HM Government

Technical Annex

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Contents

Technical Annex

1. This annex provides an overview of the methodological approach taken to analysis in the Carbon Budget Delivery Plan and the Net Zero Growth Plan.

2. Part one, "Emissions Analysis," details the approach to accounting for greenhouse gas emissions. This includes a discussion of the baseline from which policy emission savings are calculated and wider uncertainty in modelling. Part two, "Sector Modelling", sets out further detail on the approach to emissions modelling adopted for each sector and how the policies and proposal have been quantified. Part three covers Wider Analysis, including detail of the methodology used for analysis using data on job adverts. Finally part four, "Progress Against Net Zero Strategy Reporting Commitments," sets out what we committed to report against in the Net Zero Strategy and updates on performance against these commitments.

Emissions Analysis

Accounting Framework

UK Greenhouse Gas Inventory figures

3. Estimates of UK GHG emissions (back to 1990) are revised annually to incorporate methodological improvements, updated data, and changes to international guidelines. The latest UK GHG Inventory includes emissions estimates up to 2021. These are included as our reference year for this publication. Net UK territorial emissions reduced 48% between 1990 and 2021. Although emissions in both 2020 and 2021 were impacted by lockdown measures in response to the coronavirus pandemic, (particularly road transport)[i] the long-term trend for UK emissions has been downward.

4. The net carbon account (on which carbon budget performance is assessed) can also include the UK's net purchases/sales of international carbon units, if any. Carbon units can include allowances issued under cap-and-trade systems, and international carbon credits issued under international schemes. While the UK intends to meet each of carbon budgets 4 to 6 through reducing emissions domestically, it reserves the right to use such voluntary cooperation under Article 6 of the Paris Agreement. This could occur through linking the UK ETS to another emissions trading system, or through the use of international emissions reductions or removals units. Our policies and proposals have been prepared on the basis that the UK will meet carbon budgets 4 to 6 through domestic reductions and do not have implications for the crediting of carbon units to the net UK carbon account.

5. Emissions from each greenhouse gas are weighted by its Global Warming Potential (GWP) so that total emissions can be reported on a consistent basis in terms of carbon dioxide equivalent (CO2e). GWP values are set out in Intergovernmental Panel on Climate Change (IPCC) assessment reports. In November 2021, it was agreed by the international community at COP26 (2021 United Nations Climate Change Conference) that greenhouse gas emissions shall be reported under the Paris Agreement transparency framework using 100-year GWPs from table 8.A.1 of the IPCC Fifth Assessment Report (without climate-carbon feedback)[ii]. Emissions estimates are reported on this basis in this publication.

6. In accordance with section 89 of the CCA 2008[iii], emissions from the UK territory (including UK coastal waters and UK sector of the continental shelf) are in scope of UK Carbon Budgets and Net Zero. Therefore, emissions estimates presented in this publication are on this basis and do not include emissions from UK Crown Dependencies and Overseas Territories (CDOTs).

7. In addition, UK international aviation and shipping (IAS) emissions estimates have been included from 2033 as the sixth carbon budget is the first that will include IAS emissions. Previous budgets have not included IAS emissions but were set such that headroom was left for IAS emissions. In line with current UNFCCC reporting guidelines where IAS emissions are reported separately to total territorial emissions, we have used bunker fuel sales to calculate IAS emissions for the sixth carbon budget. Under this method, IAS emissions are estimated from the amount of refuelling from bunkers at UK airports and ports, whether by UK or non-UK operators, for onward international journeys.

Carbon markets

8. Calculations of emissions figures against our carbon budgets historically followed an accounting framework that adjusted for the UK's net purchases/sales of international carbon units. For the years 2008-20, the net carbon account includes adjustments for net trading of EU ETS emissions allowances between UK and EU operators. For further information, see the Annual Statement of Emissions 2020[iv].

9. Now that the UK is no longer participating in the EU ETS and UK operators are not trading emissions allowances with operators outside the UK, adjustments for the period 2021-2037 are no longer needed. Adjustments for the effects of carbon markets may become appropriate again in the future: for example through voluntary cooperation under Article 6 of the Paris Agreement or linking the UK ETS to another emissions trading system. In line with our approach in the Net Zero Strategy, we have assumed that no such adjustments will be necessary over this period.

Table 1: Accounting basis of UK greenhouse gas emissions reduction targets[1]

[1] Estimates of UK GHG emissions (back to 1990) are revised annually to incorporate methodological improvements, updated data and changes to international guidelines. Base year emissions and percentage reductions implied by CB levels are therefore subject to change.

	Carbon Budget 3	Carbon Budget 4	NDC[2]	Carbon Budget 5	Carbon Budget 6
Years	2018-2022	2023-2027	2030	2028-2032	2033-2037
MtCO2e limit (average annual equivalent)	2,544 (509)	1,950 (390)	% based target (approx. 261)	1,725 (345)	965 (193)
ETS handling	2018-20 - adjustment for net EU ETS trading 2021-22 - no adjustment	No adjustment	No adjustment	No adjustment	No adjustment
International Aviation and Shipping (IAS)	Excluded	Excluded	Excluded	Excluded	Included
Geographic coverage	UK only	UK only	UK plus Crown Dependencies and Overseas Territories that have had the UK's ratification of the Paris Agreement extended to them[3]	UK only	UK only
Base year emissions (MtCO2e)[4]	816	816	816	816	840
Percentage reduction on base year emissions	Approx. 37%	Approx. 52%	68%	Approx. 58%	Approx. 77%
Emissions estimates for final accounting	UK 1990-2022 GHG Inventory	UK 1990-2027 GHG Inventory	UK 1990-2030 GHG Inventory	UK 1990-2032 GHG Inventory	UK 1990-2037 GHG Inventory

[2] Accounting for the UK's Nationally Determined Contribution is different from that for Carbon Budgets. In particular, the NDC is a single year fixed percentage reduction target. This means that any changes to the inventory base year will change the MtCO2e limit required to meet the NDC, while the carbon budgets are fixed targets in MtCO2e.

[3] The UK is committed to extending its ratification of the Paris Agreement to the UK's 17 Crown Dependencies and Overseas Territories who are eligible, and who request it. Extending the Paris Agreement will bring CDOTs into the scope of the UK's Nationally Determined Contribution. To date, the Paris Agreement has been extended to Jersey and Gibraltar in 2022, and Isle of Man in March 2023. All NDC figures in this publication exclude emissions from CDOTs.

[4] Base year emissions are calculated as emissions of CO2, N2O and CH4 in 1990, and fluorinated gases in 1995. Base year emissions for CB6 includes 24 MtCO2e for IAS.

10. Analysis in this report is presented using the same sector definitions as were used in the Net Zero Strategy. An updated mapping of emissions sources in the UK 1990-2021 GHG Inventory to NZS sectors is published alongside this report.

Baseline Emissions Projections

11. While the GHG inventory is the source for historical emissions data, a combination of sector modelling and the 2021-2040 Energy Emission Projections (EEP 2021-2040) are used to project future baseline emissions. This section sets out the assumptions about the baseline used for the purpose of this analysis, which is an adjusted version of EEP 2021-2040.

12. The EEP 2021-2040 reference scenario is the main source for the baseline from which HMG evaluates the impact of the policies set out in the Carbon Budget Delivery Update report. The reference scenario sets out HMG's central projections of how the energy and emissions system will evolve under EEP-ready policies[5]. This projection assumes no further government policy action beyond policies that are in very late stages of development or have already been implemented. Emission savings from policies included in EEP 2021-2040 are therefore counted in the Carbon Budgets Delivery Update baseline.

13. The EEP 2021-2040 reference case was published in October 2022[6] and the next EEP update is due to be published in autumn 2023. However, recent changes in the greenhouse inventory and underlying trends in some areas have affected baseline emissions. We have therefore made some adjustments to the EEP 2021-40 baseline, detailed below. Any calculations of performance against our Carbon Budgets compare projected emission savings against this adjusted baseline.

UK GHG Inventory and the baseline

14. The EEP 2021-2040 emissions projections (published October 2022) were aligned with emissions estimates from the UK 1990-2020 GHG Inventory (published February 2022). For the LULUCF (land use, land-use change, and forestry) sector, emissions projections were aligned with the UK 1990-2019 GHG Inventory as projections aligned with the UK 1990-2020 GHG Inventory were not available at the time.

15. UK GHG Inventory emissions estimates are revised annually (across the whole time series) to incorporate methodological improvements, updated data, and changes to international guidelines. UK 1990-2021 GHG Inventory emissions estimates were published in February 2023. Generally, it has not been possible to adjust the EEP

[5] EEP-ready policies include those policies that have been implemented and those that are planned where the level of funding has been agreed and the design of the policy is near final. Policies outside the power sector were included if they had reached the EEP-ready stage of development by January 2022. Power sector policies are included if they had reached the EEP-ready stage by July 2022. A full list of EEP-ready policies was published in October 2022 as Annex D of the EEP 2021-2040 publication.

[6] A small revision to the reference case was published on 10th March 2023. This adjustment has been accounted for in the presentation of emission figures throughout this report. A full comparison of how the EEP 2021-2040 changed since the EEP Net Zero Strategy Baseline was published in section 5 of the Updated Energy and Emissions Projections 2021-2040.

2021-2040 baseline to reflect revisions from the 1990-2021 GHG Inventory in the time since publication (see table 2 for summary by sector).

16. UK GHG Inventory emissions estimates are revised annually (across the whole time series) to incorporate methodological improvements, updated data, and changes to international guidelines. UK 1990-2021 GHG Inventory emissions estimates were published in February 2023. Generally, it has not been possible to adjust the EEP 2021-2040 baseline to reflect revisions from the 1990-2021 GHG Inventory in the time since publication (see table 2 for summary by sector).

17. However, for the LULUCF sector, an adjustment has been made to reflect major changes to the methodology of how peatland emissions are estimated. Overall, this has reduced the LULUCF sector baseline emissions by around 2.9 MtCO2e per year.

18. Updated EEP projections aligned with emissions estimates in the UK 1990-2021 GHG Inventory will be published as part of the next EEP publication.

19. Overall, UK emissions estimates (including IAS) in the UK 1990-2021 GHG Inventory are lower than those in the EEP 2021-2040 emissions projections. For 2020, total emissions (including from IAS) estimates have been revised down by around 2.1 MtCO2e although this downward revision varies across sectors. The largest revisions were for LULUCF (down 2.9 MtCO2e), buildings (down 1.7 MtCO2e), and industry (up 1.4 MtCO2e).

Table 2 – Revisions to 2020 GHG emissions estimates in the UK 1990-2021 GHG Inventory (published February 2023)

NZS sector	UK 1990-2020 GHG Inventory / EEP 2021-40 baseline	UK 1990-2021 GHG Inventory	Difference
Agriculture	46	47	0.4
Buildings	84	82	-1.7
Domestic Transport	99	99	0.6
F-Gases	12	12	-0.0
Fuel Supply	22	22	0.1
Industry	73	74	1.4
LULUCF	4	1	-2.9
Power	49	49	-0.1
Waste	19	19	-0.2
Total emissions (exc. IAS)	**409**	**406**	**-2.4**
IAS	21	21	0.4
Total emissions (inc. IAS)	**429**	**427**	**-2.1**

Adjustments to EEP 2021-2040 Baseline

20. We have adjusted the EEP 2021-2040 baseline projections for some sectors to reflect the latest developments in policy, technological developments, underlying trends, and the science of climate change. Put together, these adjustments lead the Carbon Budget Delivery Plan baseline emissions to be c.4MtCO2e/year higher (in CB6 period) than that set out in EEP 2021-2040. This increases the need for government policy to achieve our Carbon Budgets. Figure 1 contrasts the EEP 2021-2040 with the final adjusted baseline used in analysis. Table 3 summarises the differences between EEP 2021-2040 and the Carbon Budget Delivery Plan baseline. Adjustments cover the following sectors:

21. Transport: two adjustments to the baseline have been made. The first is to account for updated real world emissions uplift factors, especially for Plug-in hybrid Electric Vehicles (PHEV). Recent evidence suggests PHEVs are 3-5 times more polluting in the real world than in test drives. This adjustment raises baseline emissions.

22. The second is a result of the use of updates to traffic projections in the National Transport model. Post-COVID car demand has been lowered by 5% to reflect lower levels of commuting. However, the Department for Transport forecasts that HGV and van miles will be higher than that forecast in EEP 2021-2040 – due to outturn data showing higher van and HGV traffic than previously assumed. There have been a range of other model updates made[7].

23. Together, these adjustments lead to an increase in baseline emissions of 4MtCO2e/year on average in the 4th Carbon Budget period, 9Mt/year for 5th Carbon Budget, and 13Mt/year in the 6th Carbon Budget period.

24. Industry[8]: an adjustment has been made to the EEP 2021-2040 baseline to account for an expected reduction in refinery output to align with assumed decarbonisation for the UK and world economies. This amounts to a downward adjustment to baseline emissions across each of the carbon budget periods (averaging 2.6MtCO2e/year in the Carbon Budget 4 period, 3.9MtCO2e/year in Carbon Budget 5, and 4.9MtCO2e/year in Carbon Budget 6).

25. Land Use, Land-use Change, and Forestry: an adjustment has been made to the EEP 2021-2040 baseline to reflect revisions made in the latest UK 1990-2021 Inventory. See previous section "UK GHG Inventory and the Baseline".

26. Fuel Supply: since EEP 2021-2040 was published, a new baseline for the upstream oil and gas sector has been provided by the North Sea Transition Authority. The baseline was updated to reflect the most up-to-date assessment of future emissions and latest data from the GHG Inventory. Because of this, an analytical adjustment has been applied to provide more accurate projections of emissions reduction scenarios. This adjustment represents an average 0.4MtCO2e/year decrease across the fourth carbon budget period, 0.6Mt/year in the fifth period, and 0.7Mt/year in the sixth.

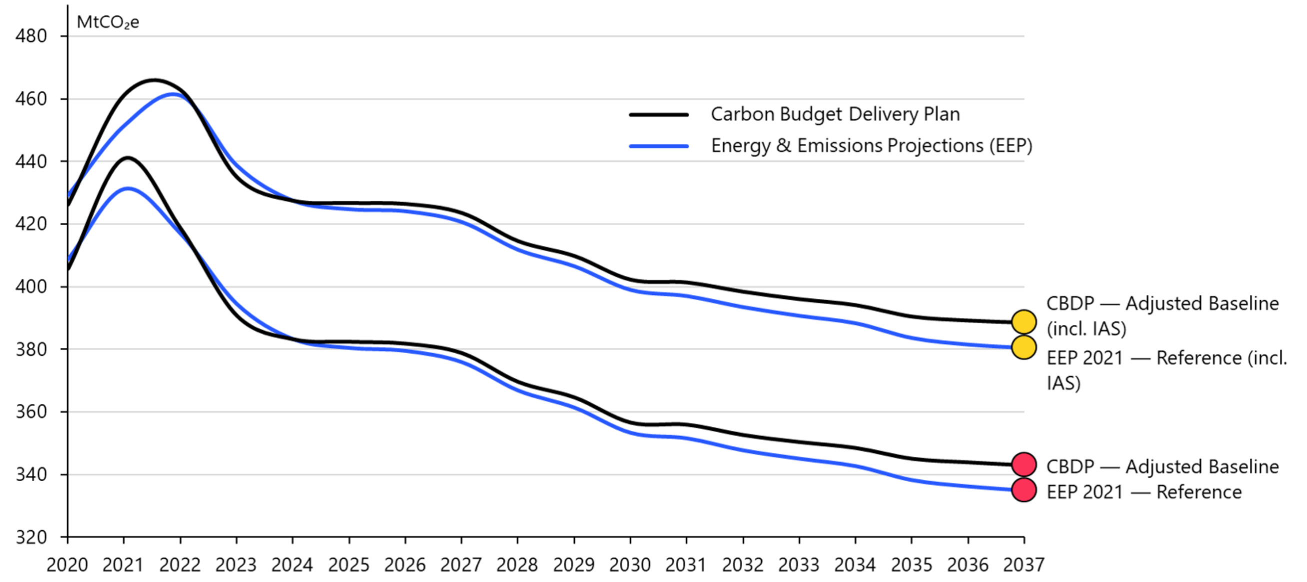
[7] See National Road Traffic Projections for more detail: https://www.gov.uk/government/publications/national-road-traffic-projections.

[8] A further adjustment has been made to calibrate industry modelling with the Energy Emissions Projections 2021-2040. See Sector Modelling section for more details.

Table 3 – Changes from EEP 2021-2040 to CBDP Baseline

Sector	CB4	CB5	CB6
Fuel Supply	-0.4	-0.6	-0.7
Industry	-2.6	-3.9	-4.9
Transport	4.1	8.6	13.0
Agriculture	-2.9	-2.9	-2.9
Total Impact[9]	**-2.2**	**0.8**	**3.8**

Figure 1: EEP 2021-2040 vs Adjusted Baseline used in Carbon Budget Delivery Plan



Energy & Emissions Projections, 2022 • Dept. DESNZ internal analysis, 2023.

Calculation of Emission Savings from Policies

27. The baseline used in the Carbon Budget Delivery Plan provides a projection for emissions out to 2037. The emissions savings estimated from the quantified policies and proposals set out in Carbon Budget Delivery Plan are additional to this baseline, such that we can sum the savings across all these policies and proposals, subtract from the baseline, and compare the resulting total (residual emissions) against the carbon budgets to assess our performance. Where we present figures showing the percentage of a carbon budget met, this shows how much of the savings required to meet a carbon budget, relative to baseline projection emissions for that carbon budget, are delivered by the relevant quantified policies set out in the Carbon Budget Delivery Update report.

28. The Net Zero Strategy set out an indicative 'delivery pathway' of emissions reductions to meet our climate targets up to and including Carbon Budget 6 (2033-37). This is

[9] Figures in this table do not sum up due to a separate adjustment made to calibrate industry modelling with the Energy Emissions Projections 2021-2040. See Sector Modelling section for more details.

based on our understanding of the potential for each sector to reduce emissions, considering the balance between sectors that is optimal for the entire economy. The indicative delivery pathway as set out in the Net Zero Strategy has not changed, and the sector ranges continue to provide direction for sector level policy development.

29. The pathway is indicative only. The exact path we take, and the contribution of each sector to achieving carbon budgets, is likely to differ from the pathway and must respond flexibly to changes that arise over time. While we continue to use the pathway as a means of developing and testing policy, it plays no role in our conclusion that the package of policies and proposals set out in the Carbon Budget Delivery Plan enable Carbon Budgets to be met.

30. The policies and proposals set out in the Carbon Budget Delivery Plan show the current planned package of policies and proposals and their projected emissions savings. Estimates for policy level savings are presented on a sector basis. They are estimated using a variety of different models and analytical approaches, appropriate to both the sector and the policy intervention, consistent with relevant government appraisal guidance where appropriate. The basic approach is to model the impact of policy on real-world outcomes, and then estimate the carbon savings associated with these outcomes. For example, policy to require or incentivise the uptake of zero-emission vehicles would be assessed to determine the resulting level of zero-emission vehicles, and the subsequent emissions savings of these additional zero-emission vehicles would be estimated given standard assumptions about vehicle mileage and the relative carbon-intensity of non-zero emission vehicles. Appendix C in the Carbon Budget Delivery Plan sets out deployment assumptions which illustrate the ‘real-world outcomes’ consistent with the quantified policies and emission savings.

31. Some policies in the Carbon Budget Delivery Plan return negative emissions savings numbers. This means that these policies and proposals generate additional emissions for the UK despite being designed for the decarbonisation of the UK economy. This arises through two predominant avenues. The first is that emissions are a by-product of the policy framework to deliver the increased production of a fuel and its associated carbon savings. For example, in order to decarbonise other sectors in the economy, there will be a small amount of emissions associated with the production of hydrogen for our ambition.

32. The second avenue is when there’s an inter-temporal element to the savings. This can occur when emissions savings are realised over a longer timeframe, and often after some emissions have been produced to set up the policy design. For example, there can be operational emissions generated during the creation of woodlands from the machinery used and soil disturbance, which means there are a small amount of negative carbon savings over CB4. However, this policy generates carbon savings over the fifth and sixth carbon budget period as more emissions are sequestered by trees over time.

33. More information on the sector-specific methodologies used in calculating policy emission savings can be found in the Sector Modelling section of this annex.

Modelling uncertainty

34. Given the complexity of the economy-wide transition necessary to meet carbon budgets and net zero, there is considerable inherent uncertainty, with outcomes dependent on a variety of factors. We recognise that there are both upside and downside risks which could make it easier or harder to meet future carbon budgets. In our approach to modelling and the assumptions we need to make, we have taken, on balance, a conservative approach to err on the side of caution, with the effect of either increasing the size of emission savings required (as discussed above on the baseline) or of reducing the potential effectiveness of policies (for example by assuming slower take-up of technologies than recent evidence suggests). This suggests that, all else equal, there is likely to be more upside than downside risk, which could support meeting carbon budgets.

UK GHG Inventory emissions estimates and uncertainty

35. The UK GHG Inventory collates all greenhouse gas emissions by sources and removals by sinks across the UK. However, measurements of greenhouse gas emissions will always have a degree of uncertainty associated with them. Further, changes to international guidelines on emissions factors and methodological improvements can lead to revisions in the GHG Inventory.

36. When looking at measurement uncertainty alone, HMG estimates that current total UK GHG Inventory emission figures could be around 3% higher or lower[10]. There is greater uncertainty associated with the measurement of emissions of the non-CO2 greenhouse gases. This means there is greater scope for measurement error with LULUCF, agriculture, waste, and F-gases.

Baseline modelling uncertainty

37. The projections are sensitive to macro-economic and other input assumptions and to modelling uncertainty. For EEP 2018 (published in 2019), HMG carried out Monte Carlo analysis to assess the impact of the main sources of uncertainty of the projections.

38. The analysis reflected a 95% confidence interval around the baseline to reflect uncertainty in future macro-economic trends (such as economic growth, population size and fossil fuel prices), uncertainty in the impacts of certain existing policies on emissions and uncertainty in the current evidence base on emissions (such as land use emissions). It also accounted for statistical uncertainty about the accuracy of the projection methodology.

39. The economic growth projections (growth in Gross Domestic Product (GDP)) used in EEP 2021-2040 are the Office for Budget Responsibility (OBR) March 2022 projections. The OBR have since updated long-term growth projections in July 2022 and medium-term projections (most recently in March 2023). Although the March publication revised growth projections upwards, these – along with the July 2022 lower

[10] Subject to a 95% confidence interval.

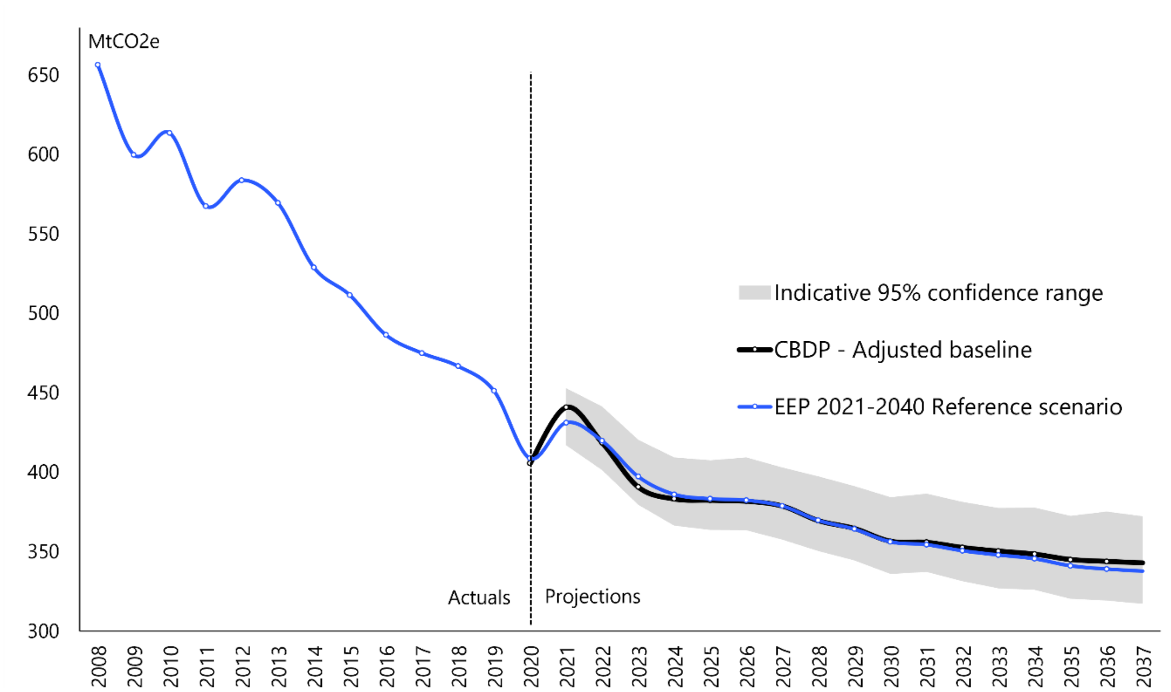
long-term growth projections – remain lower than the assumptions used in EEP 2021-2040.

40. We did not adjust the baseline used in our analysis for these lower updates to GDP projections. The decision not to adjust represents a conservative assumption of future emissions because lower projected growth would lead to lower baseline emissions, reducing the burden of government policy in achieving our Carbon Budgets.

41. The 95% confidence range shown in Figure 2 provides an indication of uncertainty, derived from the EEP 2018 analysis by assuming the percentage uncertainty around the projections is the same in EEP 2021-2040. The Monte Carlo EEP analysis does not capture uncertainty in the policies and proposals brought forward since it was completed.

42. There is also increased uncertainty over long-term fossil fuel prices, in part a consequence of policy responses to the war in Ukraine. The EEP 2021-2040 reference case assumes that prices return to levels similar to their recent, historical average from around 2025. However, fossil fuel prices may remain elevated beyond this point. All else equal, if they are significantly higher than expected this would likely increase the speed of decarbonisation and probability of hitting carbon budgets.

Figure 2: Uncertainty in UK projected territorial emissions (excluding IAS), MtCO2e



Note: Annual total territorial emissions
The uncertainty ranges are indicative and are based on modelling from EEP 2018.
The projected net carbon account range is based on the 95% confidence interval.
This does not capture all sources of uncertainty or the full range of uncertainty (see Chapter 6 of the EEP 2018 report for more details).
The chart includes Land Use, Land Use Change and Forestry (LULUCF).

Energy & Emissions Projections, 2022 • Dept. DESNZ internal analysis, 2023.

Policy-level Modelling Uncertainty

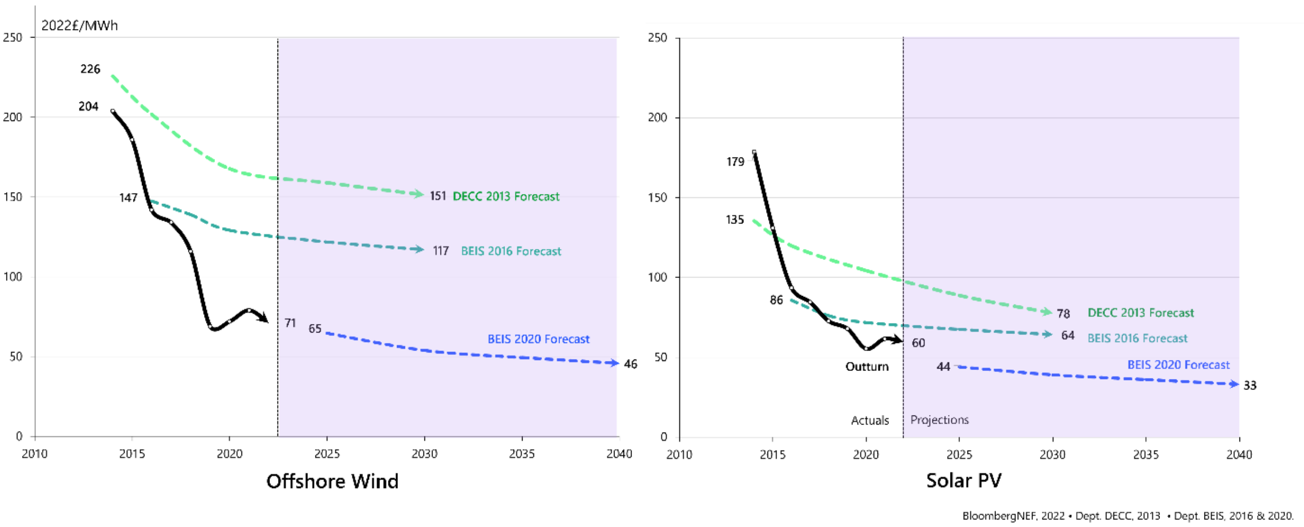
43. The modelled estimates of energy and emissions savings from policies are subject to uncertainty and rely on assumptions of technology performance, consumer behaviour

and other inherently uncertain variables. Whilst this may result in policy impacts being lower than projected, there is also historical evidence that real-world technology performance has sometimes been better than expected. On balance we judge that we are taking a cautious approach, and this section collates some of the factors that support this. We will continue to monitor and evaluate the policies set out in the Carbon Budget Delivery Plan and retain flexibility to adjust our plans as circumstances change.

44. Factors considered are: lower-than-expected technology costs, tipping points to mass adoption, changes in British society over the coming decades, unforeseen uptake of decarbonisation measures, and feedback effects.

45. *Lower than expected costs:* modelling approaches which are typically used to underpin assessments of global and national carbon abatement potential have historically underestimated cost reductions in renewable technologies by not fully accounting for “experience” or “learning” curves[v]. Increased production reduces costs as experience and innovation produce savings. This could result in faster than expected deployment of technologies. Figure 3 demonstrates how the actual costs of offshore wind and solar PV technology in the UK have reduced faster than DECC 2013 and BEIS 2016 projections and could potentially fall faster than forecast in 2020.

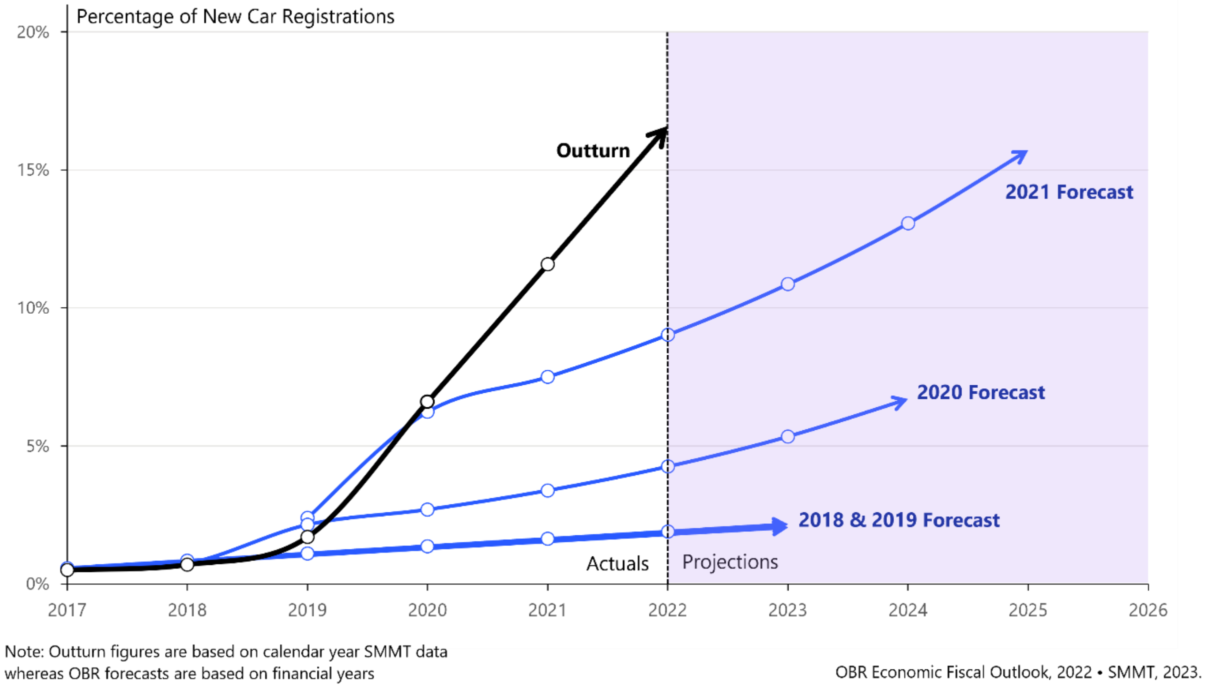
Figure 3: Levelised Cost of Energy, historical forecasts from DESNZ against outturn[vi]



46. *Tipping Points:* Once early investments in manufacturing have been made and consumer preferences start to shift, the second wave of adoption is amplified. Successful technologies follow an S-shaped adoption curve whereby sales move at a gradual pace in the early-adopter phase, before increasing dramatically as the technology proves itself. Eventually take up plateaus as the technology approaches saturation point[vii]. Although some of the modelling underpinning this report accounts for S-curves, there is a risk that such tipping points could occur sooner or later than anticipated in analysis – or at a faster pace than expected. The deployment assumptions set out in the Carbon Budget Delivery Update report provide an overview of assumptions made on the uptake of some key technologies used in the transition to

net zero. Figure 4 shows how the uptake of electric vehicles has been faster than past OBR forecasts.

Figure 4: Uptake of electric vehicles in the UK relative to recent OBR forecasts



47. *Unforeseen uptake of decarbonisation measures:* A breakthrough in a particular technology may supersede the current technologies. For instance, nuclear fusion may displace existing energy sources. A deployment of one technology may facilitate the rollout of another. For example, National Grid's demand-side response (DSR) trials over the recent winter were enabled by a cascade of previous policy decisions including smart-meter rollout, which bolstered the adoption of smart devices and the provision of time-of-use energy tariffs.

48. *Systems approaches and the identification of feedback effects:* Modelling cannot always consider systemic feedback effects, such as co-benefits from technology roll-out or price reductions as markets mature. Such co-benefits are inherently uncertain and can be difficult to quantify. Exploring these systemic effects has the potential to improve our understanding of future emissions trends or provide new opportunities to make positive interventions. For example, the take-up of electric vehicles will have a range of impacts and cyclical effects to the market, technology, and public perception, impacting further take-up.

49. To better capture these effects, we are embedding the consideration of systems impacts in net zero policymaking. We have developed systems maps across the sectors of net zero bringing together stakeholders from across government, industry, and academia to consider key interactions within net zero systems. These have been used to understand interdependencies amongst different policies, feedback behaviour, and risks to delivery.

Policy Uncertainty

50. The scope of policies in this report primarily reflects policies led by the UK Government, with some limited assumptions made on savings from Devolved Administrations. However, across the UK, actors at all levels of government have committed to achieving net zero emissions. For example, each Devolved Administration has a net zero target (2050 for Northern Ireland and Wales, 2045 for Scotland) with ambitious interim targets along their respective pathways, and of the ten city regions with elected mayors, eight have plans for carbon neutrality or net zero emissions by 2050.

51. A significant degree of policy effort across all levels of government within the UK will be required to meet these targets, supported by UK government policies. This can be expected to deliver additional carbon savings to those presented in this report, suggesting this analysis may underestimate the UK’s overall performance against our Carbon Budgets.

52. Furthermore, policymaking has continued since analysis in this report was completed. This report represents only a “snapshot” of policies and proposals under consideration. The scope of some policies in this report will be expanded, or delivery may be brought forward in time. Other policies may be scaled back or delayed. This uncertainty particularly affects emissions modelling in later carbon budget periods.

53. Finally, there is uncertainty over the delivery of policies. The precise means by which some policies will achieve their objectives may not yet be determined, particularly for early-stage policies. Figures for emission savings from policies presented in this report may therefore differ from those that are achieved when the policy is enacted.

Other Factors in Emissions Analysis

Hydrogen Deployment in Alternative Scenarios

54. HMG remains open to the role of new technologies that could be used in future decarbonisation. For example, HMG continues to support the potential deployment of hydrogen in heat (through commercialising hydrogen deployment through funding via the Net Zero Innovation Fund, for instance) while also supporting electrification of heat, for instance through increased use of heat pumps.

55. Because of this, different decarbonisation trajectories have been modelled for key sectors that vary depending on the successful uptake of hydrogen across the economy. For instance, we have modelled heat pump and hydrogen heat deployment under three scenarios. Modelled scenarios show how differing uptake rates of hydrogen may displace the uptake of heat pumps (in replacing conventional technologies), and how this could deliver corresponding emission savings out to 2037.

56. These scenarios are mutually exclusive of one another, but each are consistent with meeting the emissions levels required for carbon budgets. In modelling emissions, savings from the high electrification scenario cannot be summed together with those savings from a "medium" or "high" hydrogen scenarios. Likewise, savings from "high"

and "medium" hydrogen scenarios cannot be summed together. A similar approach is taken to modelling emission savings from potential “on gas grid” regulations.

Sector Modelling

Power

Background

DESNZ models the power sector using the Dynamic Dispatch Model, which simulates investment and dispatch decisions out to 2050 and is configured to always have sufficient generating capacity to ensure security of supply. When modelling the power sector, analysts and policy experts within the department have worked closely together to define how the power sector can achieve the carbon savings required to meet carbon budgets and Net Zero. This has been an iterative process over many years.

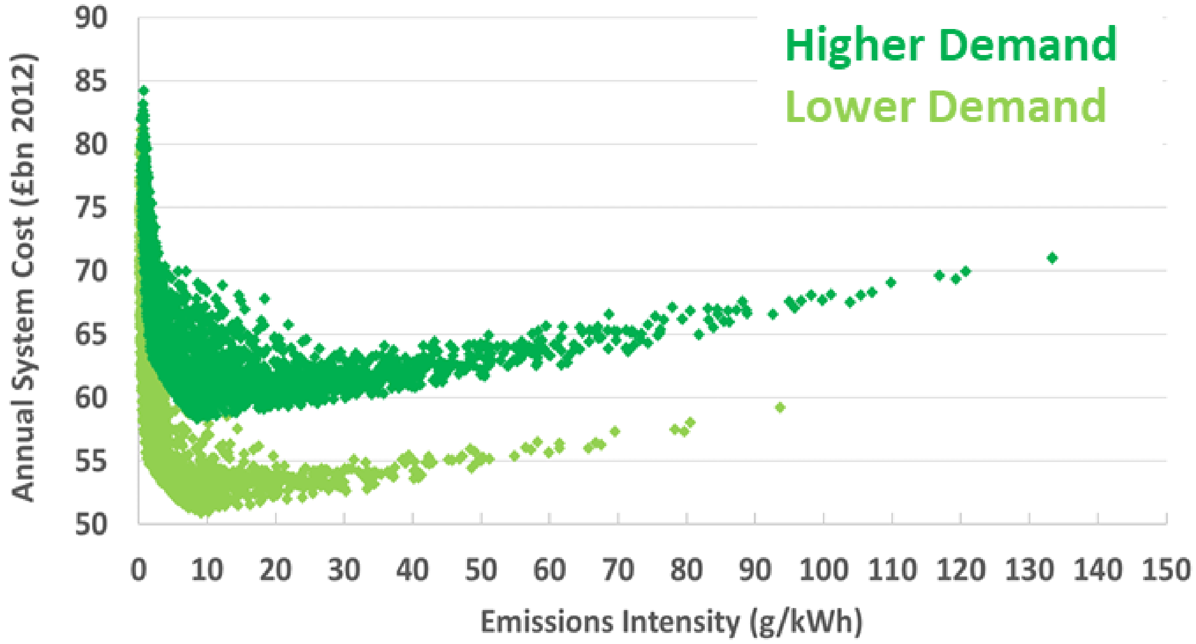
Power sector analysts have worked with analysts from other sectors and those responsible for economy-wide modelling to determine a range of demand that the electricity system would need to meet to deliver our carbon budgets. This level of demand reflects our policies and proposals in other sectors, for example from the electrification of heat and transport.

Analysts have also worked with policy experts to understand a range of potential capacities, costs, and other assumptions to feed into the modelling. For 2035, these are based on the policies and proposals that policy experts have advised are required to remain on course to deliver the maximum technically feasible capacities for each technology in this timeframe. We do not typically publish all these maximum technical feasible capacities broken down by technology and date (as opposed to public ambitions or policy goals), as this information could be market sensitive and could potentially affect the government's future commercial negotiations with generators and impact on value for money for the taxpayer.

Analysts have then used this information to generate thousands of potential capacity mixes at key dates (e.g. 2035, 2050) which can meet different levels of demand and which produce different levels of emissions and have different costs. A selection of this work was published in the 'Modelling 2050 – Electricity System Analysis' paper (with Figure 1 from this report duplicated below).

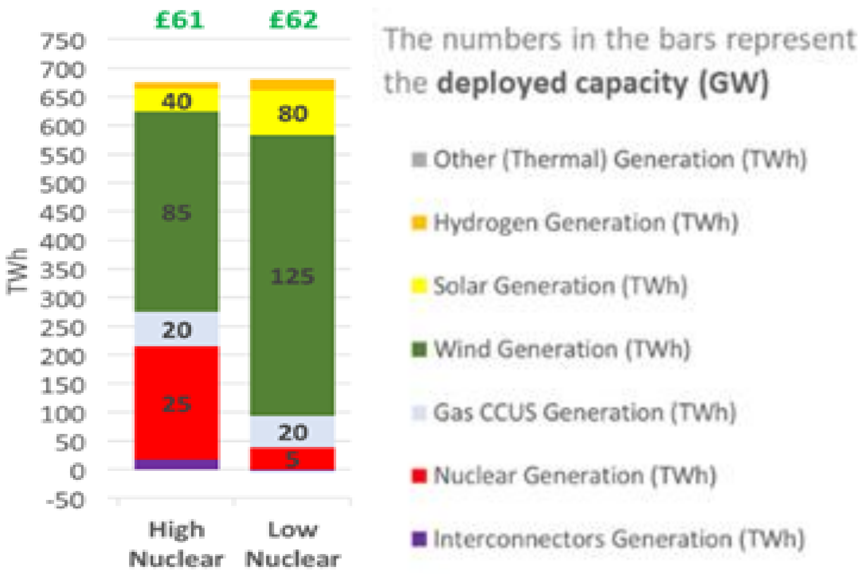
The modelling below focuses on capacity mixes for 2050 which deliver Net Zero. We are confident that the policies and proposals necessary and sufficient to keep us on a credible pathway to deliver an electricity system required to meet Net Zero in 2050, also enable us to deliver an electricity system compatible with CB6.

Emission intensities and system costs for a large range of power sector capacity mixes in 2050*[viii] *- *In 2050, the emissions intensity of the power sector will need to be below 5 g/kWh to achieve to achieve savings consistent with Net Zero.*



The capacity of any given technology within a Net Zero consistent capacity mix can vary significantly (see figure below), and the Government is not targeting a specific capacity mix for CB6 and Net Zero. Instead, ministers and policy experts have put in place a policy framework that enables a broad range of electricity infrastructure to deliver to levels that maintain optionality while keeping system costs low. This approach has led to the successful delivery of multiple policies in the power sector and contributed to sector emissions dropping by 70% since 1990.

Deployed capacity (GW) against generation (TWh) for two scenarios that achieve Net Zero in 2050 [ix]



<u>Calculation of Emissions Savings</u>

As illustrated in Box 1, the emissions savings from individual policies in the power sector are non-additive, that is, calculating the emissions savings of each policy in isolation yields a different total emissions savings figure than looking at all policies collectively. In this context, attempting to calculate emissions savings for individual policies is likely to be both misleading and inaccurate, we therefore only provide a single aggregate figure for the power sector. This is in line with the reporting approach taken by the Committee on Climate Change.

As emissions (and thus emission savings) for the power sector depend on multiple factors, such as demand profiles, weather patterns, generation capacity, and generation costs for each technology; emissions savings are calculated by comparing the emissions from two illustrative scenarios.

The ‘Net Zero’ scenario, which assumes that the policies listed in the Carbon Budget Delivery Plan (for both power and other sectors) have their desired impact, and the ‘Known Policy’ scenario, which outlines what the power sector would look like if the government made no further interventions beyond what has already been implemented or adopted (as defined in the Energy and Emission Projections). For already established policies this may result in part of their impact being incorporated into the Known Policy scenario. For instance, the Contract for Difference scheme has already delivered several allocation rounds and any capacity procured through these auctions will be included in the Known Policy scenario, while capacity that we expect to be procured in future allocations rounds will only be included in the Net Zero scenario.

Table 1: Power sector emissions savings for CB4, CB5 and CB6

Emissions (MtCO2e)	CB4					CB5					CB6				
	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
Known Policy	38.8	32.2	31.7	28.4	25.6	20.3	19.8	17.0	19.3	19.7	20.5	20.6	18.9	19.0	19.3
Net Zero	37.1	30.3	28.6	25.6	21.6	15.5	14.1	11.7	11.6	9.9	9.4	9.4	9.2	7.1	7.0
Difference	1.7	2.0	3.1	2.8	4.1	4.9	5.7	5.3	7.7	9.8	11.1	11.2	9.7	11.8	12.3
Average	2.7					6.7					11.2				

The development of each scenario involves several steps. First, based on the policies defined in the Carbon Budget Delivery Plan, we assess the range of potential capacities for each technology, including what is considered to deploy as part of the Known Policy scenario and the maximum that might be deployed through our various policies. This work is informed by projects known to be in planning or development, the level of support provided by our various policies (and when these will impact), estimates of the manufacturing capacity for each technology, and what is achievable given the current labour market and other constraints (such as network reinforcement).

For the Net Zero scenario we then apply the approach detailed in our ‘Modelling 2050 – Electricity System Analysis’ paper to define a starting capacity mix for our modelling work. The model is subsequently iterated with the capacity and generation mixes refined until they are consistent with our policy framework, have emission levels consistent with achieving CB6 and Net Zero, keep costs low, and ensure security of supply. The policy and proposals that have been put forward as part of this Carbon Budget Delivery Plan are those that policy experts have advised will enable us to remain on course to deliver the maximum technically feasible capacities that were inputted into the modelling.

This approach maintains optionality in low carbon generation technologies to allow markets to optimise the generation mix, whilst delivering critical system enablers and reforms, and removing barriers to deployment. Given that the modelling shows that we do not need all technologies to deliver at their maximum technically achievable capacity, this collection of policies and proposals represents a credible pathway to delivering our carbon budgets.

Linking Policies and Proposals to Modelling

The following table shows the capacities included in the two scenarios. We highlight below the policies and proposals that we are confident put us on credible pathway to delivery. Some of these policies are already in place and have delivered emissions savings, some will enable or deliver emissions savings in the future, and others will enable and de-risk delivery.

Table 2: Generation capacities included in the Net Zero and Known Policy scenarios in key years

Capacity of Power Sources (GW)	2030		2035		2050	
	Known Policy	Net Zero	Known Policy	Net Zero	Known Policy	Net Zero
Nuclear	5	5	8	9	8	24
Offshore Wind	40	44	39	68	43	100
Onshore Wind	17	27	15	37	6	50
Solar	21	39	28	63	42	90
Gas Carbon Capture & Storage	1	3	1	9	1	18
Bioenergy with Carbon Capture & Storage	0	1	0	2	0	2
Energy from Waste	2	2	2	2	1	0
Hydrogen	0	5	0	5	0	45
Interconnectors	16	19	16	21	16	25

Nuclear: Sizewell C is a major policy focus for the department. The Government has invested £679m in this project (Sizewell C Government Investment Scheme) and the project has been designated under the Regulated Asset Base model, allowing Sizewell C to utilise a new approach to financing nuclear power plants. Our nuclear policies and proposals also include the establishment of Great British Nuclear, the Advanced Nuclear Fund, the Future Nuclear Enabling Fund, and the Nuclear Fuels Fund. These will help the nuclear sector innovate, and also support the delivery of nuclear capacity beyond Sizewell C.

Offshore Wind & Floating Offshore Wind: Significant offshore wind capacity has already been deployed through the Contracts for Difference (CfD) scheme and its predecessor the Final Investment Decision for Enabling Renewables (FIDER) scheme. Allocation Round 4 saw the first CfD-supported Floating Offshore Wind project come forward and the CfD scheme remains our main policy for the delivery of new offshore capacity. We regularly review the Contracts for Difference mechanism to ensure it best meets Government's objectives, recently publishing a consultation on potential future changes to the scheme (Review of Contracts for Difference Mechanism) and will soon launch a Call for Evidence on whether Non-Price Factors should be included in future rounds. The scheme is also being reviewed as part of the wider Review of Electricity Market Arrangements.

The Government has been working to accelerate the deployment of Offshore Wind through the Offshore Wind Acceleration Taskforce and work of the UK Offshore Industry Champion. It has been supporting deployment through the Floating Offshore Wind Taskforce and has two grant schemes to support manufacturing and port infrastructure development: the Offshore Wind Manufacturing Investment Scheme and the Floating Offshore Wind Manufacturing Investment Scheme. We are also supporting innovation through the Floating Offshore Wind Demonstration Programme.

We have several policies and proposals to ensure that this capacity can be connected into the grid and can be delivered in the wider context: the Offshore Coordination Support Scheme, supporting National Grid with their Holistic Network Design and Follow-Up Exercise, the Offshore Transmission Network Review, the Offshore Wind Environmental Improvement Package, Marine Spatial Prioritisation Programme, and the Radar and Offshore/Onshore Wind policy. These measures will not deliver new capacity directly but address key challenges and blockers that might otherwise inhibit deployment.

Onshore Wind: Like offshore wind, we expect onshore wind capacity to continue to be deployed through the Contracts for Difference scheme and we are confident this can deliver high levels of onshore wind capacity. To de-risk delivery, we have two policies to help new developments get planning permission quickly: Local Partnerships for Onshore Wind (England) and National Planning Policy Framework (Local, England).

Solar: Solar capacity in the UK has increased significantly in the last decade driven both by Government schemes and merchant deployment. It is expected that the Contracts for Difference scheme will continue to deliver significant levels of ground-mounted solar.

Several of our policies and proposals remove barriers to the deployment of roof top solar on homes and businesses. These include the Removal of VAT from Residential Solar announced in the Spring Statement in 2022, exploring options for Low-Cost Finance for Solar for Homes and Small Businesses, Advice and Guidance to Public Sector on Procurement, and the Emerging Workforce Challenges policies. We are also consulting as part of the Permitted Development Rights, and Future Homes and Building Standards polices. A key policy for all types of solar is the establishment of a Solar Taskforce and commitment to develop and publish a solar roadmap for deployment up to 2035, which will encourage investors by giving them clarity and confidence.

Carbon Capture, Usage and Storage (CCUS): The Government recently announced £20 bn to support the roll-out of CCUS and is looking to negotiate a subsidy contract to support a Power CCUS project to be operational by 2027. Negotiations will be based on the business model contract – the Dispatchable Power Agreement (DPA) – which allocates risk to make this, and future power CCUS projects in receipt of a DPA, investable. We are confident that this will deliver a first-of-a-kind power CCUS project and, through the Track 1 expansion, Track 2, our Decarbonisation Readiness policy, and policies in other sectors, we are enabling the wide-scale roll-out of CCUS infrastructure and further power CCUS plants by the end of CB6.

Power Bioenergy with Carbon Capture and Storage (BECCS): The Government is developing a business model for power BECCS, which will de-risk the deployment of this technology. The Government will also shortly publish the Biomass Strategy which will set out how biomass can be used to decarbonise the economy and generate negative emissions. Deployment of power BECCS will contribute to our ambition of 5Mtpa of engineered Greenhouse Gas Removals by 2030.

Emissions savings attributed to greenhouse gas removal technologies such as power-BECCS are accounted for in the Greenhouse Gas Removal section; whereas the contribution of that technology to low-carbon power generation is represented as part of the single Power sector return.

Energy from Waste (EfW): Our Energy from Waste and Emissions Trading Scheme (ETS) policy is actively looking at how to include waste incineration in the ETS. Doing this will encourage the pre-sorting of waste to reduce emissions, and, alongside our CCUS policies, incentivise the deployment of EfW with CCUS. While EfW plants are not large producers of electricity they are a major source of emissions for the power sector in the 2030s so these policies will help ensure that the sector has low total emissions.

Long Duration Storage: The Government is actively supporting the deployment of new forms of storage through the Longer Duration Energy Storage (LODES) Competition, and we are developing policies to support Large Scale Long Duration Electricity Storage technologies. Longer duration storage has the potential to improve power sector resilience and reduce costs. While this technology is not currently assumed to deploy in our modelled scenarios, encouraging innovation and deployment of this technology will increase optionality in the power sector and de-risk the path to CB6 and Net Zero.

The Government will be taking powers to establish the Future System Operator and will be creating a new governance framework for the energy codes, both of which will facilitate the transition to net zero.

Hydrogen: In 2023 the Government will consult on the need and potential design options for hydrogen to power market intervention and has commissioned external research on the need and case for market intervention to support hydrogen to power plants. Hydrogen to power remains a nascent technology but it has the potential to significantly improve optionality in the power sector and reduce systems costs.

Networks & Interconnectors: As the power sector evolves to satisfy increasing demand and include increasing amounts of low carbon capacity, particularly offshore wind, there is requirement to ensure that sufficient transmission and distribution network infrastructure is in place in a timely manner.

DESNZ will work closely with Ofgem in line with the vision and actions set out in the Electricity Networks Strategic Framework including on the Accelerated Strategic Transmission Investment decision, ensuring the price control process including RIIO-ED2 incentives investment ahead of need and addressing the forthcoming recommendations of the Electricity Networks Commissioner on accelerating transmission infrastructure. We are also addressing reforms to the consenting process to speed up delivery of new network capacity, including through working with DLUCH on the Nationally Significant Infrastructure Programme Action Plan and through our Land Rights and Consenting for Electricity Networks call for evidence, and our consultation on options for Community Benefits for network infrastructure. We believe this work will deliver sufficient network capacity to the end of CB6 so ensure security of supply and minimise costs.

We and Ofgem have put in place a cap in floor regime to support the deployment of interconnectors and have recently run a regulatory pilot for Multi-Purpose Interconnectors. The purpose of both these policies is to support the deployment of these assets by limiting developers' exposure to electricity market price risk, with a known pipeline of 19GW of interconnector projects in construction or with regulatory approval.

Markets & Governance: The market structure for the power sector has evolved over time and the current structure, including the procurement of capacity through the Capacity Market has been very successful. We are, nevertheless, mindful that the market will need to continue to evolve to meet new challenges and we have undertaken two consultations on this: the Capacity Market 2023 Consultation and the wider Review of Electricity Market Arrangements. These will help to ensure that we have the processes and market frameworks in place to meet CB6.

Linked to this the Government will be taking powers to establish the Future System Operator and will be creating a new governance framework for the energy codes, both of which will enable the sector to operate more efficiently.

Smart systems: Smart and flexibility systems have a key role keeping costs for consumers low and ensuring security of supply and the Government is encouraging innovation and removing barriers by delivering on the actions set out in both the Smart Systems and Flexibility Plan, and Energy Digitalisation Strategy. It is also directly supporting innovation through the Flexibility Innovation Programme.

Box 1: Calculation of Emissions Savings from Two Policies

In this calculation we look at the emissions savings in 2035 from two hypothetical policies:

1. A policy that leads to the deployment of 17.5 GW of offshore wind, and
2. A policy that leads to the deployment of 4.9 GW of nuclear capacity

This leads to the following four system mixes:

No.	Description	Wind (GW)	Nuclear (GW)	Emissions ($MtCO_2e$)
1	Min capacity	50.0 GW	4.5 GW	10.1
2	Low wind, high nuclear	50.0 GW	9.4 GW	9.4
3	High wind, low nuclear	67.5 GW	4.5 GW	9.2
4	Max capacity	67.5 GW	9.4 GW	8.7

Emissions savings can then be calculated by:

1. Adding one or more policies to the 'min capacity' scenario, or
2. Removing one or more policies from the 'max capacity' scenario

Doing this yields the following emissions savings:

	Reference Scenario		Counter-Factual		Savings ($MtCO_2e$)
Wind					
Remove from max capacity	2	9.4	4	8.7	0.7
Add to min capacity	1	10.1	3	9.2	0.9
Nuclear					
Remove from max capacity	3	9.2	4	8.7	0.5
Add to min capacity	1	10.1	2	9.4	0.7
Collective Appraisal	1	10.1	4	8.7	1.4

From these calculations, the emissions savings will vary significantly based on the calculation approach used. For instance, if we calculate the emissions savings for both the wind and nuclear policies relative to the max capacity scenario (equivalent to the Net Zero scenario here) we would get emissions savings of 0.7 + 0.5 = 1.2 $MtCO_2e$. While if we calculate the emissions savings relative to the min capacity scenario (equivalent to the Known Policy scenario here) we would get emissions savings of 0.9 + 0.7 = 1.6 $MtCO_2e$. Neither of these sum to the emissions savings calculated collectively (of 1.4 $MtCO_2e$) and the effect magnifies for each policy / technology included.

The difference in emissions savings arises because there is both significant exporting of electricity and curtailment of low carbon generation in the Net Zero scenario. While removing some low carbon capacity (be that nuclear or offshore wind) will lead to some additional gas generation, a lot of lost generation is made up by generation from other low carbon capacity already in the system – generation that would otherwise be exported or curtailed in the Net Zero scenario. However, as increasingly more low-carbon capacity is removed from the system the amount that can be made up by the excess generation from other low carbon capacity falls, leading to higher and higher proportions of gas generation and correspondingly higher emissions.

Fuel Supply and Hydrogen

Hydrogen: Overall hydrogen demand - consistent with the policies set out in the Carbon Budget Delivery Plan for industry, power, buildings, and transport - was estimated as set out in the other sector modelling descriptions in this annex. Estimates of the hydrogen production capacity that could be needed to meet demand have been calculated assuming hydrogen production plants run at a 70% load factor on average. In 2030, we assume 10 GW of hydrogen production capacity in line with the ambition announced in the British Energy Security Strategy. In 2035, we estimate we could need 14-25 GW of production capacity. The policies and proposals required to bring forward this capacity, in particular the Net Zero Hydrogen Fund, Industrial Decarbonisation and Hydrogen Revenue Support (IDHRS) scheme and Hydrogen Transport and Storage Business Models are set out in the Carbon Budget Delivery Plan.

These figures are uncertain. Hydrogen demand is dependent on a range of factors including the relative cost of hydrogen compared to other fuels; hydrogen availability and infrastructure rollout; and policy decisions around the role of hydrogen for heat. Demand could be higher or lower than this range, which would lead to a higher or lower production capacity requirement. The load factor of hydrogen production plants is uncertain and dependent on the hydrogen supply mix and availability of low carbon power. A higher load factor would lead to a lower capacity requirement, and vice versa. We do not model hydrogen imports or exports, which could lead to higher or lower domestic production requirements.

Government policies and proposals on hydrogen, such as the Net Zero Hydrogen Fund and Hydrogen Revenue Support schemes support the development of hydrogen production. Emission savings from this technology would be realised and accounted for in downstream sectors – such as the buildings and industry sectors.

Because of this, the hydrogen production rows in the Carbon Budget Delivery Plan show the direct emissions from blue hydrogen production only and exclude indirect emissions from electricity use for green hydrogen production (these emissions have been accounted for in the Power sector estimates). Emissions savings from using hydrogen to displace high-carbon fuels in end use sectors including industry, power, transport and potentially buildings are reported against policies and proposals in those sectors in the Carbon Budget Delivery Plan. Emissions from blue hydrogen production are calculated using standard emissions factors for natural gas combustion and assume a 95% carbon capture rate[x]. Energy demand estimates are calculated using efficiency assumptions from the Hydrogen Production Costs 2021 report, which provides further detail on the parameters underpinning this analysis.[xi] These estimates are also illustrative and uncertain, and dependent on the hydrogen supply mix, load factors and efficiencies of plants.

Upstream Oil and Gas: The emissions savings for upstream oil and gas were developed using the projected abatement from offshore electrification and flaring provided by the North Sea Transition Authority (NSTA).

Estimates of potential abatement from offshore electrification (scope 1 emissions only) were developed using the data provided to the NSTA by industry as of July 2022. It assumes that there will be a mixture with some installations being partially electrified and others being fully electrified. The list of these installations was provided by industry. Fully electrified installations were estimated, in line with industry representatives' assessment, to have 70% of power demand provided by electrification, while partially electrified ones have 43%. Additionally, it is assumed that full abatement starts a year after project completion and that electrification of the installation would not affect previously reported economic cessation of production dates.

The estimate of GHG emissions abatement via flaring reduction from offshore oil and gas infrastructure was developed assuming that zero routine flaring will be in place across all UKCS assets in 2030. Routine flaring is assumed to be consistent with category 1 flaring - now defined by the NSTA as category A flaring. Future expected flare volumes were calculated by subtracting the routine element of flaring from total anticipated flaring per facility after 2030, with data taken from the UK Continental Shelf Stewardship Survey[xii].

Flared gas values, in both mass and volume units, have been converted to CO2 emissions using emission factors observed in published datasets (e.g. EEMS)[xiii].

Industry

The policies and proposals set out in the Carbon Budget Delivery Plan are quantified using the Net Zero Industrial Pathways (NZIP) model and a range of other policy specific models and analysis.

The NZIP model was developed by Element Energy for BEIS and the Climate Change Committee (CCC) and used to underpin the manufacturing and construction sector analysis in the CCC's Sixth Carbon Budget report, the Government's Industrial Decarbonisation Strategy (IDS), published in March 2021 and the October 2021 Net Zero Strategy (NZS) publication. The model calculates the least cost technically feasible pathway for a range of technologies, assessed on their capital and operating costs, along with cost reductions over time due to technology learning, and a number of key constraints impacting their deployment (e.g. technology readiness level, hydrogen and CO2 transport and storage availability, supply chain capacity). The model has been updated to reflect latest Energy Emission Projections, fossil fuel prices, hydrogen production costs and availability.

For developed policies, quantified savings not already included in the baseline used for the Carbon Budget Delivery Plan are informed by business cases based on bespoke modelling which are designed to quantify the impact of government interventions on the deployment of CCS, fuel switching and efficiency measures displacing carbon-intensive activity. The quantified savings of designed and early-stage policies and proposals are estimated in line with the socially cost-effective technically feasible pathway modelled in NZIP, delivered by the identified policy instruments set out in the Carbon Budget Delivery Plan. For instance, estimated savings from industrial carbon capture reflect the socially optimal abatement from industrial carbon capture by the end of Carbon Budget 6. Policies and proposals, such as the industrial carbon capture business model, will therefore be developed to deliver the cost-effective abatement identified by the modelling. The carbon savings from decarbonisation of the steel sector are estimated by assuming policy incentivises the electrification of production processes. Assumptions about the impact of policies and proposals in the Carbon Budget Delivery Plan on industrial non-road mobile machinery (NRMM) decarbonisation are aligned with CCC's CB6 advice and will be refined further ahead of the publication of the NRMM strategy.

This modelling relies on many exogenous assumptions and inputs that are uncertain and will evolve over time. This includes industrial output according to emission projections which could increase or decrease delivery requirements, and the technical potential for emissions savings from resource and energy efficiency (REEE).

Investment requirements as set out in the Net Zero Growth Plan associated with the deep decarbonisation of industry (e.g. fuel switching and CCS) are based on NZIP technological cost assumptions and exclude networks related operating expenditure. Investment requirements for industrial energy efficiency are based on the Industrial Decarbonisation and Energy Efficiency Roadmaps (BEIS, 2015) and include additional estimates for non-roadmaps sectors. Investment requirements associated with resource efficiency measures have not been quantified.

An adjustment to the CBDP baseline has been made to account for minor discrepancies between the DESNZ Net Zero Industrial Pathways model, used to model emission savings in the industry sector, and the EEP 2021-2040. This alignment is needed to calibrate sub-sector breakdowns in both EEP21-40 and NZIP models. This is a minor calibration that amounts to 0.5MtCO2e/year on average over each of the carbon budget periods.

Heat and Buildings

Overview: Calculated emission savings for heat and buildings policies and proposals under all scenarios (high electrification and hydrogen scenarios) are developed to be consistent with completely decarbonising buildings by 2050. Calculations assume that a typical heating appliance has a lifetime of 15 years. This implies that no new fossil fuel heating systems can be installed after 2035, and as such our policies and proposals are designed to achieve this ambition.

For most policies and proposals, we quantify savings under the central scenario. However, we have modelled different decarbonisation pathways options for some policies and proposals in the buildings sector. The emissions savings attached to these measures vary depending on the level of deployment of hydrogen across the economy. This applies to policies and proposals covering heat pump deployment, buildings “on the gas grid”, and the emissions associated with hydrogen production.

These measures would be subject to future consultation. The modelled scenarios show how differing uptake rates of hydrogen may displace some technologies that rely on electrification (and the policies that support them) across the economy. For domestic buildings, we will seek to grow the market and help consumers transition to different supplies of heat – all while continuing to follow natural replacement cycles and working with the grain of consumer behaviour. For non-domestic buildings, we will focus policy interventions on key segments of the building stock, for example based on tenure or building use.

The high electrification scenario assumes that hydrogen is not available as an option for heating buildings. It therefore assumes the level of heat pump deployment grows from its current level of around 55,000 in 2021 to be able to meet the turnover of fossil fuel systems in 2035. In scenarios involving hydrogen, heat pump deployment meets the common ambition of 600,000 heat pumps by 2028.

In both hydrogen scenarios, the impact of policies and proposals are modelled such that hydrogen deployment is optimised to displace the same volume of emissions as the heat pumps would in the electrification scenario. Installation of energy efficiency measures and deployment of low carbon heat networks is assumed to be same in all scenarios.

A summary of the hydrogen and electrification scenarios is in Appendix B of the Carbon Budget Delivery Plan.

Domestic Energy Efficiency: modelling of domestic energy efficiency policies was carried out using the National Household Model (NHM)[xiv]. This model is applied to policies that directly support the installation of energy efficiency measures (such as the Social Housing Decarbonisation Fund, future phases of Home Upgrade Grant and Local Authority Delivery Scheme) or indirectly encourage homeowners to install measures (such as early-stage, minimum energy efficiency regulations). From this, emission savings for each proposal or policy are then derived.

The NHM estimates the impact of installing different energy efficiency measures in different properties by applying the Standard Assessment Procedure[xv] to a representative sample of the housing stock based on the English Housing Survey[xvi]. Further adjustments are made to modelled savings to account for factors such as the real-life performance of policies and people heating their homes to a more comfortable temperature when their energy bills are reduced.

Non-Domestic Buildings - commercial and public: the emissions trajectory to the sixth carbon budget for commercial and public sector buildings policies and proposals (covering early-stage regulatory changes and measures to support growth of the heat pump market) was created using the DESNZ Non-Domestic Buildings Model (NDBM). This models the deployment of low carbon heating and energy efficiency measures in non-domestic buildings, consistent with the policies set out in the Carbon Budget Delivery Plan, which is then used to estimate projected emission savings from each proposals or policy.

The NDBM uses building stock characteristics and potential energy efficiency information from the Building Energy Efficiency Survey (BEES) dataset[xvii]. Data on energy consumption and emissions come from the Digest of UK Energy Statistics, Energy and Emissions Projections, and Energy Consumption UK statistics.[xviii] The model has been supplemented with updated information on off-gas grid buildings from the Non-domestic National Energy Efficiency Data-Framework (ND-NEED); and updated efficiency assumptions for Heating Ventilation and Cooling (HVAC) technologies in non-domestic buildings.[xix] Modelling assumptions for public sector buildings policies have been further refined through monitoring the on-going rollout of phase 1, 2 and 3 of the Public Sector Decarbonisation Scheme.

Products Policy: For policies and proposals on product energy efficiency standards, data on efficiencies, cost, usage, sales, lifetime, range of products on the market and number and make up of UK manufacturers is taken from published government statistics, consultation with trade associations, and research provided by external contractors to develop the evidence base (as well as the source information listed above on energy efficiency). The average energy consumption of products currently on the market is compared to the average energy consumption following the introduction of new efficiency standards (consistent with the policies and proposals set out in the Carbon Budget Delivery Plan, such as the Energy-Related Product Standard and standards for Domestic Cooking Appliances) to forecast energy and carbon savings, taking into account product lifetime, usage and different technology types.

Domestic Heat Pumps: Deployment of domestic heat pumps is based on simple analysis of the residential stock, segmenting homes by heating fuel, and considering natural replacement cycles. The trajectory of heat pumps is based on estimates of deployment from current and planned policies (supported by policies and proposals such as the Boiler Upgrade Scheme and set out in the Carbon Budget Delivery Plan), supply chain growth required to meet phasing out of new fossil fuel heating systems, and use of the natural replacement cycle to remove all fossil fuel heating in homes by 2050. Assumptions on appliance performance and on potential supply chain growth, are based on published research.[xx] Assumptions on the current building stock and heat demand are from the NHM and domestic NEED.[xxi] Assumptions on new build homes are based on DLUHC's 2021 Interim Part L Uplift Final Stage Impact Assessment - these were produced externally by consultants and an independent consortium.[xxii] These are for appraisal purposes only and are not an official forecast of housing supply.

Hydrogen for heat: Hydrogen used for heat will vary depending on the commercial viability of hydrogen and the uptake of competing technologies (such as heat pumps) as well as continued government support through policies and proposals.

Deployment of hydrogen for heat in buildings up to the sixth carbon budget has been modelled using a spatial analysis approach considering the metered gas demand from residential, commercial and public buildings. This assumes different rates of gas grid conversion to hydrogen in an expanding radius around potential industrial cluster sites. The rate of change depends on the hydrogen scenario (see discussion of electrification, medium, and high hydrogen scenarios in the Carbon Budget Delivery Plan).

As set out in the Carbon Budget Delivery Plan, deployment will depend on wider commercial factors such as the cost of heat pumps (both their upfront costs and running costs) and the successful commercialisation of hydrogen to heat buildings - as well as continued government action through a range of measures. Government is planning to take a strategic decision on the role of hydrogen heating in 2026.

Heat Networks: Heat network emission savings are calculated by appraising the fuel demand changes from deploying low-carbon heat networks compared to a predominately gas counterfactual, as well as improving the efficiency of existing networks. The extent of heat networks' deployment – and the volume of heat supplied by heat networks (see Appendix C: Deployment Assumptions) - are estimated from the modelled trajectories of capital support programmes and the policies and proposals set out in Carbon Budget Delivery Plan based on expected costs and performance, as well as partly informed by Heat Networks Zoning Pilot research. This reflects the support provided to building new low-carbon heat networks as well as the decarbonisation of existing heat networks stock, where the displacement of all fossil fuel heat networks by 2050 has been accounted for. Assumptions on technology mix, performance and improvement measures are informed by the National Comprehensive Assessment research on opportunity areas for district heating networks[xxiii], the Heat Network Investment Projects, the Heat Network Optimisation Opportunities project and expert judgements.

Biomethane: Policies and proposals set out in the Carbon Budget Delivery Plan are designed to support anaerobic digestion (AD) plant deployment, based on a combination of historic deployment under the Renewable Heat Incentive (RHI) and commercial intelligence, incentivising the production and commercial-scale gasification of biomethane, which by displacing natural gas will deliver emission savings. The amount of heat generated is estimated from the resulting plant deployment and using estimates for biomethane injection as a proportion of capacity[11]. The internal DESNZ Biomass Heat Pathways Tool provides assumptions on biogeneration emissions. Rothamsted Research has provided assumptions on upstream carbon savings, linked to diverting feedstocks from counterfactual uses to AD, and ammonia impacts[12]. Downstream carbon savings from the policies and proposals, linked to the displacement of natural gas with biomethane, are estimated using emissions factors provided in the HMT Green Book supplementary guidance.[xxiv] Full methodology and assumptions for AD deployment emissions savings can be found in the final stage impact assessment for the Green Gas Support Scheme. Gasification emission savings were calculated based on estimated deployment of gasification to grid deployment and the associated natural gas displacement[xxv], based on market intelligence and historic and planned Energy from Waste (EfW) deployment.

UK Scaling to Heat and Buildings: Policy responsibility in heat and buildings is a mix of reserved and devolved responsibilities across HMG and the Devolved Administrations. To generate estimates of emissions reductions at the UK level, where it is reasonable to assume policy action is ongoing or planned in the Devolved Administrations, scalars are applied to the emission savings estimated for England, England and Wales or GB policies, and are included in the savings of each relevant policy line.

The value of the scalar varies according to the nature of the policy, reflecting relative population or household numbers, or share of UK gas demand.

Transport

Domestic Transport: The policies and proposals set out in the Carbon Budget Delivery Plan for domestic transport cover road transport, rail, domestic shipping and domestic aviation.

The quantified savings for road transport reflect a variety of policy mechanisms which are estimated to deliver carbon savings from road transport, based on our understanding of how these policy interventions will change behaviour and encourage the uptake of new technologies to facilitate a switch away from existing carbon-intensive modes of transport. This includes measures to increase the sale of zero emission vehicles (ZEVs), and limit emissions from non-ZEVs – for example, the car and van ZEV mandate, and further measures to accelerate the replacement of the oldest vehicles in the fleet. The modelled effect of these measures is to reduce the sales and accelerate the replacement of fossil fuel vehicles, changing the carbon-intensity of the vehicle fleet over time, and thereby reducing transport emissions. It also includes measures which encourage alternative (low or zero carbon) modes of transport or greater vehicle utilisation – for example, investment in active travel. The modelled effect of these interventions is to reduce the required amount of road transport trips, compared to the baseline without these measures, thereby reducing emissions.

[11] This model is based on historic RHI data.

[12] These are consistent with those used to compile the 1990-2019 National Atmospheric Emissions Inventory (NAEI).

The modelling of vehicle sales and vehicles in the fleet is undertaken using the Road Carbon and Fuel Fleet model (RoCaFF). It uses DfT licensing statistics to define the current vehicle fleet, and to estimate vehicle scrappage rates(i). It also uses licensing statistics to estimate new vehicle emissions (gCO2 per km) as measured on test cycles. These are then adjusted to real world emissions estimates based on ICCT data(ii). Demand for road transport vehicles is projected using the National Transport Model (NTM) (iii), which projects road transport demand (i.e. vehicle km) based on socio-economic variables including GDP, population growth and fuel prices. Outputs from NTM runs have been adjusted to reflect fuel prices aligned with EEP 2021-2040 and updated evidence on real world emissions including from Plug-in Hybrid Electric Vehicles. ZEV policy is designed to deliver a stated ZEV sales trajectory, which is then used to estimate the emissions savings for these policies (e.g. car and can ZEV mandate). For measures that encourage alternative modes of transport, estimates ae made of the reduction in mileage consistent with the intervention. The vehicle mileage projections are then modified accordingly, reducing emissions. Road transport measures are modelled sequentially to ensure that overlaps are accounted for and that carbon savings are not double counted.

The quantified rail savings were modelled by the Great British Rail Transition Team. The modelling assesses proposals and polices to electrify some lines, enabling carbon emissions reductions by replacing diesel trains with electric trains. It also assesses the replacement of diesel trains with bi-mode or zero emission train technologies on unelectrified lines.

The quantified savings presented for domestic aviation and shipping align with the approaches developed for international aviation and shipping – see below for further details.

International Aviation and Shipping: The quantified savings for international aviation are estimated using the evidence base developed for the Jet Zero Strategy, aligned with the “high ambition” scenario, but with updated assumptions on GDP and passenger growth[xxvi]. International and domestic carbon savings are estimated using the same DfT Aviation model and assumptions. This model is an established suite of interrelated components used to produce forecasts for aviation demand at the national level, and the associated passenger numbers, aircrafts and CO2 emissions from flights departing from UK airports[xxvii]. Three abatement measures are considered within the modelling; system efficiencies, sustainable aviation fuels (SAF), and zero emission aircraft. The policy interventions set out in the Carbon Budget Delivery Plan, such as the SAF mandate, are designed to facilitate the deployment of these abatement measures, which, by reducing the carbon-intensity of aviation, deliver carbon savings.

The quantified savings for domestic and international shipping set out in the Carbon Budget Delivery Plan, are based on research commissioned by the DfT.[xxviii] For both sub-sectors, the estimates from this research are adjusted to align them with the latest UK greenhouse gas emissions national statistics (2020). Therefore, the emission projections for domestic shipping and international shipping are consistent with the definitions of domestic shipping and international shipping used in these national statistics.[13] Given the emerging nature of zero emission shipping fuels, the quantified savings set out for domestic shipping and international shipping should be interpreted as reflecting one abatement pathway for meeting the government's commitment to zero maritime emissions, with policies to be designed to meet this ambition, enabling the deployment of the necessary emissions reduction options. The emissions savings reflect the reduction or substitution of existing carbon-intensive fuels by the uptake of efficiency improving technologies and/or operating practices, and the use of lower emissions fuels (e.g. electricity, ammonia or methanol), deployed consistent with the overarching policy ambition for the sector's emissions. Efficiency improving technologies and/or operating practices improve fuel efficiency, and lower emission fuels replace traditional fossil fuel. The result is a reduction in emissions from the shipping sector.

Natural Resources and Waste

Agriculture: The emissions savings set out in the Carbon Budget Delivery Plan attributed to all agriculture policies and proposals in the English agriculture emissions trajectory are based on scientific assessment of the technologies' ability to mitigate emissions and social research on feasible deployment of those technologies. [xxix]

Each technology's maximum technical emissions mitigation potential was assessed. This was derived from expert review of published literature and modelling to scale experimental data to the national level. This builds upon previous work by the CCC. These estimates have been independently peer reviewed. This provides a basis for determining what emission savings can be delivered if particular agricultural technologies/measures are implemented in full.

The extent to which these maximum potential savings can be realised, depends on the degree to which they are deployed. Feasible deployment rates, lead-in times and uptake rates for each technology were therefore estimated, through consultation with academic, industry and policy experts to reflect barriers, technology readiness, and research and development lead-in times. Workshops with different types of livestock and crop farmers were also used to inform this feasibility assessment.

The final emissions trajectories for each agriculture measure are based on the most ambitious assessment of what the feasible deployment rates are for these measures as identified from these consultations. For methane suppressing feed additives and mobile machinery, additional analysis by Defra has adjusted implementation rates to generate an even more ambitious trajectory. The policies and proposals set out in the Carbon Budget Delivery Plan are designed to deliver these trajectories.

Biomass: The Carbon Budget Delivery Plan sets out a number of policies and proposals, such as the Renewable Transport Fuel Obligation, Sustainable Aviation Fuels Mandate

[13] For example, the estimates of the greenhouse gas emissions from international shipping represent estimates of the greenhouse gas emissions from fuel sold in the UK for use in international shipping.

and the development of business models to support Bioenergy Carbon Capture and Storage, which will support the demand for domestic planting of energy crops and short rotation forestry, and which could be further underpinned by government support for planting. The emissions savings expected from delivering domestic planting of perennial energy crops and short rotation forestry are based on an indicative technical assessment derived from potential carbon abatement that assumes optimal matching between species, sites, and climate, which has informed policy modelling and ambition of the amount of future planting available. It also takes a relatively simplistic approach to modelling carbon removals. Five biomass crop categories were modelled, deployed in broadly fixed proportions: exotic short rotation forestry (SRF) (4-8%); conifer SRF (4%); broadleaf SRF (poplar, aspen) (27%); short rotation coppice (SRC) willow (31%); miscanthus (31%). All SRF and SRC crops were assumed to comply with the requirements of the UK Forestry Standard; as such, only 70% of the gross area planted was assumed to support biomass production, with 10% open ground and 20% native woodland managed for biodiversity objectives. A high-level analysis of land availability has been undertaken, indicating that the deployment profile is feasible.

To calculate changes in the stock of carbon contained in biomass crops, a linear approach to modelling has been adopted which may overestimate initial growth of bioenergy crop yield and thus abatement. For all crops, appropriate biomass expansion coefficients were applied to account for branches and/or roots, as appropriate. Biomass was converted to carbon, assuming 50% is made up of carbon. Emissions savings are modelled as the time-averaged increase in biomass carbon stocks across multiple rotations resulting from planting of the crop, assuming the land use change is permanent. No change in carbon stocks was assumed for the open ground element of the SRF/SRC crops; carbon stock change for the ‘biodiversity woodland’ component was modelled as unmanaged broadleaf woodland, using the conventional forestry model (see below).

Forestry: The Nature for Climate Fund and Environment Land Management schemes are designed to provide grants and incentives to increase tree canopy and woodland cover to ultimately meet the ambition to cover 16.5% of total land area in England by 2050. To estimate the greenhouse gas removals that these proposals and polices will deliver, we use output from Forest Research’s CSORT model, an off-line version of Carbine, which is the greenhouse gas accounting model used to calculate the forestry contribution to the UK LULUCF GHG inventory.[xxx] The model enables us to estimate the emission savings for the level of additional forestry, given the types of trees expected to be planted, consistent with the policies and proposals. Three indicative woodland types are represented in the model: productive conifer, productive broadleaf, and unmanaged. The modelled abatement is for England only[xxxi]. Linear expansion of afforestation, supported by government tree planting policy, is assumed between 2025 and 2035 (see Carbon Budget Delivery Plan Appendix C: Deployment Assumptions). The deployment trajectory for England assumes that the 16.5% Environment Act tree canopy and woodland cover target is achieved by 2050. Non-market benefits are calculated using various research, compatible with the Enabling a Natural Capital Approach services data book[xxxii].

Agroforestry: The Environmental Land Management schemes will be designed to provide incentives to increase silvo-arable agroforestry to cover 10% of all arable land by 2050. The emission savings that this policy will deliver are estimated using modelling which utilises three in-field planting[14] designs representing lower, middle and higher numbers of trees per hectare. To reflect the early-stage nature of the policy, with the necessary Sustainable Farming Incentive (SFI) standard for agroforestry yet to be implemented, the uptake rates for the three design options are assumed to match the uptake rates for the three levels of the SFI hedgerow standard, a similar standard aimed at similar farmers and also listed in the Carbon Budget Delivery Plan. A range for carbon savings from agroforestry policy is provided by adopting two models: Woodland Carbon Code look-up tables and the managed broadleaf option in Forest Research's CSORT model also used for modelling conventional woodland creation.[xxxiii] 2.5m spacing between trees is assumed, adjusted to the lower stocking density typical of agroforestry systems by using a conversion factor derived from yield tables for widely spaced poplar, representing the design with the highest proportion of land sharing and highest stocking density. Carbon savings were further scaled-down to reflect the two other designs with fewer trees per hectare. Soil carbon sequestration is assumed at a conservative rate of 1 tCO2/ha/yr, based on measured soil sequestration for abandoned arable land over a period of 120 years[xxxiv]. This is applied to the area of uncultivated land in each of the three agroforestry system designs modelled, which ranges from 3.3% to 10%.

Peatland: The peatland trajectory includes estimates of emissions savings from peatland restoration policies and proposals, technical potential modelling of responsible management measures set to be implemented and estimates for the impact of the imminent end of peat extraction. Emissions savings from peatland restoration measures are calculated using emission factors obtained from a report for Defra and the IUCN Peatland Programme (Evans et al 2022), produced in March 2022. These are applied to the peatland restoration profiles, to be delivered via the Nature for Climate Fund and blended finance (public and private) post 2025 up to 2050, restoring 35,000 hectares of peatlands by 2025 and 280,000 by 2050 (using an interim trajectory in advance of the Peat Restoration Roadmap being developed by Natural England).

The technical potential modelling covers responsible management measures. This is activity that does not seek to re-establish peat habitats, but which significantly reduces the impact of using peatland for its current purpose through raising the water table. The profile for responsible management is interim and will be developed further as recommendations of the Lowland Agricultural Peat Task Force are implemented. A default assumption is made that the water table depth is raised from 39cm from surface to 30cm from the surface on wasted peat (as an interim approach whilst further assessment is made of the mitigation measures for wasted peat). For peat >40cm depth a combination of a range of different water table depths is assumed for the next ten years, the period in which investment in water infrastructure is required to raise the water table. This takes into account the limitations of the current infrastructure for significant rewetting. The emission reductions are estimated using the site-specific methodology proposed in Evans et al 2022.

Resources and Waste: Emissions savings attributed to municipal wastewater policies and proposals use the Carbon Accounting Workbook developed by UK Water Industry Research to estimate operational GHG emissions across the industry. The workbook has been in place since 2004 and is updated annually to reflect the needs of the industry, including changes in carbon accounting practices with updated emission factors to align

[14] Also known as alley-cropping.

with the latest UK and international data. From this, emissions savings for each proposal or policy are then derived. There are still significant gaps in our understanding of the magnitude and main sources of these.

The Water UK Routemap to 2030 sets out industry plans to achieve net zero by 2030[xxxv]. This Routemap has been used as the basis for Defra to develop net zero consistent policies and proposals set out in the Carbon Budget Delivery Plan, such as on wastewater treatment and management, for example, using assumptions from industry on cost and feasibility of policy deployment. Water companies are making concerted efforts to start monitoring and detection of GHG emissions across a range of sites, taking a strategic approach to sampling.

The Methane Emissions from Landfill Model (MELMod) has been used to calculate savings in landfill emissions after the policies and proposals set out in the Carbon Budget Delivery Plan for the near elimination of biodegradable waste from landfill. We have changed our modelling approach from using the Landfill Environmental and Financial Model (LEAF) to using MELMod as it is aligned with the IPCC methodology and is able to calculate emissions from dynamic tonnages to landfill[15]. MELMod is for England only.

F-Gases: The emissions savings attributed to the metered-dose inhalers phasedown and the additional HFC phasedown policies and proposals were estimated through modelling. This primarily used the GB-Level HFC Outlook Model developed by Gluckman Consulting. Non-HFC F-gas emissions are estimated using the DESNZ Energy and Emissions Projections. The level of ambition for metered dose inhalers is derived from the ambition within the NHS report 'Delivering a 'Net Zero' National Health Service' and advice from industry on the likely pace of conversion to low GWP propellants[xxxvi]. Costs were developed using the CCC report 'Assessment of the potential to reduce UK F-gas emissions beyond the ambition of the F-gas Regulation and Kigali Amendment'. Conversion to AR5 without feedback was made against projected mix of F-Gases. Emissions savings are reported for Great Britain as Northern Ireland remains part of the EU F-gas system.

UK Scaling for Natural Resources and Waste policies: Agriculture, forestry and other land use (AFOLU) and waste are fully devolved policy areas. Defra thus projects greenhouse gas emissions reductions in these sectors on an England only basis. From the CCC's advice to the Devolved Administrations and their own carbon plans, it is clear however that action will be necessary and is planned to reduce emissions in these sectors. Given the different stages of development and time horizons of the Devolved Administration's carbon plans, we have taken a simple approach, in line with that taken in the Net Zero Strategy, to produce an initial estimate for emissions savings in these sectors in Scotland, Wales and Northern Ireland. These estimates should not be taken to indicate specific details about Welsh, Northern Irish or Scottish greenhouse gas emissions nor their climate mitigation policies. They are intended as estimates to give a sense of what overall UK savings in these sectors might be. These estimates are presented separately from the England-only policy savings as Devolved Administrations' emissions savings in these sectors are a relatively higher proportion of the UK total, due to differences in natural

[15] MELMod was developed by AEA-Technology under contract to Defra. It is based on previous models developed by AEA (1999), Land Quality Management (2003) and Golder Associates (2005).

environment and land use in different UK nations affecting, for example, the potential for afforestation and peatland restoration.

For agriculture and waste, Devolved Administrations' greenhouse gas emissions are assumed to reduce by the same proportion relative to 2020 levels as Defra's projections for English agricultural greenhouse gas emissions.

For forestry and peat, Devolved Administration afforestation and peatland restoration are assumed to follow the same proportions relative to English afforestation and peatland restoration as used in the CCC's Balanced Net Zero pathway.

Biomass policies are assumed to only be implemented in England, as a conservative assumption.

F-gas emissions savings are modelled for Great Britain only as Northern Ireland remains within the EU F-gas system. Northern Irish F-gas emissions are assumed to reduce by the same proportion relative to 2020 levels as projections for F-gas emissions in Great Britain.

Greenhouse Gas Removals

The engineered removals that have been quantified for the Carbon Budget periods 4-6 include the following technologies: Direct Air Carbon Capture and Storage (DACCS), Power Bioenergy with Carbon Capture and Storage (Power BECCS), Industry BECCS, and BECCS applications based on advanced gasification technologies (Hydrogen generation with waste, Hydrogen generation with biomass). Other engineered removals solutions that have not been quantified for Carbon Budget periods 4-6 include Biofuels, Biogas, and Biomethane generation with CCS as well as enhanced weathering, carbon-negative cements, ocean carbon sequestration and biochar.

The emissions removals quantified for Carbon Budgets 4-6 have been developed through a combination of bottom-up sectoral modelling, which includes models such as NZIP and whole-system modelling (using UKTIMES) to ensure they are consistent with policies and proposals covered by other sectors. The analysis (including build rates, energy demand, and costs) relies on assumptions from published sources on BECCS and DACCS, alongside a benchmarking study commissioned by BEIS (now DESNZ)[xxxvii].The benchmarking study presented evidence based on an original review of the published literature, feedback received through the GGR Call for Evidence and additional stakeholder engagement.[xxxviii]

An investment lead-in time of four years is assumed for power BECCS, and five years for hydrogen BECCS and DACCS. Power and hydrogen generation with BECCS are assumed to operate at baseload. DACCS is assumed to rely on low carbon energy inputs.

The specific deployment pathway of each GGR technology may in reality deviate from this technical assessment, as this will be subject to commercial negotiations. But this technical analysis underpins the overall GGR ambition (at least 5 Mt CO2/yr by 2030) and will inform the design and implementation of policies and business models that aim to achieve this ambition and the overall GGR ambition.

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Wider Analysis

Estimation of Jobs Impacts

1. It is estimated that over 80,000 green jobs across the UK economy are currently being supported – or are in the pipeline as a result of – government policies introduced since November 2020. The figure is based on estimates of number of jobs supported through:

    a. Monitoring and evaluation of government policies,
    b. Applying a jobs multiplier to estimates of capital expenditure for key government policies,
    c. Public announcements of jobs expected to be supported by successful applicants of HMG funding,
    d. Government analysis of supply-chain plans from industry. These plans use their own methodologies and are subject to uncertainty.

2. The estimate includes jobs that have already been delivered and also those that are secured for the future. Delivered jobs represent those that are currently being supported, whereas those secured have been announced and had funding agreed but are not on the ground yet and are expected to materialise later in the decade, in line with policy implementation.

3. Our estimates are intended to illustrate the contribution that government policies since November 2020 have made towards green jobs. They are based on a different methodology and approach to the statistics published by the ONS on the Low Carbon and Renewable Energy Economy which should be used as the official estimate of the total employment in low carbon sectors.

Jobs Advertisement Analysis

4. Experimental analysis has been undertaken to identify green job advertisements across four net zero sectors: electric vehicles, wind, heat and buildings and new and advanced nuclear power. These were selected as they formed the largest sectors identified in the Government's Ten Point Plan for a Green Industrial Revolution. This analysis uses web-scraped online job adverts supplied by LightcastTM, 2023 to provide trend information on the demand across these sectors. The Government will continue to develop this methodology to understand and monitor the jobs and skills associated with the transition to net zero. This section explains the methodology used for the analysis.

Methodological Approach

5. To understand the trends, it is necessary to identify adverts which belong to the chosen green job sectors. There are three steps to developing this methodology: deriving the keyphrases used to define each net zero sector; labelling the data; training the models.

6. Government officials with expertise of each net zero sector produced a list of relevant keyphrases that define them (See Table 1). These were chosen to be specific enough such that if a job advert contains a given keyphrase, then it may belong to that the sector.

Table 1. Keyphrases used to define the four net zero sectors

Sectors	Keyphrases
Electric Vehicles	Battery electric vehicles, Battery technology, Charging infrastructure, Charging point, Electric car, Electric truck, Electric vehicles, Hybrid vehicles, Lithium-ion batteries, Low emission vehicles, Zero emission vehicles
Wind	Array cable, Export cable, Floating wind, Monopile foundation, Offshore wind, Onshore wind, Subsea cable, Turbine blade, Turbine tower, Wind energy, Wind engineer, Wind farm, Wind operator, Wind power, Wind services, Wind technician, Wind turbine
Heat and Buildings	Air source heat pumps, Building energy, Centralised heating, Communal heating, Community heating, Condenser coil, Cooling and ventilation maintenance, Cooling and ventilation upgrade, District heating, District network, Efficient lighting, Energy performance, Evaporator coil, Expansion valve, Geothermal, Ground collectors, Ground source heat pumps, Heat network, Heat pumps, Heat storage technology, Heating maintenance, Heating network, Heating upgrade, Home retrofit, Hydrogen boiler, Insulation, Local heating, Low carbon cooling, Low carbon energy, Low carbon heat, Low embodied carbon material, Other energy efficiency, Other thermal efficiency, Reciprocating compressor, Scroll compressor, Smart controls, Thermal controls, Thermal stage, Waste heat recovery, Water source heat pumps
New and Advanced Nuclear Power	Advanced modular reactor, Generation 3 reactor, Hinkley Point C, Nuclear construction, Nuclear demonstration, Nuclear fusion, Nuclear innovation, Nuclear plant construction, Nuclear research, Sizewell C, Small modular reactor

7. Filtering was applied to the LightcastTM online advert data so that only job descriptions containing these relevant keyphrases were considered for the analysis. The filtering identified an advert as potentially belonging to a sector if it included at least one of the sector’s keyphrases. It is possible that a green job can belong to multiple sectors.

8. For the purposes of this analysis, we define a green job in accordance with the methodology used for the Low Carbon and Renewable Energy Economy Survey

(LCREE) produced by the ONS. Generally speaking, a green job reflects employment in an activity that contributes to protecting or restoring the environment, including those that mitigate against or adapt to climate risks; any job for a company engaged in green sector activities will count – whether it is a wind engineer or an accountant, for example. The analysis looks at green jobs across four of the sub-sectors of the Green Economy defined in the Government's Ten Point Plan for a Green Industrial Revolution.

9. To improve the accuracy for the keyphrase filtering, a sample of 1,000 adverts identified for each of the four sectors were then manually labelled as 'green jobs' or not by Government officials. The labelled data was then used to train four separate machine learning models, one for each sector, that could classify each job as being a green job or not. The models use this sample data to establish an association between distinguishing features of the job description and the sample of correctly labelled jobs. The type of model used was a random forest, with the specification of each model set to ensure high level of accuracy – i.e. a preference was given to ensure high confidence that green jobs were correctly labelled, even if this came at some expense of not capturing every green job.

10. Once this modelled association between job adverts and the correct labelling of a green job has been built, it is then applied to the whole sample of job advertisements. The whole sample captures, for each sector, the application of keyphrase filtering to every online job advertisement gathered by LightcastTM between 2014 and 2022. The sector specific machine learning model was then applied to this sample to extract green jobs more accurately.

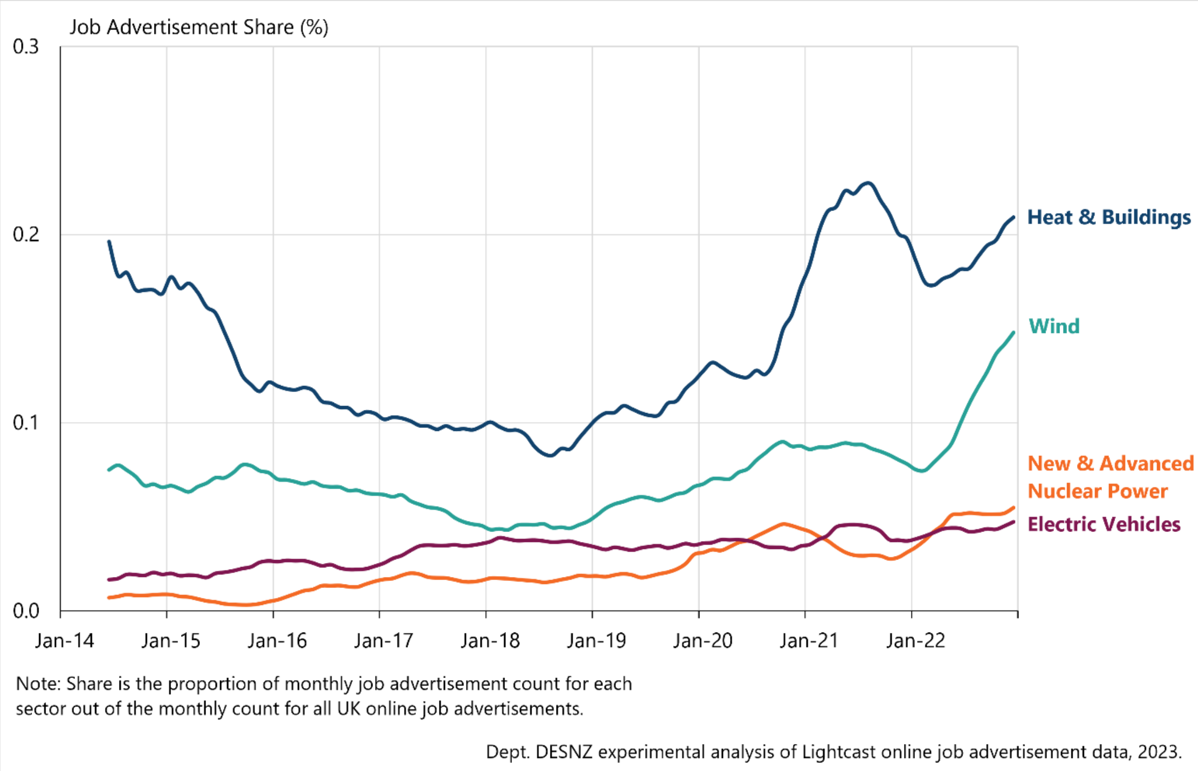
Interpretation of Results

11. This experimental analysis provides insight into the demand for net zero skills in areas of the green economy that are not neatly derived from traditional sectoral classifications. However, the nature of the data and analysis does not allow an estimate of total job counts for the green sectors: LightcastTM data only include adverts that are promoted online and omits other channels; the analysis also takes a probabilistic approach to classify job adverts and, therefore, the number of classified job adverts is dependent on the level of precision selected.

12. Nonetheless, observing the trends, as opposed to the value at one point in time, provides the most reliable insight into the direction of green jobs. A six-month rolling average has been used to smooth the daily LightcastTM data and extract the longer-term trends. Advertisements with missing data for a variable (e.g., salary) cannot be used in the analysis of that variable. To adjust for the evolution LightcastTM data collection processes affecting the volume of adverts sampled, the percentage share is chosen in

figure 1 to indicate whether the sector's job adverts are growing faster or slower than the overall online jobs market.

Figure 1. Share of total online job advertisements, by Net Zero sector, UK, 2014 to 2022



13. The features of the data and choice of methodology behind this experimental analysis carries implications, discussed below, on the type of results produced and their impact.

Working with Lightcast^{TM} Data

14. This analysis uses LightcastTM's web-scraped UK online jobs adverts data which has been acquired by the Department and has been curated internally for analytical use over

a number of years. Any potential biases within LightcastTM data will feed through to the analysis, including the representation of different locations, sectors and types of role.[16]

15. Web-scraping outputs often require cleaning. For example, multiple adverts can be collected which refer to the same role. LightcastTM apply processes to clean the data and reduce double counting, but these may not be 100% effective.

16. As previously noted, the data only captures online job adverts. This means the analysis is based on a proportion of the job adverts published within the UK and will likely under-represent the contribution of green jobs in certain sectors of the economy.

17. Analysis included in this document have been approved by LightcastTM. The Terms and Conditions agreed with LightcastTM prohibit us from publishing any outputs using the data without their prior consent.

18. Not all job adverts include location and salary information. Of those identified as green job adverts, approximately 55% include data on salary, and around 61% include data on location in the form of local authority, 34% have data for both. This means that the salary index chart and local authority maps display about half of the green job adverts extracted.

19. Data from LightcastTM is collated and curated internally for analytical use. The dataset set is constantly updated to host the latest data. Due to these updates, the latest version of the data may differ slightly to when analysis was undertaken.

Features of the Methodological Design

20. The adverts identified through the analysis are highly dependent on the keyphrases used. Any changes in the keyphrases used over the time span will impact the analysis and any unidentified keyphrases for a sector will result in adverts being excluded from the analysis. Not all variation in keywords from alternative word inflections will be captured (e.g. charging points, or charge points), though the pluralisation of terms will be.

21. Not all job adverts captured under the keyphrase filtering will pertain to that sector. Similarly, the use of 'green' phrases in job adverts in an attempt to make a job more attractive can reduce the validity of the methodology. The machine learning model, built using labelled data Government Officials, is applied to increase accuracy by removing those job adverts not within that sector; since this is probabilistic it is not a completely error-proof step in the process.

22. The machine learning model used for this analysis may become less accurate at classifying over time. This could be due to changes or evolution in keyphrases, new emerging trends and words used in the job adverts. The machine learning model was

[16] There are other suppliers of similar online job advertisement data. For example, the ONS recently started to publish online job advert data using data from Adzuna and analysis of labour demand using data from Textkernel.

initially designed to ensure 90% of the job adverts it predicted as green jobs would also be deemed as green jobs by an expert group.

23. As the classification of green jobs for each sector is produced by a separate model, it is possible for the same advert to be identified as belonging to multiple sectors. This would happen if the advert contained keywords relating to a range of sectors.

Additional Notes

24. The different groups of sector experts independently came to varying conclusions on the number of keywords needed to define each sector. The keyphrases used for the new and advanced nuclear power sector are more specific than other sectors in terms of area and programme. This is due to nuclear projects being large in scale but small in frequency. This may lead to the keyphrases not capturing job adverts corresponding to future nuclear projects. Also, the keyphrases focus on the new and advanced nuclear power sector, but the jobs identified may have some overlap with the nuclear defence and decommissioning sector.

25. On a similar note, the keyphrases identified for the wind sector place greater emphasis on the offshore wind sector and lead to an underrepresentation of broader parts of the wind sector, such as onshore wind.

26. Three keyphrases for the new and advanced nuclear power sector were added to the methodology after the machine learning model was trained. This could result in the machine learning model being less accurate than for other studied sectors. However, a manual check of the job adverts classified as green jobs suggest the machine learning model is operating as well as the other sectors.

27. Each job advert in the data is assumed to have an equal weighting towards capturing job totals. Where roles are advertised as part-time, this has the impact of inflating job figures throughout the dataset (both for jobs identified as green or not green).

28. There have been other publications on green jobs, including using job adverts, though it is difficult to compare against results for validation purposes.[17] Results are dependent on the data used, the methodology used and the definition of green jobs. As such, they are likely to differ from other publications on green jobs. The results should be taken in context of the experimental methodology used.

[17] For example, complementary research by the London School of Economics - Sato M, Cass L, Saussay A, Vona F, Mercer L (2023) - reviewing skills and wage gaps in the low carbon transition compares job advert data from the US and UK.

Summary of Progress Against NZS Reporting Commitments

As part of the Net Zero Strategy, we committed to provide a public update on progress against a range of our climate targets and ambitions. The below table shows the quantitative metrics used to report against those commitments where data exists. We have gone beyond those commitments made in the Net Zero Strategy and collated data on other, relevant variables which show progress towards our climate ambition. Where quantitative data does not exist to report against a commitment – as is the case with some emerging technologies – an update on delivery progress can also be found in sector chapters.

As part of our commitment to improve the monitoring and evaluation of our progress towards net zero, we will expand this list to capture more variables of interest in future Progress Reports. This will include collecting data on heat networks and expanding our reporting on the industrial sector.

Table 1: Net Zero Strategy Reporting Commitments

Sector	Ambition set in Net Zero Strategy	Corresponding, Quantitative Metric(s)
Power	By 2035 all our electricity will come from low carbon sources subject to security of supply.	Power generation from low carbon sources (TWh)
		Low carbon power generation as a percentage of total projected generation required in 2035 (GB only)
	Up to 50GW of offshore wind by 2030, including up to 5GW floating wind[18].	Cumulative, installed offshore wind energy capacity (MW)
		Of which floating offshore wind (MW)
	Other related metrics	Emissions intensity of electricity grid (gCO2e/kwh)
Industry[19]	Ambition to deliver 6 MtCO2 per year of industrial CCUS by 2030, and 9 MtCO2 by 2035.	Industry demand for Industrial CCUS – *Please see Carbon Budget Delivery Plan appendix of on Deployment Assumptions for projected performance against this ambition*
Fuel supply and hydrogen	10GW of low carbon hydrogen production capacity by 2030[20].	Low Carbon Hydrogen Production capacity (GW) - *Please see Carbon Budget Delivery Plan appendix of on Deployment Assumptions for projected performance against this ambition*
	Achieve a final decision on whether to enable blending up to 20% hydrogen by volume into the Great Britain gas network by 2023, subject to successful completion of safety trials.	*N/A*

[18] The British Energy Security Strategy increased the ambition set in the Net Zero Strategy for offshore wind from 40GW to 50GW, of which up to 5GW would be floating offshore wind.

[19] HMG is looking at ways in which it can improve the monitoring of decarbonisation policies across the industrial sector, with a view to include that in subsequent progress reports. For industrial carbon capture (ICC), this could include measuring that amount of ICC capacity for which there is a planned ICC project in place. Other metrics under consideration include electricity, hydrogen or bioenergy use across the sector, material substitution, and MtCO2e abated through resource and energy efficiency measures.

[20] The British Energy Security Strategy increased the ambition set in the Net Zero Strategy from 5GW of low carbon hydrogen production by 2030 to 10GW.

Sector	Ambition set in Net Zero Strategy	Corresponding, Quantitative Metric(s)
	The offshore oil and gas sector to have an absolute reduction in production emissions of 10% by 2025, 25% by 2027, and 50% by 2030 on the pathway to net zero by 2050	Percentage change in offshore oil & gas emissions (with respect to 2018 baseline)
Heat and buildings	Aim to reduce direct emissions from public sector buildings by 75% by 2037 compared to 2017.	Percentage reduction in public sector buildings emissions (with respect to 2017 baseline)
	Achieve a minimum market capacity of 600,000 heat pumps per year by 2028.	Annual heat pump installations[21]
	As many homes to reach EPC Band C as possible by 2035, where practical, cost effective, and affordable.	Proportion of homes at EPC C and above (England only)
		Number of homes with minimum EPC C (England only)
	As many fuel poor homes as reasonably practicable to EPC Band C by 2030.	Number of households that have received energy efficiency support (ECO, GHGV, LAD)
Transport	Double cycling from 2013 to 2025	Cycling activity (as percentage of 2013 baseline), England
	Increase walking activity by 2025	Walking activity (as percentage of 2025 target of 365 stages per person per year), England
	Deliver 4,000 new zero emission buses and the infrastructure needed to support them.	Share of buses/coaches first registered per annum that are zero emission
	25% of the government car fleet ultra low emission by December 2022 and 100% of the government car and van fleet zero emission by 2027.	Share of total government car and van fleet that is ultra-low emission[22]

[21] This document reports heat pump sales volumes (as reported in BSRIA, 2022, "Heat Pumps Market Analysis 2021 – United Kingdom") as a proxy for the number of installations. No reliable data source currently collects data on annual heat pump installations in the UK.

[22] Defra will update on the share of government's vehicle fleet which is zero-emission as part of future reporting against HMG's Greening Government commitments.

Sector	Ambition set in Net Zero Strategy	Corresponding, Quantitative Metric(s)
	100% of new cars and vans sold are zero emission by 2035.	Share of cars and vans first registered p.a. that are zero emission
	100% of new HGV sold are zero emission.	Share of HGV first registered p.a. that are zero emission
	100% of new buses/coaches sold are zero emission.	Share of buses and coaches first registered p.a. that are zero emission
	Maximise GHG savings from low carbon fuel use in transport by increasing the Renewable Transport Fuel Obligation main obligation from 9.6% in 2021 to 14.6% in 2032.	*N/A*
	Other related metrics	Number of EV charging points (UK) and number constructed in last year
		Average emissions intensity of new cars sold (gCO2e/km)
		Change in road traffic vs 2019 baseline (%), Great Britain
		Number of rail passenger journeys (millions, GB only)
		Number of passenger journeys on local bus services (millions, GB only)
		MtCO2e emissions from aviation
		MtCO2e emissions from shipping
Natural resources, waste, and F-gases	Restore at least 35,000 ha of peatlands in England by 2025 and approximately 280,000 hectares of peat in England by 2050.	Yearly area of peatland under restoration (ha)
	Increase tree canopy and woodland cover to 16.5% of total land area in England by 2050[23]	Yearly area of afforestation in the UK (ha)

[23] In the Net Zero Strategy, we committed to report against a different target; to increase tree planting rates from 13,660 hectares across the UK in 2020 to 30,000 hectares each year by the end of this Parliament. This has now been superseded by our legally binding commitment to increase tree canopy.

Sector	Ambition set in Net Zero Strategy	Corresponding, Quantitative Metric(s)
	Deliver the UN Sustainable Development Goal 12.3 to halve food waste by 2030.	Biodegradable municipal waste (BMW) sent to landfill (Mt)
	Explore policies to work towards the near elimination of biodegradable municipal waste to landfill by 2028.	Biodegradable municipal waste (BMW) sent to landfill (Mt)
	Meet the Kigali Amendment target of reducing HFC consumption by 85% by 2036, as well as the F-gas Regulation's target of a 79% reduction by 2030.	HFC Consumption (as a % of 2015 use)
	Other related metrics	Recycling rates for waste from households (%)
Greenhouse gas removals	At least 5 MtCO2/yr of engineered removals by 2030.	*N/A*
Aggregate		Total UK greenhouse emissions and by sector (MtCO2e)

Table 2: Quantitative Reporting Against Net Zero Strategy Targets and Associated Metrics[24]

Sector	Metric	2017	2018	2019	2020	2021	2022
Power	Low carbon power generation as a proportion of total projected generation required in 2035[25], Great Britain	29-34%	30-35%	31-35%	32-37%	29-33%	-
Power	Cumulative, installed offshore wind energy capacity (MW)	6,988	8,181	9,888	10,383	11,257	13,928
Power	Of which floating wind energy capacity (MW)	30	30	32	32	80	80
Fuel Supply	Change in offshore oil & gas emissions with respect to 2018 baseline			1.2%	- 8.1%	-20.6%	-
Heat and Buildings	Annual heat pump installations	22,000	26,000	34,000	38,000	55,000	-
Heat and Buildings	Proportion of homes at EPC C and above (England)	30%	34%	40%	46%	47%	-
Heat and Buildings	Number of homes with minimum EPC C (England)	7.2m	8.3m	9.9m	10.9m	11.3m	-
Heat and Buildings	Number of households that have received energy efficiency support, thousands (ECO, GHGV, LAD/HUG[26])	ECO: 168	ECO: 178	ECO: 130	ECO: 154 GHG: 0.7 LAD: 0.2	ECO: 173 GHG: 39 LAD: 11	ECO: 68 GHGV: 0.1 LAD/HUG: 29
Heat and Buildings	Percentage change in public sector buildings emissions with respect to 2017 baseline		1%	1%	-7%	-2%	-

24 All figures are UK-wide unless stated otherwise.

25 Figures are calculated using high and low range estimates of 2035 generation; this metric shows progress to achieving the goal of having all electricity come from low carbon sources in 2035 (subject to security of supply), as such, 100% of all generation should be low carbon in 2035. Although more offshore wind capacity was installed in 2021, unusually low wind levels meant renewable generation was lower than that of 2020.

26 Energy Company Obligation, Green Homes Grant Voucher, and Local Authority Delivery/Home Upgrades Grant schemes.

Sector	Metric	2017	2018	2019	2020	2021	2022
Natural Resources, Waste and F-Gases	Yearly area of peatland under restoration (thousand hectares)		639	448	4,175	1,633	-
Natural Resources, Waste and F-Gases	Yearly area of afforestation in the UK (thousand hectares)	6.53	9.05	13.53	13.68	13.29	-
Natural Resources, Waste and F-Gases	Hydrofluorocarbons (HFC) Consumption (as a percentage of 2015 use)	93%	63%	63%	63%	45%	45%
Natural Resources, Waste and F-Gases	Recycling rates for waste from households (%)	45%	45%	46%	44%	-	-
Natural Resources, Waste and F-Gases	Biodegradable municipal waste (BMW) sent to landfill (thousand tonnes), England	5,684	5,598	5,418	4,916	-	-
Transport	Share of cars first registered in the UK p.a. that are zero emission	0.54%	0.66%	1.62%	6.52%	11.35 %	-
Transport	Share of light goods vehicles first registered in the UK p.a. that are zero emission	0.35%	0.42%	0.93%	1.89%	3.59%	-
Transport	Share of total government car and van fleet that is ultra-low emission[27]			8%	13%	18%	25.5%[28]
Transport	Share of Heavy Goods Vehicles first registered in the UK p.a. that are zero emission	0.01%	0.03%	0.05%	0.05%	0.36%	-
Transport	Share of buses and coaches first registered in the UK p.a. that are zero emission	0.50%	1.11 %	1.70 %	6.11 %	12.27 %	-
Transport	Number of EV charging devices, UK	-	-	16,505	20,775	28,375	37,055

[27] For years beginning in April and running to end March the following year.
[28] Final figure may be higher for the financial year.

Sector	Metric	2017	2018	2019	2020	2021	2022
Transport	Average emissions of cars registered for the first time by year (gCO2e/km)	-	-	152.0	133.6	118.5	
Transport	Road traffic (as a proportion of 2019 baseline), Great Britain	98%	99%	100%	79%	88%	-
Transport	Number of rail passenger journeys (millions, GB only)[29]	1,704	1,753	1,739	388	990	-
Transport	Number of passenger journeys on local bus services (millions, GB only)[30]	4,832	4,779	4,523	1,731	3,126	-
Transport	Cycling activity (as percentage increase from a 2013 baseline), England	20%	22%	17%	45%	6%	-
Transport	Walking activity (as percentage of 2025 target of 365 stages per person per year), England	94%	95%	91%	77%	76%	-
Transport	Cycling activity (as percentage increase from a 2013 baseline), England	20%	22%	17%	45%	6%	
Transport	Walking activity (as percentage of 2025 target of 365 stages per person per year), England	94.0%	95%	91%	77%	76%	

Table 3: UK Net Territorial Greenhouse Gas Emissions by NZS sector (MtCO2e)

Sector	1990	2017	2018	2019	2020	2021
Power	*204.0*	*72.0*	*65.7*	*57.7*	*49.4*	*54.2*
Industry	*160.4*	*81.4*	*79.6*	*78.4*	*74.4*	*76.4*

[29] For years beginning in April and running to end March the following year. In 2020, the coronavirus (COVID-19) pandemic led to an unprecedented number of season ticket refund claims. This required the use of an alternative methodology to estimate season and other ticket usage for the financial year Apr 2020 to Mar 2021. As a result, there is more uncertainty around these estimates than in other years.

[30] For years beginning in April and running to end March the following year.

Sector	**1990**	**2017**	**2018**	**2019**	**2020**	**2021**
Fuel Supply	*59.3*	*24.6*	*24.3*	*24.4*	*22.5*	*20.0*
Buildings	*108.7*	*84.2*	*86.5*	*84.0*	*82.3*	*87.9*
Agriculture & LULUCF	*65.5*	*49.8*	*49.7*	*49.8*	*47.8*	*49.0*
Waste & F-gases	*86.9*	*34.4*	*34.0*	*33.1*	*30.6*	*29.6*
Domestic Transport	*128.6*	*126.7*	*125.0*	*123.1*	*99.3*	*109.5*
IAS	*23.6*	*44.1*	*44.5*	*44.1*	*20.9*	*19.5*
Total territorial emissions (excluding IAS)	***813.4***	***473.2***	***464.8***	***450.4***	***406.3***	***426.5***

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