



UK Government

Annex N: Projected emissions of non-CO₂ greenhouse gases



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Executive summary

This report presents the methodology the Department for Energy Security & Net Zero (DESNZ) used to produce the non-CO₂ greenhouse gas emissions projections. The non-CO₂ greenhouse gases are methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF₆) and nitrogen trifluoride (NF₃). The last four gases are collectively referred to as fluorinated gases or F-gases. The projections are a best estimate of future emissions up to 2050, accounting for expected technological developments, key drivers such as population and known policy commitments.

1. Introduction

1.1 Overview

In 2019, the UK Government set a legally binding target for net zero greenhouse gas emissions by 2050, via an amendment to the Climate Change Act¹. Emissions projections are used as a way of monitoring progress towards this target and to identify emissions sources which would need additional measures. The UK is also required to submit projected emissions of greenhouse gases periodically in the form of National Communications and Biennial Transparency Reports to the United Nations Framework Convention on Climate Change (UNFCCC).

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

- The historical greenhouse gas emissions which form the baseline for these projections undergo annual updates to comply with the Intergovernmental Panel on Climate Change (IPCC) 2006 Guidelines². We incorporate any annual changes into our projections to remain consistent with the latest historic estimates.
- We have produced these estimates using a baseline of the latest historical greenhouse gas emissions estimates covering the years 1990-2023³.

1.2 Scope

Non-CO₂ emission sources this document covers

This document covers projections of the non-CO₂ component of the Kyoto Protocol's basket of greenhouse gases. We refer to these as the 'non-CO₂ greenhouse gases'. The gases are:

- Methane (CH₄)
- Nitrous oxide (N₂O)
- Hydrofluorocarbons (HFCs) *
- Perfluorocarbons (PFCs) *
- Sulphur hexafluoride (SF₆) *
- Nitrogen trifluoride (NF₃) *

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 2025. See final UK greenhouse gas emissions statistics 1990-2023:

<https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-statistics-1990-to-2023>

* HFCs, PFCs, SF₆ and NF₃ are also collectively known as fluorinated gases, or “F-gases”.

Geographical scope, time horizon and units

- The geographical scope of these projections is territorial, covering emissions that occur within the UK’s borders
- We project emissions up to 2050
- We present emissions in CO₂ equivalents (CO₂e), according to 100-year Global Warming Potentials (without climate-carbon feedback) set out in the IPCC Fifth Assessment Report.

For the purposes of reporting, we allocate greenhouse gas emissions to Territorial Emissions Statistics (TES) sectors. These are a small number of broad, high-level sectors and are as follows:

- Electricity supply
- Fuel supply
- Domestic transport
- Buildings and product uses
- Industry
- Agriculture
- Waste
- Land use, land use change and forestry (LULUCF).

These high-level sectors are comprised of more detailed source categories that follow IPCC definitions for greenhouse gas 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 occurred⁴. A complete mapping of IPCC sectors to TES sectors is available on the DESNZ website⁵. We use these sectoral assignments in this report.

1.3 Current UK greenhouse gas emissions and targets

As part of UK commitments for reporting greenhouse gas emissions, we produce a national inventory of emissions each year. This contains estimates of historic greenhouse gas emissions from all anthropogenic sources in the UK. This is referred to as the Greenhouse Gas Inventory (GHGI) and is submitted annually to the UNFCCC⁶. The most recent full year of data is for 2023.

⁴ 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>

⁵ See Excel table 6.1 in Final UK greenhouse gas emissions statistics 1990-2023: <https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-statistics-1990-to-2023>

⁶ UK National Inventory Document 1990-2023: <https://naei.energysecurity.gov.uk/reports/uk-greenhouse-gas-inventory-1990-2023-annual-report-submission-under-framework-convention>

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

- **Methane (CH₄)** – CH₄ represents the majority of non-CO₂ greenhouse gas emissions, at 69% in 2023. Agriculture was the largest sector, accounting for 48% of all CH₄ emissions that year, followed by waste which accounted for 32%. The remaining CH₄ emissions were largely from the LULUCF sector or fugitive emissions from energy supply.
- **Nitrous oxide (N₂O)** – N₂O represented 22% of non-CO₂ greenhouse gas emissions in 2023. Agriculture was responsible for the majority of N₂O emissions (69%). Other notable sectors include waste and LULUCF, accounting for 9% and 7% respectively.
- **F-gases (HFCs, PFCs, SF₆ and NF₃)** – HFCs represented 8% of non-CO₂ greenhouse gas emissions in 2023, while PFCs, SF₆ and NF₃ represented about 1% between them. Refrigeration, air conditioning and heat pumps account for the majority of HFC emissions, accounting for 80% of HFC emissions in 2023. Other significant HFC emissions sources include aerosols and metered dose inhalers (e.g. asthma inhalers). The major sources of PFC emissions are halocarbon production and the electronics industry. SF₆ emissions largely come from electrical insulation and NF₃ emissions from the electronics industry.

The latest statistics release provides the most recent data and further details of the emissions of each of these gases by specific activities over the period 1990-2023⁷.

The UK has both international and domestic targets for reducing greenhouse gas emissions. These targets encompass all greenhouse gas emissions, not just the non-CO₂ component discussed in this annex. The DESNZ Energy and Emissions Projections (EEP)⁸ report provides more information about how we forecast overall UK greenhouse gas emissions and compares them with our targets.

⁷ Final UK greenhouse gas emissions statistics 1990-2023:

<https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-statistics-1990-to-2023>

⁸ DESNZ 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 1990-2023 GHGI as the baseline for these projections. The GHGI calculates emissions by combining activity data (e.g. fuel use, livestock numbers) and emission factors (e.g. emissions 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 calendar years previously (e.g. the GHGI published in 2025 covers 1990-2023). This means that the base year for these projections was 2023.

We revise historical emissions estimates each year to account for methodological improvements and new information that becomes available. We review the data and compilation methods for the GHGI annually. A summary of the main methodology changes made in the historic estimates is shown in the latest statistical release⁹. The most notable changes to the GHGI affecting non-CO₂ gases since the last set of projections are:

- An update to include a 6-month delay between waste deposition and the start of methane generation assumed in the landfill estimates, to better reflect IPCC guidelines. Organic material in solid waste degrades over time, with methane emissions from anaerobic decomposition occurring over multiple years. Whilst there is no impact on total landfill CH₄ emissions that are estimated to have occurred, the implementation of a 6-month delay has a significant impact on the distribution of emissions between years.
- Estimates of CH₄ emissions from active coal mines have been updated to incorporate site-specific data for the Aberpergwn colliery, which has led to an increase in CH₄ emissions from the fuel supply sector.
- Several assumptions have been updated in the agriculture estimates, in particular to reflect recent regulatory changes in different parts of the UK.

Overall impact on emissions

In total, the changes we made to the methods and data for the 1990-2023 GHGI led to a decrease in total greenhouse gas emissions (including CO₂) for 2022 of 1.5 million tonnes carbon dioxide equivalent (MtCO₂e) compared with the 1990-2022 GHGI we used in the last set of projections¹⁰, although there was an increase in total non-CO₂ emissions of 1.9 MtCO₂e for the same year (this is the latest year for which we can make a comparison).

⁹ See 2023 UK greenhouse gas emissions: final figures - statistical release:
<https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-statistics-1990-to-2023>

¹⁰ DESNZ Energy and emission projections 2023-2050:
<https://www.gov.uk/government/publications/energy-and-emissions-projections-2023-to-2050>

Projections

We project the emissions from each source in the GHGI from the latest year of historic data up to 2050. 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-CO₂ 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-CO₂ projections include the effects of government policies which mitigate greenhouse gas emissions. The standard 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 (2006¹¹, 2014¹² and Mobile Air-Conditioning Directive¹³)
- 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) and the Collection and Packaging Reforms¹⁴
- Transport policies (including the Local Sustainable Transport Fund, the Renewable Transport Fuel Obligation (RTFO), road investment strategies, fuel efficiency policies for road vehicles, rail electrification and active travel spending from the Department for Transport (DfT) activity projections)
- LULUCF afforestation policies for England¹⁵, Wales¹⁶, Scotland¹⁷ and Northern Ireland¹⁸
- English Greenhouse Gas Agriculture Action Plan¹⁹
- The Scottish Government's Climate Change Plan²⁰ and the Farming and Water Scotland initiative²¹
- Climate Change Strategy for Wales²² and Water Resources (Control of Agricultural Pollution) (Wales) Regulations 2021²³
- Nutrients Action Programme for Northern Ireland²⁴.

¹¹ 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>

¹² 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

¹³ 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>

¹⁴ Defra waste policy:
<https://www.gov.uk/environment/waste-and-recycling>

¹⁵ Defra (2020): England Trees Action Plan
<https://www.gov.uk/government/publications/england-trees-action-plan-2021-to-2024>

¹⁶ Welsh Government (2016): Climate Change Strategy for Wales
<https://gov.wales/climate-change>

¹⁷ Scottish Government (2015): United Kingdom Regional Development Programme (Regional) - Scotland
<https://webarchive.nrscotland.gov.uk/3000/https://www.gov.scot/Resource/0047/00477381.pdf>

¹⁸ DARDNI (2020): Forest Expansion Scheme and Small Woodland Grant Scheme
<https://www.daera-ni.gov.uk/articles/daera-forestry-grants>

¹⁹ NFU (2011): Agriculture Industry Greenhouse Gas Action Plan
<http://www.nfuonline.com/assets/2889>

²⁰ Scottish Government (2018) The Climate Change Plan: The Third Report on Proposals and Policies 2018-2032
<https://www.gov.scot/Topics/Environment/climatechange>

²¹ Farming & Water Scotland
<https://www.farmingandwaterscotland.org/>

²² Welsh Assembly Government (2010) Climate Change Strategy for Wales
<https://www.gov.wales/sites/default/files/publications/2019-04/climate-change-strategy-summary.pdf>

²³ The Water Resources (Control of Agricultural Pollution) (Wales) Regulations 2021
<https://www.gov.wales/water-resources-control-agricultural-pollution-wales-regulations-2021-guidance-farmers-and-land>

²⁴ Northern Ireland Department of Agriculture, Environment and Rural Affairs (2019) Nutrient Action Programme Regulations
<https://www.daera-ni.gov.uk/publications/nutrient-action-programme-regulations-northern-ireland-2019-22-and-associated-documents>

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 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 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. F-gases (Buildings & product uses, domestic transport and industry)

Background

All F-gas emissions are in the buildings and product uses, domestic transport, and industry sectors.

Emissions of HFCs were 45% lower in 2023 than in 1990. There has been a 40% fall in HFC emissions since 2015 following the introduction of the 2014 EU F-gas regulation. Prior to that, they had been rising due to their use as replacement gases in the phasing out of Chlorofluorocarbons (CFCs) mandated by the Montreal Protocol. HFCs are predominantly 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 know the effects of previous 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.
- **Metered dose inhalers** – Emissions are exempt from the 2014 EU F-gas regulation, and we project emissions using population growth²⁵ 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.
- **Refrigeration & air conditioning** – We use the GHGI model and apply assumptions from the 2014 EU 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.

²⁵ ONS (2025), 2022-based National Population Projections:

<https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections/datasets/2014basednationalpopulationprojectionstableofcontents>

- **Foams** – We extend the mapping of activity and emissions to 2050 from the GHGI 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 EU F-gas regulation. 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 (SF₆)** – 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.
- **Production of halocarbons** – We project PFC emissions will be constant as they exhibit no discernible trend.
- **Electronic manufacture (HFCs / PFCs / SF₆ / NF₃)** – We project constant emissions due to limitations of the historical data.
- **Airborne warning and control systems (SF₆)** – 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.
- **Training shoes (PFCs / SF₆)** – 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 (SF₆)** – Emissions are very small and we project they will be constant.
- **Tracer gas (SF₆)** – 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://www.consultations-publiques.developpement-durable.gouv.fr/IMG/pdf/etude_preparatoire_pour_la_revue_du_reg_fgaz.pdf

4. Buildings & product uses and industry (CH₄/N₂O)

Background

N₂O 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, CH₄ emissions from domestic combustion and N₂O emissions from anaesthetic use have been the dominant CH₄/N₂O emission sources in the buildings and product uses and industry sectors.

There are several other small emissions sources in these sectors:

- **Fletton brick manufacture** CH₄ 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.
- **House and garden machinery** CH₄/N₂O emissions have decreased due to a reduction in the CH₄ emissions factor as older machines are replaced with newer ones. This trend outweighs the increase in machinery usage.

How we project emissions

- **Industrial machinery (CH₄/N₂O)** – We project activity data using EEP industrial economic drivers and emissions factors by a simple vehicle turnover model.
- **House and garden machinery (CH₄/N₂O)** – We project activity data using projected household numbers from the Office for National Statistics (ONS)²⁷ and emission factors by a simple vehicle turnover model.
- **Nitric acid production (N₂O)** – We project nitric acid emissions using the Chemistry Growth Strategy Group baseline scenario for chemical sector growth, an annual 1.7% increase²⁸. This follows consultation with the Environment Agency chemicals sector leads who also expect a growth in overall chemical production.

²⁷ ONS (2020), 2018-based household projections for England:

<https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections/datasets/householdprojectionsforengland>

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>

- **Fletton brick manufacture (CH₄)** – We project Fletton brick emissions using a simple 1:1 scaling against an index for CO₂ emissions from total brick manufacturing in the UK.
- **Anaesthetic use (N₂O)** – We project this using the EEP population driver based on the methods the GHGI uses.
- **Cream consumption (N₂O)** – We project constant emissions in line with historical data.
- **Other chemical industry processes (N₂O)** – In the absence of a data source for projections or a discernible historical trend, we project constant emissions.
- **Recreational use of N₂O (N₂O)** – We project constant emissions as the historic data exhibits no discernible trend.

5. Domestic transport (CH₄/N₂O)

Background

Non-CO₂ emissions are a very small fraction of all domestic transport emissions, at around 2% in 2023. Of these emissions, 61% were HFCs (see Section 3), 35% N₂O, and 3% CH₄.

- Road transport N₂O emissions fell from 2000 to 2009, before increasing from 2010 due to the upward trend in diesel emissions taking over from the downward trend in petrol emissions. There was a large fall in emissions in 2020 due to lower road traffic resulting from COVID-19 pandemic restrictions. There was a partial recovery in 2021, but emissions since then have remained below 2019 levels.
- CH₄ road transport emissions have been decreasing since 1990 due to stricter standards on emissions from new road transport vehicles.
- The remaining domestic transport CH₄ and N₂O emissions are from aircraft support vehicles, domestic aviation, domestic shipping, and military vehicles.

How we project emissions

Road transport CH₄ and N₂O 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 DfT forecasts for road traffic in Great Britain²⁹ and for vehicle sales.

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 projections³⁰. We project military transport emissions will be constant.

²⁹ DfT (2022), National road traffic projections 2022:

<https://www.gov.uk/government/publications/national-road-traffic-projections>

³⁰ DfT (2017), UK aviation forecasts 2017:

<https://www.gov.uk/government/publications/uk-aviation-forecasts-2017>

6. Fuel supply

Background

The fuel supply sector emissions covered in this report are fugitive emissions, i.e. those due to leakage, and they are all CH₄. 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 source of CH₄ emissions in the UK outside of the agriculture and waste sectors, accounting for 6% of all CH₄ emissions in 2023. It was responsible for the majority of the CH₄ emissions in the fuel supply sector. Coal mining and handling used to be a large source of CH₄ emissions but now represents only 1% of a total CH₄ emissions. Fuel supply sector non-CO₂ emissions were approximately 34 MtCO₂e lower in 2023 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-CO₂ emissions. We give further details about this in the DESNZ EEP report⁸.

How we project emissions

- **Closed coal mines (CH₄)** – We use a model developed by WSP in 2011³¹ to project closed coal mine emissions. The model catalogues mines and estimates CH₄ 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 GHGI calculation for these emissions.
- **Coal mining (CH₄)** – We project coal mining emissions will be constant based on expert advice from the Oil & Gas Authority. Deep-mined coal production and surface mining have both remained at a relatively low level in recent years.
- **Charcoal/coke/solid-smokeless fuel production (CH₄)** – These are very small sources of emissions. We project emissions from charcoal and solid-smokeless fuel production will be constant. 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 (CH₄) – Here, a 30-year programme to replace the gas distribution network drives a reduction in emissions³². In 2013, the Office of Gas and Electricity

³¹ 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

³² HSE (2011), HSE/Ofgem: 10 year review of the Iron Mains Replacement Programme:

<http://www.hse.gov.uk/research/rrpdf/rr888.pdf>

Markets (Ofgem) set gas distribution network leakage targets³³ 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 emissions 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 CO₂ emissions from domestic gas use following consultation with GHGI experts.

³³ OFGEM (2012), RIIO-GD1: Final Proposals - Supporting Document – Outputs, incentives and innovation: <https://www.ofgem.gov.uk/ofgem-publications/48155/2riiogd1fpoutputsincentivesdec12.pdf>

7. Waste

Background

The major source of emissions from this sector is CH₄ from landfill sites. This contributed 18% of all non-CO₂ emissions in 2023. CH₄ and N₂O emissions from wastewater handling and composting make up most of the remaining waste emissions. There are also small contributions from biological waste treatment (BWT) processes, accidental fires, and waste incineration plants without energy recovery. The last of these refers to burning of waste outside of the normal waste stream, such as clinical and chemical waste.

Landfill emissions in 2023 were 77% 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 around 2006. Emissions from BWT processes – composting, anaerobic digestion, and mechanical biological treatment – have generally been rising since 1990. Meanwhile, emissions from incineration without waste recovery and accidental fires have fallen since 1990.

How we project emissions

- **Landfill (CH₄)** – Defra project the tonnages of future residual (i.e. not recycled or recovered) waste arisings using a set of forecast models³⁴, then estimate the amount of this waste which will go to landfill by deducting the amount estimated to be sent to alternative residual waste treatment (using alternative treatment capacity estimates as described in Defra's Residual waste infrastructure capacity note³⁵). These projections of the amount of waste to landfill are split into material components using historical data on landfilled waste tonnages³⁶ with mixed municipal waste broken down further according to a waste composition synthesised in 2017 by the Waste and Resources Action Programme (WRAP)³⁷.

These forecasts of waste materials sent to landfill are used to estimate methane generation within landfills using the MELMod landfill emissions calculation model, using the same model version as for the latest GHGI (as described in the latest UK National Inventory Document⁶), before applying assumptions around the proportion of landfill gas which will be captured for combustion in engines or flare (~54% capture until 2027, then ~49%) or oxidised in the soil at landfills (10% of the remainder). Methane which is not

³⁴ Defra – Future Waste Arisings - EV0155: <https://sciencesearch.defra.gov.uk/ProjectDetails?ProjectId=20915>

³⁵ Defra – Residual waste infrastructure capacity note: <https://www.gov.uk/government/publications/residual-waste-infrastructure-capacity-note/residual-waste-infrastructure-capacity-note>

³⁶ Environment Agency (2024), 2023 Waste Data Interrogator: <https://www.data.gov.uk/dataset/59ab8448-3905-49c6-9122-ae762f96f66b/2023-waste-data-interrogator>

³⁷ WRAP (2020), Quantifying the composition of municipal waste: <https://www.wrap.ngo/resources/report/quantifying-composition-municipal-waste>

captured or oxidised is assumed to be emitted to the atmosphere. Modelling is carried out for England and scaled up to the UK using the UK:England ratio of landfill emissions from the latest GHGI³⁸.

The process for modelling emissions with the Collection and Packaging Reforms included is the same as for modelling them without this policy, but with the residual waste reduced according to the central policy impact assumptions taken from the Collection and Packaging Reforms policies' Impact Assessments³⁹. Further details of this projection methodology can be found in the technical annex of the Carbon Budget and Growth Delivery Plan⁴⁰.

- **Wastewater treatment (CH₄/N₂O)** – ONS population projections drive our domestic wastewater emission projections. We project industrial wastewater emissions will be constant due to lack of data.
- **BWT (CH₄/N₂O)** – We use a model that extends existing anaerobic digestion ammonia projections to cover greenhouse gas 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.
- **Incineration without energy recovery (CH₄/N₂O)** – We project constant emissions using the 5-year historical average.
- **Sewage and sludge decomposition (CH₄/N₂O)** – ONS population projections drive the emissions projections. CH₄ 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.
- **Household composting and accidental fires (CH₄/N₂O)** – We project these emissions sources will be constant from the latest GHGI year.

³⁸ Greenhouse Gas Inventories for England, Scotland, Wales & Northern Ireland: 1990-2023:

<https://naei.energysecurity.gov.uk/reports/greenhouse-gas-inventories-england-scotland-wales-northern-ireland-1990-2023>

³⁹ Packaging Extended Producer Responsibility: https://www.legislation.gov.uk/ukia/2024/152/pdfs/ukia_20240152_en.pdf,
Simpler Recycling: https://www.legislation.gov.uk/ukia/2024/97/pdfs/ukia_20240097_en.pdf,

Deposit Return Scheme for drinks containers: <https://www.legislation.gov.uk/ukia/2025/67/impacts>.

⁴⁰ Carbon budget and growth delivery plan: <https://www.gov.uk/government/publications/carbon-budget-and-growth-delivery-plan-2025>

8. Agriculture

Background

Agriculture emissions result from (i) enteric fermentation from livestock, (ii) manure management, (iii) agricultural soils and (iv) fuel combustion in agricultural machinery. The two biggest sources are enteric fermentation in cattle and fertiliser use for CH₄ and N₂O respectively. CH₄ and N₂O from manure management also represent a significant source of emissions. Agriculture non-CO₂ emissions were 19% lower in 2023 than in 1990.

How we project emissions

We use agriculture emission projections produced by Defra based on activity data projections (livestock numbers, milk yield, crop areas and production) from the UK Agricultural Market Model (UKAMM)⁴¹. Defra converts the UKAMM activity using the latest agriculture GHGI model to provide emissions projections for methane from enteric fermentation; methane from manure management; nitrous oxide from manure management; nitrous oxide from agricultural soils; and carbon dioxide from urea and liming.

While the assumptions in the modelling include the effects of several mitigation measures, it does not produce estimates for the impact of individual policies. It has therefore not been possible to estimate the impact of all policies included in the projections. The projections presented include increased uptake of mitigation methods for manure storage, and for the application of manure to soils using low emissions slurry spreading equipment based on the Nutrients Action Plan for Northern Ireland; the Farming and Water Scotland initiative for Scotland, and the Control of Agricultural Pollution Regulations for Wales.

However, they do include estimates of the impact of the Climate Change Strategy for Wales (reducing annual emissions by 0.2 MtCO₂e by 2020) and the Climate Change Plan from Scotland (reducing annual emissions by 0.8 MtCO₂e by 2032 with savings starting in 2021).

To estimate CH₄ and N₂O emissions from agricultural machinery we use a simple vehicle turnover model.

⁴¹ Defra (2021), UK Agricultural Market Model (UKAMM):
<https://www.gov.uk/government/publications/uk-agricultural-market-model-ukamm>

9. LULUCF

Background

While we estimate that the land use, land use change and forestry (LULUCF) sector was a net sink of CO₂ in 2023, it was a source of non-CO₂ emissions of 7.1 MtCO₂e. The major contributor is CH₄ and N₂O emissions from the drainage, rewetting and other management of organic and mineral soils. Direct N₂O emissions from changes in soil organic matter following the disturbance of soil in land conversion is also a significant source.

How we project emissions

The Centre for Ecology & Hydrology (CEH) and Forest Research project LULUCF emissions and removals with methods consistent with the current GHGI methodology. They produce scenarios reflecting policy needs. 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 governments. Broadly, the “Central 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 case” scenario and “Baseline” scenarios to evaluate policy impacts in the LULUCF sector.

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

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