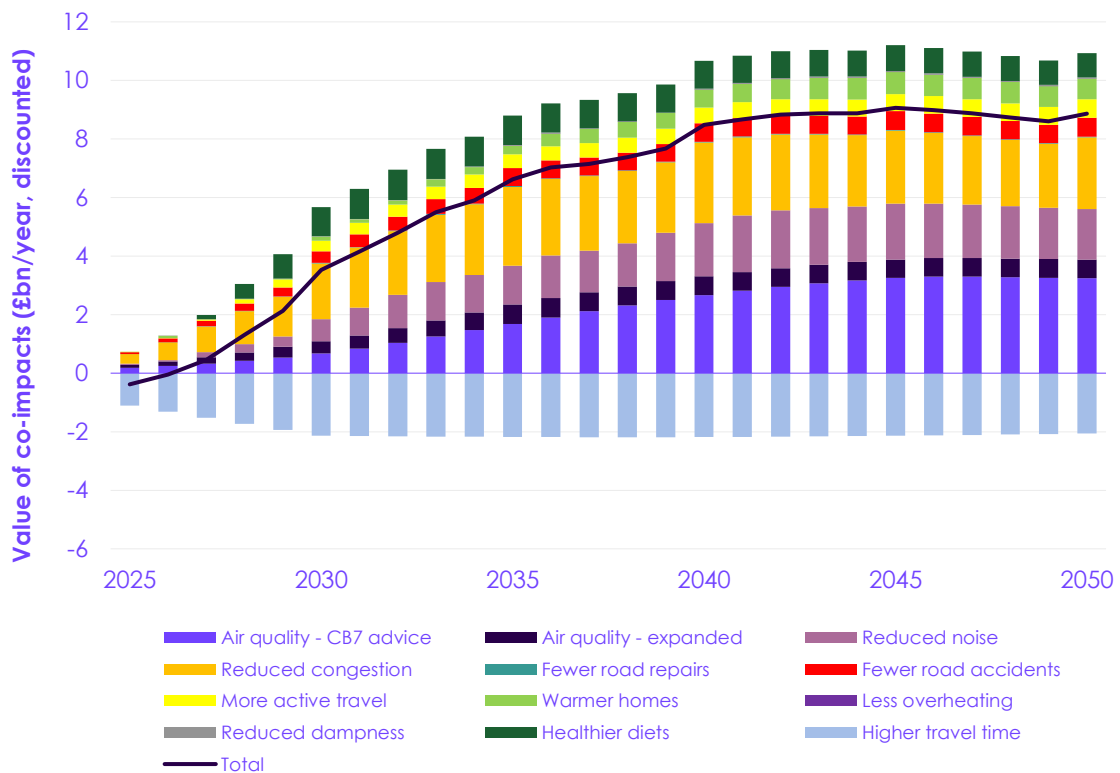
Figure 1.3 Quantified co-impacts in the Balanced Pathway



(a) Undiscounted quantified co-impacts



(b) Discounted quantified co-impacts



Description: Improved air quality from changes to aviation and land increase the total positive co-impacts associated with measures in the Balanced Pathway.

Source: CCC analysis.

Notes: Figures shown are in 2023 prices, both undiscounted (top) and discounted (bottom). Stacked bars show the total value of co-impacts from the Balanced Pathway over time, by co-impact type. Lines show the total net co-impact. Positive values represent a net benefit. This analysis does not include a rebound effect, with rebound effects explored as a sensitivity in Section 2.5.

1.4 The value of emissions savings

1.4.1 Approach to estimating the value of emissions savings

Climate change poses numerous threats to the UK through increased frequency and severity of extreme weather events and gradual climate warming. These include risks to buildings and infrastructure, the natural environment, and human health and life.

- The UK already experiences significant economic loss from impacts related to climate change. It damages the economy and imposes additional costs on businesses and households.^{22;23;24} Avoiding further climate change damages through shared global mitigation action is the most significant benefit of the Net Zero transition.
- In the Seventh Carbon Budget advice report, our headline cost of the Balanced Pathway does not include the value of reducing emissions, nor the cost of loss and damage that would result from failing to take action to address climate change.

For the purposes of this cost-benefit analysis, we calculate the value of damage avoided by reducing carbon emissions in the Balanced Pathway and include this alongside our whole-economy costs. This ensures that we are presenting a full assessment of the costs and benefits of the Balanced Pathway.

1.4.2 The cost of inaction

The economic cost of climate change

Climate hazards, such as floods, storms, and heatwaves, have social and economic consequences when society is exposed to them. These consequences can be more severe when the exposed population are vulnerable. For example, without sufficient adaptation measures, climate change-induced heatwaves can lead to poor productivity, damage to health, and increased mortality. These impacts on economic activity and social welfare can be valued in monetary terms (Box 1.3). Combined with hazard projections from climate models, these can then be used to estimate the total economic costs of climate change.

Estimates of the overall cost of climate change (across all hazards – and including the effects of climate change overseas on the UK) vary, as they come from a range of sources and modelling approaches.* Based on a range of available estimates, climate change damages in the UK could reach 2-4% of GDP under a 2°C global warming level by 2050.† Under a high-end scenario towards 4°C global warming by 2100, aggregated climate damages could cost 4-10% of GDP each year by the end of the century.^{25;26;27;28}

Some of the cost of climate change is already inevitable from historic emissions and unavoidable future emissions, but we can benefit from the avoided cost of further climate damages by reaching global Net Zero emissions.

* In particular, top-down models which simulate systems within the economy, and bottom-up meta-analyses which aggregate sector-specific impact pathways.

† Range is based on estimates of similar scenarios from OBR (2024), Rising et al (2026) (forthcoming), Rising et al (2022), Kahn et al (2021).

Global action on climate change

UK efforts towards Net Zero, alongside efforts from other countries, will lower global warming levels and reduce the associated economic cost from climate change. The UK does not work in isolation:

- 193 countries and the European Union, accounting for 84% of global GHG emissions, have ratified the Paris Agreement.^{29;30} All but one of these have committed to reducing emissions through national plans.³¹ Even following the United States' withdrawal from the Paris Agreement, more than 100 countries (as of the end of 2025), representing 80% of global emissions, had submitted a further Nationally Determined Contribution (NDC) commitment for the next round of climate pledges for 2035.³² Many of these have committed to Net Zero, either through law, policy documents or political pledges.³³
- Global CO₂ emissions from fossil fuel use are estimated to have risen by 1.1% in 2025, below the peak rate of growth of nearly 3% during the 2000s. Global CO₂ emissions from deforestation and land use have also fallen in the past decade.³⁴ China's CO₂ emissions have been flat or falling for the 18 months to September 2025.³⁵ Coal power generation fell in both China and India in 2025.³⁶ As of 2024, 35 countries accounting for 27% of global emissions have achieved a reduction in fossil CO₂ emissions alongside growing their economies over the latest 10 year period, almost double the number of countries as over the preceding 10 years.³⁷
- As a global leader in climate policy, the UK's decisions around decarbonisation have significant influence on other countries' abilities to meet their climate targets.³⁸ Reaching Net Zero domestically is likely to influence emissions reductions in other countries, driving further global reduction in climate damages.³⁹

1.4.3 Valuing carbon emissions in the Balanced Pathway

In 2050, emissions in the Balanced Pathway are 490 MtCO₂e lower than emissions in the baseline.* We can estimate the economic value of this abatement by applying a carbon value to each unit of emissions avoided. The carbon value represents the monetary value to society of avoiding emitting one additional tonne of CO₂e.

- There are two main ways to calculate carbon values in policy appraisal (Box 1.3):
 - A social cost of carbon approach (which estimates the total global damages from climate change, and then scales this down to the damage cost associated with one unit of emissions).
 - A target-consistent approach (which considers the cost of abatement required to meet pre-determined climate targets).
- The Green Book endorses the second approach to carbon valuation, but there continues to be debate over which approach is most useful in appraising climate policy.⁴⁰
- In developing the Balanced Pathway, we used the Government's target-consistent carbon values to determine when measures become cost effective for inclusion in the pathway. Therefore, the Balanced Pathway generally does not include measures for which the cost per unit of emissions avoided exceeds this value. See Chapter 2 of the Seventh Carbon Budget advice report for further details.

* Emissions in the baseline increase relative to today, due to population and GDP growth.

Carbon values are not the same as carbon prices, such as those in the UK Emissions Trading Scheme (UK ETS). Carbon prices represent the traded price for emissions permits in a carbon trading system and depend on the intersection between supply and demand of permits, and other market conditions. Carbon values reflect the economic cost of emitting carbon across the whole economy.

Box 1.3 Approaches to valuing carbon

Social cost of carbon:

The social cost of carbon (SCC) estimates the present value of global damages resulting from one additional tonne of CO₂e emitted today. The SCC is usually calculated through complex integrated assessment models (IAMs), which simulate the chain from emissions to global economic losses.

- IAMs have varying assumptions, including economic factors, such as future population and GDP growth, climate model responses to emissions, and the pathway of global emissions.
- Given the range of assumptions and inputs required to estimate the SCC, estimates vary by practitioner and over time, as models are improved and updated based on the latest climate science.
- Extensive literature on the SCC shows a broad range of values depending on these assumptions. For example, a recent meta-analysis found that the 2050 SCC could range from £72/tCO₂e to £945/tCO₂e.^{*:41}
 - The SCC increases over time for two reasons: climate damages become larger as emissions accumulate, and rising income increases the economic value of avoided damages.

Target-consistent carbon values:

Given the significant range of methods and assumptions required to estimate the SCC, the UK Government has opted for a more practical and transparent approach of basing carbon values on existing targets.

- In the UK, target-consistent (TC) carbon values reflect the marginal abatement cost needed to meet agreed targets, including legislated UK carbon budgets, Net Zero, and international targets under the Paris agreement.
- UK TC carbon values are anchored in 2040 global marginal abatement cost estimates, primarily from the IPCC 1.5°C pathway, and wider IAMs.⁴² A constant real growth rate of 1.5% constructs a trajectory of carbon values for each year between 2025 and 2050.⁴³ Using this method, the central estimate for the TC carbon value is £281/tCO₂e in 2025 and £409/tCO₂e in 2050.
- Given modelling variability, a plus or minus 50% sensitivity range is applied around the central value, constructing a high and low bound. The range of TC values is within the range of SCC values found in the literature.
- This approach does not directly incorporate the value of welfare damage from carbon emissions. However, the underlying Net Zero target and IPCC pathways used to construct it are justified by climate science. Therefore, the target-consistent approach anchors in welfare benefits indirectly.
 - The IPCC find that limiting warming to 1.5°C substantially reduces climate-related risks, losses and damages across natural and human systems, with lower projected risks to health, livelihoods, food and water security, and ecosystems than a 2°C scenario.⁴⁴
 - The IPCC's 6th Assessment Report (AR6) finds that, even without accounting for co-benefits of mitigation, the global benefits of pathways limiting warming to below 2°C outweigh global mitigation costs over the 21st century.⁴⁵

* These carbon values are calculated by converting the central estimates in the paper into GBP, at 2023 prices, and applying a 2.2% growth rate to 2050, as suggested in the paper.

Both approaches to valuing carbon carry uncertainty. However, UK emissions avoided from reaching Net Zero are certain. Irrespective of the approach used, it is clear that emissions avoided from reaching Net Zero represent a significant, quantifiable benefit.

- Our efforts to reduce emissions will benefit countries beyond the UK. Equally, we also benefit from efforts to reduce emissions in other countries, which are considerable (see Section 1.4.2). SCC values account for the global benefit of emissions reductions, not just the benefit to the UK. The value of emissions reductions using this approach represents the climate damage that we are no longer causing in the UK, nor contributing to the rest of the world.
- The TC approach is not damage-based, however it is inferred using a global pathway to Net Zero based on the best available climate science, so does account for global damages indirectly (see Box 1.3).
 - We align our assessment with the Green Book TC values and present a low to high uncertainty range based on the recommended low to high carbon values. Using these values, the savings from UK emissions reduction grow over time to reach £40 billion to £130 billion per year in 2050.
- Given the uncertainty around carbon valuation, we also test a sensitivity using a lower SCC-derived carbon value series, recommended for use in cost-benefit analysis by the Government of Canada (see Section 2.2).

1.5 Assessing the range of costs and benefits in the Balanced Pathway

1.5.1 Costs and benefits in the Balanced Pathway

Figure 1.4 combines the whole-economy costs and cost savings, the quantified co-impacts, and the value of carbon emissions saved (using central carbon values) to show a range of costs and benefits in the Balanced Pathway. The profile can be explained in terms of costs (above the axis) and benefits (below the axis):

- **Costs:** mostly consist of additional investment and some additional operating costs required to meet the Balanced Pathway, with a small amount of negative co-impacts. Where low-carbon technologies are more expensive than their high-carbon counterparts, or where there is greater deployment of low-carbon technologies, the additional cost represents the premium paid in the Balanced Pathway compared to the baseline scenario. In many cases, this premium falls in later years as the cost of low-carbon technologies falls.
- **Benefits:** include operating cost savings, driven by improved efficiency of electric technologies, and some capital cost savings as the cost of low-carbon technologies (especially EVs) falls below the cost of their high-carbon counterparts. Other benefits include health and wellbeing co-benefits, and significant benefit in the value of emissions avoided.

When these costs and benefits are combined, the Balanced Pathway will begin to deliver net benefits from 2029.

- When applying DESNZ's central carbon values, the Balanced Pathway delivers a net benefit of +£110 billion per year between 2025 and 2050. This represents the annual average of the

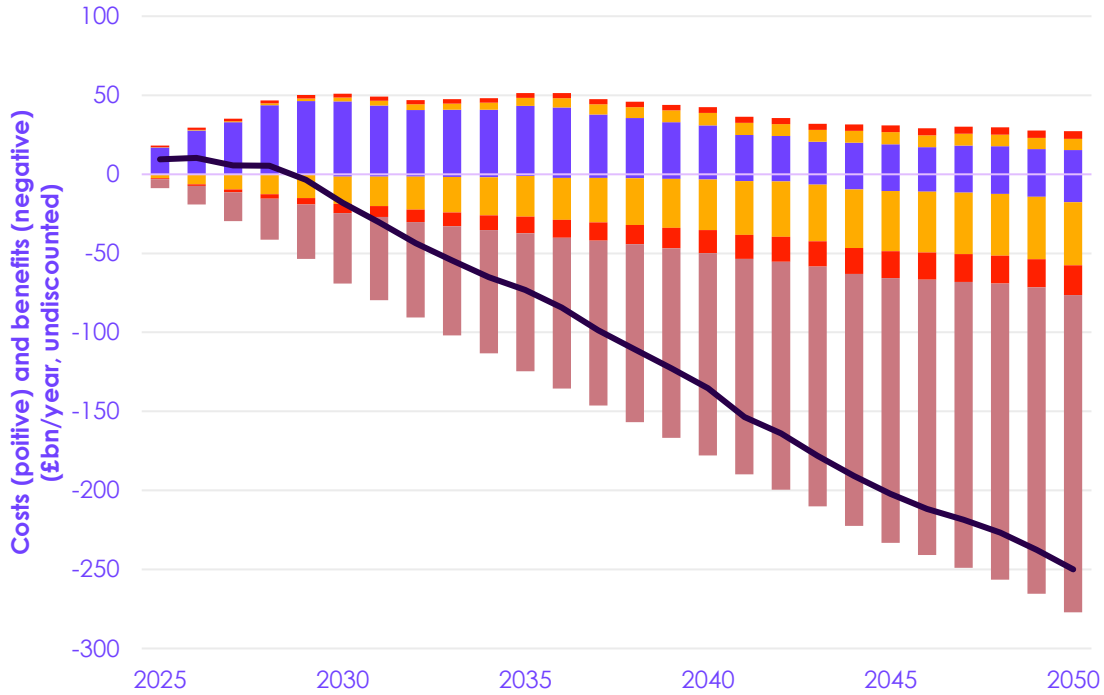
benefits minus the costs, without discounting (Figure 1.4a). When we discount future costs and benefits, the Balanced Pathway delivers a net benefit of +£60 billion on average per year between 2025 and 2050 (Figure 1.4b).

- The largest single component of the costs and benefits in the Balanced Pathway between 2025 and 2050 is the savings from emissions avoided in the Balanced Pathway, compared to our baseline scenario.

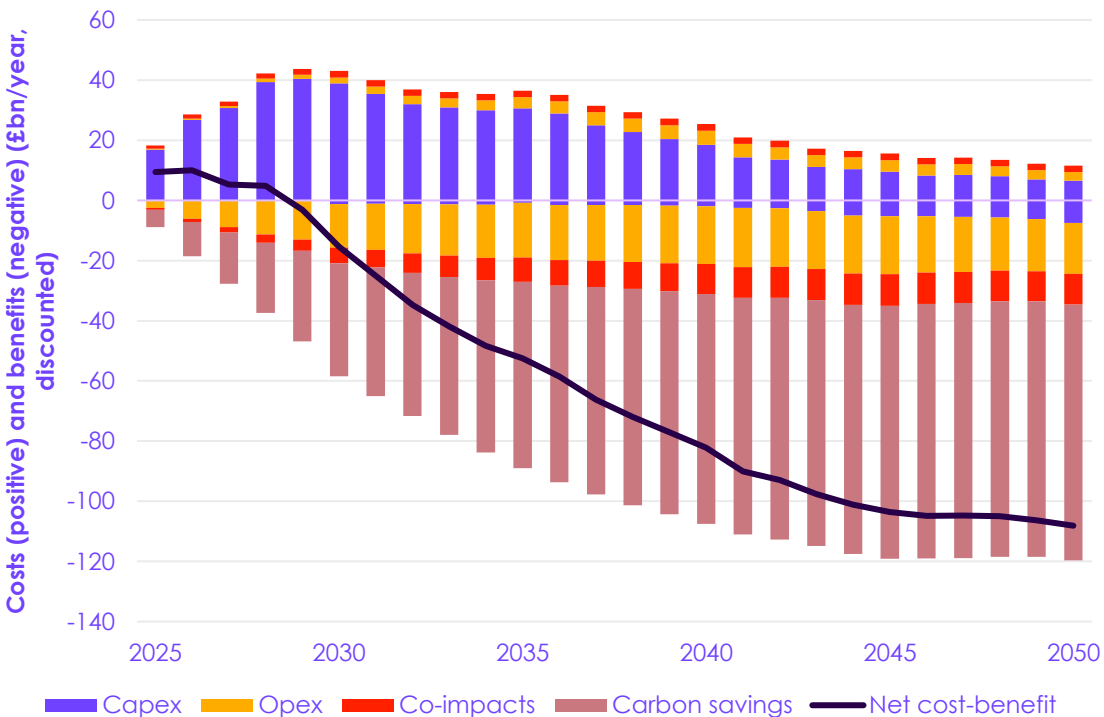
Figure 1.4 Costs and benefits in the Balanced Pathway (undiscounted and discounted)



(a) Undiscounted costs and benefits



(b) Discounted costs and benefits



Description: When a full range of costs and benefits are considered, the Balanced Pathway begins to deliver net benefits from 2029.
Source: CCC analysis.
Notes: Costs and benefits are relative to a baseline of 'no further decarbonisation', aligning with our baseline case in the Seventh Carbon Budget. Emissions savings apply the DESNZ central carbon value. The net cost-benefit line represents the quantified impact of the Balanced Pathway on society. Discounted costs and benefits (including carbon savings) apply a 3.5% standard discount rate. Health-related co-benefits apply a 1.5% discount rate.

1.5.2 Economy-wide cost-benefit analysis results

Table 1.1 shows the results of the cost-benefit analysis for the Balanced Pathway, incorporating the range of discounted costs and benefits set out in Section 1.5.1.

- The Balanced Pathway has a large net present value (NPV)* of around +£1,580 billion (+£790 billion to +£2,370 billion using the range of low to high carbon values) and a benefit-cost ratio (BCR)† of 3.3 (2.1 to 4.4).
- This shows that the Balanced Pathway yields significant net value due to the value of the operating cost savings, co-benefits, and emissions savings it delivers. The present-value of the benefits delivered by the pathway are 2.1 to 4.4 times higher than present-value of its costs.

Elements included	Net present value	Benefit-cost ratio
Capital and operating costs, co-impacts, emission savings, relative to the baseline	£1,580 bn (£790 bn – £2,370 bn)	3.3 (2.1 – 4.4)

Source: CCC analysis.
Notes: Assessment is aligned with Green Book principles. Central estimates apply the central DESNZ carbon value. The range of NPV and BCR use the high and low carbon values according to DESNZ carbon valuation guidance. Investment and operating costs, non-health related co-impacts and carbon emissions savings are discounted at 3.5% and health-related co-impacts are discounted at 1.5%. An appraisal period of 26 years in used (2025 to 2050). Costs are in real 2023 prices.

* The net present value (NPV) sums the discounted future net cost streams (benefits and costs) to find a present-value view of the return on the project. The NPV is the additional value delivered by a project (in discounted terms), over and above its cost, across the appraisal period as a whole.

† The benefit-cost ratio (BCR) finds the ratio between the present-value benefits and present-value costs. A BCR above 1 means, in discounted terms, the project delivers more benefit than cost, while a BCR below 1 means the project's costs exceed the benefit.

Endnotes

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- ⁴⁵ IPCC (2022) *Climate change 2022: Mitigation of climate change. Working group III contribution to the sixth assessment report of the intergovernmental panel on climate change*. https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_FullReport.pdf

Chapter 2: Sensitivities to costs and benefits

Our confidence in the cost of the Net Zero transition has strengthened over the past decade, with the cost of many key low-carbon technologies falling rapidly as markets develop. However, there remain uncertainties around how costs will change over the next 25 years.

In the Seventh Carbon Budget advice and methodology reports, we identify a range of uncertainties and test their impact on our emissions conclusions. This chapter builds on that analysis, testing the impact of a range of key sensitivities on our costing conclusions from the Seventh Carbon Budget advice, and our cost-benefit analysis findings in Chapter 1. Our key messages are:

- **When tested under a range of sensitivities, the benefits of Net Zero still outweigh the costs.** When assessing the impact of our sensitivities on our cost-benefit analysis set out in Chapter 1, we find that the benefits of the transition to Net Zero significantly exceed the costs in all cases. Under our sensitivities, the range of benefit-cost ratios (BCRs) is 1.8 to 5.1.
- **Investment in low-carbon technologies will unlock savings for the UK.** In each sensitivity, between 2025 and 2050, the net additional cost of the Balanced Pathway is between 0% and 0.5% of GDP per year. Upfront investment unlocks significant savings in the future as inefficient fossil fuel technologies are replaced by more efficient, low-carbon alternatives. These savings grow over time and begin to exceed in-year costs during the Seventh Carbon Budget period (2038 to 2042).
- **Over a longer time horizon, the Balanced Pathway delivers further cost savings.** We extend our costing profile by 10 years (until 2060), in order to account for the costs and benefits of Net Zero beyond 2050. This sensitivity delivers a BCR between 2.6 and 5.1. In terms of investment and operating costs, this sensitivity delivers a net cost saving across the whole economy compared to a no further decarbonisation baseline. In our central case, where we account for costs between 2025 and 2050, the pathway delivers a net additional cost of £4 billion per year, or 0.2% of GDP.

2.1 Approach to sensitivities

The costs of high and low-carbon technologies depend on a number of factors, including the rate of technological innovation, policy and regulation, international markets and changes in consumer behaviour. However, there have been considerable reductions in the cost of several key low-carbon technologies over recent years.

- While offshore wind investment costs have seen recent increases, this follows significant cost reductions seen over the 2010s and into the early 2020s. The strike prices achieved in Allocation Round (AR) 7 were 55% lower than those seen in AR1 (see Box 2.3 for details).
- Electric vehicle (EV) battery prices have decreased dramatically over the past decade, with the speed of reduction significantly outpacing our early projections. Despite small price increases in 2022 due to supply chain disruptions, prices continued to fall in 2023 and 2025. Overall, prices fell by 77% between 2015 and 2025.¹

Our Seventh Carbon Budget advice report, methodology report, and associated data publications detail the key assumptions and evidence sources underpinning our advice. These reflect the best

available evidence at the time of writing. We supplement this with uncertainty analysis, exploring the impact on emissions in our Balanced Pathway of uncertainties in key technology costs and the future costs of oil, gas, electricity, and hydrogen (see Chapter 6 of the advice report and Chapter 5 of the methodology report).

In this report, we build on this sensitivity analysis, making use of an updated evidence base. We set out 10 sensitivities which vary elements of the costs and benefits of Net Zero, as set out in Chapter 1. These include sensitivities to our economic appraisal parameters, our assumptions around fuel costs, the cost of key technologies, and the extent of realised co-benefits. We assess the impact of these sensitivities on our costing conclusions from the Seventh Carbon Budget advice, and our cost-benefit analysis conclusions.

- We have developed these sensitivities to test different parameters in our economic appraisal methodology, and possible future scenarios for fuel costs, key technology costs, and consumer behaviour.
 - Technology and fuel cost sensitivities should be understood to represent plausible variations from the cost assumptions used in the advice report. In many cases significant uncertainty remains.
 - Each sector in our pathway includes a mix of technologies. If one technology is more expensive than modelled, we would expect the deployed mix of technologies to rebalance towards more cost-effective solutions. In the case of our sensitivities for electricity system technology costs and fossil fuel prices, we do not adjust for this balance due to modelling constraints. Therefore, the impact of these sensitivities is likely to be overstated.
 - We treat each sensitivity as independent and have not modelled for interactions or cascading impacts. Therefore, sensitivities should not be combined.

2.2 Economic appraisal sensitivities

2.2.1 Uncertainty around the discount rate

In our cost-benefit analysis, we follow standard Green Book guidance for discounting future costs and benefits (see Section 1.1). Over the course of the pathway, financial costs and benefits and carbon savings are discounted at 3.5% per year in real terms, and health impacts are discounted at 1.5% per year in real terms.

- The choice of discount rate for standard policy appraisal is based on a wide range of evidence, last reviewed in 2018.² As set out in Section 1.1.3, this evidence is currently under review.
- The social time preference rate (STPR) (the Government's recommended standard discount rate) has two components: a 'time preference' and 'wealth effect'. The time preference is the rate at which consumption and public spending are discounted over time, assuming no change in per capita consumption. The wealth effect reflects expected growth in per capita consumption over time, where future consumption grows relative to current consumption. In the Green Book, the time preference component is estimated to discount costs and benefits by 1.5% per year. The wealth effect is comprised, in part, by expected growth in future real per capita consumption, assumed to be 2%. The sum of the time preference rate (1.5%) and the wealth effect (2%) is the Green Book's recommended STPR of 3.5%.³

- The growth rate of real consumption per capita is strongly correlated to real productivity growth (output per worker). This is because growth in productivity leads to higher incomes, and therefore more affordable spending per person. However, the UK has seen consistently low productivity growth in recent years. Annual productivity growth fell from an average of 2.1% in the decade before the global financial crisis, to 0.6% between 2010 and 2019, and has since stalled.⁴ In November 2025, the Office for Budget Responsibility (OBR) revised down their central forecast for underlying productivity growth to 1%.^{*5}

To reflect the lower estimate of productivity growth over the last 15 years, we test a sensitivity using a lower discount rate of 2.5%. This applies a growth rate in real per capita consumption of 1% per year, rather than the 2% assumed in the previous review of Government discounting. Health impacts continue to be discounted at the standard rate set out in Section 1.1.3.

2.2.2 Extending the appraisal period beyond 2050

In our Seventh Carbon Budget analysis, and the cost-benefit analysis in Chapter 1, we use a 26-year time horizon (or appraisal period). This accounts for costs and benefits between the year of our advice report publication in 2025 and the Net Zero target in 2050.

- In the Green Book, the recommended appraisal period is defined as the time horizon over which the costs and benefits of a policy choice are evaluated. As set out in Section 1.1.2, there is no single 'correct' appraisal period in cost-benefit analysis, but the guidance typically recommends matching it to the economic life of the project or policy. The Green Book states that the appraisal period may be extended if there is evidence that a longer time period is required for the full effects of an intervention to materialise.
- Many technologies deployed in the later years of the Balanced Pathway will continue to deliver savings beyond the Net Zero target in 2050. By extending our appraisal period, we can account for the savings from low-carbon technologies which are deployed in the lead up to 2050.
 - For example, an electric car purchased in 2045 has an expected lifetime of 15-years and so would continue delivering operating cost savings until 2060 with no further investment. Using a 26-year appraisal period for the Balanced Pathway, the total upfront investment for the electric car is included in our assessment of costs and benefits, but the full corresponding savings across the lifetime of the technology are not.

In order to account for these later costs and savings we test a sensitivity which extends the appraisal period by 10 years (from 2025 to 2060). Due to modelling limitations, instead of comprehensively assessing costs beyond 2050, we assume that costs and costs savings broadly stay constant.

- By 2050, many of our sectors have reached Net Zero. At this point, the additional investment and operating costs from each sector are mostly associated with continued running of low-carbon technologies and the replacement of low-carbon technologies which have reached the end of their lifetime. When we extend the sector-level costs beyond 2050, we assume that the running and replacement costs modelled for the year 2050 continue to be incurred each year.
- Some sectors will still be decarbonising in 2050, and therefore still deploy one-off structural investment that will not need to be spent the following year. For example, in the buildings sector, some investment in 2050 is still required for building ancillary works, rather than just the cost of replacing assets at the end of their lifetime. Due to modelling constraints, we

* The OBR's measures of productivity growth represent the medium-term growth in trend output per hour worked.

include one-off investment incurred in 2050 in the years between 2051 and 2060, and, as a result, overestimate investment over this time period.

- We would expect a portion of decommissioning costs for gas infrastructure, and some additional decommissioning costs for renewable energy to be spent after Net Zero is reached in 2050. When we extend the cost profile to 2060, we include these further decommissioning costs that we expect to be spent between 2051 and 2060.
- After 2050, we do not assume any further deployment of low-carbon technologies beyond replacement of existing technologies, so co-impacts are assumed to be constant. We also assume that emissions abatement remains at 2050 levels compared to the baseline.*

2.2.3 Uncertainty around the carbon value

In Section 1.4, we set out the two main approaches to valuing the damage avoided from reduced carbon emissions: a target-consistent approach and a social cost of carbon (SCC) approach. To align with the Green Book, our central approach applies target-consistent carbon values.

- As discussed in Box 1.3 (in Section 1.4), estimates of the SCC vary significantly by practitioner and over time. This is predominately due to varying assumptions in the Integrated Assessment Models (IAMs) used to estimate the SCC. These include different assumptions around economic factors, climate model responses and expected damages. The UK Government therefore recommends the use of target-consistent values instead.
- Some Governments do recommend the use of SCC values in climate policy appraisal. We reviewed the guidance of carbon appraisal across G7 economies, and found that two – Canada and Germany – endorse an SCC approach for carbon valuation in policy appraisal, and publish recommended SCC values.
 - The Government of Canada recommends applying a range of carbon values. In 2050, this range is equivalent to £166/tCO_{2e} to £390/tCO_{2e}.
 - The German Environment Agency (UBA) also recommend applying a range of carbon values. In 2050, this range is equivalent to £355/tCO_{2e} to £881/tCO_{2e}.
- As a conservative approach, we test a sensitivity to our cost-benefit analysis that uses the carbon values from the Government of Canada, as the lower range of carbon values.⁶

2.3 Fossil fuel price sensitivity

2.3.1 Uncertainty around the price of oil and gas

Our analysis for the Seventh Carbon Budget assumes largely flat fossil fuel costs after 2030. In reality, fossil fuel prices are highly volatile, and driven by international commodity markets that can fluctuate sharply in response to geopolitical events, supply constraints, and global demand shifts. A system that relies heavily on fossil fuels is therefore exposed to significant price shocks and heightened risk to energy security. To illustrate this vulnerability, we model the impact of a sudden spike in fossil fuel prices on overall system costs within the Balanced Pathway.

* This assumption may be an underestimate, as we expect carbon sequestration from tree planting in the years up to 2050 to increase in scale as trees mature well beyond 2050. However, as the Seventh Carbon Budget analysis does not model policy drivers beyond 2050, we have taken a conservative approach and kept emissions abatement constant at 2050 levels.

Our energy modelling in the Seventh Carbon Budget advice uses long-run variable costs (LRVCs) to value changes in energy consumption.^{*7} The LRVCs for fossil fuels in our Balanced Pathway apply the central value from the Department for Energy Security and Net Zero (DESNZ) fossil fuel price assumptions.⁸ These balance global scenarios of supply and demand, to determine a stable global price for fossil fuels in future years. Historically, fossil fuel prices have been volatile and difficult to forecast.

- Constraints on global crude oil supply led to prices rising nearly four-fold in 1974, falling and then increasing nearly three-fold in 1979.⁹ This contributed, along with other factors, to recessions in the 1970s and early 1980s, with high inflation (peaking at 24% in 1975) and rising unemployment (peaking at 12% in 1984).^{10;11}
- In 2022, the invasion of Ukraine led to rising prices of wholesale gas and electricity in the UK.¹² The OBR has estimated that the average price of electricity, petrol, and gas in 2022 was around 20% higher than the inflation-adjusted peaks of the 1979 and 2011 to 2012 oil shocks, even after adjusting for the Ofgem price cap and the Energy Price Guarantee.¹³ This triggered a rise in the cost of living in the UK and contributed to a recession, with one in ten firms reporting that they ceased operations in one or more of their businesses.¹⁴
- The OBR modelled the impact of a gas price spike every decade, replicating the 2022 spike.[†] They found that the cost to the Exchequer could be between 2–3% of GDP in each year that the spike occurs, under the assumptions that the Government provides a similar level of fiscal support to households and businesses in each gas-price-spike year as was seen in 2022 to 2023. Taking account of debt interest and reductions in economic activity, this would result in an increase in public debt of 13% of GDP by 2050 relative to a scenario in which there are no further gas price spikes in the future.¹⁵
- The transition to a more electrified, efficient, renewables-based system will reduce overall exposure to fossil fuel price volatility. In the OBR's gas spike scenario, they found that continued reliance on gas would result in the UK being over 40% more exposed to a spike in the late 2020s than if gas usage followed the Government's 2021 Net Zero Strategy's 'indicative delivery pathway'. For a spike in the late 2030s, the UK would be twice as exposed, and in the late 2040s, the UK would be five times more exposed.¹⁶

We test a sensitivity of a potential future spike in global oil and gas prices in 2040 (Figure 2.1), replicating the fossil fuel price spike following the invasion of Ukraine in February 2022. This takes a similar approach to the OBR fiscal risk and sustainability reporting in 2023.¹⁷

- In the sensitivity, the residential gas LRVC increases by around 160% between 2039 and 2040, before falling to pre-spike levels over 7 years. The wholesale petroleum LRVC increases by around 50% between 2039 and 2040 and falls to pre-spike levels across the same 7-year period. This profile of the spikes in 2022 and 2040 are modelled using a combination of observed prices and forecasting from DESNZ.[‡]
- Households and businesses reduced their energy consumption in response to the recent gas price spike. It may have also acted as a catalyst to increase deployment of low-carbon

* For oil, gas and coal, we use LRVCs from DESNZ supplementary Green Book guidance. The guidance does not include LRVCs for shipping or aviation fuels, which we develop separately. We also develop electricity LRVCs. See Chapter 1 of the methodology report for more detail.

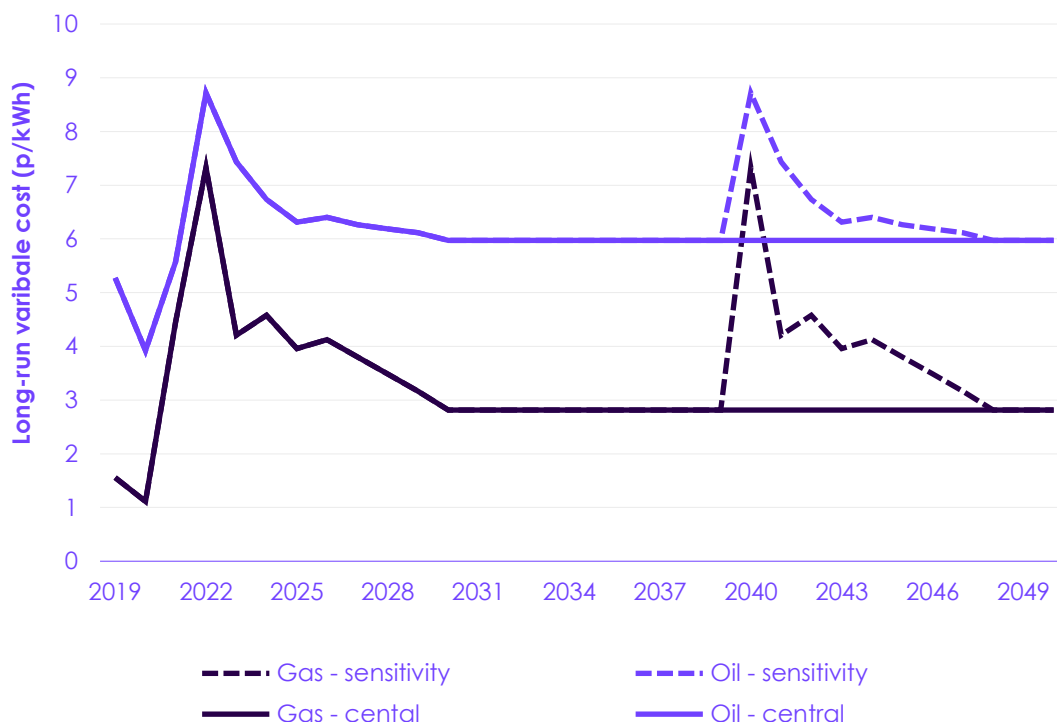
† In this scenario, the OBR assume that the UK remains reliant on natural gas for around 40% of its energy needs rather than achieving the decarbonisation expected in a net zero scenario, and therefore remains exposed to volatility in global wholesale gas markets.

‡ LRVCs are based on the latest Green Book guidance on valuing energy use, published in 2023. We have not updated costs to reflect recent trends in energy costs.

technologies across Europe, reducing dependence on gas and exposure to further shocks.¹⁸ Due to modelling constraints, neither of these effects are included in our sensitivity test.

- In the current system, electricity is often generated by gas. Therefore, electricity cost uncertainties are closely linked to the uncertainty on gas costs in our baseline and the early years of our pathway. By 2040, renewables have replaced much of the gas in the electricity supply sector in the pathway, reducing exposure of the electricity supply system to a spike in fossil fuel prices.

Figure 2.1 Impact of fossil fuel price sensitivity on oil and gas cost



Description: The sensitivity in fossil fuel prices replicates the spike in energy prices in 2022 following the invasion of Ukraine, in 2040.

Source: Department for Energy Security and Net Zero (2023) Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal; CCC analysis.

Notes: (1) Gas represents the LRVC for residential gas prices, and oil represents the LRVC for road petrol. (2) The central case applies the latest Green Book guidance on LRVCs from 2023. Costs have not been adjusted to reflect the latest market trends.

2.4 Technology cost sensitivities

2.4.1 Uncertainties in electricity system investment costs

In the Balanced Pathway, significant investment in electricity generation, storage, and network infrastructure is required. This is both to replace ageing assets and to enable widespread electrification, as the economy switches from fossil fuel technologies to more energy-efficient electric alternatives.

Even in a world where no further decarbonisation takes place (represented by our baseline scenario), a significant amount of investment would still be required to replace existing assets as

they come to end of their operational life. We would also need to service demand from a growing population and economy.

Across the energy system, both low and high-carbon technologies have seen upward pressure on investment costs over recent years (see Box 2.1 and Box 2.3). Evidence we have reviewed suggests combined cycle gas turbines (CCGTs), offshore wind, and transmission networks are among technologies whose investment costs have been affected.

Gas CCGTs

Over half of the current CCGT fleet is expected to close by 2035.¹⁹ Our baseline scenario builds around 35 GW of new unabated CCGTs between 2025 and 2050 to replace these assets as they retire and to service increasing demand from future population and economic growth. The investment and operating costs (including fuel costs) of unabated gas are included in the total gross costs of the baseline and are therefore important determinants of additional costs of the Balanced Pathway. The investment costs of CCGTs have increased in recent years (see Box 2.1).

Box 2.1 Increases in investment costs for combined cycle gas turbines (CCGT)

Recent data from DESNZ, following an evidence collection exercise from energy sector experts, indicate increases in the investment costs of Combined Cycle Gas Turbines (CCGTs).²⁰

- In the DESNZ 2025 Generation Costs data, the assumed unit construction cost for new-build unabated CCGT plants has increased by 51% in real terms relative to the previous data published in 2023.²¹
- Some reports suggest cost increases could be higher. SSE, the company which built the last new CCGT plant in the UK in 2023, has indicated that costs to build an equivalent plant today could be up to three and a half times higher.²² Similar rates of increase have been reported in the US.²³

Evidence suggests the main factors driving this increase are strong global demand and constrained supply chains.^{24;25}

- The lack of active construction of new CCGTs in the UK means it is challenging to determine the drivers of higher costs, but a review of available evidence suggests that many of the same factors impacting other investment costs in the electricity system would also apply.
- A report published by GridLab in May 2025 found that nearly all of the key components in constructing CCGTs are seeing price increases, and that scarcity has led to increased pricing power by original equipment manufacturers (OEMs).²⁶ This report focused on the US market, but many of these same inflationary factors would be expected to also apply to the UK, given the global nature of the supply chain and the likelihood that developers in the UK would need to use the same OEMs as developers in the US. Gas turbine manufacturing in both Europe and the Americas is dominated by the 'big three' companies (GE Vernova, Siemens Energy, and Mitsubishi Power).²⁷

These factors would also likely affect the cost of constructing new build gas-CCS and hydrogen-powered plants. In the DESNZ 2025 Generation Costs data, the assumed unit construction cost for hydrogen CCGTs increased by 42% in real terms compared to the 2023 Generation Costs report, and the assumed unit construction cost values for gas-CCS increased by 31% in real terms relative to the 2020 Generation Costs report (gas-CCS costs were not covered in the 2023 report).

Offshore wind

When modelling offshore wind costs in our Seventh Carbon Budget analysis, we applied a 25% uplift (which we assumed to be linearly unwound by 2030) to the 2025 capex estimates from the DESNZ 2023 Generation Costs report.²⁸ This reflected evidence available at the time on recent supply chain inflation.^{29;30;31} We then applied a 12% learning rate.* See Box 10.2 of the methodology report for more details.

New evidence corroborates these inflationary pressures, now indicating they are expected to be more sustained, especially in the short to medium term.

- Contracts for Difference (CfD) AR6 results for offshore wind achieved an average strike price of £80/MWh relative to £51/MWh for AR4, with AR5 having received no offshore wind bids. AR7 results were announced in January 2026, with the average clearing price for offshore wind being £89/MWh.[†]
 - As there is a multi-year lag (typically around 4-8 years) between a CfD contract being awarded and offshore wind coming online, many of the projects with low CfD strike prices from AR3 and AR4 have not yet become operational.³² As more become operational, these projects are expected to exert downward pressure on consumer bills.
 - Projects commissioning in the late 2020s and into the early 2030s are more exposed to recent price pressures. This is reflected in the higher strike prices of AR6 and AR7 compared to AR4.
- DESNZ published updated generation cost assumptions in their 2025 Generation Cost report, including updated investment costs, which are a key input to our electricity system cost modelling (Box 2.2). The updated assumptions suggest offshore wind capex has increased substantially relative to the 2023 Generation Cost report. The drivers of increased costs are discussed further in Box 2.3.

In the medium and long term, there is a high degree of uncertainty around the investment costs of offshore wind. It remains unclear to what extent the drivers of the recent cost increases will persist (Box 2.3). For the purposes of sensitivity testing, we look at two options: a short-term shock in investment costs which partially unwinds before returning to a steady learning rate; and a long-term structural increase combined with a more gradual learning rate to 2050. These reflect a more conservative outlook on cost reductions relative to our Seventh Carbon Budget analysis, which assumes a full unwinding of cost pressures.

In both of these scenarios we assume:

- A starting investment cost in 2025 aligned with our Seventh Carbon Budget value in 2025.
- A linear ramp up in investment costs to align with DESNZ's medium scenario by 2030, maintaining alignment until 2032.[‡] This is expected to be conservative given the strike

* Learning rates refer to the percentage reduction in costs assumed per doubling of global capacity deployed.

† The average AR6 clearing price quoted excludes permitted reduction CfDs. Note all costs are given in real 2023 prices.

‡ The 2030 DESNZ medium scenario capital cost includes construction and pre-development costs of around £2,600/kW. To be consistent with our Seventh Carbon Budget analysis, we have also included 'infrastructure costs' and applied an 11% optimism bias. This increases the 2030 medium scenario capital cost to around £3,700/kW.

prices achieved in AR7. It also allows also for the possibility of cost increases for subsequent allocation rounds.*

Offshore wind: supply shock

Under this sensitivity we assume that cost pressures begin to unwind from 2032, before returning to more stable learning rates from 2037.

- We assume the cost reduces linearly from the DESNZ medium scenario in 2032 to the DESNZ low scenario value by 2037, reflecting a plausible scenario for partial resolution of the supply shock. Factors driving this could include the return of raw material prices to the pre-COVID-19 pandemic average, easing of supply pressures as investments are made in bottlenecks, or increased market competition.
- Following this, the sensitivity returns to the learning rate assumed in our Seventh Carbon Budget analysis.†

Offshore wind: structural increase

An alternative scenario is that inflated costs persist, due to factors such as increased commodity prices and supply chain constraints continuing, resulting in offshore wind costs remaining consistently higher over the long-term. In this scenario, there is no unwinding of the supply shock, with cost reductions restricted to more conservative learning rates.

Under this sensitivity, from 2032 we continue to align with the medium capital cost assumptions in the DESNZ 2025 Generation Costs report, which assumes cost reductions occur based on a learning rate of 7%.

* Within the DESNZ 2025 report, the 2030 medium scenario is reported to have a levelised cost of energy (LCOE) of £101/MWh. In general, a project's strike price is expected to be above its underlying LCOE as strike prices include additional factors such as commercial risk and revenue considerations that do not form part of its LCOE. This suggests that the cost assumptions within DESNZ's 2030 medium scenario are more conservative than the projects procured through AR7, which achieved a strike price of £89/MWh. Note all cost and prices are given in real 2023 prices.

† This is more ambitious than the DESNZ learning rates of between 5-9% (depending on scenario) but less ambitious than the International Renewable Energy Agency (IRENA) OECD learning rate of 16%.

The Seventh Carbon Budget electricity sector costings reflect **electricity system costs**. This includes the costs of individual generation technologies and the wider costs of building and running the system such as network costs and energy storage costs, also accounting for system balancing. Our electricity system costs were modelled using AFRY's BID3 model, also used by DESNZ.³⁴

- Our energy system costs reflect the Green Book-aligned principles used by Government, including the cost of raw materials, installation and labour required to build and operate assets, but excluding transfers such as taxes and subsidies (see Section 1.2).
- Key inputs to our electricity system costs include the necessary investment and operating costs of the grid, energy generation and energy storage.
- To ensure consistency with Green Book guidance, we uplift these investment costs to account for optimism bias.

In our advice report, we also give **levelised cost of energy (LCOE)** estimates for renewable electricity generation technologies. These are not used as an input to our system modelling but are rather an output metric, designed to facilitate comparison between generation technologies. The levelised costs we report differ from the electricity system costs as follows:

- LCOEs are technology-specific and show the per unit cost of generation over an asset's lifetime. This is based on assumptions about energy generation, generation investment and operational costs, and an assumed hurdle rate.
- LCOE estimates reported in our advice report consider Green Book-aligned investment and operational costs. Green Book-aligned costs do not include all the costs to a project developer. LCOEs additionally do not include the wider costs of running the electricity system, which are included in our electricity system costs.
- Where LCOEs shown in our advice include costs which are not Green Book-aligned (such as hurdle rates), these do not feature in our electricity system costs.

CfD strike prices are another commonly cited metric for renewables costs, reflecting the outcome of the UK's Allocation Rounds. They are influenced by commercial circumstances, policy choices, and the economic and political context. Strike prices differ from both LCOEs and from electricity system costs:

- Strike prices are technology-specific and are the result of a competitive, commercial auction. They are influenced by a range of commercial factors including profit margins, financing costs, anticipated energy generation (yield), projected investment and operational expenditure.
- Strike prices take into account commercial risk and revenue considerations. For example, strike prices reflect risk associated with uncertainty around post-CfD revenues and the absence of CfD payments during negative pricing periods. They also include other non-Green Book costs such as seabed lease option fees. These components are not reflected in the LCOE or electricity system costs we report.
- While strike prices would also be expected to reflect some of the wider costs of running the system where these are borne by the generator (e.g. connection and use of system charges), full system costs are not reflected.

These three metrics are not directly comparable and may differ substantially. For a given set of projects, strike prices would be expected to exceed the associated LCOEs, since strike prices include additional factors such as commercial risk and revenue considerations. It is therefore incorrect to compare our LCOE estimates directly with strike prices from AR7 or future allocation rounds. Nevertheless, they share some common underlying cost drivers which can drive positive correlations between them, in particular investment and operational costs. Our sensitivities, which reflect an assessment of electricity system costs (rather than LCOE or strike prices), focus on alternative estimates for investment costs.

Box 2.3 Historic and current trends in offshore wind costs

The offshore wind sector has experienced price spikes before, most notably in the mid-2000s to early-2010s. During this period investment costs in the UK doubled.^{35;36} The reasons for this price spike are generally recognised to have been commodity price movements, supply chain bottlenecks, and the location of new projects in deeper waters further away from shore.

Following this period, offshore wind investment costs declined rapidly, falling by around 35% from 2010 to the early-2020s.^{37;38} The decline was the result of increased turbine size, economies of scale, and technological innovation around cables and foundations. This investment cost reduction, combined with lower financing costs, lower operating costs, and higher load factors, led to even sharper CfD strike price reductions during this period, falling by 65% between the first and third allocation rounds.^{39;40} These reductions were greater than many in the sector had expected.^{41;42}

DESNZ's 2025 Generation Costs report assumed 2030 offshore wind investment costs have increased by around 100% in real terms compared to the 2023 report.* Consultancies report that offshore wind investment costs have increased by 30% between 2020 and 2023 and by up to 50% between 2021 and 2025.^{43;44}

While there is some uncertainty in the relative importance of each individual cost driver, the most commonly reported reasons for these more recent cost increases are: ^{45;46;47;48}

- Higher material costs (e.g. steel, copper, rare earths) from energy price spikes and trade disputes.
- Intensified competition for components (e.g. export cables, HV equipment, permanent magnets) for other use-cases (e.g. transmission network, interconnectors, electric vehicles) domestically and in other countries.
- Supply chain constraints in key areas such as turbines, foundations, installation vessels, and port infrastructure.
- 'Stop-go' demand, worsened by major project delays, cancellations, and failed auctions leading to utilisation challenges and increasing per unit costs.

Offshore wind strike prices have also increased due to higher financing costs.

Comparing the cost drivers of the previous and current price spike, there are some common factors, most notably commodity price changes and supply chain pressures. As noted above, some of these cost pressures will be shared across high and low-carbon technologies. Although there is a high degree of uncertainty around future costs, there is some research to suggest these cost pressures may ease in the medium to long term.⁴⁹ Additionally, opportunities for cost reduction through innovation, economies of scale and learning-by-doing remain, reflected in our assumed learning rates.

Transmission networks

The transmission network is the high-voltage grid that transports electricity across the country, moving power from where it's generated to where it's needed. Significant investment is needed in the network to replace old assets, reduce network congestion, and accommodate new generation and demand. Even in our baseline case of no further decarbonisation, a substantial proportion of this investment would still be needed; not only for asset replacement and congestion management, but also to serve demand growth unrelated to decarbonisation (such as from data centres).

As detailed in Section 10.2.7 of the methodology report, transmission network investment costs for the Seventh Carbon Budget advice were derived using AFRY's BID3 model. The model identifies reinforcement needs across key system boundaries, with near-term investment aligned with the National Energy System Operator's (NESO) Beyond 2030 plans and additional reinforcements

* To be consistent with the advice report, the offshore wind capex is the sum of pre-development, construction and infrastructure cost. This approach differs from DESNZ's LCOE methodology in which the cost of offshore transmission assets is considered part of connection and use of system charges.

determined through model optimisation.⁵⁰ Network investment costs were then calculated using assumed boundary-level reinforcement cost rates.

Since the publication of our advice report, the Office of Gas and Electricity Markets (Ofgem) and NESO have published new data on potential future transmission networks spend, through the final determinations for the RIIO-3 price control period and the Future Energy Scenarios (FES) 2025 economics annex respectively.^{*,51:52} Drivers of the differences between the newer data sources and previous estimates include:

- **Higher unit costs:** driven by supply chain inflation and global competition for key components.
 - Analysis by the International Energy Agency (IEA) published in February 2025 suggested that, since 2019, prices for transmission cables nearly doubled and the price of power transformers rose by around 75%. This has been driven by increased material costs (primarily copper, steel, and aluminium) and high demand.⁵³
 - A report published in April 2025 by the Institution of Engineering and Technology (IET) on transmission infrastructure costs noted significant global inflationary pressures and competition for components with limited supply chains.⁵⁴
- **Updated estimates of network build needs:** RIIO-3 final determinations data reflect the latest view of approved and prospective investment in the transmission network up until the first quarter of 2031. This also represents the most comprehensive view of potential spend for transmission-related infrastructure, including both boundary reinforcement and wider infrastructure.

We test a sensitivity in which transmission investment costs align more closely with these new data sources from Ofgem and NESO. In doing this, we estimate the proportion of the investment spend from these sources that would have been required in our baseline scenario. Due to the conservative nature of the assumptions used, this sensitivity is intended to reflect an upper bound scenario on additional costs of the Balanced Pathway relative to the baseline.

- **Costs from 2025-2030:** We assume total network investment costs for 2025–2030 match the values for capital expenditure in the RIIO-3 Business Plan Financial Model (BPFM) data published by Ofgem.⁵⁵ We assume 44% of the spend is allocated to the baseline. This reflects essential spend such as replacing end-of-life assets, investment in non-network assets like IT, buildings and vehicles, and routine capital investment needed for day-to-day operations. It also includes investment we estimate is needed to efficiently serve existing generation and reduce constraint costs in the baseline, which would be required even without further decarbonisation. This allocation is informed by engagement with transmission owners (TOs) and Ofgem, and by CCC analysis of NESO's 2024 Electricity Ten Year Statement.⁵⁶
- **Costs from 2031-2050:** For the period 2031 to 2050, we assume in the sensitivity that transmission investment costs are equal to the levels of transmission capital expenditure in the Holistic Transition Scenario from NESO's FES 2025 economics annex.⁵⁷ The costs reported by NESO project a constant profile of annual investment costs from 2037, based on the average spend between 2031 and 2036.⁵⁸ We assume that 22% of the spend also appears in the baseline. This reflects asset replacement and routine investment needed for day-to-day operations.

* RIIO stands for "Revenue = Incentives + Innovation + Outputs". This is the regulated price-control system that limits how much UK energy networks can earn while incentivising them to innovate, improve services, and support the transition to a low-carbon energy system. RIIO-3 is the third price control period under RIIO, covering April 2026 to March 2031 for electricity transmission.

This approach may overstate the impact of higher transmission investment costs on additional costs of the Balanced Pathway for several reasons:

- The RIIO-3 data include prospective investment reflecting what TOs have bid for, much of which is yet to undergo full regulatory approval. The actual amount of spend may be lower.
- Reducing system constraints, and the costs associated with them, is a key consideration for TOs and Ofgem when determining the economically optimal level of network investment. It is expected that the upfront investment costs of more rapid build should drive savings in investment or operating costs elsewhere in the system. We have not been able to account for these knock-on system impacts due to modelling limitations.
 - Ofgem have estimated that there could be £4 billion or more of avoided constraint costs, equivalent to around £55 saving per average domestic consumer, resulting from the network investment in RIIO-3, relative to a no further transmission deployment scenario.⁵⁹
- Some of the spend in the RIIO-3 period will be driven by demand growth which is unrelated to decarbonisation (such as the rapid build-out of data centres) and will not impact additional costs. However, we have not been able to quantify this spend for the purposes of this sensitivity and so have not included it in the baseline. The sensitivity will overestimate additional costs on this basis.
- There remains significant uncertainty around transmission investment costs in the period from 2031-2050.
 - It is possible that investment costs further reduce over the 2030s and 2040s, for instance where investments over the next decade include sufficient strategic investment to accommodate later increases in load, lowering further reinforcement needs. Our Balanced Pathway analysis projects reduced transmission investment needs in the 2040s due to a slow-down in the required levels of boundary reinforcement.
 - The actual level of necessary long-term network reinforcement could be further reduced through improved locational investment signals for generation and demand through the Government's upcoming Reformed National Pricing programme.
- To ensure consistency with the analysis for the Seventh Carbon Budget advice and Green Book guidance, we have uplifted the investment costs from the source data by 11% to account for the tendency to underestimate future investments (known as 'optimism bias'). The underlying analysis by TOs may already account for optimism bias in some form, meaning double counting may be present in our analysis.

2.4.2 Uncertainties in buildings and surface transport investment costs

In 2050, the surface transport and buildings sectors account for 24% and 20% of abatement in the Balanced Pathway respectively. Much of this is the result of households switching to low-carbon technologies, in particular EVs and heat pumps.

In recent years, we have seen the costs of low-carbon technologies fall rapidly in the UK as markets have begun to establish supply chains and benefit from learning-by-doing and economies of scale. In our advice report, we modelled the continuation of these trends as low-carbon technologies are deployed in the UK, with prices falling with learning rates as markets grow. We modelled the following cost reductions for heat pumps and EVs.

- **Heat pumps:** the cost of heat pumps falls by around one-third between 2025 and 2050. This is driven by a combination of technology cost reductions and falling costs of installation. As

heat pump deployment rolls out across the UK, installers are expected to gain familiarity with the UK building stock, improving efficiency and reducing costs.

- **Electric vehicles:** the cost of an EV falls between 19% and 34% between 2025 and 2050, depending on vehicle type. This is driven by innovation, growing manufacturing economies of scale, and new market entrants.

Some industry bodies go further, projecting greater cost reductions than we assumed. On this basis, we test the impact of two low-cost sensitivity scenarios for heat pumps and EVs.

Heat pumps

In our residential buildings cost analysis, we applied unit capital costs for heat pump installations. These unit costs were based on evidence from a recent DESNZ-commissioned report.⁶⁰ More detail on our modelling of residential buildings costs can be found in Chapter 7 of the methodology report.

- The report and underpinning data provided a range for the cost of each heat pump technology. In the Balanced Pathway, the average cost for each technology was used. The cost of a heat pump installation is dependent on numerous factors such as size, property type, age, and level of insulation, as well as the extent to which ancillary work needs to be carried out (for example, upgrading radiators).
- Recently published evidence, including NESO's 2025 Future Energy Scenarios (FES), suggests that heat pump costs could be lower than we assumed in our Seventh Carbon Budget advice. For example, in 2050, NESO assume a cost of around £4,100 for heat pump technology excluding retrofit, compared to our assumption of £7,520.*⁶¹
- Emerging evidence from real-world heat pump monitoring suggests that it may be possible to achieve higher efficiencies than modelled in our residential buildings analysis (see Box 2.4). Heat pumps with higher efficiencies use less energy to deliver the same service, reducing operating costs.

We test a low sensitivity for heat pump costs, based on the lower-cost scenario in the DESNZ-commissioned study used in our residential buildings analysis. This study reviewed available evidence on heat pump costs and identified a range of costs for different heat pump technologies. The low-cost scenario represents the lowest cost identified by the study for each of air-to-water and ground source heat pumps.

- In this sensitivity, the technology cost of an air-to-water heat pump falls to £3,310 by 2050, while ground source heat pump costs are also lower than assumed in our Balanced Pathway.[†]
- The ancillary costs, such as the cost of hot water tanks and pipework required to make buildings suitable for a heat pump, are not changed in this sensitivity.
- In theory, similar reductions could also be applied to heat pump technology costs in our non-residential buildings sector. However, we do not include this in our proposed sensitivity due to limited data availability.

* In the NESO analysis, 'retrofit' refers to additional, one-off costs when a heat pump is installed for the first time. These are assumed to be equivalent to the ancillary costs in the Balanced Pathway.

[†] Unit costs include the cost of technology and installation of the heat pump. They do not include the ancillary costs (for example, pipes and radiators) required to make the building suitable for a heat pump.

Box 2.4 Emerging evidence on heat pump performance

Recent evidence suggests that the seasonal performance factor (SPF), a measure of the real-world efficiency of a heat pump, could be higher than assumed in our analysis for the Balanced Pathway.⁶² A higher efficiency heat pump would require less energy to deliver the same energy service. This leads to lower operating costs.

This study uses open-source data from HeatpumpMonitor.org to look at the in-situ performance of heat pump systems across the UK. For the purposes of the study, analysis was carried out on the subset of air-source heat pumps that meet the SPF H4 boundary, a standardised metric for measuring the efficiency of the entire heating system. The study limited the sample to 169 heating systems. Analysis of these heating systems shows that the average SPF achieved is 3.86. In our Seventh Carbon Budget analysis, we assumed an average efficiency of 2.81, which was informed by the Electrification of Heat trial.

This study demonstrates that higher efficiencies of heat pumps can be achieved across the building stock if they are designed and installed correctly. Specifically, the study concludes that heat pumps should be:

- Designed to operate at low flow temperatures. To achieve the highest efficiency (SPF ≥ 4), the study recommends that systems are designed to operate at an average flow temperature of no more than 42°C.
- Commissioned and operated with optimisation of the system in mind, including the potential for third party optimisation to adjust for factors such as weather conditions.

Heat pump monitoring through HeatpumpMonitor.org is voluntary and will be skewed to those who are invested in optimising and tracking their heat pump performance. This means the findings from this study are likely to be an upper-end estimate of the achievable SPFs. This, along with data limitations (including sample size), means this evidence is insufficient to inform a sensitivity. While the suggested increased efficiency could reduce operating costs, and subsequently household bills, more data is needed to better understand this.

However, this study demonstrates the potential for improvements in performance based on better installation and design. In our Balanced Pathway, we assume that heat pump performance improves year-on-year, reflecting that as the heat pump market scales up, there will be efficiencies achieved in the design and installation process.

Electric vehicles

In our Seventh Carbon Budget surface transport cost analysis, we model new electric cars as reaching price parity with equivalent petrol and diesel vehicles between 2026 and 2028, depending on vehicle size. Following this, we adjust our projections on vehicle price based on varying assumptions about the underlying costs. More detail on our modelling of EV costs can be found in Chapter 6 of the methodology report.

- Between 2028 and 2035, we model continued learning rate cost reductions, incorporating evidence from the International Council on Clean Transportation (ICCT). Between 2035 and 2050, we model a conservative assumption on cost reductions based on projected battery cost reductions found in the literature.
- Recent market analysis finds that EVs prices are falling in line with what would be required to reach price parity between 2026 and 2028. While new EVs remain more expensive to buy than a comparable petrol vehicle on average, prices have declined steadily in recent years. The price premium between EVs and comparable petrol and diesel cars fell to 33% in 2024 and has since dropped to 19% as of September 2025.⁶³
 - Some manufacturers already offer electric and ICE vehicles at price parity for certain models.^{64;65}
 - We expect falling prices to pass through to the second-hand market. Preliminary data shows that many used EVs are already price-competitive with ICE equivalents.^{66;67}

- As the roll-out of EVs progresses worldwide, it is likely that economies of scale and competition will drive continued cost reductions for EVs. These cost reductions could increase further than we model in our surface transport analysis as a result of strong learning rates for EV batteries.
 - In the IEA's Net Zero Emissions scenario, the global stock of EVs and plug-in hybrids – including battery electric, plug-in hybrid and fuel cell electric light-duty vehicles (cars and vans) – is expected to grow to 350 million in 2030 and almost 2 billion in 2050.⁶⁸
 - There is substantial evidence for strong learning rates for EV batteries, which could accelerate cost reductions as the market grows. In our surface transport analysis, we model a learning rate of 16%, compared to historic learning rates between 16% and 25% (see Table 1.5 in the methodology report).⁶⁹ If the learning rate exceeds our modelled rate, battery costs would fall faster than the 21% reduction modelled in the Balanced Pathway between 2035 and 2050.

We therefore test a sensitivity for the cost of EVs, which involves higher reductions in battery costs between 2035 and 2050. The sensitivity does not impact costs before 2035 and therefore does not bring forward the modelled point of price parity.

- In this sensitivity, battery costs are assumed to decrease by 43% between 2035 and 2050, which is double the reduction in our Balanced Pathway.
 - This is based on the upper estimate for potential battery cost reductions from a meta-analysis of battery cost forecasts in the literature.⁷⁰
 - It equates to a typical medium-sized EV decreasing in purchase price by around £2,300 (8.4%) over 2035 to 2050, compared to £1,200 (4.2%) over the same period in our central assumptions. This would increase the upfront saving offered against a comparable petrol or diesel car in 2050 by around one-third.
 - The weighted average purchase price of a new EV falls by 23% between 2025 and 2050, compared to 20% across the same period in our central assumptions.
- This sensitivity would not affect emissions or EV uptake, as costs only differ from the Balanced Pathway from 2035, by which time 100% of new cars and vans are EVs.

2.5 Co-impacts sensitivity

2.5.1 Uncertainty around the potential for an EV rebound effect

In Section 1.3, we present our analysis on the value of co-impacts in the Balanced Pathway. In our central case for the co-impacts component of the cost-benefit analysis, we assume that there is no 'rebound effect', where levels of driving increase due to lower running costs of EVs.

- A rebound effect occurs where there is an increase in demand for an energy service following an efficiency improvement, which offsets some portion of the expected benefit.
- Efficiency improvements in EVs will result in lower energy waste and reduce both energy consumption from driving and running costs per mile driven. If consumers respond to lower running costs by increasing the amount they drive, then overall levels of congestion could increase, resulting in negative co-impacts on congestion, road safety, and repairs.

We test a sensitivity where the rebound effect does occur, reducing the overall value of quantified co-impacts in the Balanced Pathway.

- As presented in Section 8.4 of the Seventh Carbon Budget advice report, if the full extent of the modelled rebound effect were to occur, this would reduce total co-impacts compared to our central case. This was presented in the advice report in Figure 8.6.
- In Section 1.3, we expand our estimates of quantified air quality benefits to cover the aviation and land use sectors. To enable clear comparison with the findings in the Seventh Carbon Budget advice report, we do not include these additional quantified air quality benefits in this sensitivity.

2.6 Sensitivity results

We test our Seventh Carbon Budget costing conclusions, and our cost-benefit analysis conclusions, under the range of sensitivities in Sections 2.2 to 2.5 (Table 2.1). We test the impact of the sensitivity on three key measures:

- **Additional cost of the Balanced Pathway:** in the Seventh Carbon Budget advice, we found that the additional cost of the Balanced Pathway was around £4 billion per year on average between 2025 and 2050, compared to the baseline. This is equivalent to 0.2% GDP. We test the additional cost of the Balanced Pathway under each sensitivity.
 - This measure is calculated using additional investment and operating costs only. Therefore, we only present this for sensitivities where the level of investment or operating cost is varied.
- **Net present value (NPV) of the Balanced Pathway:** as set out in Section 1.5, the NPV is a measure of the additional value delivered by a project, over and above its cost. For each sensitivity, we present the NPV of the pathway.
- **Benefit-cost ratio (BCR) for the Balanced Pathway:** as set out in Section 1.5, the BCR measures the level of benefit for each unit of cost. For each sensitivity, we present the BCR of the pathway.

Table 2.1 Sensitivity results			
Scenario	Additional cost of the Balanced Pathway (as a % of GDP) per year between 2025 and 2050	Net Present Value of the Balanced Pathway	Benefit-cost ratio for the Balanced Pathway
CB7 (no sensitivity)	0.2%	£1,580 bn (£790 bn - £2,370 bn)	3.3 (2.1 - 4.4)
Lower discount rate		£1,850 bn (£930 bn - £2,760 bn)	3.4 (2.2 - 4.6)
Extended appraisal period		£2,480 bn (£1,340 bn - £3,630 bn)	3.9 (2.6 - 5.1)
Social cost of carbon		£630 bn - £1,560 bn	1.9 - 3.2
Fossil fuel price shock	0.0%	£1,670 bn (£880 bn - £2,460 bn)	3.4 (2.3 - 4.5)
Offshore wind a) supply chain shock b) sustained increase	a) 0.4%	a) £1,480 bn (£690 bn - £2,260 bn)	a) 2.8 (1.9 - 3.8)
	b) 0.5%	b) £1,440 bn (£660 bn - £2,230 bn)	b) 2.7 (1.8 - 3.7)
Transmission networks	0.4%	£1,520 bn (£730 bn - £2,310 bn)	3.0 (2.0 - 4.0)
Electric vehicles	0.2%	£1,590 bn (£800 bn - £2,380 bn)	3.3 (2.2 - 4.4)
Heat pumps	0.1%	£1,640 bn (£850 bn - £2,430 bn)	3.6 (2.3 - 4.8)
Rebound effect		£1,480 bn (£690 bn - £2,270 bn)	3.1 (2.0 - 4.2)

Notes: (1) Costs of the Balanced Pathway are relative to the costs in a no further decarbonisation baseline. (2) Sensitivity results represent distinct scenarios and therefore should not be combined. (3) The range of net present value and benefit-cost ratios are based on the low to high range of carbon values used. For all sensitivities except 'the social cost of carbon', the carbon value range is aligned with the Green Book. For the social cost of carbon sensitivity, this carbon value range is aligned with the low to high range recommended by the Government of Canada.

2.6.1 Economic appraisal sensitivity results

Both extending the appraisal period and lowering the discount rate give greater weight to the operating cost savings that are delivered by the Balanced Pathway, increasing the BCR (Table 2.1). These higher values are representative of the long-term value that the Net Zero transition will provide to society.

- **Testing a lower discount rate.** Under this sensitivity, the NPV and BCR of the Balanced Pathway increase to +£930 billion to +£2,760 billion and 2.2 to 4.6 respectively. This is because future benefits from emissions savings and operating cost savings are discounted to a lesser extent.
- **Extending the appraisal period.** Under this sensitivity, the NPV and BCR for the Balanced Pathway increase to +£1,340 billion to +£3,630 billion and 2.6 to 5.1 respectively. This

increase is due to the appraisal period including the full operating cost savings associated with low-carbon technologies deployed in the later years of the Balanced Pathway.

- Under this longer appraisal period, the whole-economy costs of the Balanced Pathway, combining only investment and operating cost components, represents a net cost saving compared to the baseline. This is in contrast to the net cost of £4 billion per year over the original 26-year appraisal period.
- An extension of just four years, to 2054, is sufficient to produce a net cost saving in our whole economy costs, across the whole pathway.
- **Testing a range of SCC carbon values.** Under this sensitivity, the NPV and BCR for the Balanced Pathway fall to +£630 billion to +£1,560 billion and 1.9 to 3.2 respectively. This is because the SCC values tested assume a lower value per tonne of carbon emissions avoided.

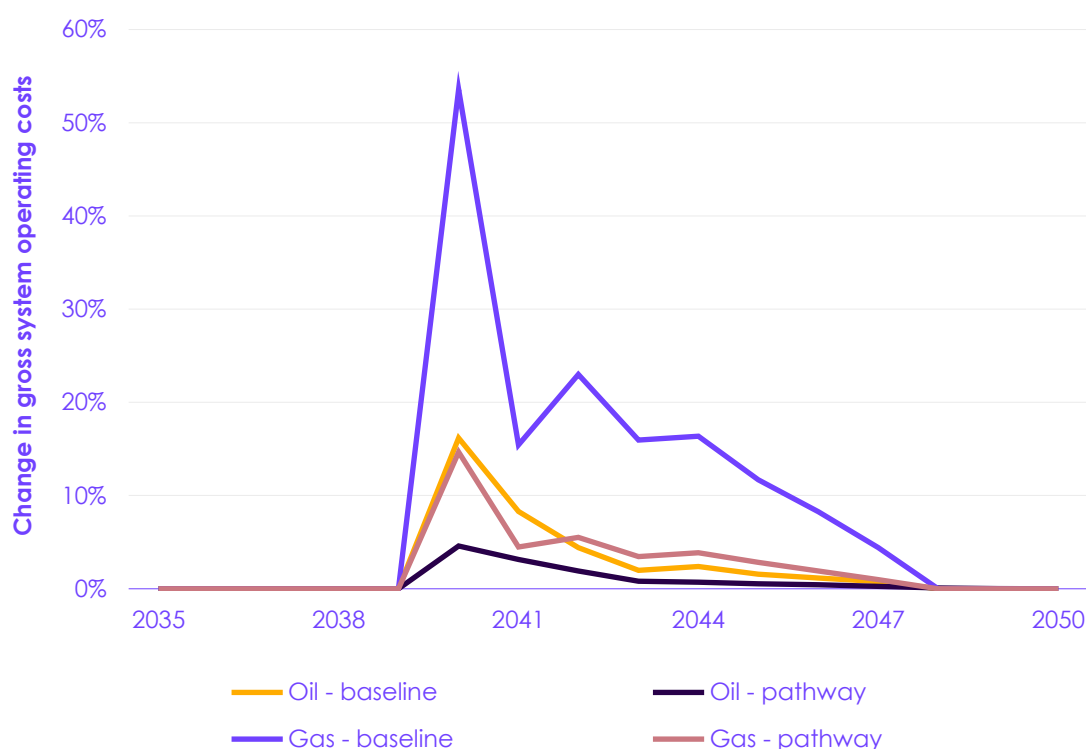
2.6.2 Fossil fuel price sensitivity results

Variation in fossil fuel prices will disrupt costs in the baseline and (to a lesser extent) in the pathway. Spikes in the price of oil and gas from our central cost scenario will increase the cost of the baseline relative to the pathway, lowering the net cost of the transition (Table 2.1).

- **Fossil fuel price spike:** under this sensitivity, benefits from switching to low-carbon energy increase. This increases the NPV to £880 billion to £2,460 billion and increases the BCR to 2.3 to 4.5.
 - A spike in fossil fuel prices has a higher impact in the baseline, where sectors are more dependent on fossil fuels, than in the pathway, where sectors are more electrified and reliant on UK-generated renewable energy.
 - Figure 2.2 shows the impact of the fossil fuel spike on operating costs across the economy. In the year of the spike, baseline operating costs increase by around 70%, combining the impact of oil and gas. Comparatively, in our Balanced Pathway, the same spike increases operating costs in the year of the spike by around 20%.
 - As a result, the net additional cost of the Balanced Pathway relative to the baseline falls, compared to our central case. We find that the net cost falls to around zero, meaning that under this sensitivity, the Balanced Pathway imposes no additional cost. This means that the additional cost of a modelled fossil fuel price spike in the baseline is as large as the total additional cost of meeting the Balanced Pathway between 2025 and 2050.
 - In the Seventh Carbon Budget advice report, we assess the same spike in gas prices as set out in Section 2.3. We find that under this sensitivity in 2040, the average dual-fuel energy bill would increase by 59% in the baseline, relative to central gas cost assumptions, compared to an increase of only 4% in the Balanced pathway.*
 - The impact of a spike in fossil fuel prices on bills is not the same as a spike in fossil fuel prices on whole-economy operating costs. This is broadly because the bill is made up of many different components, one of which is wholesale costs, and households have different levels of fossil fuel dependency to the rest of the economy in the baseline and the pathway.

* This impact on bills is based on a spike in gas prices. It does not align with our sensitivity entirely, because it does not also include the impact of the spike in oil prices.

Figure 2.2 Impact of fossil fuel spike sensitivity on gross system operating costs



Description: A spike in gas and oil prices to 2022 levels in 2040 would increase baseline operating costs by around 70% in the year of the spike, when combining the impact of higher costs for oil and gas, compared to around 20% in the Balanced Pathway.

Source: Department for Energy Security and Net Zero (2023) Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal; CCC analysis.

Notes: The fossil fuel price spike sensitivity replicates spikes in the oil and gas price from the 2022-23 energy crisis in 2040. The sensitivity tests the impact of a change in underlying energy costs on whole-economy operating costs. It does not adjust demand for fossil fuels based on changes in prices.

2.6.3 Technology cost sensitivity results

Under each of our sensitivities for technology costs, the profile of whole-economy costs is similar to our central case in our Seventh Carbon Budget advice, with upfront investment leading to operating cost savings that grow over time. In each sensitivity, the UK should start saving compared to a high-carbon economy during the Seventh Carbon Budget period. The benefit-cost ratio under each sensitivity continues to show strong value for money (Table 2.1).

- **Offshore wind:** in the two sensitivities tested, average additional investment costs increase compared to our central case. These costs are frontloaded, and operational cost savings later on mean that the Balanced Pathway continues to deliver net cost savings from the Seventh Carbon Budget period. The BCR falls to 1.9 to 3.8 for a supply shock, and 1.8 to 3.7 for a structural increase. This continues to represent strong value for money.
 - Investment costs relate to the years in which investment is undertaken by renewable developers, not the years in which the costs are paid for by consumers. Wind investment costs are typically paid for by consumers indirectly through CfD payments over the duration of the CfD contract (15 or 20 years).
 - Our analysis finds that under both wind sensitivities, a decarbonised power system remains cheaper, per unit of power generated, than the baseline (Box 2.5).

- **Transmission networks:** the sensitivity increases the average additional investment costs compared to our central case. This increase occurs across the period from 2025 to 2050, peaking in 2029. The BCR falls slightly to 2.0 to 4.0.
 - These figures relate to the investment costs in the year in which investment is undertaken by TOs, not the year the costs are paid for by consumers. Transmission investment costs are paid for by consumers over an extended depreciation period (typically 45 years).⁷¹
 - Our analysis finds that when accounting for increased network costs in the sensitivity, a decarbonised power system remains cheaper, per unit of power generated, than the baseline (Box 2.5).
- **EVs:** the sensitivity reduces the average additional investment required to meet the Balanced Pathway compared to our central case between 2035 and 2050. Operating costs are left unchanged. The BCR for the Balanced Pathway under this sensitivity is very similar to that in our central case, rising slightly to 2.2 to 4.4.
- **Heat pumps:** the sensitivity reduces the average additional investment required to meet the Balanced Pathway compared to our central case throughout the transition. As a result, the year in which we would expect to see savings moves closer by one year compared to our central case, and the BCR increases to 2.3 to 4.8.

Box 2.5 Electricity cost impacts

In Chapter 7 of the Seventh Carbon Budget advice report, we present our conclusions on the annualised system cost of electricity. We found that delivering the Balanced Pathway results in lower annualised system costs per unit of electricity than in the baseline (see Figure 7.5.8 in the advice report). This finding remains robust to our sensitivities.

- For each of the electricity system technology cost sensitivities, the annualised average per unit system cost of power in the Balanced Pathway falls over time and remains below the baseline from 2026 onwards.
- The key driver of cost savings is the transition to an energy system based on low-cost variable renewables.
- Annualised per unit system costs reflect annualised capital and operating expenditure, with technology-specific hurdle rates applied. They reflect costs across the system, including the costs associated with integrating variable renewables. They also include market-value carbon costs from DESNZ's projections of future traded carbon costs in the UK Emissions Trading Scheme.⁷²

Annualised system costs differ from the retail price of electricity. The retail price of electricity is a function of policy design, and will include transfers (for example, legacy policy costs and taxes).

- The wholesale market price (a component of retail prices) reflects the cost of the last unit of generation required to meet the demand for electricity. In Great Britain, this is typically gas, which has significant fuel and carbon cost. As lower-cost renewable generation comes online, it increasingly displaces gas from this price-setting role. Recent research from the UK Energy Research Centre suggests that the proportion of time that gas sets the electricity price could fall from around 90% today to about 60% over the next three years due to the expansion of renewables.⁷³
- Retail prices are higher than the wholesale prices because they include additional costs associated with government policy and the running of the electricity system.
- The Committee have recommended that policy should ensure that electricity retail prices reflect the low cost of adding low-carbon capacity, so that barriers to electrification are reduced. The UK Government took some steps towards making electricity cheaper in the 2025 Autumn Budget.

Further detail on wholesale and retail prices is set out in Annex 3 of the [2025 report to Parliament on the UK's progress in reducing emissions](#).

2.6.4 Co-impact sensitivity results

In this sensitivity, we assume that a rebound effect increases levels of driving compared to our central assumptions, following efficiency improvements in EVs.

We also remove the expanded air quality benefits set out in Section 1.3. Therefore, these sensitivity results are consistent with our minimum estimate of co-impacts presented in the Seventh Carbon Budget advice.

- **EV Rebound effect:** This sensitivity reduces the value of co-impacts by generating more costly outcomes in terms of congestion, road safety and noise, and to a lesser extent air quality and road maintenance. In this sensitivity, the NPV falls to £690 billion to £2,270 billion and the BCR falls to 2.0 to 4.2.

Endnotes

- ¹ BNEF (2025) *Lithium-ion battery pack prices fall to \$108 per kilowatt-hour, despite rising metal prices.* <https://about.bnef.com/insights/clean-transport/lithium-ion-battery-pack-prices-fall-to-108-per-kilowatt-hour-despite-rising-metal-prices-bloombergnef/>
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- ³ HM Treasury (2026) *Discounting: Green Book supplementary guidance.* https://assets.publishing.service.gov.uk/media/698f30a4492ea446ea7f43d3/Green_Book_supplementary_guidance_-_discounting.pdf
- ⁴ HM Treasury (2025) *Spring statement 2025.* <https://www.gov.uk/government/publications/spring-statement-2025-document/spring-statement-2025-html?#economic--fiscal-outlook>
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- ⁶ Government of Canada (2022) *Social cost of greenhouse gas estimates – Interim updated guidance for the Government of Canada.* <https://www.canada.ca/en/environment-climate-change/services/climate-change/science-research-data/social-cost-ghg.html-toc1>
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Chapter 3: Baseline and gross system costs

In our Seventh Carbon Budget advice, we present costs as relative to a baseline with no further decarbonisation action. In this chapter, we break down this approach and provide more information about costs in the baseline and the Balanced Pathway. Our key messages are:

- **The cost of Net Zero should be assessed relative to a baseline scenario.** The cost of Net Zero is the difference in cost between delivering a business-as-usual system, and a low-carbon system. There is no zero cost high-carbon alternative – business-as-usual requires continued spending, for example on oil and gas, and on assets such as petrol cars and gas boilers. We use the baseline to model the business-as-usual system cost, and the Balanced Pathway to model the low-carbon system cost. Our additional costs, presented in our Seventh Carbon Budget advice, are the difference between these two system costs.
- **Costs in the Balanced Pathway fall below costs in the baseline during the Seventh Carbon Budget period.** The Balanced Pathway requires additional upfront investment that generates operating cost savings compared to the baseline scenario. We expect the gross system cost of the Balanced Pathway to fall below the baseline cost around 2041. This is consistent with our finding in our Seventh Carbon Budget advice that investment in low-carbon technologies generates operating cost savings.
- **The transition to Net Zero creates an opportunity for investment.** A key component of the Balanced Pathway system cost is investment in low-carbon technologies. These investments are crucial to unlock operating cost savings and create significant opportunities for returns on invested capital.

3.1 Baseline, gross system, and additional costs

3.1.1 Baseline costs in the Seventh Carbon Budget

The role of the baseline

In our Seventh Carbon Budget advice, we present the additional cost of the Balanced Pathway relative to a baseline that assumes no further decarbonisation. We do this by comparing investment and operating costs in the Balanced Pathway to those in the baseline.

- Our baseline scenario models the system we have now, to 2050. It generally maintains the stock of low-carbon and high-carbon technologies that exist today, and rolls this forward, making adjustments for GDP and population growth. The baseline represents no further decarbonisation action, but still includes low-carbon technologies that are already deployed.
- The baseline reflects the latest evidence on the current stock share of low-carbon technologies and demand for high-carbon activities. This includes progress that has been made over recent years and therefore differs from the baseline used in previous carbon budget advice. For example, the baseline in our Sixth Carbon Budget advice, published in 2020, included very few electric vehicles (EVs) in 2050. Reflecting progress in decarbonising

the transport sector since, the baseline in our Seventh Carbon Budget advice includes around 1 million EVs in 2050.

- The baseline also reflects the latest evidence on associated investment and operating costs. Therefore, the costs in our baseline scenario also differ compared to previous carbon budget advice.
- There is more detail on the construction of our baseline scenario in Chapter 2 of the Seventh Carbon Budget advice report and Chapter 1 of the methodology report.

Comparing costs in the Balanced Pathway against a baseline is essential for estimating the additional cost required to deliver the emissions reduction pathway needed to reach carbon budgets and Net Zero. This approach recognises that investment in the Balanced Pathway is often an alternative for investment in the baseline scenario. Ignoring the cost of these alternative investments would imply that high-carbon alternatives (e.g. petrol cars, gas boilers, and energy from fossil fuels) are effectively free of charge (see Box 3.1).

Costs in the baseline

We calculate costs in our baseline by modelling the investment and operating costs required to build, maintain, and operate all baseline assets and activities. Reflecting the system of today, our baseline includes a mix between high-carbon and low-carbon assets and activities. Our baseline costs do not account for all spending in the economy, as some is not relevant to emissions (and therefore not relevant to carbon budgets) (see Section 3.1.2).

- The transition to low-carbon electricity is already well underway. Therefore, the baseline costs for electricity supply include costs for a range of technologies. The 46GW of existing variable renewable energy generation modelled in 2025 is replaced like-for-like at end of engineering life, incurring baseline replacement costs. We also include costs for the nuclear plant Hinkley Point C, which is already under construction. Electricity demand in the baseline increases by 29% between 2025 and 2050. This is primarily met by the building of new unabated combined cycle gas turbines (CCGTs); there is a total of 35GW of cumulative new build gas CCGT between 2025 and 2050, covering both asset replacement and increased capacity needed for demand growth (see Section 2.4.1).
- The baseline models around 3% of cars as electric in 2025, based on the number of EVs on the road in 2023 (our last available evidence at the time of modelling). We assume that the mix of EVs, plug-in hybrid electric vehicles (PHEVs), and internal combustion engine cars (ICEs) in 2023 is fixed to 2050, and that EVs are replaced like-for-like when they reach the end of their lifetime. There are no zero-emission heavy goods vehicles (HGVs) in the baseline, to reflect the current lack of zero-emission HGV uptake at scale.
- Gas boilers are the predominant heating technology in the baseline for residential and non-residential buildings. The baseline models around 1% of homes as having a heat pump heating system in 2025, based on 2023 data. Non-residential buildings rely more on electricity in the baseline than residential buildings, but gas remains the primary heating fuel. We assume existing heating systems are replaced with equivalent systems when they reach the end of their lifetime. We assume that all new homes in the baseline are fitted with gas boilers.

3.1.2 The Balanced Pathway gross system cost

Whole-economy gross system costs

The gross system cost in the Balanced Pathway is the cost of building, maintaining, and operating all assets and activities in the Balanced Pathway.* This is the system cost of a scenario which meets Net Zero, as opposed to the baseline scenario, which does not make further progress to meeting Net Zero or carbon budgets.

- The gross system cost is made up predominantly of low-carbon investment and operating costs required to decarbonise the economy. It also includes some high-carbon investment and operating costs, especially in the earlier years of the transition as deployment of low-carbon technologies ramps up.

Sector-level gross system costs

Our gross system costs in the Balanced Pathway are aggregated from sector-level analysis. Table 3.1 summarises the sector-level boundaries for inclusion in the gross system cost. Similarly to the baseline, the gross system cost does not account for all spending in the economy, as some spending is not relevant to emissions (and therefore not relevant to carbon budgets).

- Within our sectoral analysis, there is some variation in what is included in gross system costs. For example, in our residential buildings sector, gross system costs include the cost of the heating system, including any ancillary costs required to upgrade buildings for low-carbon systems, but not the cost of the building itself. In our surface transport sector, gross system costs include the cost of the whole vehicle.
- Since we compare our gross system costs to a no further decarbonisation baseline, it is important that we account for all costs relevant to decarbonisation. Beyond this, our sector-level boundaries for costing depend on what is most meaningful and straightforward to model, given available data. When choices are made to include costs that go beyond the requirements for decarbonisation, this changes the definition of the system. This is reflected in Table 3.1.
- These choices do not impact the additional cost of the Balanced Pathway, because we are consistent in our sector boundaries between the baseline and pathway scenarios.

Sector	Included in gross investment costs	Included in gross operating costs
Agriculture	High-carbon and low-carbon mobile machinery (tractors, combine harvesters) and stationary machinery (heating systems for livestock), and some farm practices (including grass-legume mix).	Machinery maintenance and energy costs (mostly electricity, petrol and bioenergy), and costs associated with planting cover crops, avoided costs of fertilisers, and anaerobic digestion.
Aviation	Engine and airframes associated with UK aviation emissions and energy efficiency improvements.	Aircraft operating and maintenance costs (including crew costs) and energy costs (mostly kerosene and sustainable aviation fuel (SAF)).

* Costs in the Balanced Pathway include costs of assets and activities in the economy which are relevant to emissions, and therefore decarbonisation. The gross system cost is the whole-economy cost of building, maintaining, and operating the assets and activities required within this system.

Residential buildings	High-carbon heating systems (including gas boilers), low-carbon heating systems (including direct electric, heat pumps, and additional ancillary costs required to upgrade buildings for low-carbon systems), energy efficiency improvements, and labour for installation.	Heating system maintenance costs and energy costs (mostly electricity and gas).
Non-residential buildings	High-carbon and low-carbon heating systems, catering appliances, ancillary works, energy efficiency improvements, and labour for installation.	Heating system and catering appliance maintenance costs and energy costs (mostly electricity and gas).
Electricity supply	Electricity generation technologies (including gas turbines, nuclear, solar, and wind), network infrastructure, and storage.	Operating and maintenance costs, and energy costs (mostly gas).
F-gases	Low-GWP (global warming potential) F-gases across refrigeration, air-conditioning, and inhalers, and retrofitting small equipment for low-GWP.	Operating and maintenance costs.
Fuel supply	Equipment and processes on oil and gas platforms (including compressors, generators, gas recovery, and leak detection and repair), fossil fuel transportation (including gas network decommissioning), and refining, as well as hydrogen, bioenergy, and other low-carbon fuel infrastructure.	Operating and maintenance costs.
Land use	Habitat creation and restoration (woodlands, peatlands, and hedgerows), site survey and water level establishment, agroforestry and energy crop planting, and fencing for woodlands.*	Land management and ongoing maintenance (including woodland management) and site monitoring for peatlands.
Industry	High-carbon and low-carbon industrial equipment (including boilers, furnaces, and heat pumps), carbon capture and storage (CCS) installation, transportation and storage infrastructure, hydrogen pipelines, and electricity connection upgrades.	Operating and maintenance costs, energy costs (including gas, oil, coal, electricity, bioenergy, and hydrogen), and costs of transporting captured CO ₂ to offshore storage.
Engineered removals	CO ₂ transport and storage infrastructure, bioenergy with carbon capture and storage (BECCS) and direct air carbon capture and storage (DACCS) plants, and costs required to deliver enhanced weathering and biochar techniques.	Operating and maintenance cost and energy costs (mostly electricity and gas), and costs of transporting captured CO ₂ to offshore storage.
Surface transport	Fossil fuel, electric, and plug-in hybrid vehicles (for cars, vans, buses, HGVs, motorbikes), rail capital costs (trains and modifications to tracks), and charging infrastructure for EVs (including public and private infrastructure) and HGVs.	Vehicle maintenance costs and energy costs (mostly electricity, petrol, diesel, and biofuels).
Shipping	Engines, fuel storage systems, and energy efficiency technologies (including additions to propellers and wind propulsion equipment).	Maintenance costs (for engines and energy efficiency technology) and energy costs (mostly ammonia, methanol, electricity, and oil).

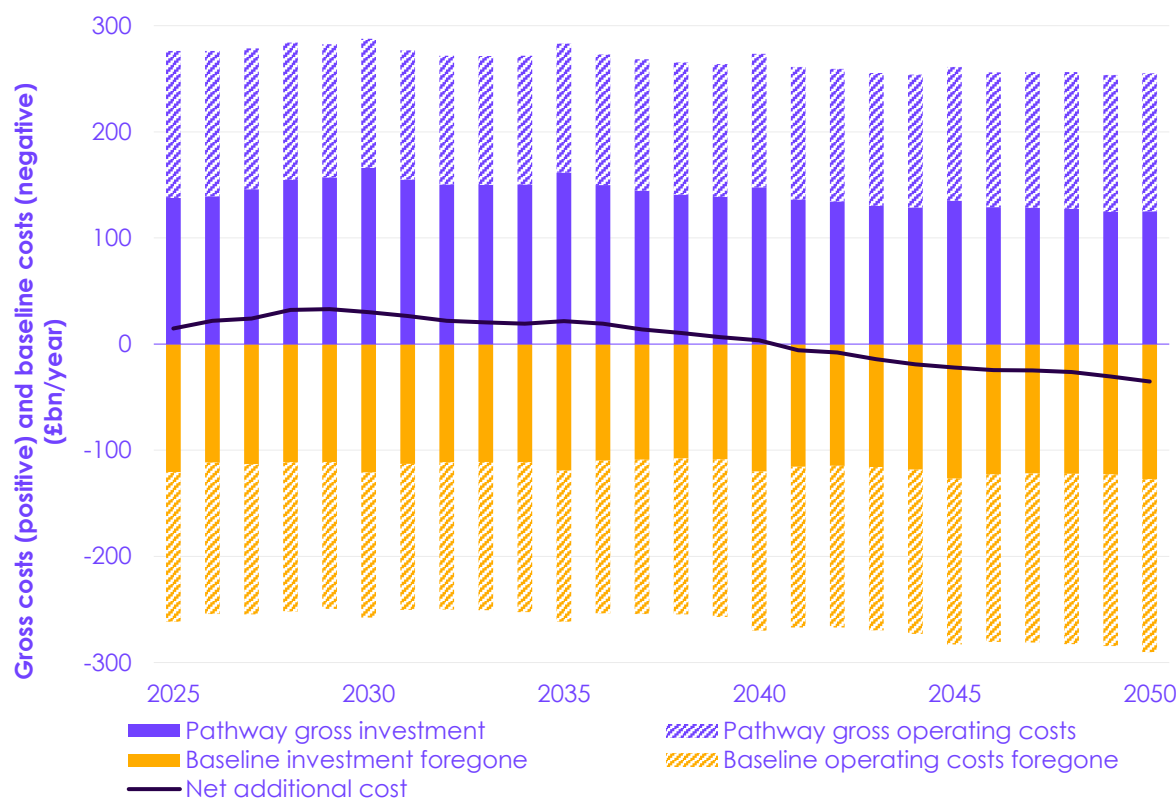
Waste	Construction and replacement of waste infrastructure, including recycling centres, anaerobic digestion, and energy-from-waste (EfW) plants (including installation of CCS at EfW).	Operating and maintenance costs, plus energy costs for EfW only (bioenergy and hydrogen).
<p>Source: CCC analysis.</p> <p>Notes: The sum of sector-level gross system costs does not amount to all spending in the economy. This is because some spending is not relevant to emissions (and therefore not relevant to carbon budgets). Most of our sectors calculate the additional cost by finding the difference between baseline and gross costs. However, some calculate the additional cost directly. In these cases, we have expanded our analysis to estimate their gross system costs.</p> <p>*We do not include the cost of land, which is a transfer between actors, not a net cost to the economy.</p>		

3.1.3 Additional costs of the Balanced Pathway

The additional cost of meeting the Balanced Pathway is the difference between the cost of the baseline and the gross system cost of the Balanced Pathway. Figure 3.1 presents the gross system cost alongside the baseline cost that is displaced under the Balanced Pathway.

- Under the Balanced Pathway, high-carbon technologies existing today are generally replaced with low-carbon technologies over time. Therefore, the continued costs associated with high-carbon technologies in the baseline are not all incurred in the Balanced Pathway. We present the baseline cost as negative in Figure 3.1 to represent the baseline cost which is displaced by the Balanced Pathway scenario.
- The additional cost of the Balanced Pathway is the in-year difference between the gross system cost and baseline cost which is not spent (baseline cost foregone). This represents the investment and operating cost required to meet the Balanced Pathway, over and above the baseline level of spending that would have been required anyway.
- In the early part of the transition, the Balanced Pathway gross system cost is higher than the baseline cost, generating a positive additional cost. As low-carbon technologies begin to deliver operating cost savings at scale, the Balanced Pathway gross system costs begin to fall relative to the baseline. From 2041 onwards, the Balanced Pathway is net saving compared to the baseline.
- In the baseline, system costs remain similar to today, increasing slightly due to factors such as rising population and GDP. By contrast, gross system costs in the Balanced Pathway fall slightly from 2025 to 2050. This is driven by falling operating costs as a result of the uptake of more efficient low-carbon technologies, in particular in the surface transport and electricity supply sectors. Gross system costs fall from 12% of GDP today to 7% of GDP by 2050.

Figure 3.1 Baseline, gross system, and additional costs



Description: The net additional cost of the Balanced Pathway is equal to the gross system cost required to build and operate assets in the Balanced Pathway, less the cost to build and operate baseline assets needed in a UK with no further decarbonisation.

Source: CCC analysis.

Notes: Pathway refers to the Balanced Pathway. Costs above the axis (in purple) are gross system costs across all sectors. The costs below the axis (in orange) represent the cost foregone in our Balanced Pathway. This is the inverse of our baseline costs: the cost that we would expect in a scenario of no further decarbonisation. The net additional cost line sums the in-year pathway gross investment and gross operating costs, and the baseline investment and operating costs foregone. The net additional cost line is the same as the net cost line presented in Figure 1.1, and in Chapter 4 of the Seventh Carbon Budget advice report.

3.2 Low-carbon investment in key technologies

3.2.1 Total low-carbon investment in the Balanced Pathway

As set out in Section 3.1, a key component of the gross system cost in the Balanced Pathway is investment in low-carbon technologies. To demonstrate the extent of this investment opportunity, we present the total low-carbon investment required for a core set of technologies in the Balanced Pathway (Figure 3.2). We show this alongside the investment foregone in our baseline case. This demonstrates how low-carbon investment is often an alternative to high-carbon investment in the baseline.

- **Electric vehicles dominate near-term capital investment.** EVs deliver whole-economy cost savings over their lifetime due to significant efficiency advantages and lower operating costs compared to fossil fuel alternatives. They are also attractive to long-term private investment, due to their predictable demand and falling production costs.
 - Private investment could come in a number of forms, including businesses investing in EV fleets for their operations, lease finance products for consumers, and investment in charging infrastructure. Given the already growing market in the UK and worldwide,

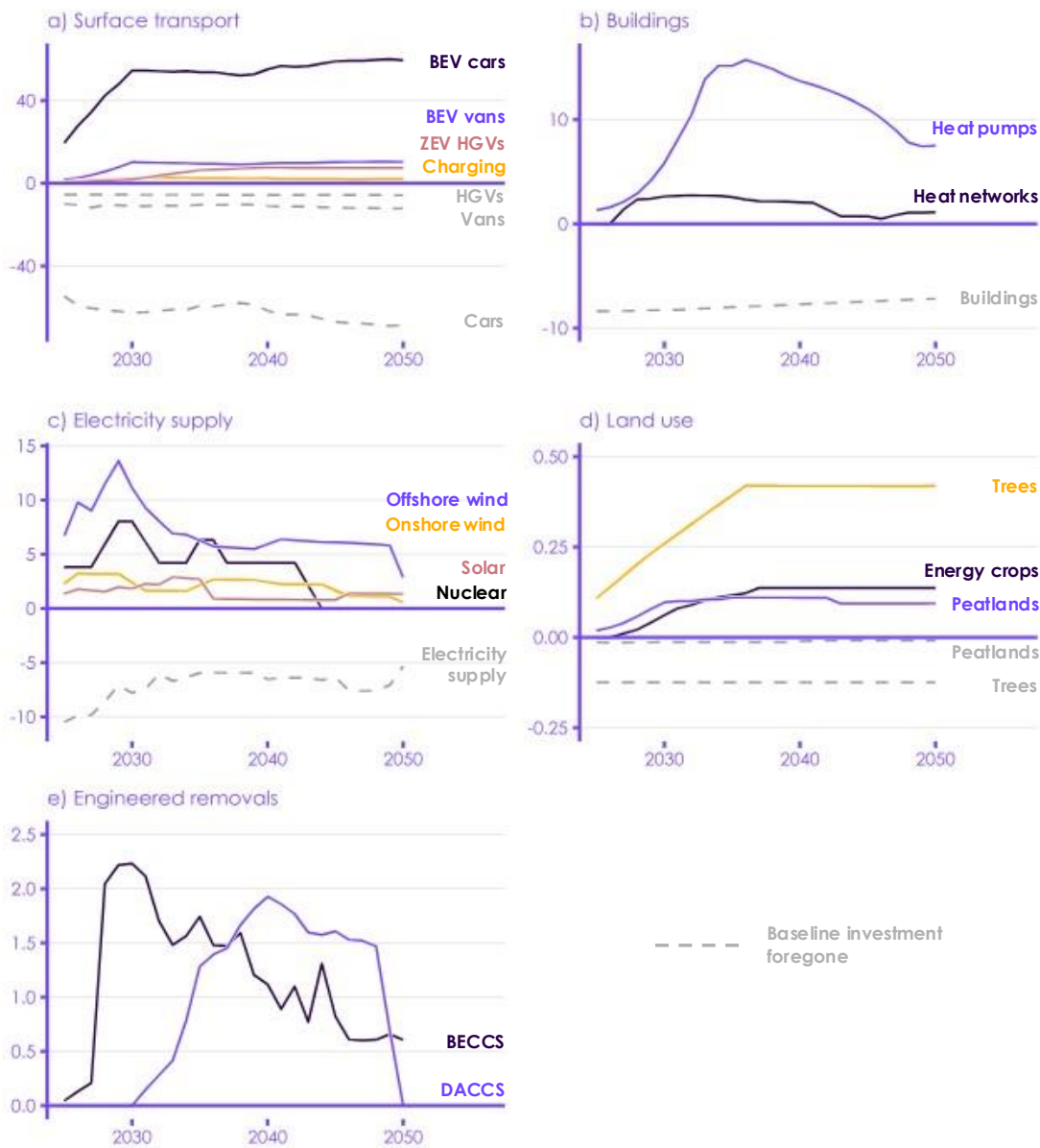
- this presents a significant investment opportunity for the private sector – all of which can be encouraged by clear and consistent policy signals from Government.
- Low-carbon investment in this sector is similar in scale to the investment foregone in the baseline. This reflects that this is primarily a transition from people and businesses buying petrol and diesel vehicles to buying EVs instead. The technology unit costs are similar, with small savings on electric cars and vans after price parity between EV and petrol cars is reached between 2026 and 2028.
- **Heat pump investment requires policy support.** In the Balanced Pathway, heat pump investment grows rapidly, peaking in the 2030s, and remains high throughout the transition.
 - As a result of supportive policy, the UK market for heat pumps is expected to grow. This presents investment opportunities in scaling up manufacturing, but also in installation and servicing – including in developing novel financing models such as heat-as-a-service.¹ As familiarity with heat pump installations increases, there is scope for further cost reductions in the installation process.²
 - This investment is partially offset by foregone costs in the baseline associated with the need to replace gas boilers at the end of their lifetimes (15 years on average). The pathway represents a transition from replacing high-carbon heating systems like-for-like, as in the baseline, to replacing them with more efficient low-carbon heating systems.
 - The cost of transitioning from a high-carbon to low-carbon heating system is significantly higher than a like-for-like replacement of low-carbon heating, due to one-off structural changes required to prepare a home for a heat pump (for example, rerouting pipes). Investment begins to fall in the 2040s once most first-time installations are complete.
 - **Electricity supply investment peaks early, then falls.** Investment is frontloaded as the system builds major new low-carbon generation and network capacity. Like EVs, these assets have lower operating costs than high-carbon equivalents, contributing to the invest-to-save pattern observed in the whole-economy costs.
 - For investors, this early deployment is more capital intensive but is well-supported by Government contracts for difference (CfDs) and regulatory arrangements for investment in networks.
 - Electricity supply investment in the Balanced Pathway is partially offset by the baseline costs foregone. This represents investment required to replace existing generation assets (including gas CCGT plants) when they reach the end of their lifetime. It also includes some necessary network investments and investment already committed through Government-contracted energy projects, most notably Hinkley Point C nuclear power station.
 - **Investing in tree planting and peatland restoration.** These are established solutions in the voluntary carbon market, but further investment will be needed to increase planting and restoration rates to 2050 and beyond. This investment provides a range of benefits to society including carbon sequestration.
 - Increased funding from the UK and devolved Governments for planting and simplified application processes for grant support led to significant planting growth in 2023 and 2024, demonstrating the capacity for the sector to grow quickly when the investment is there.^{3;4}

- Some continuing investment will be needed in these areas to maintain current rates of woodland creation (around 15,000 hectares/year) and peatland restoration (around 7,000 hectares/year). This is often undertaken for delivery of wider ecosystem services such as biodiversity, flood management, and air quality, and is shown as the baseline investment foregone.
- **Emerging investment opportunity for engineered removals.** Engineered removals are required to offset residual emissions in the Balanced Pathway and will need time to scale up to reach that level. Bioenergy with carbon capture and storage (BECCS) – which serves as a fuel across several sectors – is expected to be the earliest to deploy. In the 2030s, direct air carbon capture and storage (DACCS) and other removal technologies scale up, driven primarily by the demand from sectors with unabated fossil fuel emissions, particularly aviation.
 - The fundamental necessity of engineered removals to deliver Net Zero makes a clear case for private investment in both R&D and scale-up, but Government policy will be required to ensure projects are economically viable. Recent policy progress is mixed: the GGR business model (applicable to BECCS in several sectors and DACCS) was finalised in 2025, though there has been no recent progress on the power BECCS business model (applicable to large-scale power BECCS).^{5,6}
 - In the Balanced Pathway all engineered removals are located in the UK, for which investment will be needed to grow domestic supply. In practice, engineered removals are also likely to operate in an internationally-traded market. Robust rules must be in place to govern international trade in removals credits if the UK were to consider substituting a share of domestic for international supply. We do not recommend planning for this outcome at this stage.

The nature of investment varies across these technologies, with some requiring household-level retail finance and others demanding large-scale project or commercial finance. Recognising this distinction is important for designing finance mechanisms that unlock private capital at the scale necessary for the transition.

- **Retail finance for household-level technologies:** Privately-owned EVs and heat pumps can be financed by consumers through loans, leasing, or emerging models such as heat-as-a-service. This is often supported by Government grants. Financing relies on affordability and access to credit, so policy support should focus on reducing upfront costs, ensuring that the efficiency gains of these technologies are reflected in energy bills, and improving consumer finance options.
- **Project and commercial finance for business technologies and large-scale infrastructure:** Investment in electricity supply infrastructure, EV charging networks, heat networks, and engineered removals projects, as well as business decisions, such as transitioning fleets to EVs, are not dependent on household-level decisions. Instead, these require structured financing models that allocate risk effectively. These projects attract institutional investors seeking stable returns, supported in some cases by Government mechanisms such as CfDs that enhance revenue certainty with a guaranteed per unit price.

Figure 3.2 Low-carbon investment, and baseline investment foregone, for selected measures in the Balanced Pathway (£ billion)



Description: There is a significant opportunity for investment in low-carbon technologies in the Balanced Pathway, some of which offsets high-carbon investment which is no longer required.

Source: CCC analysis.

Notes: (1) Total low-carbon investment figures represent the social cost of technology and therefore are not the same as the retail price of technology, which includes other elements, such as tax, subsidies and transfers (2) Costs are in real 2023 prices. (3) Investment is recorded in the year it is incurred. This can result in spikes in investment when technologies become cost-effective (for example, BECCS). (4) Land use costs do not include the cost of land, which is transferred rather than created. Trees is the cost of woodland creation and management. It does not include agroforestry. (5) The baseline investment foregone is inverted investment costs that occur in the baseline. This is largely high-carbon investment which does not need to be incurred in the Balanced Pathway. (5) Our baseline and pathway costs include both high and low-carbon expenditure. There may be some low-carbon spending in the baseline investment foregone. Similarly, in the Balanced Pathway gross system costs there may be some high-carbon spending, which is not shown in this chart.

A range of aggregate measures of costs associated with Net Zero can be constructed. Many of these are relevant measures in certain contexts, but do not represent the cost of Net Zero. Nonetheless, they are sometimes misrepresented as such. Here, we set out some of these metrics and explain why they are not the cost of Net Zero.

As presented in Section 3.1, the cost of Net Zero is the difference between costs in a Net Zero scenario – where the UK decarbonises to reach Net Zero – and a baseline scenario – where there is no further decarbonisation.

The cost of Net Zero is not the same as:

- **The gross system cost of a Net Zero pathway.** Investment and operating costs are required in the economy regardless of whether the UK pursues Net Zero. Referring to all spending in a Net Zero system as 'the cost of Net Zero' ignores the spending which would have occurred anyway.
 - This combines the cost of low-carbon assets and operations, without comparing it to the high-carbon alternative. Without this comparison, the implication is that the high-carbon alternative, including petrol cars, gas boilers, and fossil fuels, is effectively free.
- **The total investment in low-carbon technologies.** Investment in low-carbon technologies will be required to meet Net Zero. These technologies are typically more efficient and generate lower running costs than the high-carbon alternatives. Referring to the total cost of low-carbon investment as 'the cost of Net Zero' ignores both these running cost savings, and the investment that would have occurred anyway.
 - This is comparable to considering the full upfront cost of an electric vehicle without considering the cost of the alternative petrol car, or the relative savings from fuel efficiency improvements.
- **The additional investment required in a Net Zero pathway.** Delivering the Balanced Pathway requires additional investment in the near-term compared to the baseline. This investment generates operating cost savings, which grow towards 2050. As above, presenting the additional investment without considering the operating cost savings ignores significant cost-savings as a result of the investment.
 - This is comparable to considering the additional investment required to build variable renewable generation in the UK compared to fossil fuel energy generation, but ignoring the relative cost savings from operating renewable energy at zero-fuel cost compared to the cost of gas or other fossil fuels required in a high-carbon alternative.
- **The cost of the energy system in a Net Zero pathway.** Decarbonising electricity and fuel supply is an important element of reaching Net Zero. However, a full transition will require decarbonisation of other sectors, including those which use decarbonised energy. In line with our whole-economy analysis of the Balanced Pathway, the cost of Net Zero must also account for these other sectors.
 - Considering only costs associated with producing and supplying energy doesn't account for cost savings associated with the use of that energy. Given that a large part of the savings associated with Net Zero are from more efficient low-carbon technologies, this approach omits a large benefit of the transition.
 - Simply comparing the cost of the electricity system ignores the fact that in the Net Zero pathway, electricity substitutes for fossil fuel use that would need to be paid for in a high carbon alternative.

Endnotes

- ¹ World Business Council for Sustainable Development (WBCSD) (2023) *Heat as a service: how to decarbonise commercial and industrial heat use with third-party capital investments*. <https://www.wbcsd.org/wp-content/uploads/2023/10/Heat-as-a-Service.pdf>
- ² Winkler et al (2024) *Reducing heat pump installed costs: Reviewing historic trends and assessing future prospects*. <https://www.sciencedirect.com/science/article/pii/S0306261924013977>
- ³ Forestry Commission (2025) *Key Performance Indicators. Report for 2024-25*. <https://assets.publishing.service.gov.uk/media/685c093b89ba18761d97612a/FC-Key-Performance-Indicators-Report-2024-25.pdf>
- ⁴ Woodland Trust (2025) *Root of the problem: underfunding, underdelivering*. <https://www.woodlandtrust.org.uk/press-centre/2025/07/root-of-the-problem-underfunding-underdelivering/>
- ⁵ DESNZ (2025) *Greenhouse gas removals (GGR) business model summary*. <https://assets.publishing.service.gov.uk/media/68ad77c2969253904d1557ff/greenhouse-gas-removal-business-model-summary-august-2025.pdf>
- ⁶ DESNZ (2023) *Power Bioenergy with Carbon Capture and Storage. Government response to consultation*. <https://assets.publishing.service.gov.uk/media/64254f8260a35e00120cb174/power-beccs-consultation-government-response.pdf>

March 2026

Supplementary analysis of the Seventh Carbon Budget

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