Department for
Business, Energy
& Industrial Strategy

Annex N: Projected emissions of non-CO_2 greenhouse gases

October 2020

Any enquiries regarding this publication should be sent to us at:
emissionsprojections@beis.gov.uk

Contents

Executive Summary

This report presents the methodology BEIS used in producing the non-CO_2 greenhouse gas emission projections. The non-CO_2 gases are methane (CH_4), nitrous oxide (N_2O) and the fluorinated gases (HFCs, PFCs and SF_6). The projections are a best estimate of future emissions up to 2040, accounting for expected technological developments, key drivers such as population and known policy commitments. It is important to note that policies affecting these projected emissions are still being developed and will be incorporated in future updates.

1. Introduction

1.1 Overview

In 2019, the Government set a new legally binding target for net zero greenhouse gas (GHG) emissions by 2050, via an amendment to the Climate Change Act that came into force on Thursday 27 June 2019[1]. Emissions projections are used as a way of monitoring progress towards this target and to identify emission sources which would need additional measures. The UK is also required to submit projected emissions of greenhouse gases biennially under the European Union Monitoring Mechanism Regulation, and periodically in the form of National Communications and Biennial Reports to the UN Framework Convention on Climate Change (UNFCCC).

Process changes and improvements to note in this year's publication are:

- The historical GHG emissions which form the baseline for these projections undergo annual updates to comply with the Intergovernmental Panel on Climate Change (IPCC) 2006 Guidelines[2]. We incorporate any annual changes into our projections to remain consistent with the latest historic estimates.
- We have produced combustion-related greenhouse gas emissions using a baseline of the latest 2020 (1990-2018) historical GHG emissions estimates[3]. However, we produced our non-combustion-related emissions projections using a different baseline: the 2019 (1990-2017) GHG emissions estimates[4] as this was the data available at the time modelling was carried out. The majority of non-CO_2 emissions are not combustion related and so use the 1990-2017 estimates as a baseline. The impact of the differing baselines should be limited as we have not significantly changed the way we estimate historical non-CO_2 emissions between the two publications. For consistency, we present projections from 2019 onwards in all cases alongside the latest historic estimates for all years up to 2018.

[1] Climate Change Act 2008 (2050 Target Amendment) Order 2019
https://www.legislation.gov.uk/uksi/2019/1056/contents/made
[2] 2006 IPCC Guidelines for National Greenhouse Gas Inventories
http://www.ipcc-nggip.iges.or.jp/public/2006gl/
[3] Published in February 2020. See final UK greenhouse gas emissions national statistics: 1990-2018
https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-to-2018
[4] Published in February 2019. See final UK greenhouse gas emissions national statistics: 1990-2017
https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-2017

1.2 Scope

Non-CO_2 emission sources this document covers

This document covers projections of the **non-CO_2** component of the Kyoto Protocol's basket of greenhouse gases. We refer to these as the 'non-CO_2 GHGs'. The gases are:

- Methane (CH_4)
- Nitrous oxide (N_2O)
- Hydrofluorocarbons (HFCs) *
- Perfluorocarbons (PFCs) *
- Sulphur hexafluoride (SF_6) *

* HFCs, PFCs and SF_6 are also collectively known as fluorinated gases, or "F-gases".

Nitrogen trifluoride (NF_3) is also included in the Kyoto Protocol's basket of greenhouse gases and in the UK's historic greenhouse gas emission estimates but is not included in these projections as it is not included in the UK's carbon budget targets.

Geographical scope, time horizon and units

- The geographical scope of these projections is the UK only, covering emissions that occur within the UK's borders ("territorial" emissions)
- This year, we project emissions up to 2040. Last year the projections were until 2035
- We present emissions in CO_2 equivalents (CO_2e), according to Global Warming Potentials set out in the IPCC Fourth Assessment Report[5] Sector assignment

For the purposes of reporting, we allocate greenhouse gas emissions to National Communication sectors. These are a small number of broad, high-level sectors and are as follows:

- Energy supply
- Business
- Transport
- Public sector
- Residential
- Agriculture
- Industrial processes
- Land Use, Land Use Change and Forestry (LULUCF)
- Waste management.

[5] IPCC Fourth Assessment Report: Climate Change 2007: Direct Global Warming Potentials https://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html

These high-level sectors are comprised of more detailed sectors that follow IPCC definitions for GHG emissions reporting. We submit international reporting tables against these to the UNFCCC every year. The sectors assign emissions to their source activity as opposed to where the end user activity occurred[6]. A complete mapping of IPCC sectors to National Communication sectors is available on the BEIS website[7]. We use these sectoral assignments in this report.

1.3 Current UK GHG emissions and targets

As part of the UK's commitments for reporting its GHG emissions, we produce a national inventory each year. This contains estimates for the UK's GHG emissions from all anthropogenic sources. This is referred to as the GHG Inventory (GHGI) and is submitted annually to the UNFCCC. Previous GHGI reports are available on the National Atmospheric Emissions Inventory website[8]. At the time of modelling, the most recent full year of data was 2017 for the majority of non-CO2 emissions sources. However, we modelled the combustion-related emissions estimates after the release of the 2018 data.

The GHGI forms the baseline for the projections. However, the geographical scope of the projections is slightly different to the UNFCCC GHGI submission. The UNFCCC submission covers the UK plus Crown Dependencies and Overseas Territories. In contrast, this report only includes the UK. All references to the GHGI in this report refer to UK-only emissions.

- **Methane (CH_4)** – CH_4 represents the majority of non-CO_2 GHG emissions, at 60% in 2018[9]. Agriculture was the largest sector, accounting for 49% of all CH_4 emissions that year, followed by waste management which accounted for around 37%. The remaining CH_4 emissions were largely from fugitive energy emissions.

- **Nitrous oxide (N_2O)** – N_2O represented 24% of non-CO_2 GHG emissions in 2018. Agriculture was responsible for the majority of N_2O emissions (70%). The rest were largely split between the waste management, transport, energy supply, business and LULUCF sectors, with minor contributions from the industrial processes, residential and public sectors.

- **F-Gases (HFCs, PFCs and SF_6)** – HFCs represented 15% of non-CO_2 GHG emissions in 2018, while PFCs and SF_6 represented about 1% between them. Refrigeration and air conditioning account for the majority of HFC emissions, accounting for 82% of HFC emissions in 2018. Other significant HFC emissions sources include aerosols and metered dose inhalers (e.g. asthma inhalers). The major sources of PFC emissions are

[6] This differs from the Digest of UK Energy Statistics which uses an economy sector-based taxonomy, see: https://www.gov.uk/government/publications/energy-balance-methodology-note
[7] See Excel table 12 in Final UK greenhouse gas emissions national statistics: 1990-2018 https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-to-2018
[8] UK National Inventory: https://naei.beis.gov.uk/reports/reports?report_id=1000
[9] All inventory figures within the body of this report are from the inventory data published in February 2020.

halocarbon production and the electronics industry. SF_6 emissions largely come from electrical insulation.

The latest National Statistics release provides the most recent data and further details of the emissions of each of these gases by specific activities over the period 1990-2018[10].

The UK has both international and domestic targets for reducing greenhouse gas emissions. These targets encompass all GHG emissions, not just the non-CO_2 component we project in this report. BEIS's Energy and Emissions Projections[11] provide more information about how we forecast the UK's overall GHG emissions and compares them with our targets.

[10] Final UK greenhouse gas emissions national statistics: 1990-2018
https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-to-2018
[11] BEIS Energy and emissions projections:
https://www.gov.uk/government/collections/energy-and-emissions-projections

2. Projections methodology

2.1 Overview of methodology

Baseline

We used emissions statistics from the 1990-2018 GHG Inventory (GHGI) as the baseline for combustion-related non-CO_2 emissions projections. We used the 1990-2017 GHGI as the baseline for all non-combustion related sources. Each source was the most recent available at the time we carried out the modelling. The GHGI calculates emissions by combining activity data (e.g. fuel use, livestock numbers) and emission factors (e.g. per kg of pollutant, per tonne of fuel used, per head of livestock). A new GHGI is produced each year detailing emissions from each source from 1990 up to two years previously (e.g. the GHGI published in 2020 provides emissions from 1990-2018). This means that the base year for these projections was 2018 for the combustion-related sources and 2017 for the non-combustion related sources.

We revise historical emissions estimates each year to account for methodological improvements and for new information that becomes available. We review the data and compilation methods for the GHGI annually. The most notable changes to this year's GHGI affecting non-CO_2 gases are:

- Change in fossil-carbon factors used for Municipal Solid Waste (MSW)
- Landfill methane corrections
- Updated agriculture data
- Update to EMEP/EEA Guidebook N_2O emission factors.

Overall impact on emissions

In total, the changes we made to the methods and data for the 1990-2017 and 1990-2018 inventories led to an increase in total emissions (all gases) for 2016 of 4.5 $MtCO_2e$ compared with the 1990-2016 inventory we used in the last set of projections[12]. They caused a decrease in total non-CO_2 emissions of 1.7 $MtCO_2e$ for the same year (this is the latest year for which we can make a comparison).

We made most of these changes in the 1990-2017 inventory. This means they are included in both combustion-related and non-combustion related emissions despite the differing baselines these use. We describe the most important impacts in the relevant chapters of this report.

[12] BEIS Energy and emission projections 2018: https://www.gov.uk/government/publications/updated-energy-and-emissions-projections-2018

Projections

We project the emissions from each source in the GHGI from the latest year of historic data year up to 2040. Given the disparate nature of the emission sources, we use many different methods to project the emissions. We discuss the drivers of emissions and the methods we use in the relevant sector chapters. These drivers range from simple assumptions to complex analytical models depending on data availability and emissions magnitude.

As noted above, the baseline GHGI is defined by activity data and emission factors. The emission projections can similarly be thought of as the combination of:

- Projections of the change in activity data, e.g. changes to livestock numbers or changes in the amount of waste going to landfill.
- Projections of the change in emission factors, e.g. improvements to technology for the abatement of emissions.

Annual updates to the non-CO_2 projections involve one of the two following methods:

- If there are apparent major changes to the emissions drivers then we perform a formal review of the methods we use to project emissions from that source.
- We rerun the existing projections model if there are no apparent major changes to the drivers but the historical emissions have changed due to a GHGI methodology update.

We discuss changes in projections for each source in the relevant sector chapter.

Policies

The non-CO_2 projections include the effects of Government policies which mitigate GHG emissions. The standard EU/UNFCCC definitions we use to categorise policies are:

- **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:
    - national legislation is in force;
    - one or more voluntary agreements have been established;
    - financial resources have been allocated;
    - 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;
- **Planned policies** and measures are options under discussion with a realistic chance of being adopted and implemented in future.

An 'existing policies' scenario includes all currently expired, implemented and adopted policies. A 'reference' scenario includes all the above policies, plus planned policies.

The policies that we have explicitly included in the projections are:

- F-gas regulations (2006[13], 2014[14] and Mobile Air-Conditioning Directive[15])
- Solid waste policies (including those that support commitments to the Waste Framework Directive and Landfill Directive. These, such as the Landfill Tax, all contribute to the waste activity projections Defra provide)[16]
- Resources & Waste Strategy policies from Defra; Consistency of municipal waste collection, Reform of the packaging producer responsibility system, and Introducing a deposit return scheme for drinks containers. These are all planned for implementation in 2023 in England[17].
- Transport policies (covers the Local Sustainable Transport Fund, road biofuels, road vehicle efficiencies and road investment strategy from the DfT activity projections)[18]
- LULUCF afforestation policies for England[19], Wales[20], Scotland[21] and Northern Ireland[22]
- English GHG Agriculture Action Plan[23]
- The Scottish Government's Climate Change Plan[24]
- Climate Change Strategy for Wales[20].

[13] REGULATION (EC) No 842/2006 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 17 May 2006
http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32006R0842
[14] REGULATION (EU) No 517/2014 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 April 2014
http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2014.150.01.0195.01.ENG
[15] Directive No 2006/40/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 17 May 2006
http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32006L0040
[16] Defra waste policy:
https://www.gov.uk/waste-legislation-and-regulations
[17] Defra (2018): Resources and waste strategy for England
https://www.gov.uk/government/publications/resources-and-waste-strategy-for-england
[18] DfT (2018): Road traffic forecasts 2018
https://www.gov.uk/government/publications/road-traffic-forecasts-2018
[19] Defra (2015): RDPE programme document 2014 to 2020
https://www.gov.uk/government/publications/rdpe-programme-document-2014-to-2020
[20] Welsh Government (2016): Climate Change Strategy for Wales
https://gov.wales/climate-change
[21] Scottish Government (2015): United Kingdom Regional Development Programme (Regional) - Scotland
http://www.gov.scot/Resource/0047/00477381.pdf
[22] DARDNI (2015): Rural Development Programme 2014-2020
https://www.daera-ni.gov.uk/sites/default/files/publications/dard/2014-2020%20RDP%https://www.daera-ni.gov.uk/sites/default/files/publications/dard/2014-2020%20RDP%20Version%202.pdf20Version%202.pdf
[23] NFU (2011): Agriculture Industry GHG Action Plan
http://www.nfuonline.com/assets/2889
[24] Scottish Government (2018) The Climate Change Plan: The Third Report on Proposals and Policies 2018-2032
https://www.gov.scot/Topics/Environment/climatechange

2.2 Quality Assurance / Quality Control procedures

The business-as-usual Quality Assurance / Quality Control (QA/QC) process involves the following:

- We quality assure all the data sources we use in the projections. Many of the new data sources are publicly available (see references). Where possible we subject data to peer review.
- Sector experts provide QC on the assumptions used.
- The production team provides significant verification and error checks. These include but are not limited to the following: consistency checks when transferring data; independent checks of every calculation; verification of workbook structure through mapping; comparison of absolute/percentage changes from the previous publication, checking unusual values and checking final projections against source projections.
- The changes we have incorporated into this update have been checked and overseen by the non-CO_2 GHG emissions projections Steering Group.

The main benefit of the QA/QC is that the processes aim to find any errors at any point in the methodology, rather than focusing on changes made in the last year.

3. Projections methodology Industrial processes, Residential & Business (F-gases)

Background

All F-gas emissions are in the industrial processes, residential and business sectors. The F-gases are HFCs, PFCs and SF_6.

Compared with 1990, emissions of HFCs were 10% lower in 2018. There has been an 18% fall in emissions since 2015 following the introduction of the 2014 EU F-gas regulation. Prior to that, HFC emissions had been higher than in 1990 due to their use as replacement gases in the phasing out of Chlorofluorocarbons (CFCs) mandated by the Montreal Protocol. HFCs were especially used in refrigeration and air conditioning systems and these are now the dominant source of F-gas emissions. In 1990, F-gas emissions largely arose as by-products from halocarbon manufacture. There was a large fall in these emissions in the late 1990s when plants producing halocarbons applied abatement equipment.

How we project emissions

- **Primary aluminium production** — We now know the effects of all the recent abatement measures and we expect no further abatement, so we project constant emissions from aluminium production.
- **Magnesium cover gas** — We project magnesium emissions based on (i) sector expert knowledge on short-term replacement of F-gases and (ii) long-term replacement of F-gases due to the 2014 EU F-gas regulation.
- **Production of halocarbons** — We project HFC emissions based on (i) short-term company planning information and (ii) long-term replacement of F-gases due to the 2014 EU F-gas regulation. We project PFC emissions will be constant as they exhibit no discernible trend.
- **Metered dose inhalers** — Emissions are exempt from the 2014 EU F-gas regulation and we project emissions using population growth[25] as the driver.
- **Aerosols** — We project sector growth will be zero in line with the trend in recent years. We model the gas bans and phase down resulting from the 2014 EU F-gas regulation.

[25] ONS (2019): Summary Results, 2018-based National Population Projections https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections/datasets/2014basednationalpopulationprojectionstableofcontents

- **Refrigeration & air conditioning** — We use the same model as for the historical emissions calculation. Then we apply the assumptions from the 2014 F-Gas regulation, the most important of which is the HFC phase down which caps the amount of HFCs placed on the market each year. F-gas sector experts reviewed and updated this model in 2015.

- **Foams** — We extend the mapping of activity and emissions to 2050 from the historical inventory model. Then we model the gas bans and phase down resulting from the 2014 EU F-gas regulation.

- **Firefighting** — We extrapolate the latest GHGI model out to 2050 using emissions factors based on UNFCCC sectoral guidance and Article 5 of the 2014 F-gas regulations. From 2018, we assume that new fire protection systems no longer use HFCs based on our understanding from the industry.

- **Solvents** — We project sector growth will be zero, in line with the trend in recent years. We model the phase down resulting from the 2014 EU F-gas regulation.

- **High voltage switchgear (SF_6)** — We project sector growth based on expert advice which is in line with Schwarz et al (2011[26]). This assumes continuing decreasing leakage due to the 2006 EU F-gas regulation.

- **Electronic manufacture (HFCs / PFCs / SF_6)** — We project constant emissions due to limitations of the historical data.

- **AWACS (SF_6)** — We project constant emissions in line with historical data.

- **Training shoes (PFCs / SF_6)** — Emissions from this source have ceased and we do not expect they will resume. We therefore assume no emissions from this source in future years.

- **Particle accelerators (SF_6)** — Emissions are very small and we project they will be constant.

- **Tracer gas (SF_6)** — Emissions are very small and we project they will be constant.

[26] Schwarz et al (2011): Preparatory study for a review of Regulation (EC) No 842/2006 on certain fluorinated greenhouse gases
https://ec.europa.eu/clima/sites/clima/files/f-gas/docs/2011_study_annex_en.pdf

4. Industrial Processes, Residential & Business (CH_4 / N_2O)

Background

Nitrous oxide emissions from nitric acid and adipic acid production have historically been a significant contributor to emissions. However, following plant closures (no adipic acid production facilities remain) and the adoption of improved abatement technology, these emissions have decreased significantly compared with 1990 levels.

In recent years, CH_4 emissions from domestic combustion and N_2O emissions from anaesthetic use have been the dominant CH_4 / N_2O emission sources in the industrial processes, business and residential sectors.

There are several other small emission sources in these sectors:

- **Fletton brick manufacture** CH_4 emissions are very small and correlate relatively well with the number of manufacturing plants operating. Emissions have generally been falling since 1990, with a notable drop when the last plant to burn coal closed in 2008.
- **Household composting** CH_4 / N_2O emissions have risen continually since 2004 but emissions are still very small.
- **Accidental fires** CH_4 emissions are very small and have decreased since 1990, though they have levelled out more in recent years.
- **House & garden machinery** CH_4 / N_2O emissions have decreased due to a reduction in the CH_4 emission factor as older machines are replaced with newer ones. This trend outweighs the increase in machinery usage.

How we project emissions

- **Industrial machinery (CH_4 / N_2O)** – We project activity data using EEP industrial economic drivers and emission factors by a simple vehicle turnover model.
- **House & garden machinery (CH_4 / N_2O)** – We project activity data using projected household numbers from ONS[27] and emission factors by a simple vehicle turnover model.
- **Nitric acid production (N_2O)** – We project nitric acid emissions using the Chemistry Growth Strategy Group baseline scenario for chemical sector growth, an annual 1.7%

[27] ONS (2018): 2016-based household projections in England
https://www.ons.gov.uk/releases/2016basedhouseholdprojectionsinengland

increase[28]. This follows consultation with the Environment Agency chemicals sector leads who also expect a growth in overall chemical production.

- **Fletton brick manufacture (CH_4)** – We project Fletton brick emissions using a simple 1:1 scaling against an index for CO_2 emissions from total brick manufacturing in the UK.
- **Household composting / Accidental fires** – We project these emissions sources will be constant from the latest GHGI year.
- **Anaesthetic use (CH_4 / N_2O)** – We project this using the EEP's population driver based on the methods the GHGI uses.

[28] CGA (2013): Strategy for delivering chemistry fuelled growth of the UK economy https://www.soci.org/-/media/Files/Innovation-Group/CGP-Strategy-for-delivering-chemistryfuelled-growth-of-the-uk-economy.ashx?la=en

5. Energy supply

Background

The energy supply sector emissions covered in this report are fugitive emissions, i.e. those due to leakage, and they are all of methane. These emissions result from natural gas leakage, operational and closed coal mines, and solid fuel transformation.

Leakage from the gas distribution network is the largest CH_4 source in the GHGI outside of the agriculture and waste sectors, comprising approximately 7% of all CH_4 emissions in 2018. It accounted for the majority of CH_4 emissions in the energy supply sector. Methane emissions from coal mining and handling have also historically made a substantial contribution but these have now reduced (to around 1% of CH_4 emissions). Energy sector non-CO_2 emissions were approximately 29 $MtCO_2e$ lower in 2018 than in 1990, mainly because of decreased coal mining activity and a programme to fix leaks in the gas distribution network.

Economic demand drives a small percentage of combustion-related non-CO_2 emissions. We give further details about this in BEIS's Updated Energy and Emissions Projections report[11].

How we project emissions

- **Closed coal mines (CH_4)** — We use a model developed by WSP in 2011[29] to project closed coal mine emissions. The model catalogues mines and estimates methane gas reserves and emission rates to construct a profile of emissions up to 2050. The model was updated in 2016 to reflect more recent information about the closure dates of some mines and changes to the inventory calculation for these emissions.

- **Coal mining (CH_4)** — We project coal mining emissions will be constant based on expert advice from the Oil & Gas Authority. Deep-mined coal production virtually ceased in 2017 while surface mining could continue almost indefinitely unless policies change.

- **Charcoal/coke/solid-smokeless fuel production (CH_4)** — These are very small sources of emissions. We project emissions from charcoal and solid-smokeless fuel production will be constant as we did in last year's projections. We project coke production using a driver from the EEP representing coal consumed by the iron and steel industry. The historical relationship is very strong.

  Gas supply leakage (CH_4) — Here, a 30-year programme to replace the gas distribution network drives a reduction in emissions[30]. In 2013, OFGEM set gas

[29] WSP Environmental (2011): Projections of Coal Mine Methane to 2050
http://uk-air.defra.gov.uk/assets/documents/reports/cat07/1107080945_1775-ghg-improvement-project-wsp-report.pdf
[30] HSE (2011): HSE/Ofgem: 10 year review of the Iron Mains Replacement Programme
http://www.hse.gov.uk/research/rrpdf/rr888.pdf

distribution network leakage targets[31] as part of the roll-out of a new price control period (Apr 2013-Mar 2021). This equated to an emissions reduction of approximately 20%. We linearly extrapolated these targets out to 2032 when the 30-year programme ends, and then set gas leakage from natural gas supply and transmission values to be constant after 2032. These targets form the long-term emission projections. In the short term, we revise the projections downwards to reflect the faster-than-required progress we have seen. We assume the same reductions apply to gas transmission leakage. We project gas leakage at point of use using the EEP index for CO_2 emissions from domestic gas use following consultation with GHGI experts.

[31] OFGEM (2012): RIIO-GD1: Final Proposals - Supporting Document – Outputs, incentives and innovation https://www.ofgem.gov.uk/ofgem-publications/48155/2riiogd1fpoutputsincentivesdec12.pdf

6. Waste management

Background

The major source of emissions from this sector is CH_4 from landfill sites. This contributed 17% of all non-CO_2 emissions in 2018. CH_4 and N_2O emissions from wastewater treatment and non-household composting make up most of the remaining waste emissions. There are also small contributions from Biological Waste Treatment (BWT) processes and from waste incineration plants without energy recovery. The latter burn waste outside of the normal waste stream, such as clinical and chemical waste.

Landfill emissions in 2018 were approximately 75% lower than when the Landfill Directive was introduced in 2000. This had the aim of reducing the amount of waste going to landfill and improving the collection of methane from landfill sites. Emissions from wastewater treatment have been largely constant since 2000. Emissions from BWT processes—composting (excluding household composting), anaerobic digestion and mechanical biological treatment—have been rising since 1990 and composting is the biggest emission source of the three.

How we project emissions

- **Landfill (CH4) —** Defra provides tonnages of waste to landfill projections for municipal waste and HMRC provides commercial & industrial waste projections. New in this edition, the projections take into account the English landfill diversion expected from three main policies announced by Defra in the Resources & Waste Strategy. These are all planned for implementation in 2023[32]. They are: consistency of municipal waste collection, reform of the packaging producer responsibility system and introducing a deposit return scheme for drinks containers. We project the composition of the waste from the changes to BWT processes and Defra projections of waste arisings. We then run these projections of waste to landfill through the MELMod landfill emissions calculation model[33]. MELMod is based on first-order decay IPCC methodology. The UK National Inventory report summarises this[8].

- **Wastewater treatment (CH_4 / N_2O)** — ONS population projections drive our domestic wastewater emission projections. We project industrial wastewater emissions will be constant due to lack of data.

- **BWT (CH_4 / N_2O)** — We created a model in 2018 to improve projections from this sector. The model includes extension of existing anaerobic digestion ammonia

[32] Defra (2018): Resources and waste strategy for England https://www.gov.uk/government/publications/resources-and-waste-strategy-for-england
[33] Eunomia (2010): Inventory Improvement Project – UK Landfill Methane Emissions Model http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=17448&FromSearch=Y&Publisher=1&SearchText=UK%20Landfill%20Methane%20Emissions%20Model%20&SortString=ProjectCode&SortOrder=Asc&Paging=10#Description

projections to cover GHG emissions up to 2050 and utilises expert knowledge from Defra waste experts. It includes the impact of relevant policies such as the Circular Economy Package recycling targets, and the evidence base for composting and mechanical biological treatment projections. The model also accounts for the Defra England food waste collection policy. This introduces mandatory separate collection of food waste for homes and businesses in England from 2023 in order to increase recycling and divert waste away from landfill. The model therefore assumes that all additional food waste collected due to this policy goes to anaerobic digestion.

- **Incineration without energy recovery (CH_4 / N_2O)** — We project constant emissions using the 5-year historical average.
- **Sewage and sludge decomposition (CH_4 / N_2O)** — ONS population projections drive the emissions projections. CH_4 emissions from private systems remain constant at the latest GHGI figure since we assume the biological oxygen demand per person will be the same in future years.

7. Agriculture

Background

Agriculture emissions result from (i) enteric fermentation from livestock, (ii) manure management and (iii) agricultural soils. The two biggest sources are enteric fermentation in cattle and fertiliser use for CH_4 and N_2O respectively. CH_4 and N_2O from manure management also represent a significant source of emissions. Agriculture emissions were roughly constant in the mid-1990s, but then decreased in all sources from the late 1990s until the late 2010s, since when they have remained fairly constant.

How we project emissions

We use agriculture emission projections produced by Defra based on activity data projections (livestock numbers, crop production, fertiliser nitrogen use) to 2030[34] using the Food and Agricultural Policy Research Institute (FAPRI) methodology[35]. The FAPRI projections are based on an economic model assuming a specific set of international prices for agricultural commodities and a particular path for the sterling exchange rate. Together, these factors are important determinants of the returns to farmers and hence total agricultural production. Defra converts the FAPRI activity projections to agriculture emissions projections using the latest agriculture GHGI model.

Since the UK agricultural inventory model does not currently capture mitigation we had to adjust the GHG estimates for the impacts of existing mitigation policies. In particular, we have included the English agricultural industry's GHG Action Plan[36]. Monitoring by Defra suggests that from its implementation to 2015, the Action Plan reduced emissions from English agriculture by 1 $MtCO_2e$. Additionally we have also included policies from the Climate Change Strategy for Wales (reducing annual emissions by 0.2 $MtCO_2e$ by 2020) and the Climate Change Plan from Scotland (reducing annual emissions by 0.8 $MtCO_2e$ by 2032 with savings starting in 2021).

[34] Note that we assume constant emissions post 2030 in the absence of activity data projections.
[35] FAPRI (2010): FAPRI-UK Greenhouse Gas Emission Modelling System for England, Wales, Scotland and Northern Ireland https://www.afbini.gov.uk/sites/afbini.gov.uk/files/publications/%5Bcurrent-domain%3Amachine-name%5D/2010%20december%20greenhouse%20gas%20emission%20modelling%20system%20for%20england%20wales%20scotland%20and%20northern%20ireland.pdf
[36] NFU (2011): Agriculture Industry GHG Action Plan http://www.nfuonline.com/assets/2889

8. Transport

Background

Non-CO_2 emissions are a very small fraction of all transport emissions, at around 1% in 2018.

- The major contributor is road transport N_2O emissions, representing 83% of non-CO_2 transport emissions. These emissions had been falling since the mid-1990s but have started to increase since 2010. This is due to the upward trend in diesel emissions taking over from the downward trend in petrol emissions.
- CH_4 road transport emissions have been decreasing since 1990 due to increasing European standards on emissions from new road transport vehicles.
- The remaining transport emissions are from aircraft support vehicles, domestic aviation and military vehicles.

How we project emissions

Road transport emissions projections follow a bottom-up calculation methodology in line with that for estimating the historical time series of emissions. We project the activity data — vehicle distance travelled — using 2018 DfT traffic forecasts[37].

Aircraft support vehicle projections are based on forecasts of the number of UK airport terminal passengers and the driver for domestic aircraft activity is DfT's air traffic movement projections[38]. We project military transport emissions will be constant.

[37] DfT (2018): Road traffic forecasts 2018
https://www.gov.uk/government/publications/road-traffic-forecasts-2018
[38] DfT (2017): UK aviation forecasts 2017
https://www.gov.uk/government/publications/uk-aviation-forecasts-2017

9. LULUCF

Background

Under assumptions consistent with the 1990-2017 and 1990-2018 inventories, for overall emissions (CO_2 and non-CO_2) we estimate that the Land Use, Land Use Change and Forestry (LULUCF) sector is and will continue to be a net sink in the UK over the period up to 2040 that we are projecting (see the dedicated LULUCF publication[39] for insight about longer term evolutions). However, the non-CO_2 component is a source of emissions, albeit a relatively small source (approximately 1.4 $MtCO_2e$ in 2018). The major contributor is direct N_2O emissions from changes in soil organic matter following the disturbance of soil in land conversion. Other N_2O emissions are the result of drainage of organic soils, biomass burning and the application of nitrogen-based fertiliser to forested land.

Methane is a comparatively small contributor to overall emissions from LULUCF currently reported, contributing only 2% of non-CO_2 LULUCF emissions in 2018. Emissions of CH_4 are driven by wildfires and deforestation through controlled burning, both of which have large inter-annual variability.

How we project emissions

The Centre for Ecology & Hydrology (CEH) and Forest Research project LULUCF emissions and removals with methods consistent with the current inventory methodology. They produce five scenarios (two Baseline scenarios, Central, Low and Stretch). The assumptions deal with afforestation, wildfires, peat extraction, land use change and deforestation. We developed scenario assumptions with relevant policy makers including colleagues from the UK devolved administrations. Broadly, the “Central/Reference case” scenario is a continuation of current policies over their agreed duration (especially relevant for policies involving dedicated public funding) and activity rates. This is the scenario we used in generating emissions projections for the purpose of this report. We use the difference between the “Central/Reference case” scenario and “Baseline 2” scenarios to evaluate policy impacts in the LULUCF sector.

[39] CEH & Forest Research: Projections of emissions and removals from the LULUCF sector to 2050 https://naei.beis.gov.uk/reports/reports?section_id=7

This publication is available from: https://www.gov.uk/government/collections/energy-and-emissions-projections

If you need a version of this document in a more accessible format, please email emissionsprojections@beis.gov.uk. Please tell us what format you need. It will help us if you say what assistive technology you use.