# Annex B: Carbon budgets analytical annex

## Contents

## Note on methodology

All analysis presented in this annex is consistent with the methodology laid out in Department of Energy and Climate Change/HM Treasury Green Book guidance on the appraisal of emissions impacts.[1]

Energy and emissions savings have been valued using an updated set of fossil fuel[2] and carbon values[3] consistent with the Department of Energy and Climate Change's Updated Energy and Emissions Projections baseline,[4] all of which were published in October 2011. An interim set of energy prices was used to value changes in energy use. Further details on the appraisal approach are set out in relevant sections throughout this annex.

[1] DECC (2010) *Valuation of Energy Use and Greenhouse Gas Emissions for Policy Appraisal and Evaluation*. Available at: www.decc.gov.uk/assets/decc/statistics/analysis_group/122-valuationenergyuseggemissions.pdf

[2] DECC (2011) *DECC fossil fuel price projections*. Available at: www.decc.gov.uk/en/content/cms/about/ec_social_res/analytic_projs/ff_prices/ff_prices.aspx

[3] DECC (2011) *Update Short Term Traded Carbon Values for UK Public Policy Appraisal*. Available at: www.decc.gov.uk/assets/decc/11/cutting-emissions/carbon-valuation/3137-update-short-term-traded-carbon-values-uk.pdf

[4] DECC (2011) Updated Energy and Emissions Projections 2011. Available at: www.decc.gov.uk/assets/decc/11/about-us/economics-social-research/3134-updated-energy-and-emissions-projections-october.pdf

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# B1. Carbon budget levels and the net UK carbon account

## Legislated carbon budgets

B1.1 The first three legislated carbon budgets are consistent with the UK's share of the current European Union (EU) target to reduce emissions by 20% below 1990 levels by 2020. There is a commitment to tighten the second and third carbon budget levels following an EU move to a more stringent 2020 emissions target.

B1.2 In June 2011, the Government set in legislation the fourth carbon budget at the level recommended by the Committee on Climate Change (CCC),[5] 1,950 million tonnes of $CO_2$ equivalent ($MtCO_2e$), equivalent to a 50% reduction below the 1990 baseline. See the Impact Assessment accompanying that decision for details of the evidence base for setting the level of the fourth carbon budget.[6]

## Scope of the UK carbon budgets and the net UK carbon account

B1.3 **The UK's performance against its legislated carbon budgets is assessed relative to the net UK carbon account** (section 27 of the Climate Change Act 2008[7]). The net UK carbon account:

- includes emissions from the UK (not including Crown Dependencies and UK Overseas Territories) of the 'Kyoto basket' of greenhouses gases (GHGs) which includes all carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride ($SF_6$) emissions;
- includes net emissions/removals[8] from land use, land use change and forestry (LULUCF); and
- is net of the purchase and sale of international carbon units. Carbon units include allowances issued under cap and trade systems, such as the EU Emissions Trading System (ETS) (see below), and international carbon units representing developing country emissions reductions issued under the Clean Development Mechanism.[9]

Table B1: UK's legislated carbon budgets ($MtCO_2e$)

| | First carbon budget (2008–12) | Second carbon budget (2013–17) | Third carbon budget (2018–22) | Fourth carbon budget (2023–27) |
|---|---|---|---|---|
| **Legislated budgets[10]** | **3,018** | **2,782** | **2,544** | **1,950** |
| of which traded | 1,233 | 1,078 | 985 | 690 |
| of which non-traded | 1,785 | 1,704 | 1,559 | 1,260 |
| **Average annual percentage reduction from 1990[11]** | **23%** | **29%** | **35%** | **50%** |

[5] CCC (2010) *The Fourth Carbon Budget: Reducing emissions through the 2020s*. Available at: www.theccc.org.uk/reports/fourth-carbon-budget

[6] DECC (2011) *Impact Assessment of Fourth Carbon Budget Level*. Available at: www.decc.gov.uk/assets/decc/what%20we%20do/a%20low%20carbon%20uk/carbon%20budgets/1685-ia-fourth-carbon-budget-level.pdf

[7] www.legislation.gov.uk/ukpga/2008/27/contents

[8] In this context, 'removals' refers to where emissions are taken out of the atmosphere. See box B1 on page 145 for further details.

[9] Under the Clean Development Mechanism, emissions reduction projects in developing countries can earn Certified Emissions Reduction credits. These credits can be used by countries to meet a part of their emissions reduction targets under the Kyoto Protocol, or to meet targets under domestic legislation.

[10] Assumed share for the second and third carbon budgets, based on the best estimate of the UK share of an EU 20% reduction target when the first three carbon budgets were legislated in 2009.

[11] These percentages have changed since 2009 when legislated and quoted in the Low Carbon Transition Plan (DECC (2009) *The UK Low Carbon Transition Plan*. Available at: www.decc.gov.uk/en/content/cms/tackling/carbon_plan/lctp/:aspx) owing to an update in the *National Greenhouse Gas Inventory* which revised total 1990 baseline UK GHG emissions from 777.4 $MtCO_2e$ to 783.1 $MtCO_2e$. This number is the denominator in this calculation, hence while the budget levels (in $MtCO_2e$) have not changed, the 1990 baseline and percentage reductions have.

B1.4 Each carbon budget sets a maximum level for the total net UK carbon account over a five-year period, in tonnes of carbon dioxide equivalent ($tCO_2e$). The first four carbon budgets are set out in table B1. More information on the net UK carbon account and carbon accounting rules can be found on the Department of Energy and Climate Change website.[12]

B1.5 The Climate Change Act 2008, and therefore by definition the net UK carbon account, currently excludes emissions from international aviation and shipping. The Act requires the Government, by the end of 2012, either to make regulations to specify the circumstances in which, and the extent to which, emissions from international aviation or international shipping[13] are to be included in carbon budgets and the 2050 target, or to lay before Parliament a report explaining why such regulations have not been made.[14] This decision will need to be considered alongside development through 2012/13 of the UK's sustainable aviation policy framework, which will also consider whether to adopt the previous administration's 2050 aviation $CO_2$ target.

## The European Union Emissions Trading System

B1.6 The EU ETS covers direct emissions from power generation and heavy industry (and aviation from 2012) and sets a cap at the EU level for these emissions. In the UK this represents around 40%[15] of emissions (referred to as the traded sector). For the purposes of calculating the net UK carbon account, emissions in the traded sector are taken to be equal to the UK's share of the EU ETS cap. While there is volatility in the level of UK territorial emissions, driven by variables such as the carbon price and fossil fuel prices, there is near certainty over the traded sector share of the net UK carbon account, which derives from the established level of the EU ETS cap.[16]

B1.7 The UK share of the EU ETS cap is the sum of the allowances allocated for free to UK installations[17] covered by the EU ETS and the UK's share of auctioned allowances. Once negotiated, this share of the fixed cap is relatively stable.[18] This certainty over the traded sector component of the net UK carbon account provides a significant advantage in managing carbon budgets, and the EU ETS is an important instrument for guaranteeing emissions reductions.

B1.8 The overall environmental outcome (total EU-wide emissions from the traded sector) is fixed, although the level of territorial emissions in the UK or any other EU Member State may vary.

- If the UK went further and reduced territorial emissions below the UK share of the EU ETS cap, this would not lead to an additional reduction in global emissions. Going further would, in the absence of other measures, result in a net outflow of allowances from the UK, increasing the availability of allowances to

[12] DECC (2009) *Guidance on Carbon Accounting and the Net UK Carbon Account*. Available at: www.decc.gov.uk/en/content/cms/what_we_do/lc_uk/carbon_budgets/carbon_budgets.aspx

[13] Note that international aviation emissions associated with all flights arriving at and departing from European Economic Area (EEA) airports will be included in the EU ETS from 2012. The European Commission is also encouraged, by recitals in Directive 2009/29/EC and Decision 406/2009/EC, to introduce legislation to limit international maritime emissions, in the event that a global agreement has not been reached in the International Maritime Organization or United Nations Framework Convention on Climate Change by the end of 2011.

[14] Climate Change Act 2008, section 30.

[15] On average over the first three carbon budgets.

[16] The Government has informed UK installations of their provisional levels of free allocation for Phase III (2013–20), although these are not yet finalised. Exact levels of free allocation for each installation will not be known until the Commission publishes details of the level of the cross-sectoral correction factor (in 2012). At the same time, we expect the Commission to publish figures on the number of allowances each Member State will receive to auction. Some uncertainty will remain over the extent to which UK installations have access to the New Entrants' Reserve or have their free allocation reduced as a result of closures. The latter will also affect the number of allowances to auction that the UK receives and this uncertainty will not be reduced until the end of the trading period.

[17] For the purposes of carbon budgets, this includes all allowances received by static installations located in the UK along with a proportion of aviation allowances which correspond to UK domestic aviation.

[18] It varies only with small changes to the distribution of allowances resulting from closures and new entrants to the system, and current uncertainty associated with the level of free allocation each installation is likely to receive. This will not be known until after all Member States have submitted their National Implementation Measures (NIMs) Plan, which is likely to be in early 2012.

installations outside the UK, whose emissions could increase within the overall EU ETS cap. The net UK carbon account would be unchanged because the increased export of allowances from the UK would cancel out the reduction in UK territorial emissions.

- Likewise, if UK territorial emissions exceed the UK share of the cap, then compliance requires that UK installations covered by the scheme purchase allowances from other installations with a surplus in other Member States, or (subject to strictly defined limits) international offset credits.

## Baseline emissions levels and the 2050 target

B1.9 The baseline level of UK greenhouse gas (GHG) emissions in 1990 from which the emissions reduction targets in the Climate Change Act 2008 are referenced is 783.1 $MtCO_2e$. This is referred to as 'the 1990 baseline' and consists of net UK emissions in 1990 for $CO_2$, methane and nitrous oxide GHGs, and 1995 for fluorinated gases (as recorded in the latest GHG emissions inventory[19] and calculated according to the latest international reporting practice as required by the Act).

B1.10 The long-term target set out in the Climate Change Act, to reduce emissions levels by at least 80% below the 1990 baseline, would therefore require the net UK carbon account to decline to at most 156.6 $MtCO_2e$ by 2050.

# B2. Meeting carbon budgets

## Progress against the first three carbon budgets

B2.1 The provisional emissions estimates for 2010[20] published in early 2011 show that the net UK carbon account (which includes the impact of emissions trading) increased by 1.8% to 585.6 $MtCO_2e$ in 2010 from 575.4 $MtCO_2e$ in 2009.[21] This increase in emissions resulted primarily from a rise in residential gas use related to the fact that 2010 was, on average, the coldest year since 1986.

B2.2 The net UK carbon account in 2010 was 25.2% below 1990 levels. The first carbon budget requires that total UK GHG emissions do not exceed 3,018 $MtCO_2e$ over the five-year period 2008–12, which is approximately 23% below the 1990 level, on average, over the period.

B2.3 Table B2 summarises the UK's progress towards meeting the first carbon budget by comparing the average emissions per annum required to meet the budget with the average emissions to date in the first budgetary period.

[19] DECC (2011) UK Greenhouse Gas Inventory. Available at: www.decc.gov.uk/en/content/cms/statistics/climate_change/gg_emissions/uk_emissions/2009_final/2009_final.aspx

[20] Please note that territorial emissions and the net UK carbon account estimate for 2010 are provisional and may be subject to change. More details on the provisional emissions figures for 2010 can be found at: www.decc.gov.uk/en/content/cms/statistics/climate_stats/gg_emissions/uk_emissions/2010_prov/2010_prov.aspx

[21] Territorial emissions which exclude the impact of trading within the EU ETS increased by 2.9% to 577.9 $MtCO_2e$ from 561.8 $MtCO_2e$ in 2009.

Table B2: Actual emissions against the first carbon budget ($MtCO_2e$)

| First carbon budget | | Actual emissions including EU ETS $MtCO_2e$ | | | | | Average emissions p.a. required in 2011/12 to meet budget |
|---|---|---|---|---|---|---|---|
| Total emissions (2008–12) | Equivalent average emissions p.a. | 2008 | 2009 | 2010 (p) | Cumulative emissions to date (2008–10) | Average emissions p.a. (2008–10) | |
| 3,018 | 604 | 597 | 575 | 586 | 1,758 | 586 | 630 |

B2.4 Emissions have averaged 586 $MtCO_2e$ over the course of 2008–10, which means that emissions in the remaining two years would have to exceed 630 $MtCO_2e$ per annum in order to miss the first budget. The latest emissions projections suggest that the UK will be comfortably below this level during the remaining two years.

## Future projections

B2.5 The Department of Energy and Climate Change's Updated Energy and Emissions Projections,[22] published in October 2011, provide forecasts for UK emissions over the short and medium term and are an essential tool for tracking progress and risks towards meeting the carbon budgets.

### Box B1: The Department of Energy and Climate Change's emissions projections

**The Department of Energy and Climate Change's energy and emissions model** projects energy demand using econometric equations of the interaction between supply and demand for each sub-sector of the economy, models of the UK energy market, various assumptions on the key external drivers of energy demand (i.e. expectations of future GDP growth, international fossil fuel prices, carbon prices and UK population) and the impacts of government policies.

The input data and assumptions in the model are subject to uncertainty. For example:

- the exogenous inputs (GDP, fossil fuel prices and UK population growth) are all subject to their own assumptions and levels of uncertainty about what the actual level may be in the future;
- expected policy savings are uncertain – numerous factors can affect whether policies will deliver as expected; and
- the parameters in the model are uncertain, particularly in the longer run. For example, the energy demand responses to prices and output are estimated from analysis of past data trends.

The model is calibrated to the 2009 UK Greenhouse Gas Inventory and the latest available Digest of United Kingdom Energy Statistics (DUKES) data, the former is currently based on 2009 levels (published February 2011, the latest available to carry out this modelling exercise).

[22] For full details of these projections, see DECC (2011) Updated Energy and Emissions Projections 2011. Available at: www.decc.gov.uk/assets/decc/11/about-us/economics-social-research/3134-updated-energy-and-emissions-projections-october.pdf

**Box B1: The Department of Energy and Climate Change's emissions projections *(continued)***

**The Department of Energy and Climate Change's non-$CO_2$ GHG projections** use the methodologies set out in the Greenhouse Gas Inventory report.[23] Projections are calculated using forecast activity statistics, emissions factors and various other sector specific assumptions for each of the main sources of emissions. GHG emissions projections are calculated by sector and aggregated to provide an estimate of total projected emissions. The projections system is designed to be transparent, flexible and easy to update.

**The Department of Energy and Climate Change's LULUCF projections** cover $CO_2$ emissions from forestry, crop and grassland management, and other land uses. It is the only sector where $CO_2$ can be removed from the atmosphere (through photosynthesis). LULUCF can therefore show net emissions, net removals or zero change, if emissions and removals are in balance. Projections are estimated by the Centre for Ecology and Hydrology[24] under contract to the Department of Energy and Climate Change, using methods consistent with the UK Greenhouse Gas Inventory, coupled with projections of future land use and land use change, based on what has happened historically and possible future scenarios. The LULUCF projections have recently been revised to reflect the latest survey and inventory data available.[25]

**Monte Carlo simulation** is used in all three areas of emissions projections to take account of the uncertainty inherent in the range of input assumptions necessary to produce these projections.

B2.6 These projections suggest that the UK is on track to meet its first three legislated carbon budgets with current planned policies. By 2020, the UK is forecast to reduce net UK emissions by 38% from 1990. Territorial emissions over the first three carbon budgets are expected to be 2,877, 2,604 and 2,322 $MtCO_2e$ respectively, while the net UK carbon account is expected to be 2,922, 2,650 and 2,457 $MtCO_2e$ respectively (see table B3). We therefore expect, on central projections, to reduce emissions to below the level of the first three carbon budgets. This means that the UK is expected to exceed the first three carbon budgets by 96, 132 and 87 $MtCO_2e$ respectively.

B2.7 In respect of the fourth carbon budget, the Department of Energy and Climate Change's emissions projections set the baseline against which to assess the level of additional abatement required to reach the fourth carbon budget. UK territorial emissions are projected to be 2,207 $MtCO_2e$ over the fourth budget period (average of 441.4 $MtCO_2e$ per annum). This represents a 43.6% emissions reduction on average over the budget period relative to 1990 levels.

B2.8 In the traded sector, the UK's level of emissions over the fourth budget period will be dictated by the UK's share of the EU ETS cap over the period. However, there is uncertainty about the level of ambition of the EU ETS, and the UK's share of the cap, beyond 2020. Analysis suggests that the UK's share of the assumed cap could be between 590 and 860 $MtCO_2e$ over the period, depending on the level of ambition to reduce emissions leading up to the period, and the methodology for determining the UK's share. The fourth budget was set assuming that the UK's traded sector cap would be at 690 $MtCO_2e$ over the period.[26]

B2.9 The UK's net carbon account, assuming a cap on traded sector emissions of 690 $MtCO_2e$, is projected to be 2,131 $MtCO_2e$ over the fourth carbon budget (426 $MtCO_2e$ per annum). This represents a reduction in emissions of around 46% relative to 1990 levels.

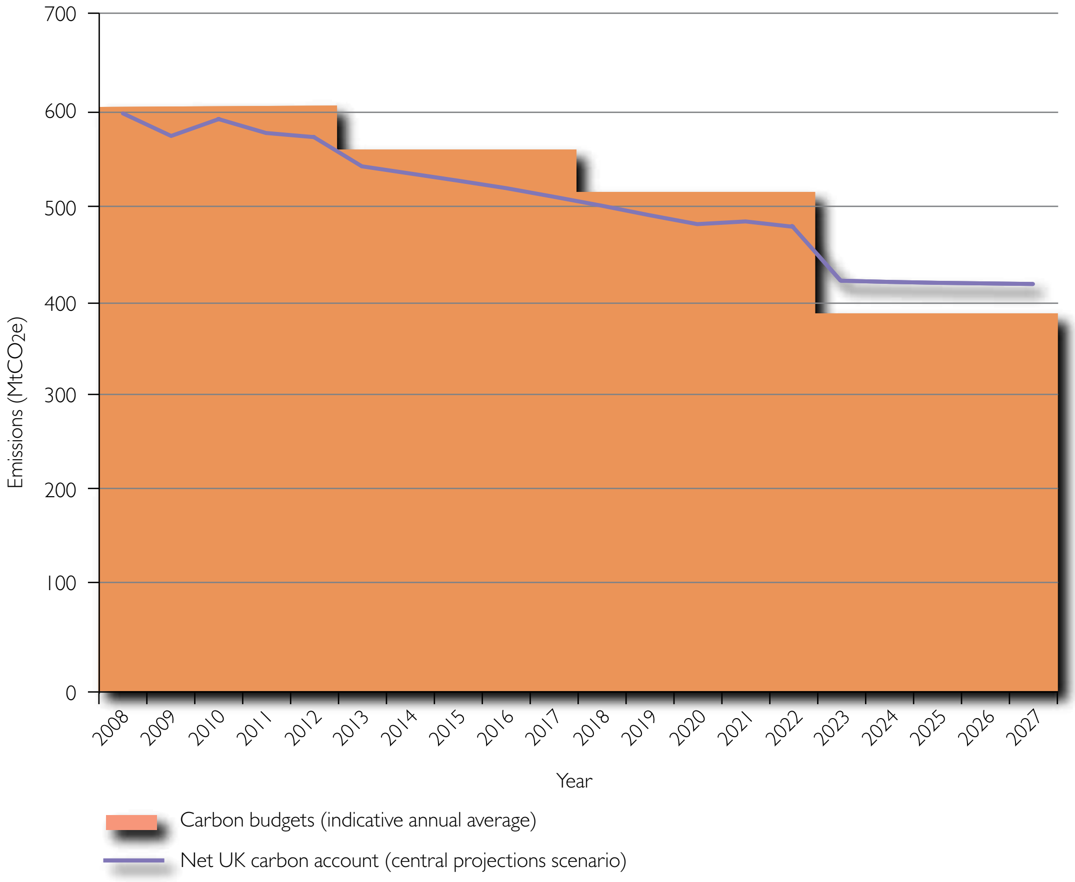
[23] AEA (2011) *National Inventory Report*. Available at: http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/5888.php

[24] Available at: www.ceh.ac.uk

[25] DECC (2011) *Non-$CO_2$ Land and Land Use Change and Forestry (LULUCF) GHG emissions projections summary tables*. Available at: www.decc.gov.uk/en/content/cms/about/ec_social_res/analytic_projs/en_emis_projs/en_emis_projs.aspx

[26] In line with the CCC's recommendation. See footnotes 5 and 6.

Chart B1: Historic and projected net UK carbon account, 2008–27 ($MtCO_2e$)




Source: DECC energy model $CO_2$ energy projections, non-$CO_2$ GHG projections and LULUCF projections

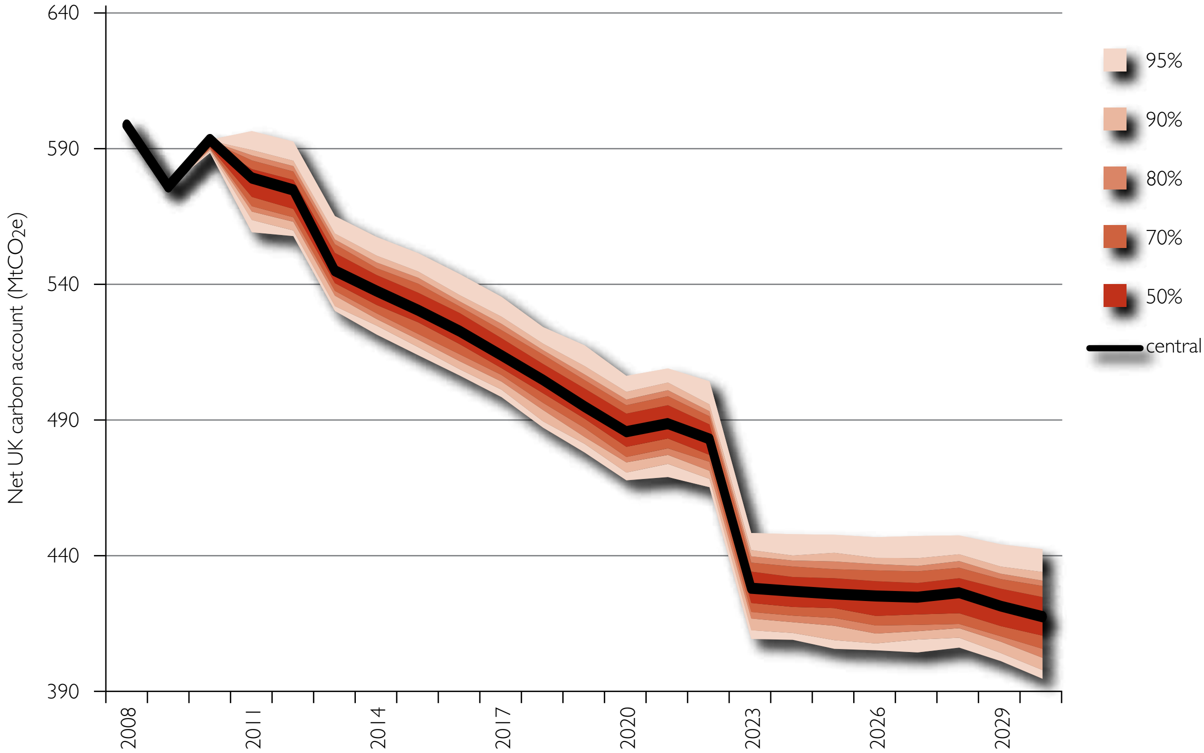
B2.10 On a net UK carbon account basis, the shortfall to the fourth budget of 1,950 $MtCO_2e$ is therefore projected to be around 181 $MtCO_2e$ over the fourth budget period. This incorporates a significant legacy of impacts from the current policy package over the fourth carbon budget.

## Uncertainty around projections

B2.11 Projections of emissions levels are inherently uncertain as they depend upon projected future levels of a number of key factors, including economic and population growth and fossil fuel prices. The Department of Energy and Climate Change's emissions projections capture some of this uncertainty through the use of Monte Carlo simulations, using assumed distributions of the levels of the key variables to provide a range of outcomes. This analysis provides an indication of the impact of uncertainty in fossil fuel prices, economic growth, temperature, policy delivery, power station capital costs, non-$CO_2$ GHG emissions and LULUCF emissions and removals.[27] Chart B2 reflects the range of uncertainty around net UK carbon account projections.

[27] This does not account for all sources of uncertainty. In particular, uncertainties over the modelling parameters, which will increase over time, are only partially reflected. The emissions projections also do not attempt to take account of climate science uncertainty.

## Chart B2: Indicative uncertainty around the net UK carbon account projections, 2008–30 ($MtCO_2e$)[28]




Source: DECC energy model $CO_2$ energy projections, non-$CO_2$ GHG projections and LULUCF projections

B2.12 Table B3 below provides the Department of Energy and Climate Change's latest emissions projections for the net UK carbon account for the first four carbon budgets, and the projected over-achievement margins under central, low and high modelled uncertainty ranges.

## Table B3: Projected performance against carbon budgets 1 to 4 ($MtCO_2e$)

| | Carbon budget 1 (2008–12) | Carbon budget 2 (2013–17) | Carbon budget 3 (2018–22) | Carbon budget 4[28] (2023–27) |
|---|---|---|---|---|
| Legislated carbon budgets | 3,018 | 2,782 | 2,544 | 1,950 |
| Territorial emissions | 2,877 | 2,604 | 2,322 | 2,207 |
| Net UK carbon account | 2,922 | 2,650 | 2,457 | 2,131 |
| Projected performance against carbon budgets (negative implies emissions under budget) | −96 | −132 | −87 | 181 |
| Uncertainty range (high to low emissions projections) | −73 to −124 | −73 to −172 | −19 to −142 | 250 to 117 |

Source: DECC energy model $CO_2$ energy projections, non-$CO_2$ GHG projections and LULUCF projections

[28] The projected performance against the fourth carbon budget assumes an EU ETS cap of 690 $MtCO_2e$ from 2023.

## Annual indicative range

B2.13 Section 12 of the Climate Change Act 2008 requires the Government to publish, as soon as possible after making an Order setting a carbon budget, an indicative annual range for the net UK carbon account for each year within the period. An indicative annual range in relation to a year is a range within which the Secretary of State expects the amount of the net UK carbon account for the year to fall. The annual indicative range for the first three carbon budgets was set in July 2009. Table B4 shows these ranges, to reflect the latest data and updated projections, along with the annual indicative range for the fourth carbon budget.

**Table B4: Indicative annual uncertainty range for the net UK carbon account projections, 2008–27 ($MtCO_2e$)[29]**

| | Carbon budget 1 | | | | | Carbon budget 2 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Net UK carbon account projections ($MtCO_2e$) | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
| Upper bound | 599 | 576 | 593 | 596 | 593 | 565 | 557 | 552 | 544 | 535 |
| Central | 599 | 576 | 593 | 579 | 575 | 545 | 538 | 531 | 523 | 514 |
| Lower bound | 599 | 576 | 593 | 559 | 558 | 530 | 522 | 514 | 506 | 498 |

| | Carbon budget 3 | | | | | Carbon budget 4 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Net UK carbon account projections ($MtCO_2e$) | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 |
| Upper bound | 524 | 518 | 506 | 509 | 504 | 449 | 448 | 448 | 447 | 447 |
| Central | 505 | 495 | 486 | 489 | 483 | 428 | 427 | 426 | 425 | 425 |
| Lower bound | 487 | 478 | 468 | 469 | 465 | 409 | 409 | 406 | 405 | 405 |

Source: DECC energy model $CO_2$ energy projections, non-$CO_2$ GHG projections and LULUCF projections

## Carbon budgets management

B2.14 The uncertainty inherent in emissions projections means that the Government cannot rely on central estimates alone to demonstrate that the UK is on track to meet carbon budgets. There are a number of things which the Government is doing to ensure that the UK remains on track.

B2.15 First, the EU ETS, which covers emissions from the power generation and industrial sectors, effectively eliminates uncertainty in these sectors as emissions are capped and, for carbon budget accounting purposes, the traded sector contribution to the net UK carbon account is equal to the UK's share of the EU ETS cap (rather than territorial emissions). On this basis the UK cannot under- or over-perform on its traded sector share of the carbon budgets. Given that this represents around 40% of the UK carbon account, the EU ETS is an important instrument for guaranteeing net emissions reductions.

B2.16 In the remaining non-EU ETS sectors there are a number of ways in which the Government is working to increase confidence that the budgets will be met:

[29] The tables show the indicative annual uncertainty around the net UK carbon account. For the fourth carbon budget, an EU ETS cap of 690 $MtCO_2e$ is assumed. The upper and lower bounds represent the 95% confidence interval.

- the surpluses projected (on the central scenario) in each budget period provide a contingency reserve that will offer some resilience to unexpected events, such as higher than anticipated emissions driven by fossil fuel prices that are significantly lower than assumed in our central scenario;
- the Climate Change Act 2008 provides the flexibility to bank over-achievement across carbon budget periods or undertake limited borrowing (constrained at 1%) from the next budget. This increases the contingency to cope with unanticipated increases in emissions;
- the Government is continuing to explore new, cost effective policy options to further reduce emissions in a variety of areas over the first three budget periods, e.g. ways to help small businesses to save carbon; and
- the Government recognises the importance of placing the UK on an appropriate pathway to meet its longer-term carbon targets and it aims to meet the first four carbon budgets through domestic action. However, the Government also recognises the benefits of international offsets in allowing emissions reductions to occur where they are least costly and as a mechanism to help decarbonise developing economies. Consequently, purchasing international credits to offset UK emissions remains an option, although a limit must be set for each budgetary period. The limits for the first and second carbon budget periods are zero and 55 $MtCO_2e$ (outside the EU ETS) respectively.

# Policy savings

B2.17 The emissions projections take into account the estimated impact of government policies and proposals announced to date. Re-evaluations of policies are made periodically and, where appropriate, savings are adjusted and reflected in the emissions projections. See box B2 overleaf for details on appraisal methodology.

## Box B2: Greenhouse gas appraisal guidance

Valuing energy use and GHGs is vital to ensure that the Government takes full account of climate change and energy impacts when appraising and evaluating public policies and projects. In consultation with analysts across government, the Department of Energy and Climate Change and HM Treasury have jointly produced supplementary guidance to the HM Treasury Green Book that provides government analysts with a set of rules for valuing energy use and emissions.[30] The guidance helps the appraisal and evaluation of proposals leading to an increase or reduction in energy use and/or GHG emissions in the UK. It covers proposals that have a direct impact on energy use and supply and those with an indirect impact through planning, construction, land use change or the introduction of new products that use energy.

Moreover, it helps analysts to quantify the carbon impacts of their policies and to value significant impacts using the revised carbon valuation methodology (July 2009),[31] as required by the revised Impact Assessment guidelines[32] of the Better Regulation Executive (BRE). There is also a complementary spreadsheet calculation 'toolkit' designed to convert increases or decreases in energy consumption into changes in GHG emissions and to value the changes in both emissions and energy use.[33] This spreadsheet also contains the latest assumptions for carbon values, energy prices, long run variable energy supply costs, emissions factors and air quality damage costs to be used in UK policy appraisal.

### Avoiding double counting of emissions savings

Monitoring overall progress against legislated carbon budgets requires precise and robust projections of emissions savings from a package of policies and an assessment of their combined, aggregated effectiveness.

The primary purpose of the aggregation is to show the total costs, benefits and impacts of the package of policies and proposals to meet the carbon budgets. In this respect, it is important to avoid the 'double counting' of energy and GHG emissions impacts when assessing the combined, aggregated effectiveness of a package of policies. Emissions savings from policies have been sequenced with respect to the following criteria: permanency; bindingness; cost effectiveness; timing of implementation; and pragmatism. This means that emissions impacts vary from those set out in individual Impact Assessments which analyse policies on a purely chronological basis in order to identify the marginal impact of their introduction.

30 DECC and HM Treasury (2010) *Valuation of Energy Use and Greenhouse Gas Emissions for Policy Appraisal and Valuation*. Available at: www.decc.gov.uk/assets/decc/statistics/analysis_group/122-valuationenergyuseggemissions.pdf

31 DECC (2009) *Carbon Valuation in UK Policy Appraisal: A Revised Approach*. Available at: www.decc.gov.uk/en/content/cms/emissions/valuation/valuation.aspx

32 See: www.berr.gov.uk/whatwedo/bre/index.html

33 See: www.decc.gov.uk/en/content/cms/about/ec_social_res/iag_guidance/iag_guidance.aspx

B2.18 As set out above, the Department of Energy and Climate Change's Updated Energy and Emissions Projections indicate that current policies are projected to over-achieve against the first three carbon budgets and will continue to deliver savings over the fourth carbon budget (see chart B3 below). See tables B25 to B28 for full details on the emissions savings delivered by individual policies.

## Aggregate costs of the current policy package

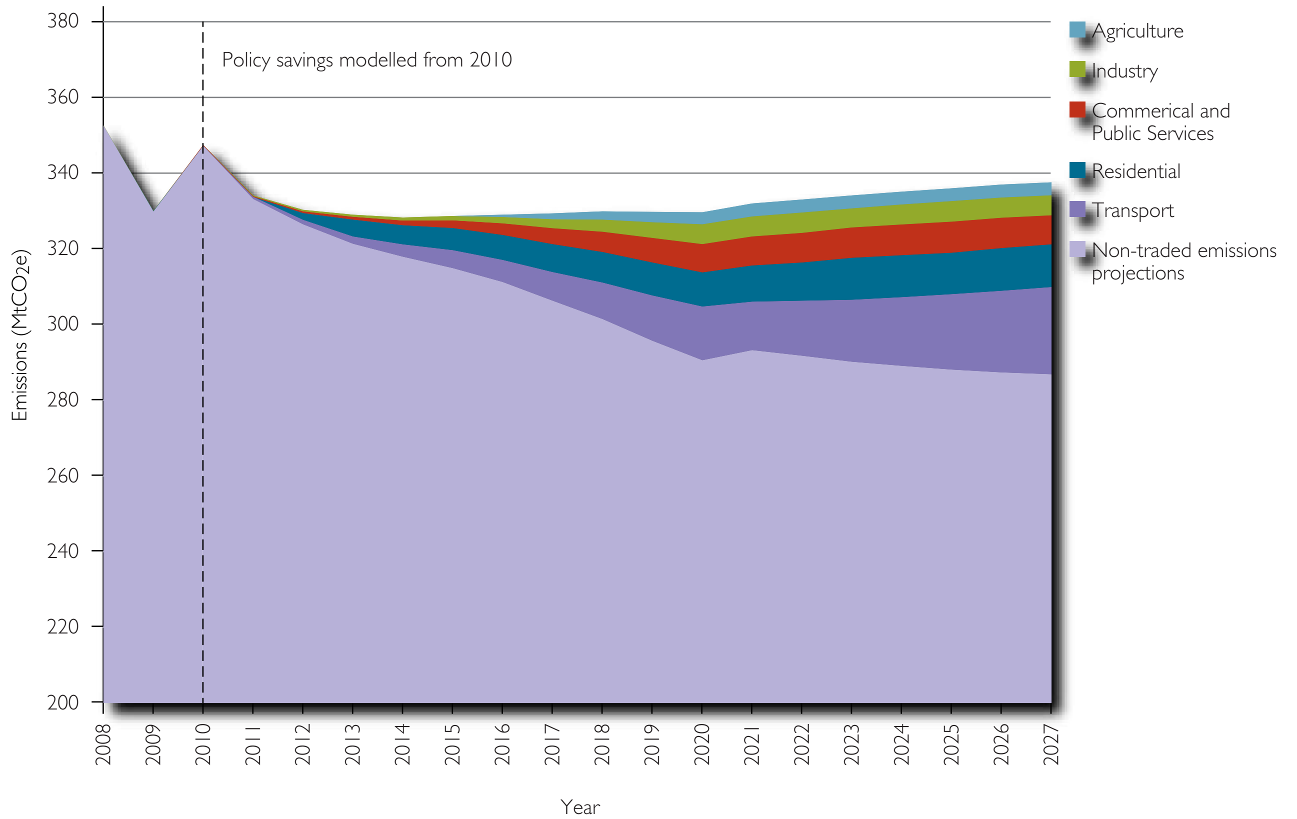
B2.19 The total net present lifetime cost of the current policy package is estimated at £9 billion (excluding the value of GHG emissions savings in the non-traded sector). Including the value of GHG savings in the non-traded sector results in the package delivering a net benefit, on central estimates, of £45 billion.

B2.20 This represents the net present value of the Government's current policy package that places the UK on track to meet its first three carbon budgets, reducing the UK's net carbon account by 38% in 2020 versus 1990.

B2.21 In line with HM Treasury Green Book guidance, the costs are presented as net present values that reflect discounted societal costs and benefits over the lifetime of the policy, some of which may extend over six decades. The resource costs of low carbon technologies are relative to the cost of technologies that would have been installed in the baseline counterfactual, i.e. without legislated carbon budgets.

B2.22 Table B5 sets out the net present cost of delivering the emissions savings over the first three carbon budgets. It excludes the value attributed to the GHG emissions themselves.

Chart B3: Illustrative reduction in non-traded emissions by sector, 2008–27 ($MtCO_2e$)[34]




[34] Does not include indirect effects of policies. Only shows impact of non-traded savings additional to the baseline (Low Carbon Transition Plan and newer policies).

## Table B5: Net present value of policy by measure, excluding value of non-traded emissions (£ million 2011)[35]

| Policy (positive = benefit) | Central fossil fuel prices | Low fossil fuel prices | High fossil fuel prices |
|---|---|---|---|
| **EU Emissions Trading** | | | |
| EU Emissions Trading System[36] | −3,290 | n/a | |
| **Power and low carbon heat** | | | |
| Carbon Price Floor[37] | −620 | −6,250 | 4,260 |
| Carbon capture and storage demonstration | −8,940 | −9,710 | −8,510 |
| Carbon capture readiness[38] | −6 to −80[39] | n/a | |
| Large-scale electricity (Renewables Obligation (RO))[40] | −42,820 | −67,450 | −33,130 |
| Small-scale electricity Feed-in Tariffs (FiTs) | −3,370 | n/a | |
| Renewable Heat Incentive (RHI)[41] | −6,530 | n/a | |
| **Total** | **−62,280 to −62,350** | **n/a** | |
| **Transport[42]** | | | |
| 8% of transport fuel from renewable sources by 2020 | −5 | −320 | 110 |
| EU new car average fuel efficiency standards – $CO_2$ mid-term target (130g $CO_2$/km) | 10,780 | 2,510 | 16,850 |
| Additional impact of further new car efficiency improvements to 95g/km | −22,010 | −35,430 | −11,640 |
| EU new van $CO_2$ regulation | 180 | −2,690 | 2,060 |
| Low carbon emissions buses | 890 | 310 | 1,290 |
| EU new car complementary measures | −4,060 | −5,500 | −3,230 |
| Local Sustainable Transport Fund (LSTF) | 1,480 | 1,650 | 1,580 |
| HGV low rolling resistance tyres | 1,100 | 640 | 1,300 |
| Industry-led action to improve HGV efficiencies | 1,710 | 910 | 2,140 |
| Rail electrification | 2,310 | 2,210 | 2,530 |
| **Total** | **−7,640** | **−35,710** | **13,010** |

35 Values have been rounded to the nearest £10 million.

36 The costs of the EU ETS are made up of the costs to UK installations of abatement incentivised by the carbon price, project credits purchased, EUA allowances purchased, minus the revenues earned from the UK Government and installations selling allowances. The estimates shown in the table reflect the costs over the period 2008–20 and include all UK (static) installations plus domestic aviation. In estimating these figures, the baseline excludes all policies in and announced since the Low Carbon Transition Plan (LCTP) (2009). The choice of baseline is critical in determining the costs; use of a baseline which included recently implemented policies would actually show a negative cost of the EU ETS, as the UK is expected to be a large net seller of allowances once these policies have been introduced.

37 New policy since the Low Carbon Transition Plan.

38 There are no fossil fuel price sensitivities, as energy savings are not a significant component of the costs and benefits.

39 Range of costs reflects the varying complexities of projects, in particular variations in the cost of land.

40 An approximate adjustment has been made to the large-scale (mainly RO) net present values (NPVs) and costs per tonne of carbon saved to avoid double-counting with the small-scale renewable electricity data also given in this table. This adjustment was made on the basis of estimated small-scale generation, and does not take into account the generally higher unit costs of small-scale renewable electricity compared with large-scale renewable electricity. It is therefore likely to slightly overestimate the large-scale (mainly RO) renewable electricity costs.

41 The RHI figures in this annex have not been updated to reflect the most recent changes to policy, Impact Assessment, including the change of large biomass tariff as a result of EU ruling, meaning that they differ from the RHI IA published in Q4 2011.

42 Transport costs include technology costs associated with improved fuel efficiency and costs associated with the rebound effect (the additional kilometres driven as the fuel cost of driving decreases with improved efficiency), including congestion, accidents, noise, infrastructure and air quality. Costs for rail electrification include operating costs.

## Table B5: Net present value of policy by measure, excluding value of non-traded emissions (£ million 2011) *(continued)*

| Policy | Central fossil fuel prices | Low fossil fuel prices | High fossil fuel prices |
|---|---|---|---|
| **Energy efficiency policies** | | | |
| Carbon Reduction Commitment | 1,690 | n/a | |
| Climate Change Agreements (CCAs)[43] | 0 | n/a | |
| Community Energy Saving Programme[44] | 110 | n/a | |
| Carbon Emissions Reduction Target (CERT) | 12,970 | 8,780 | 21,140 |
| CERT extension | 6,950 | 3,960 | 11,940 |
| Energy Company Obligation (ECO) and Domestic Green Deal | 1,897 | −3,658 | 6,839 |
| Non-Domestic Green Deal | 1,320 | 530 | 1,900 |
| Building Regulations 2010 Part L[45] | 13,550 | n/a | |
| Zero Carbon Homes | −2,090 | −2,510 | −1,690 |
| Smart Metering (households)[46] | −4,510 | n/a | |
| Smart Metering (small and medium-sized enterprises (SMEs))[47] | −1,820 | n/a | |
| Energy Performance of Buildings Directive[48] | −830 | n/a | |
| Products Policy (Tranche 1) | 11,080 | n/a | |
| Products Policy (Tranche 2)[49] | 5,450 | n/a | |
| Carbon Trust[50] | 1,040 | n/a | |
| **Total** | **48,110** | **n/a** | |
| **Agriculture** | | | |
| Voluntary Action Plan[51] (England only) | 6,110 (6,410 to 4,890)[52] | n/a | |
| **Total[53]** | **−9 billion** | **−82 billion** | **45 billion** |

Source: Consolidation of individual policy cost benefit analysis, drawing on evidence from the Department for Transport, the Department for Environment, Food and Rural Affairs and the Department for Communities and Local Government

43 Energy intensive business package in LCTP. Net costs have been re-estimated at zero, as CCAs are considered to not incentivise additional abatement beyond the revised baseline.

44 Not updated since the LCTP.

45 This analysis is from the implementation stage of the Impact Assessment (www.communities.gov.uk/publications/planningandbuilding/partlf2010ia) and was based on the December 2008 DECC/HMT GHG Appraisal Guidance. While energy and carbon values have been updated using values published in 2009, these are not consistent with the 2011 values used in most of the policy assessments presented here. The Impact Assessment included benefits in its NPV calculation from the avoided cost of renewables. This benefit has been removed in the numbers presented here for consistency with other policy NPVs.

46 All Smart Metering (household) figures in this document are based on the latest published Impact Assessment, available at: www.decc.gov.uk/assets/decc/11/consultation/smart-metering-imp-prog/2549-smart-meter-rollout-domestic-ia-180811.pdf

47 All Smart Metering (SMEs) figures in this document are based on the latest published Impact Assessment, available at: www.decc.gov.uk/assets/decc/11/consultation/smart-metering-imp-prog/2550-smip-rollout-small-and-med-non-dom.pdf

48 See: www.communities.gov.uk/archived/publications/planningandbuilding/regulatoryimpactenergyperformanc

49 New policy since the LCTP.

50 Carbon Future, Salix and Interest Free loans are not included.

51 No fossil fuel price sensitivities are included as energy savings are not a significant component of net costs.

52 There is sensitivity about non-GHG costs and benefits, given high uncertainties in this area.

53 Where figures from published Impact Assessments have been listed in the table, an adjustment factor has been applied in order to ensure that all policies are incorporated into the total figure on a consistent basis.

B2.23 The full net present value of the policies delivering emissions reductions in the non-traded sector are shown below – where GHG reductions in the non-traded sector have been valued using the Department of Energy and Climate Change's non-traded price of carbon, part of the Government's revised carbon valuation methodology published in July 2009.[54] Table B6 also shows the cost per tonne of GHG abatement delivered.

### Table B6: Net present value and cost effectiveness of non-traded sector policies by measure (£ million 2011)[55]

| Policy (positive = benefit) | Net present value (£ million) | Cost effectiveness (£/t$CO_2$e non-traded) |
|---|---|---|
| **Transport** | | |
| 8% of transport fuel from renewable sources by 2020 | 820 | 0 |
| EU new car average fuel efficiency standards – $CO_2$ mid-term target (130g$CO_2$/km) | 14,310 | −136 |
| Additional impact of further new car efficiency improvements to 95g/km | −13,870 | 118 |
| EU new van $CO_2$ regulations | 1,440 | −6 |
| Low carbon emissions buses | 1,430 | −73 |
| EU new car complementary measures | −2,380 | 108 |
| Local Sustainable Transport Fund (LSTF) | 1,810 | −224 |
| HGV low rolling resistance tyres | 1,540 | −110 |
| Industry-led action to improve HGV efficiencies | 2,330 | −122 |
| Rail electrification | 2,880 | −202 |
| **Energy efficiency policies** | | |
| Renewable Heat Incentive (RHI)[56] | 2,450 | 26 |
| Carbon Reduction Commitment | 2,750 | −71 |
| Climate Change Agreements (CCAs)[57] | n/a | n/a |
| Community Energy Saving Programme | 170 | −90 |
| Carbon Emissions Reduction Target (CERT) | 16,870 | −163 |
| CERT extension | 9,830 | −118 |
| Energy Company Obligation (ECO) and Domestic Green Deal | 6,430 | −20 |
| Non-Domestic Green Deal | 2,140 | −74 |
| Building Regulations 2010 Part L | 20,380 | −74 |
| Zero Carbon Homes | −660 | 68 |
| Smart Metering (households)[58] | 5,200 | −304 |

[54] See: www.decc.gov.uk/en/content/cms/what_we_do/lc_uk/valuation/valuation.aspx

[55] Values have been rounded to the nearest £10 million.

[56] See footnote 41.

[57] See footnote 43.

[58] All Smart Metering (household) figures in this document are based on the latest published Impact Assessment, available at: www.decc.gov.uk/assets/decc/11/consultation/smart-metering-imp-prog/2549-smart-meter-rollout-domestic-ia-180811.pdf

### Table B6: Net present value and cost effectiveness of non-traded sector policies by measure (£ million 2011) *(continued)*

| Policy | Net present value (£ million) | Cost effectiveness (£/t$CO_2$e non-traded) |
|---|---|---|
| Smart Metering (SMEs)[59] | 2,280 | –211 |
| Energy Performance of Buildings Directive | –380 | 85 |
| Products Policy (Tranche 1) | 10,140 | n/a |
| Products Policy (Tranche 2) | 5,500 | n/a |
| Carbon Trust[60] | 1,240 | –181[61] |
| **Agriculture** | | |
| Voluntary Action Plan (England only) | 7,570 | –181 |
| **Total (non-traded sector only)[62]** | **101 billion** | – |

## Changes since the last assessment

B2.24 The Low Carbon Transition Plan (LCTP)[63] in 2009 estimated the net cost of delivering the first three carbon budgets at £28–34 billion (£2011 prices),[64] significantly higher than the updated estimate of £9 billion presented in this report. This reduction in net costs is predominantly driven by the inclusion of new policies since 2009 that deliver significant net benefits. These include:

- **Building Regulations 2010 Part L:** The Building Regulations typically apply at original point of build, subsequent conversion and renovation, and on replacement of specified fixed components and systems. Part L of the Building Regulations sets requirements for the conservation of fuel and power on a technology-neutral basis, helping to encourage the take-up and innovation of more energy efficient and low carbon technologies. For more details on Building Regulations, see the Planning Portal website.[65]

- **Products Policy extension (Tranche 2):** Tranche 2 refers to a number of minimum energy efficiency standards that are in the process of being agreed at European level that will provide a stream of energy and emissions savings and other related benefits. Examples of items affected by these measures are household and non-domestic ICT, household tumble dryers, commercial refrigeration and non-domestic air conditioning.

- **Voluntary Action Plan for agriculture:** The Voluntary Action Plan (VAP) is being taken forward by the Climate Change Taskforce and is an industry-led partnership that is working with sector bodies and farmers to improve the GHG performance of English agriculture. The VAP is expected to deliver cost effective abatement from English agriculture over the third and fourth carbon budgets.

[59] All Smart Metering (SMEs) figures in this document are based on the latest published Impact Assessment, available at: www.decc.gov.uk/assets/decc/11/consultation/smart-metering-imp-prog/2550-smip-rollout-small-and-med-non-dom.pdf

[60] Carbon Future, Salix and Interest Free loans are not included.

[61] This refers to the lifetime impact of savings implemented in 2010/11 (latest data available).

[62] Where figures from published Impact Assessments have been listed in the table, an adjustment factor has been applied in order to ensure that all policies are incorporated into the total figure on a consistent basis.

[63] DECC (2009) *The UK Low Carbon Transition Plan*. Available at: www.decc.gov.uk/en/content/cms/tackling/carbon_plan/lctp.aspx

[64] A figure of £25–29 billion (£ 2009 prices) was published in the LCTP as the net cost of delivering the first three carbon budgets. The comparable present value of the same policy package is £28–34 billion. This represents an increase of 14% and reflects two adjustments: a nominal cost increase of 6% from 2009 based on HM Treasury's GDP deflator; and an uplift from 2009 present values of 7% based on the Green Book discount rate.

[65] www.planningportal.gov.uk/buildingregulations/approveddocuments/partl/

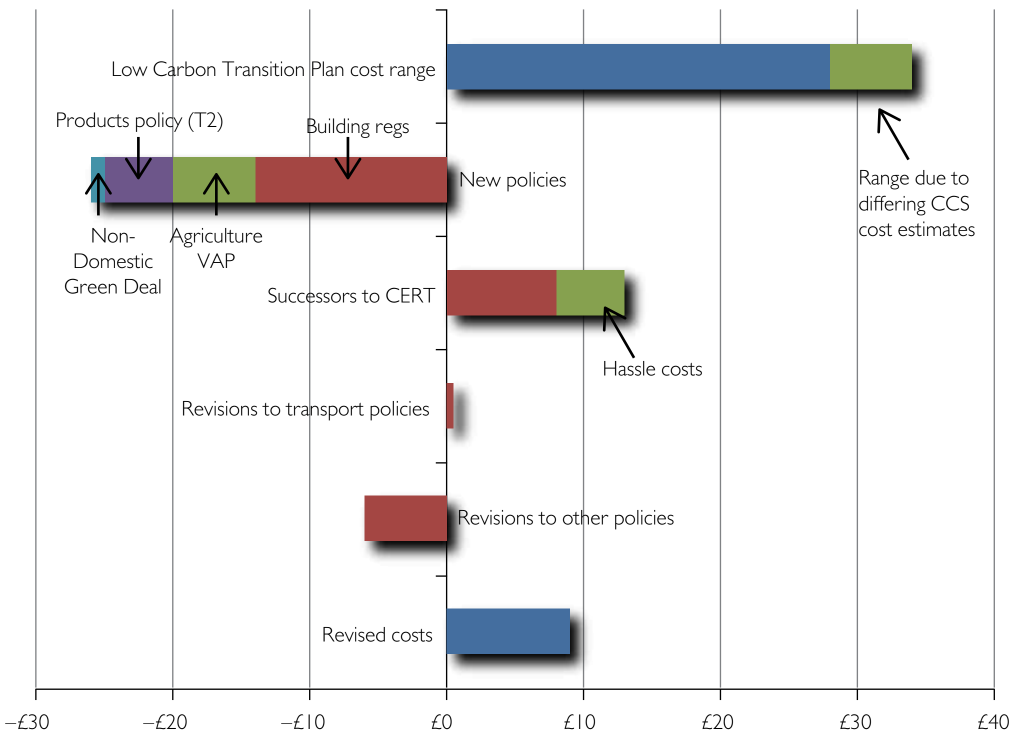
- **Non-Domestic Green Deal:** As with the Domestic Green Deal, this provides a finance mechanism for investment in energy efficiency measures with no upfront cost to the consumer. Measures are paid for by charges that are attached to energy bills. A supporting regulation in the non-domestic private rented sector would require buildings with an Energy Performance Certificate (EPC) rating of G or F to install cost effective energy efficiency measures to move to an EPC rating of E.

B2.25 The benefits from these policies have the effect of offsetting increased costs elsewhere. For example, improvements to the appraisal methodology used for the Energy Company Obligation (ECO) and Domestic Green Deal have led to the inclusion of assessment, financing and 'hassle' costs.[66] The monetisation of these costs and new cost estimates for the measures themselves have pushed up the cost figures. Chart B4 illustrates some of the key changes to the net cost figures since the estimates that were provided in the LCTP.

B2.26 There have been a number of other changes to modelling and cost–benefit analysis that have affected the emissions savings and cost estimates of policies, namely:

- there have been a number of significant updates to key input assumptions for policy cost–benefit analysis (e.g. fossil fuel prices, GDP growth assumptions) and, where possible, all policies have been reappraised in line with these updated assumptions; and
- there have also been revisions to input assumptions in respect of individual sectors such as transport. For instance, the analysis assumes that biofuels will make up 8% of transport energy in 2020, rather than 10% as previously assumed. The change of assumption is made for purely analytical reasons and is not intended to pre-empt policy decisions on biofuel use in road transport fuel beyond 2014. It is consistent with the Committee on Climate Change's recommendation for biofuel use in 2020. The change in modelling assumption leads to lower savings from biofuel than have previously been estimated.

## Chart B4: Changes to the total net present value of policy, excluding the value of non-traded emissions, since the Low Carbon Transition Plan (£ million 2011)




[66] Revised methodology based on research commissioned by DECC in 2009 that highlighted the real and substantial time and financial costs associated with domestic energy efficiency and carbon saving measures. These were excluded from the previous appraisal methodology. See ECOFYS (2009) *The hidden costs and benefits of domestic energy efficiency and carbon saving measures*, ECOFYS, May 2009.

## Policy cost effectiveness

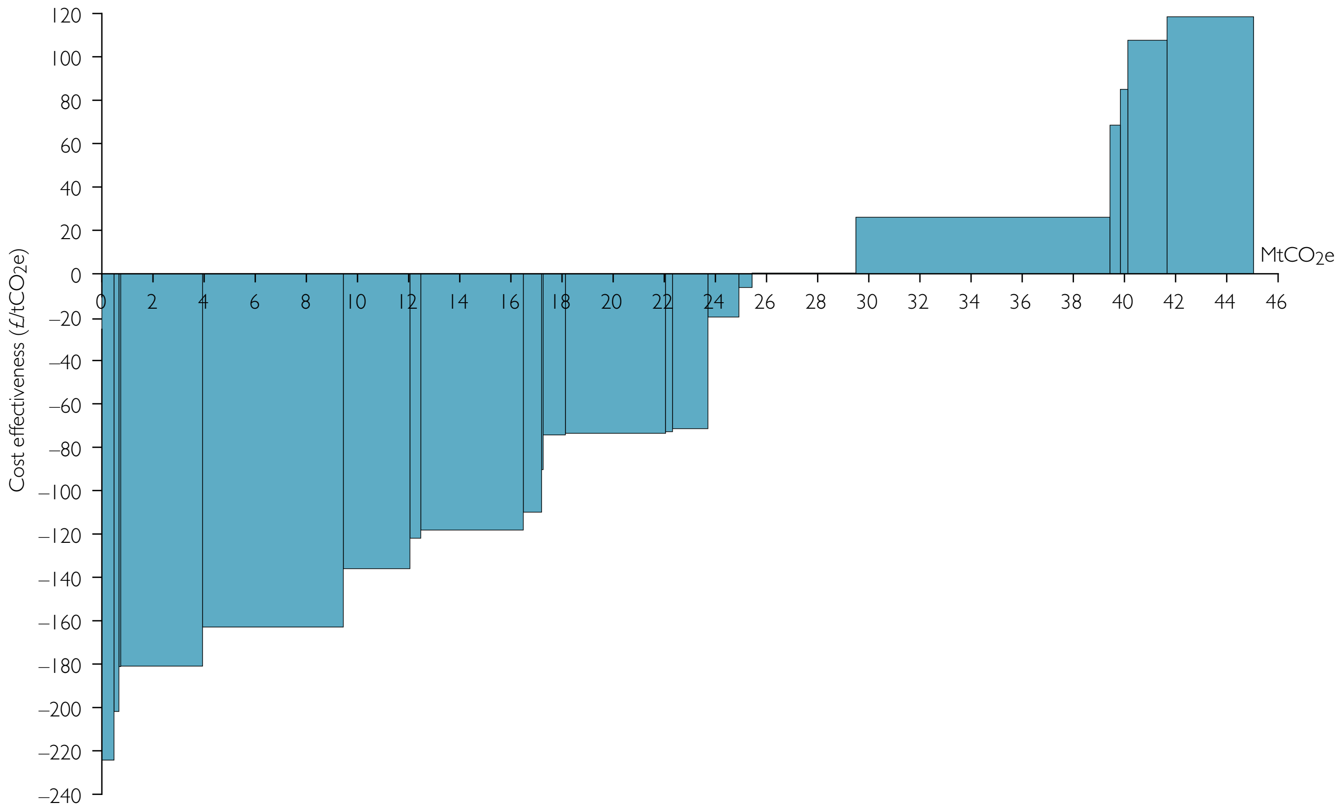
B2.27 The policy marginal abatement cost (MAC) curve set out in chart B5 provides a static 'snapshot' of the potential emissions reductions and average costs in 2020 of government policies to deliver the first three carbon budgets in the non-traded sector (each policy being represented by its own bar).

B2.28 MAC curves provide a useful tool for comparing the cost effectiveness of policies by ranking them in order of cost per tonne of $CO_2$e saved,[67] such that measures below the horizontal axis indicate negative costs or savings to society and measures above the horizontal axis indicate costs to society.

B2.29 The cost effectiveness figure for each of the policies represents the cost effectiveness of the whole policy per tonne of abatement in the non-traded sector. Where the policy has an impact in the traded sector, the costs and benefits of this impact are included in the cost effectiveness calculation.

B2.30 It must be remembered that MAC curves are sensitive to input assumptions and that policies reflected in them may not monetise all costs and benefits associated with each policy. This will inevitably result in the cost effectiveness of policies changing as input assumptions change.

**Chart B5: Non-traded emissions policy marginal abatement cost curve, 2020**




Key

| | |
|---|---|
| 0.0 – 0.5 | Local Sustainable Transport Fund |
| 0.5 – 0.7 | Rail electrification |
| 0.7 – 0.7 | Carbon Trust |
| 0.7 – 3.9 | Agriculture Voluntary Action Plan |
| 3.9 – 9.4 | Carbon Emissions Reduction Target (CERT) |
| 9.4 – 12.2 | EU new car average fuel efficiency standards (130 $gCO_2$/km) |
| 12.2 – 12.7 | HGV technology measures |
| 12.7 – 16.7 | CERT extension |
| 16.7 – 17.4 | HGV low rolling resistance tyres |
| 17.4 – 17.5 | Community Energy Savings Programme |
| 17.5 – 18.3 | Non-Domestic Green Deal |
| 18.3 – 22.2 | Building Regulations 2010 part L |
| 22.2 – 22.5 | Low carbon emission buses |
| 22.5 – 23.9 | Carbon Reduction Commitment |
| 23.9 – 25.1 | Energy Company Obligation (ECO) and Domestic Green Deal |
| 25.1 – 25.7 | EU new van $CO_2$ regulation |
| 25.7 – 30.0 | 8% transport fuel from renewable sources by 2020 |
| 30.0 – 40.0 | Renewable Heat Incentive |
| 40.0 – 40.4 | Zero Carbon Homes |
| 40.4 – 40.7 | Energy Performance of Buildings Directive |
| 40.7 – 42.2 | EU new car complementary measures |
| 42.2 – 45.8 | Further new car efficiency improvements to 95 $gCO_2$/km |

[67] Further information on the cost effectiveness methodology is available at: www.decc.gov.uk/en/content/cms/about/ec_social_res/iag_guidance/iag_guidance.aspx

# B3. Potential for the fourth carbon budget

## Additional abatement potential

B3.1 As indicated above, on a net UK carbon account basis, the shortfall to the fourth budget of 1,950 $MtCO_2e$ is projected to be around 181 $MtCO_2e$. This shortfall is in the non-traded sector, as the UK's traded sector emissions will be determined by the EU Emissions Trading System cap.

B3.2 This means that additional effort beyond current policy is required to meet the fourth carbon budget. An economy-wide UK marginal abatement cost (MAC) curve evidence base has been developed to investigate potential sources of additional abatement. It consolidates information on abatement potential through various technology measures over the fourth budget period, and the associated cost effectiveness of these measures. See box B3 for further information on the UK MAC curves evidence base.

B3.3 Abatement opportunities have been assessed by considering varying levels of abatement potential over the period for each sector, and do not consider the policy mechanisms through which abatement could be delivered. Assumptions about the feasible roll-out, emissions savings and costs of these technologies have been made to produce scenarios of potential abatement.

B3.4 The evidence base includes abatement opportunities through energy efficiency measures and low carbon heat technologies in the residential, services and industry sectors; abatement technologies in domestic and commercial transport; and abatement opportunities in agriculture. Although some consideration has been given to further abatement potential through small-scale electricity generation, and through abatement in the land use, land use change, forestry and waste sectors, scenarios of abatement have not been assessed for these measures.

### Box B3: UK MAC curves evidence base

The Government's UK MAC curves evidence base contains information on the abatement potential, cost and cost effectiveness of measures to reduce emissions over the fourth budget period. This information was consolidated across a range of models and sources as set out below.

- **Residential energy efficiency in existing buildings**

Scenarios for abatement potential in the domestic housing stock have been modelled in econometric work supporting the Impact Assessment of the Green Deal consultation. Analysis incorporated findings from consumer research to differentiate between abatement potential across different segments of the domestic housing stock, and modelling reflected updated information on the trajectories of supply capacity and costs.

- **Services energy efficiency in existing buildings**

Data from the Valuation Office Agency gives the number and rateable value of buildings by sector in the year 2010, to a substantial level of disaggregation. The scale of abatement potential from Green Deal eligible measures is estimated using the National Non-Domestic Buildings Energy and Emissions Model (N-DEEM), together with technology penetration rates as estimated by consultants Element Energy. This potential is then adjusted for take-up brought about by other, non-Green Deal policies, based on projected policy savings that are derived from the Department of Energy and Climate Change energy model. A decision tree is used to determine the process of moving towards a decision to take out a Green Deal.

### Box B3: UK MAC curves evidence base *(continued)*

A review and update of the evidence base on non-domestic energy efficiency is planned. An initial pilot to determine an appropriate methodology, using the food and mixed retail sector as a test case, should be complete in spring 2012. A full economy-wide study may be launched shortly afterwards.

- **Services and residential energy efficiency in new buildings**

The cost effectiveness information for new buildings is based on evidence published in the *Implementation Stage Impact Assessment of revisions to Part L of the Building Regulations*, published in March 2010.[68]

- **Industrial process efficiency and carbon capture and storage (CCS)**

Abatement potential from industrial processes and further energy efficiency improvements has been derived from four principal sources:

- The Energy End-Use Simulation Model (ENUSIM) is a technology based, bottom-up industrial energy end-use simulation model which projects the uptake of energy-saving and/or fuel-switching technologies taking into account the cost effectiveness of technology options under future carbon and fossil fuel prices.[69]
- Further detail on future abatement potential has been derived from work undertaken by AEA Technology. The major sources of abatement covered within this work focus on six major sectors: cement, refineries, glass, chemicals, food and drink, and iron and steel.[70]
- The Department of Energy and Climate Change commissioned further analysis to assess abatement potential beyond that considered in the AEA work. This project is based on top-down energy and abatement projections for 17 wider groups of manufacturing.
- In addition, the Department of Energy and Climate Change has undertaken further modelling analysis to estimate abatement from the uptake of low carbon heat and the initial deployment of CCS.[71]

- **Low carbon heat in residential, services and industry**

Scenarios for low carbon heat have been modelled using the detailed cost effectiveness model developed for the Committee on Climate Change by consultants NERA and AEA. This model looks at the potential for low carbon heat technologies to replace fossil fuel use up to 2030. The model has drawn upon and extended the evidence base used for previous low carbon heat modelling in the Department of Energy and Climate Change, and includes technology assumptions and input data that have been extended to 2030. Additional technologies have been incorporated to reflect a wider range of possible future developments (e.g. synthetic biogas from the gasification of biomass, and heat pumps with heat storage that can shift electricity load profiles).

[68] See: www.communities.gov.uk/publications/planningandbuilding/partlf2010ia

[69] See: http://downloads.theccc.org.uk/AEAUpdateofUKabatementtCh6.pdf

[70] See: www.aeat.com/cms/assets/Documents/Final-Report-CCC.pdf

[71] Element Energy (2010) *Potential for the Application of CCS to UK Industry and Natural Gas Power Generation*, Report for the Committee on Climate Change, Final Report, Issue 3.

### Box B3: UK MAC curves evidence base *(continued)*

- **Transport**

Scenarios for transport abatement potential in the 2020s have been developed reflecting research and evidence on possible uptake rates and the costs for new technologies; and through consultation with industry.

The Department for Transport's National Transport Model (NTM) has been used to assess the emissions savings that the measures could deliver, with off-model adjustments made to reflect the impact of an illustrative technology mix of plug-in vehicles. The NTM also provides the changes in vehicle kilometres driven; fuel consumption; air quality and congestion associated with the measures and that are used in the cost–benefit analysis of the measures.

- **Agriculture**

There is considerable uncertainty over estimates of emissions from the agricultural sector due to the complex nature of the biological systems that are the source of greenhouse gas emissions from the sector. External research, based on detailed assessment of on-farm measures, has, however, identified cost effective abatement potential from the sector – i.e. it reduces farmer costs.[72] The voluntary action plan being taken forward by industry is expected to deliver annual savings of around 3 $MtCO_2e$ from English agriculture by 2020. These are expected to be delivered from measures that improve crop nutrient, livestock breeding, feeding and manure management practices.

The Department for Environment, Food and Rural Affairs, in collaboration with the Devolved Administrations, has an extensive research programme that will help to deliver an improved agricultural inventory. This research will help to reduce the uncertainties over the current inventory and potentially support identification of further mitigation potential from the sector.

B3.5 To assess potential abatement it is necessary to project emissions forward, making assumptions about the level and source of emissions, and the possible abatement technologies available. There is significant uncertainty around the level of emissions and abatement potential available owing, among other things, to uncertainties over how technologies may develop, as well as public acceptance of new technologies. Further information on uncertainty in the analysis of marginal abatement costs is set out in the *Impact Assessment of Fourth Carbon Budget Level.*[73]

B3.6 This uncertainty will also affect the anticipated achievement, costs and cost effectiveness associated with the measures installed. The analysis in this report represents a best estimate of the impacts of measures under central assumptions about underlying fundamentals, such as fossil fuel prices, GDP growth and technology cost assumptions. If these fundamentals change significantly, the emissions impact, costs and cost effectiveness associated with abatement measures could be significantly different.

[72] Scottish Agricultural College (2010) *Review and Update of UK Marginal Abatement Cost Curves for Agriculture.*

[73] DECC (2011) *Impact Assessment of Fourth Carbon Budget Level.* Available at: www.decc.gov.uk/assets/decc/what%20we%20do/a%20low%20carbon%20uk/carbon%20budgets/1685-ia-fourth-carbon-budget-level.pdf

B3.7 The ranges of abatement potential have been assessed accounting for potential overlaps and interdependencies between technology measures. As such, the traded and non-traded sector scenarios are consistent with one another and with the Updated Energy and Emissions Projections baseline published in October 2011.[74]

B3.8 Tables B7 and B8 below set out the range of abatement potential identified for the traded and non-traded sectors (abatement potential in the power sector is considered separately below). These ranges are illustrative, and reflect a judgement on feasible abatement potential in each sector.

**Table B7: Range of additional potential abatement in the non-traded sector, 2023–27 ($MtCO_2e$)**

| | Ambition | 2023 | 2024 | 2025 | 2026 | 2027 | Total |
|---|---|---|---|---|---|---|---|
| Agriculture | – | 1.9 | 3.0 | 4.0 | 4.0 | 4.0 | 16.9 |
| Residential new build | – | 0.4 | 0.4 | 0.5 | 0.5 | 0.5 | 2.4 |
| Industrial processes | High | 3.2 | 4.0 | 4.2 | 4.2 | 4.3 | 19.9 |
| | Low | 1.2 | 1.5 | 1.6 | 1.6 | 1.6 | 7.6 |
| Low carbon heat (business) | High | 1.7 | 2.2 | 2.7 | 3.2 | 3.7 | 13.6 |
| | Low | 0.7 | 0.9 | 1.1 | 1.2 | 1.4 | 5.3 |
| Low carbon heat (industry) | High | 3.6 | 4.6 | 5.7 | 6.9 | 8.0 | 28.9 |
| | Low | 1.2 | 1.6 | 2.0 | 4.9 | 5.5 | 15.3 |
| Low carbon heat (public) | High | 1.0 | 1.3 | 1.6 | 1.9 | 2.2 | 8.0 |
| | Low | 0.5 | 0.6 | 0.7 | 0.9 | 1.0 | 3.7 |
| Low carbon heat (residential) | High | 4.2 | 6.0 | 8.0 | 10.1 | 12.3 | 40.7 |
| | Low | 0.8 | 0.9 | 1.1 | 1.2 | 1.3 | 5.3 |
| Residential retrofit | High | 0.5 | 1.0 | 1.4 | 1.9 | 2.4 | 7.2 |
| | Low | 0.1 | 0.3 | 0.4 | 0.5 | 0.6 | 1.9 |
| Services new build | High | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.5 |
| | Low | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.3 |
| Services retrofit | High | 1.2 | 1.1 | 1.1 | 1.1 | 1.2 | 5.7 |
| | Low | 0.7 | 0.6 | 0.6 | 0.6 | 0.7 | 3.2 |
| Transport | High | 12.5 | 14.2 | 16.1 | 18.0 | 20.0 | 80.8 |
| | Low | 4.9 | 5.1 | 5.6 | 6.0 | 6.4 | 28.0 |
| Total | High | 30.2 | 38.0 | 45.5 | 52.0 | 58.7 | 224.3 |
| | Low | 12.5 | 15.0 | 17.6 | 21.5 | 23.3 | 89.9 |

[74] DECC (2011) *Updated Energy and Emissions Projections*. Available at: www.decc.gov.uk/assets/decc/11/about-us/economics-social-research/3134-updated-energy-and-emissions-projections-october.pdf

**Table B8: Range of additional potential abatement in the traded sector (excluding power sector, 2023–27) ($MtCO_2e$)**

| | Ambition | 2023 | 2024 | 2025 | 2026 | 2027 | Total |
|---|---|---|---|---|---|---|---|
| Industrial processes | High | 6.0 | 7.4 | 7.5 | 7.7 | 7.9 | 36.5 |
| | Low | 3.9 | 4.8 | 4.9 | 5.2 | 5.6 | 24.5 |
| Low carbon heat (industry) | High | 3.5 | 4.1 | 4.7 | 6.7 | 7.4 | 26.3 |
| | Low | 2.3 | 2.6 | 2.8 | 3.2 | 4.9 | 15.7 |
| Total | High | 9.5 | 11.5 | 12.1 | 14.4 | 15.3 | 62.8 |
| | Low | 6.2 | 7.4 | 7.8 | 8.4 | 10.5 | 40.2 |

## Abatement potential in the power sector

B3.9 In the power sector, analysis for the fourth carbon budget is based on the ongoing Electricity Market Reform (EMR) programme, which aims to undertake fundamental reforms to the electricity market. The section on 'Secure, low carbon electricity' in Part 2 of the main report provides further details on the programme.

B3.10 The quantitative analysis that informed the EMR White Paper and accompanying Impact Assessment (IA)[75] was undertaken using a dynamic model of the British electricity market, developed by consultants Redpoint Energy. This model simulates how investment decisions are made, and the results provide an illustrative narrative to the potential impacts of the options examined.

B3.11 Since the publication of the EMR White Paper and IA, the Department of Energy and Climate Change has updated its projections of fossil fuel and carbon prices, technology costs and electricity demand. The EMR White Paper analysis was modelled to meet a decarbonisation ambition of 100 $gCO_2$/kilowatt hour (kWh) in 2030. A sensitivity of 50 $gCO_2$/kWh was also examined. While these aspects remain unchanged, it was also assumed that renewables would increase to a 35% share of generation by 2030 to drive the decarbonisation ambition. The revised approach does not impose a specific renewables target but assumes that low carbon technologies are deployed on the basis of least cost to achieve that illustrative decarbonisation ambition. In light of the revisions to input assumptions and methodology, the analysis underpinning the lead EMR package, i.e. Feed-in Tariffs with Contracts for Difference (FiT CfD, or CfD) with a capacity mechanism, has been updated.

B3.12 The updated analysis shows that a baseline without the EMR has more new gas-fired power stations owing to favourable conditions on profitability for gas-fired compared with coal-fired generation. In addition, a significant percentage of existing coal plant retires (around 2020), the majority of which is also replaced by new gas plants. Moreover, the modelling suggests that the first nuclear plant becomes operational in 2027, with three more new nuclear plants being built by 2030.[76] Renewables capacity to 2030 remains around a similar level to that presented in the EMR White Paper. Under this baseline scenario, the carbon intensity of the power generation sector is 216.74 $gCO_2$/kWh in 2020, which then falls to 165.96 $gCO_2$/kWh in 2030 as a result of increased generation from new nuclear, carbon capture and storage (CCS) and wind.

[75] See: www.decc.gov.uk/en/content/cms/legislation/white_papers/emr_wp_2011/emr_wp_2011.aspx

[76] The results reported here differ from those reported in the Department of Energy and Climate Change latest published Updated Energy and Emissions Projections (www.decc.gov.uk/en/content/cms/about/ec_social_res/analytic_projs/en_emis_projs/en_emis_projs.aspx). This is because the Department of Energy and Climate Change emissions model differs from the Redpoint Energy model in the assumptions about how electricity producers behave. In the Department of Energy and Climate Change model, producers behave as if they know what future demand and prices will be (i.e. the model assumes perfect foresight). The model used for EMR analysis takes account of the impact of uncertainty about future returns on decisions made under current market arrangements.

B3.13 As mentioned earlier, the lead EMR proposal was for a FiT CfD with a capacity mechanism (strategic reserve (SR) or capacity market (CM) – the choice to be finalised). The package is also to be implemented alongside an Emissions Performance Standard (EPS).

B3.14 Meeting a decarbonisation ambition of 100 $gCO_2$/kWh in 2030 with these mechanisms results in more low carbon generation than in the baseline, in the form of new nuclear and biomass, owing to the levels of financial support provided through FiT CfDs. Over the fourth carbon budget period (2023–27) this scenario would reduce UK territorial emissions by around 120 $MtCO_2$ relative to the baseline without EMR.

### *Decarbonisation with 50 $gCO_2$/kWh ambitions*

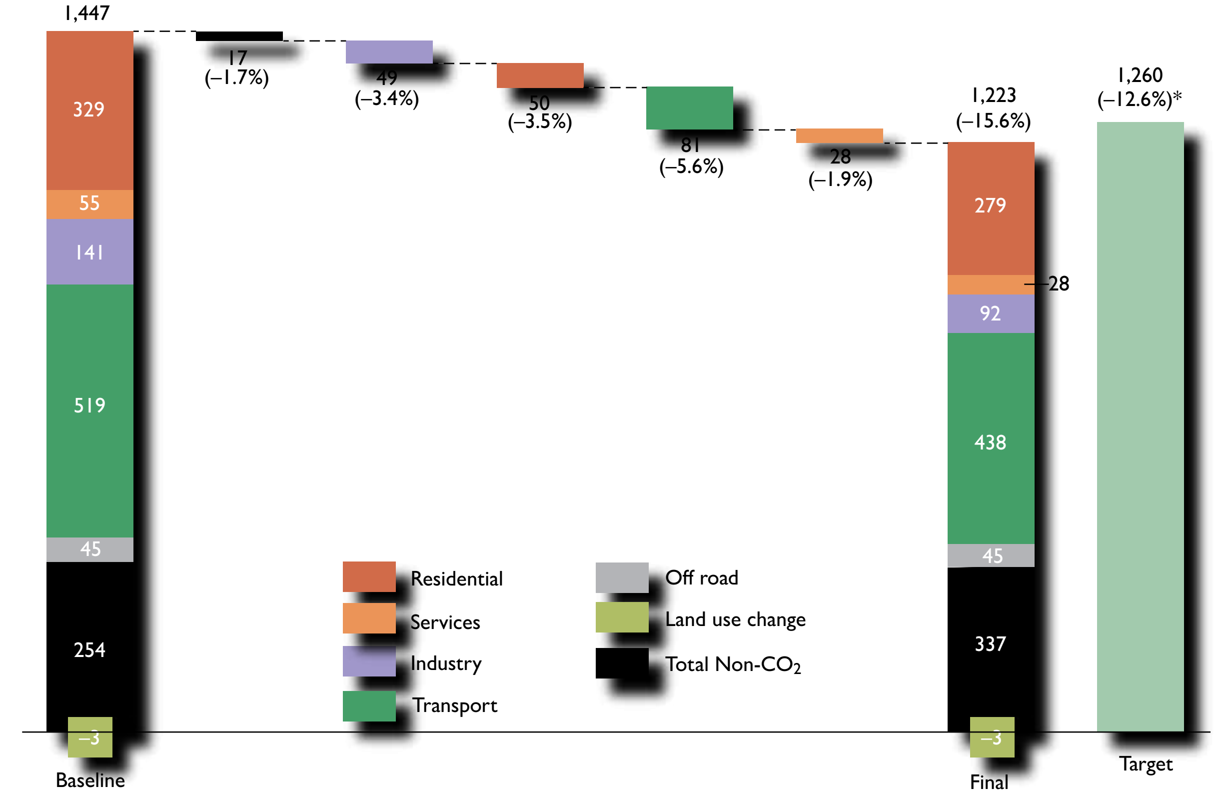
B3.15 This sensitivity is an update to that in the EMR White Paper and examines the implications of following a more stringent decarbonisation pathway on the CfD with SR package.

B3.16 The results show that a more stringent decarbonisation pathway would lead to greater amounts of low carbon generation being incentivised through the CfD mechanism. With central electricity demand assumptions, investment in new nuclear is the same as under the CfD with SR package and is constrained by assumptions related to nuclear plant build rates. However, under this sensitivity there is significant investment in new CCS capacity as well as greater investment in wind and biomass. The introduction of such large quantities of low carbon generation (towards the mid to late 2020s) allows the carbon intensity of the power generation sector to drop to 50 $gCO_2$/kWh in 2030, compared with 223 $gCO_2$/kWh in 2020. Over the fourth carbon budget period (2023–27) this scenario would reduce UK territorial emissions by an additional 40 $MtCO_2$ relative to the 100 $gCO_2$/kWh pathway.

## Overview of abatement potential across the economy

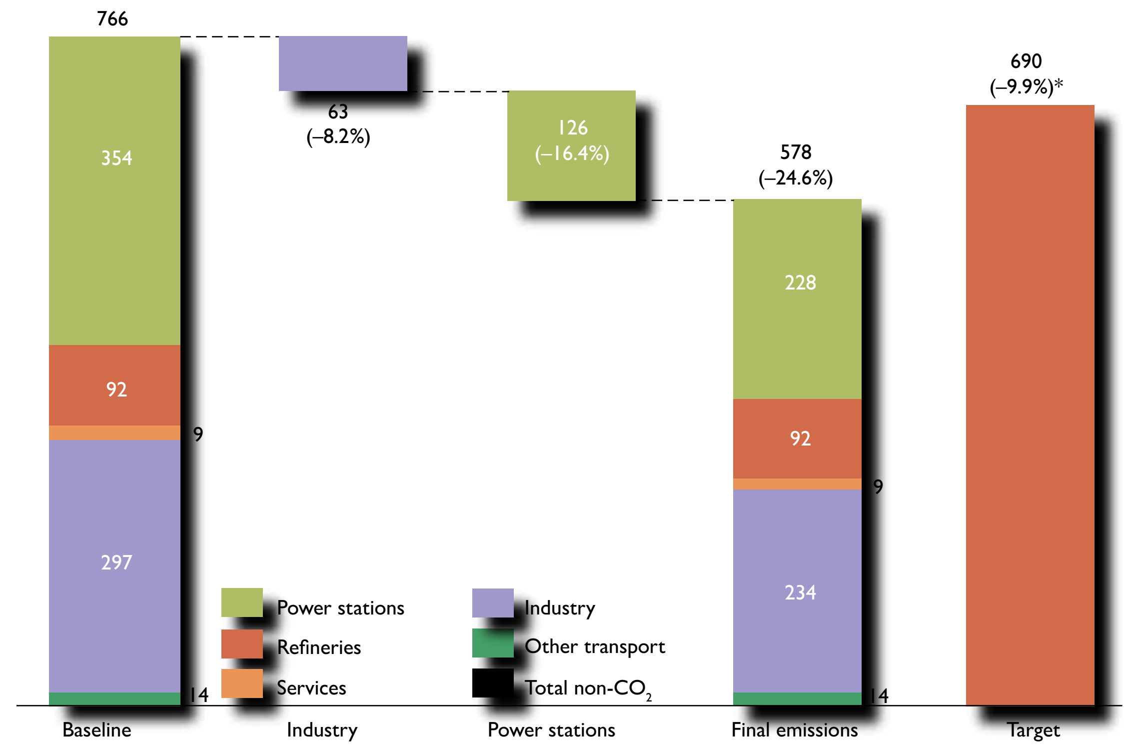
B3.17 A consolidated assessment of the additional abatement potential beyond 2022 indicates that there is sufficient abatement potential to meet the fourth carbon budget. Charts B6 and B7 reflect the highest levels of abatement potential identified in the non-traded and traded sectors.

## Chart B6: Total potential abatement identified in the non-traded sector, 2023–27 ($MtCO_2e$)




*Percentage reduction from baseline

## Chart B7: Total potential abatement identified in the traded sector, 2023–27 ($MtCO_2e$)



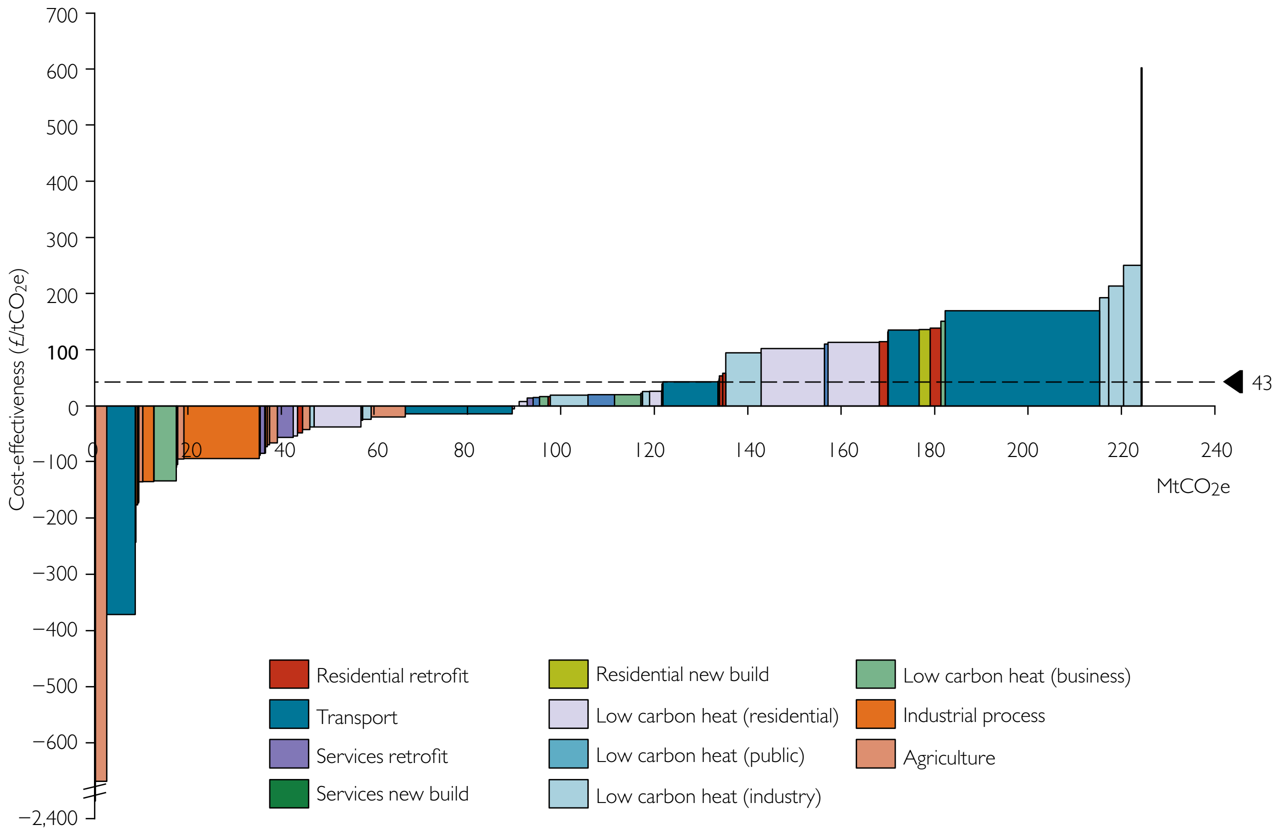

*Percentage reduction from baseline

## Cost effectiveness of abatement potential

B3.18 The Government's approach to meeting the fourth carbon budget aims to ensure that we can manage the low carbon transition cost effectively. In order to do so, it has been necessary to consider a wide range of factors that will influence the total cost.

B3.19 Chart B8 reflects all the abatement potential identified in the non-traded sector compared against the weighted average discounted (WAD) carbon price of £43/t$CO_2$e. See box B4 for an explanation of this metric. Chart B8 also shows the marginal abatement cost (MAC) associated with the identified abatement measures, but has several limitations, which are highlighted in box B5. These limitations have been accounted for in the development of the carbon budget scenarios.

**Chart B8: Marginal abatement cost curve of the total potential abatement identified in the non-traded sector, 2023–27 (Mt$CO_2$e)**



### Box B4: Weighted average discounted (WAD) cost of carbon

The WAD cost of carbon is designed to provide a single carbon value that is reflective of the value of all the greenhouse gas emissions saved by a package of abatement. It is calculated using the Government's standard carbon valuation methodology, in which all emissions savings are valued at the carbon price relevant to the year in which they are realised, and then discounted to get a present value figure. This aggregate value for the present value of emissions saved is then divided by the total number of emissions saved to get the relevant WAD cost of carbon. The cost is weighted, because more weight is effectively given to years in which emissions savings are larger. Consequently, two abatement measures that save the same amount of emissions, but at different times, will have different WAD costs of carbon to reflect the different value of carbon when the savings are expected to be realised. The £43/t$CO_2$e noted above is the WAD cost of carbon in the non-traded sector discounted to 2011 for each of the non-traded sector scenarios. It can be compared with the cost per tonne saved in order to determine whether or not the scenario package as a whole is cost effective.

### Box B5: Limitations of marginal abatement cost (MAC) analysis

While MAC analysis is a useful tool, it does have a number of limitations and needs to be used appropriately.

Cost effectiveness estimates may not reflect non-monetised impacts of abatement opportunities, such as impacts on competitiveness, distributional impacts and impacts on other environmental and social considerations.

The lack of granularity in the analysis may misrepresent individual increments and measures; for example, a relatively cost ineffective block of abatement could include a mix of measures that are cost effective and cost ineffective.

There may be a substantial difference between the costs identified in this analysis, and the policy costs required to deliver this potential for some measures. For example, negative cost abatement measures identified in this analysis are not always fully taken up without policy and government intervention. This may result in costs increasing substantially.

MAC curves are limited in portraying the range of uncertainty surrounding abatement potential and cost effectiveness. There are considerable uncertainties over the development of technologies and their associated costs so far into the future, as well as uncertainties around other key factors such as fossil fuel prices. The estimated abatement potential and cost effectiveness presented in this document are best estimates and are based on assumptions about technology uptake rates and costs that may need to be revised in future. While every attempt has been made to be comprehensive in this analysis, some technical options and savings may be omitted, for example potential opportunities for emissions abatement through forestry, savings from improved landfill methane capture rates and demand reduction measures.

B3.20 In addition to these limitations, MAC curve analysis suffers from an inability to account for the dynamic impact of different abatement options. The cost of each measure is a single number and cannot reflect how the cost of different technologies is likely to evolve with different levels of take-up over time. It is also limited in reflecting interdependencies across measures, both within and across different sectors.

B3.21 MAC curves also fail to account for the lead-in time necessary to implement various technologies or measures and so are limited in informing decisions on the optimal timing of different abatement options. In considering levels of action in the period 2023–27 therefore, government needs to combine information from static comparisons of cost effectiveness with a consideration of the dynamic cost efficiency of different implementation timescales. Fundamentally, it must consider how the timing and scale of implementation affects the evolution of costs, and ensure that sufficient cost effective abatement is made available in future decades to meets its 2050 target.

B3.22 Investment in the research, development and demonstration of emerging low carbon technologies is likely to be crucial in ensuring the availability of key technologies, such as carbon capture and storage. It is also important in developing new, enabling technologies, such as in heat and electricity storage, and for bringing down the costs of low carbon technologies that reach the deployment stage. As well as incentivising early-stage investment, market-pull policies can enable/accelerate deployment and dramatically bring down the costs of emerging technologies. This suggests that there is a case for pushing the development and deployment of technologies before they are considered statically cost effective (i.e. cost effective in a given year). The rationale for this is that by doing so, the costs of the technology could be reduced in future periods through learning-by-doing or induced innovation, and that their availability could be increased through the development of the supply chain.

B3.23 This approach could apply to a range of critical technologies, for instance heat pumps and low carbon vehicles. Additionally, although some relatively low carbon technologies may be useful for decarbonising over the next few decades, they may not satisfy longer-term abatement needs in a least-cost pathway to 2050.

B3.24 Uncertainty over the future structure of the economy, future technology costs, technical performance and dynamic interactions within the economy make it difficult to determine today a least-cost/maximum-benefit pathway to 2050. Consequently, it may be beneficial to adopt a diverse range of measures in order to mitigate the risk that some of these currently immature technologies do not work as expected or that viable alternative/substitute technologies become available in the future. This approach is advocated by the Committee on Climate Change and cited in their recommendations in chapter 3 of their report,[77] where they emphasise the importance of flexibility and of keeping a range of abatement scenarios in play. The option value of a diverse range of measures has to be balanced against the cost of developing more solutions and the risk of diverting resources from the right technology families to the wrong technology families on the basis of flawed information.

B3.25 In light of these factors, government has sought to develop options that meet the fourth carbon budget cost effectively while still leaving open probable least-cost options to meet the 2050 target. This additional constraint can suggest the need to use abatement measures that might not be cost effective considering the fourth carbon budget target alone, but should nevertheless support a more efficient transition to the 2050 goal.

[77] Committee on Climate Change (2010) *The Fourth Carbon Budget: Reducing emissions through the 2020s*. Available at: www.theccc.org.uk/reports/fourth-carbon-budget

## Scenarios to deliver the fourth carbon budget

B3.26 Part 3 of the main report set out illustrative scenarios for how the additional emissions reductions to meet the fourth carbon budget could be delivered. These scenarios were developed using evidence on the abatement potential and cost effectiveness identified and with regard to the Government's desire to encourage a portfolio of technologies. Consequently, the fourth carbon budget scenarios have been developed taking into account a number of factors:

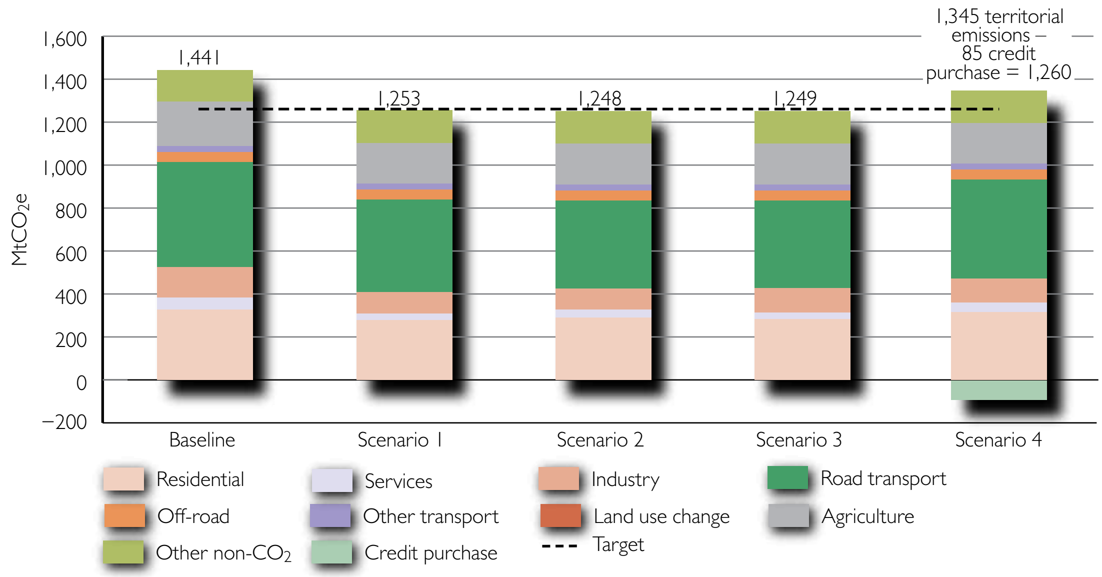
- static cost effectiveness – comparing the estimated cost of a measure with the forecast carbon price for the same time period;
- dynamic cost effectiveness – considering what action needs to be taken in the fourth budget period to be on track to meet the 2050 target in the most cost effective way;
- technical feasibility – taking account of likely technological development and necessary build rates; and
- practical deliverability and public acceptability – considering potential barriers to delivery.

B3.27 These illustrative scenarios focus on the sectors that are key to achieving the 2050 target in a cost effective way and offer the greatest potential for emissions reductions over the fourth carbon budget period, although these scenarios do not directly link to any specific 2050 future set out in Part 1. This section provides detail on the composition of these scenarios in the non-traded and traded sectors separately before considering the cross-economy implications and wider impacts of the different scenarios.

### *Delivering emissions reductions in the non-traded sector*

B3.28 The four scenarios for the non-traded sector illustrate different ways in which emissions could be reduced to 1,260 $MtCO_2e$, the level of emissions required in the non-traded sector over the fourth carbon budget period to meet the overall 1,950 $MtCO_2e$ level. Chart B9 shows greenhouse gas emissions under each scenario and the contribution from different sectors.

## Chart B9: Aggregate non-traded emissions under the illustrative scenarios to meet the fourth carbon budget, 2023–27




### *Scenario 1: High abatement in low carbon heat*

B3.29 Under this scenario, emissions over the fourth carbon budget period would be reduced to 1,253 $MtCO_2e$ in the non-traded sector. The table below summarises the key components of this scenario.

## Table B9: Expected activity under illustrative Scenario 1

| Sector | Expected activity |
|---|---|
| Buildings | • 3.7 million solid walls insulated over the period 2023–30<br>• 8.6 million low carbon heat installations in total by 2030, delivering around 165.5 terawatt hours (TWh) of low carbon heat and a further 38.6 TWh from district heating |
| Transport | • Average new car emissions = 60 $gCO_2$/km in 2030<br>• Average new van emissions = 90 $gCO_2$/km in 2030<br>• 8% biofuel, by energy<br>• 5% heavy goods vehicle (HGV) efficiency improvement over five years |
| Industry | • All 'realistic' and some further cost effective measures, including whole-refinery optimisation in the refineries sub-sector, clinker substitution in the cement sector and increased recycling in iron and steel<br>• Committee on Climate Change's central scenario of industrial carbon capture and storage<br>• 44,000 additional low carbon heat installations in industry by 2030, delivering around 95 TWh of low carbon heat in industry |
| Agriculture | • On-farm measures such as improved management of nutrients (excluding introducing new species), improved soil drainage, anaerobic digestion, livestock breeding and livestock diet and health measures<br>• Woodland creation rates across the UK are assumed to increase, maintaining the sector as a sink and providing about 1 $MtCO_2e$ abatement in the fourth budget period over and above current planting rates |

## *Detail*

B3.30 This scenario envisages very significant levels of low carbon heat in buildings and significant improvements in the thermal efficiency of buildings. For example, we might need as much as 166.5 TWh of low carbon heat from more than 8.6 million low carbon heat installations by 2030 (cumulative total, including low carbon heat delivered prior to the fourth carbon budget). The majority of these installations are likely to be heat pumps, with low carbon heat also coming from biomass boilers. District heating will contribute a further 38.6 TWh.

B3.31 In terms of thermal efficiency, this scenario assumes that most cavity and loft insulations have been completed by 2020. It also assumes that a high number of properties with solid walls (as opposed to cavity walls) are insulated, with 3.7 million insulations being carried out by 2030, in addition to the up to 1.5 million by 2020 that we expect from current policy. Elsewhere in buildings, it is assumed that the zero carbon homes standard is met in 2016 and 2019 for the residential and business sectors respectively. In the business sector, cost effective energy efficiency improvements are made to buildings. This scenario also envisages high ambition on low carbon heat in industry, mostly from biomass boilers and the use of biogas for combustion.

B3.32 In the transport sector, this scenario assumes that average new car emissions (including conventional combustion engine cars as well as ultra-low emission cars such as battery electric, plug in hybrid and fuel cell electric vehicles) improve to 60 $gCO_2$/km by 2030 and average new van emissions (again, including conventional vans and ultra-low emission vans) improve to 90 $gCO_2$/km by 2030. This could be delivered through different mixes of conventional vehicles and ultra-low emission vehicles, such as electric, plug-in hybrid and even hydrogen vehicles. The analysis considers an illustrative technology mix where emissions from conventional cars and vans improve to 80 $gCO_2$/km and 120 $gCO_2$/km respectively, and 40% of new cars and vans sold are battery electric, range extended electric or plug-in hybrid vehicles in 2030.[78]

B3.33 This scenario assumes that the proportion of biofuels by energy in the road transport sector remains at 8% through the 2020s. This might reflect a situation where sustainability concerns are not resolved, or where there is relatively little innovation in new feedstocks, or where there is greater uptake of bioenergy in other sectors.

B3.34 Elsewhere in transport, this scenario assumes continuing improvement in HGV efficiencies (a cumulative 5% improvement over each five-year period between 2016 and 2030). It assumes a 2% reduction in car trips in urban areas owing to either continued funding of sustainable travel measures or no diminution of the impacts of the Local Sustainable Transport Fund, as assumed in the baseline for the fourth carbon budget analysis.

B3.35 In addition to the low carbon heat measures mentioned in the summary table, this scenario assumes some initial uptake of carbon capture and storage in industry and energy efficiency improvements such as clinker substitution in cement, elimination of flaring in refineries, reduction in energy consumption during the melting process in glass furnaces, nitrous oxide reduction from nitric acid production in the chemicals sector, increased recycling of steel in the steel sector, and some additional savings through switching to electric arc furnaces.

B3.36 In agriculture we have assumed the take-up of measures such as improved nutrient management (excluding introducing new species), improved soil drainage, anaerobic digestion, improved livestock breeding, and diet and health measures. In forestry, woodland creation rates across the UK are assumed to increase, maintaining the sector as a sink and providing about 1 $MtCO_2e$ abatement in the fourth budget period over and above current planting rates.

[78] There is currently insufficient evidence to include fuel cell vehicles explicitly in the modelling of the illustrative technology mix.

## *Scenario 2: High abatement in transport and bioenergy demand*

B3.37 Under this scenario, emissions over the fourth carbon budget period would be reduced to 1,248 $MtCO_2e$ in the non-traded sector.

### Table B10: Expected activity under illustrative Scenario 2

| Sector | Expected activity |
|---|---|
| Buildings | • 3.7 million solid walls insulated over the period 2023–30<br>• Around 7.2 million low carbon heat installations in total by 2030, delivering around 138.0 TWh of low carbon heat and a further 9.6 TWh from district heating |
| Transport | • Average new car emissions = 50 $gCO_2$/km<br>• Average new van emissions = 75 $gCO_2$/km<br>• 10% biofuel, by energy<br>• 8% HGV efficiency improvement over five years |
| Industry | As Scenario 1 |
| Agriculture | As Scenario 1 |

### *Detail*

B3.38 This scenario sees a high uptake of home insulation (specifically solid wall insulation), owing to high consumer acceptance (e.g. hassle factors regarding solid wall insulation are limited), strong policy drivers (e.g. attractive long-term financing options for domestic retrofit) and strong exogenous drivers (e.g. high energy prices). But this scenario illustrates a situation where specific barriers to the uptake of low carbon heat installations are encountered, resulting in a lower number of heat pumps and lower biomass use in buildings than in Scenario 1. The high use of biomass in industry, however, suggests that this is a cost effective use of bioenergy resource in this scenario.

B3.39 This scenario assumes around 138 TWh of low carbon heat from around 7.2 million low carbon heat installations in buildings by 2030 (cumulative total, including low carbon heat delivered prior to the fourth carbon budget). A further 9.6 TWh is provided by district heating. The same level of ambition in non-domestic retrofit measures, and domestic and non-domestic new build, as in Scenario 1 is assumed.

B3.40 To still be able to meet the fourth carbon budget under this scenario, greater fuel efficiency improvements in road transport would be required relative to Scenario 1. Scenario 2 therefore assumes that average new car emmisions (including conventional combustion engine cars as well as ultra-low emission cars such as electric and plug-in hybrid vehicles) improve to 50 $gCO_2$/km, and average new van emissions (again, including conventional vans and ultra-low emission vans) improve to 75 $gCO_2$/km. As in Scenario 1, this could be delivered through different mixes of conventional vehicles and ultra-low emission vehicles such as battery electric, range extended electric, plug-in hybrid vehicles and even hydrogen vehicles. The analysis assumes an illustrative technology mix where the emisssions from conventional cars and vans fall to 80 $gCO_2$/km and 120 $gCO_2$/km respectively, as in Scenario 1, with battery electric, range extended electric and plug-in hybrid vehicles making up 50% of new car and van sales (compared with 40% in Scenario 1).

B3.41 This scenario assumes that the proportion of biofuels by energy in road transport increases from 8% in 2020 to 10% by 2030. Elsewhere in transport, this scenario assumes that HGV efficiency improves by a cumulative 8% over each five-year period between 2016 and 2030. It also assumes that rail electrification is extended to the Midland Mainline and the Welsh Valleys. There is a 5% reduction in urban car trips, which might be seen if additional funding of sustainable travel measures leads to, for example, learning benefits across local authority borders.

B3.42 As this scenario envisages high ambition in transport biofuels, as well as significant biomass use in industry, it could be considered as a high bioenergy demand scenario and gives a sense of what the maximum demand implications might be. This might reflect constraints around sustainability being overcome and technological innovation that make more advanced feedstocks viable. See paragraphs B4.42–B4.49 of this annex for an assessment of the sustainability of bioenergy supply under the fourth carbon budget scenarios.

### *Scenario 3: Focus on high electrification*

B3.43 Under this scenario, emissions over the fourth carbon budget period would be reduced to 1,249 $MtCO_2e$ in the non-traded sector.

**Table B11: Expected activity under illustrative Scenario 3**

| Sector | Expected activity |
|---|---|
| Buildings | • 1 million solid walls insulated over the period 2023–30<br>• 8.6 million low carbon heat installations in total by 2030, delivering around 165.5 TWh of low carbon heat and a further 38.6 TWh from district heating |
| Transport | • Average new car emissions = 50 $gCO_2/km$<br>• Average new van emissions = 75 $gCO_2/km$<br>• 10% biofuel, by energy<br>• 8% HGV efficiency improvement over five years |
| Industry | • All 'realistic' and some further cost effective measures, including whole-refinery optimisation in the refineries sub-sector, clinker substitution in the cement sector and increased recycling in iron and steel<br>• Committee on Climate Change's central scenario of industrial carbon capture and storage<br>• 22 ,000 additional low carbon heat installations in industry by 2030, delivering around 42 TWh of low carbon heat in industry |
| Agriculture | As Scenario 1 |

### *Detail*

B3.44 In low carbon heat the level of ambition in Scenario 1 (8.6 million low carbon heat installations, delivering 165.5 TWh of low carbon heat in buildings by 2030) is assumed. In transport the level of ambition in Scenario 2, 50 $gCO_2$/km average new car emissions is assumed. Depending on the mix of conventional and ultra-low emission cars in the fleet, this could be delivered by up to 50% of new car and van sales being battery electric or plug-in hybrids.

B3.45 This scenario assumes a lower level of ambition on residential sector retrofit (solid wall insulations) than previous scenarios. This might reflect specific consumer barriers to taking up insulation of solid walls, such as a lack of financing options. It assumes 1 million insulations being carried out by 2030, in addition to the almost 1.5 million expected by 2020 under current policy.

## *Scenario 4: Purchase of international credits*

B3.46 Under this scenario, emissions over the fourth carbon budget period would be reduced to 1,345 $MtCO_2e$ in the non-traded sector. The Government would therefore need to purchase around 85 $MtCO_2e$ worth of carbon credits. At the forecast carbon price of £51 $tCO_2e$ (£ 2011, undiscounted) on average over the fourth carbon budget period, this would cost the Government £2.7 billion in present value terms. In this scenario, both transport and low carbon heat are assumed to deliver levels of emissions reductions that are at the lower end of the ranges described in Part 2. This will necessitate faster levels of technology uptake beyond 2030, and more detail is given in the relevant sections of Part 2.

B3.47 This scenario assumes 3 million solid wall insulations over the fourth carbon budget period. The level of ambition in sectors other than transport and buildings is as in Scenarios 1, 2 and 3.

#### Table B12: Expected activity under illustrative Scenario 4

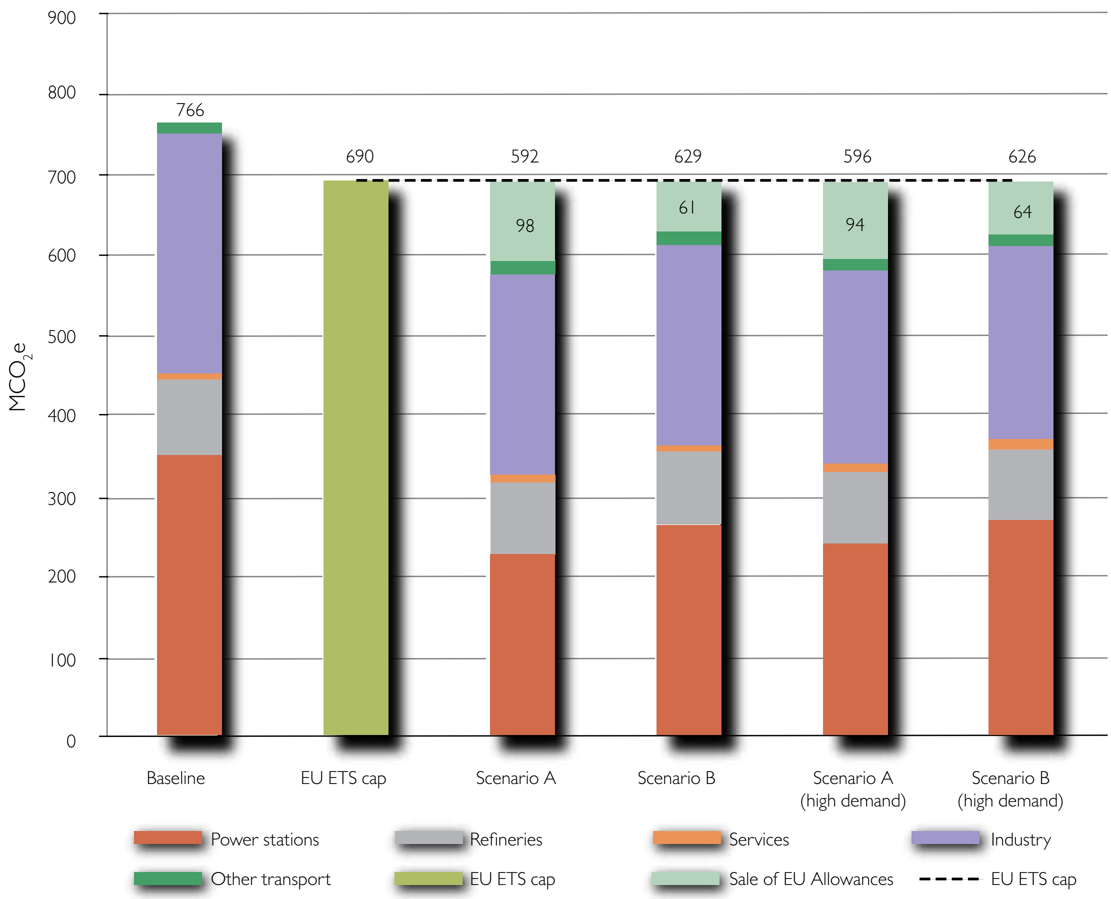
| Sector | Expected activity |
|---|---|
| Buildings | • 3 million solid walls insulated over the period 2023–30<br>• Around 1.6 million low carbon heat installations in total by 2030, delivering around 83.3 TWh of low carbon heat and a further 9.6 TWh from district heating |
| Transport | • Average new car emissions = 70 $gCO_2$/km<br>• Average new van emissions = 105 $gCO_2$/km<br>• 6% biofuel, by energy |
| Industry | As Scenario 3 |
| Agriculture | As Scenario 1 |
| Credit purchase | 85 million credits at a cost of £2.7 billion |

## *Delivering emissions reductions in the traded sector*

B3.48 The level of emissions reductions in the traded sector is dictated by the level of the EU Emissions Trading System (ETS) cap. As set out in paragraphs B3.1–B3.8 above, the trajectory at which the EU ETS cap is currently set to shrink would not be sufficient to deliver the emissions reductions needed in the power and heavy industry sectors to meet a fourth carbon budget of 1,950 $MtCO_2e$. In this respect, the fourth carbon budget was set on the assumption that the EU ETS cap will be tightened in the future.

B3.49 This report considers two illustrative scenarios showing how emissions could be reduced to 690 $MtCO_2e$, the level of traded sector emissions required over the fourth carbon budget period to meet the overall 1,950 $MtCO_2e$ level. Chart B10 below shows by how much each scenario would reduce emissions and the contribution from different sectors. Both scenarios in the traded sector assume that the EU ETS cap is tightened sufficiently to meet the fourth carbon budget. Given the assumed level of the EU ETS cap, however, both scenarios provide an opportunity for EU Allowances (EUAs) to be sold.

**Chart B10: Aggregate territorial traded sector emissions under the illustrative traded sector scenarios, 2023–27**



### *Scenario A: Power sector carbon intensity of 50 $gCO_2$/kWh*

B3.50 Under this scenario, emissions over the fourth carbon budget period would fall to either 592 $MtCO_2e$ or 596 $MtCO_2e$ in the traded sector, depending on the level of electricity demand assumed.

B3.51 In this scenario, it is assumed that emissions in the power and heavy industry sectors are reduced sufficiently in the UK to deliver the traded sector component of the fourth carbon budget. This will require significant decarbonisation of the power sector, and in Scenario A the carbon intensity of electricity generation has been modelled to reach 50 $gCO_2$/kWh by 2030. The power sector section in Part 2 gives more details on the potential implications of this for the generation mix.

B3.52 In the industry sector the same assumptions as in Scenarios 1–4 have been made.

### *Scenario B: Power sector carbon intensity of 100 $gCO_2$/kWh*

B3.53 In this scenario, emissions in the power and heavy industry sectors are reduced in the UK but with a lower level of decarbonisation in the power sector than assumed in Scenario A. This illustrative scenario assumes that the carbon intensity of electricity generation falls to 100 $gCO_2$/kWh by 2030. Emissions in this scenario are reduced to either 629 $MtCO_2e$ or 626 $MtCO_2e$ in the traded sector, depending on the level of electricity demand.[79]

B3.54 In the industry sector the same assumptions as in Scenarios 1–4 have been made.

### ***Combined impacts of traded and non-traded sector scenarios***

### *Electricity demand implications*

B3.55 The high levels of electrification in heat and transport included in the non-traded sector scenarios imply increased levels of electricity demand to be met by the power sector. For instance, Scenario 3 includes significant electrification of both heat and transport which is partially offset by increases in energy efficiency but still implies a level of electricity demand that is about 10% higher than the current government assumption of approximately 410 TWh in 2030. As a result, sensitivities reflecting high electricity demand have been modelled in both Scenario A (50 $gCO_2$/kWh) and Scenario B (100 $gCO_2$/kWh).

### *Bioenergy demand implications*

B3.56 Scenarios reflecting increased abatement in transport, heat and electricity generation imply increased demand for bioenergy. For instance, the demand for biofuels in transport, biomass and biogas for heat and the use of biomass and waste in electricity generation require a consideration of whether sufficient, sustainable supplies of bioenergy will be available. An assessment of current estimates of sustainable bioenergy supply compared with the demand trajectories implied by the fourth carbon budget scenarios is set out in paragraphs B4.42–B4.49 of this annex.

## Costs of delivering the fourth carbon budget

B3.57 Delivering the emissions reductions set out in the illustrative fourth carbon budget scenarios will impose costs on the UK economy but will also deliver benefits well beyond the end of the fourth carbon budget period. As discussed above, costs will be determined by the combination of traded and non-traded sector scenarios. On this basis, the net discounted costs of meeting the fourth carbon budget are estimated to range from **£26 billion to £56 billion (excluding the value of greenhouse gas emissions savings)** depending on the choice of ambition in different sectors and the associated electricity demand implications. When the benefits of the carbon savings that will be delivered by the illustrative scenarios are also taken into account, the net present value (NPV) ranges from a **net benefit of £1 billion to a net cost of £20 billion**.

[79] Emissions are lower under high demand owing to higher assumed low carbon heat in the industrial sector.

B3.58 These cost and benefit estimates draw on best available evidence from the UK marginal abatement cost curves evidence base and appropriate values for energy resource costs and carbon benefits as described in the methodological note that begins this annex. The costs include technical costs associated with the abatement measures in each of the scenarios, energy consumption and wider impacts such as air quality, congestion and hidden or hassle costs, where it is possible to monetise these. In the traded sector, the EUA cost of complying with the EU Emissions Trading System is also valued. Since the illustrative scenarios do not include specific policies, this assessment does not include any policy costs associated with the delivery of measures. See charts B13–B18 (pp. 204–207) of this annex for the abatement and cost effectiveness of the measures contained in each of the illustrative scenarios.

B3.59 Costs will vary between scenarios as each one comprises different levels of abatement in the key sectors. Table B13 provides a breakdown of the overall costs and benefits of each illustrative scenario in the non-traded sector of the economy.

B3.60 Scenario 4 delivers the fourth carbon budget at the lowest cost (£27 billion) since the cost of purchasing international credits is cheaper than undertaking further territorial abatement. However, Scenarios 1 and 3 have the highest net present values because of their additional emissions savings.

B3.61 The key driver of the variation in costs between the scenarios is the level of ambition in the transport and low carbon heat sectors. The effects of the different levels of ambition on costs can be counter-intuitive. For example, district heating is only included in the higher ambition scenarios for low carbon heat. District heating is considered ambitious because of a number of barriers to deployment that will need to be addressed. These include planning and consent from local authorities, identifying and matching demand for heat with supply, and raising capital for investment in heat networks. Nevertheless, the network benefits of district heating mean that it is relatively cost effective compared with installing large numbers of heat pumps. For this reason, Scenario 2, which does not include district heating,

**Table B13: Emissions levels and NPV of the illustrative non-traded sector scenarios**

| | **Fourth carbon budget emissions ($MtCO_2e$)** | **Costs (£ billion 2011)** | | | | **Benefits (£ billion 2011)** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Scenario | Non-traded | Capital | Admin | Other | Credit purchase | Energy savings | EU Allowances savings | Other | Non-traded savings | NPV | Net present cost (excluding the value of greenhouse gas emissions) |
| 1 | 1,253 | −77.6 | −1.5 | −5.7 | – | 37.4 | −3.0 | 6.6 | 41.8 | −2.0 | −43.8 |
| 2 | 1,248 | −79.5 | −1.5 | −4.6 | – | 33.0 | −2.9 | 7.3 | 36.5 | −11.7 | −48.2 |
| 3 | 1,249 | −80.9 | −0.5 | −0.3 | – | 37.8 | −3.4 | 5.7 | 39.3 | −2.4 | −41.6 |
| 4 | 1,260 (1,345) | −38.2 | −1.2 | −11.1 | −2.7 | 21.5 | −0.1 | 5.3 | 19.0 | −7.5 | −26.5 |

### Table B14: NPV of the illustrative traded sector scenarios, central electricity demand (£ billion 2011)

| | Costs | | Benefits | | | |
|---|---|---|---|---|---|---|
| Scenario | Capital | Other | Energy savings | EU Allowances savings | Other | NPV |
| A (50 $gCO_2$/kWh) | −31.8 | −1.4 | 11.6 | 17.5 | 1.7 | −2.5 |
| B (100 $gCO_2$/kWh) | −23.2 | −1.4 | 8.8 | 14.6 | 1.7 | 0.5 |

appears to be relatively costly despite its lower level of ambition in low carbon heat.

B3.62 In the traded sector of the economy, the difference in costs between the two illustrative scenarios is driven by the different levels of ambition in the power sector. For instance, decarbonising the power sector to reach a carbon intensity target of 50 $gCO_2$/kWh by 2030 is more costly – imposing a net cost – than aiming for a target of 100 $gCO_2$/kWh by 2030, which delivers a small net benefit. Table B14 provides a breakdown of the overall costs and benefits of the traded sector scenarios under a central electricity demand scenario.

B3.63 The high levels of electrification in heat and transport included in the non-traded sector scenarios imply increased levels of electricity demand to be met by the power sector. For instance, Scenario 3 includes significant electrification of both heat and transport which is partially offset by increases in energy efficiency but still implies a level of electricity demand that is about 10% higher than the current government assumption of approximately 410 TWh in 2030. To take account of this impact, sensitivity analysis of the power sector under both Scenarios A and B has been conducted.

B3.64 Table B15 provides a breakdown of the overall costs and benefits of the traded sector scenarios under a high electricity demand scenario. The energy savings shown have been adjusted to avoid the double counting of costs when the traded and non-traded scenarios are combined. For this reason, it is not possible to compare costs of the high electricity demand scenario directly with those of the central electricity demand scenario.

### Table B15: NPV of the illustrative traded sector scenarios, high electricity demand (£ billion 2011)

| | Costs | | Benefits | | | |
|---|---|---|---|---|---|---|
| Scenario | Capital | Other | Energy savings* | EU Allowances savings | Other | NPV |
| A (50 $gCO_2$/kWh) | −38.0 | −1.7 | 11.7 | 18.4 | 1.7 | −7.9 |
| B (100 $gCO_2$/kWh) | −28.7 | −1.7 | 16.1 | 15.6 | 1.7 | 3.0 |

*Adjusted to allow summation with non-traded scenarios

## *Combined impact of traded and non–traded sector scenarios*

B3.65 Scenarios 1–4 in the non-traded sector imply different levels of electricity demand. Consequently, it is important to combine the non-traded and traded sector scenarios so that the electricity demand assumptions are consistent when assessing the whole-economy effects of the illustrative scenarios. For example, Scenario 3, which includes high levels of electrification in heat and transport, has the impact of increasing electricity demand by about 10% in 2030. This scenario is only compatible with traded sector Scenarios A or B under high electricity demand. Levels of electrification in Scenario 4 suggest that Scenarios A or B under central demand would be an appropriate combination. The electricity demand implications for Scenarios 1 and 2 fall between the central and high demand levels shown for the traded sector scenarios and could be consistent with either of the Government's central or high electricity demand assumptions. Consequently, Scenarios 1 and 2 could potentially be combined with Scenarios A or B under either central or high electricity demand. Table B16 reflects the aggregate costs of the fourth carbon budget scenarios under the various appropriate traded and non-traded sector combinations.

### Table B16: Cumulative NPV of the illustrative non-traded and traded scenarios (£ billion 2011)

| | Net present cost (excluding value of greenhouse gas emissions) | NPV |
|---|---|---|
| **Central electricity demand** | | |
| Scenarios A + 1 | −£46bn | −£4bn |
| Scenarios A + 2 | −£51bn | −£14bn |
| Scenarios A + 4 | −£29bn | −£10bn |
| Scenarios B + 1 | −£43bn | −£2bn |
| Scenarios B + 2 | −£48bn | −£11bn |
| Scenarios B + 4 | **−£26bn** | −£7bn |
| | | |
| **High electricity demand** | | |
| Scenarios A + 1 | −£52bn | −£10bn |
| Scenarios A + 2 | **−£56bn** | **−£20bn** |
| Scenarios A + 3 | −£49bn | −£10bn |
| Scenarios B + 1 | −£41bn | **+£1bn** |
| Scenarios B + 2 | −£45bn | −£9bn |
| Scenarios B + 3 | −£39bn | +£1bn |

*The upper and lower bounds in each column have been highlighted

## *Uncertainty in cost estimates*

B3.66 Cost estimates for all the illustrative scenarios are subject to significant uncertainty given the range of assumptions included about the evolution of future economic growth, fossil fuel prices and technology costs so far into the future.

B3.67 The tables below reflect the results of some limited sensitivity analysis on fossil fuel prices, technology costs and the extent of transport rebound effects and indicate that the overall costs of delivering the fourth carbon budget could vary significantly.

## *Technology sensitivities*

B3.68 In transport, government's central assumption is that battery costs will fall to $300/kWh by 2030 (from up to $1,000/kWh reported currently). This contrasts with the Committee on Climate Change (CCC) analysis, which assumed that battery costs in 2030 would be $200/kWh. Table B17 shows how the NPV of the high transport ambition scenarios would change under different battery cost assumptions.

### Table B17: Sensitivity of the NPV estimates to vehicle battery costs (£ billion 2011)

| High ambition transport | Low battery costs ($150/kWh) | High battery costs ($800/kWh) |
|---|---|---|
| Scenario 2 −£12bn NPV | −£3bn | −£45bn |
| Scenario 3 −£2bn NPV | +£7bn | −£36bn |

B3.69 The modelling on the costs and benefits of low carbon heat shown here assumes that heat pumps' coefficient of performance (COP) improves by 0.7 by 2030. This contrasts with the CCC's assumption that the COP will improve by 1.5 by 2030. Table B18 shows how the NPV of Scenario 2 would change under different assumptions. The low improvement sensitivity assumes that the COP improves by no more than 0.1. The high improvement sensitivity assumes that the COP improves by 1.5.

### Table B18: Sensitivity of the NPV estimates to improvements in heat pumps' coefficient of performance

| Central ambition low carbon heat | Low improvements in heat pump COP | High improvements in heat pump COP |
|---|---|---|
| Scenario 2 −£12bn NPV | −£15bn | −£11bn |

## *Fossil fuel price sensitivities*

B3.70 Many of the abatement measures included in the illustrative scenarios also reduce the consumption of fossil fuels. This reduction in energy use is valued as a benefit. Given the uncertainty around energy prices, the Department of Energy and Climate Change frequently shows how costs and benefits would differ under different energy price assumptions. Table B19 shows how the NPV of the high transport ambition scenarios would change if different fossil fuel price assumptions were used for the transport analysis.[80] Note that these changes reflect changes to the NPV of the transport measures only. If the effect of different fossil prices were accounted for in all sectors, the change would be significantly larger.

### Table B19: Sensitivity of the NPV estimates to the fossil fuel price assumptions used for the transport analysis only (£ billion 2011)

| High ambition transport | Low fossil fuel prices | High fossil fuel prices |
|---|---|---|
| Scenario 2 −£12bn NPV | −£20bn | −£6bn |
| Scenario 3 −£2bn NPV | −£10bn | +£4bn |

B3.71 Table B20 shows how the NPV of Scenario 2 would change if different fossil fuel price assumptions were used for the low carbon heat analysis. Note that these changes reflect changes to the NPV of the low carbon heat analysis only.

[80] For more information on the Department of Energy and Climate Change's fossil fuel price assumptions see: www.decc.gov.uk/en/content/cms/about/ec_social_res/analytic_projs/ff_prices/ff_prices.aspx

### Table B20: Sensitivity of the NPV estimates to the fossil fuel price assumptions used for the low carbon heat analysis only (£ billion 2011)

| Central ambition low carbon heat | Low fossil fuel prices | High fossil fuel prices |
|---|---|---|
| Scenario 2 −£12bn NPV | −£12bn | −£11bn |

B3.72 Table B21 shows how the NPV of Scenario B (central demand) would change if different fossil fuel price assumptions were used for the power sector analysis. Note that these changes reflect changes to the NPV of the power sector analysis only.

### Table B21: Sensitivity of the NPV estimates to the fossil fuel price assumptions used for the power sector analysis only (£ billion 2011)

| Central ambition power sector | Low fossil fuel prices | High fossil fuel prices |
|---|---|---|
| Scenario B (central demand) +£1bn NPV | −£8bn | +£6bn |

## *Rebound effect sensitivities*

B3.73 Evidence suggests that greater vehicle efficiency will result in a rebound effect, in which lower driving costs encourage additional driving. The costs of this additional driving, such as increased congestion, are included in the estimated total costs of the scenarios. Table B22 shows how the NPV of the high transport ambition scenarios would change if the rebound effect were omitted, in order to demonstrate the significance of assumptions on the scale of the rebound effect.

### Table B22: Sensitivity of the NPV estimates to the rebound effect in the transport analysis only (£ billion 2011)

| High ambition transport | No rebound effect |
|---|---|
| Scenario 2 −£12bn NPV | −£10bn |
| Scenario 3 −£2bn NPV | −£0bn |

# B4. Wider impacts

## Impact of energy and climate change policies on UK growth

B4.1 Overall, studies indicate that the long-term growth benefit from avoiding climate change will exceed the cost of co-ordinated global action to tackle climate change by helping to avoid the potentially catastrophic implications of failing to act.[81] In the shorter term, policies to meet the UK carbon budgets can bring economic benefits from increased resource and energy efficiency, innovation in low carbon technologies, and resilience to the impacts of high fossil fuel prices. However, there will be transition costs from the increased costs of energy for some businesses and households, the investment and innovation foregone in other areas, and the competitiveness impact if UK policy is out of step with competitor countries. Current economic circumstances highlight the need for climate policy to be cost effective, to maximise the economic benefits and growth opportunities and minimise negative impacts.

B4.2 Most published analysis suggests that current UK ambition on climate change can be achieved without large impacts on overall short-term economic output. The impacts of the policies to meet the first three carbon budgets and illustrative measures to meet the fourth budget have been modelled using the HM Revenue and Customs Computable General Equilibrium model. Results indicate that the first three carbon budgets could be met at an average cost of around 0.4% of GDP a year over the period 2011–22, and the fourth carbon budget could be met at an average cost of around 0.6% of GDP a year over the period 2023–27. The impacts on GDP could be lower or higher depending on a range of factors, including primary (fossil) energy costs and the costs of low carbon technologies.

B4.3 It should be noted that this modelling does not reflect all the potential benefits and costs. On the benefits side, it does not reflect social externalities such as health benefits from, for example, improved air quality and lower congestion, innovation benefits are not fully captured, and the modelling largely assumes that the UK acts unilaterally, rather than reflecting action to reduce emissions by other countries. Importantly, the modelling results also do not account for the benefit of avoiding significant risks to future UK growth (particularly in the long term) from global climate change. On the costs side, the modelling assumes that policies are implemented both on time and to cost, and does not take account of any social costs such as the welfare impacts of any behaviour change (e.g. reduced travel).

## Fiscal impact of energy and climate change policies

B4.4 Meeting the fourth carbon budget requires no new policies this Parliament, and thus is consistent with Government's deficit reduction plans as set out in Spending Review 2010, Budget 2011, and the recent Autumn Statement.

B4.5 In the longer term, government will take into account the fiscal impact, including the impacts on taxation, public spending and public borrowing, when deciding upon the mix of policies used to meet the fourth carbon budget. The technical abatement characterised in section B3 of this annex could be accessed by a range of different policies including voluntary agreements, regulation, taxation and spending. The fiscal impacts of climate policy will also depend upon a range of factors such as technology costs, carbon prices, fossil fuel prices and policy effectiveness.

81 The Stern Review (www.hm-treasury.gov.uk/sternreview_index.htm) found that the global costs of climate change could be between 5% and 20% of GDP per annum if we fail to act, dwarfing the costs of effective international action, estimated at 1–2% of global per capita consumption by 2050. The lower figure is a minimum. When the model incorporates non-market impacts and more recent scientific findings, the total average cost is 14.4%. The 20% figure also reflects the disproportionate burden of impacts on poor regions of the world.

B4.6 Broadly speaking, the taxable capacity of the economy is linked to GDP. Within overall taxable capacity, as noted by the Committee on Climate Change[82] and the Office for Budget Responsibility,[83] the move to a low carbon economy could increase receipts from some taxes while putting downward pressure on others, suggesting that the contribution of different taxes to revenues is likely to change over the long term. In the Coalition Agreement,[84] the Government committed to increase the proportion of tax revenue accounted for by environmental taxes.

## Impacts on electricity security of supply

B4.7 There are three different linked challenges under the general banner of security of electricity supply:

- **diversification of supply:** how to ensure that we are not over-reliant on one energy source or technology and reduce our exposure to high and volatile prices;
- **operational security:** how to ensure that, moment to moment, supply matches demand, given unforeseen changes in both; and
- **resource adequacy:** how to ensure that there is sufficient reliable capacity to meet demand, for example during winter anticyclonic conditions where demand is high and wind generation low for a number of days.

B4.8 Increasing amounts of inflexible and/or intermittent low carbon generation should help to address the first challenge. However, a higher level of intermittent generation potentially makes the second and third challenges greater.

B4.9 As part of the Electricity Market Reform (EMR) programme, the Department of Energy and Climate Change has concluded that there are risks to future security of electricity supply. The analysis and evidence underpinning that judgement are contained in the EMR White Paper and the accompanying Impact Assessment.[85] In order to reduce the risks to security of electricity supply, the Department of Energy and Climate Change has indicated that a capacity mechanism is necessary and, as part of the EMR White Paper, the Government has consulted on the most appropriate type of capacity mechanism. The Government will publish its decision on the choice of capacity mechanism at the turn of the year.

B4.10 The assessment of future security of electricity supply has been updated to take account of revised fossil fuel prices, demand assumptions and carbon values as part of the Carbon Plan. Evidence from modelling of the electricity system by consultants Redpoint Energy suggests that in the absence of a capacity mechanism, margins could fall to low levels and increase risks to security of supply. Chart B11 shows de-rated capacity margins over the period to 2030 under both 100 $gCO_2/kWh$ and 50 $gCO_2/kWh$ scenarios (i.e. the percentage by which generation exceeds peak demand taking into account the probability that plants of different types will be unavailable). It also shows that with a capacity mechanism, margins can be maintained at a higher level.[86]

B4.11 The years immediately after 2010 are characterised by increasing capacity margins. This is a result of a combination of pre-committed

[82] Committee on Climate Change (2010) *The Fourth Carbon Budget: Reducing emissions through the 2020s*. Available at: www.theccc.org.uk/reports/fourth-carbon-budget

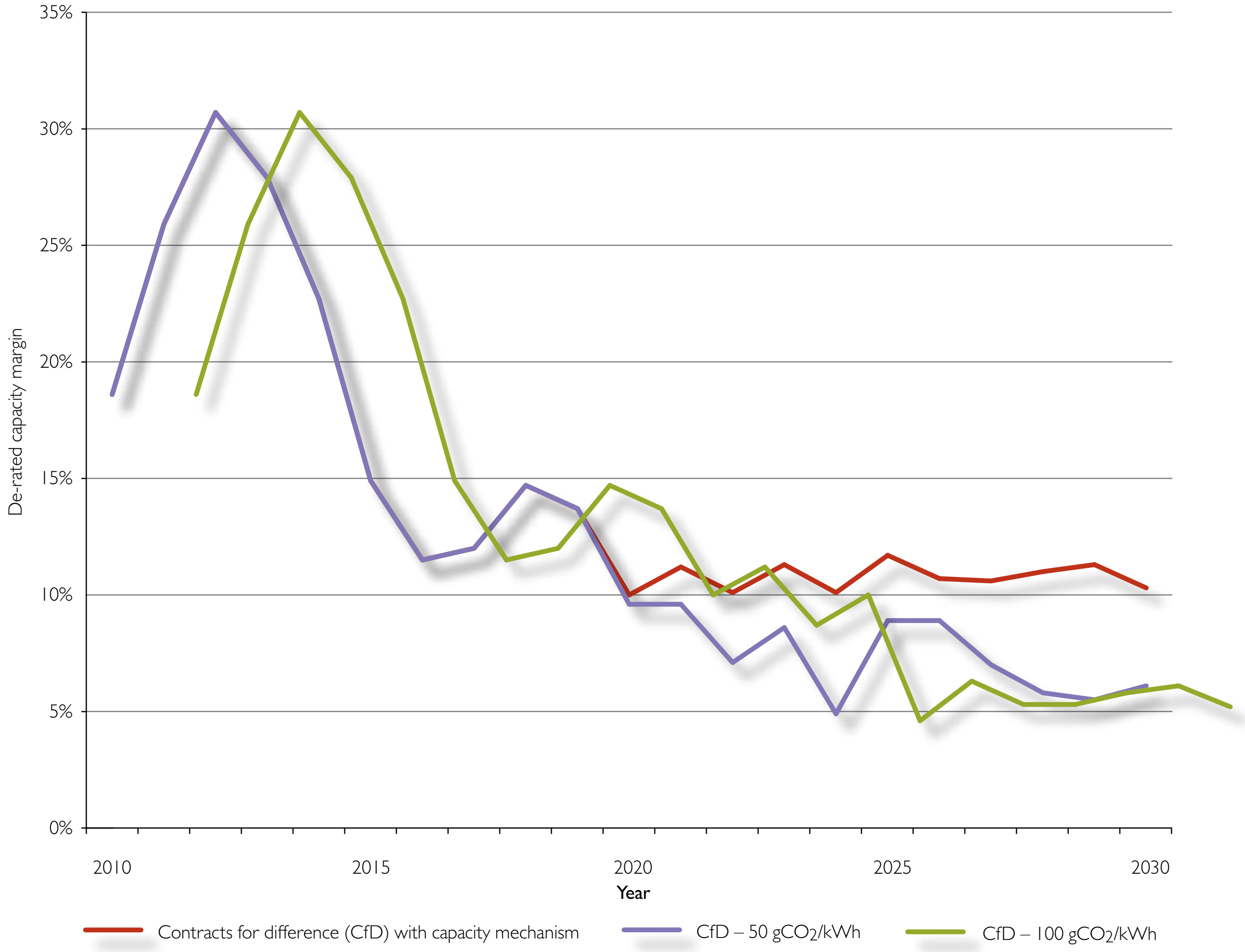
[83] Office for Budget Responsibility (2011) *Fiscal Sustainability Report*. Available at: http://budgetresponsibility.independent.gov.uk/fiscal-sustainability-report-july-2011/

[84] www.cabinetoffice.gov.uk/news/coalition-documents

[85] See: www.decc.gov.uk/en/content/cms/legislation/white_papers/emr_wp_2011/emr_wp_2011.aspx

[86] Note that the capacity mechanism reflected in this chart is a strategic reserve, but in the modelling, either a strategic reserve or a market-wide mechanism will have the effect of increasing de-rated capacity margins to around 10% or as close as is possible given the lumpy nature of investment.

## Chart B11: De-rated peak capacity margins under different power sector scenarios




gas-fired stations coming online and demand being lower than expected given the economic downturn. After 2012, the de-rated capacity margin falls as old coal stations are scheduled to retire under the Large Combustion Plant Directive around the middle of the decade, and nuclear plants reach the end of their scheduled lifetimes. Note that demand is not projected to rise to 2020 due to relatively low economic growth forecasts and improvements in energy efficiency. However, plant retirements and increasing amounts of intermittent generation lead the de-rated capacity margin to fall below 10% in the early 2020s and reaching 5% in more than one year under both decarbonisation policies.

B4.12 Note that in the modelling analysis, following a 100 $gCO_2$/kWh or 50 $gCO_2$/kWh decarbonisation trajectory makes relatively little difference in terms of capacity margins as the modelling assumes that retirement and new build decisions for unabated fossil fuel plant adjust to the different wholesale price signals under the two scenarios. In the 100 $gCO_2$/kWh scenario, the wholesale electricity market provides sufficient price signals for investment in new gas stations. In the 50 $gCO_2$/kWh scenario, wholesale electricity prices fall significantly due to the amount of new low carbon, low generating cost plant in the generation mix, thereby reducing the opportunities for conventional generators to earn a return on their investment. Consequently, there is no new investment in gas power stations beyond the pre-committed gas plant that comes online around 2012. Under both scenarios, a capacity mechanism reduces the risk of demand not being met.

## Sustainability and wider environmental impacts

### Summary

B4.13 Policies to meet the fourth carbon budget pose risks and opportunities relating to air quality, water, noise, biodiversity and landscape and their associated ecosystem services. Increased **use of bioenergy** in particular appears to have the greatest potential impacts on the wider environment.

B4.14 **Scenario 3**, which assumes high abatement from **electrification**, has the highest potential benefits for air quality and noise.

B4.15 Various mechanisms exist already to limit extreme impacts on the wider environment from decarbonisation policies; however, the use of an **ecosystem approach** at policy and project level is needed to achieve a more optimal use of natural capital that addresses risks and synergies at the appropriate spatial scale.

### Purpose, scope and approach

B4.16 This section offers a preliminary and broad assessment of the wider environmental impacts of the policy directions and scenarios envisaged for the fourth carbon budget. Section 13(3) of the Climate Change Act 2008 states that proposals and policies for meeting carbon budgets must, when taken as a whole, 'be such as to contribute to sustainable development'. Tackling climate change is essential for maintaining a healthy, resilient natural environment, as highlighted in the Government's **Natural Environment White Paper**,[87] published in June 2011. The White Paper re-committed to ensuring that the value of nature (which is often hidden) is appropriately reflected in all relevant policy decisions.[88]

B4.17 The White Paper, building on the ground-breaking **UK National Ecosystem Assessment** (NEA), uses the concept of 'natural capital': nature represents a stock of assets, which provides flows of 'ecosystem services'[89] from which society benefits in numerous although often undervalued ways. It includes living things in all their diversity, the landscape and its heritage, wildlife, rivers, lakes and seas, urban green space, woodland and farmed land. Natural capital interacts with produced, human and social capital to support economic activity and human wellbeing.[90]

B4.18 **Monetised estimates of the ecosystem values at stake are partial and uncertain but substantial.** For instance, one major study found that optimising climate change policies to improve air quality could yield benefits of £24 billion by 2050; the annual value of protecting marine biodiversity in UK waters is estimated at £1.7 billion, and the annual benefits of achieving good ecological status for water bodies are in the region of £1 billion. The NEA sets out further evidence on monetised values classified by ecosystem service type.[91]

B4.19 A range of policies at domestic and European level have been developed to safeguard and enhance these values, such as air emission limits, the Water Framework Directive, the Birds and Habitats Directive, the Environmental Noise Directive and marine planning. In October 2010 the UK Government played a key role in concluding the historic global agreement in Nagoya to protect and enhance biodiversity worldwide, which led to the England Biodiversity Strategy, launched in August 2011. The strategy, like the NEA, emphasises the importance of long-term planning to achieve a more integrated use of natural capital that delivers multiple ecosystem services. The White Paper and the NEA also stress

87 Defra (2011) *The Natural Choice: securing the value of nature*. Available from: www.defra.gov.uk/environment/natural/whitepaper/

88 This assessment is intended to also inform the White Paper commitment to 'establishing a research programme to fill evidence gaps about impacts on the natural environment of the level of infrastructure needed to meet 2050 [low carbon] objectives'.

89 See: Millennium Ecosystem Assessment and TEEB (2010) *The Economics of Ecosystems and Biodiversity*. These services have been categorised as: **provisioning** (e.g. food, timber); **regulating** (e.g. water purification, pollination); **cultural** (e.g. recreation, aesthetic) and **supporting** (e.g. soil formation, genetic diversity).

90 Defra (2010) *A Framework for Understanding the Social Impacts of Policy and their Effects on Wellbeing*. Available from: www.defra.gov.uk/publications/files/pb13467-social-impacts-wellbeing-110403.pdf

91 See: www.defra.gov.uk/publications/files/pb13583-biodiversity-strategy-2020-110817.pdf

the need for decision making at appropriate spatial scales, valuing changes in services where possible but considering 'shared social values' as well as economic valuations.

B4.20 The Department for Environment, Food and Rural Affairs (Defra) environmental appraisal guidance incorporates this ecosystems approach and the White Paper has also committed to publishing supplementary HM Treasury Green Book guidance on valuing the natural environment in appraisals.[92] **This guidance has informed this initial assessment and will be important to incorporate into policy and project development.**

## *Assessment of risks and opportunities*

B4.21 Table B23 below summarises the most important risks, synergies and trade-offs that the fourth carbon budget presents to the wider environment. The rest of this section provides a more detailed assessment by type of measure and sector, and the potential for mitigating risks, drawing on qualitative and (for air and noise) quantitative analysis.

B4.22 A high-level assessment of the impacts from the fourth carbon budget scenarios in the wider environment is set out in the list on page 186, followed by more detail on particular technologies and their wider impacts.

### Table B23: Risks and opportunities associated with the fourth carbon budget

| | Risks | Opportunities |
|---|---|---|
| Air quality | • Use of biomass, with an estimated cost of £48 million in Scenario A and £31 million for the non-traded Scenario 2<br>• **Transport** – increased fuel efficiency leading to increased vehicle usage | • **Clean electricity production** (excluding biomass) has potential benefits of between £25 million and £72 million for Scenarios A and B respectively<br>• **Electrification of transport** creates potential benefits of approximately £102 million (as per Scenario 1) |
| Biodiversity | • Potential long-term impacts from the conversion of natural habitats to comply with high **bioenergy** scenarios (i.e. increased use of biomass and biofuels from first generation crops) | • Potential benefits if domestic **bioenergy** expansion brings unmanaged woodland into management and diversifies range of habitats<br>• **Cleaner power stations** could reduce eutrophication |
| Landscape | • Potential risks from siting and design of **new electricity generation** infrastructure | • Potential benefits where fourth carbon budget policies incentivise active management of woodlands (**bioenergy**) |
| Noise and nuisance | • **Transport** – increased vehicle efficiency leading to increased vehicle usage<br>• Noise from some **renewable sources** may lead to unwelcome neighbourhood-level impacts | • **Impacts of transport measures, including sustainable travel measures**, could reduce noise, with a net benefit of £61 million in Scenario 1 |
| Marine | • Risk of impacts to marine habitat and noise-sensitive species from expansion of **offshore activities and tidal energy** | • Possible ecological benefits from the artificial reef provided by foundations to **offshore wind turbines** |
| Water | • Impacts on water availability arising from abstraction by new power stations, depending on location and climate<br>• Ground-source heating and cooling schemes impact water quality and ecology | • Fourth carbon budget policies could incentivise active management of woodlands (**bioenergy**) |

[92] See: www.defra.gov.uk/corporate/about/how/policy-guidance/env-impact-guide/

- **Scenario 1**, having a focus on high abatement in low carbon heat, implies that higher tensions are expected from noise.
- **Scenario 2**, which has a focus on high abatement in transport and bioenergy demand, is associated with higher tensions in air quality and biodiversity from increased biomass use, although there may be some biodiversity and landscape benefits.
- **Scenario 3**, which has a focus on high electrification, has the highest potential benefits for air quality and noise.
- **Scenario 4** and **Scenario B** allow for the **use of international credits** and so the ambition of domestic climate change mitigation policies is reduced. As a result, both potential opportunities and risks could be shifted abroad.
- **Scenario A** refers to **high ambition in the power sector** and presents a wider range of potential for tensions: air quality, landscape, noise, water and marine. There is potential for mixed impacts in biodiversity and waste, but also some potential opportunities for air quality.

## *Agricultural measures*

B4.23 On-farm voluntary measures contained in the fourth carbon budget offer both synergies and tensions between reducing greenhouse gas emissions and other environmental outcomes, such as air quality, biodiversity and water pollution. Broader soil measures to reduce carbon (such as measures to maintain soil organic matter and reduction in the horticultural use of peat as outlined in the Natural Environment White Paper) could bring carbon and biodiversity benefits. Defra will be working with stakeholders to minimise adverse impacts and develop integrated advice for farmers.

## *Low carbon heat and bioenergy expansion*

B4.24 One of the fourth carbon budget scenarios focuses on the **expansion of low carbon heat** using technologies such as ground-source heat pumps and air-source heat pumps (**Scenario 1**). There is a need to carefully balance the desire to see take-up in these technologies with the need to ensure that local impacts are acceptable. Unless properly designed, ground-source heat pumps can pose risks to water ecology. Air-source heat pumps can also produce unwelcome **noise** for the surrounding neighbourhood; poor siting, installation and maintenance can exacerbate these effects. Where the fourth carbon budget scenarios focus on the expansion of **biomass use for electricity** and/or low carbon heat (as per Scenario 2 in the non-traded sector and Scenario A in the traded sector), this can have unintended environmental impacts that must also be considered. A large-scale move to biomass boilers could emit levels of harmful particulate matter and nitrous oxide that impact on **air quality**. This may in turn threaten compliance with both ambient air quality and national emission ceilings directives. The air quality impacts of the increased use of biomass under Scenario A are around £48 million and approximately £31 million for Scenario 2 where there is low carbon heat ambition but relatively higher use of biomass compared with Scenarios 1 and 3.

B4.25 Domestically, a change of **land management** from arable crops or grassland to biomass or energy crops brings opportunities as well as risks. More active and sustainable management of woodlands for wood fuel could lead to landscape, recreational and biodiversity gains. Analysis in the National Ecosystem Assessment (NEA) (using Wales as a case study) highlights the potential for major recreational benefits where woodland is created in lowland urban fringe areas, close to population centres. It also indicates the dual risks where the planting of forests in peatland areas dries out wetlands and can result in net carbon release rather than storage. There is strong evidence to support woodland creation in appropriate locations to achieve water management and water quality objectives, including tackling diffuse pollution and regulating water flow.

B4.26 Department of Energy and Climate Change analysis on the sustainability of bioenergy supply highlights that certain sectors may need to rely on imports to meet demand in the near and longer term (i.e. biofuels for transport, and woody biomass and domestic biogas for heat). This could lead to land use change abroad, with direct or indirect loss of natural or near natural habitats/ecosystems and the services provided to local populations if adequate sustainability controls are not in place. See from paragraph B4.42 below for a discussion on bioenergy supply.

B4.27 Combined heat and power could also have air quality impacts by moving combustion closer to residential locations. Some of these negative impacts may be offset through associated increases in efficiency and emissions control.

B4.28 **Potential to mitigate risks:** Air pollution from the combustion of biomass can be controlled through strong limits on the levels of emissions on both large-scale use (through the Industrial Emissions Directive) and small-scale sources (such as introducing emissions standards on domestic boilers). Negative landscape impacts could be minimised by carefully considering the location of land use changes and uptake of sustainable management practices. The ability to reduce site specific impacts on biodiversity is reinforced by current requirements to carry out Environmental Impact Assessments (EIAs) where there are likely to be significant environmental effects. Through judicious choice of location, good design and good management, there will be opportunities to mitigate and in some places enhance biodiversity and associated ecosystem services as envisaged in national biodiversity action plans.

## *New power plants*

B4.29 Virtually all nationally significant energy infrastructure projects will have effects on the **landscape**. Landscape effects depend on the existing character of the local landscape, how highly it is valued and its capacity to accommodate change. Impacts on biodiversity may be reduced by the construction of cleaner power stations (coal power stations produce nitrogen oxides that cause eutrophication and acidification), but there may also be potential for habitat disturbance from construction of stations and power lines.

B4.30 Impacts on **water** availability could occur in the future if new stations are built in areas where water or discharge capacities are not adequately developed. These impacts could exacerbate future water availability issues as a result of climate change and population growth. Traditional power plants tend to have low water loss[93] factors, which vary depending on the generation type and the method of cooling used, yet volumes of water abstracted can impact on fish and other aquatic life. Reduction in river flows due to climate change could exacerbate this issue. **Carbon capture and storage (CCS)** can increase water use. Recent studies of the extra water demand associated with CCS indicate that it can increase **water** use by 91–100%,[94] which may have implications in the catchments where fossil fuel power stations are currently clustered. This could make such CCS power stations more vulnerable at low water flow times (late summer), with potential to affect security of electricity supply. Defra is working closely with the Department of Energy and Climate Change and the Environment Agency over the coming year to further understand these issues.

B4.31 CCS could also have an impact on air quality as CCS requires more power (in particular for capture and compression) than conventional plants. However, it should be noted that plants fitted with CCS will have to comply with emissions limits set by the Industrial Emissions Directive. CCS generation as assumed in **Scenario A**, where carbon intensity in the power sector falls to 50 g/kWh by 2030, leads to an estimated air quality cost of around £69 million relative to a counterfactual without the Electricity Market Reform measures. In contrast, **Scenario B**, with a carbon intensity of 100 g/kWh by 2030 and a lower reliance on CCS generation relative to the same counterfactual, leads to an estimated benefit of £3 million.

B4.32 **Potential to mitigate risks:** There are various ways to minimise the wider environmental impacts of new power stations, including measures that can be taken at the planning and design

[93] Water that is not returned to the river after being used for cooling (such as water losses produced by evaporation).

[94] Zhai, H and Rubin, ES (2010) Performance and cost of wet and dry cooling systems for pulverised coal power plants with and without carbon capture and storage. *Energy Policy* 38(6):5653–5660; National Energy Technology Laboratory (2005) *Power Plant Water Usage and Loss Study*. United States Department of Energy.

stage. The *Overarching National Policy Statement for Energy* sets out guidance for considering the wider impacts of nationally significant energy developments, including when they are proposed within a protected area.[95]

## *Offshore and onshore wind power*

B4.33 Commercial-scale wind turbines by their nature (typically 125–150 m tall) will have an impact on the **landscape** and **seascape**. There may also be impacts on areas that are important for nature and heritage conservation. Large-scale wind farms, especially offshore, also pose significant demands for new cable links and substations that can cover large areas (around 20 ha).

B4.34 The construction of offshore turbines mainly poses risks for **marine biodiversity**. Noise from exploration, construction, operation and decommissioning of wind power can have a negative impact on noise-sensitive species. While new offshore turbine foundations that provide a hard substrate can increase the diversity of the immediate environment, they can also act as stepping stones for invasive species that can colonise and spread.

B4.35 **Potential to mitigate risks:** National Policy Statements (NPSs) for energy infrastructure and other planning policy steer major and large-scale commercial development of onshore turbines away from protected landscapes and internationally designated sites. For onshore wind turbines that are likely to have significant environmental effects, an EIA will be necessary, which should identify mitigation measures to remove or reduce the effects to acceptable levels.

B4.36 Larger offshore wind developments will be covered by NPSs for energy instrastructure, while wider decisions on offshore development[96] will now be taken under the new system of marine planning and licensing. Regulators will also require an EIA for any renewable energy licence applications where there is a likelihood of significant environmental effects and will identify mitigation options. There are explicit requirements under the Marine Strategy Framework Directive to ensure that permanent alterations to hydrographical conditions, including underwater noise, do not adversely affect the marine environment.

## *Tidal and wave power generation*

B4.37 Tidal energy generation and installation can affect **marine biodiversity** through habitat change and loss, depending upon the type of device and habitat. Devices with moving parts are likely to have greater impacts than those without. Tidal power may also affect the characteristics of the flow regime in estuaries. There may also be the potential for direct impacts on species, for example barrier effects (especially for migratory species), collisions and noise from installation, operation and decommissioning.

## *Transport*

B4.38 There are potential synergies and tensions for **air quality** in the transport sector that relate to measures identified in the fourth carbon budget. The transport measures assumed in Scenario 1 lead to potential improvements in air quality of around £102 million over the period (2011–27). This figure only takes into account the direct impacts on transport emissions, with the additional power sector impacts accounted for elsewhere.

B4.39 **Noise** benefits under this scenario would be approximately £61 million and relate to sustainable transport measures, which reduce car kilometres travelled, as well as some additional benefits from increased electrification.

B4.40 Improvements in average fuel efficiency that are achieved through increased conventional car fuel efficiency would have notable noise impacts. Analysis of the impacts of current policies that help to meet the first three carbon budgets reveals significant costs associated with increased noise and nuisance (approximately £402 million over the period). This is mainly a consequence of the increase in kilometres driven in response

[95] DECC (2011) *Overarching National Policy Statement for Energy (EN-1)*.

[96] This framework also applies to tidal and wave power generation as described in the next section.

to greater fuel efficiency and the resultant fall in driving costs.

B4.41 **Potential to mitigate impacts:** Higher blends of biofuels than are currently envisaged for use in the UK vehicle fleet could potentially increase emissions from vehicles[97], whereas others – such as biomethane – can deliver air quality benefits. Moving away from diesel vehicles could also have a positive impact on air quality. Any actions that encourage the electrification of the vehicle fleet are expected to improve both environmental noise by reducing engine noise and air pollution by reducing emissions.

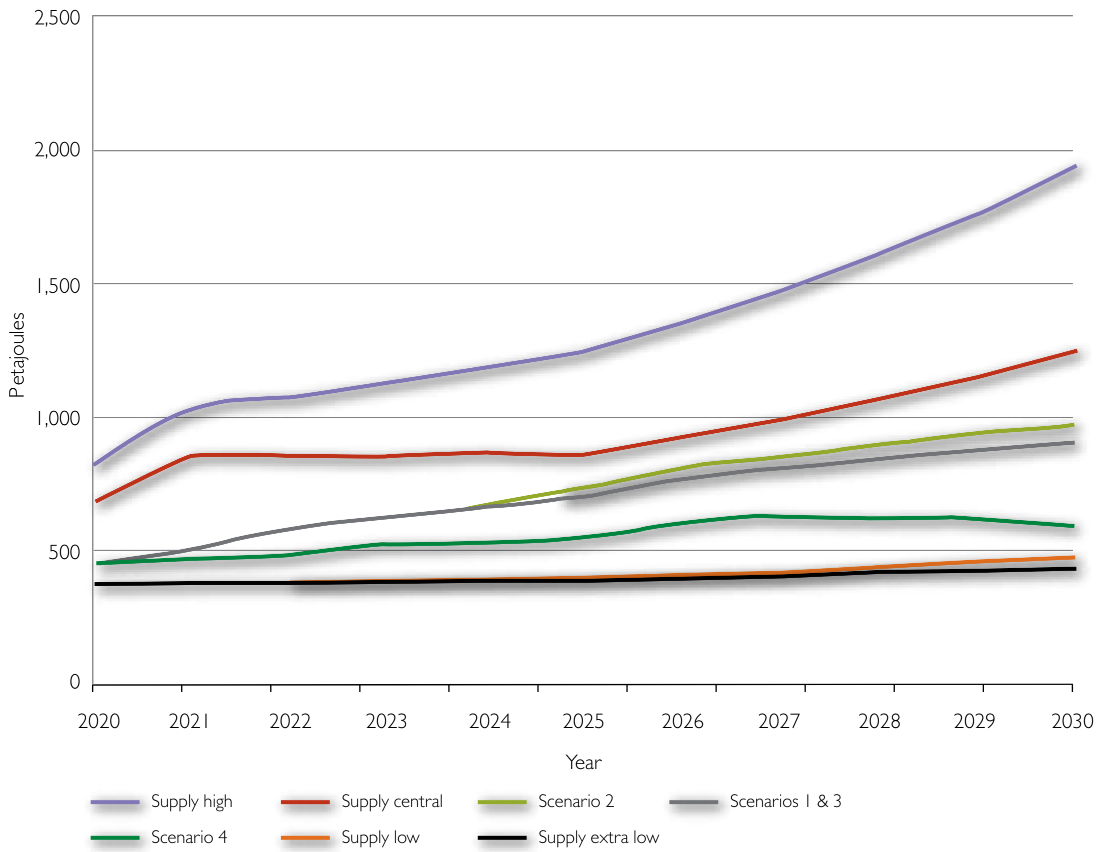
## *Sustainability of bioenergy resource supply*

B4.42 A high-level assessment was carried out to compare current estimates of sustainable bioenergy supply with the bioenergy demand trajectories forecast for the Carbon Plan.

B4.43 The potential range of bioenergy demand was derived from the emissions projections and analysis of the additional abatement measures described from paragraph B3.26. This consolidated the demand for biofuels from transport; the demand for biomass and biogas from low carbon heat measures; and the use of waste and biomass in electricity generation. The available supply of bioenergy was considered drawing on three scenarios from AEA's *UK and Global Bioenergy Resource* report[98] and E4Tech's[99] biofuel supply projections for the Department for Transport Modes work.

B4.44 **The analysis suggests that, when considering bioenergy as a whole, there should be sufficient sustainable supply to meet demand**

Chart B12: Biomass supply and demand, including heat, power and transport, 2020–30 (petajoules)




[97] Such as NOx from high strength biodiesel or aldehydes from bioethanol.

[98] AEA (2011) *'UK and Global Bioenergy Resource – Final report'.*

[99] See: www.e4tech.com/en/consulting-projects.html#Bioenergy

**trajectories.** Chart B12 shows total biomass supply and demand for the heat, power and transport sectors.

B4.45 However, considering biomass as a whole can mask the sustainable supply constraints that may be felt for certain sectors and technologies. Although the actual deployment levels are highly uncertain and will depend on investment decisions that renewable energy generators choose to make based on the economics of the technologies, scenario analysis of the potential pathways indicates that some tensions between supply and demand for feedstocks could appear during the 2020s.

B4.46 Although domestic resources will play an important role in the supply of woody biomass, the UK is likely to require significant **woody biomass** imports in addition to UK resources. To meet the demand of the potential deployment trajectories to 2030 would require a greater proportion of woodland resource to be managed for wood fuel production, more woody feedstocks to be harvested and, possibly, the establishment of new energy forests and short rotation coppice. Higher demand trajectories might also require a significant expansion of marginal land devoted to woody biomass production to meet the demand from domestic sources. The use of energy crops would also play an important role in meeting potential needs. Removing energy crops from supply estimates in order to test for the uncertainties of the availability of these resources given potential land availability and indirect impact constraints shows that supply could be sufficient to meet demand in the near term but that tensions could start appearing from the mid 2020s onwards.

B4.47 In addition, demand for **biofuels** may also prove constrained in low sustainable supply scenarios for the fourth carbon budget period, especially when considering biodiesel feedstocks. However, testing higher availability scenarios based on the existing literature shows that sustainable supply could be sufficient to meet the potential ranges of demand. Future supply for biodiesel and bioethanol will largely depend on the sustainability of first generation feedstocks and the impact of forthcoming policy on indirect land use change.

B4.48 Finally, the scenario analysis also shows that the supply of feedstocks for **biogas in the heat sector** may prove constrained and potentially hinder the significant deployment in the sector over the fourth carbon budget period. In contrast, supply of biogas to the power sector, which uses different feedstocks[100] than the heat sector, is expected to surpass demand for the whole period.

B4.49 The analysis highlights that, in future, different technologies and sectors are likely to experience different pressures on the availability of sustainable feedstocks. This will have an impact on the price at which the UK can access these feedstocks and will depend not only on the UK's ability to successfully exploit domestic resources but also on the development of international markets and associated demand. The forthcoming cross-government Bioenergy Strategy will make a more thorough assessment of the potential availability of sustainable feedstocks to 2020 and beyond and the implications of this on the potential role of bioenergy across electricity, heat and transport as a way of achieving cost effective carbon reductions.

[100] This analysis assumes total supply of biogas from: sewage sludge, landfill gas, food waste and livestock manure. It is assumed that the power sector uses only biogas from sewage sludge and landfill.

# B5. Detailed tables

## Emissions by sector

The table below shows the updated emissions projections (UEP) broken down by the main National Communication sectors.[101]

### Table B24: Projected net UK carbon account by sector, National Communication basis ($MtCO_2e$)

| Total greenhouse gas emissions ($MtCO_2e$) | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| National Communication sector breakdown | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** | **2022** | **2023** | **2024** | **2025** | **2026** | **2027** |
| Energy supply | 219 | 195 | 196 | 184 | 185 | 178 | 177 | 166 | 150 | 145 | 131 | 127 | 129 | 124 | 118 | 116 | 115 | 110 | 104 | 100 |
| Business | 97 | 86 | 94 | 91 | 90 | 90 | 91 | 91 | 89 | 88 | 86 | 84 | 82 | 82 | 81 | 79 | 78 | 78 | 77 | 77 |
| Industrial processes | 16 | 10 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| Transport | 128 | 122 | 122 | 118 | 117 | 117 | 116 | 115 | 114 | 113 | 112 | 111 | 109 | 112 | 111 | 111 | 110 | 109 | 108 | 108 |
| Residential | 83 | 79 | 88 | 79 | 76 | 72 | 71 | 70 | 69 | 68 | 68 | 67 | 66 | 67 | 67 | 68 | 68 | 69 | 70 | 70 |
| Public | 9 | 8 | 9 | 10 | 10 | 10 | 10 | 10 | 10 | 9 | 9 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| Agriculture | 50 | 49 | 50 | 49 | 49 | 49 | 49 | 49 | 48 | 47 | 47 | 46 | 46 | 45 | 46 | 46 | 46 | 46 | 46 | 46 |
| Land use change | −4 | −4 | −4 | −3 | −3 | −3 | −3 | −2 | −2 | −2 | −2 | −2 | −1 | −1 | −1 | −1 | 0 | 0 | 0 | 0 |
| Waste management | 18 | 18 | 18 | 17 | 17 | 16 | 15 | 15 | 15 | 14 | 14 | 13 | 13 | 13 | 12 | 12 | 12 | 12 | 11 | 11 |
| Total | **618** | **564** | **586** | **557** | **553** | **541** | **538** | **524** | **505** | **495** | **476** | **467** | **463** | **461** | **454** | **450** | **448** | **442** | **436** | **431** |
| EU ETS allowances purchased by UK | **19** | **−12** | **−7** | **−23** | **−21** | **−4** | **1** | **−6** | **−17** | **−19** | **−29** | **−28** | **−22** | **−27** | **−29** | **22** | **21** | **16** | **11** | **6** |
| Net UK carbon account[102] | **599** | **576** | **593** | **579** | **575** | **545** | **538** | **531** | **523** | **514** | **505** | **495** | **486** | **489** | **483** | **428** | **427** | **426** | **425** | **425** |

[101] See: www.decc.gov.uk/en/consent/cms/about/ec_social_res/analytic_projs/en_emis_projs/en_emis_projs.aspx

[102] The net UK carbon account estimates for the fourth carbon budget (2023–27) assume an EU ETS cap of 690 $MtCO_2e$.

# Emissions savings by policy

The tables in this section set out the updated policy emissions savings to deliver the first three carbon budgets.[103, 104]

### Table B25: Projected non-traded sector emissions savings by policy in the baseline ($MtCO_2e$)[105]

| | Carbon budget 1 | | | | | Carbon budget 2 | | | | | Carbon budget 3 | | | | | Carbon budget period | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | 1 | 2 | 3 |
| **Residential** | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2008–12 | 2013–17 | 2018–22 |
| Building Regulations Part L (2002 and 2005/06) | 2.6 | 3.2 | 3.7 | 4.5 | 4.9 | 5.4 | 5.8 | 6.2 | 6.5 | 6.8 | 7.1 | 7.3 | 7.5 | 7.3 | 6.9 | 18.8 | 30.6 | 36.1 |
| Warm Front and fuel poverty measures | −1.2 | −1.4 | −1.7 | −1.8 | −1.8 | −1.7 | −1.4 | −1.2 | −1.1 | −0.9 | −0.8 | −0.7 | −0.5 | −0.4 | −0.2 | −7.9 | −6.3 | −2.7 |
| Supplier Obligation (EEC1, EEC2, original CERT) | 1.9 | 2.7 | 3.9 | 5.2 | 5.4 | 5.4 | 5.5 | 5.4 | 5.4 | 5.7 | 5.8 | 5.8 | 5.5 | 5.1 | 4.8 | 19.0 | 27.4 | 27.0 |
| **Total** | **3.3** | **4.4** | **5.9** | **7.8** | **8.5** | **9.1** | **9.8** | **10.4** | **10.8** | **11.5** | **12.0** | **12.4** | **12.5** | **12.0** | **11.6** | **30.0** | **51.6** | **60.5** |
| **Commercial and public services** | | | | | | | | | | | | | | | | | | |
| Carbon Trust measures | 1.2 | 1.1 | 1.1 | 0.9 | 0.7 | 0.6 | 0.4 | 0.3 | 0.3 | 0.3 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 4.8 | 2.0 | 0.5 |
| Energy Performance of Buildings Directive[106] | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 1.5 | 1.5 | 1.5 |
| UK Emissions Trading Scheme | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 |
| Building Regulations Part L (2002 and 2005/06) | 0.7 | 0.9 | 1.0 | 1.2 | 1.2 | 1.3 | 1.4 | 1.4 | 1.4 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.4 | 5.1 | 7.0 | 7.5 |
| **Total** | **2.2** | **2.3** | **2.4** | **2.4** | **2.2** | **2.2** | **2.1** | **2.0** | **2.1** | **2.1** | **2.0** | **1.9** | **1.9** | **1.8** | **1.7** | **11.5** | **10.4** | **9.4** |

[103] For detail on how the policy emissions savings have been modelled please see chapter 4 of the latest published Updated Energy and Emissions Projections report available from: www.decc.gov.uk/en/content/cms/about/ec_social_res/analytic_projs/en_emis_projs/en_emis_projs.aspx

[104] Demand reduction through the impact of price uplifts are included in the baseline and have generally not been quantified in these tables. The exceptions are the impact of the EU ETS carbon price and Carbon Price Floor in the ESI, which are quantified. Such price impacts arise from: CCL fuel duties, the need to purchase CRC allowances and the cost recovery of policy measures undertaken by energy suppliers, this includes supply side measures such as grid reinforcement, RO and FiTs, as well as CERT/ECO.

[105] For the purposes of this table, baseline is akin to the updated emissions projections baseline (pre-Low Carbon Transition Plan policies). The table shows emissions savings from only some of the policies included in the baseline. It is not possible to quantify the emissions savings from all baseline policies individually. However, it should be noted that this does not impact on either the baseline or any of the newer policy emissions projections scenarios. Savings in the transport sector from the Renewable Transport Fuels Obligation and EU voluntary agreements on new car emissions have been published previously. These have not been re-estimated for this publication.

[106] The original Energy Performance of Buildings Directive (EPBD) introduced Energy Performance Certificates, Display Energy Certificates and other measures to improve the energy performance of buildings. Carbon savings given here only reflect the impact of the policy on the small and medium-sized enterprises sector, to avoid overlap with policies in other areas. The numbers relating to the EPBD in this annex are the same as given in the *Low Carbon Transition Plan* (DECC, 2009) and so are not consistent with numbers for the other policies here, which use updated energy and carbon assumptions. The EPBD recast currently being developed does not feature in these numbers owing to overlaps with the savings already accounted for elsewhere.

| Industry | Carbon budget 1 | | | | | Carbon budget 2 | | | | | Carbon budget 3 | | | | | Carbon budget period 1 | 2 | 3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2008–12 | 2013–17 | 2018–22 |
| Carbon Trust measures | 0.5 | 0.5 | 0.5 | 0.4 | 0.3 | 0.3 | 0.2 | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 2.2 | 0.9 | 0.3 |
| UK Emissions Trading Scheme | 0.2 | 0.2 | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.9 | 0.4 | 0.1 |
| Building Regulations Part L (2002 and 2005/06) | 0.3 | 0.4 | 0.4 | 0.5 | 0.5 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.7 | 0.6 | 0.6 | 2.1 | 3.0 | 3.2 |
| **Total** | **1.0** | **1.0** | **1.1** | **1.1** | **1.0** | **0.9** | **0.9** | **0.8** | **0.8** | **0.8** | **0.8** | **0.7** | **0.7** | **0.7** | **0.6** | **5.2** | **4.3** | **3.5** |
| **Overall total** | **6.5** | **7.7** | **9.4** | **11.2** | **11.7** | **12.2** | **12.8** | **13.3** | **13.7** | **14.4** | **14.8** | **15.1** | **15.1** | **14.5** | **13.9** | **46.6** | **66.4** | **73.4** |

## Table B26: Projected non-traded sector emissions savings by policy additional to the baseline ($MtCO_2e$)[107]

| | Carbon budget 1 | | | | | Carbon budget 2 | | | | | Carbon budget 3 | | | | | Carbon budget period 1 | Carbon budget period 2 | Carbon budget period 3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Residential** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** | **2022** | **2008–12** | **2013–17** | **2018–22** |
| Supplier Obligation (CERT +20% and CERT extension) | 0.0 | 0.1 | 0.2 | 0.4 | 2.0 | 4.1 | 4.1 | 4.1 | 4.0 | 4.0 | 4.0 | 4.1 | 4.0 | 3.9 | 3.9 | 2.7 | 20.3 | 19.9 |
| Building Regulations Part L (2010) | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.8 | 1.1 | 1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0 | 3.2 | 3.5 | 0.4 | 7.4 | 14.9 |
| Smart Metering[108] | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.4 | 0.6 | 0.8 | 0.9 | 1.0 | 1.0 | 1.0 | 1.0 | 0.1 | 2.1 | 5.0 |
| EU Products policy (Tranche 1, Legislated)[109] | 0.0 | 0.0 | −0.2 | −0.5 | −0.7 | −1.0 | −1.2 | −1.4 | −1.6 | −1.7 | −1.9 | −2.0 | −2.0 | −2.0 | −1.9 | −1.4 | −7.0 | −9.8 |
| EU Products policy (Tranche 2, Proposed)[110] | 0.0 | 0.0 | 0.0 | 0.0 | −0.1 | −0.1 | −0.1 | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.5 | 0.5 | −0.1 | 0.0 | 2.1 |
| Community Energy Saving Programme | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.3 | 0.3 |
| Zero Carbon Homes | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.0 | 0.1 | 2.0 |
| Energy Company Obligation and Domestic Green Deal[111] | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.3 | 1.4 | 1.5 | 1.2 | 1.4 | 1.5 | 0.0 | 4.4 | 6.9 |
| Renewable Heat Incentive | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.8 | 0.9 | 0.9 | 0.9 | 0.1 | 1.6 | 4.1 |
| **Total** | **0.0** | **0.1** | **0.1** | **0.0** | **1.8** | **4.4** | **5.0** | **5.8** | **6.6** | **7.4** | **8.1** | **8.7** | **9.0** | **9.5** | **10.0** | **1.9** | **29.2** | **45.3** |

[107] This table shows non-traded emissions savings additional to the baseline (Low Carbon Transition Plan and newer policies).

[108] All Smart Metering emissions savings are based on the latest published Impact Assessment, available at: www.decc.gov.uk/assets/decc/11/consultation/smart-metering-imp-prog/2549-smart-meter-rollout-domestic-ia-180811.pdf

[109] Products policy includes legally binding EU minimum standards on energy-related products, which raise the minimum level of efficiency of energy-using products available in the market. It also includes labelling which encourages manufacturers to go beyond the minimum standards. The first tranche of measures has been delivered; the energy savings are taken from the related Impact Assessments.

[110] The second tranche of measures has not been completed and therefore any projected savings are less well understood, as the scope, timing and stringency of these measures has not been finalised. The current modelling reports projections of energy savings from products policy. These are more uncertain over later years as it becomes less clear whether products policies drive efficiency improvements, or whether this would be driven regardless by (i) consumers' future preferences for better products, and/or (ii) forecast energy prices and traded carbon prices that increase at a faster rate post-2020. Tapers are applied post-2020 to signal uncertainties in the long run on energy savings. For the net present values, further caution still is applied, with the estimates provided only for the savings until the end of the third carbon budget reporting period – given that it is unclear whether the market will have responded or whether energy efficiency improvements will need to continue to be delivered through products policy in later years.

[111] All ECO and Domestic Green Deal emissions savings are based on the latest Impact Assessment. The latest estimates differ from the estimates included in the October 2011 Updated Emissions Projections which are based on the December 2010 Impact Assessment and include heating measures. Non-traded emissions savings fall in 2020 owing to assumptions about the roll-out of heat systems in fuel poor households. See the Impact Assessment for further details: www.decc.gov.uk/assets/decc/11/consultation/green-deal/3603-green-deal-eco-ia.pdf

| Commercial and public servicesl | Carbon budget 1 | | | | | Carbon budget 2 | | | | | Carbon budget 3 | | | | | Carbon budget period 1 | 2 | 3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2008–12 | 2013–17 | 2018–22 |
| Building Regulations Part L (2010) | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.2 | 0.3 | 0.3 | 0.4 | 0.5 | 0.5 | 0.6 | 0.7 | 0.7 | 0.8 | 0.1 | 1.7 | 3.4 |
| Business Smart Metering | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.3 | 0.4 | 0.6 | 0.7 | 0.7 | 0.8 | 0.7 | 0.7 | 0.0 | 1.4 | 3.6 |
| EU Products policy (Tranche 1, Legislated) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | −0.1 | −0.1 | −0.1 | −0.1 | −0.1 | −0.1 | −0.1 | −0.1 | −0.1 | −0.1 | −0.1 | −0.6 | −0.7 |
| EU Products policy (Tranche 2, Proposed) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | −0.1 | −0.1 | −0.1 | −0.1 | −0.1 | −0.1 | −0.2 | −0.2 | −0.2 | −0.1 | −0.4 | −0.7 |
| Small business energy efficiency interest-free loans | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.0 |
| Salix, public sector loans, 10% commitment for central govt | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.1 | 0.0 |
| Non-Domestic Green Deal | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.3 | 0.4 | 0.5 | 0.6 | 0.6 | 0.6 | 0.7 | 0.0 | 0.8 | 3.0 |
| Carbon Reduction Commitment Energy Efficiency Scheme | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.2 | 0.3 | 0.3 | 0.4 | 0.6 | 0.7 | 0.8 | 0.9 | 1.0 | 1.1 | 0.2 | 1.8 | 4.5 |
| Renewable Heat Incentive | 0.0 | 0.0 | 0.0 | 0.1 | 0.2 | 0.4 | 0.7 | 1.2 | 1.7 | 2.4 | 3.2 | 4.0 | 4.9 | 4.9 | 4.9 | 0.3 | 6.4 | 21.8 |
| **Total** | **0.0** | **0.0** | **0.1** | **0.2** | **0.5** | **0.8** | **1.2** | **2.1** | **3.0** | **4.2** | **5.4** | **6.5** | **7.5** | **7.7** | **7.8** | **0.8** | **11.3** | **34.8** |

| Industry | Carbon budget 1 | | | | | Carbon budget 2 | | | | | Carbon budget 3 | | | | | Carbon budget period 1 | Carbon budget period 2 | Carbon budget period 3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2008–12 | 2013–17 | 2018–22 |
| Building Regulations Part L (2010) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 | 0.2 | 0.2 | 0.3 | 0.3 | 0.3 | 0.0 | 0.6 | 1.3 |
| EU Products policy (Tranche 1, Legislated) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| EU Products policy (Tranche 2, Proposed) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | −0.1 |
| Small business energy efficiency interest-free loans | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.0 |
| Climate Change Agreements (2011–18)[112] | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Non-Domestic Green Deal | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.2 | 0.2 | 0.2 | 0.3 | 0.3 | 0.3 | 0.0 | 0.3 | 1.2 |
| Carbon Reduction Commitment Energy Efficiency Scheme | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.2 | 0.3 | 0.3 | 0.4 | 0.4 | 0.5 | 0.6 | 0.6 | 0.1 | 1.0 | 2.5 |
| Renewable Heat Incentive | 0.0 | 0.0 | 0.0 | 0.1 | 0.2 | 0.4 | 0.5 | 0.7 | 1.2 | 1.7 | 2.4 | 3.3 | 4.2 | 4.2 | 4.2 | 0.4 | 4.5 | 18.3 |
| **Total** | **0.0** | **0.0** | **0.0** | **0.2** | **0.4** | **0.6** | **0.8** | **1.1** | **1.7** | **2.4** | **3.2** | **4.1** | **5.2** | **5.3** | **5.4** | **0.6** | **6.5** | **23.2** |

[112] CCAs and the Climate Change Levy are estimated to have no additional savings beyond business as usual emissions projections. CCA targets will be set in 2012 following negotiations with industry.

| | Carbon budget 1 | | | | | Carbon budget 2 | | | | | Carbon budget 3 | | | | | Carbon budget period | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | 1 | 2 | 3 |
| Transport[113] | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2008–12 | 2013–17 | 2018–22 |
| EU new car $CO_2$ mid-term target 130 $gCO_2$/km in 2015 | 0.0 | 0.0 | 0.0 | 0.1 | 0.3 | 0.5 | 0.7 | 1.0 | 1.4 | 1.7 | 2.0 | 2.3 | 2.6 | 3.1 | 3.4 | 0.4 | 5.3 | 13.4 |
| EU new car $CO_2$ long-term 95 $gCO_2$/km in 2020 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.2 | 0.2 | 0.7 | 1.4 | 2.3 | 3.4 | 5.0 | 6.1 | 0.1 | 1.5 | 18.2 |
| Renewable Energy Strategy transport biofuel (8% by energy in 2020)[114] | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 1.1 | 1.8 | 2.4 | 3.0 | 3.5 | 4.1 | 0.0 | 0.0 | 0.0 | 5.7 | 10.5 |
| EU new van $CO_2$ regulation 147 $gCO_2$/km in 2020 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 | 0.3 | 0.3 | 0.5 | 0.8 | 1.0 | 0.0 | 0.6 | 3.0 |
| EU complementary measures for cars | 0.0 | 0.0 | 0.0 | 0.1 | 0.2 | 0.3 | 0.5 | 0.7 | 0.9 | 1.0 | 1.1 | 1.3 | 1.5 | 1.8 | 1.9 | 0.3 | 3.4 | 7.7 |
| Low rolling resistance tyres for HGVs | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.3 | 0.4 | 0.6 | 0.7 | 0.7 | 0.7 | 0.0 | 0.5 | 3.2 |
| Industry-led action to improve HGV efficiencies | 0.0 | 0.0 | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.4 | 0.5 | 0.6 | 0.7 | 0.4 | 0.4 | 0.6 | 0.3 | 2.2 | 2.7 |
| Local Sustainable Transport Fund | 0.0 | 0.0 | 0.0 | 0.2 | 0.4 | 0.6 | 0.8 | 1.0 | 0.8 | 0.6 | 0.5 | 0.5 | 0.5 | 0.4 | 0.2 | 0.6 | 3.7 | 2.0 |
| Low carbon buses | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.2 | 0.3 | 0.3 | 0.4 | 0.0 | 0.2 | 1.4 |
| Rail electrification[115] | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.0 | 0.1 | 1.0 |
| **Total** | **0.0** | **0.0** | **0.0** | **0.6** | **1.2** | **2.0** | **3.3** | **4.7** | **5.8** | **7.6** | **9.6** | **12.0** | **14.2** | **12.8** | **14.6** | **1.8** | **23.4** | **63.1** |

[113] Transport savings for the EU new car and van regulations and Renewable Energy Strategy biofuel are modelled directly in the Department of Energy and Climate Change's Energy Model. Other transport savings are forecast using the Department for Transport's National Transport Model.

[114] Estimates of the savings from Transport biofuels are based on achievement of 8% fuel share by 2020. An assumption of 10% was used in the June 2010 projections. This change is for modelling purposes only and does not imply any change in policy or in the Government's commitment to renewables.

[115] Electrification of the Great Western Main Line as far as Cardiff, and the North West.

| Agriculture and waste (non-$CO_2$) emissions[116] | Carbon budget 1 | | | | | Carbon budget 2 | | | | | Carbon budget 3 | | | | | Carbon budget period 1 | Carbon budget period 2 | Carbon budget period 3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2008–12 | 2013–17 | 2018–22 |
| Agriculture Action Plan | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.6 | 1.5 | 2.2 | 2.7 | 3.2 | 3.4 | 3.4 | 0.0 | 2.1 | 14.9 |
| Landfill tax | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Defra waste policy | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **Overall total** | **0.0** | **0.1** | **0.2** | **0.9** | **3.8** | **7.7** | **10.3** | **13.7** | **17.8** | **23.0** | **28.4** | **34.0** | **39.1** | **38.7** | **41.2** | **5.1** | **72.5** | **181.4** |

[116] Latest projections for waste emissions do not include an explicit estimate of the impact of landfill tax or waste policy: these have been absorbed into a single baseline projection.

## Table B27: Projected traded sector emissions savings by policy included in the baseline ($MtCO_2e$)[117]

| | Carbon budget 1 | | | | | Carbon budget 2 | | | | | Carbon budget 3 | | | | | Carbon budget period | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | 1 | 2 | 3 |
| **Power** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** | **2022** | **2008–2012** | **2013–2017** | **2018–2022** |
| EU Emissions Trading System | 13.0 | 9.5 | 7.6 | 12.2 | 7.6 | 5.5 | 5.2 | 5.3 | 4.5 | 4.9 | 6.1 | 7.4 | 8.2 | 6.0 | 5.6 | 49.8 | 25.4 | 33.3 |
| Renewables | 8.0 | 9.3 | 9.6 | 11.6 | 13.6 | 14.0 | 14.5 | 15.0 | 16.1 | 17.2 | 18.6 | 20.0 | 21.5 | 22.0 | 22.0 | 52.0 | 76.9 | 104.2 |
| Large Combustion Plant Directive | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 14.0 | 8.4 | 0.0 |
| **Total** | **23.8** | **21.6** | **20.0** | **26.6** | **23.9** | **22.4** | **22.5** | **23.1** | **20.6** | **22.2** | **24.7** | **27.4** | **29.8** | **28.0** | **27.6** | **115.8** | **110.7** | **137.5** |
| **Residential** | | | | | | | | | | | | | | | | | | |
| Building Regulation Part L (2002 and 2005/06) | 0.1 | 0.1 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.8 | 1.0 | 1.1 |
| Warm Front and fuel poverty measures | 1.2 | 1.4 | 1.7 | 1.8 | 1.8 | 1.7 | 1.4 | 1.2 | 1.0 | 0.9 | 0.8 | 0.7 | 0.6 | 0.4 | 0.2 | 7.9 | 6.2 | 2.7 |
| Supplier Obligation (EEC1, EEC2, original CERT) | 1.4 | 2.7 | 3.7 | 4.2 | 4.2 | 4.0 | 3.8 | 3.7 | 3.6 | 3.0 | 2.4 | 1.8 | 1.8 | 1.7 | 1.6 | 16.2 | 18.2 | 9.3 |
| **Total** | **2.7** | **4.3** | **5.5** | **6.2** | **6.1** | **5.9** | **5.5** | **5.1** | **4.9** | **4.1** | **3.4** | **2.7** | **2.6** | **2.3** | **2.1** | **24.9** | **25.4** | **13.1** |
| **Commercial and public services** | | | | | | | | | | | | | | | | | | |
| Carbon Trust measures | 1.2 | 1.2 | 1.2 | 0.9 | 0.7 | 0.6 | 0.4 | 0.4 | 0.4 | 0.4 | 0.3 | 0.1 | 0.0 | 0.0 | 0.0 | 5.2 | 2.0 | 0.5 |
| Energy Performance of Buildings Directive | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 2.2 | 2.2 | 2.2 |
| UK Emissions Trading Scheme | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 |
| Building Regulations Part L (2002 and 2005/06) | 0.2 | 0.2 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 1.3 | 1.8 | 1.9 |
| **Total** | **1.9** | **1.8** | **1.9** | **1.7** | **1.5** | **1.3** | **1.2** | **1.2** | **1.2** | **1.2** | **1.1** | **1.0** | **0.9** | **0.9** | **0.8** | **8.8** | **6.1** | **4.7** |

[117] For the purposes of this table, baseline is akin to the updated emissions projections baseline (Pre-Low Carbon Transition Plan policies). The table shows emissions savings from only some of the policies included in the baseline. It is not possible to quantify the emissions savings from all baseline policies individually. However, it should be noted that this does not impact on either the baseline or any of the newer policy emissions projections scenarios.

| Industry | Carbon budget 1 | | | | | Carbon budget 2 | | | | | Carbon budget 3 | | | | | Carbon budget period 1 | Carbon budget period 2 | Carbon budget period 3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** | **2022** | **2008–2012** | **2013–2017** | **2018–2022** |
| Carbon Trust measures | 0.9 | 0.9 | 1.0 | 0.7 | 0.6 | 0.5 | 0.4 | 0.3 | 0.3 | 0.3 | 0.2 | 0.1 | 0.1 | 0.0 | 0.0 | 4.1 | 1.7 | 0.5 |
| UK Emissions Trading Scheme | 0.5 | 0.4 | 0.4 | 0.4 | 0.3 | 0.3 | 0.2 | 0.2 | 0.2 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 2.0 | 1.0 | 0.1 |
| Building Regulations Part L (2002 and 2005/06) | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.5 | 0.7 | 0.7 |
| **Total** | **1.5** | **1.4** | **1.4** | **1.2** | **1.0** | **0.9** | **0.7** | **0.6** | **0.6** | **0.6** | **0.5** | **0.3** | **0.2** | **0.2** | **0.2** | **6.6** | **3.4** | **1.3** |
| **Overall total** | **29.8** | **29.2** | **28.9** | **35.7** | **32.6** | **30.5** | **29.9** | **30.0** | **27.3** | **28.0** | **29.7** | **31.5** | **33.4** | **31.3** | **30.7** | **156.0** | **145.6** | **156.6** |

## Table B28: Projected traded sector emissions savings by policy additional to the baseline ($MtCO_2e$)[118]

| | Carbon budget 1 | | | | | Carbon budget 2 | | | | | Carbon budget 3 | | | | | Carbon budget period | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | 1 | 2 | 3 |
| **Power** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** | **2022** | **2008–12** | **2013–17** | **2018–22** |
| Industrial Emissions Directive | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.2 | 1.3 | 1.3 | 0.0 | 0.0 | 2.8 |
| Carbon Capture and Storage Demonstration Programme | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.1 | 1.5 | 2.1 | 2.3 | 4.4 | 5.6 | 5.6 | 5.6 | 5.6 | 0.0 | 7.0 | 26.8 |
| Carbon Price Floor | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 5.7 | 0.9 | 0.7 | 0.9 | 1.8 | 2.7 | 1.1 | 0.3 | 0.8 | 5.8 | 0.2 | 9.9 | 10.8 |
| Renewables[119] | 0.0 | 0.0 | 0.0 | 0.0 | 0.6 | 3.3 | 5.8 | 10.1 | 14.2 | 16.3 | 17.8 | 19.8 | 21.1 | 22.4 | 23.5 | 0.6 | 49.7 | 104.6 |
| **Total** | **0.0** | **0.0** | **0.0** | **0.0** | **0.7** | **9.0** | **7.8** | **12.3** | **17.1** | **20.4** | **24.9** | **26.7** | **27.1** | **30.1** | **36.2** | **0.8** | **66.7** | **145.0** |

| **Residential** | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Supplier Obligation (CERT +20% and CERT extension) | 0.0 | 0.1 | 0.2 | 0.3 | 0.5 | 0.9 | 0.8 | 0.8 | 0.8 | 0.8 | 0.7 | 0.6 | 0.6 | 0.6 | 0.6 | 1.2 | 4.1 | 3.0 |
| Building Regulations Part L (2010) | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.3 | 0.3 | 0.4 | 0.4 | 0.5 | 0.5 | 0.6 | 0.6 | 0.1 | 1.3 | 2.5 |
| Smart Metering | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.5 | 0.7 | 0.9 | 1.1 | 1.2 | 1.2 | 1.2 | 1.2 | 0.1 | 2.4 | 5.9 |
| EU Products policy (Tranche 1, Legislated) | 0.0 | 0.0 | 0.5 | 1.4 | 2.2 | 3.0 | 3.7 | 4.3 | 4.9 | 5.3 | 5.7 | 6.0 | 6.2 | 6.1 | 5.9 | 4.1 | 21.2 | 29.9 |
| EU Products policy (Tranche 2, Proposed) | 0.0 | 0.1 | 0.2 | 0.3 | 0.6 | 1.0 | 1.4 | 1.7 | 2.1 | 2.4 | 2.6 | 2.8 | 3.1 | 3.1 | 3.1 | 1.2 | 8.6 | 14.8 |
| Community Energy Saving Programme | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.4 | 0.4 |
| Zero Carbon Homes | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.3 | 0.3 | 0.0 | 0.0 | 1.0 |
| Energy Company Obligation and Domestic Green Deal | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.6 | 1.0 | 1.3 | 1.6 | 1.9 | 2.2 | 2.9 | 2.9 | 2.9 | 0.0 | 4.9 | 12.8 |
| Renewable Heat Incentive | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.2 | 0.2 | 0.0 | 0.1 | 0.7 |
| **Total** | **0.0** | **0.2** | **0.9** | **2.1** | **3.5** | **5.5** | **7.1** | **8.7** | **10.1** | **11.4** | **12.6** | **13.6** | **14.9** | **14.9** | **14.9** | **6.7** | **42.7** | **70.9** |

[118] This table shows traded emissions savings additional to the baseline (Low Carbon Transition Plan and newer policies).

[119] Renewables savings include savings from the Renewables Obligation, Electricity Market Reform (Feed-in Tariffs with Contracts for Difference) and small-scale Feed-in Tariffs.

| Commercial and public services | Carbon budget 1 | | | | | Carbon budget 2 | | | | | Carbon budget 3 | | | | | Carbon budget period 1 | Carbon budget period 2 | Carbon budget period 3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2008–12 | 2013–17 | 2018–22 |
| Building Regulations Part L (2010) | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.4 | 0.6 | 0.8 | 1.0 | 1.1 | 1.3 | 1.5 | 1.6 | 1.8 | 1.9 | 0.2 | 3.9 | 8.0 |
| Business Smart Metering | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.0 | 0.6 | 1.6 |
| EU Products policy (Tranche 1, Legislated) | 0.0 | 0.0 | 0.2 | 0.5 | 0.9 | 1.2 | 1.5 | 1.6 | 1.8 | 2.0 | 2.2 | 2.3 | 2.4 | 2.4 | 2.3 | 1.6 | 8.2 | 11.6 |
| EU Products policy (Tranche 2, Proposed) | 0.0 | 0.0 | 0.1 | 0.2 | 0.3 | 0.5 | 0.7 | 0.9 | 1.1 | 1.2 | 1.4 | 1.6 | 2.0 | 2.1 | 2.1 | 0.6 | 4.4 | 9.3 |
| Small business energy efficiency interest-free loans | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.0 |
| Salix, public sector loans, 10% commitment for central govt | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.1 | 0.0 |
| Non-Domestic Green Deal | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.3 | 0.4 | 0.5 | 0.6 | 0.6 | 0.6 | 0.6 | 0.0 | 0.8 | 2.9 |
| Carbon Reduction Commitment Energy Efficiency Scheme | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 0.4 |
| Renewable Heat Incentive | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | −0.1 | −0.1 | −0.2 | −0.3 | −0.5 | −0.7 | −0.9 | −1.0 | −1.0 | −1.0 | 0.0 | −1.2 | −4.6 |
| **Total** | **0.0** | **0.1** | **0.4** | **0.8** | **1.5** | **2.1** | **2.9** | **3.4** | **4.0** | **4.6** | **5.1** | **5.5** | **6.1** | **6.2** | **6.4** | **2.8** | **16.9** | **29.2** |

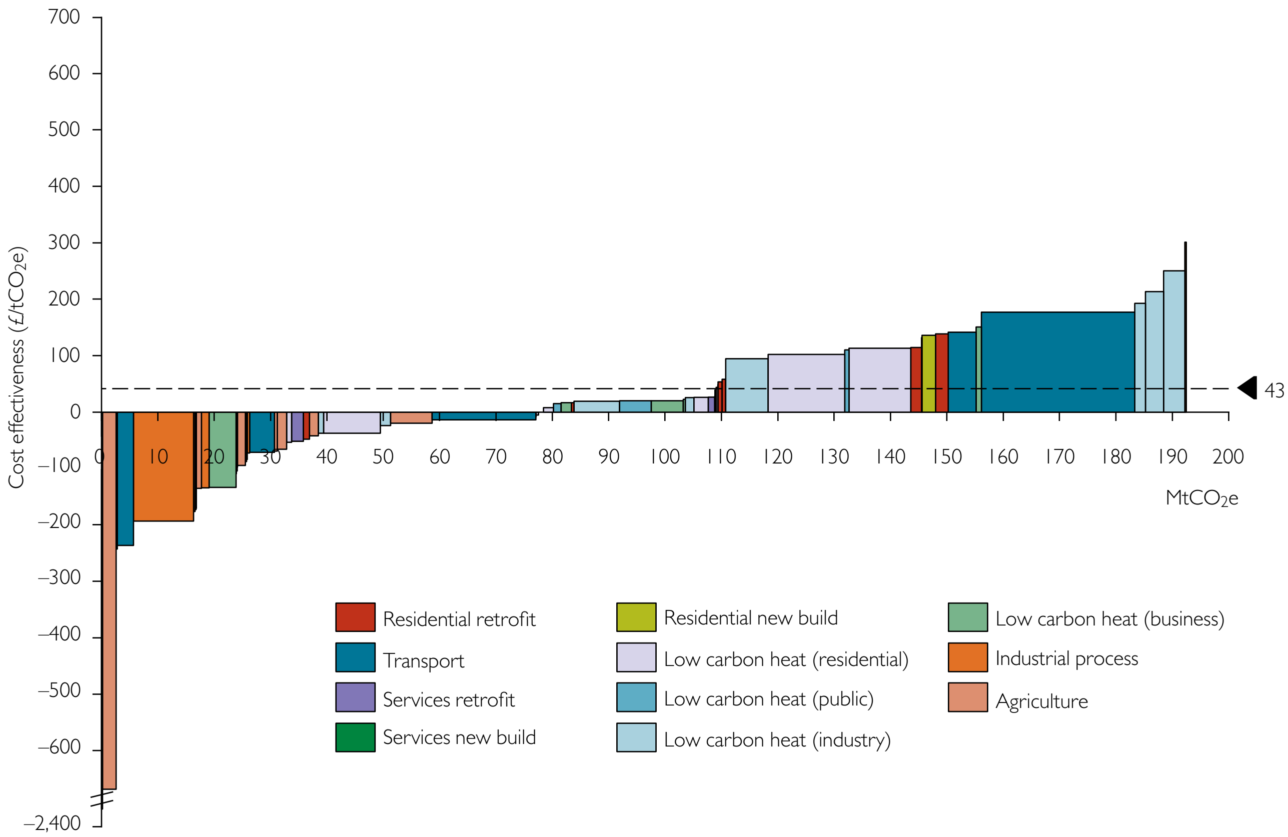
| | Carbon budget 1 | | | | | Carbon budget 2 | | | | | Carbon budget 3 | | | | | Carbon budget period | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | 1 | 2 | 3 |
| **Industry** | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2008–12 | 2013–17 | 2018–22 |
| Building Regulations Part L (2010) | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.3 | 0.3 | 0.4 | 0.4 | 0.5 | 0.5 | 0.6 | 0.6 | 0.1 | 1.3 | 2.6 |
| EU Products policy (Tranche 1, Legislated) | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.2 | 0.3 | 0.4 | 0.5 | 0.5 | 0.6 | 0.7 | 0.6 | 0.6 | 0.2 | 1.5 | 3.0 |
| EU Products policy (Tranche 2, Proposed) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 | 0.3 | 0.3 | 0.4 | 0.4 | 0.4 | 0.1 | 0.7 | 1.6 |
| Small business energy efficiency interest-free loans | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.1 | 0.1 |
| Climate Change Agreements (2011–18) | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Non-Domestic Green Deal | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.2 | 0.3 | 0.3 | 0.3 | 0.3 | 0.0 | 0.4 | 1.3 |
| Carbon Reduction Commitment Energy Efficiency Scheme | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Renewable Heat Incentive | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.2 | 0.4 | 0.6 | 0.8 | 1.1 | 1.5 | 1.9 | 2.4 | 2.4 | 2.4 | 0.1 | 3.2 | 10.6 |
| **Total** | **0.0** | **0.0** | **0.1** | **0.2** | **0.4** | **0.7** | **1.0** | **1.4** | **1.8** | **2.4** | **2.9** | **3.6** | **4.2** | **4.2** | **4.2** | **0.7** | **7.2** | **19.2** |
| **Transport** | | | | | | | | | | | | | | | | | | |
| Rail electrification | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | −0.1 | −0.1 | −0.1 | −0.1 | −0.1 | −0.1 | 0.0 | −0.1 | −0.5 |
| **Overall total** | **0.0** | **0.3** | **1.4** | **3.1** | **6.1** | **17.3** | **18.7** | **25.8** | **33.1** | **38.6** | **45.4** | **49.2** | **52.2** | **55.4** | **61.6** | **10.9** | **133.4** | **263.7** |

# Fourth carbon budget scenarios marginal abatement cost curves

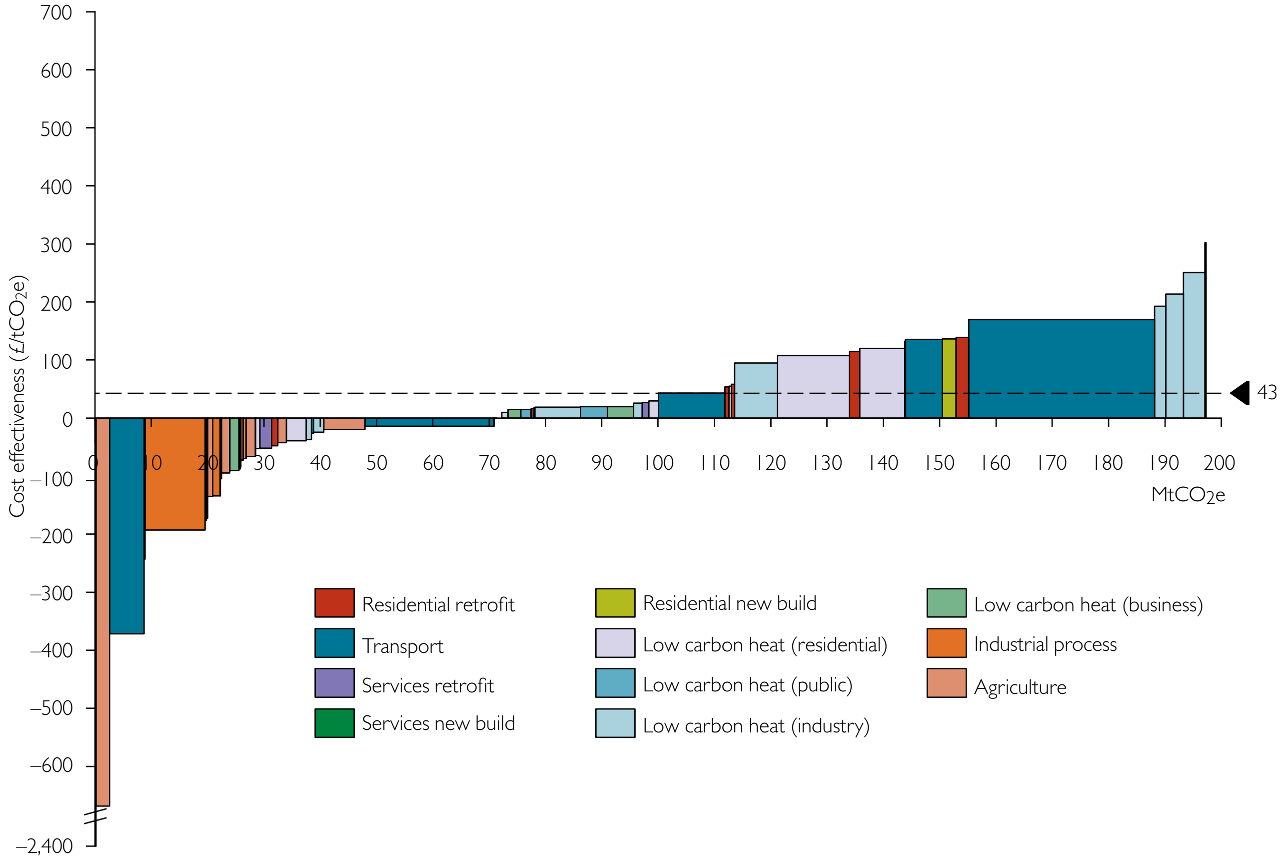
## Charts B13–B16: Abatement included under illustrative Scenarios 1 to 4

The marginal abatement cost (MAC) curves below show the abatement and cost effectiveness of those measures taken up under the fourth carbon budget scenarios and described in section B3 of this annex. The abatement covers the five-year fourth carbon budget (2023–27). The cost effectiveness covers the lifetime of the measure. They do not purport to show all potential abatement, only that abatement potential that is actually taken up under the scenario.

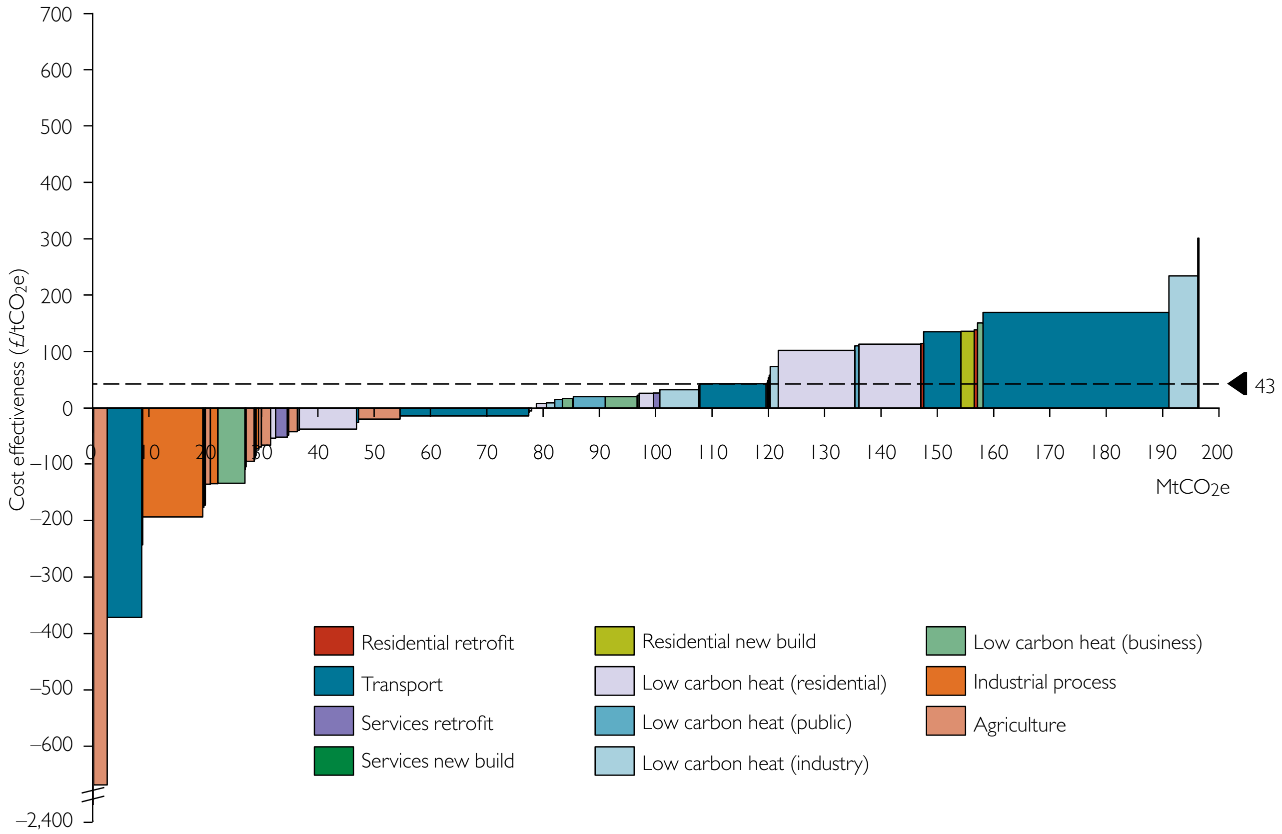
### Scenario 1



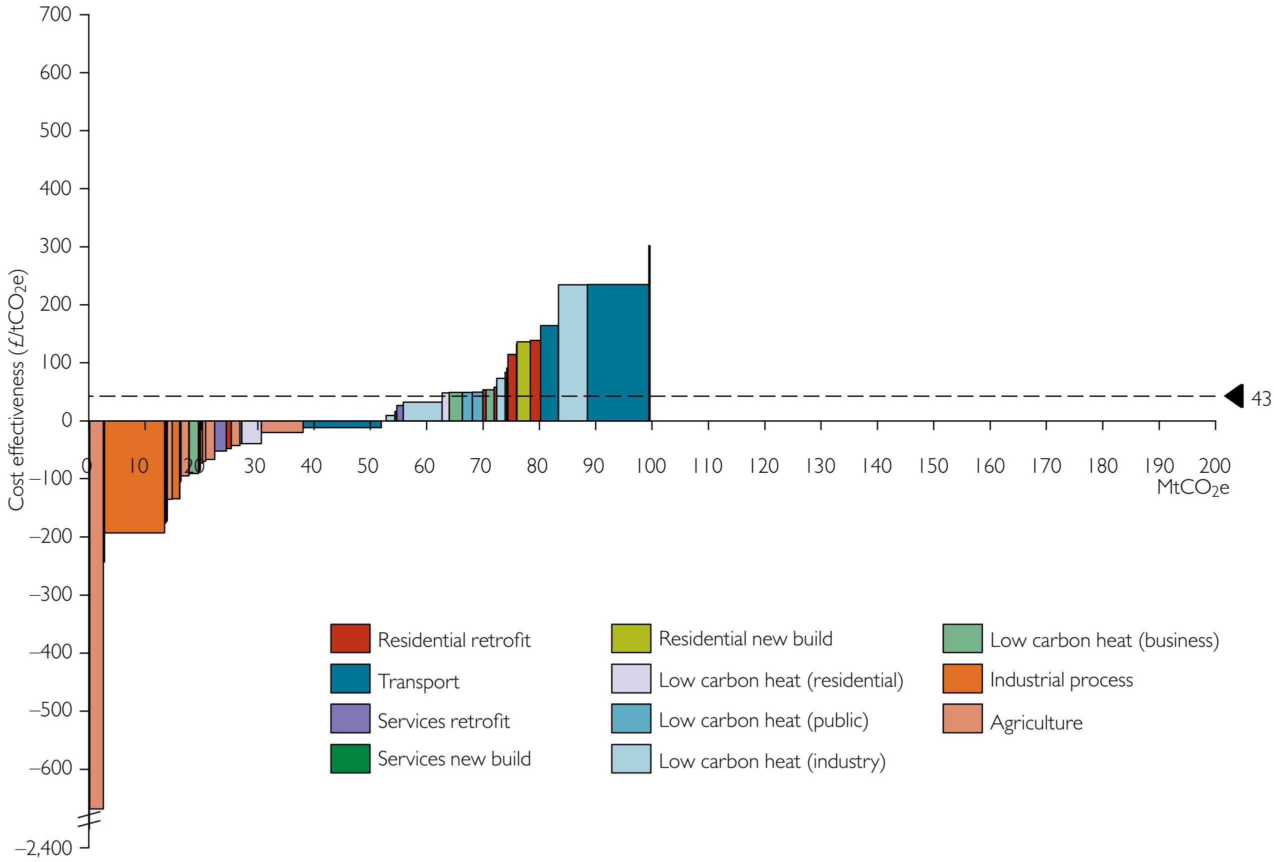
## Scenario 2




## Scenario 3

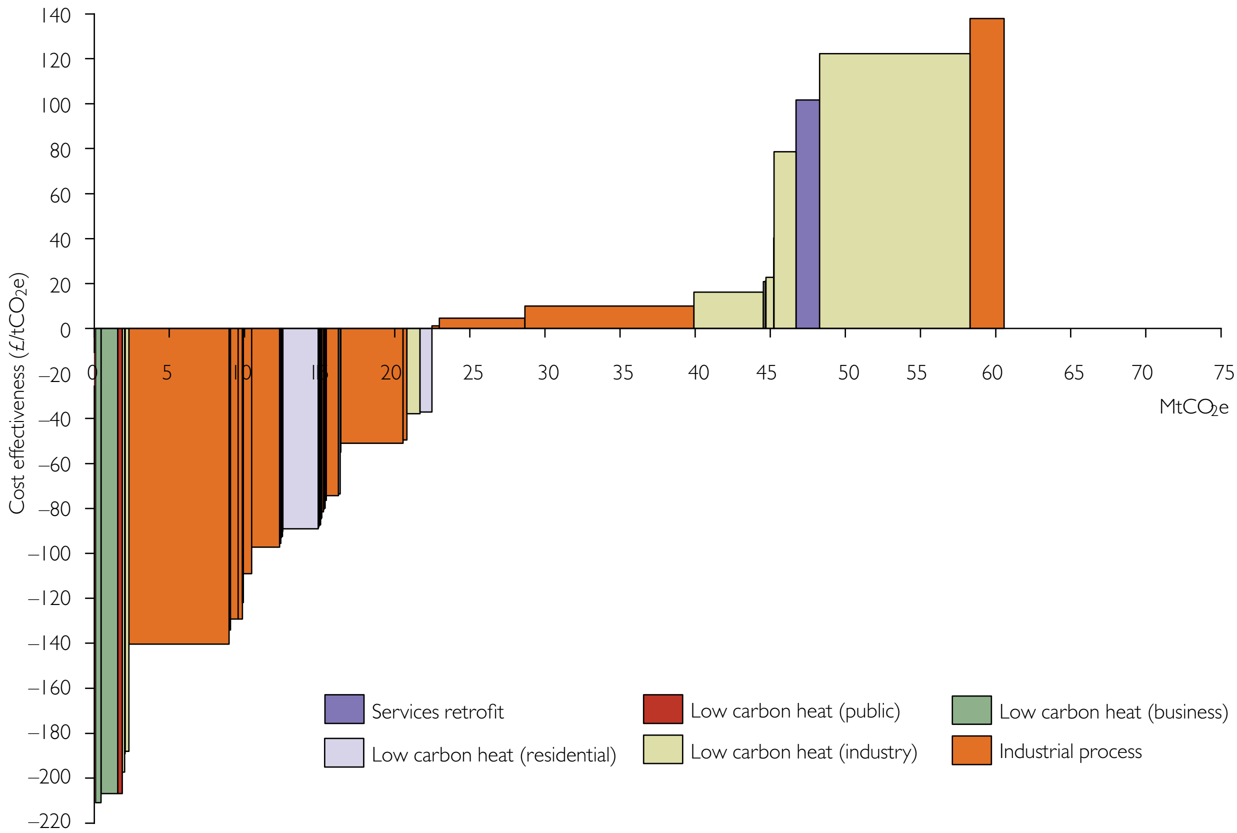


## Scenario 4


700
600
500
400
300
200
100
0
–100
–200
–300
–400
–500
–600
–2,400
Cost effectiveness (£/tCO2e)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
MtCO2e
43
Residential retrofit
Transport
Services retrofit
Services new build
Residential new build
Low carbon heat (residential)
Low carbon heat (public)
Low carbon heat (industry)
Low carbon heat (business)
Industrial process
Agriculture

## Charts B17–B18: Abatement included under the illustrative traded sector scenarios (excluding Electricity Market Reform) under central and high electricity demand

### Central demand




### High demand