Department for
Business, Energy
& Industrial Strategy

UPDATED ENERGY AND EMISSIONS PROJECTIONS 2018

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Executive summary

Through our world-leading performance, the UK has shown that clean growth – cutting emissions while growing the economy – can be achieved. Since 1990, we have cut emissions by over 40%[1] while growing the economy by 72%. To build on this success, our Clean Growth Strategy[2] set out an ambitious plan for decarbonising the economy through to 2032. Clean growth is also at the heart of the UK's Industrial Strategy, as one of four Grand Challenges[3].

Each year, BEIS produces projections of UK energy demand and greenhouse gas emissions, currently up to 2035. The projections in this report and associated annexes are based on policy analysis from July 2018 and modelling from September 2018.

The Climate Change Act[4], passed in 2008, committed the UK to reducing greenhouse gas emissions by at least 80% by 2050 when compared with 1990 levels. It also established a system of legally-binding carbon budgets which limit the net amount of greenhouse gases that can be emitted in successive five-year periods. The Energy and Emissions Projections (EEP) are one way that we monitor progress towards the UK's legislated targets.

The updated projections for UK territorial emissions[5] have changed little compared with the last edition (EEP 2017). UK territorial emissions include both emissions which fall under the EU Emissions Trading System (EU ETS), referred to as "traded" emissions, and emissions outside this system, referred to as "non-traded" emissions. Traded emissions include almost all power sector emissions and energy-intensive industrial sectors. These are important for meeting the UK's commitments under the Kyoto protocol but do not directly affect how performance is measured against carbon budgets[6].

BEIS updates the projections every year to incorporate new evidence, policy development, methodology improvements and other changes. The updated 2018 projections for traded emissions are lower than EEP 2017, due to lower projections for electricity demand and renewable generation technology costs. Projections of non-traded emissions are slightly higher, principally as a result of improvements to our methodology and small changes to our assessment of savings from policy (see

[1] All inventory figures within the body of this report and used for modelling are from the inventory data published in February 2018, which was the most recently published at the time of modelling (September 2018). The updated statistics published in February 2019 give this figure as 42%.
[2] Clean Growth Strategy (October 2017): https://www.gov.uk/government/publications/clean-growth-strategy
[3] The Industrial Strategy sets out Grand Challenges to put the UK at the forefront of the industries of the future: https://www.gov.uk/government/publications/industrial-strategy-the-grand-challenges/industrial-strategy-the-grand-challenges
[4] https://www.legislation.gov.uk/ukpga/2008/27
[5] Includes expired, implemented, adopted and planned policies as defined by UNFCCC.
[6] Carbon budget performance is measured by the net carbon account. In this calculation, emissions attributed to the traded sector are set equal to the UK's share of the EU ETS cap (the total emissions permitted in the European traded sector), not actual traded emissions.

Chapters 1 and 3). As performance against carbon budget targets depends only on non-traded emissions, the shortfall between projected performance and carbon budget targets is larger than in EEP 2017. We discuss this in more depth in Chapter 2, which sets out projections for emissions and performance against carbon budgets.

1 Introduction

- This report contains projections of performance against UK greenhouse gas (GHG) targets under existing policies.
- Legally binding carbon budgets are set for five-year periods and track towards the UK's long-term target of reducing emissions by at least 80%, relative to 1990 levels, by 2050. These must be set 12 years in advance.
- Performance against carbon budgets is measured by the net carbon account (see Box 1 in Chapter 2) and primarily depends on the level of non-traded emissions. These are emissions not covered by the European Union Emissions Trading System (EU ETS).
- The carbon budgets which have been legislated so far are: 2008 to 2012 (CB1); 2013 to 2017 (CB2); 2018 to 2022 (CB3); 2023 to 2027 (CB4); and 2028 to 2032 (CB5).

About this document

Since the late 1970s, the Government has published projections of UK energy demand and supply, and in the 1990s these were extended to include projected carbon dioxide (CO_2) and other greenhouse gas (GHG) emissions as well. The Department for Business, Energy & Industrial Strategy (BEIS) is responsible for publishing these projections annually.

The main projection is the "reference case", which is one view of how the UK energy and emissions system could evolve under implemented, adopted and agreed[7] Government policies if no new policies or changes to existing policies were introduced. Other views of the future are possible and there are significant uncertainties in these projections.

This report sets out the 2018 projections[8], with a comparison against the projections published for 2017 (EEP 2017, published in January 2018) and explanations of differences between these (mainly focusing on changes in the fourth and fifth carbon

[7] Agreed policies are at the point where policy-specific analysis has been published with sufficient detail for inclusion in the Energy and Emissions Projections (EEP). Annex D provides details on how we include policies in the EEP.

[8] The report and annexes contain outputs from projections under various different macro-economic assumptions. All of these include implemented, adopted and planned policies except the "baseline" projection which projects energy and emissions in the absence of policies brought in since the 2009 Low Carbon Transition Plan, and the "existing policies" projection which excludes planned policies.

budget periods). The projections bring together statistical and modelled information from a wide variety of different sources[9]:

- The main source of energy consumption data is the annual Digest of UK Energy Statistics (DUKES). The most recent full year of data is 2017 (published July 2018). We therefore report energy consumption trends against a comparison year of 2017.
- The main source of emissions statistics is the Greenhouse Gas Inventory, updated each February. At the time of modelling, the most recent full year of data was 2016 (published February 2018). We therefore report emissions trends against a comparison year of 2016. However, in tables and figures showing the performance against Carbon Budgets we use data from the February 2019 inventory.
- We combine these data sets with economic and demographic data to update equations that project forward energy demand and emissions in the absence of policy.

To produce these projections, the main model we use is the Energy Demand Model (EDM), which is an econometric model of energy demand and combustion-related GHG emissions for the UK economy. We run this in combination with two other BEIS models of retail electricity prices and the electricity supply sector. Together these three models project primary and final energy demand by year, economic sector and fuel.

Other Government departments and external bodies project the following "non-energy-related" GHG emissions. We add these to the EDM projections:

- Emissions from agriculture and waste;
- Emissions from Land Use, Land Use Change and Forestry (LULUCF).

As with previous EEP editions, we have published the data for the report, its annexes, and all tables and figures online. Further details about the projection methodology are now available in a separate document[10].

This report includes projections of the UK's progress towards its own targets for GHG emissions. The targets were introduced by the 2008 Climate Change Act, which established a long-term target for the UK to reduce its net emissions in 2050 by at least 80% compared with 1990[11]. The Act also established a system of legally binding limits on the net amount of GHGs (greenhouse gases) that can be emitted, called

[9] Energy and emissions projections: https://www.gov.uk/government/collections/energy-and-emissions-projections
[10] The methodology document is available at: https://www.gov.uk/government/publications/updated-energy-and-emissions-projections-2018
[11] Compared with a base year of 1990 for CO_2, CH_4 and N_2O, and 1995 for fluorinated gases: https://www.legislation.gov.uk/ukpga/2008/27/contents

carbon budgets[12]. Each carbon budget spans five years and is set with a view to keeping the UK on track to its 2050 target.

The reference case and other scenarios

The main projection presented in this report is the BEIS "reference case" or central projection. The reference case is based on central assumptions for the key drivers of energy and emissions, such as fossil fuel prices, Gross Domestic Product (GDP) and population.

We produce projections of energy demand and emissions outside the power sector by applying standard statistical techniques (based on trends and relationships identified in past data) to project forward energy demand and emissions. We adjust these to take account of the estimated impact of implemented, adopted and agreed Government policies (as at July 2018).

The projection of electricity supply is based on a model of supplier behaviour, rather than statistical analysis of past trends. It reflects current policy up to the early 2020s. Beyond then, the electricity generation scenario includes assumptions that go beyond current Government policy and is therefore illustrative. The reference electricity generation scenario therefore represents one particular view of how the system could evolve and is not a forecast or preferred scenario.

The UK Government develops and implements policies with the aim of reducing GHG emissions in line with the carbon budgets and international commitments. These projections indicate the scale of action that is needed to keep emissions within the carbon budgets. This is the subject of Chapter 3, which discusses policy impacts on emissions. For this, we compare the reference scenario against a "baseline" scenario which excludes the impact of all climate change policies brought in since the 2009 Low Carbon Transition Plan[13] (LCTP).

Besides the reference and baseline scenarios, the annexes to this report also set out the following additional scenarios: low and high fossil fuel price scenarios, low and high economic growth scenarios, and an "existing policies" scenario which only includes policies that have been implemented or adopted (but not planned policies). For all these scenarios, there are significant uncertainties in the projections and other views of the future are possible. Some of this uncertainty is captured in our projections modelling and presented in this report (see Chapter 6).

[12] See page 143 of the Clean Growth Strategy for more background on carbon budgets: https://www.gov.uk/government/publications/clean-growth-strategy
[13] The Low Carbon Transition Plan publication is available at: https://www.gov.uk/government/publications/the-uk-low-carbon-transition-plan-national-strategy-for-climate-and-energy

Model changes since EEP 2017

The changes compared with EEP 2017 are due to policy updates, model improvements and updates to other inputs. Table 1.1 below shows the main changes made, and the impact they have on non-traded emissions in the fourth and fifth carbon budget periods.

Table 1.1: Changes which affect non-traded emissions (in comparison with EEP 2017)

			$MtCO_2e$
Type of change since EEP 2017	Carbon budget 3 (2018-22)	4 (2023-27)	5 (2028-32)
Change in policy savings	23	25	27
BEIS modelling improvements	52	47	42
Updated inputs	-16	-22	-13
Other*	-4	-6	-8
Total change since EEP 2017	*55*	*45*	*49*

**"Other" includes inputs too small to quantify and interactions between changes that mean individual impacts cannot be fully isolated.*

The main reasons for these change in non-traded emissions[14] when compared with EEP 2017 are:

- BEIS modelling improvements led to projected non-traded emissions being higher than EEP 2017 by 47 $MtCO_2e$ and 42 $MtCO_2e$ in the fourth and fifth carbon budget periods respectively. There were four main BEIS modelling improvements: improved modelling of emissions from heat that is sold, improved econometric equations for residential energy demand, improvements to industry emissions estimates, improved commerce energy projections.
- The update of projected emissions savings from climate change policies led to an increase in projected non-traded emissions by 25 $MtCO_2e$ and 27 $MtCO_2e$ in the fourth and fifth carbon budget periods respectively. We project that new policies such as Boiler Plus, Streamlined Energy and Carbon Reporting for Business (SECR) and Industrial Heat Recovery Support (IHRS) will provide increased emissions savings, while projected savings from some other policies have reduced. We discuss policy savings in detail in Chapter 3.

[14] The attribution of changes between types of input is approximate as it is not possible to fully isolate the impact of every update. The residual changes in the fourth and fifth carbon budget periods respectively are -6 and -8 $MtCO_2e$.

- Updated input data (primarily revised assumptions for land use and forestry input data[15]) partially offset the above increases and lead to projected non-traded emissions being 22 $MtCO_2e$ and 13 $MtCO_2e$ lower than EEP 2017 in the fourth and fifth carbon budget periods respectively.

Improvements in the projection methodology

Since EEP 2017 was published in January 2018, the BEIS modelling team have concentrated on updates to the modelling methodology and quality assurance.

These changes improve the accuracy of the projections in representing energy and emissions trends, based on the most recent available data and evidence. Overall, the updated projections show lower traded emissions and higher non-traded emissions in comparison with EEP 2017.

The improvements to the BEIS energy demand model in the 2018 projections were:

- **Inclusion of emissions from heat sold**: In 2017, modelling for CHP plants was integrated into BEIS's power sector modelling. We changed the method for incorporating the energy used to generate heat that is sold to align with DUKES and reflect this improved CHP modelling. The second phase of this work, completed this year, incorporated improved statistics on heat sold. During this work we identified that the new CHP model emissions outputs only included emissions from fuels used for electricity generation. To better reflect actual emissions, the 2018 EEP also includes emissions for fuel used to generate heat that is sold. The effects of this change are:
  - Better consistency with DUKES and power sector modelling.
  - Compared with EEP 2017, projected non-traded emissions are higher by 18 $MtCO_2e$ in both the fourth and fifth carbon budget periods.
- **Industrial sector emissions: Improvements to sub-sector projections and the allocation between traded/non-traded emissions**: In early 2018 we carried out a review of industry emissions and improved the subsector emission allocations we use to calculate EU ETS traded shares. The effects of this change are:
  - Industry emissions are now consistent and fully reconciled with available sources.
  - Compared with EEP 2017, projected non-traded emissions increased by 9 $MtCO_2e$ and 4 $MtCO_2e$ in the fourth and fifth carbon budget periods respectively.

[15] This year's modelling includes revised assumptions for settlements, cropland and grassland. These project a higher amount of greenhouse gas removal when compared with last year's EEP, particularly for the removal of emissions (sequestration) by forest land. More details about the updated methodology are available at: https://www.gov.uk/government/publications/planned-methodology-changes-for-uk-greenhouse-gas-emissions

- **Update of residential sector demand projections**: Every year, the EEP team identify which equations are performing less well. The residential sector was the focus for 2018 improvement. We revised the econometric equations which project gas and electricity demand in the residential sector using the latest data and improved econometric methodology. The effects of this change are:
  - Compared with EEP 2017, projected non-traded emissions are higher by 12 $MtCO_2e$ and 11 $MtCO_2e$ in the fourth and fifth carbon budget periods respectively (lower electricity demand affects the power sector, where emissions are mostly in the traded sector).
- **Update of commercial sector demand projections**: Quality assurance identified that the commerce electricity fuel share equation projected an upward trend in the electricity fuel share: this had become out of line with recent trends. We addressed the problem by reducing the projected electricity fuel share projection in line with DUKES data. The effects of this change are:
  - The updated equations project higher gas demand and lower electricity demand than EEP 2017.
  - The projected non-traded emissions are higher by 8 and 9 $MtCO_2e$ in the fourth and fifth carbon budget periods respectively.

All the model improvements mentioned above relate to the BEIS energy demand model. There were also improvements to some of the other models that provide inputs to the projections, and these changes are detailed in the next section on changes due to input updates. These include Department for Transport (DfT) models for road traffic projections and the National Atmospheric Emissions Inventory (NAEI) shipping model[16] used to produce the Inventory estimates for domestic shipping.

Changes due to input updates

In all editions of the energy and emissions projections, we update the model to use the most recent emissions data (2016 Inventory, published Feb 2018[17]), energy statistics (DUKES) and macro-economic projections at the time of update. The projections depend on inputs such as GDP assumptions, temperature and fossil fuel prices, and can therefore fluctuate considerably from year to year. As well as data for the most recent historic year becoming available, historic Inventory and DUKES data can also be revised.

[16] The new shipping model is described on page 6 of the following document: https://www.gov.uk/government/publications/planned-methodology-changes-for-uk-greenhouse-gas-emissions

[17] EEP 2018 uses historic (Inventory) GHG emissions data to 2016 and projects emissions from 2017. This is based on the Inventory data published in February 2018: the most recent available at the time of modelling in September 2018.

We summarise input changes in Table 1.2 below in the order of their impact on emissions in the fourth carbon budget period compared with EEP 2017.

Table 1.2: Updated inputs which affect non-traded emissions (in comparison with EEP 2017)

			$MtCO_2e$
Updated inputs	Carbon budget 3 (2018-22)	4 (2023-27)	5 (2028-32)
Shipping model update	18	18	18
Updated DUKES	12	10	10
Power sector updates	3	5	6
Non-CO_2 updates	-3	-4	-4
Economic growth indicators (e.g. GDP)	0	-5	-7
Fossil fuel prices	-16	-8	-1
DfT updates	-4	-9	-11
LULUCF update	-26	-29	-23
Total change due to updated inputs	*-16*	*-22*	*-13*

We give more detail below for the key drivers that increased projected greenhouse gas emissions in the fourth and fifth carbon budget periods:

- **Shipping model (Inventory)**: In 2017, Ricardo Energy & Environment (the UK's Inventory Agency) updated the NAEI shipping model to incorporate automatic identification system (AIS) data and thereby better track the geographic location of vessels and thereby more accurately estimate domestic shipping emissions. This led to an upwards revision for estimates of domestic shipping emissions in the UK Greenhouse Gas Inventory (February 2018). The Inventory Agency also produced a forecast for shipping emissions[18] showing a broadly flat trajectory out to 2035. The EEP shipping emissions projections have been revised to include these new assumptions.

- **Energy statistics (DUKES)**: In the EEP model, emissions are mainly projected from statistics on the most recent level of energy demand. Projected emissions from oil consumption in industry and commerce are higher. This is due to DUKES revisions and updates which led to DUKES estimates of 2017 oil consumption being higher than 2016[19].

[18] See figure 2 of this report: http://naei.beis.gov.uk/reports/reports?report_id=950
[19] More detail is available here: https://www.gov.uk/government/collections/digest-of-uk-energy-statistics-dukes#2018

- **Updated assumptions for power sector modelling:** Although overall territorial emissions from the power sector are lower than in EEP 2017, non-traded emissions (which contribute to the net carbon account) are slightly higher due to increased projected generation of electricity from waste[20] which is excluded from the EU ETS.

We give more detail below about the key drivers that reduced projected greenhouse gas emissions for the fourth and fifth carbon budget periods:

- **Land Use, Land Use Change and Forestry (LULUCF):** Overall, this category is an emissions sink removing greenhouse gases from the atmosphere. This year's modelling is based on revised assumptions for settlements, cropland and grassland. The changes project more greenhouse gas removal when compared with last year's EEP, particularly for emission sequestration by forest land[21].
- **Light Goods Vehicles (LGV) model update**: The Department for Transport has updated the model used to project LGV traffic to reflect the latest evidence and to implement an improved methodology. This has significantly reduced the projected emissions from LGVs in future years.
- **Fossil fuel prices:** Projected emissions are lower in the third carbon budget period because of higher short-term assumptions for fossil fuel prices compared with those used in EEP 2017. Higher fossil fuel prices generally have the effect of dampening energy demand. The change has mostly affected the road transport sector.
- **Economic growth indicators (e.g. GDP)**: Short-run economic growth projections published by the OBR in March 2018 were revised downwards leading projected emissions to be lower.

Reporting changes

There has been one reporting change for EEP 2018:

- **Off-road Category**: Emissions which in past EEP editions were reported as "off-road" are now allocated to industry, services or other transport. This improves consistency with DUKES sector definitions. This has no effect on total territorial emissions, and a minimal effect on the traded and non-traded emissions split. Annex B shows this in more detail.

[20] "Energy from Waste" and "Advanced Conversion Technologies" are aggregated into "Renewables" in our Annex reporting. However, they do produce GHG emissions and inorganic waste is not renewable.
[21] More details about updated methodology is available at:
https://www.gov.uk/government/publications/planned-methodology-changes-for-uk-greenhouse-gas-emissions

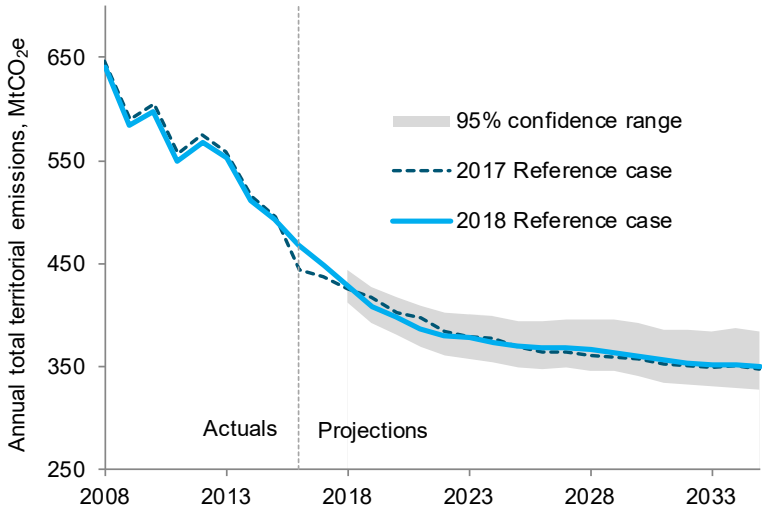
2 UK emissions projections

- The UK met the first and second carbon budgets with headroom of 36[22] and 384[23] $MtCO_2e$ respectively. The UK is projected to meet the third carbon budget with headroom of 88 $MtCO_2e$.
- There are projected shortfalls against the fourth and fifth carbon budgets of 139 and 245 $MtCO_2e$ respectively. As policies and proposals in the Clean Growth Strategy are developed more fully, their impacts will be included in future EEP editions.

Figure 2.1 shows actual and projected UK territorial emissions. These projections are uncertain. Some of this is captured in our projections modelling, but our uncertainty analysis excludes the electricity supply industry and possible "structural breaks" in society or the economy which might significantly affect emissions. For example, societal and behavioural step changes or breakthrough technologies like improved storage could have profound impacts on our energy mix and emissions but are hard to anticipate. The methodology only looks at future uncertainty, rather than analysis of inputs or outputs historically (before 2018). We show modelled uncertainty as a fan chart around the projections (Fig. 2.1). This is higher for later years, reflecting the increased uncertainty of our projections further into the future (see Chapter 6).

[22] Performance against carbon budgets depends on the level of non-traded emissions. It is not affected by the actual level of traded emissions under current carbon accounting rules.
[23] The statistics was published in the Feb 2019 Greenhouse Gases inventory: https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-2017. Performance against the budget will be confirmed in the final statement for the second carbon budget period, which will be published in May 2019.

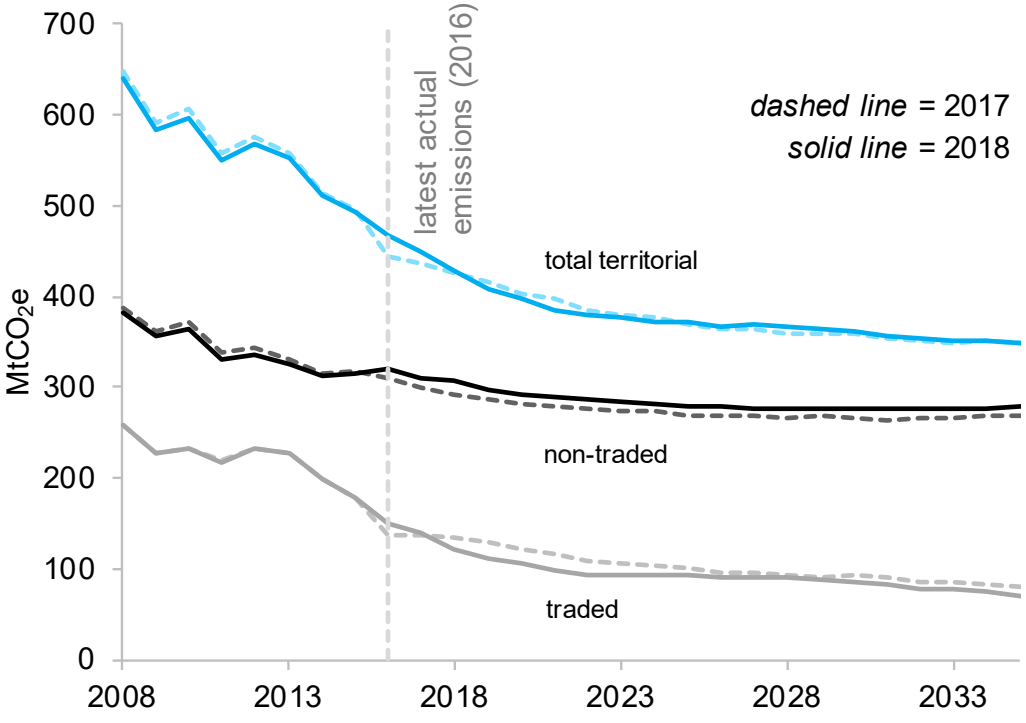
Figure 2.1: Uncertainty in projected overall territorial emissions



Comparison with the 2017 projections

Figure 2.2 below compares emissions trends from EEP 2018 with the same trends from EEP 2017.

Figure 2.2: Emissions trends



The 2018 projections for territorial emissions overall are similar to EEP 2017[24]. For example, over the fourth carbon budget period (2023-27 inclusive), projected territorial emissions are 5 $MtCO_2e$ (0.2%) higher than in the 2017 projections, while in the fifth carbon budget period they are 20 $MtCO_2e$ (1.1%) higher.

In EEP 2018, there is a decrease in traded emissions of 40 $MtCO_2e$ and 29 $MtCO_2e$ in the fourth and fifth carbon budget periods respectively; and we project non-traded emissions to be slightly higher than in EEP 2017, (45 $MtCO_2e$ higher in the fourth carbon budget period and 49 $MtCO_2e$ higher in the fifth carbon budget period).

In comparison with EEP 2017, projected traded emissions are on average 10% lower, with the largest decrease in the short run. Industry traded emission projections are similar to EEP 2017. Lower traded emissions in this year's projections are due to reduced electricity demand and increased renewables generation displacing both coal and gas generation from now until the mid-2020s. Increases in renewables generation are due to lower projected technology costs, whilst projected electricity demand is lower due to revisions that we made to the demand equations for the commercial and residential sectors which had been overestimating electricity demand. These changes were described in Chapter 1.

Progress towards the carbon budgets

The Energy and Emissions Projections are one measure of the UK's progress towards future targets for greenhouse gas (GHG) emissions. The 2008 Climate Change Act established a long-term target for the UK to reduce its net emissions in 2050 by at least 80% compared with 1990[25]. The Act also established a system of legally-binding carbon budgets which limit the net amount of GHGs that can be emitted in successive five-year periods, starting in 2008[26].

The first carbon budget covered the period 2008 to 2012 and the UK met this budget with headroom of 36 $MtCO_2e$. The second carbon budget covered the period 2013 to 2017, and the UK met this budget with headroom of 384 $MtCO_2e$ [27]. Budget levels have so far been set for three further periods: 2018 to 2022, 2023 to 2027, and 2028 to 2032. The performance against the second carbon budget was published in the February 2019 Greenhouse Gases inventory report, after the EEP analysis was completed. We have updated Figure 2.3 and Table 2.1 which show carbon budget

[25] Compared with a base year of 1990 for CO_2, CH_4 and N_2O, and 1995 for fluorinated gases: https://www.theccc.org.uk/publication/building-a-low-carbon-economy-the-uks-contribution-to-tackling-climate-change-2/

[26] For more details on the UK's climate change targets, including the carbon budgets, see: https://www.gov.uk/guidance/carbon-budgets

[27] The statistic was published in the February 2019 Greenhouse Gases inventory: https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-2017. Performance against the budget will be confirmed in the final statement for the second carbon budget period, which will be published in May 2019.

performance, but all the other tables and figures across the report are still based on data from the February 2018 inventory.

Box 1: The UK net carbon account

Compliance with the budgets is assessed by comparing the UK "Net Carbon Account"[1] (NCA) against the carbon budget level.

The NCA is currently defined as the sum of three components: 1) Emissions allowances allocated to the UK under the EU Emissions Trading System (EU ETS); 2) UK emissions not covered by the EU ETS; 3) Credits/debits from other international crediting systems.

1. Emissions covered by the EU ETS, or "traded sector emissions" generally include those from power generation and from large energy-intensive industrial plants. For the net carbon account, traded sector emissions are measured as the UK's allocation of allowances under the EU ETS. To project future carbon budget performance, the level of allocation must be estimated. The levels used are based on the assumed shares at the time of setting the respective carbon budgets, as the UK's actual future shares were not fully known at that stage. Projections for the actual level of allocation covered by the EU ETS can be found in the web tables.
2. "Non-traded emissions" include all UK GHG emissions which are not covered by the emissions trading system (EU ETS). For example, this includes road transport, heating in buildings, agriculture, waste and some industry. Since EEP 2017, projections of emissions from 'Energy from Waste' power plants have been accounted for as 'non-traded', bringing this into line with the ETS directive. The UK net carbon account reflects the actual emissions from the UK in those sectors.
3. Credits/debits are also included from other international credit systems.

On 23 June 2016, the EU referendum took place and the people of the United Kingdom voted to leave the European Union. Until the date of exit, the UK remains a full member of the European Union and all the rights and obligations of EU membership remain in force. With exit negotiations still in progress at the time of EEP model runs and analysis, the Energy and Emissions Projections were produced on that basis.

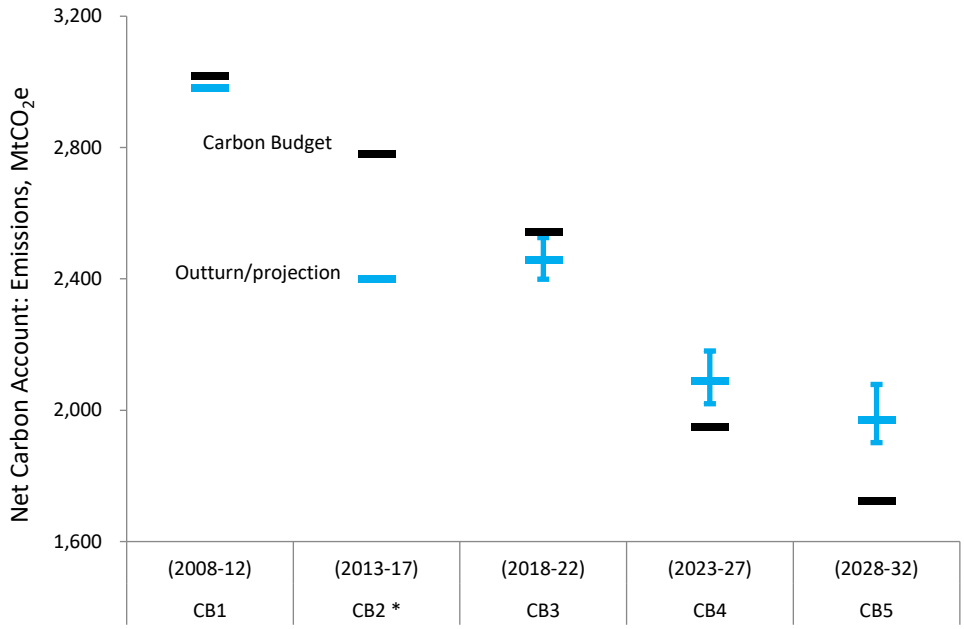
The UK Net Carbon Account measures performance against carbon budgets—this is described in Box 1. Figure 2.3 and Table 2.1 show the actual and projected performance against legislated carbon budgets.

The range presented in the projected net carbon account is the 95% confidence interval for the uncertainties that have been modelled. Chapter 6 of this report gives

more details about how we carried out this uncertainty analysis, and Table 6.1 summarises the variables we considered. This does not capture all sources of uncertainty or its full range (discussed in Chapter 6).

The chart below (Fig 2.3) shows cumulative values over five-year periods from 2008 to 2032.

Figure 2.3: Actual and projected performance against carbon budgets



Vertical bars show uncertainty in the projections and indicate 95% confidence intervals for the central reference scenario. Please note that for the first and second carbon budget the actual net carbon accounts have been used. The projections for the other carbon budgets use the traded cap assumed when the budgets were set[28]*. Overachievement in the second carbon budget is partly due to differences between actual UK EU ETS allowances and those assumed when the budget was set. This is purely an accounting impact and not related to actual UK emissions.*

We project progress against future carbon budgets to be as follows. All figures quoted in this section relate to non-traded emissions:

- The 2018 projections show that the third carbon budget (2018 to 2022) is very likely to be achieved with a central margin of 88 $MtCO_2e$. Uncertainty analysis indicates that even the highest emission scenario (based on the upper 95% confidence

[28] EEP uses the UK allocation of EU ETS allowances assumed at the time of setting the respective carbon budgets for projections, as the allocations are not finalised until after the budget period to which they relate (see Box 1 for details). EEP 2017 used the UK allocation of EU ETS allowances assumed at the time of setting the second carbon budget, as the allocations were not finalised at that stage. In EEP 2018 instead we have used the final net carbon account as published in the February 2019 Greenhouse Gases inventory.

interval) would be within budget. Taking account of the uncertainty around the projections, this margin could be as low as 18 $MtCO_2e$ or as high as 145 $MtCO_2e$[29].

- For the fourth carbon budget (2023 to 2027), the UK's emissions are currently projected to be greater than the cap set by the budget. We will continue with our ambitious implementation of the policies and proposals set out in the Clean Growth Strategy to address the gap. The projected shortfall was 94 $MtCO_2e$ in EEP 2017 and has now increased to 139 $MtCO_2e$. Taking account of the uncertainty around the projections, this shortfall could be as low as 70 $MtCO_2e$ or as high as 230 $MtCO_2e$[30]. Many policies which will affect the 2020s and beyond have not yet been developed to the point at which they can be included in these projections[31].
- For the fifth carbon budget (2028 to 2032), the UK's emissions are currently projected to be greater than the cap set by the budget. We will continue with our ambitious implementation of the policies and proposals set out in the Clean Growth Strategy to address the gap. In EEP 2017 the reference case shortfall was 196 $MtCO_2e$: this has increased to 245 $MtCO_2e$. Taking account of the uncertainty around the projections, this shortfall could be as low as 176 $MtCO_2e$ or as high as 353 $MtCO_2e$[32]. Many policies which will affect the 2020s and beyond have not yet been developed to the point at which they can be included in these projections.

In October 2017, the Government published its Clean Growth Strategy, setting out policies and proposals for meeting future carbon budgets, together with illustrative pathways to the 2050 target[33]. EEP 2017 provided an updated version of the Clean Growth Strategy's summary of performance against carbon budgets, which was Table 2.1 of the EEP 2017 report. For the 2018 projections, we have updated Table 2.1: as with last year, this includes the initial estimates of the subset of early stage policies and proposals quantified in the Clean Growth Strategy.

Due to the methodological and input changes mentioned earlier, projected performance against carbon budgets has fallen from the level seen in the EEP 2017 projections. The gap between projected performance and the fourth and fifth carbon budgets (before Clean Growth Strategy policies and proposals) has increased by 45 and 49 $MtCO_2e$ respectively.

[29] In the 2017 projections, the headroom for the third carbon budget period was projected to be between 66 and 200 $MtCO_2e$.
[30] In the 2017 projections, the fourth carbon budget period shortfall was projected to be between 23 and 180 $MtCO_2e$.
[31] Within the main EEP projections, we include policies if they are either currently implemented or firmly planned in the future: i.e. we do not include policies which are still under development.
[32] In the 2017 projections, we projected this fifth carbon budget period shortfall to be between 117 and 287 $MtCO_2e$.
[33] Clean Growth Strategy: published in October 2017. See: https://www.gov.uk/government/publications/clean-growth-strategy

The 2018 projections (including the estimates of emission reductions from a subset of Clean Growth Strategy policies and proposals[34]) suggest that we could deliver 95 per cent and 93 per cent of our required performance against 1990 levels, for the fourth and fifth carbon budgets respectively.

Table 2.1 shows projected performance against the carbon budgets, including the estimates of emission reductions from a subset of Clean Growth Strategy policies and proposals.

The headroom for the second carbon budget in this report is bigger than the headroom reported in EEP 2017. EEP 2017 used the UK allocation of EU ETS allowances assumed at the time of setting the second carbon budget, as the allocations were not finalised at that stage. The EEP 2018 version of table 2.1 contains instead the final performance against the second carbon budget, as reported in the final greenhouse gas emissions statistics, which uses the actual EU ETS allocation.

Overachievement in the second carbon budget is partly due to differences between actual UK EU ETS allowances and those assumed when the budget was set (296 $MtCO_2e$). This is purely an accounting impact and not related to actual UK emissions. The remaining 88 $MtCO_2e$ is due to non-traded emissions being lower than the target level.

[34] This subset of early stage policies and proposals from the Clean Growth Strategy gives an additional potential reduction of up to 30 or 80 $MtCO_2e$ over the fourth and fifth carbon budget periods respectively.

Table 2.1: Performance against carbon budgets

			Carbon budget: 1 (2008-12)	2[35] (2013-17)	3 (2018-22)	4 (2023-27)	5 (2028-32)
			Actual	**Projection**	**Projection**	**Projection**	**Projection**
Carbon Budget level (cumulative)		emissions, $MtCO_2e$	3,018	2,782	2,544	1,950	1,725
Average required reduction vs. 1990 emissions		%	-25%	-31%	-37%	-51%	-57%
2017	**Existing policies**	projected emissions, $MtCO_2e$	2,982	2,657	2,401	2,044	1,921
	Existing and new policies and proposals	projected emissions, $MtCO_2e$	2,982	2,657	2,401	2,014	1,841
2018	**Existing policies**	projected emissions, $MtCO_2e$	2,982	2,398	2,456	2,089	1,970
	Existing and new policies and proposals[36]	projected emissions, $MtCO_2e$	2,982	2,398	2,456	2,059	1,890
	Result vs. Budget	emissions, $MtCO_2e$	*-36*	*-384*	*-88*	*109*	*165*
		%	*-1.2%*	*-13.8%*	*-3.4%*	*5.6%*	*9.6%*
	Cumulative surplus (+) or deficit (-)	emissions, $MtCO_2e$		*+384*	*+471*	*+363*	*198*

Non-traded emissions projections by sector

Non-traded emissions for all years are based on estimates of the proportion of emissions by sector that were not included in the EU ETS in 2016. Projections of non-traded emissions are derived by applying these proportions to sectoral projections.

Overall, we project a fall in non-traded emissions from 319 $MtCO_2e$ in 2016 to 279 $MtCO_2e$ in 2035 (a reduction of 13%). The projections show how different sectors of the economy[37] contribute to the total.

[35] EEP 2017 used the UK allocation of EU ETS allowances assumed at the time of setting the second carbon budget, as the allocations were not finalised at that stage. The EEP 2018 version of table 2.1 contains instead the final performance against the second carbon budget, as reported in the final greenhouse gas emissions statistics, which uses the actual EU ETS allocation.

[36] This subset of early stage policies and proposals from the Clean Growth Strategy gives an additional potential reduction of up to 30 or 80 $MtCO_2e$ over the fourth and fifth carbon budget periods respectively

[37] These are as defined in the Digest of UK Energy Statistics (DUKES), see: https://www.gov.uk/government/collections/digest-of-uk-energy-statistics-dukes

Figure 2.4 depicts the projected trends in sector emissions.

Industry[38]**, commercial services** and **public administration, agriculture** and **waste** contributed around 41% of non-traded emissions in 2016. This is projected to fall to around 36% by 2035.

Land Use, Land Use Change and Forestry (LULUCF) emissions contribute to carbon budgets. They include both sources and sinks[39] of greenhouse gases from forest land, cropland, grassland, human settlements and those due to changes of land use between any of these categories[40]. LULUCF is currently a sink for atmospheric CO_2 but a source of other greenhouse gases – notably nitrous oxide caused by changes in soil decomposition following the disturbance of soil in land conversion. In 2016, this sector removed around 3% of total greenhouse gas emissions. This figure is projected to fall to 2% in 2035. Further information on non-CO_2 emissions from LULUCF can be found in Annex N of this report.

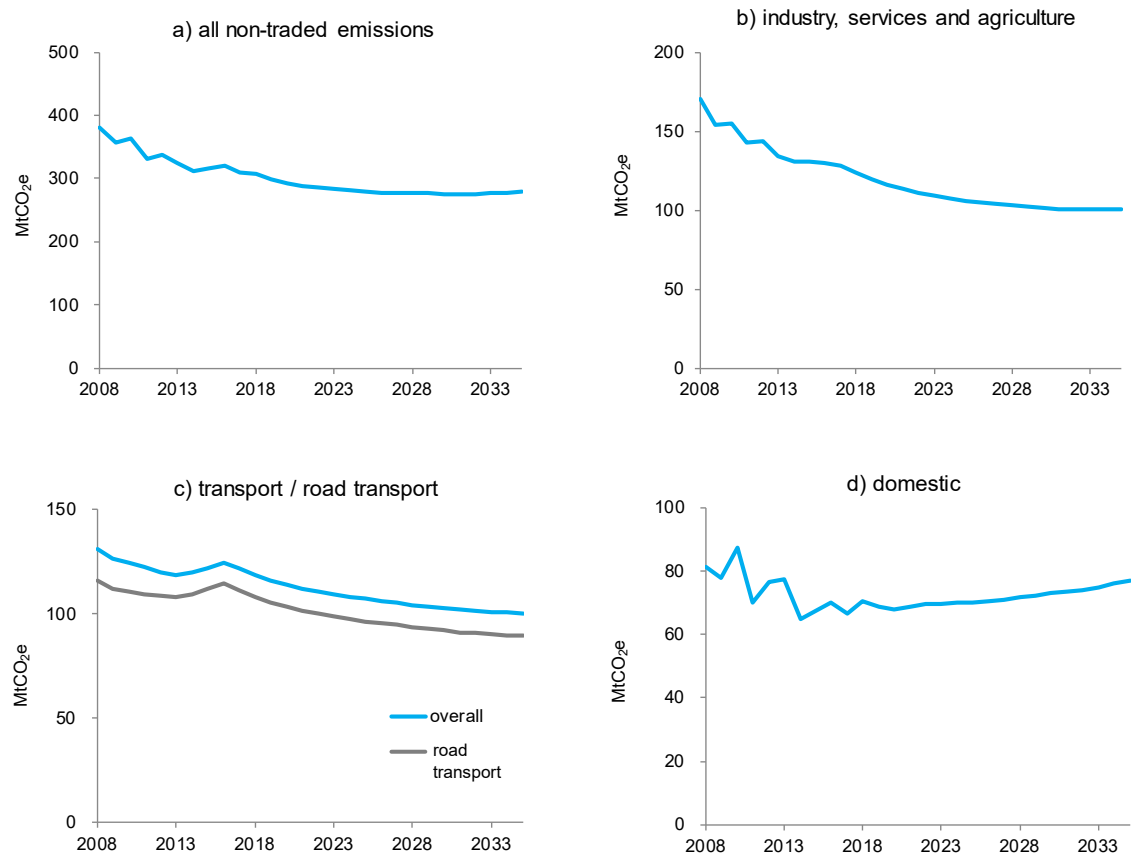
Transport, mostly road transport, contributed around 40% of UK non-traded emissions in 2016 (Figure 2.4c). The projections show a decline to 2035 (emissions are projected to fall by 19% from 2016 levels).

The **domestic** (residential) sector (Figure 2.4d) was responsible for 22% of non-traded emissions in 2016. All emissions from this sector are non-traded. In comparison with 2016 levels, they are projected to rise by 7 $MtCO_2e$ (10%) by 2035 when they will account for 28% of non-traded emissions. The increase is mostly due to the update of residential sector demand projections discussed in Chapter 1.

In past editions of the EEP, all **power sector** emissions were considered traded but since EEP 2017, emissions from 'Energy from Waste' (municipal waste) have been excluded from the traded sector in line with ETS directive 2003/87/EC. These are projected to account for 3.7 $MtCO_2e$ (1.3% of total non-traded emissions) in 2035.

[38] This includes CO_2 emissions from agriculture due to the burning of fuels and fertiliser use.
[39] Carbon sinks are elements of the carbon system that absorb or store carbon dioxide, for example the forests and oceans.
[40] A detailed discussion of the components of LULUCF is available here: http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_files/GPG_LULUCF_FULL.pdf

Figure 2.4: Non-traded emissions in the economy



Non-traded emissions by consumer sector, 2008 to 2035. a) All non-traded emissions, b) Industry, services and agriculture, c) Transport (road transport in grey), d) Domestic.

Annexes A and B contain detailed emission projections by sector and type of greenhouse gas. Section 4 discusses the projections of energy demand which lead to these emissions.

3 Effect of policies on emissions

- Government policies are projected to reduce non-traded GHG emissions. The projected reduction in the fourth carbon budget period is 275 $MtCO_2e$ (or about 20% of non-traded emissions in that period).
- 79% of the reduction in non-traded GHG emissions during the fourth carbon budget period comes from policies adopted since the Low Carbon Transition Plan (LCTP) of 2009. The remainder is from policies adopted before the LCTP.
- Projected non-traded emissions are 25 $MtCO_2e$ and 27 $MtCO_2e$ higher than EEP 2017 in the fourth and fifth carbon budget periods respectively. This is due to revisions to policy savings from some existing policies.
- Compared with EEP 2017, we include three new policies in the projections. These are: Boiler Plus, Streamlined Energy and Carbon Reporting for Business (SECR) and Industrial Heat Recovery Support (IHRS).

Policies for emissions reduction

This chapter looks at the impact of government policies that directly influence energy use and emissions. Government estimates individual policy impacts by comparing modelled emissions from scenarios which contain a policy against scenarios which do not. The savings from some policies cannot currently be explicitly identified, particularly in the agriculture and waste management sectors. Although not separately identifiable, the baseline includes these policy savings and we therefore capture them in the projections. Descriptions of some policies for which GHG savings have not been quantified are given in Annex D.

These projections include policies from the Clean Growth Strategy if they were classed as implemented, adopted or planned at the cut-off point of July 2018 (see the next page for definitions). As the policies and proposals in the Clean Growth Strategy are further developed, their impacts will be included as appropriate in future EEP editions.

As in the EEP 2017 report, Table 2.1 reports projections, with the inclusion of the Clean Growth Strategy's estimate of savings from a further subset of planned policies (estimated savings of 30 $MtCO_2e$ during the fourth carbon budget period and 80 $MtCO_2e$ during the fifth carbon budget period).

This chapter focuses on policies that produce savings in the non-traded sector since they directly contribute to meeting the carbon budgets (see Box 1 in Chapter 2). It also includes a discussion of the government policies which reduce emissions from electricity generation.

We group policies according to whether they were adopted before or after the Low Carbon Transition Plan (LCTP) of 2009. This was the UK's first comprehensive plan for moving to a low carbon economy.

Within this chapter, we quote savings which refer only to policies adopted after the LCTP ('post-LCTP') unless otherwise stated; estimates for these are more robust than for policies adopted before the LCTP ('pre-LCTP').

Table 3.1 shows that Government policies are estimated to reduce non-traded emissions by 899 $MtCO_2e$ over carbon budgets 2 to 5.

Table 3.1: Non-traded GHG emissions savings from policies

					$MtCO_2e$
Carbon budget:	2 (2013-2017)	3 (2018-2022)	4 (2023-2027)	5 (2028-2032)	**Total (2013-2032)**
Savings from pre-LCTP policies	67	67	59	49	**242**
Savings from post-LCTP policies	39	137	216	266	**658**
Savings from all policies	**105**	**204**	**275**	**314**	**899**

The reference projection includes all *expired, implemented, adopted* and *planned* policies[41]. The following categories are used to describe the implementation status of policies, which are consistent with UNFCCC definitions[42]:

- *"Expired* policies and measures are closed policies that still provide legacy carbon savings.
- *Implemented* policies and measures are those for which one or more of the following applies:
  - (i) national legislation is in force;
  - (ii) one or more voluntary agreements have been established;
  - (iii) financial resources have been allocated;
  - (iv) human resources have been mobilised.
- *Adopted* policies and measures are those for which an official Government decision has been made and there is a clear commitment to proceed with implementation.

[41] In UNFCCC reporting standards this is known as a "*with additional measures"* (WAM) projection. In the annexes we also give energy and emissions projections without *planned* policies, a "*with existing measures"* (WEM) projection. The baseline projection excludes policies adopted since the Low Carbon Transition Plan (LCTP) of 2009.

[42] For instance, see point 15 of: https://unfccc.int/resource/docs/2015/tp/03.pdf

- *Planned* policies and measures are options under discussion with a realistic chance of being adopted and implemented in future."

Changes to policy savings since EEP 2017

For EEP 2018, we have improved the methodology used to estimate the split of policy emissions savings between traded and non-traded sectors[43]. This change provides better consistency with the emissions projections methodology and published policy impact assessments.

For the comparisons presented in this chapter, we have recalculated the EEP 2017 policy savings using the improved 2018 reporting methodology (published as "2017 Annex D under improved traded&non-traded methodology"). This allows us to clearly highlight changes driven by policy development and revision, in contrast to those where only the reporting approach has changed.

We project lower non-traded greenhouse gas savings from some government policies in the 2018 projections in comparison with EEP 2017. In the third carbon budget, policy savings reduce from 228 to 204 $MtCO_2e$, in the fourth carbon budget from 300 to 275 $MtCO_2e$ and in the fifth carbon budget from 342 to 314 $MtCO_2e$ overall. Reductions in policy savings result in an increase in projected emissions.

Key drivers increasing projected emissions savings from policies were:

New BEIS policies: some policies contained in the Clean Growth Strategy have now been included in the EEP; these are projected to increase total non-traded savings by 4 $MtCO_2e$ in the fourth carbon budget period and by 5 $MtCO_2e$ in the fifth carbon budget period:

i. **Boiler Plus** (technical standards for domestic boiler installations). A policy aiming to lower domestic gas demand by setting a compulsory technical standard for households. It is estimated to produce non-traded savings of 2 and 3 $MtCO_2e$ in the fourth and fifth carbon budget periods respectively.

ii. **Streamlined Energy and Carbon Reporting for business**. Reporting framework obligating companies to report their energy use and associated emissions. It is projected to provide total savings of 2 $MtCO_2e$ (1.5 $MtCO_2$ of which is in non-traded sectors) in both the fourth and fifth carbon budget periods.

[43] The change just improves the allocation of reported savings between traded and non-traded savings. It has no effect on the modelled projections of total, traded or non-traded emissions, but just ensures that the report and Annex D are more consistent with the modelling methodology.

iii. **Industrial Heat Recovery Support**. Policy providing funding to support the uptake of heat recovery projects. Additional savings (mostly traded) are projected to be 0.5 $MtCO_2$ in both the fourth and fifth carbon budget periods.

Agricultural Action Plan: non-traded savings are higher than EEP 2017 by 1.5 $MtCO_2e$ in the fourth carbon budget period and by 3 $MtCO_2e$ in the fifth carbon budget period. Policy savings are higher in the agriculture sector due to the inclusion of savings from the Climate Change Strategy of Wales and the Climate Change Plan from Scotland.

Key drivers reducing projected emissions savings from policies were:

Renewable Transport Fuel Obligation (RTFO): in these projections, non-traded emissions savings from the implemented RTFO are lower by 10 $MtCO_2e$ in the fourth carbon budget period and by 9 $MtCO_2e$ in the fifth carbon budget period in comparison with EEP 2017. In previous EEP editions, the availability of waste-derived fuels as well as the level of renewable energy in road and rail that counts towards targets set under the Renewable Energy Directive (RED) was underestimated. More waste-derived fuels are now assumed to be available: these have a scaling factor in the RTFO which means their contribution is weighted at least twice as much as other fuels. Under these new assumptions, less biofuels in total are required to meet the biofuels target, which gives lower projected emissions savings. UK policy aims to promote sustainable biofuels with the highest possible greenhouse gas savings, including when indirect land use change is considered. If sufficient sustainable feedstocks are available, RTFO targets may be raised further in future reviews.

Vehicle efficiency policies: savings attributable to road vehicle efficiency policies are lower compared with EEP 2017 by 11 $MtCO_2$ and 17 $MtCO_2$ in the fourth and fifth carbon budget periods respectively. This is mostly due to lower projections for Light Goods Vehicles (LGV) and car traffic which reduced the potential for emissions reduction through policy. Projected LGV traffic has reduced mainly because of DfT revisions to LGV modelling, while projected car traffic decreased mainly due to a reduction in projected population since EEP 2017 (see the “Changes due to input updates” section in chapter 1 for more details).

F-gas Regulation: non-traded savings are projected to be lower by 6 $MtCO_2$ in the fourth carbon budget and by 7 $MtCO_2$ in the fifth carbon budget in comparison with the EEP 2017 projections. This is due to a combination of changes to the historical inventory and updates to models. Amongst the latter, the update of the Refrigeration and Air Conditioning Model (RAC) attributed more of the projected reduction in emissions to underlying sectoral trends, and reduced the amount which can be assigned to policy savings.

Smaller decreases in policy savings. The projected savings from a few policies are slightly lower compared with EEP 2017:

- **Renewable Heat Incentive (RHI):** non-traded savings for RHI are lower by about 2 $MtCO_2$ in the fourth and fifth carbon budget periods compared with EEP 2017. This is in line with the updated data and assumptions used in the most recent impact assessment[44].
- **Energy Company Obligation (ECO):** ECO non-traded savings are lower by about 1 $MtCO_2$ in both the fourth and the fifth carbon budget periods compared with EEP 2017. This is due to an update of the policy, which is now focused purely on tackling fuel poverty and therefore the scheme is targeted to a lower income affordable warmth group (approximately 6.7 million homes). Measures are aimed at reducing households' heating bills, which results in less non-traded carbon being saved, especially when households switch from electricity to gas heating (which switches emissions from more expensive electricity in the traded sector, to cheaper gas in the non-traded sector).
- **Smart Meters**: non-traded savings due to Smart Meters are lower by approximately 1 $MtCO_2$ in both the fourth and the fifth carbon budget periods compared with EEP 2017. This is because of an update to the technology rollout assumptions and a reduction in the level of residential gas consumption[45] to which smart meter savings are applied.

Emissions savings from policies by sector

In the **domestic (residential) sector**, Part L of the Building Regulations continues to provide the largest share of the sector's total policy savings: approximately 50% in the fourth carbon budget period. Carbon Emissions Reduction Target (CERT), F-gas, smart metering and the RHI together provide non-traded savings of 21 $MtCO_2e$ in the fourth carbon budget period.

In **commercial services,** the largest savings come from F-gas regulation which aims to displace fluorinated gas with gases of lower global warming potential. In the fourth carbon budget period, the F-gas regulation is projected to save 33 $MtCO_2e$, increasing to 50 $MtCO_2e$ of non-traded savings in the fifth carbon budget period.

Public services contribute approximately 2% of total emissions in the fourth carbon budget period. Over this period, emissions savings in the public services sector account for 3% of total emissions savings from policies, with the largest savings coming from Building Regulations and RHI.

[44] Impact Assessment for RHI: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/680624/ukia_20180029_en.pdf
[45] Policy savings were provided in July 2018, and used demand projections from EEP 2017 which were lower.

In **industry**, over 70% of emissions for all projected years are within the traded sector where GHG reductions are incentivised by the EU Emissions Trading System (EU ETS). Non-traded savings in industry are 11 $MtCO_2e$ during the fourth carbon budget period compared with 13 $MtCO_2e$ in EEP 2017. The difference is mostly due to slightly lower RHI savings.

The **transport sector** accounts for 38% of non-traded policy savings in the fourth carbon budget period. Non-traded savings from car, Light Goods Vehicle (LGV) and Heavy Goods Vehicle (HGV) efficiency improvements are projected to be 52, 13 and 5 $MtCO_2e$ respectively in the fourth carbon budget period.

Agriculture contributes between 10-12% of total emissions in all years between 2017 and 2035, most of which do not relate to energy use. In the fourth carbon budget period, the Agricultural Action Plan is projected to save 18 $MtCO_2e$ in non-traded emissions.

There are details of the emissions savings from all policies grouped by economic sector in Annex D, along with descriptions of policies and measures.

Emissions savings from policies in electricity supply

Most emissions from electricity supply fall under the EU Emissions Trading System and therefore do not affect the UK's net carbon account (see Chapter 2, Box 1). Since the 2009 Low Carbon Transition Plan, new Government policies have resulted in significant emissions savings from the Electricity Supply Industry (ESI).

Supply-side policies comprise:

- Large Combustion Plant Directive
- Industrial Emissions Directive
- EU ETS
- UK Carbon Price Support
- Feed-in-Tariffs (for small scale generation)
- Renewables Obligation and Contracts for Difference (for large-scale generation)

We are unable to provide a breakdown of the individual effect of these policies on greenhouse gas emissions due to the highly interrelated nature of power supply markets. However, we estimate that overall these policies reduced emissions from the power sector by 55 $MtCO_2e$ (46%) in 2017 alone.

ESI policy savings are projected to be 292 $MtCO_2e$ during the fourth carbon budget period (2023 to 2027) as compared with the 231 $MtCO_2e$ projected in EEP 2017. However, beyond 2020 policy savings are illustrative and future market and policy developments could lead to different outcomes. We report aggregated emissions savings from power supply policies in the "All, by sector" section of Annex D.

4 Demand for energy

- Total final energy demand is projected to fall until 2025: from 139 Mtoe (million tonnes of oil equivalent) in 2017 to 135 Mtoe in 2025, a 3% decline.
- It is then projected to increase steadily, reaching 141 Mtoe in 2035. This is 1% higher than in 2017.

Please see the separate methodology document[46] or previous EEP reports for more detail about the methodology used for demand projections.

Final energy demand

Final energy demand[47] is up to 3% per year higher in the 2018 projection than in EEP 2017. This is mainly due to increased gas demand in services and the domestic sector. It is partly offset by lower electricity demand and lower industry demand across all fuels, except petroleum-based fuels.

Final energy demand is projected to reach 135 Mtoe in 2025, its lowest level for the projected period. This is 3% lower than in 2017. It is then projected to rise, as the effects of included policies diminish and macroeconomic drivers continue to push demand up so that by 2035 slightly more energy is needed than in 2017. Against this overall trend, patterns of demand vary somewhat across the four major energy consuming sectors of transport (Figure 4.2b), domestic (Figure 4.2d), industry (Figure 4.2c) and services (Figure 4.2e).

Transport is the largest consumer on a final energy basis, accounting for 40% of final energy demand in 2017 if international aviation is included[48]. This share is projected to fall to 37% by 2035. Around 97% of 2017 transport final energy consumption was from oil-based fossil fuels but by 2035 this is projected to fall to 93% due to uptake of electric vehicles and increased use of biofuels (Figure 4.1b).

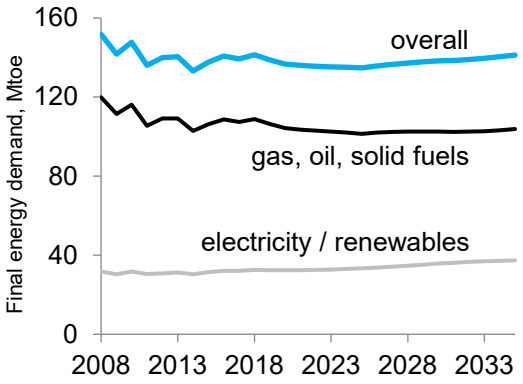
The **domestic (residential) sector** accounted for 29% of final energy consumption in 2017; this rises to 34% in 2035. In the domestic sector the drivers of projected demand are projected numbers of households, retail fuel prices and the weather. Electricity and renewables accounted for 28% of domestic final energy consumption in 2017, and

[46] The methodology document is available at: https://www.gov.uk/government/publications/updated-energy-and-emissions-projections-2018
[47] Please refer to DUKES Annex B for the definition of final energy demand: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/729427/AnxB.pdf
[48] Emissions from fuel used for international aviation do not currently count towards UK emissions reduction targets.

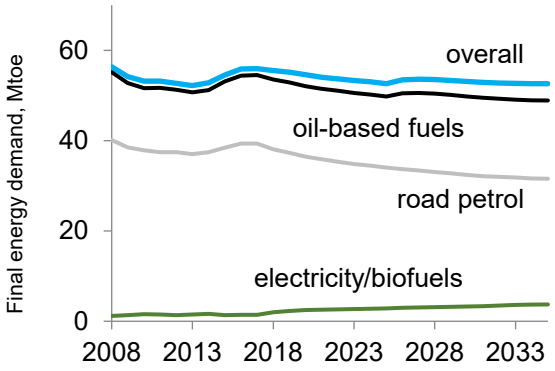
we project this will rise to 30% in 2035. Figure 4.1d gives the projected trends in demand by fuel for this sector.

Figure 4.1: Final energy demand by fuel and consumer sector 2008 to 2035

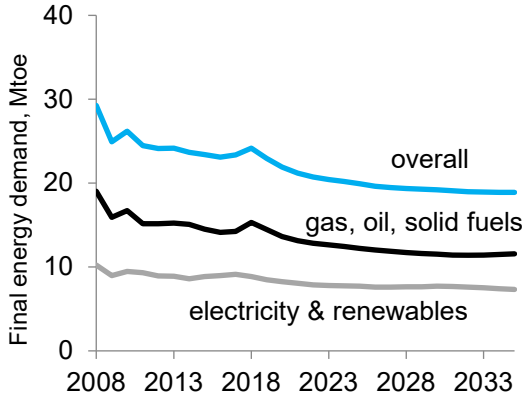
a) Total demand, broken down by fuel



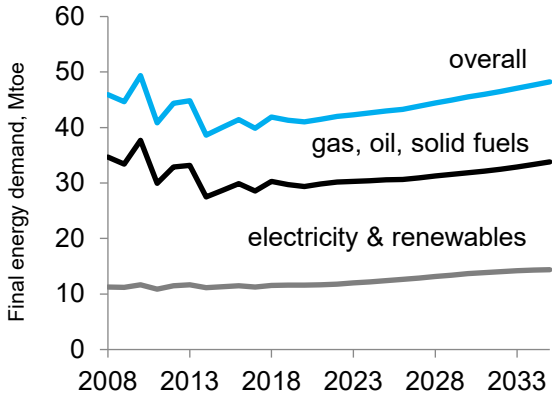
b) Demand in transport



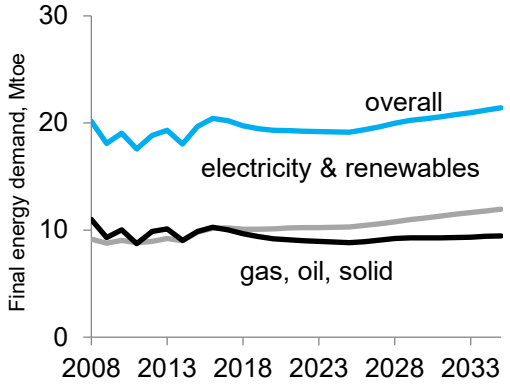
c) Demand in industry



d) Demand in domestic sector (households)



e) Demand in services sector (including agriculture)



We project energy demand in the domestic sector to be lower than the 2017 projection by an average of 2% between 2018 and 2035. Gas demand is higher and electricity demand is lower relative to EEP 2017. This is due to the revised demand equations described in Chapter 1.

The **industrial sector** accounted for 17% of total final energy in 2017. Demand is projected to be around 5% per year lower than in the 2017 projections due to higher projected energy prices.

In these projections, industrial energy demand is projected to fall by 19% overall between 2017 and 2035. Renewables are projected to meet 6% of industrial energy demand in 2035 compared with 5% in 2017. Projected trends in demand by fuels for the industrial sector are shown in Figure 4.2c.

The **services sector**[49] accounted for 13% of final energy demand in 2017 and this share remains almost constant through to 2035. The share of demand met by electricity and renewables is projected to increase to 55% in 2035 from 50% in 2017.

Final energy demand in the services sector in 2035 is 10% higher than in EEP 2017, due to the update of commercial sector demand projections described in Chapter 1.

Primary energy demand

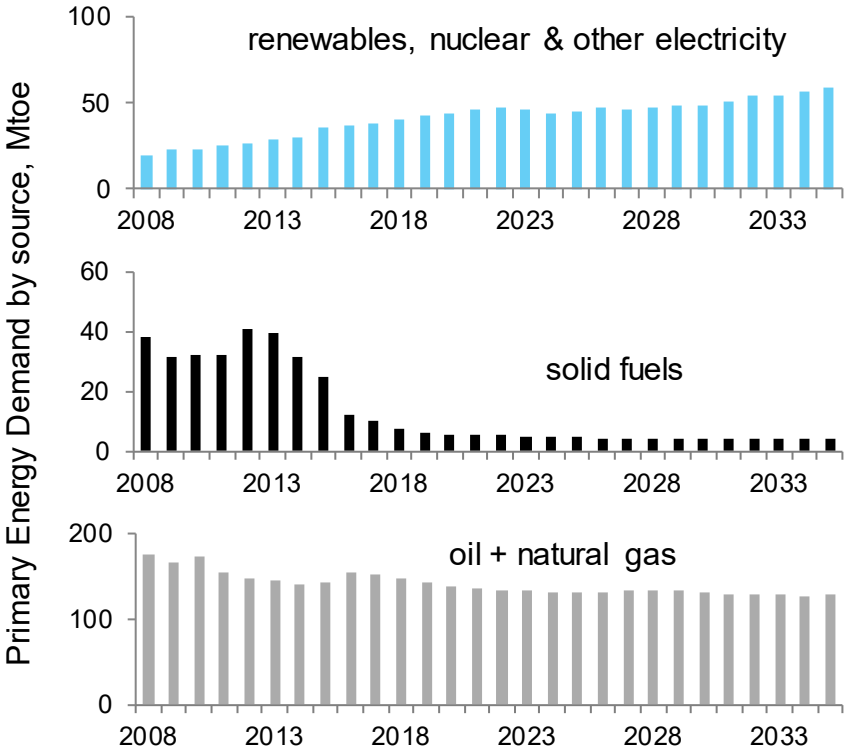
Trends in total primary energy demand[50] are similar to those in EEP 2017, falling 9% between 2017 and 2025, from 200 to 182 Mtoe. After 2025, primary energy demand is projected to rise again to 192 Mtoe in 2035.

Coal use has fallen rapidly since 2013 as electricity generation has switched to using more renewables, waste and gas. By 2035, we project that only 4 Mtoe (2%) of primary energy demand will be met by coal (none of which is used for electricity generation). Oil use is projected to decline by 10% in 2035 from 2017 levels as biofuels and electricity meet an increasing proportion of road fuel demand.

In the year 2035, primary energy demand in the latest projection is 1% lower than in EEP 2017. Use of gas as a primary fuel varies in comparison with last year's projections: overall it is 3% higher but in some (up to 8% in 2025). However, demand met by renewables and waste is at least 5% higher than in EEP 2017[51].

[49] Services comprises the commercial sector, public sector and agriculture.
[50] Primary energy includes primary fuels and primary electricity. Refer to DUKES Annex B for further explanation. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/729427/AnxB.pdf
[51] This is a maximum of 13% greater than EEP 2017 in the year 2026.

Figure 4.2: Primary energy demand by fuel



5 Electricity supply

- CO_2 emissions from power stations have reduced by 60% since 1990, including a 48% fall between 2010 and 2016.
- We project CO_2 emissions from major power producers to fall by 80% between 2010 and 2020.
- The low carbon share of UK electricity generation (renewables and nuclear generation, as a proportion of all power producers)[52] is projected to rise from 22% in 2010 to 65% in 2020.
- Beyond the early 2020s, the scenario presented here is illustrative and includes assumptions that may go beyond current Government policy.

We undertook the electricity supply sector modelling in September 2018 using BEIS's "Dynamic Dispatch Model" (DDM)[53]. The DDM models the impact of all relevant policies including small scale Feed-in Tariffs, the Renewables Obligation, Contracts for Difference, Carbon Price Support, the Capacity Market[54] and Industrial Emissions Directive.

Since EEP 2017, the DDM reference case assumptions have been updated with new fossil fuel and carbon price assumptions, a revised carbon price floor trajectory and updated electricity generation and storage costs. The new lower costs of renewable technologies have led to increased deployment of renewables. There have also been improvements to the modelling of interconnector flows and updates to the assumptions about when new interconnectors will come online.

Up to the early 2020s, the reference scenario reflects current power sector policies. Beyond the early 2020s, the reference scenario includes some assumptions that go beyond current Government policy and is therefore illustrative. The results here do not indicate a preferred outcome.

The report annexes give separate results for "Major Power Producers" (MPPs) and "All Power Producers" (which includes autogenerators). As of 2017, MPPs accounted for around 95% of the UK's electricity generation.

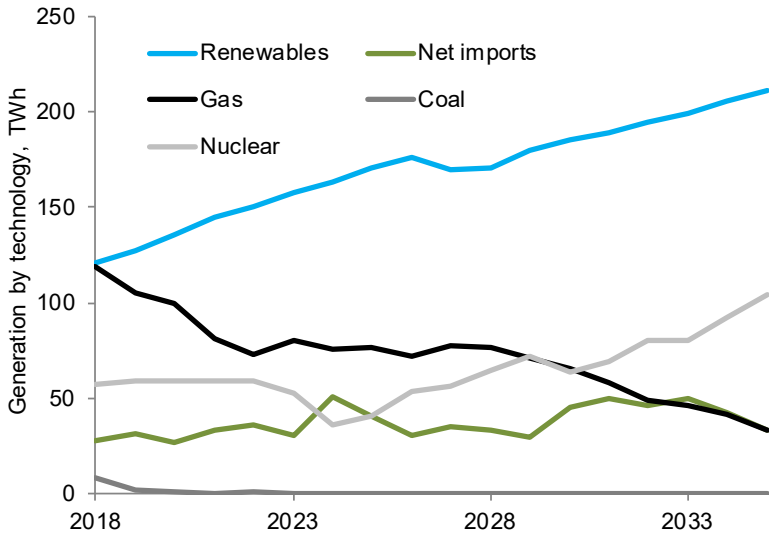
[52] Statistics quoted in this chapter pertain to "All Power Producers".
[53] For background information on the DDM please see:
https://www.gov.uk/government/publications/dynamic-dispatch-model-ddm
[54] The modelling and analysis within this report was carried out before the Tempus ruling on the Capacity Market in November 2018.

Summary of projections

Report annexes J and L contain total electricity generation and generating capacity projections.

Figure 5.1 below shows the projections of generation by technology for all power producers up to 2035. Overall electricity demand projections are lower than in EEP 2017 with reduced electricity imports and gas fired generation but increased renewables generation.

Figure 5.1: Electricity generation by fuel source



The DDM projects a gradual decline in gas fired generation out to 2035. Coal generation remains low due to fossil fuel and carbon prices, with the remaining plants closing by the early 2020s. Fossil fuels are displaced by more renewables and eventually nuclear generation. Interconnection imports after 2020 are lower than the EEP 2017 projections. This is in part a result of the higher level of renewables, but also reflects more granular modelling of interconnected markets in the DDM in 2018.

Emissions from electricity production are projected to fall steadily over the full period as shown in annexes B and C. The majority of these are covered by the EU Emissions Trading System and therefore emissions savings have minimal direct impact on progress towards meeting UK Carbon Budgets (see Box 1). However, reducing power sector emissions is important to meet our 2050 greenhouse gas emissions target.

In the reference case, CO_2 emissions from electricity generation[55] by major power producers fall from 43 $MtCO_2e$ in 2017 to 31 $MtCO_2e$ by 2020. In the illustrative scenario presented for beyond 2020, emissions fall further (to 6 $MtCO_2e$) by 2035.

Figure 5.2: Emissions intensity (all power producers)

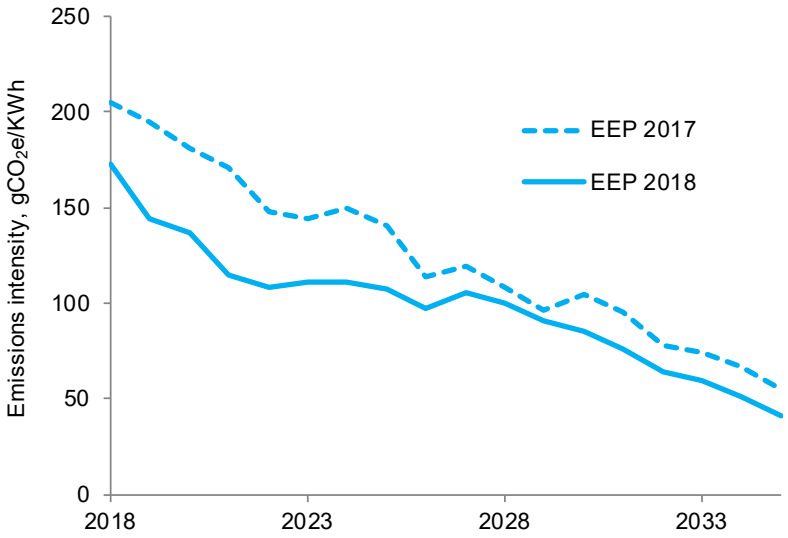


Figure 5.2 shows a lower trajectory of power sector emissions intensity in EEP 2018 when compared with EEP 2017. The change is predominantly due to the higher level of renewables generation than projected in EEP 2017, along with earlier closure of coal plants and slightly lower gas generation after 2030.

The projected emissions intensity is 41 gCO_2e/kWh in 2035 whereas in EEP 2017 this was projected to be 55 gCO_2e/kWh.

Projections of non-traded emissions from the power sector are higher than in EEP 2017 due to greater deployment of thermal renewables technologies generating electricity from waste.

[55] Figure 5.2 includes both CO_2 and non-CO_2 greenhouse gases

6 Uncertainty in emissions projections

- In this chapter, we report on four categories of uncertainty in the projections: policy savings, evidence base inputs, state of the world (which includes factors such as GDP, population and fossil fuel prices) and model equations.
- Compared with EEP 2017, we have now included in this analysis the uncertainty from some non-CO_2 emissions sources and from the model equations in the domestic sector.
- By the fourth carbon budget period, the greatest uncertainty comes from the state of the world category (approximately +/- 5%). The evidence base inputs and model equations categories in the industrial and domestic sectors (respectively) both show +/- 2% variability, while policy savings vary by about 1.5% for this carbon budget period.

This chapter sets out different sources of uncertainty and the extent to which they are reflected in these projections. As with last year, please note that uncertainty analysis excludes the electricity supply industry and so does not capture uncertainty on the effects of policies in this sector. The methodology only focuses on future uncertainty, rather than analysis of historic (before 2018) uncertainty of inputs or outputs.

In reviewing the projections, it is helpful to understand the significant scale of their uncertainty, the scope for the future to turn out differently and what influences this. This is important context in our efforts to reduce emissions, highlighting the value of a flexible and responsive approach.

The methodology we used to perform the uncertainty analysis is the same as last year (described in Chapter 6 of the EEP 2017 report), but with some additional variables included: these are agricultural methane and nitrous oxide emissions and the regression residuals of the equations in the domestic sector. A list of all variables is shown in Table 6.1.

Parameters considered for uncertainty analysis

For the uncertainty analysis, we considered the most influential drivers of energy use and emissions[56], and all policy savings estimates[57]. We also considered the

[56] We used sensitivity analysis to identify these variables as having the highest impacts on the model outputs.
[57] These are based around 5 fuels (electricity, gas, oil, solid fuel and renewables) across 5 of the modelled sectors (domestic, commercial services, public services, industry and agriculture).

uncertainty in the relationship between key drivers and energy use by considering the regression residuals[58] of the 38 main equations in the industry sector and of the 2 in the domestic sector.

Parameters used for uncertainty analysis fall into the following categories:

Table 6.1: Categorisation of parameters and variables considered

Category	Variables we evaluated in this group	Unevaluated variables
State of the world: Macroeconomic, demographic and temperature	Gross domestic product (GDP), public employment, household income, gas price, oil price, coal price, carbon price, population, household numbers, temperature[59], basic oxygen steelmaking (BOS) output etc.	Interest rates Electricity price
Policy impact estimates and innovation[60]	Non-transport policy energy savings (electricity, gas, oil, solid fuel and renewables in domestic, commercial services, public services, industry and agriculture) Transport policies: (car fuel efficiencies, Light Goods Vehicle [LGV] fuel efficiencies, Heavy Goods Vehicle [HGV] fuel efficiencies etc.)	Supply side policies Policy savings from non-energy policies (e.g. fluorinated gas regulation, Agricultural Action Plan)
Evidence base	Land Use, Land Use Change and Forestry (LULUCF) emissions, agricultural methane and nitrous oxide emissions	Emissions factors Global warming potentials
Regression residuals of equations in industry and domestic sector	(Industry and domestic sectors only) Regression residuals of equations	Regression residuals for other sectors

[58] In statistical terms, the residual of an observed value is the difference between the observed value and the estimated value of the quantity of interest. For this analysis, we considered the difference between the output of the regression equations and the historical actual values and included it in the future uncertainty.
[59] The impact of temperature is measured by two variables related to Winter Degree Days—over the winter, the number of cold days multiplied by the number of degrees each day is below a given temperature.
[60] These projections only consider implemented, adopted and planned policies. New policies or changes to existing policies which have not yet reached the planned stage are not considered in uncertainty analysis.

We carried out a Monte Carlo simulation using these categories of parameters to explore the impact of uncertainty on emissions from the model. We first derived historical distributions of the input values. Then we ran the emissions projections model using samples from these distributions and recorded the resulting projections over a large number of simulations[61].

This method underpins the 95% Confidence Interval (CI) estimates in all tables and figures on uncertainty within this report. The upper and lower boundaries represent the projected emissions corresponding to the lower 2.5% and upper 97.5% percentiles of the simulations respectively.

To understand the size of the impact on total GHG emissions from each of the categories of parameters, Figure 6.1 shows the uncertainty range.

Figure 6.1: Total GHG emissions: uncertainty range for each category separately

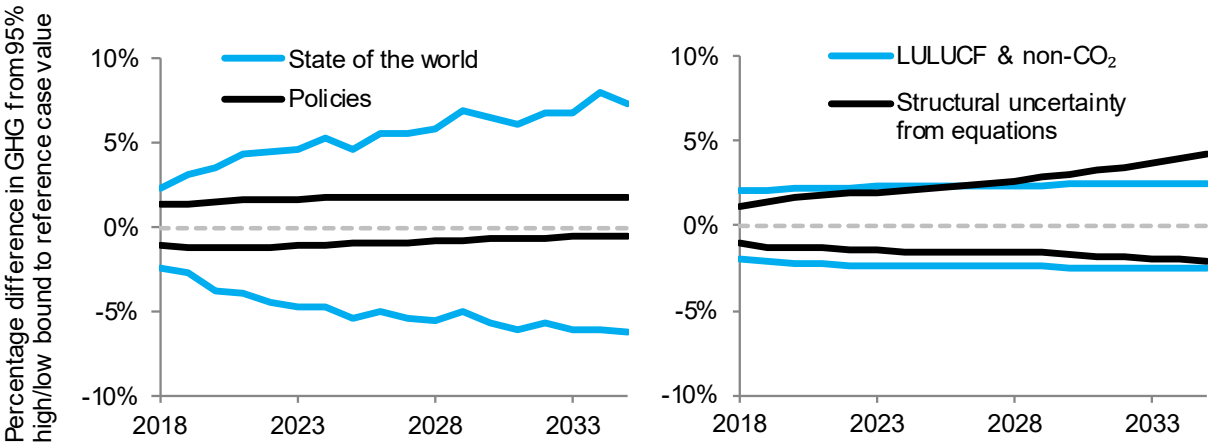


Figure 6.1 shows that each set of parameters have different trends over time in the way that they affect uncertainty:

- The main uncertainty impact on projected emissions comes from the category of parameters classified in Table 6.1 as state of the world. This uncertainty is projected to grow over time, as the effects tend to compound.
- Uncertainty around policy savings has a relatively small impact on projected GHG emissions. This uncertainty impact peaks in the mid-2020s: this is because policies are only included if they are either currently implemented or firmly planned in the future (therefore policies which are still under development are excluded).

[61] See here: https://en.wikipedia.org/wiki/Monte_Carlo_method
We used historical data and expert elicitation estimate probability distributions and cross-correlations for the selected variables. We then carried out multiple runs of the model, randomly extracting the values for variables based on these probability distributions.

- The uncertainty from the evidence base (LULUCF and non-CO_2 emissions in the agriculture sector) is relatively constant over time, due to the potential for methodological improvements which may lead to both future and retrospective revisions.

The main analysis quoted within this report is based on all variables (the combination of all 4 categories of uncertainty together).

Table 6.2: Net carbon account for the fourth carbon budget period: uncertainty ranges by category

			$MtCO_2e$
Net Carbon Account for the fourth carbon budget period			
Categories included	Upper 95% confidence range	Reference case	Lower 95% confidence range
All (State of the world, LULUCF & Non-CO2, policies and industrial equations)	2,215	2,089	1,990
1) State of the world	2,183	2,089	1,996
2) LULUCF & Non-CO2	2,133	2,089	2,045
3) Policies	2,121	2,089	2,070
4) Structural uncertainty from equations	2,130	2,089	2,061

7 Lists of supporting material

Annexes

Annex A: Greenhouse gas emissions by source

Annex B: Carbon dioxide emissions by source

Annex C: Carbon dioxide emissions by IPCC category

Annex D: Policy savings in the projections

Annex E: Primary energy demand

Annex F: Final energy demand

Annex G: Major power producers' generation by source

Annex H: Major power producers' cumulative new electricity generating capacity

Annex I: Major power producers' total electricity generating capacity

Annex J: Total electricity generation by source

Annex K: Total cumulative new electricity generating capacity

Annex L: Total electricity generating capacity

Annex M: Growth assumptions and prices

Annex N: 2018 non-CO_2 GHG emissions projections report

Web tables and charts

Web tables and charts have been uploaded alongside this report. Some of these replicate tables and figures within this report, others are supplementary.

Appendix A: List of abbreviations

BEIS	Department for Business, Energy & Industrial Strategy
CB	Carbon budget
CGS	Clean Growth Strategy (published by BEIS in October 2017)
CHP	Combined Heat and Power
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
DUKES	Digest of UK Energy Statistics
EEP	Energy and Emissions Projections (also sometimes called UEP)
ETS	Emissions Trading System
EU	European Union
F-gas	Fluorinated (greenhouse) gases
g	Grams
GDP	Gross Domestic Product
GHG	Greenhouse gas
GVA	Gross Value Added
GW	Gigawatt
IED	Industrial Emissions Directive
IPCC	Intergovernmental Panel on Climate Change
kWh	Kilowatt-hours
LULUCF	Land Use, Land-Use Change, and Forestry
MPP	Major Power Producer
Mt	Million tonnes
Mtoe	Million tonnes of oil equivalent
NCA	Net Carbon Account
RHI	Renewable Heat Incentive
UK	United Kingdom