National Atmospheric Emissions Inventory

GREENHOUSE GAS INVENTORIES FOR ENGLAND, SCOTLAND, WALES AND NORTHERN IRELAND: 1990-2023

Report for: the Department for Energy Security and Net Zero, The Scottish Government, The Welsh Government and The Northern Ireland Department for Agriculture, Environment and Rural Affairs

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RICARDO

UK Centre for Ecology & Hydrology

Forest Research

Aether

Gluckman Consulting
specialists in refrigeration and climate change

ADAS

Customer:
Department for Energy Security and Net Zero (DESNZ), The Scottish Government, The Welsh Government and The Northern Ireland Department for Agriculture, Environment and Rural Affairs

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Contact:
Roxy Cottey,
Aether Ltd,
Blue Boar Court, 9 Alfred Street, Oxford,
OX1 4EH, UK

T: + 44 1865 259200
E: roxy.cottey@aether-uk.com

Author:
Bennett L, Blannin L, Cottey R, Miles J, Mitchell J, Putman S (Aether Ltd), Richmond B, Willis D (Ricardo)

With Contributions from:
Anthony S, Aston C, Broomfield M, Brown P, Buys G, Cardenas L, Carnell E, Carswell A, Clilverd H, Del Vento S, Dragosits U, Elliott M, Gibbs, M, Gilhespy S, Gluckman R, Gorji, S, Hamilton N, Henshall P, Hobson M, Ingledew D, Karagianni E, Kelsall A, King K, Levy P, London J, MacCarthy J, Malcolm H, Manning A, Matthews R, Milne A, Misra A, Mullen P, Murrells T, Nickerson R, O'Doherty S, Pang Y, Passant N Pearson B, Pitt J, Quinn P, Raine B, Redington A, Richardson J, Sandars D, Skirvin D, Stanley K, Stewart R, Szanto C, Thistlethwaite G, Thomson A, Thornton A, Tomlinson S, Vaughan A, Wakeling D, Walker C, Watterson J, Wong J, Young D, Young H

Approved by:
Hampshire, K.

Ricardo reference:
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CONTENTS

Appendices

SUMMARY

This report presents an overview of the data, methods, and results of the analysis to derive greenhouse gas (GHG) emission inventories for England and the Devolved Administrations (DAs): Scotland, Wales, and Northern Ireland (hereafter referred to collectively as the 'DA inventories')[1]. The DA inventories data are presented in a separate Microsoft Excel file published on the NAEI website at:

https://naei.energysecurity.gov.uk/greenhouse-gases/devolved-administration-greenhouse-gas-emissions

Scope of the Inventory

The 1990-2023 GHG inventories for England, Scotland, Wales, and Northern Ireland presented in this report are based on the latest UK GHG inventory, which covers territorial GHG emissions, meaning emissions occurring within the UK's borders. The GHG inventory covers the following items:

- Emissions are presented for years 1990, 1995 and every year from 1998 to 2023.
- The Base Year for carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) is 1990, but for all F-gases (HFCs, PFCs, SF_6 and NF_3) it is 1995.
- GHG emissions are expressed in terms of carbon dioxide equivalent (CO_2e). This is the unit of measurement that standardises the climate impact of the GHGs mentioned above.
- Emissions are categorised into 'Territorial Emissions Statistics' (TES) Sectors, which is a UK classification system to define the sectors where emissions occur in the UK. These sectors are: Electricity supply, Fuel supply, Domestic transport, Buildings and product uses, Industry, Agriculture, Land use, land use change and forestry (LULUCF) and Waste.
- Emissions are also categorised into Common Reporting Tables (CRT) categories, in accordance with the Paris Agreement reporting. This ensures the emissions presented in DA inventories are categorised in a transparent and comparable way, consistent with the international community.
- Carbon dioxide data are based on the net emissions of carbon dioxide, including net emissions/removals of carbon dioxide in the LULUCF sector.
- Emissions are consistent with international and UK GHG inventory reporting protocol and exclude emissions from international aviation and shipping for England and Northern Ireland, which are reported as "memo items". Emissions for Scotland and Wales are reported including international aviation and shipping as they are included in national targets.
- Emissions in the UK GHGI from offshore oil and gas exploration and production activities are not allocated to any country and are reported as 'Unallocated'. In addition, process emissions from vessels serving the oil and gas sector (e.g. from oil loading onto shuttle tankers) are also reported as "Unallocated".

The GHG emission estimates are presented in three different ways:

- *By source*: emissions are accounted for in the country and source sector in which they are emitted.
- *End user*: emissions related to energy supply are reallocated to the sectors where the "end-use" of the energy occurred. This re-allocation of the upstream energy supply sector emissions to the ultimate consumers of the energy provides a much better representation of the sector-specific consumption patterns.
- *Traded/ Non-traded*: Traded refers to emissions that are controlled under the EU Emission Trading System and UK's Emissions Trading Scheme (ETS), and non-traded are all the emissions that are outside the scope of the ETS.

[1] The England and DA inventories are collectively referred to as the "DA inventories" throughout this report, although it is acknowledged that England does not have a devolved government. This term is for ease of reference only. Four separate inventories are produced each year, one for each country, but they are compiled together and share the same approach.

Recalculations

Each year, the DA inventories are extended and updated – i.e. the previous inventory covered the years up to and including 2022, whilst this report gives emission estimates for the years up to and including 2023.

While preparing the new inventory year, the entire inventory is also updated to include the latest data available. Improvements to the methodology are backdated as necessary to ensure a consistent timeseries. The nature of inventories is such that ongoing improvements to data collection or estimation techniques will inevitably lead to some revisions of historical data and our understanding of the trends.

Uncertainties

The DA inventories aim to use the best data available. However, due to a lack of data in some sectors and/or low-quality data, the DA inventories are based on a wide range of data sources which will include statistical differences, assumptions, proxy datasets, modelled data and some expert judgement. This introduces some uncertainty into the inventory, which means there is potential for inaccuracy (over- or under-estimating the true value of emissions or removals) and imprecision. Therefore, it is necessary to quantify the inventory uncertainty to be transparent, and to help identify areas for future improvement.

The analysis of the DA inventories indicates that the 95% confidence intervals around each country's 2023 GHG emissions total are in the range of ±3% to ±6%.

By-Source Summary

- In 2023, England's GHG emissions are estimated to be 284.8 million tonnes CO_2e ($MtCO_2e$), which represents a 74.0% share of total net UK GHG emissions. England has seen a decrease of 55% in GHG emissions between the Base Year and 2023. Emissions between 2022 and 2023 have decreased by 5%.
- In 2023, Scotland's GHG emissions are estimated to be 37.8 $MtCO_2e$ which represents a 9.8% share of total net UK GHG emissions in 2023[2]. Scotland has seen a decrease of 51% in GHG emissions between the Base Year and 2023. Emissions between 2022 and 2023 have decreased by 2%.
- In 2023, Wales's GHG emissions are estimated to be 33.7 $MtCO_2e$ which represents an 8.8% share of total net UK GHG emissions in 2023[3]. Wales has seen a decrease of 38% in GHG emissions between the Base Year and 2023. Emissions between 2022 and 2023 have decreased by 6%.
- In 2023, Northern Ireland's GHG emissions are estimated to be 18.2 $MtCO_2e$, which represents a 4.7% share of total net UK GHG emissions in 2023. Northern Ireland has seen a decrease of 31% in GHG emissions between the Base Year and 2023. Emissions between 2022 and 2023 have decreased by 7%.

End User Summary

- In 2023, England's end-user emissions were 295.3 $MtCO_2e$, which represents a 76.7% share of total net end-user GHG emissions. End-user emissions were 3.7% higher than the by-source estimates in 2023 as a result of emissions attributed to England in the end user inventories that come from energy production activities (e.g. electricity generation) outside England in the by source inventories. End-user emissions have declined by 54% since 1990.
- In 2023, Scotland's end-user emissions were 40.4 $MtCO_2e$, which represents a 10.5% share of total net end-user GHG emissions. End-user emissions were 6.9% higher than the by-source estimates in 2023[4]. The carbon intensity of energy generated at Scottish power

[2] Including international aviation and shipping, Scotland emissions in 2023 are 39.5 $MtCO_2e$, representing 9.3% of total net UK GHG emissions.

[3] Including international aviation and shipping, Wales emissions in 2023 are 34.1 $MtCO_2e$, representing 8.0% of total net UK GHG emissions.

[4] Including international aviation and shipping, Scotland end user emissions were 2.1% higher than by-source estimates in 2023.

stations has been lower than the remainder of the UK across much of the timeseries, a reflection of the early phase out of coal-powered generation, with the closure of Longannet marking the cessation of coal-fired energy generation in Scotland in 2016. End-user emissions have declined by 54% since 1990.

- In 2023, Wales's end-user emissions were 30.7 $MtCO_2e$, which represents an 8.0% share of total net end-user GHG emissions. End-user emissions were 9.0% lower than the by-source estimates in 2023[5] as a result of a net export of emissions attributed to energy production activities from Wales (e.g. exported electricity and refined oils that are generated in Wales and used in other parts of the UK). End-user emissions have declined by 45% since 1990.
- In 2023, Northern Ireland's end-user emissions were 18.6 $MtCO_2e$, which represents a 4.8% share of total net end-user GHG emissions. End-user emissions are only 1.9% higher than by-source emission. End-user emissions have declined by 33% since 1990.

Traded/ Non Traded Summary

- England's share of ETS (traded) emissions comes from a number of categories, principally power generation, iron and steelworks, and refineries. Traded emissions are estimated to have been around 21% of total GHG emissions in England in 2023.
- Scotland has a slightly lower share of ETS emissions to that in England, with traded emissions mainly arising from categories such as refineries, upstream oil and gas and chemicals. The traded share of the total GHG emissions in Scotland in 2023 was 17%.
- In Wales, the coverage of the ETS is higher than the rest of the UK, reflecting the high share of heavy industry (e.g. emissions from power stations, refineries and integrated iron and steelworks) and, as a result, the traded share of the total GHG emissions in Wales in 2023 was 44%.
- Northern Ireland has a lower share of the ETS emissions compared to Great Britain, reflecting the absence of refineries, iron and steelworks, or oil and gas terminals. The traded share of the Northern Ireland GHG emissions in 2023 was 15%.

Legal Context

The United Kingdom has a legal obligation to reduce GHG emissions over time.

The UK is a party to the United Nations Framework Convention on Climate Change (UNFCCC), which has the objective to stabilise GHG emissions to the atmosphere and reduce the impacts of human activity on the climate. The UK has also ratified the Paris Agreement, and is therefore required to set emission reduction targets every five years.

It is the UK's Climate Change Act (2019 amendment) which establishes the legal requirement to reduce net GHG emissions by 100% in 2050 (i.e. Net Zero), compared to the baseline year of 1990. The Climate Change Act 2008 also introduced carbon budgets, legally binding limits on the total amount of greenhouse gas emissions the UK can emit over five-year periods. In addition to the UK targets, each DA government has their own legal targets:

- The Climate Change (Emissions Reduction Targets) (Scotland) Act 2019 sets out Scotland's ambition to achieve net-zero GHG emissions by 2045. It sets the following interim targets: 2020 is at least 56% lower than the baseline, 2030 is at least 75% lower than the baseline, and 2040 is at least 90% lower than the baseline.
- The Environment (Wales) Act 2016[6] introduced a statutory emission reduction framework for Wales, including a 2050 target, interim targets for 2020, 2030 and 2040 and a system of five-yearly carbon budgets to support the target delivery. Subsequent Regulations update the original 80% reduction by 2050, to commit Wales to achieving net zero by 2050. They also set the interim targets for 2020 (27% reduction); 2030 (63% reduction), and 2040 (89%

[5] Including international aviation and shipping, Wales end user emissions were 10.1% lower than by-source estimates in 2023

[6] https://www.legislation.gov.uk/anaw/2016/3/contents

reduction), as well as the limit for carbon budgets 1 (2016-2020), CB2 (2021-2025) and CB3 (2026-2030).

- The Climate Change Act (Northern Ireland) 2022 sets a target of an at least 100% reduction in GHG emissions by 2050, along with interim targets including an at least 48% reduction in net emissions by 2030.

The DA inventories help to support evidence-based development of climate change policy by the Scottish Government, Welsh Government and the Northern Ireland Executive. The DA inventories help track progress towards these country-specific GHG emission reduction targets.

ABBREVIATIONS

Abbreviation	Definition
CAA	Civil Aviation Authority
CH_4	Methane
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
CRT	Common Reporting Tables
DAs	Devolved Administrations
DEFRA	Department for Environment, Food and Rural Affairs
DESNZ	Department of Energy Security and Net Zero
DEC	Display Energy Certificate
DomCom	Domestic Combustion
DUKES	Digest of UK Energy Statistics'
EFs	Emission Factors
EPC	Energy Performance Certificate
ETS	Emissions Trading Scheme
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GHGI	Greenhouse Gas Inventory
GHGIIP	Greenhouse Gas Inventory Improvement Programme
GVA	Gross Value Added
GWP	Global Warming Potential
HFCs	Hydrofluorocarbons
HGV	Heavy Goods Vehicle
HWP	Harvested Wood Products
IDBR	Inter-Departmental Business Register
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
ISSB	Iron and Steel Statistics Bureau
LDVs	Light-Duty Vehicles
LESSE	Low Emissions Slurry Spreading Equipment
LULUCF	Land use, land use change and forestry
NAEI	National Atmospheric Emissions Inventory
NC	National Communication
NDCs	Nationally Determined Contributions
NID	National Inventory Document
NF_3	Nitrogen trifluoride
NRMM	Non-Road Mobile Machinery
OPG	Other Petroleum Gases
PFCs	Perfluorocarbons
PI	Pollution Inventory
SCA	Smoke Control Area
SF_6	Sulphur hexafluoride
TES	Territorial Emissions Statistics
UK	United Kingdom of Great Britian and Northern Ireland
UNFCCC	Framework Convention on Climate Change

1. INTRODUCTION

This report presents an overview of the data, methods, and results of the analysis to derive greenhouse gas (GHG) emission inventories for England and the Devolved Administrations (DAs): Scotland, Wales, and Northern Ireland (hereafter the DA inventories). The DA inventories data are presented in a separate Microsoft Excel file published on the NAEI website at:

https://naei.energysecurity.gov.uk/greenhouse-gases/devolved-administration-greenhouse-gas-emissions

This report aims to provide the necessary insights into how the inventory estimates have been derived and any significant changes in the inventory data and methods compared to previous inventory cycles, including where changes to the UK GHG Inventory (GHGI) data have led to revisions for DA estimates. This paper also includes a summary of the reported emission trends for the most significant source categories within each DA, including high-emitting source categories and those that have a notable impact on the overall reported emission trends by DA.

1.1 LEGISLATION AND POLICY CONTEXT

The GHG inventories for England, Scotland, Wales and Northern Ireland help to support evidence-based development of climate change policy by the Scottish Government, Welsh Government and the Northern Ireland Executive. The inventories help track progress towards country-specific GHG emission reduction targets.

The implementation of new UK and country-specific legislation means that the requirements of the GHG inventories for the DAs is evolving, with a much greater focus on (i) sector-specific data accuracy, and (ii) sensitivity to policy impacts

1.1.1 The United Nations Framework Convention on Climate Change (UNFCCC)

The UNFCCC was ratified by the United Kingdom in December 1993 and came into force on the 21st March 1994. The objective of the Convention is to stabilise GHG emissions to the atmosphere and reduce the anthropogenic interference with the climate system. In order to achieve this, the international community needs to monitor progress, which requires accurate information on trends of emissions of GHGs, and the collective ability to alter these trends.

The UK, as an Annex I Party to the Convention, having ratified the Kyoto Protocol, where the final submission was published in 2022, is required to submit to the UNFCCC Secretariat net national GHG inventories, including all anthropogenic emissions of GHGs by sources and removals by sinks. Parties are required to submit information on their national inventories on an annual basis and within National Communications (NC) periodically, according to dates established in the Conference of the Parties.

The UK has also ratified the Paris Agreement, which has now superseded the Kyoto Protocol. A requirement of the Paris Agreement is to set emission reduction targets every five years known as Nationally Determined Contributions (NDCs). For its First NDC, the UK has committed to reduce total net GHG emissions by at least 68% in 2030, compared to 1990 level. For its Second NDC, the UK has committed to reduce total net GHG emissions by at least 81% in 2035, compared to 1990 levels.

The UK Climate Change Act (2008) established new legal requirements to monitor and report UK GHG emission reductions. The CCA established a long-term legally binding framework to reduce total UK net GHG emissions by at least 100% below 1990 levels by 2050. The Act also introduced a Carbon Budgeting System whereby emission caps are set over 5-year periods, to map out the emission trajectory to 2050. The UK has met its first, second and third Carbon Budgets covering the periods 2008-12, 2013-17 and 2018-22 respectively.

1.1.2 Devolved Administration's Climate Change Commitments

Powers to implement measures to deliver reductions in emissions of GHGs in Scotland, Wales and Northern Ireland are devolved to the Scottish Government, Welsh Government and the Northern Ireland Executive. Each of the DAs has developed national climate change legislation or strategies establishing targets for reductions in GHG emissions together with accompanying national climate change policy frameworks:

- The Climate Change (Emissions Reduction Targets) (Scotland) Act 2019)
- The Environment (Wales) Act 2016 and Climate Change (Wales) Regulations 2021
- The Climate Change Act (Northern Ireland) 2022

1.1.2.1 Scotland

The Climate Change (Emissions Reduction Targets) (Scotland) Act 2019[7] builds on the Climate Change (Scotland) Act 2009[8], demonstrating Scotland's increased ambition to achieve net-zero GHG emissions by 2045. It sets the following interim targets: 2020 is at least 56% lower than the baseline, 2030 is at least 75% lower than the baseline, and 2040 is at least 90% lower than the baseline.

The 2019 Act also removes the emissions accounting adjustments related to the operation of trading schemes such as the UK-Emissions Trading Scheme (ETS), and also imposes restrictions on the use of carbon units ("credits") to offset domestic emissions for the purposes of assessing progress to targets. The Act proposals set a default limit of zero for all future years, unless Ministers bring forward regulations subject to the affirmative procedure allowing for the possibility of credit use in specified future years.

1.1.2.2 Wales

The Environment (Wales) Act 2016[9] introduced statutory emission reduction targets for Wales, including at least an 80% reduction in emissions by 2050 against a 1990 baseline, interim targets for 2020, 2030 and 2040 and a system of five-yearly carbon budgets to support the target delivery.

The Climate Change (Wales) Regulations 2021[10] provides an update on this target, committing to achieve net zero by 2050. It also sets the following interim targets: emissions reduction of 27% against the baseline by 2020; 63% reduction by 2030, and 89% reduction by 2040. In addition, the Climate Change (Carbon Budgets) (Wales) Regulations set the carbon budget limits for Carbon Budget 1 (2016-2020), an average reduction of 23% lower than the baseline, Carbon Budget 2 (2021-2025), an average reduction of 37% lower than the baseline, and Carbon Budget 3 (2026-2030), an average reduction of 58% lower than the baseline,

1.1.2.3 Northern Ireland

The Climate Change Act (Northern Ireland) 2022[11] sets a target of an at least 100% reduction in GHG emissions by 2050, along with interim targets including an at least 48% reduction in net emissions by 2030. The Act also sets other sectoral targets including 2030 targets at least 80% of electricity consumption from renewable sources and 70% of waste is recycled, as well as a target for a minimum spend of 10% of overall transport budgets on active travel.

[7] https://www.legislation.gov.uk/asp/2019/15
[8] https://www.legislation.gov.uk/asp/2009/12/contents
[9] https://www.legislation.gov.uk/anaw/2016/3/contents
[10] https://www.legislation.gov.uk/wsi/2021/332/made
[11] https://www.legislation.gov.uk/nia/2022/31/contents/enacted

1.2 ABOUT THE GREENHOUSE GAS EMISSIONS INVENTORY

The 1990-2023 GHG inventories for England, Scotland, Wales, and Northern Ireland presented here are based on the latest UK GHGI[12]. The following points apply to the inventories presented in this report:

- The years in scope for the DA GHGI are 1990, 1995 and each year from 1998 to 2023.
- The estimates are expressed in terms of global warming potentials (GWPs) defined on a 100-year horizon (IPCC, 2006), which is explained further in Section 1.1.3 below. The estimates and the GWPs are consistent with the UNFCCC reporting guidelines. In line with international reporting conventions, emissions are published using GWPs from the Intergovernmental Panel on Climate Change (IPCC)'s Fifth Assessment Report (IPCC, 2014).
- Emissions are categorised into 'Territorial Emissions Statistics' (TES) Sectors. These were introduced in the 1990-2022 GHGI cycle, whereas prior to this, emissions were categorised in NC Sectors.
- Emissions are also categorised into Common Reporting Tables (CRT) categories, in accordance with the Paris Agreement[13]. This ensures the emissions presented in DA inventories are categorised in a transparent and comparable way, consistent with the international community. These were introduced in the 1990-2023 inventory cycle, and supersede the previously used Common Reporting Format (CRF) categories.
- Emissions are consistent with international and UK GHGI reporting protocol and exclude emissions from international aviation and shipping for England and Northern Ireland, which are reported as "memo items". Emissions for Scotland and Wales are reported including international aviation and shipping as they are included in national targets.
- Emissions of biogenic carbon dioxide (CO_2) from the burning of biofuels are also excluded.
- Emissions in the UK GHGI from offshore oil and gas exploration and production activities are not allocated to any country and are reported as 'Unallocated'. In addition, vessels serving the oil and gas exploration and production sector are categorised in the same way.
- Estimates exclude the Crown Dependencies (Jersey, Guernsey, and Isle of Man) and those Overseas Territories joining UK instruments of ratification for the UNFCCC (Gibraltar, Bermuda, the Falkland Islands, and the Cayman Islands).

For details of the latest UK GHGI, please see the latest National Inventory Document (NID) and DESNZ national GHG statistics, available at:

https://naei.energysecurity.gov.uk/reports/uk-greenhouse-gas-inventory-1990-2023-annual-report-submission-under-framework-convention

https://www.gov.uk/government/collections/uk-territorial-greenhouse-gas-emissions-statistics

1.2.1 Greenhouse Gases included in the Inventory

Emissions are reported for the seven direct GHGs, and these are listed in **Table 1** alongside their GWP used in the inventory. Depending on their molecular weights, radiative properties, and residence times in the atmosphere, each GHG has a different capacity to impact global warming. The GWP is an attempt to encapsulate these parameters and provide a consistent measure of the relative radiative effects of the emissions of the relevant GHGs, through the units carbon dioxide equivalent (CO_2e). As gases have varying residence times in the atmosphere, consideration is given to the GWP variation across time-horizons; GWPs of gases with shorter residence times than carbon dioxide would increase if a shorter time-horizon is considered. All figures included in the following report are calculated using the Fifth Assessment Report (IPCC, 2014) as per **Table 1**.

[12] https://naei.energysecurity.gov.uk/sites/default/files/2025-04/NID_90-23.pdf

[13] Decision 18/CMA.1 Modalities, procedures and guidelines for the transparency framework for action and support referred to in Article 13 of the Paris Agreement. Sets out requirement to present national inventory in common reporting tables.

Table 1 – Fifth Assessment Report Global Warming Potential of GHGs on a 100-year Horizon (t CO_2 equivalent/ t gas) (IPCC, 2014)

Greenhouse Gases		Global Warming Potential (t CO_2 equivalent / t gas)
Carbon Dioxide	CO_2	1
Methane	CH_4	28
Nitrous Oxide	N_2O	265
Hydrofluorocarbons	HFCs	4 – 12,400
Perfluorocarbons	PFCs	6,630 – 17,400
Sulphur hexafluoride	SF_6	23,500
Nitrogen trifluoride	NF_3	16,100

1.2.2 Inventory Sector Definitions

The GHG inventories for England, Scotland, Wales and Northern Ireland in this report are presented using TES Sectors, to ensure the sum of the DA inventories is fully consistent with the UK GHG emissions statistics. A description of the TES Sectors is provided in **Table 2**.

Table 2 – Territorial Emission Statistics Sector Definitions

Sector Name	Territorial Emission Statistics (TES) Sector Definitions
Electricity Supply	Emissions from power stations for electricity generation, including incinerators generating energy from waste. Excludes emissions from organisations generating their own electricity (autogeneration) even when exported to the electricity grid. These emissions are instead included in the sector in which they occur.
Fuel supply	Emissions from the supply of fuels, e.g. oil, gas and coal. Includes activities such as extraction, production, venting, flaring, processing (e.g. oil refining) and distribution. Excludes emissions from coke production which are instead included in the industry sector as coke is primarily used in the iron and steel industry.
Domestic transport	Emissions from road vehicles, domestic aviation and shipping (including military), fishing vessels, and railways. Also includes emissions from transport related mobile machinery (e.g. at airports and ports) and F gases from mobile air conditioning and refrigeration. International aviation and shipping emissions are not included in the national total, though are reported separately.
Buildings and product uses	Emissions from fuel combustion in residential, public, and commercial buildings, largely for heating. Also includes emissions from house and garden mobile machinery, anaesthetics, F-gases from air conditioning, refrigeration, heat pumps, aerosols as well as other product uses. Excludes emissions from industrial buildings which are instead included in the industry sector.
Industry	Emissions from fuel combustion in the manufacturing and construction industries, industrial processes, and F-gases from industrial refrigeration. Emissions from coke production are included in this sector as coke is primarily used in the iron and steel industry. Includes emissions from organisations generating their own electricity and heat (autogeneration) even when exported to the electricity grid or used in heat networks.

Sector Name	Territorial Emission Statistics (TES) Sector Definitions
Agriculture	Emissions from agricultural machinery and fuel combustion, livestock (enteric fermentation and manure management) and agricultural soils (excluding carbon stock changes which are included in the LULUCF sector).
Land use, land use change and forestry (LULUCF)	Net carbon dioxide emissions from carbon stock changes in forestland, cropland, grassland, wetlands, settlements and harvested wood products. Other GHG emissions from drainage (excl. croplands and intensive grasslands) and rewetting of soils, nitrogen mineralisation associated with loss and gain of soil organic matter, and fires. As carbon stock changes are included in this sector, carbon dioxide emissions of biogenic origin (e.g. burning biomass for energy) are excluded from other sectors to avoid double counting of emissions.
Waste	Emissions from the treatment and disposal of waste, such as landfill, composting, incineration without energy recovery and wastewater handling. Excludes emissions from incinerators generating energy from waste as these are reported in the electricity supply sector.

To provide information that is aligned to the needs of DA policy teams, the GHGI is also provided in NC sectors at the top level, with additional detail by CRT Category.

The UK national total excludes emissions from international aviation and shipping (which are presented as memo items to national inventories, in accordance with UNFCCC reporting requirements) and of biogenic carbon dioxide from the burning of biofuels. Emission targets in Wales and Scotland do include emissions from international transport. Biogenic carbon at point of release is excluded from all inventory totals, as biogenic carbon is part of the short-term carbon cycle, having been sequestered from the atmosphere by plants. Emissions of GHGs from offshore oil and gas exploration and production, and the vessels serving this sector, are classified within this report as "Unallocated" emissions and not attributed to any of the DAs.

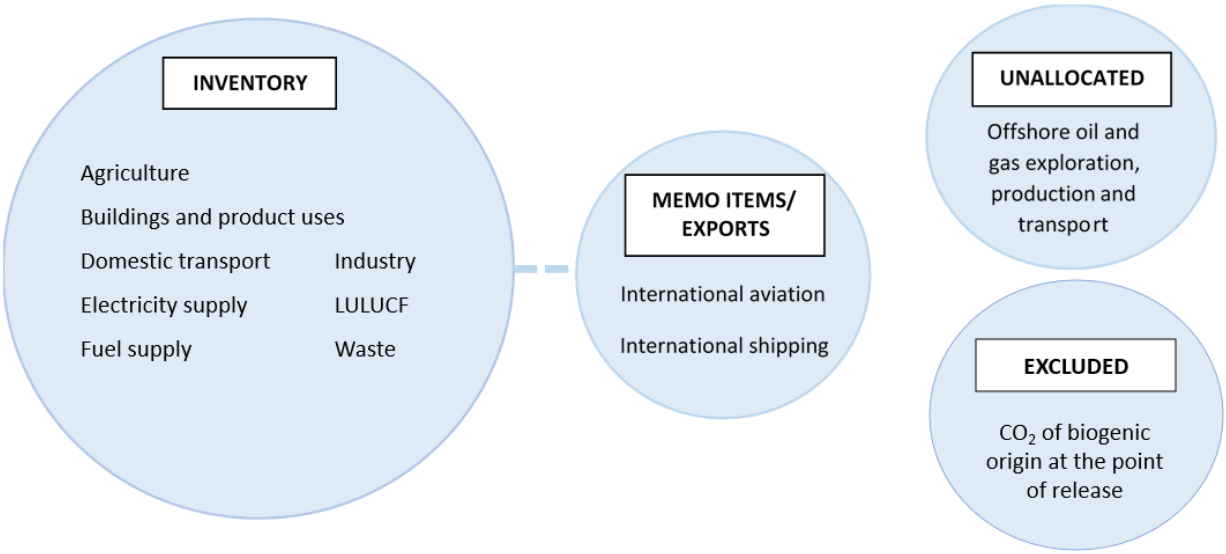

Figure 1 – Overview of the Categories within the DA Inventories

1.2.3 Inventory Scope

This report, and associated data product, presents DA emission estimates in following three formats.

1.2.3.1 By Source Inventory

The data in this report are, unless otherwise stated, presented as emission estimates at the point of emission, also called “By Source” estimates. Emissions are accounted for in the country and source sector in which they are emitted.

1.2.3.2 End User Inventory

Emissions related to energy supply are reallocated to the sectors where the “end-use” of the energy occurred. The emissions reallocated include the whole of the electricity supply and fuel supply source sectors, along with a small number of sources in the industry sector (in particular autogeneration of electricity exported to the grid and coke production). This re-allocation of the upstream energy supply sector emissions to the ultimate consumers of the processed fuels provides a much better representation of the sector-specific consumption patterns that can be targeted through climate change and energy efficiency policies, improving the understanding of demand-side energy use in the UK economy.

Note that whilst emissions from international transport (aviation and shipping) are excluded from the DA By Source inventory estimates (as they are reported as memo items), the Fuel Supply sector emissions associated with the production of international transport fuels (i.e. from upstream oil and gas extraction and oil refining) are included and attributed to the “End use outside the UK” category in the End User inventories.

The End User emission estimates at sector level are more uncertain than the country totals, and hence the absolute sector End User emission estimates and reported trends by sector since 1990 should be regarded as indicative. The methodology used for estimating the End User emissions for each DA is presented in **Appendix 6.** Traded Non-Traded Methodology.

1.2.3.3 Traded / Non-Traded Inventory

Emissions within the By Source inventory are split into two categories:

- Traded sector – emissions that are controlled under the EU’s Emission Trading System and UK’s Emissions Trading Scheme (ETS)[14]
- Non-Traded sector – all emissions that are outside of the scope of the UK ETS

Emissions from the traded (i.e. within the UK ETS) and non-traded sectors represent an important component of emissions reporting in the UK and DA GHG inventories. The ETS is jointly run by the UK ETS Authority which is comprised of the UK Government, Scottish Government, Welsh Government and the Department of Agriculture, Environment and Rural Affairs for Northern Ireland (DAERA). Policy levers available to the Scottish Government, Welsh Government and Northern Ireland Executive have limited influence over activities within the traded sector. Conversely, the devolved Governments have a wide range of policy levers available for the non-traded sectors of the UK economy, which are dominated by sources such as transport, residential, commercial and small-scale industrial emissions. It is therefore important to analyse trends in emissions for the non-traded sectors of the DA inventories.

Where possible and for relevant source categories, the By Source emissions are presented with an additional split to show the relative contribution of the traded and non-traded emissions within each DA. The split is calculated by subtracting the traded emissions from the total emissions.

[14] The UK Emissions Trading Scheme (UK ETS) replaced the UK’s participation in the EU ETS on 1 January 2021. UK based operators (except for electricity generators in Northern Ireland, who will remain in EU ETS in accordance with the terms of the Northern Ireland Protocol (or Protocol on Ireland/Northern Ireland to the Withdrawal Agreement, depending on how formal the publication is)) will now report their emissions under the UK ETS. For the purposes of calculating UK emissions statistics, teams should use EU ETS data for emissions arising up to December 31st, 2020, and use UK ETS data for emissions emitted from 1st January 2021. As the UK ETS was initially designed to provide a smooth transition for relevant sectors from the EU to the UK scheme, the two data sets are compatible.

1.3 BY-SOURCE INVENTORY ESTIMATES FOR 2023

The UK distribution of regional net[15] GHG emissions in 2023, expressed in terms of carbon dioxide equivalent (CO_2e), is summarised below with further details for each country presented in **Sections 2 to 5**. For HFCs, PFCs, SF_6 and NF_3, 1995 is used as the Base Year whilst 1990 is used for all other gases: carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), per Article 3.8 of the Kyoto Protocol. All of the carbon dioxide data are based on the net emissions of carbon dioxide, including net emissions/removals of carbon dioxide in the LULUCF sector.

- England has a 74.0% share of total net UK GHG emissions in 2023. England has seen a decrease of 55% in GHG emissions between the Base Year and 2023. Emissions between 2022 and 2023 have decreased by 5%.
- Scotland (when including international aviation and shipping estimates[16]) has a 9.3% share of total net GHG emissions in 2023. Scotland has seen a decrease of 51% in GHG emissions between the Base Year and 2023. Emissions between 2022 and 2023 have decreased by 2%.
- Wales (when including international aviation and shipping estimates[16]) has an 8.0% share of total net GHG emissions in 2023. Wales has seen a decrease of 38% in GHG emissions between the Base Year and 2023. Emissions between 2022 and 2023 have decreased by 6%.
- Northern Ireland has a 4.7% share of total net GHG emissions in 2023. Northern Ireland has seen a decrease of 31% in GHG emissions between the Base Year and 2023. Emissions between 2022 and 2023 have decreased by 7%.

The remaining 2.7% of UK emissions in 2023 (excluding international aviation and shipping) are offshore and hence are not allocated to the DA inventories. Emissions data at full precision can be found in the tables that accompany this report: “DA_GHGI_1990_2023.xlsx”.

Table 3 – Share of UK total for the DAs, both excluding and including international aviation and shipping. Unallocated emissions are offshore and not allocated to the DA inventories.

	Share of UK total excluding international aviation and shipping	Share of UK total including international aviation and shipping
England	74.0%	75.8%
Scotland	9.8%	9.3%
Wales	8.8%	8.0%
Northern Ireland	4.7%	4.4%
Unallocated	2.7%	2.5%

1.4 UNCERTAINTIES

The 1990-2023 DA GHG emission estimates are based on a wide range of data sources and include statistical differences, assumptions, proxy datasets and some expert judgement. In addition, the natural variability in processes (e.g. emissions from farming practices under different climatic conditions and across soil types, carbon content of fuels, and performance of industrial production plant and abatement plant) that are being “modelled” introduces a degree of uncertainty.

[15] Total net emissions include removals in the Land Use Land Use Change and Forestry (LULUCF) sector and exclude emissions from international aviation and shipping.

[16] As Scotland and Wales’s statutory targets include international aviation and shipping. This means that the sum of percentages in the bullet point list above do not add up to 100%, but this is expected given that the data here is expressing contribution to emissions on differing scopes

An overall analysis of the uncertainty in latest year DA inventories totals indicates that the uncertainties are in the range of ±3% to ±6%[17] with the 2.5 and 97.5 percentiles are shown in **Appendix 4** to indicate a 95% confidence range. The overall uncertainty depends on the relative contributions to the DA inventories of more uncertain categories where the NAEI team understand less about the distribution and intensity of the estimates (e.g. nitrous oxide from agricultural soils, carbon dioxide from LULUCF, solid and liquid fuel combustion). Uncertainties for each DA in 2023 are presented within **Sections 2-5** below.

- Emissions of carbon dioxide typically have the lowest uncertainty due to the high contribution from fuel consumption sources where the carbon content of fuels is generally very well documented. The main source of uncertainty in carbon dioxide estimates at the DA level is the lack of detailed DA-specific energy balances. The "outlier" in carbon dioxide inventory terms is Scotland, where there is a much greater contribution from more uncertain LULUCF sources and sinks, whilst Northern Ireland carbon dioxide inventory uncertainties are somewhat higher than the UK average due to the uncertain activity data for off-gas-grid use of oils and solid fuels outlined above. DA uncertainties in carbon dioxide inventories in the latest year are: ±2% England, ±7% Scotland, ±3% Wales and ±6% Northern Ireland.
- Emissions of nitrous oxide are associated with higher uncertainty than for other gases (±21% England, ±20% Scotland, ±19% Wales, ±28% Northern Ireland) due primarily to the high uncertainty in estimates for emissions from soils (for fertiliser application and variability of soil types).
- Emissions of methane tend to be associated with uncertainties that are between carbon dioxide and nitrous oxide (±18% England, ±14% Scotland, ±12% Wales, ±11% Northern Ireland).

Long-term trends in emissions can be estimated more accurately than short-term year-to-year differences in emissions. This is a crucial point to consider when assessing the reasons for the year-to-year changes in emissions. Year-to-year, or inter-annual trends, can be influenced strongly by short term factors such as colder winters or fuel commodity prices. Colder winters will increase fuel use relative to warmer winters, and emissions will increase. Increases in fuel commodity prices are likely to restrict increases in fuel use and might decrease fuel use. Emissions will respond accordingly. Furthermore, there is an inherent uncertainty in the representativeness of individual surveys and other datasets that underpin inventory estimates for an individual year. Averaged over several years, these uncertainties are reduced. Over the longer-term, with larger and longer-term datasets to work with, the impact of year-to-year variability in data capture in surveys, censuses and industrial regulatory reporting is reduced and longer-term trends become more visible.

A full description of the quantitative model of uncertainty is available in the UK's NID 1990 to 2023; see https://naei.energysecurity.gov.uk/reports/uk-greenhouse-gas-inventory-1990-2023-annual-report-submission-under-framework-convention.

1.5 TRADED/ NON-TRADED INVENTORY ESTIMATES

The UK and EU[14] ETS data have been analysed and used to derive a split for non-traded estimates for the by-source DA GHG emission inventories[18]. This method takes account of observed data discrepancies for specific sectors and presents a "non-traded" component to the by-source estimates. The methodology for traded/ non-traded compilation is provided in **Appendix 6.** Traded Non-Traded Methodology.

- Across the UK, the non-traded share of total GHG emissions was 76.0% of total GHG emissions in 2023.
- England's share of ETS (traded) emissions comes from a number of categories, principally power generation, iron and steelworks, and refineries. England traded emissions are estimated to be around 21% of total GHG emissions in 2023.

[17] Note that the base year uncertainty ranges between ±5% to ±9%.

[18] The traded non-traded inventory estimates exclude aviation bunkers and marine bunkers (both international and domestic).

- Scotland has a slightly lower share of ETS emissions to that in England, with traded emissions mainly arising from categories such as refineries, upstream oil and gas and chemicals. The traded share of the total GHG emissions in Scotland in 2023 was 17%.
- In Wales, the coverage of the ETS is higher than the rest of the UK, reflecting the high share of heavy industry (e.g. emissions from power stations, refineries and integrated iron and steelworks) and, as a result, the traded share of the total GHG emissions in Wales in 2023 was 44%;
- Northern Ireland has a lower share of the ETS emissions compared to Great Britain, reflecting the absence of refineries, iron and steelworks, or oil and gas terminals. The traded share of the Northern Ireland GHG emissions in 2023 was 15%.

1.6 END-USER INVENTORY ESTIMATES

In the end-user inventory analysis, all emissions associated with energy supply (e.g. power generation, coal mining, oil and gas extraction, refineries) are allocated to the energy consumer. There is a high level of uncertainty in the reported data, due to the limited availability of data on electricity generation and consumption, especially at the DA level in 1990. The net[19] GHG end-user emissions in 2023 and emission trends in the end-user inventories are summarised below[20].

- England had a 76.7% share of total net end-user GHG emissions in 2023 (compared to a 74.0% share of by-source emissions). End-user emissions were 3.7% higher than the by-source estimates in 2023 as a result of emissions attributed to England in the end user inventories that come from energy production activities (e.g. electricity generation) outside England in the by source inventories. End-user emissions have declined by 54% since 1990.
- Scotland had a 10.5% share of total net end-user GHG emissions in 2023 (compared to a 9.8% share of by-source emissions, excluding memo items). End-user emissions were 6.9% higher than the by-source estimates in 2023. The carbon intensity of energy generated at Scottish power stations has been lower than the remainder of the UK across much of the timeseries, a reflection of the early phase out of coal-powered generation, with the closure of Longannet marking the cessation of coal-fired energy generation in Scotland in 2016. End-user emissions have declined by 54% since 1990.
- Wales had an 8.0% share of total net end-user GHG emissions in 2023 (compared to an 8.8% share of by-source emissions, excluding memo items). End-user emissions were 9.0% lower than the by-source estimates in 2023 as a result of a net export of emissions attributed to energy production activities from Wales (e.g. exported electricity and refined oils that are generated in Wales and used in other parts of the UK). End-user emissions have declined by 45% since 1990.
- Northern Ireland had a 4.8% share of total net end-user GHG emissions in 2023 (compared to a 4.7% share of by-source emissions). End-user emissions are only 1.9% higher than by-source emission. End-user emissions have declined by 33% since 1990.

For further details of the end-user inventories in the 1990-2023 cycle, see **Appendix 6.** Traded Non-Traded Methodology of this report.

1.7 REVISIONS AND UPDATES TO THE INVENTORY

Each year, the GHG inventories for England, Scotland, Wales, and Northern Ireland are extended and updated. The timeseries of the inventories are extended by including a new inventory year – i.e. the previous inventory covered the years up to and including 2022, whilst this report gives emission estimates for the years up to and including 2023.

[19] Net emissions include removals in the LULUCF sector.

20 The percentages presented in these figures are rounded but are calculated from emission estimates calculated at full precision. Note that all percentages quoted in this report are based on net emission estimates held at full precision and they may differ slightly from those that can be calculated from summary tables presented in the report.

While preparing the new inventory year, the entire inventory is also updated to include the latest data available. Improvements to the methodology are backdated as necessary to ensure a consistent timeseries. The nature of inventories is such that ongoing improvements to data collection or estimation techniques will inevitably lead to some revisions of historical data and our understanding of the trends. Methodological changes are made to take account of new data sources, new guidance from IPCC, and new research.

For the energy sector, a number of sub-sectors in the DA GHGI are calculated using a top-down method (i.e. using proxy data) from the UK GHGI due to a lack of sub-national energy balances. As a result of this, the UK GHGI, and subsequently the DA GHGI utilises core energy statistics provided by DESNZ in their annual publication the 'Digest of UK Energy Statistics' (DUKES) (DESNZ, 2024a). The DUKES data is revised annually and hence the data provided may be different in the latest edition of DUKES, compared to that used in the compilation of the previous inventory. Data revisions are, generally for the latest 2-3 years, and these revisions also feed into the DA GHGI. In addition to DUKES, the DA GHGI makes use of sub-national energy statistics provided by DESNZ, which may also be revised for recent years – revisions to these only impact the DA GHGI and not the UK GHGI.

In addition, there may also be updates to the methodology used to allocate emissions to each of the DAs, especially where full and consistent sets of fuel use data are not available. For example, where emissions may previously have been allocated using surrogate statistics such as country-specific Gross Value Added (GVA) data or population, this methodology may be improved to use data more closely related to the activities producing these emissions, should more suitable statistics become available.

As a result of these improvements to underlying activity datasets and methods used to estimate and distribute emissions across DAs, data in this publication of the inventory are likely to differ from figures presented in previous DA GHG inventories. Some sectors have undergone significant revisions, which are summarised in the following sections and in **Appendix 2 – Method Changes and Recalculations**.

The following changes have been made to the UK GHGI and are captured in the related sections in the NID (Brown, et al., 2025). A short summary of recalculations is provided within the sections below, and the NID should be referred to for further detail.

2. GHG EMISSIONS IN ENGLAND (1900 – 2023)

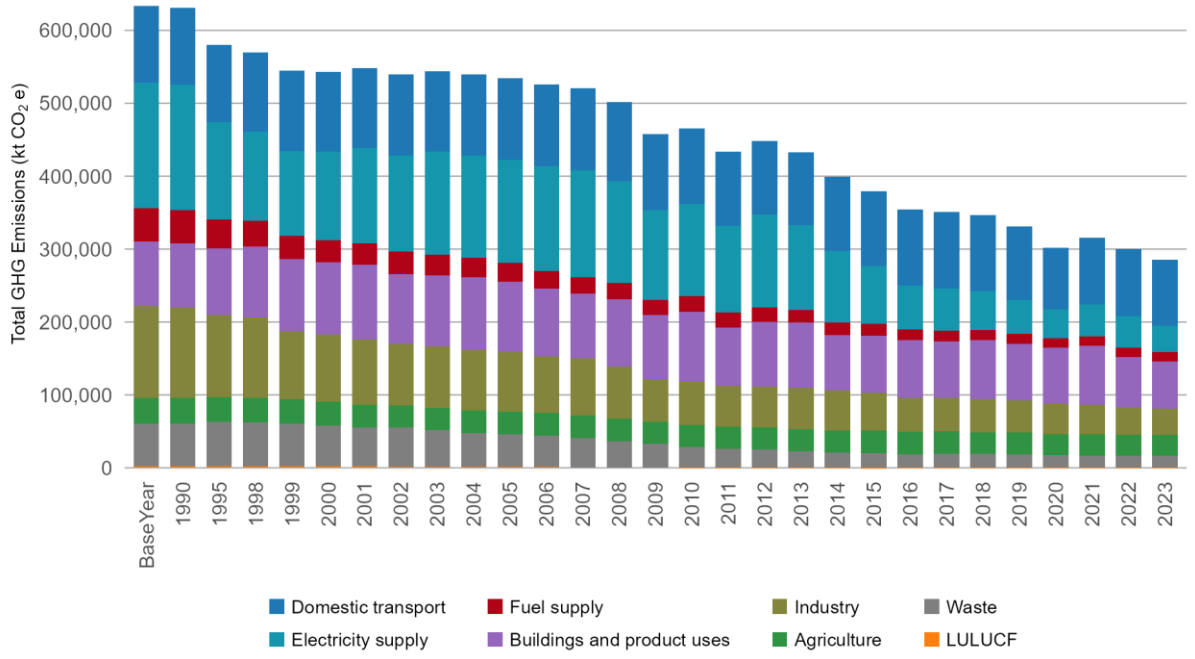

Figure 2 – England GHG Emissions 1990-2023 ($ktCO_2e$)

2.1 KEY SOURCES, SINKS AND TRENDS

Total GHG emissions (excluding memo items) from England have declined by 55% between the base year and 2023 and decreased by 5% between 2022 and 2023. The key sources influencing the overall inventory trends in England are presented by TES Sectors as follows:

Domestic Transport (32% of 2023 inventory)

- Since 2014, road transport has been the largest source of emissions in England. The timeseries shows that emissions from road transport were at a maximum in 2007 and a recent peak in 2017, declining by 14% between 2017 and 2023. This trend is observed across passenger cars, heavy duty vehicles and motorcycles. Passenger cars show the greatest decline (14%) since 2019, largely shaped by overall reductions in car use since 2019. The decline in 2020 was likely driven by COVID-19, however the emissions from passenger cars in 2022 and 2023 remain lower than 2019.

Buildings and Product Uses (23% of 2023 inventory)

- The buildings and product uses sector is dominated by residential combustion. Between the base year and 2023, emissions have decreased by 34% within the sector due to a switch from less efficient solid and liquid fuels to natural gas for heating, and improvements in energy efficiency.

Electricity Supply (13%[21] of 2023 inventory)

- Power station emissions have reduced by 79% since 1990 due primarily to the shift in fuel mix away from coal to use less carbon-intensive fuels in electricity generation, including increased use of natural gas and renewables. Much of this decline has occurred in the latter years of the timeseries (since 2012) due to the closure or conversion of a number of major power

[21] Note that this summary does not include commentary on other transport and public sector combustion emissions, and so the sum of percentages does not equal 100%

producers which has accelerated the phasing out of coal from the fuel-mix. The electricity supply sector alone accounts for 39% of the decline in England emissions between the base year and 2023.

Industry (13% of 2023 inventory)

- Industrial fuel combustion remains a major emission source in England. This is despite a decline in emissions of 59% between the base year and 2023, accounting for 12% of the total decrease in emissions in England. The trend is mainly due to plant closures, fuel-switching to less carbon-intensive fuels, and improved production efficiency.
- Chemical and fluoro-chemical production installations have also fitted abatement and undergone closures, for example the one adipic acid plant in England has closed, as have several nitric acid plants.

Agriculture (10% of 2023 inventory)

- Emissions in the agriculture sector have decreased by 18% between the base year and 2023 mainly due to reductions in fertiliser use and resulting nitrous oxide emissions from soils, and reduced animal numbers resulting in reduced methane from dairy cattle.

Waste (6% of 2023 inventory)

- Emissions have significantly declined, by 72% between the base year and 2023 largely due to the progressive introduction of methane capture and oxidation systems within landfill management.
- Between the base year and 2023, landfill emissions have decreased by 79%, and this alone accounts for 12% of the total reported reduction in GHG emissions from England.

Fuel Supply (5% of 2023 inventory)

- Emissions from coal mining and handling have decreased by 99% between the base year and 2023, largely driven by the closure of all remaining major coal mines. Minor activity remains in Coal mining and handling accounting for 225 ktCO_2e in 2023.

LULUCF (a net sink with magnitude equivalent to 0.3% of 2023 inventory)

- In the 2023 inventory the LULUCF sector has been a net sink since 2008, reducing by 133% between the base year and 2023. The reasons behind the overall decrease in emissions across the timeseries include an increase in the magnitude of the carbon sink of forest land remaining forest land, as well as significant decreases in the conversion of land to cropland and settlements, and an increase in grassland carbon storage. There have been major recalculations to the LULUCF inventory for the latest submission, which are detailed in **Appendix 2**.

2.2 RECENT TRENDS

Since 2018, emissions in England have declined by 18% and have decreased by 5% between 2022 and 2023. The key contributing factors to this recent trend are the following:

- Significant declines in emissions from power stations, driven by reduced coal combustion as part of the accelerated phase out of the fuel from the energy mix, is the dominant reason behind this trend. There is a 17% decrease in emissions from power stations between 2022 and 2023. Since 2018, the decline in emissions from power stations is responsible for 33% of the England-wide trend.
- There is an 18% decrease in emissions in industrial fuel combustion between 2018 and 2023 driven by decreases in other industrial combustion.
- Emissions from the domestic transport sector declined by approximately 13% between 2018 and 2023, reflecting long-term reductions in fuel use across most sub-sectors. Emissions from the domestic transport sector decreased by approximately 1% between 2022 and 2023. This small decline follows a period of recovery in travel demand after the COVID-19 pandemic. While emissions had rebounded in earlier years due to increased activity across passenger

cars, buses, and motorcycles, the slight drop in 2023 suggests a stabilisation in fuel consumption. The levelling off may reflect improved fuel efficiency, shifts in travel patterns, or changes in modal share following the post-pandemic peak in 2022.

- Emissions from the buildings and product uses sector have decreased by 6% between 2022 and 2023. This is likely due to changes in behaviour with residential heating in 2023, with high gas prices and above average temperatures encouraging homeowners to limit the use of heating. The decline in emissions from residential buildings is responsible for 76% of the England-wide trend between 2018 and 2023.
- Emissions from the electricity supply sector declined by 17% between 2022 and 2023.This sharp reduction contrasts with the rise in emissions seen between 2020 and 2022, which may be linked to the post COVID-19 rebound in economic activity and energy demand. The 2023 decline reflects a return to the longer-term decarbonisation trend, driven by a significant fall in fossil fuel-based electricity generation—particularly from gas—and continued growth in renewable energy sources like offshore wind and solar. Lower overall electricity demand, helped by improved energy efficiency and milder weather, also contributed to the sharp fall.

2.3 UNCERTAINTY

England uncertainty in 2023 for all GHGs (±3%): England has a relatively low overall uncertainty because the inventory has the highest overall contribution from carbon dioxide and the lowest contribution from GHGs that are dominated by sources with higher uncertainty such as methane and nitrous oxide. Carbon dioxide emissions in England are also mainly from combustion and industrial sources which have relatively low uncertainty.

2.4 RECALCULATIONS

Overall, emissions have been revised upwards across the timeseries for England, with recalculations in emissions generally between 0.1% and 1.6% between the base year and 2022. A minor downward revision of 0.1% occurred in 2022. Further detail on DA level recalculations can be found in **Appendix 2**, however the main recalculations are presented below.

Agriculture

- Full descriptions of DA specific recalculations in manure management (CRT Category 3B) and agricultural offroad vehicles (CRT Category 1A4cii) can be found in **Appendix 2**.
- Other recalculations occurred across the timeseries due to the improvement of fleece weight and protein retention effecting the methane emissions of lambs, recalculations to dairy cattle manure management impacting nitrous oxide emissions and revisions to non-manure based digestates applied to land activity data.

Buildings and product uses

A significant proportion of the recalculations in this sector are driven by changes at a UK level due to an accumulation of:

- Recalculation to the base year as a result of an improvement to redistribute pre-1998 burning oil DUKES values using the 2016-2019 DUKES reported totals. This redistribution pre-1998 ensures greater consistency across the timeseries.
- Wood data is now used completely following a DUKES revision, animal biomass and plant data now reported separately.
- Waste is now split into renewable (biomass) and non-renewable (non-biomass) and municipal and non-municipal fractions.

Additionally, the incorporation of the 2022 Defra domestic burning survey and revision of historical assumptions led to a revision of the domestic combustion (DomCom) model, and new activity data for coffee logs.

There were DA level revisions too as an outcome of the Greenhouse Gas Inventory Improvement Programme (GHGIIP) as described in **Appendix 2**.

Domestic Transport

- There were revisions to the cold start methodology to apply emission factors (EFs) related to Euro 2 to 5 petrol vehicles, impacting non- carbon dioxide emissions resulting in recalculations in the road transport model within the UK inventory

Electricity Supply

- Improvements were made to separate drivers for power stations using wood and liquid biofuels
- For later years in the timeseries there are very minor recalculations to the Pollution Inventory.

Fuel Supply

- Revisions to fuel supply in England were applied at the UK level due to an emission factor update following DUKES revisions for solid smokeless fuel production (CRT Category 1B1c)

Industry

DA specific recalculations are described in detail in **Appendix 2** and include:

- Changes to the split between DAs due to revisions of the UK sub-national residual fuel dataset, driven by an improvement to the distribution of non-domestic energy use
- Mapping grid updates at the DA level for many of the 1A2 sectors (including Cement, Chemicals, Food and drink, Lime production, Other industrial combustion and Pulp, paper and print industries).
- Previously missing data for two blast furnace sites in England and a blast furnace site in Wales resulted in driver recalculations. This results in minor changes to the proportion of Iron and steel emissions allocated to England and Wales.

UK level recalculations to Industry include:

- For later years there are recalculations to the activity data and carbon balance for pig iron and sinter production, due to revisions to DUKES
- Revisions to Non-Road Mobile Machinery (NRMM) estimates due to gas oil reconciliation improvements, leading to reallocating gas oil in the sector by DUKES. Additionally, bottom-up NRMM updates for forklifts and other industry NRMM use.

LULUCF

- Revisions to the forest land emissions across the timeseries due to a number of updates to the CARBINE model. Full descriptions of the updates and recalculations to the CARBINE model are outlined in **Appendix 2.0**
- Recalculations to emissions from grassland organic soils due to splitting the rewetted fen areas between grassland and wetland, to ensure these areas are placed in the correct LULUCF categories after 20 years.

Waste

- The recalculations to the Waste sector are due to changes to landfill emissions at a UK level. An emission factor revision for the decay reaction in MELmod, specifically applying a default 6-month delay time in line with the IPCC 2006 Guidelines, resulted in decreased emissions earlier in the timeseries and increased emissions in later years
- For 2021 and 2022 revisions to flaring data in England at the UK level.

3. GHG EMISSIONS IN SCOTLAND (1990 - 2023)

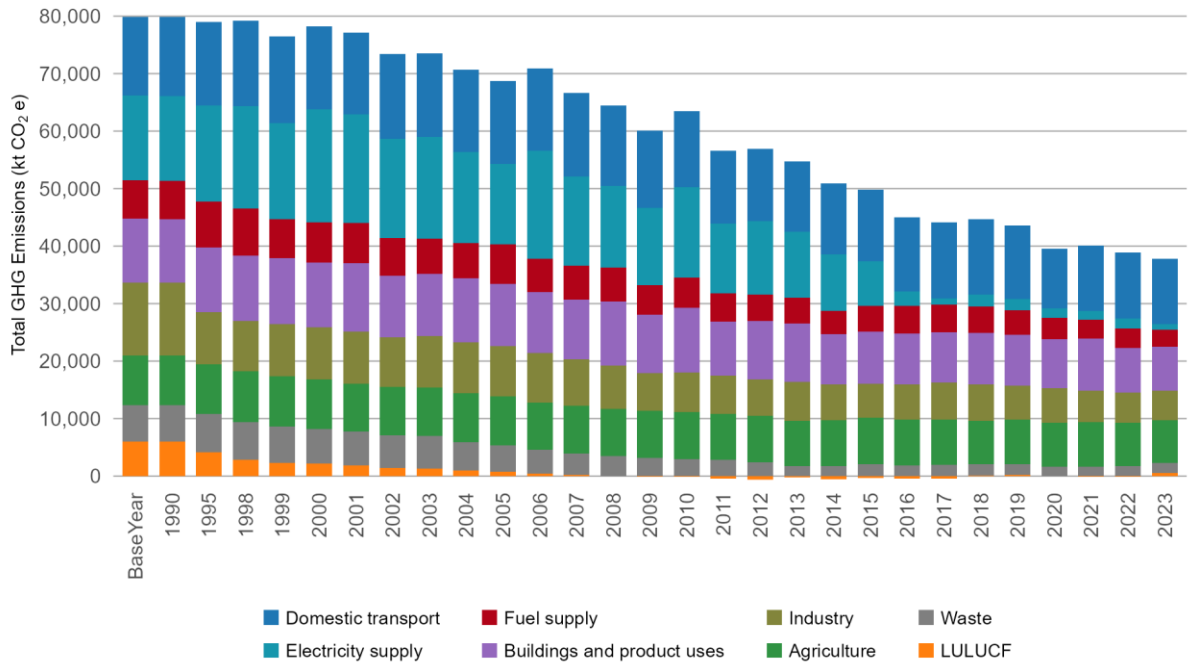

Figure 3 – Scotland GHG Emissions 1990-2023 ($ktCO_2e$)

3.1 KEY SOURCES, SINKS AND TRENDS

Total GHG emissions for Scotland have declined by 51% between the base year and 2023 when including emissions from international aviation and shipping. As international aviation and shipping emissions are included in targets for Scotland, all figures in the following section include these sectors. The key sources influencing the overall inventory trends in Scotland are presented by the TES Sectors as follows:

Domestic Transport (29% of 2023 inventory)

- Domestic transport has been the largest source of emissions in Scotland since 2013. Within domestic transport, road transport contributes to 22% of the 2023 inventory. Since emissions from the road transport sector reached a peak in 2007, increasing again to a second peak in 2017. Since 2017, there has been a decline in transport sector emissions, primarily driven by reduced fuel consumption associated with the travel restrictions imposed during the COVID-19 pandemic. Road transport emissions increased between 2020 and 2022 by approximately 14%, tending towards a return to pre COVID-19 levels, but levelled out and saw a minor decrease between 2022 and 2023.

Agriculture (19% of 2023 inventory)

- Emissions in the agriculture sector have decreased by 13% between the base year and 2023, mainly due to a decrease in livestock numbers (particularly cattle and sheep).

Buildings and product uses (19% of 2023 inventory)

- Buildings and product uses sector is dominated by residential buildings. Between the base year and 2023, emissions from residential buildings have decreased by 38% because of a switch from less efficient solid and liquid fuels to natural gas for heating, and improvements in energy efficiency.

Industry (13% of 2023 inventory)

- In the industry sector, Industrial fuel combustion remains a major emission source in Scotland but shows a strong decline of 57% between the base year and 2023. This is due to plant closures, fuel-switching to less carbon-intensive alternatives and improvements in production efficiency.
- Closure of the Ravenscraig steelworks in 1992 has contributed to an almost complete reduction in iron and steel sector emissions between the base year and 2023.

Fuel Supply (7% of 2023 inventory)

- Fuel supply emissions have decreased by 56% between the base year and 2023. Emissions from fuel supply saw a slight increase of 3% from 2021 to 2022 but returned to the usual rate of decrease in 2023, dropping 13% from the previous year.

Waste (4% of 2023 inventory)

- Waste emissions have declined by 73% between the base year and 2023, largely due to the progressive introduction of methane capture and oxidation systems within landfill management and reductions in waste landfilled.

Electricity Supply (2% of 2023 inventory)

- Power station emissions have reduced by 93% between the base year and 2023 due primarily to the shift in fuel mix away from coal to use less carbon intensive fuels for generation, including increased use of nuclear and renewables. Power stations alone account for 33% of the decline in Scotland emissions between the base year and 2023.

International aviation and shipping (4% and 0.6% of the 2023 inventory respectively)

- Emissions from international aviation in Scotland have increased by 24% between 2022 and 2023, mainly because of the post COVID-19 recovery, but emissions now sit near the pre-pandemic level. Emissions from international aviation in Scotland have returned to pre-COVID-19 levels with a less than 0.1% increase in emissions between 2019 and 2023.
- Emissions from international shipping have declined by 67% between the base year and 2023, with the overall trend showing a general decline throughout.

LULUCF (a net source worth 1% of 2023 inventory)

- LULUCF in Scotland has been a net source of GHG emissions until 2008, but most years between 2009 and 2017 were reported as net sinks. Across the timeseries, forest land and grassland are consistent sinks whereas the major sources of emissions are cropland and peatland.

3.2 RECENT TRENDS

Emissions have remained largely constant over recent years in Scotland, with a more pronounced decrease between 2019 and 2020. It is followed by an observed increase of 0.8% between 2020 and 2021 (including international aviation and shipping) due to post-pandemic recovery. However, the emissions between 2022 and 2023 decreased by a small percentage of 2% (including international aviation and shipping), owing to decreases in the emissions of electricity and fuel supply, as well as industry. The overall trend from 2018 to 2023 is a 15% decrease in emissions, with a number of sources contributing to this:

- As with recent years, variability in activity at power stations holds a major influence over the most recent trend. Between 2022 and 2023, there is a 44% decrease in emissions from power stations and the level of emissions from power stations are now at the lowest in the timeseries. This is despite a 10% increase in emissions from power stations between 2021 and 2022.
- Emissions from the domestic transport sector decreased by 1% between 2022 and 2023, with an overall 14% reduction in emissions in 2023 compared to 2017. This is principally due to reduced fuel consumption as reported in DUKES for the latest year, which is used to normalise the bottom-up road transport methodology. The reduced fuel consumption resulted

from the travel restrictions imposed during the COVID-19 pandemic, with the greater reduction in 2020 reflecting the greater travel restrictions. The increase from 2021 to 2022 shows the post-COVID 19 recovery. Passenger cars emissions have not changed significantly since 2022, but emissions from buses have decreased by 7% since 2022, and Heavy Goods Vehicles (HGV) emissions have reduced 5% each since 2022.

- Emissions decreased by 13% in the fuel supply sector, and 3% in the waste sector between 2022 and 2023. Emissions from the agriculture sector reduced by 0.1%, and emissions from the industry sector decreased by 3% from 2022 and 2023, which continues the trend since 2018, wherein the emissions from these two sectors have decreased by 1% and 18% respectively. In general, emissions in Scotland in 2023 have reduced across all sectors compared to 2018, except for LULUCF.
- Buildings and product uses sector sees a smaller decline in emissions between 2022 and 2023, than between 2021 and 2022, a 2% reduction compared to the previous 14% reduction. The main reasons for the decrease in rate of reduction is that 2022 saw a great decline in residential combustion, owing to the year being one of the hottest years in Scotland and the increase in gas prices drove consumer behaviour change. Overall, residential buildings account for 74% of the trend since 2018 and have seen a 17% reduction in emissions.

3.3 UNCERTAINTY

Scotland uncertainty in 2023 for all GHGs (±6%): Scotland has a notably higher level of overall uncertainty due to the much greater contribution to the Scotland total from sources and sinks with significant uncertainties, such as LULUCF and agriculture. In addition, Scotland has a relatively high contribution to its overall GHG total from methane and nitrous oxide; these inventories are dominated by sources that are much harder to characterise, with EFs that are highly uncertain.

3.4 RECALCULATIONS

Recalculations for 1990-2022 were typically revised upwards in the range of 0.03% - 1.2% however, there are downwards revisions between 0.04% and 0.9% in 1990, 1995, 2015, 2019 and 2022. The most significant recalculations occurred in 2010 and 2013.

Further detail on major DA level recalculations can be found in **Appendix 2**, but for Scotland include:

Agriculture

- For Scotland a negative recalculation occurred due to recalculations to agricultural stationary combustion, related to improvement of burning oil distribution by DUKES
- For later years bottom-up recalculations and revisions to Defra agricultural statistics resulted in decreases to agricultural non-road mobile machinery (NRMM) emissions at a UK level.
- Incorporation of new agricultural offroad (i.e. non-road) fuel use mapping from 2005-2023, resulting in reallocations of data across all the DAs. For Scotland this results in a decrease early in the timeseries and a small increase throughout the rest of the timeseries.
- A description of small DA specific recalculations in manure management (CRT Category 3B) and further detail of the agricultural offroad vehicles (CRT Category 1A4cii) recalculations can be found in **Appendix 2**.

Building and Product Uses

A significant proportion of the recalculations in this sector are driven by changes at a UK level due to an accumulation of:

- Recalculation to the base year as a result of an improvement to redistribute pre-1998 burning oil DUKES values using the 2016-2019 DUKES reported totals. This redistribution pre-1998 ensures greater consistency across the timeseries.
- Wood data is now used completely following a DUKES revision, animal biomass and plant data now reported separately.

- Waste is now split into renewable (biomass) and non-renewable (non-biomass) and municipal and non-municipal fractions.

Additionally, the incorporation of the 2022 Defra domestic burning survey and revision of historical assumptions led to a revision of the DomCom model, and new activity data for coffee logs.

There were DA level revisions to as an outcome of the Greenhouse Gas Inventory Improvement Programme (GHGIIP) as described in **Appendix 2.**

Domestic Transport

- There were revisions to the cold start methodology to apply EFs related to Euro 2 to 5 petrol vehicles, impacting non- carbon dioxide emissions resulting in recalculations in the road transport model within the UK inventory

Electricity Supply

- Improvements were made to separate drivers for power stations using wood and liquid biofuels
- For later years in the timeseries there are very minor recalculations to the Pollution Inventory

Fuel Supply

- No recalculation

Industry

DA specific recalculations are described in detail in **Appendix 2** and include:

- Changes to the split between DAs due to revisions of the UK sub-national residual fuel dataset, driven by an improvement to the distribution of non-domestic energy use
- Mapping grid updates at the DA level for many of the 1A2 sectors (including Cement, Chemicals, Food and drink, Lime production, Other industrial combustion and Pulp, paper and print industries).

UK level recalculations to Industry include:

- For later years there are recalculations to the activity data and carbon balance for pig iron and sinter production, due to revisions to DUKES
- Revisions to NRMM estimates due to gas oil reconciliation improvements, leading to reallocating gas oil in the sector by DUKES. Additionally, bottom-up NRMM updates for forklifts and other industry NRMM use.

LULUCF

- Revisions to the forest land emissions across the timeseries due to a number of updates to the CARBINE model. Full descriptions of the updates and recalculations to the CARBINE model are outlined in **Appendix 2.0**
- For Scotland updates to peatland restoration areas for 2013-2023, updated from Peatland Action including changes in which year hectarage is reported due to overlapping projects.
- Recalculations to emissions from grassland organic soils due to splitting the rewetted fen areas between grassland and wetland, to ensure these areas are placed in the correct LULUCF categories after 20 years.
- Recalculations to forest land converted to wetland areas for Scotland from 2013.

Waste

- The recalculations to the Waste sector are due to changes to landfill emissions at a UK level. An emission factor revision for the decay reaction in MELmod, specifically applying a default 6-month delay time in line with the IPCC 2006 Guidelines, resulted in decreased emissions earlier in the timeseries and increased emissions in later years

4. GHG EMISSIONS IN WALES (1990 - 2023)

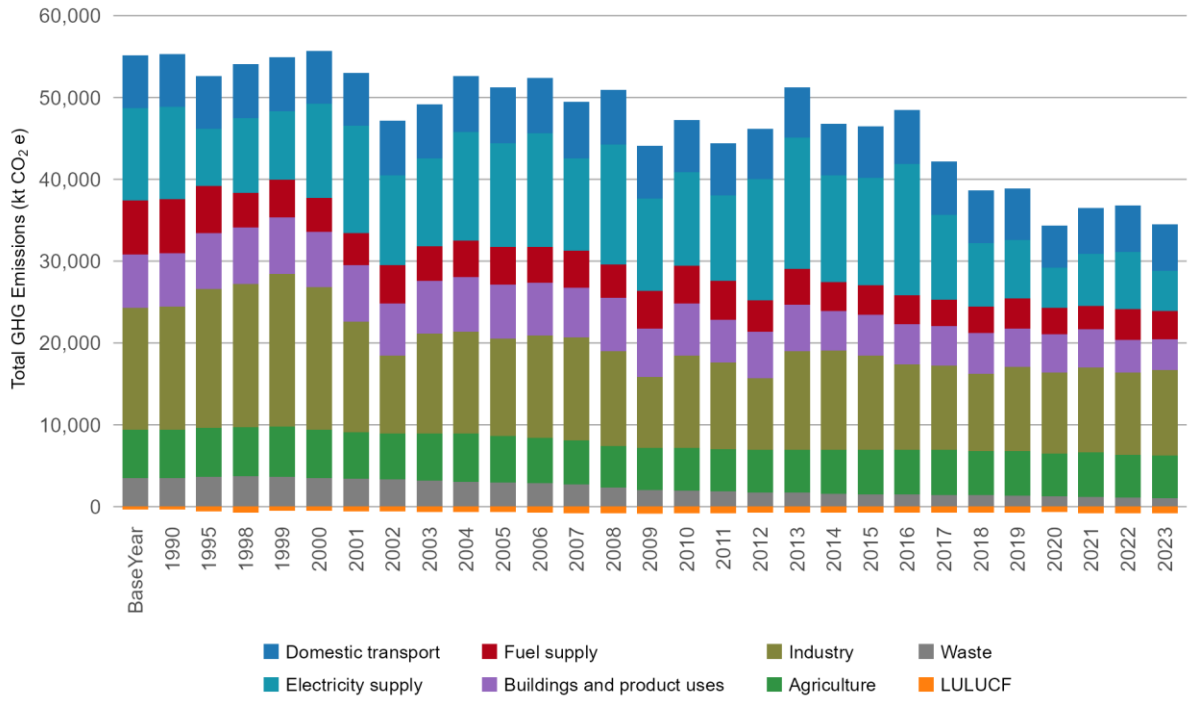

Figure 4 – Wales GHG Emissions 1990-2023 ($ktCO_2e$)

4.1 KEY SOURCES, SINKS AND TRENDS

Total GHG emissions for Wales have decreased by 38% from the base year to 2023 when including emissions from international aviation and shipping. These emission reductions are mainly due to efficiencies in energy generation and business sector heating (of buildings and for processes), the use of natural gas to replace some coal and other fuels as well as abatement in some chemical industries, reductions in emissions from anaerobic waste management, and variations in manufacturing output (e.g. in iron and steel, bulk chemical production). As international aviation and shipping emissions are included in targets for Wales, all figures in the following section are inclusive of these sectors:

Industry (31% of 2023 inventory)

- Industry emissions have decreased by 30% between the base year and 2023, primarily owing to a large reduction in industrial fuel combustion between 1999 and 2002. Industrial fuel combustion accounts for 15% to the total emissions reduction in Wales since the base year and 84% of emissions from Industry in 2023. Between 2022 and 2023, emissions from industrial fuel combustion increased by 8%. Between the base year and 2023, emissions from industrial fuel combustion have decreased 26%. This is due to plant closures, fuel-switching to less carbon-intensive alternatives and improvements in efficiency of production.
- Emissions from iron and steel production account for 72% of the total industry emissions in 2023. Emissions have reduced by 10% in this category between the base year and 2023 and have increased 15% since 2022.

Domestic Transport (17% of 2023 inventory)

- Road transport emissions have decreased by 8% between the base year and 2023. Road transport emissions have not yet returned to pre COVID-19 levels following the significant increase in activity between 2020 and 2022, although there has been a decrease in emissions of 2% between 2022 and 2023. This sector includes emissions from passenger cars, Light-

Duty Vehicles (LDVs), HGVs and buses, motorcycles and other road transport under CRT Category 1A3b.

Electricity Supply (15% of 2023 inventory)

- Power station emissions have decreased by 56% between the base year and 2023, following a number of closures and a switch in the fuel mix from coal to gas and renewables. Notably, since 2016 there has been a decrease in emissions from coal-fired power stations, with no emissions since 2020 following the closure of Aberthaw coal-fired power station. The reduction in emissions from coal-fired power stations contributes to around 58% of the reduction in emissions from electricity supply since 2016. Between 2022 and 2023, emissions from power stations sharply decreased by 29% which is likely due to reduced fossil fuel generation and a slight increase in renewable electricity generation in Wales with an overall decrease in electricity generation[22]. in contrast to the previous two years which saw some increase in emissions between 2020 and 2022, owing to increased activity in recovery from the COVID-19 pandemic.

Agriculture (15% of 2023 inventory)

- Emissions in the agriculture sector have decreased by 13% between the base year and 2023, mainly a result of a general decline in livestock numbers and nitrogen fertiliser use.
- Emissions in the agriculture sector have decreased by 2% between 2022 and 2023. This is driven by a large decrease in emissions from livestock due to a 7% decrease is sheep and numbers between 2022 and 2023. However, this decrease is partly offset by increasing emissions from agricultural combustion and agricultural soils (due to an increase in fertiliser application) between 2022 and 2023.
- Despite this, livestock remain an important factor in agriculture emissions in Wales, with the largest source of emissions coming from enteric fermentation and the management of manure from livestock (collectively 79% of agricultural emissions for Wales in 2023).

Buildings and Product Uses (11% of 2023 inventory)

- The buildings and product uses sector is dominated by residential buildings (representing 8% of all emissions in the 2023 inventory). Between the base year and 2023, emissions have decreased by 47% in residential buildings driven by the trend in domestic combustion because of a change to the fuel mix from coal to natural gas, and energy efficiency measures. The residential sector accounts for 11% of the total reduction in emissions in Wales between the base year and 2023. Reductions in the residential sector were likely driven by higher energy prices resulting in reduced energy consumption[23].

Fuel Supply (10% of 2023 inventory)

- Refineries account for 68% of total fuel supply emissions in 2023. The closure of crude oil and specialist refineries between the base year and 2023 has contributed to a 34% reduction in emissions from refineries. An emissions increase of 51% from 2021 to 2022 is observed due to an increase in refinery combustion in Wales in 2022, however in 2023 this value reduced again by 2%.
- The closure of many deep coal mines has also played a significant role in reducing emissions from the base year (there was an 86% reduction in coal mining and handling emissions between 1990 and 2018). While the expansion of activities in the Aberpergwm Colliery in 2019 led to a large increase in emissions between 2018 and 2020, emissions from coal mining and handling decreased between 2020 and 2023 by 27%.

Waste (3% of 2023 inventory)

- Emissions from the Waste sector have shown a significant decline of 69% between the base year and 2023. Within this, landfill emissions have declined by 75% over the same period. Landfills have contributed 12% to the total emissions reduction in Wales between the base

[22] Electricity generation and supply in Scotland, Wales, Northern Ireland, and England, 2019 to 2023

[23] Energy trends, March 2024

year and 2023. These reductions are largely due to the progressive introduction of methane capture and oxidation systems within landfill management.

LULUCF (a sink equivalent to 2% of 2023 inventory[24])

- Wales has been a net sink across the entire timeseries. The main influences on the emissions trends are emissions from cropland and settlements and removals from forest land. The decrease in emissions from cropland, peatland and settlements between the base year and 2023 and increased removals from forest land drive an overall increase in removals across the timeseries.

International Aviation & Shipping (0.2% & 0.9% of 2023 inventory respectively)

- GHG emissions from Wales have increased by 15% in international aviation and decreased by 44% in international shipping between the base year and 2023, but both are a minor component of total emissions in 2023. Emissions from shipping are greater than aviation in Wales and are driven by international heavy fuel oil freight transport resulting in a steady decline in emissions since 2011 due to reduced fuel use. Major declines in aviation emissions between 2019 and 2022 are primarily due to significantly reduced aviation activity as a result of the COVID-19 pandemic, although there has been a steady trend tending towards pre-pandemic levels with 2023 emissions amounting to 428% increase compared to 2021 emissions. Aviation emissions had been increasing sharply pre-pandemic; from 2015 to 2019 emissions increased by 72%.

4.2 RECENT TRENDS

Between 2022 and 2023, emissions from Wales decreased 6%. This reflects a trend over recent years, whereby emissions have been falling more significantly, with a decline of 11% between 2018 and 2023. The main factors that have influenced the trend between 2022 and 2023 are outlined below:

Variable activity at power stations in recent years has had a significant bearing on the energy supply sector trend. Emissions from power stations have decreased by 29% between 2022 and 2023, following the previous 42% increase seen from 2020 to 2022.

Emissions in domestic transport have increased since 2020 following the lifting of travel restrictions, however, there has been an overall 2% decrease in emissions between 2022 and 2023

Emissions from residential buildings decreased by 6% between 2022 and 2023, continuing the decreasing trend of emissions seen since 2021.

4.3 UNCERTAINTY

Wales uncertainty in 2023 for all GHGs (±3%): Wales GHGI has a relatively low overall uncertainty due to the high contribution of carbon dioxide emissions from well-documented emission sources such as heavy industry (power generation, oil refining and iron and steel production). The Wales GHGI also has a relatively low contribution from the uncertain sources of methane and nitrous oxide.

4.4 RECALCULATIONS

The recalculations for 1990-2002 are decreases, in the range of -0.30% and -1.3%, for the years 2003-2022 the recalculations are all increase within 0.09%-2.1 %. The most significant change occurs in 2022 and 2020 with recalculations of 2.1% and 1.6%, which causes a notable change compared to the previous year inventory.

Further detail on major DA level recalculations can be found in **Appendix 2**, but for Wales include:

[24] Since net LULUCF emissions are a sink, their contribution to the national total is a negative percentage.

Agriculture

- For Wales a negative recalculation occurred due to recalculations to agricultural stationary combustion, related to improvement of burning oil distribution by DUKES
- For later years bottom-up recalculations and revisions to Defra agricultural statistics resulted in decreases to agricultural non-road mobile machinery (NRMM) emissions at a UK level.
- Incorporation of new agricultural offroad (i.e. non-road) fuel use mapping from 2005-2023, resulting in reallocations of data across all the DAs. For Wales this results in a decrease across the entire timeseries.
- A description of small DA specific recalculations in manure management (CRT Category 3B) and further detail of the agricultural offroad vehicles (CRT Category 1A4cii) recalculations can be found in **Appendix 2**.

Building and Product Uses

A significant proportion of the recalculations in this sector are driven by changes at a UK level due to an accumulation of:

- Recalculation to the base year as a result of an improvement to redistribute pre-1998 burning oil DUKES values using the 2016-2019 DUKES reported totals. This redistribution pre-1998 ensures greater consistency across the timeseries.
- Wood data is now used completely following a DUKES revision, animal biomass and plant data now reported separately.
- Waste used in commercial and public sector combustion is now split into renewable (biomass) and non-renewable (non-biomass) and municipal and non-municipal fractions.

Additionally, the incorporation of the 2022 Defra domestic burning survey and revision of historical assumptions led to a revision of the DomCom model, and new activity data for coffee logs.

There were DA level revisions to as an outcome of the Greenhouse Gas Inventory Improvement Programme (GHGIIP) as described in **Appendix 2.**

Domestic Transport

- Revisions to the cold start methodology to apply EFs related to Euro 2 to 5 petrol vehicles, impacting non- carbon dioxide emissions. Resulting in recalculations in the road transport model within the UK inventory

Electricity Supply

- Improvements were made to separate drivers for power stations using wood and liquid biofuels
- For later years in the timeseries there are very minor recalculations to the Pollution Inventory.

Fuel Supply

- Deep-mined coal emissions have been recalculated to use Aberpergwm emissions data from the Pollution Inventory (PI), rather than coal activity data (see **Appendix 2**)
- For Wales an implied emission factor from the new PI data has been applied to all coal mined in the Neath Port Talbot region from 2002 onwards.

Industry

DA specific recalculations are described in detail in **Appendix 2** and include:

- Changes to the split between DAs due to revisions of the UK sub-national residual fuel dataset, driven by an improvement to the distribution of non-domestic energy use
- Mapping grid updates at the DA level for many of the 1A2 sectors (including Cement, Chemicals, Food and drink, Lime production, Other industrial combustion and Pulp, paper and print industries).

- Previously missing data for two blast furnace sites in England and a blast furnace site in Wales resulted in driver recalculations. This results in minor changes to the proportion of Iron and steel emissions allocated to England and Wales.

UK level recalculations to Industry include:

- For later years there are recalculations to the activity data and carbon balance for pig iron and sinter production, due to revisions to DUKES
- Revisions to NRMM estimates due to gas oil reconciliation improvements, leading to reallocating gas oil in the sector by DUKES. Additionally, bottom-up NRMM updates for forklifts and other industry NRMM use.

LULUCF

- Revisions to the forest land emissions across the timeseries due to a number of updates to the CARBINE model. Full descriptions of the updates and recalculations to the CARBINE model are outlined in **Appendix 2.0**

Waste

- The recalculations to the Waste sector are due to changes to landfill emissions at a UK level. An emission factor revision for the decay reaction in MELmod, specifically applying a default 6-month delay time in line with the IPCC 2006 Guidelines, resulted in decreased emissions earlier in the timeseries and increased emissions in later years

5. GHG EMISSIONS IN NORTHERN IRELAND (1990 - 2023)

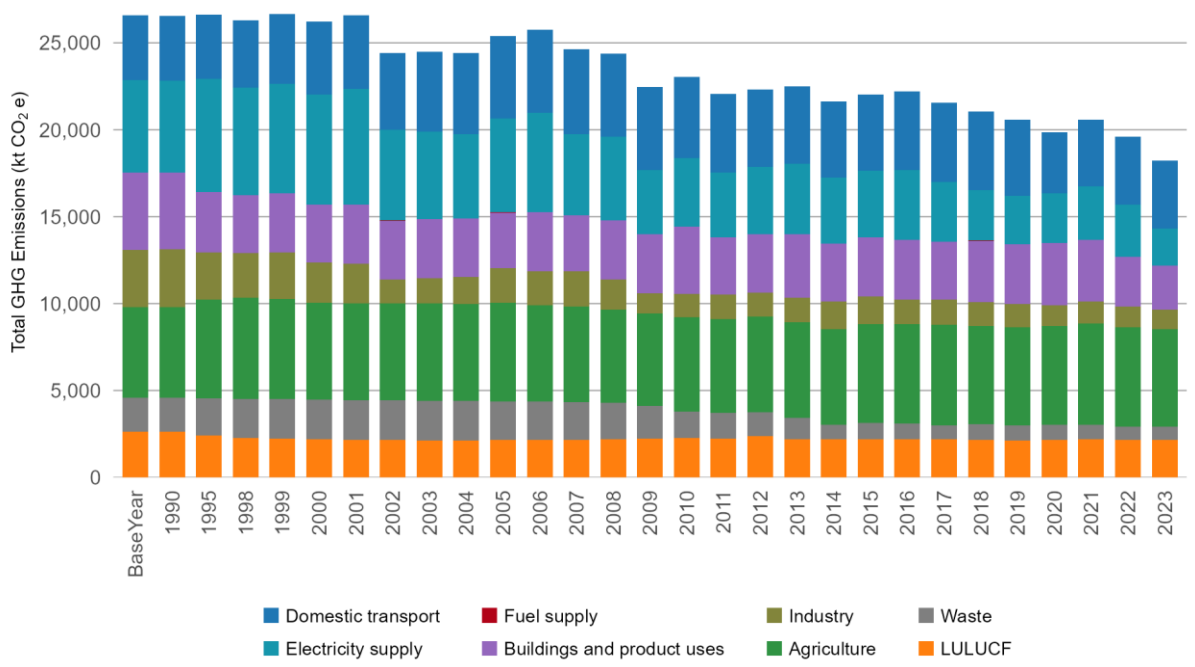

Figure 5 – Northern Ireland GHG Emissions 1990-2023 ($ktCO_2e$)

5.1 KEY SOURCES, SINKS AND TRENDS

Total GHG emissions (excluding memo items) for Northern Ireland have declined by 31% between the base year and 2023. The key sources influencing the overall inventory trends in Northern Ireland are presented by the TES Sectors as follows:

Agriculture (31%[25] of 2023 inventory)

- Agricultural emissions account for a significantly larger share of Northern Ireland's total emissions compared to the UK average, primarily because Northern Ireland has fewer industrial and energy-related emission sources, making agriculture a comparatively more dominant contributor.
- Emissions in agriculture have remained largely consistent across the entire timeseries and have steadily increased by 8% between the base year and 2023; this is due to increases in livestock numbers over this period, although this is partly offset by lower nitrogen fertiliser applications.

Domestic Transport (22% of 2023 inventory)

- Domestic transport emissions have increased by 5% between the base year and 2023; this is due to a growth in demand (cars, LDVs, HGVs), despite improvements in efficiency of vehicles, with road transport emissions increasing by 9% over this period.

Buildings and product uses (14% of 2023 inventory)

- Residential buildings accounted for 80% of Northern Ireland's buildings and produce uses emissions in 2023, with emissions primarily driven by direct fuel combustion in households. Between the base year and 2023, residential emissions fell by 46%, largely due to a shift toward natural gas use from the late 1990s, which displaced more carbon-intensive fuels such as oil and coal. Reductions in the residential buildings contributed 11% of the overall decline in Northern Ireland's emissions between the base year and 2023.

Electricity Supply (12% of 2023 inventory)

- Electricity supply sector emissions have reduced by 60% between the base year and 2023 due to fuel-switching away from coal- and oil-fired power generation.
- The mix of generation capacity is quite different in Northern Ireland from the rest of the UK and from 1990 to 1995 consisted entirely of coal and oil-fired stations. In 1996, the largest power station in Northern Ireland, Ballylumford, was converted from oil to use natural gas.
- The lack of nuclear and renewable generation up to 1996, together with the lack of natural gas contributed to the proportionately higher emissions from electricity generation compared to the other DAs. Moreover, the non-availability of natural gas led to a proportionately higher consumption of electricity than in the rest of the UK, also increasing emissions in the early part of the timeseries. Natural gas has been supplied to some industrial, commercial, and domestic users since 1999 and gas use continues to grow as the supply infrastructure is developed.

LULUCF (a net source worth 12% of 2023 inventory)

- Northern Ireland is a net source of GHG emissions from LULUCF activities throughout the timeseries. The main contributors to the LULUCF inventory are emissions from settlements, peatlands, and croplands, partly offset by removals from forest land (principally forest land remaining forest land) and grasslands (either converted to or remaining grassland).

Industry (6% of 2023 inventory)

- Emissions associated to industry have declined by 66% between the base year and 2023, representing 26% of Northern Ireland's overall trend over this period. This reflects reductions in emissions from the cement industry, chemical industry, food and drink industries, and the cessation of nitric acid production since 1990.

Waste (4% of 2023 inventory)

- Waste sector emissions have shown a significant decline of 61% in total for the sector and by 69% for landfill emissions between the base year and 2023. Reductions in landfill emissions account for 15% of the total decline in Northern Ireland emissions between the base year and

[25] Note that this summary does not include commentary on other transport and public sector combustion emissions, and so the sum of percentages does not equal 100%. Emissions from international bunkers are excluded from all figures from this section.

2023. These reductions are largely due to the progressive introduction of methane capture and oxidation systems within landfill management.

Fuel supply (0.02% of 2023 inventory)

- Northern Ireland has a much lower contribution from this sector than the UK average because, unlike the other DAs, Northern Ireland does not have any refineries, oil, and gas terminals or coal mining.
- A gas distribution system was introduced in Northern Ireland in 1996. The emissions from fuel supply are related to gas leakage from the distribution system.

5.2 RECENT TRENDS

Emissions between 2022 and 2023 decreased by 7% in Northern Ireland and have decreased by 13% since 2018. Factors influencing the trend are outlined below:

- Emissions from the buildings and product uses sector have decreased by 12% since 2022, likely due to the decreased gas demand in residential buildings. Since 2018, emissions from the buildings and product uses sector have decreased by 29%. This has been attributed to improvements in energy efficiency of dwellings.
- Emissions from power stations between 2022 and 2023 have decreased by 29%, accounting for 38% of the Northern Ireland trend. This is due to a decrease in coal-fired power generation in Northern Ireland. This decrease is primarily due to the closure of Kilroot Power Station's coal-fired units in September 2023, as part of Northern Ireland's transition away from coal and toward cleaner energy sources like natural gas.
- Emissions from agricultural and forestry mobile machinery have decreased by 2% between 2022 and 2023. This may be following the recorded rise in emissions due to favourable growing conditions for cereals and other crop products in 2021.
- Emissions from domestic transport dropped by only 0.3% between 2022 and 2023. In comparison, the trend observed between 2020 and 2021 was a 9% rise in transport emissions due to the lifting of travel restrictions that were imposed during the COVID-19 pandemic. This slowing trend is observed across all vehicle types, but particularly passenger cars which almost no change in 2022 to 2023, compared to the 9% rise between 2020 and 2021. Since 2018, domestic transport emissions have declined by 13%. As with other DAs, this trend is driven by reductions in fuel consumption as reported by DUKES from the road transport sector.

5.3 UNCERTAINTY

Northern Ireland uncertainty in 2023 for all GHGs (±6%): The Northern Ireland inventory has a high overall uncertainty due to a relatively low contribution to the emissions total from carbon dioxide; the carbon dioxide inventory is also more uncertain than for other DAs due to a greater contribution from LULUCF sources and higher uncertainty in fuel activity data, due to the greater use of solid fuels and oils in Northern Ireland. Of all the DAs, Northern Ireland has a relatively high contribution to its overall GHG total from methane and nitrous oxide, with high emissions from sources where EFs are subject to considerable uncertainty.

5.4 RECALCULATIONS

For 1990-2022 the recalculations are all downwards compared to the previous inventory and are between -3.8% and -8.3%. The largest changes occur in the years 1990 (-8.3%) and 2022 (-8.0%).

Further detail on major DA level recalculations can be found in **Appendix 2**, but for Northern Ireland include:

Agriculture

- Recalculation occurred due to recalculations to agricultural stationary combustion, related to improvement of burning oil distribution by DUKES

- For later years bottom-up recalculations and revisions to Defra agricultural statistics resulted in decreases to agricultural non-road mobile machinery (NRMM) emissions at a UK level.
- Incorporation of new agricultural offroad (i.e. non-road) fuel use mapping from 2005-2023, resulting in reallocations of data across all the DAs. For Northern Ireland this results in a decrease across the entire timeseries.
- Northern Ireland 2022 recalculations to 3D1a and 3D2ai, driven by the replacement of grass and arable fertiliser data not available in time for the previous inventory.
- Revisions to storage mitigation activity data for beef and dairy cattle in Northern Ireland across the whole timeseries
- A description of small DA specific recalculations in manure management (CRT Category 3B) and further detail of the agricultural offroad vehicles (CRT Category 1A4cii) recalculations can be found in **Appendix 2**.

Building and Product Uses

A significant proportion of the recalculations in this sector are driven by changes at a UK level due to an accumulation of:

- Recalculation to the base year as a result of an improvement to redistribute pre-1998 burning oil DUKES values using the 2016-2019 DUKES reported totals. This redistribution pre-1998 ensures greater consistency across the timeseries.
- Wood data is now used completely following a DUKES revision, animal biomass and plant data now reported separately.
- Waste is now split into renewable (biomass) and non-renewable (non-biomass) and municipal and non-municipal fractions.

Additionally, the incorporation of the 2022 Defra domestic burning survey and revision of historical assumptions led to a revision of the DomCom model, and new activity data for coffee logs.

There were DA level revisions to as an outcome of the Greenhouse Gas Inventory Improvement Programme (GHGIIP) as described in **Appendix 2.**

Domestic Transport

- There were revisions to the cold start methodology to apply EFs related to Euro 2 to 5 petrol vehicles, impacting non- carbon dioxide emissions resulting in recalculations in the road transport model within the UK inventory

Electricity Supply

- Improvements were made to separate drivers for power stations using wood and liquid biofuels
- For later years in the timeseries there are very minor recalculations to the Pollution Inventory.

Fuel Supply

- No recalculation

Industry

DA specific recalculations are described in detail in **Appendix 2** and include:

- Changes to the split between DAs due to revisions of the UK sub-national residual fuel dataset, driven by an improvement to the distribution of non-domestic energy use
- Mapping grid updates at the DA level for many of the 1A2 sectors (including Cement, Chemicals, Food and drink, Lime production, Other industrial combustion and Pulp, paper and print industries).

UK level recalculations to Industry include:

- For later years there are recalculations to the activity data and carbon balance for pig iron and sinter production, due to revisions to DUKES

- Revisions to NRMM estimates due to gas oil reconciliation improvements, leading to reallocating gas oil in the sector by DUKES. Additionally, bottom-up NRMM updates for forklifts and other industry NRMM use.

LULUCF

- Revisions to the forest land emissions across the timeseries due to a number of updates to the CARBINE model. Full descriptions of the updates and recalculations to the CARBINE model are outlined in **Appendix 2.0**
- For Northern Ireland, there were minor recalculations due to peatland restoration areas for 2020-2023 updated from DAERA.
- From 2020 forest to wetland data is now available for Northern Ireland following the peatlands update.
- Recalculations to harvested wood products (HWP) due to an update to the assumed HWP split effecting the whole timeseries. For Northern Ireland improved estimation of harvest intensity for private forests.

Waste

- The recalculations to the Waste sector are due to changes to landfill emissions at a UK level. An emission factor revision for the decay reaction in MELmod, specifically applying a default 6-month delay time in line with the IPCC 2006 Guidelines, resulted in decreased emissions earlier in the timeseries and increased emissions in later years
- In 2021 there were revisions to Northern Ireland waste data interrogator equivalent.

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APPENDIX 1. DA GHG BY-SOURCE INVENTORY COMPILATION METHODS

INTRODUCTION

The UK GHGI compiles national estimates of GHG emissions for submission to the UNFCCC under the requirements of the Paris Agreement. The UK inventory is published annually in April. This report presents separate inventories of GHG emissions for England, Scotland, Wales and Northern Ireland, and are consistent with the UK GHGI.

The seven direct GHGs are considered:

- Carbon dioxide (CO_2);
- Methane (CH_4);
- Nitrous oxide (N_2O);
- Hydrofluorocarbons (HFCs);
- Perfluorocarbons (PFCs);
- Sulphur hexafluoride (SF_6); and
- Nitrogen trifluoride (NF_3)

By source inventories allocate GHG emissions in the country that they are emitted, regardless of the end use of any fuel output or product that creates the demand for the emitting activity. The by source estimates for each DA include emissions from fuel combustion (Energy), industrial processes and product use (IPPU), agricultural practices (Agriculture), Land Use, Land Use Change and Forestry (LULUCF) and waste disposal (Waste). It should be noted that national totals for DAs exclude emissions from international aviation and shipping (which are presented as memo items) within the GHGI, but this report includes these memo items for Scotland and Wales, unless otherwise stated. Additionally, carbon dioxide from the burning of biofuels (which are considered to be renewable fuels from recently sequestered carbon) are also excluded, and emissions of GHGs from offshore oil and gas exploration and production are classified within this report as “Unallocated” emissions and are not attributed to any of the DAs.

REPORTING FORMAT

The DA GHG inventories are presented in Territorial Emission Statistics (TES) Sector reporting format to align with UK GHG reporting. Within the discussion of inventory compilation methodology, source data and trends, the CRT Category nomenclature is used, as this enables information to be presented at a much greater level of detail, aligned with specific emission sources.

The UK Inventory also reports emissions from international marine and aviation bunkers separately, as memo items to the main UK inventory dataset, in line with the reporting requirements of the UNFCCC. Therefore, the DA emission estimates for England and Northern Ireland for these international transport sources are not included within the DA totals in this report. They are presented for Scotland and Wales in accordance with their internal reporting requirements.

GENERAL APPROACH

The UK Inventory is based on UK statistics for activities producing GHG emissions. In principle, it would be ideal to obtain a complete set of equivalent statistics for each constituent country to compile each inventory. Such a set of statistics is not available for all sources and for all constituent countries and hence it is necessary to disaggregate UK emissions into the four constituent countries by an estimation procedure.

For most sources in the UK Inventory, the emission of a pollutant from a source is calculated from the general equation:

$$E = A \times EF \quad \text{[Equation 1]}$$

Where:

i. E = Emission of pollutant (tonnes)
ii. A = Activity (unit activity)
iii. EF = Emission Factor (tonnes pollutant/unit activity)

The activity unit may be fuel combustion (e.g. tonnes of gas oil), or production of product (e.g. tonnes of steel) or numbers of animals. A modified equation is used in the compilation of the DA GHG inventories:

$$E_i = \frac{d_i}{\sum_{i=1}^{5} d_i} \times (A \times EF) \quad \text{[Equation 2]}$$

Where:

i. E_i = Emission (in tonnes) from either England (1), Scotland (2), Wales (3), Northern Ireland (4) or "Unallocated" (5)
ii. d_i = A driver representing the contribution of the DA to UK emissions
iii. i = 1, 2, 3, 4, 5, where England = 1, Scotland = 2, Wales = 3, Northern Ireland = 4 and Unallocated = 5.

The driver, d_i can be any one of:

1. The value of the activity data for the DA. [For example, consumption of specific fuels or industrial production figures for the region.];
2. The fraction of the UK activity in the DA;
3. The value of a surrogate activity data statistic in the DA. Where the required activity is unavailable on a DA basis, a surrogate value may be used. [For example, employment statistics or manufacturing output of a specific product, used as a surrogate for consumption data of a given fuel.]; and
4. In cases where the emissions are derived from a complex model, the driver will be the actual emission for the DA calculated from the model.

The modified equation [2] ensures that the sum of the emissions from England, Scotland, Wales and Northern Ireland, plus any "unallocated" (i.e. offshore) emissions, equals the total UK emission reported within the national inventory.

Where the driver is fuel consumption, then the sum of the drivers should add up to the UK consumption. However, in practice this may not be the case if the data are taken from different sources or may be based on the financial rather than the calendar year. The estimation procedure removes such discrepancies.

Thus, the compilation of the GHG inventories for the constituent countries of the UK reduces to the estimation of a set of drivers, each appropriate to emissions from a specific source. In compiling the DA inventories, over 300 drivers have been calculated.

APPENDIX 2. METHOD CHANGES AND RECALCULATIONS

In the derivation of the DA GHG inventories, there are recalculations to emission estimates for a range of reasons. Where there are updates to methods, input data and/or assumptions in the UK GHGI, then these impacts flow down to the DA estimates also, and for further insight into the UK GHGI recalculations, please see Chapter 10 of the latest UK NID, at:

https://naei.energysecurity.gov.uk/reports/uk-greenhouse-gas-inventory-1990-2023-annual-report-submission-under-framework-convention

Where these recalculations have had a notable impact on the DA inventories totals, these are highlighted within the DA chapter text in this report and summarised in the accompanying MS Excel 'Greenhouse Gas Inventories for England, Scotland, Wales & Northern Ireland: 1990-2023'. Further detail is also available in the statistical release accompanying the UK inventory dataset, at:

https://assets.publishing.service.gov.uk/media/67a30e4f7da1f1ac64e5feb1/2023-final-greenhouse-gas-emissions-statistical-release.pdf

In this appendix we summarise the changes to DA GHGI methods, input data or assumptions, e.g. where changes in data provision or assumptions applied to derive the DA shares of UK emissions totals led to recalculations in the 1990 to 2022 dataset.

ACTIVE DEEP COAL MINES METHANE EMISSIONS (CRT CATEGORY 1B1)

Following a consultation with Aberpergwm Colliery operators on the figures submitted in their pollution inventory, the values were determined to be valid and incorporated in the UK and DA GHGI.

Specifically, the reported pollution inventory data for 2021-23 relating to Aberpergwm (the largest currently operating coal mine) was used instead of extrapolating EFs from other coal mines that close some years ago. The reported data are based on recent measurements representative of this remaining active coal mine, making these data a much better estimate of emissions. For England, there was a minor recalculation from updated Coal Authority statistics data on deep mined coal production.

Table 4 - Changes to emissions estimates from CRT Category 1B1 (Fugitive emissions from solid fuels) for each region in $ktCO_2e$

Region	Previous submission		Current submission	
	Base year	2022	Base year	2022
England	22,642	135	22,642	198
Scotland	890	73	890	73
Wales	2,613	286	2,613	572
Northern Ireland	-	0.1	-	0.1

MANUFACTURING INDUSTRIES AND CONSTRUCTION (CRT CATEGORY 1A2)

In the 1990-2023 DA GHGI, there have been revisions to several inputs to the DA level compilation of manufacturing industries and construction (CRT Category 1A2).

There has been a revision to the distribution of non-domestic energy use in the UK sub-national residual fuel dataset. Energy Performance Certificates (EPCs) and Display Energy Certificates (DECs) have been incorporated into the methodology to provide a better indication of where oil and solid fuels are used. Their distribution was previously based on assumptions regarding geographical constraints of oil and solid fuel use such as solid fuel use only being allocated outside of smoke control areas (SCAs). Overall, there have been shifts between DAs of commercial coal, manufactured solid fuels and petroleum distributions in the non-domestic sectors.

There have also been revisions to multiple mapping grids used in the DA level compilation such as fuel oil, gas oil, gas and solid fuel use (where applicable) in the Cement, Chemicals, Food and drink, Lime

production, Other industrial combustion and Pulp, paper and print industries. Mapping grids are estimated using the Employment Based Mapping approach outlined in Employment based energy consumption in the UK.

Table 5 – Changes to emissions estimates from CRT Category 1A2 (Manufacturing Industries and Construction) for each region in $ktCO_2e$

Region	Previous submission		Current submission	
	Base year	2022	Base year	2022
England	57,079	27,646	58,436	25,660
Scotland	6,868	3,500	6,805	3,410
Wales	5,484	2,826	4,981	2,850
Northern Ireland	4,562	1,815	2,547	932

COMMERCIAL/INSTITUTIONAL FUEL COMBUSTION (CRT CATEGORY 1A4a)

There have been revisions to several mapping grids used in the DA level compilation of commercial/institutional fuel combustion. For example, as oil, gas and solid fuel in the Public sector combustion and Miscellaneous industrial/commercial combustion. Mapping grids are estimated using the Employment Based Mapping approach outlined in Employment based energy consumption in the UK.

There were also recalculations from improvement made under the GHGIIP Project 9 DA energy improvements as described below. Modelled estimated actual gas use estimates based on a heating degree day analysis were used for non-point sources in England, Scotland and Wales from 2005-2014 rather than extrapolated estimated actual gas use estimates.

Table 6 – Changes to emissions estimates from CRT Category 1A4a (Commercial/Institutional Fuel Combustion) in TES Sector Buildings and product uses for each region in $ktCO_2e$

Region	Previous submission		Current submission	
	Base year	2022	Base year	2022
England	22,308	17,423	23,736	18,365
Scotland	3,137	2,164	3,074	2,302
Wales	1,550	844	1,482	855
Northern Ireland	871	600	676	360

RESIDENTIAL FUEL COMBUSTION (CRT CATEGORY 1A4b)

Improvements were made under the GHGIIP Project 9 DA energy improvements as described below. Modelled estimated actual gas use estimates based on a heating degree day analysis were used in England, Scotland and Wales from 2005-2014 rather than extrapolated estimated actual gas use estimates.

Table 7 – Changes to emissions estimates from CRT Category 1A4b (Residential Fuel Combustion) for each region in $ktCO_2e$

Region	Previous submission		Current submission	
	Base year	2022	Base year	2022
England	63,380	45,696	63,553	45,855
Scotland	7,950	4,873	7,973	5,003

Region	Previous submission		Current submission	
Wales	4,982	3,023	5,006	2,824
Northern Ireland	3,707	2,522	3,731	2,368

AGRICULTURAL OFFROAD VEHICLES (CRT CATEGORY 1A4cii)

There have been DA level recalculations due to the incorporation of a new agricultural offroad fuel use mapping grid from 2005-2023. Pre-2005 values were also updated to use the 2005 mapping grid resulting in reallocations of data across all the DAs. This results in an increase in the proportion of agricultural offroad fuel use to England across the timeseries, a decrease for Scotland early in the timeseries and a slight increase throughout the rest of the timeseries, and a decrease for Wales and Northern Ireland across the entire timeseries. Mapping grids are estimated using the Employment Based Mapping approach outlined in Employment based energy consumption in the UK.

Table 8 – Changes to emissions estimates from CRT Category 1A4cii (Agricultural Offroad Vehicles) for each region in $ktCO_2e$

Region	Previous submission		Current submission	
	Base year	2022	Base year	2022
England	2,031	2,762	2,538	3,357
Scotland	613	853	459	680
Wales	419	578	256	244
Northern Ireland	380	541	174	165

IRON AND STEEL PRODUCTION (CRT CATEGORY 2C1)

There have been revisions to Iron and steel production (CRT Category 2C1) in 2021 and 2022 for Wales and England due to the re-introduction of previously missing data for a blast furnace site in Wales and two blast furnace sites in England. This impacts the driver and therefore the proportion of Iron and steel production emissions attributed to England, Scotland and Wales. The UK level recalculations due to DUKES revisions drive the overall increase in emissions in the Iron and steel production sector for the DAs.

Table 9 – Changes to emissions estimates from CRT Category 2C1 (Iron and Steel Production) for each region in $ktCO_2e$

Region	Previous submission		Current submission	
	Base year	2022	Base year	2022
England	12,953	3,977	12,962	4,365
Scotland	3,110	-	3,112	-
Wales	7,628	5,598	7,633	6,134
Northern Ireland	-	-	-	-

REFRIGERATION AND AIR CONDITIONING (CRT CATEGORY 2F1)

Improvements were made under the GHGIIP Project 17 DA improvements for F-gas emissions as described in **GHGIIP Project 17: DA General Improvements**.

Table 10 – Changes to emissions estimates from CRT Category 2F1 (Refrigeration and Air Conditioning) for each region in $ktCO_2e$

Region	Previous submission		Current submission	
	Base year	2022	Base year	2022
England	61	4,784	61	4,732
Scotland	6	441	6	461
Wales	3	218	3	247
Northern Ireland	2	144	2	147

MANURE MANAGEMENT (CRT CATEGORY 3B)

There were updates to modelling assumptions for estimating emissions from spreading of organic manure to account for regulatory changes for Wales and Scotland. In Wales, a new policy was introduced in 2021 requiring the application of organic manure (slurry, digestate, and poultry manure) to bare soil or stubble to be incorporated within 24 hours, unless low emissions slurry spreading equipment (LESSE) has been used[26]. In Scotland, a new policy was introduced in 2023 requiring all liquid digestate, slurry applied by contractors or on large cattle and pig farms should be applied using LESSE[27].

In Northern Ireland, there was an update to the modelling assumptions for slurry storage in above ground tanks to account for regulatory changes requiring all new slurry stores from 2020 to be covered[28]. The update of covered stored dairy cow slurry in Northern Ireland results in proportionally larger recalculations to emissions from stored dairy cow slurry in Northern Ireland.

There are UK level recalculations to activity data (including amount of manure anaerobically digested, milk yield, slaughter weights) and the implementation of the IPCC 2019 Refinement N_2O emission factors for liquid/slurry from dairy cattle. These UK level changes drive the increase in DA level emissions.

For more detailed DA and UK level assumptions and recalculation reasons, please refer to the latest UK NID.

Table 11 – Changes to emissions estimates from CRT Category 3B (Manure Management) for each region in $ktCO_2e$

Region	Previous submission		Current submission	
	Base year	2022	Base year	2022
England	5,188	4,087	5,259	4,156
Scotland	993	860	998	869
Wales	725	757	735	770
Northern Ireland	751	995	758	1,007

[26] 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

[27] The Water Environment (Controlled Activities) (Scotland) Amendment Regulations 2021: https://www.legislation.gov.uk/ssi/2021/412/body/made#regulation-3-4-j

[28] The Nutrient Action Programme Regulations (Northern Ireland) 2019: https://www.daera-ni.gov.uk/articles/silage-slurry-and-agricultural-fueloil-ssafo-storage

LULUCF METHODOLOGICAL UPDATES (CRT CATEGORY 4)

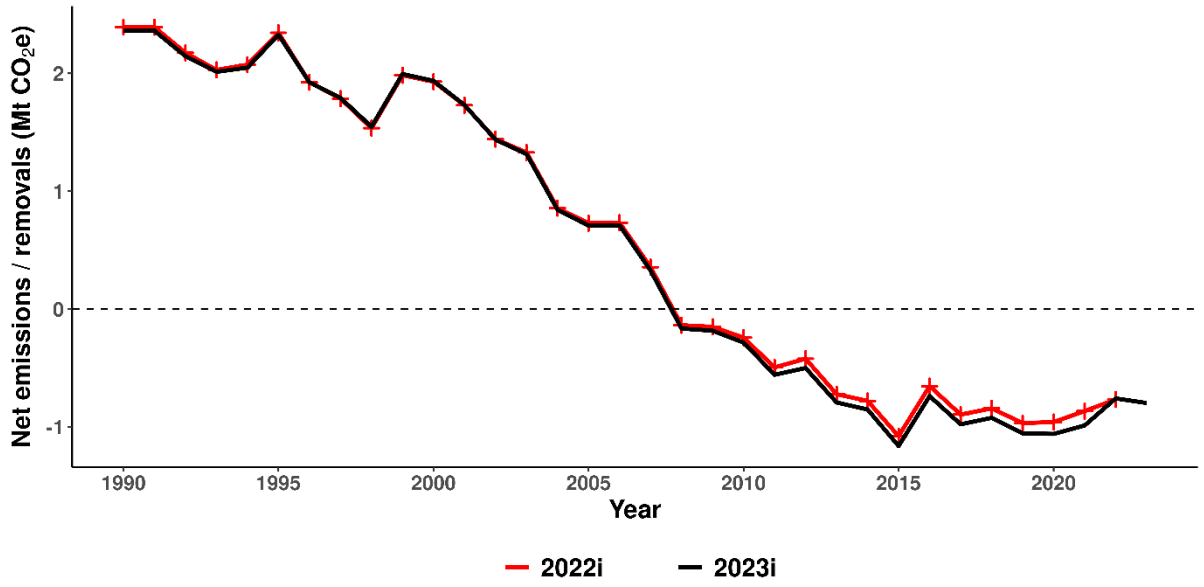
ENGLAND

LULUCF Sector Total

Recalculations to greenhouse gas net emissions / removals from the LULUCF sector - England

Revisions since the previous inventory resulted in a net decrease in total reported GHG emissions in 1990, and a net increase in the most recent comparable year 2022 (Figure 6). For 1990 there is a decrease in emissions of -0.032 $MtCO_2e$ (from 2.393 to 2.361 $MtCO_2e$), and for 2022 there is an increase of 0.027 $MtCO_2e$ (from -0.766 to -0.740 $MtCO_2e$).

Figure 6 – Net emissions/removals in Total LULUCF Sector $MtCO_2e$.



The most important changes and recalculations for England are outlined below. Note that the scales of the graphs vary. This should be borne in mind when assessing the impact of the recalculation on the LULUCF total.

Forestry

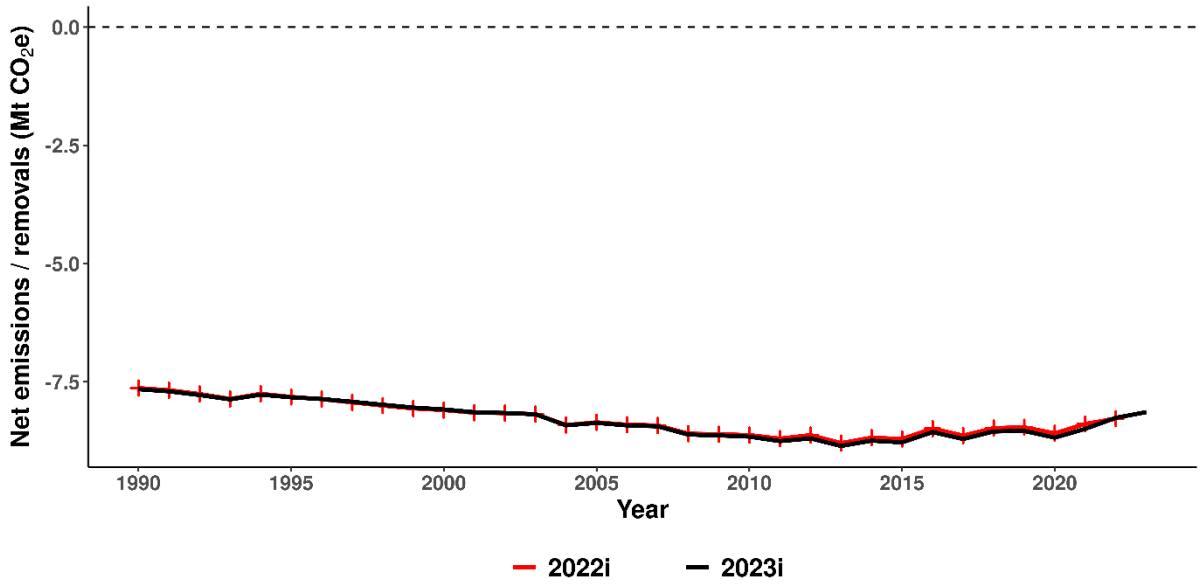
Small changes in the estimate of net removals from Forestry. There is an increase in net removals of -0.025 $MtCO_2e$ in 1990 (Figure 7) and a slight decrease in net removals in 2022 of 0.038 $MtCO_2e$. The changes are due to both model and activity data improvements, which include:

I. Updates to the CARBINE model including: improved early growth rate estimates, incorporation of carbon from branches on dead trees into soil, update of branch decay rate from 4% to 14% and fix of anaerobic conditions soil water availability modifier calculation in Scotia.

II. Minor updates to forest planting and deforestation data

III. Updates to HWP: estimate of sawmill input going to sawn wood improved, which also impacts proportions going to other products. This affects the whole timeseries due to overlap method used to ensure consistency.

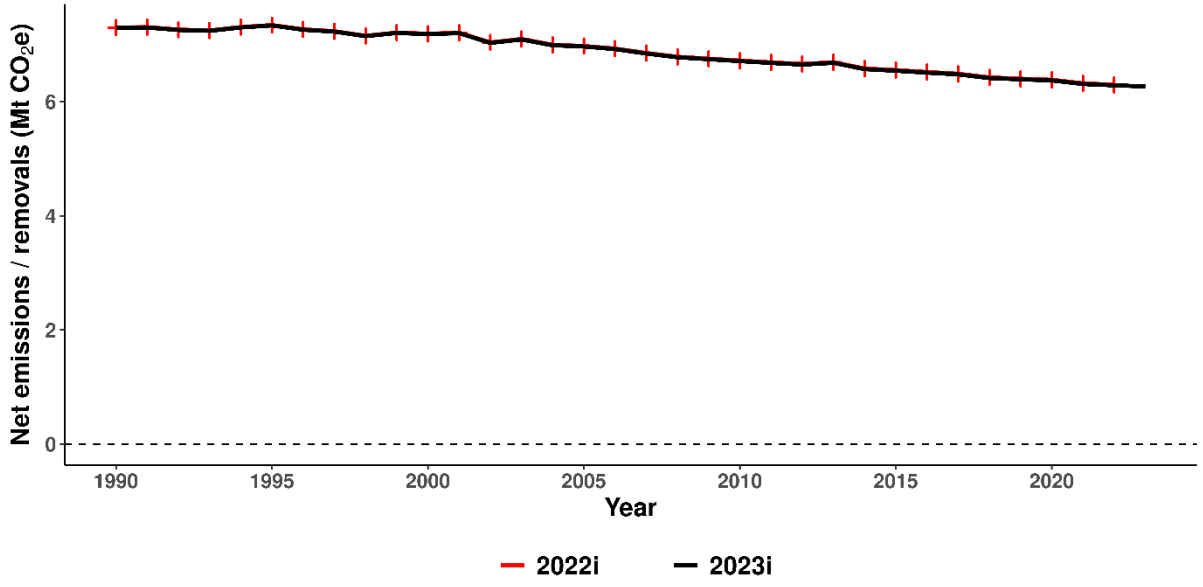
Figure 7 – Net emissions/removals within the Forestry category $MtCO_2e$.



Peatland

A small decrease in the estimate of net emissions from Peatland of -0.006 $MtCO_2e$ in 1990 and -0.01 $MtCO_2e$ in 2022 (Figure 8). This is due to minor updates to the deforestation activity data and splitting rewetted fen areas between grassland and wetland to ensure these areas end up in the right LULUCF categories after 20 years. This is the first year this split has been implemented.

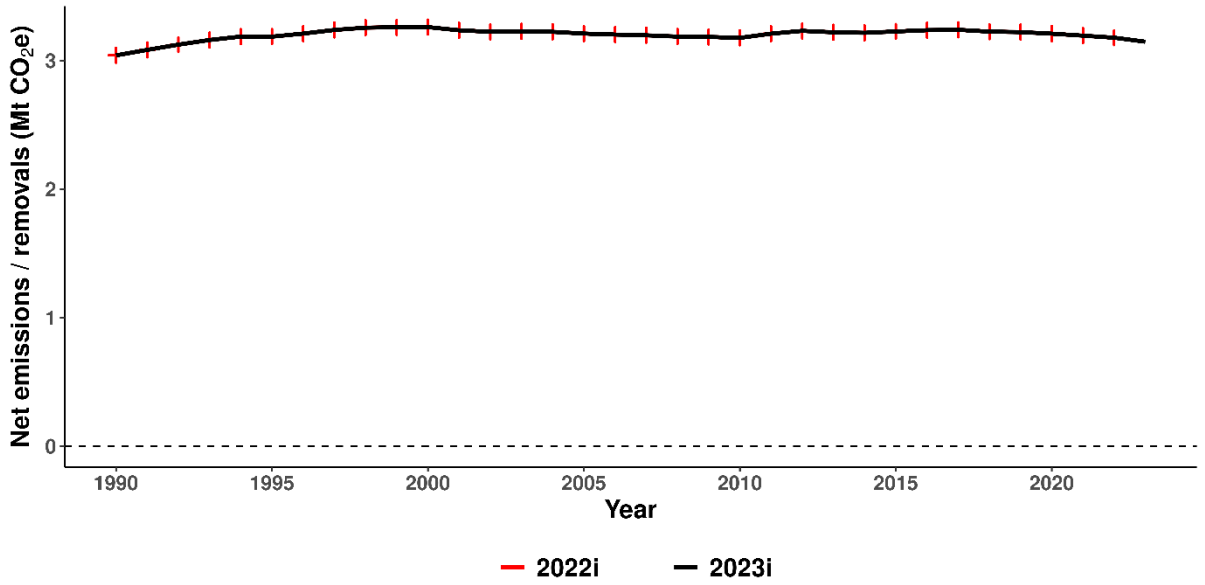
Figure 8 – Net emissions/removals within the Peatland category $MtCO_2e$.



Cropland Mineral Soils under LUC

There was no change to the estimates of net emissions from cropland mineral soils undergoing land use change.

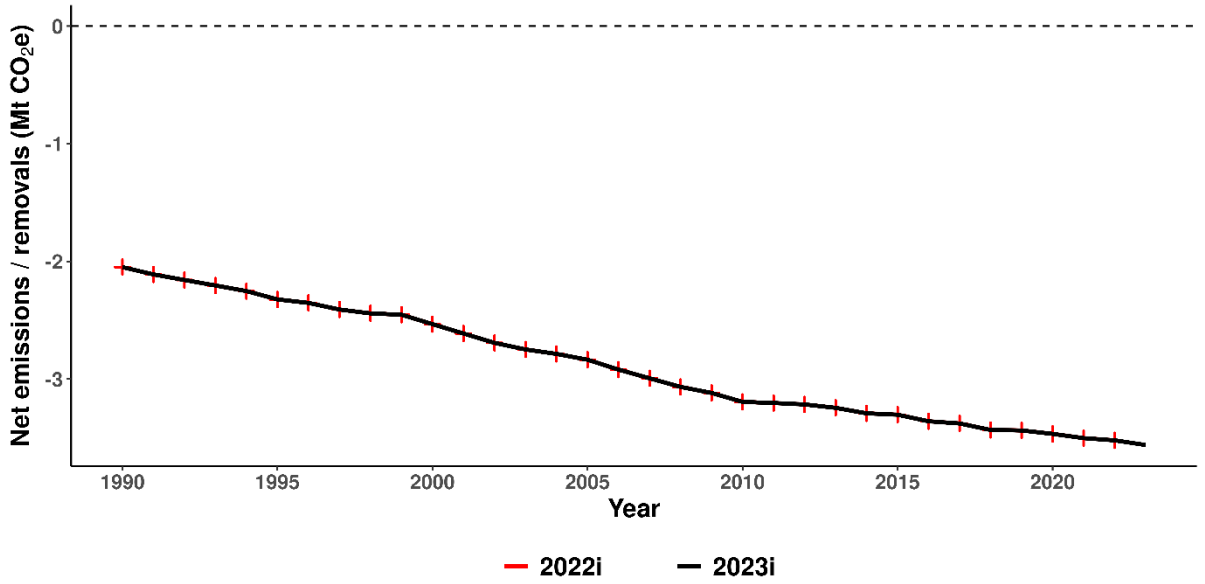
Figure 9 – Net emissions/removals within the Cropland mineral soil category. $MtCO_2e$.



Grassland Mineral Soils under LUC

There was no change to the estimates of net removals from grassland mineral soils undergoing land use change.

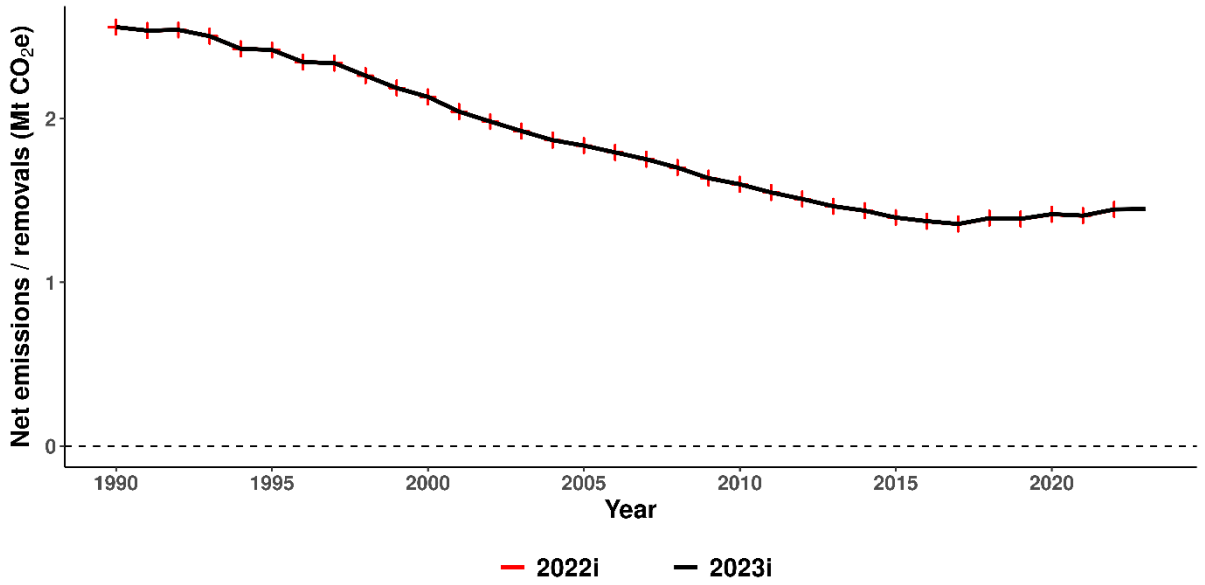
Figure 10 – Net emissions/removals within the Grassland category. $MtCO_2$



Settlement

There were no changes to the estimates of net emissions from settlement.

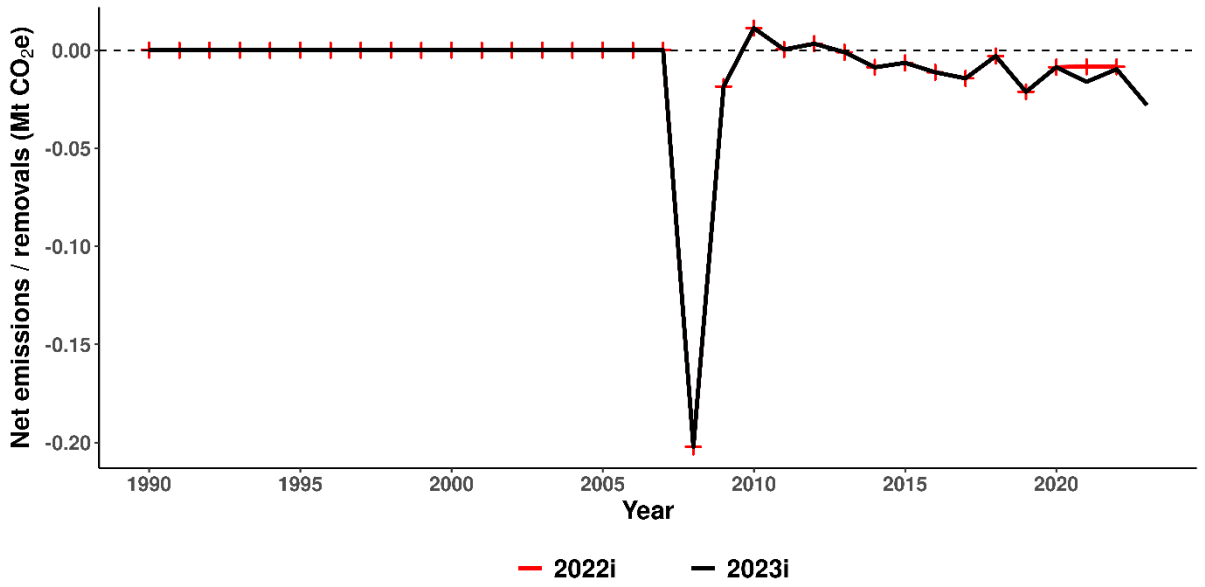
Figure 11 – Net emissions/removals within the Settlement category $MtCO_2e$.



Bioenergy

There were minor changes to the net emissions/removals from bioenergy at the end of the timeseries. This is due to new activity data becoming available where previously values had been rolled over from 2020. The difference in 2022 is -0.001 $MtCO_2e$.

Figure 12 – Net emissions/removals within the Bioenergy category $MtCO_2e$



Other LULUCF

There are insignificant changes in the other LULUCF category. Information of what is included in this category is provided in Annex 1.

Figure 13 – Net emissions/removals within the Other LULUCF category MtCO2e

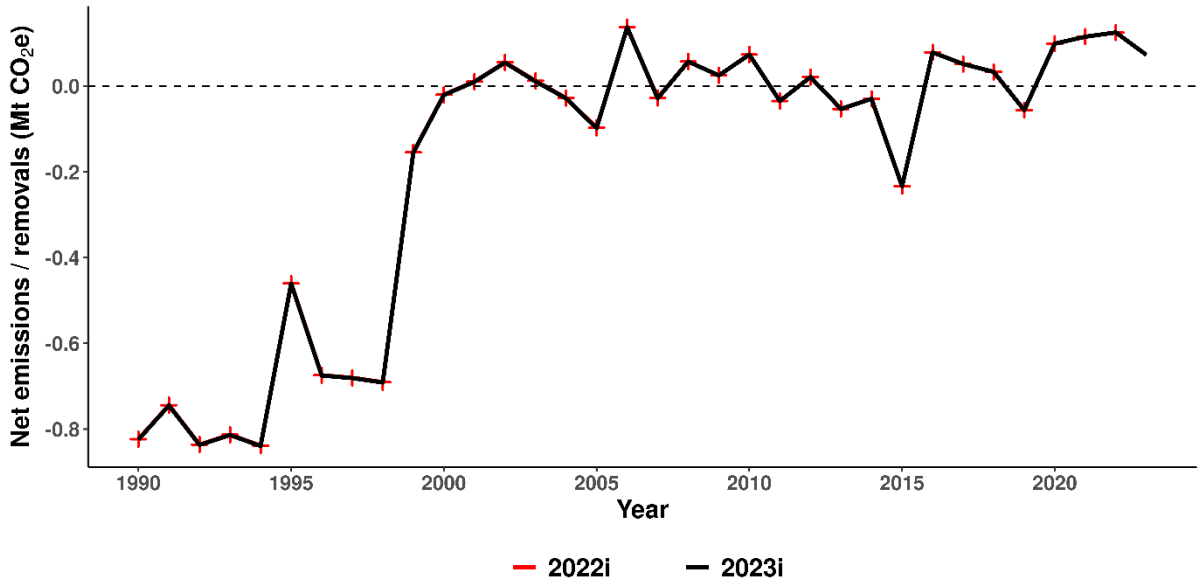


Table 12 – Changes to emissions estimates from LULUCF in England between the previous and current submissions presented in $MtCO_2e$

England LULUCF Inventory – Differences between the 1990-2022 (previous) and 1990-2023 (current) submissions							
Source category	Difference between previous and current submission 1990 $MtCO_2e$	Difference between previous and current submission 2022 $MtCO_2e$	Previous submission 1990 $MtCO_2e$	Current submission 1990 $MtCO_2e$	Previous submission 2022 $MtCO_2e$	Current submission 2022 $MtCO_2e$	**Comments**
Forestry	-0.025	0.038	-7.631	-7.657	-8.279	-8.241	Updates to the CARBINE model and use of latest Forestry Statistics activity data. Update to HWP input proportions.
Peatland	-0.006	-0.010	7.298	7.292	6.295	6.285	Minor updates to deforestation activity data and split of rewetted fen to grassland and wetland for the first time.
Cropland mineral soils under LUC	0.000	0.000	3.039	3.039	3.177	3.177	No change.
Grassland mineral soils under LUC	0.000	0.000	-2.049	-2.049	-3.521	-3.521	No change.
Settlement	0.000	0.000	2.559	2.559	1.445	1.445	No change.
Bioenergy crops	0.000	-0.001	0.000	0.000	-0.008	-0.010	Inclusion of new activity data at end of timeseries where previously data had been rolled over from the last available year.

England LULUCF Inventory – Differences between the 1990-2022 (previous) and 1990-2023 (current) submissions							
Other LULUCF	-0.001	0.000	-0.823	-0.824	0.125	0.125	Insignificant changes.

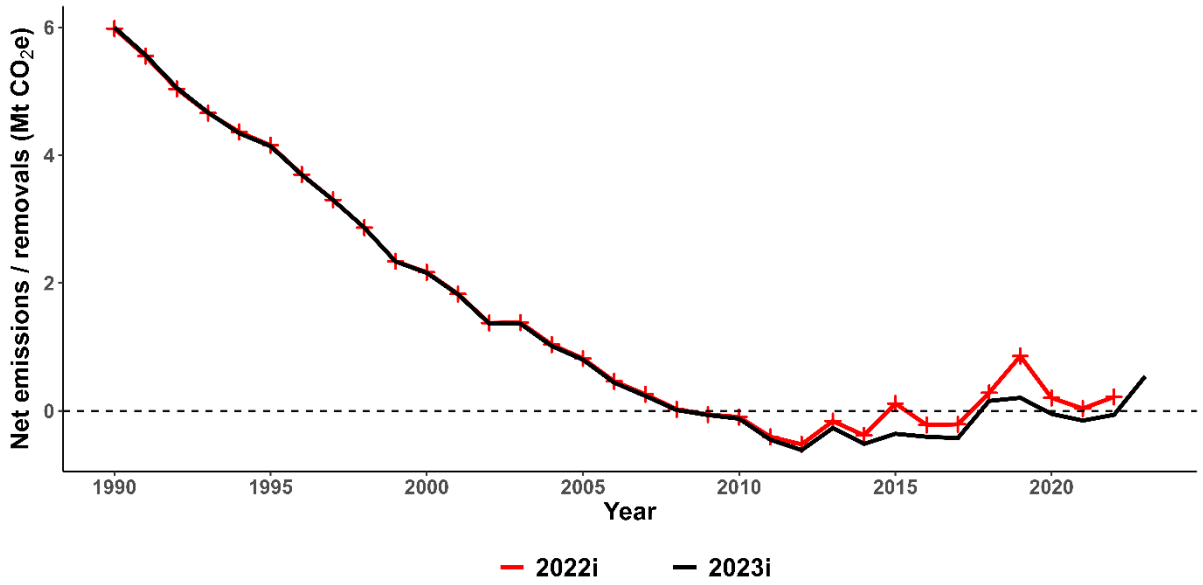
SCOTLAND

LULUCF Sector Total

Recalculations to greenhouse gas net emissions / removals from the LULUCF sector - Scotland

Revisions since the previous inventory resulted in a small net increase in total reported GHG emissions in Scotland in 1990, changing to a decrease for the most recent comparable year, 2022 (Figure 14). In 1990 there is an increase in emissions of 0.020 $MtCO_2e$ (from 5.980 to 6.000 $MtCO_2e$), and for 2022 there is a decrease in emissions of -0.281 $MtCO_2e$ (from 0.219 to -0.062 $MtCO_2e$).

Figure 14 – Net emissions/removals in Total LULUCF Sector $MtCO_2e$.



There have been several methodological changes contributing to these revisions. The most important changes and recalculations for Scotland are outlined below. Note that the scales of the graphs vary. This should be borne in mind when assessing the impact of the recalculation on the LULUCF total.

Forestry

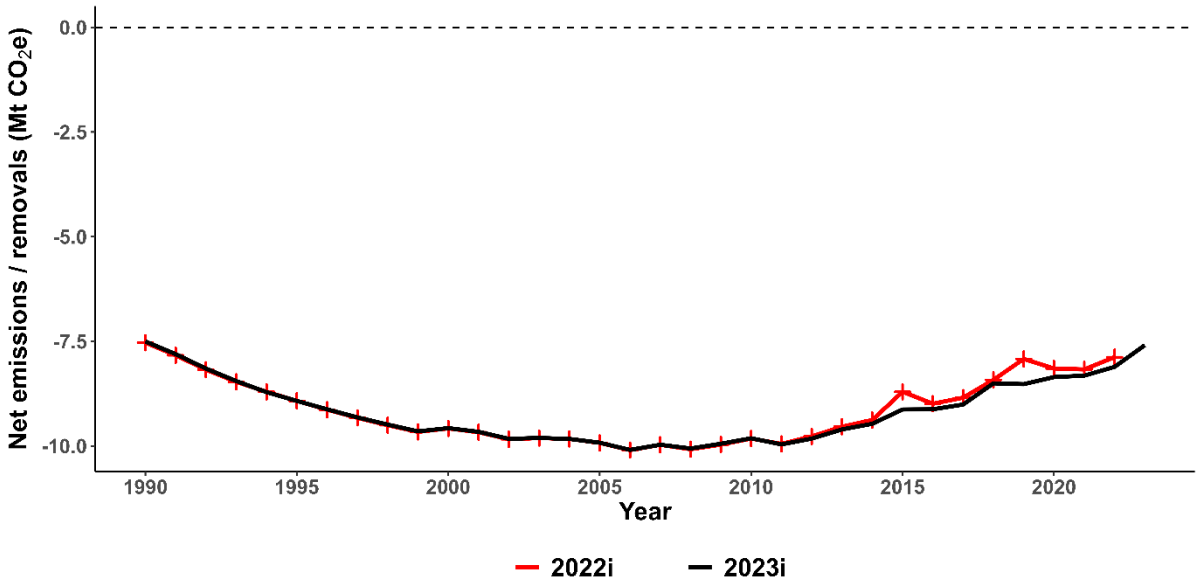
Changes in net removals from Forestry from a decrease in net removals in 1990 of 0.029 $MtCO_2e$ to an increase in net removals of -0.233 $MtCO_2e$ in 2022 (Figure 15). The changes are due to model and activity data improvements, which include:

I. Updates to the CARBINE model including: improved early growth rate estimates, incorporation of carbon from branches on dead trees into soil, update of branch decay rate from 4% to 14% and fix of anaerobic conditions soil water availability modifier calculation in Scotia.

II. Minor changes to forest planting and deforestation statistics over the timeseries. Significant updates to the forest to wetland deforestation areas from 2013 onwards.

III. Updates to HWP: estimate of sawmill input going to sawn wood improved, also affecting proportions going to other products. This affects the whole timeseries due to overlap method used to ensure consistency.

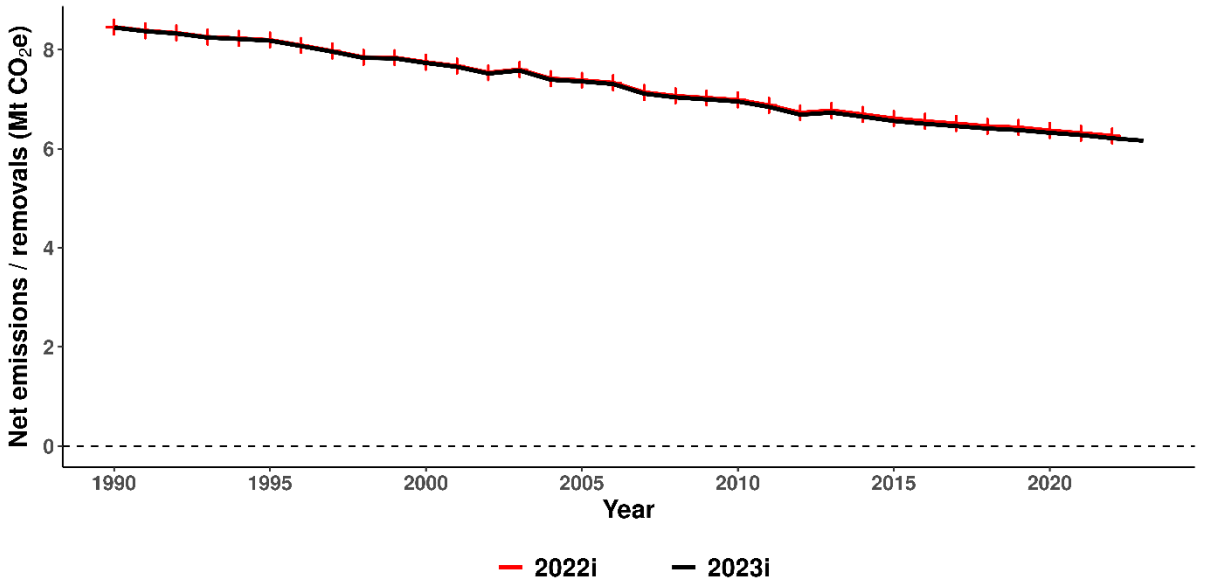
Figure 15 – Net emissions/removals within the Forestry category $MtCO_2e$.



Peatland

A decrease in the estimate of net emissions from Peatland of -0.001 $MtCO_2e$ in 1990 and -0.049 $MtCO_2e$ in 2022 (Figure 16). The changes are due to updated peatland restoration areas for 2013-2023 including changes in which year hectarage is reported due to overlapping projects. Additionally, the rewetted fen areas were split between grassland and wetland to ensure that these areas end up in the right LULUCF category after 20 years. This is the first year in which this split has been implemented.

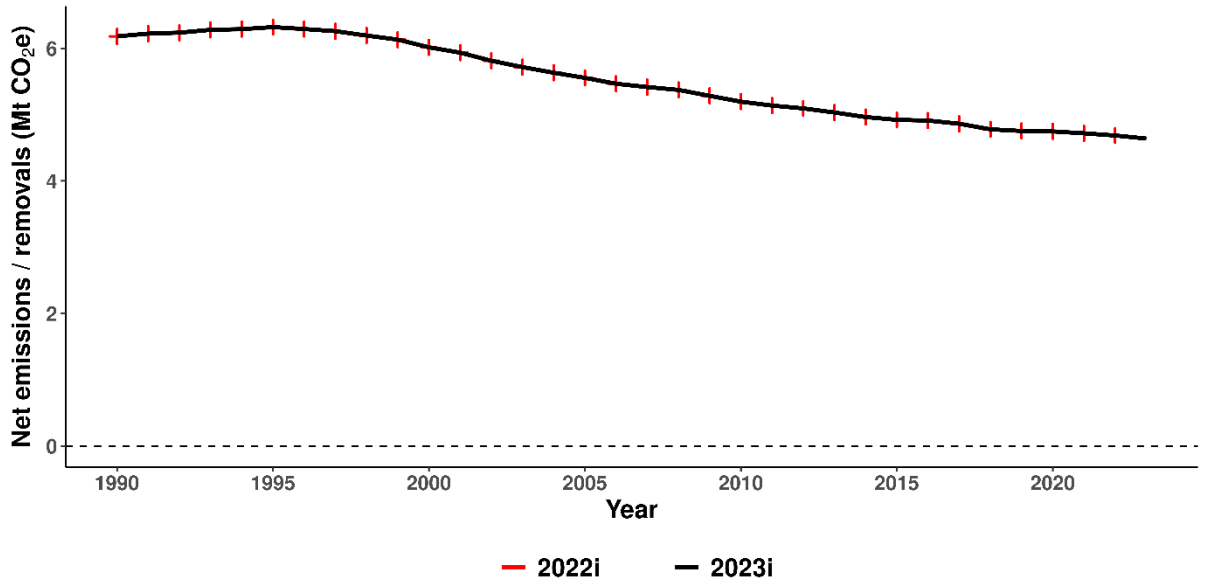
Figure 16 – Net emissions/removals within the Peatland category $MtCO_2e$.



Cropland Mineral Soils under LUC

There was no change to the estimates of net emissions from cropland mineral soils undergoing land use change.

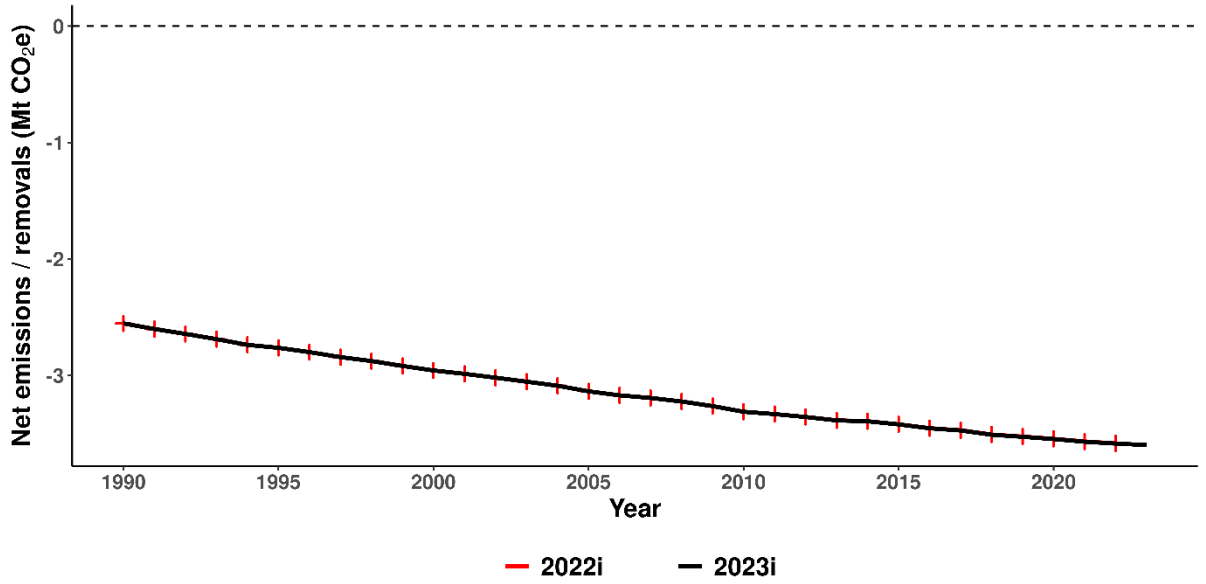
Figure 17 – Net emissions/removals within the Cropland mineral soil category $MtCO_2e$.



Grassland Mineral Soils Under LUC

There was no change to the estimates of net removals from grassland mineral soils undergoing land use change.

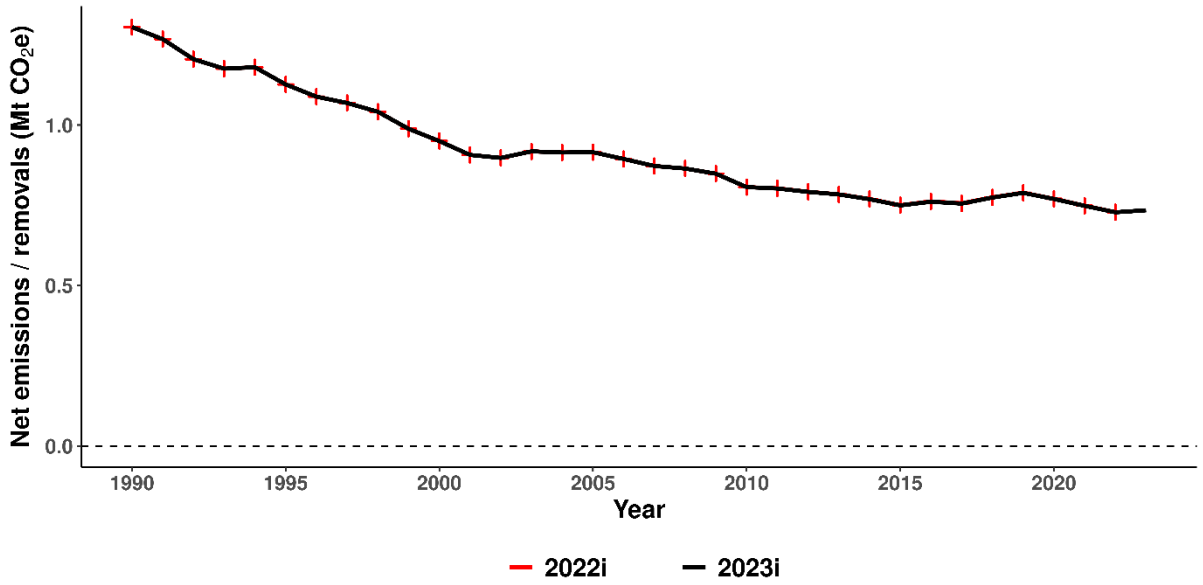
Figure 18 – Net emissions/removals within the Grassland mineral soil category $MtCO_2e$.



Settlement

There was no change to the estimates of net emissions from settlement.

Figure 19 – Net emissions/removals within the Settlement category. $MtCO_2e$.



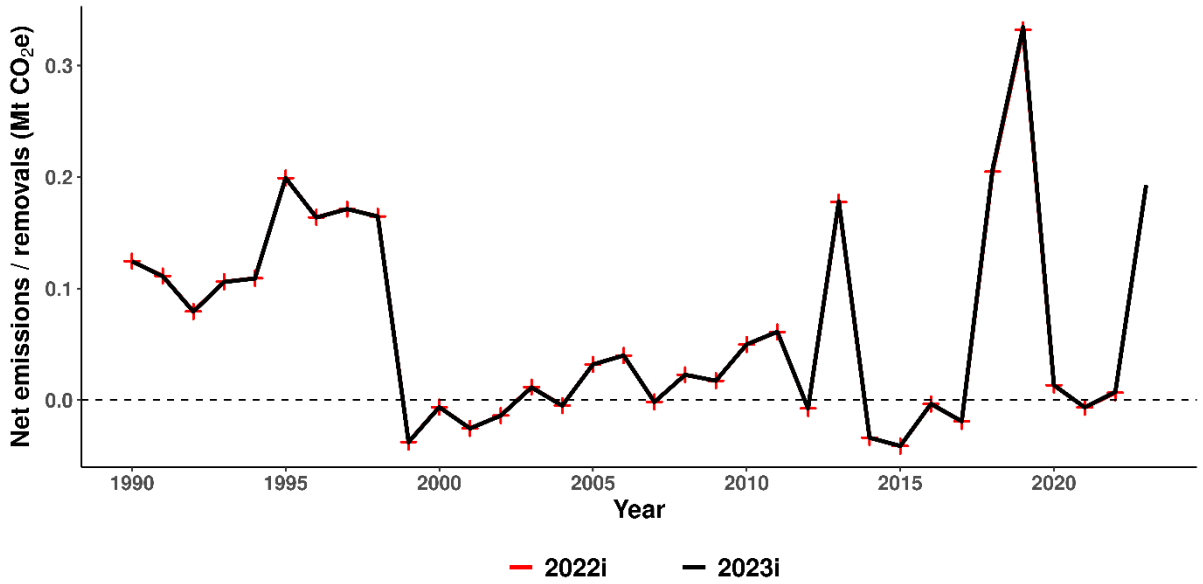
Bioenergy

There are zero emissions/removals in the bioenergy category for Scotland (activity data for areas of bioenergy crops are not available and are thought to be very small).

Other LULUCF

There are insignificant changes in the other LULUCF category. Information of what is included in this category is provided in Annex 1.

Figure 20 – Net emissions/removals within the Other LULUCF category $MtCO_2e$



Recalculations Overview

Table 13 – Changes to emissions estimates from LULUCF in Scotland between the previous and current submissions presented in $MtCO_2e$

Scotland LULUCF Inventory – Differences between the 1990-2022 (previous) and 1990-2023 (current) submissions							
Source category	Difference between previous and current submission 1990 $MtCO_2e$	Difference between previous and current submission 2022 $MtCO_2e$	Previous submission 1990 $MtCO_2e$	Current submission 1990 $MtCO_2e$	Previous submission 2022 $MtCO_2e$	Current submission 2022 $MtCO_2e$	**Comments**
Forestry	0.029	0.233	-7.532	-7.503	-7.878	-8.111	Updates to CARBINE. Updates to HWP input proportions. Minor updates to forest planting and deforestation activity data across the timeseries. Significant updates to deforestation to wetland activity data for 2013-2023.
Peatland	-0.009	-0.049	8.456	8.446	6.261	6.212	Updated peatland restoration data for 2013-2023. Split of rewetted fen to grassland and wetland for the first time.
Cropland mineral soils under LUC	0.000	0.000	6.181	6.181	4.685	4.685	No change.
Grassland mineral soils under LUC	0.000	0.000	-2.553	-2.553	-3.584	-3.584	No change.
Settlement	0.000	0.000	1.305	1.305	0.728	0.728	No change.
Bioenergy crops	0.000	0.000	0.000	0.000	0.000	0.000	Zero emissions / removals.
Other LULUCF	-0.000	0.001	0.124	0.124	0.006	0.007	Insignificant changes.

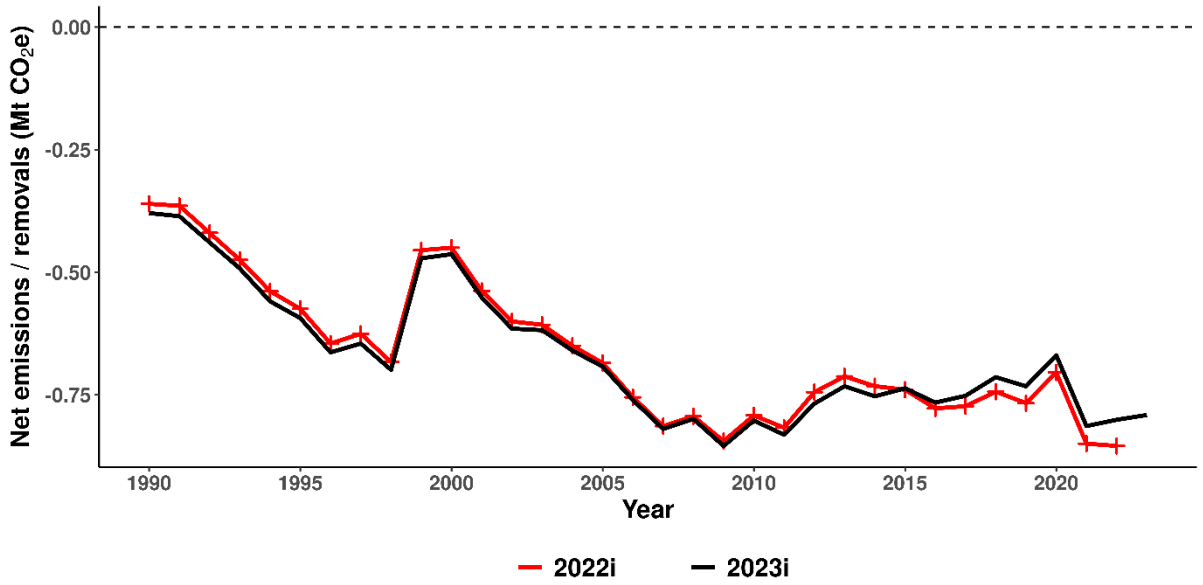
WALES

LULUCF Sector Total

Recalculations to greenhouse gas emissions from the LULUCF sector - Wales

The LULUCF sector is a net sink for Wales over the timeseries. Revisions since the previous inventory resulted in a net increase in total reported GHG removals from the LULUCF sector in Wales in 1990 changing to a net decrease in 2016, and remaining so until the end of the timeseries (Figure 21 – Net emissions/removals in Total LULUCF Sector MtCO2e.Figure 21). For 1990, net removals increase by -0.019 $MtCO_2e$ (from -0.360 to -0.379 $MtCO_2e$), and for the most recent comparable year 2022, net removals decrease by 0.053 $MtCO_2e$ (from -0.854 to -0.801 $MtCO_2e$).

Figure 21 – Net emissions/removals in Total LULUCF Sector $MtCO_2e$.



There have been several methodological changes contributing to these revisions. The most important changes and recalculations for Wales are outlined below. Note that the scales of the graphs vary. This should be borne in mind when assessing the impact of the recalculation on the LULUCF total.

Forestry

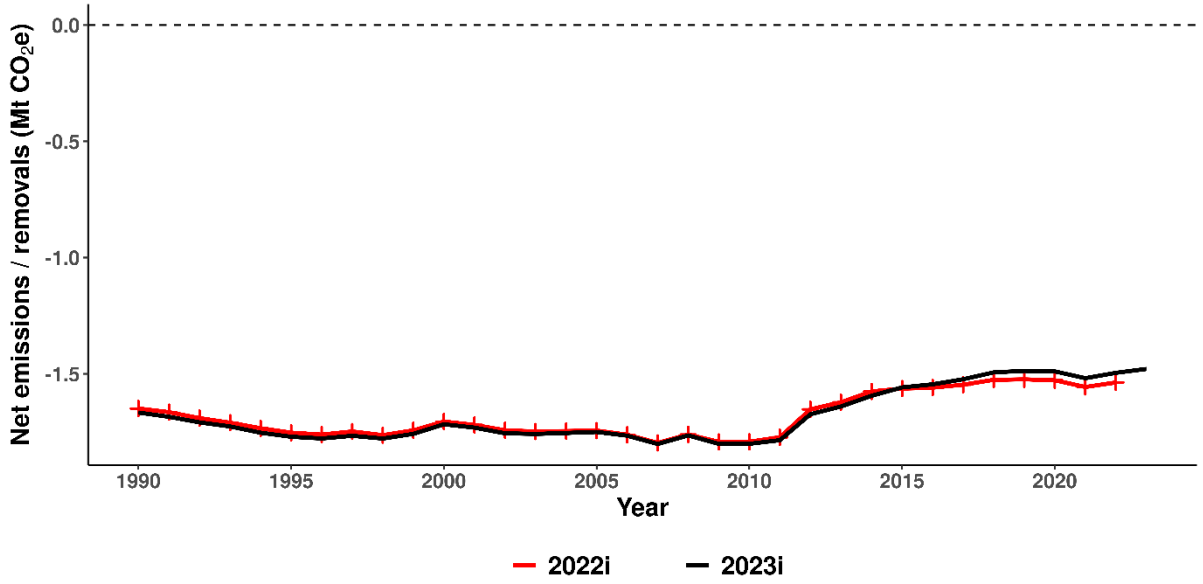
Changes in net removals from Forestry from an increase in net removals of -0.018 $MtCO_2e$ in 1990 to a decrease of 0.041 $MtCO_2e$ in 2022 (Figure 22). The changes are due to both model and activity data improvements, which include:

I. Updates to the CARBINE model including: improved early growth rate estimates, incorporation of carbon from branches on dead trees into soil, update of branch decay rate from 4% to 14% and fix of anaerobic conditions soil water availability modifier calculation in Scotia.

II. Minor changes to forest planting statistics.

III. Updates to HWP: estimate of sawmill input going to sawn wood improved, also affecting proportions going to other products. This affects the whole timeseries due to overlap method used to ensure consistency.

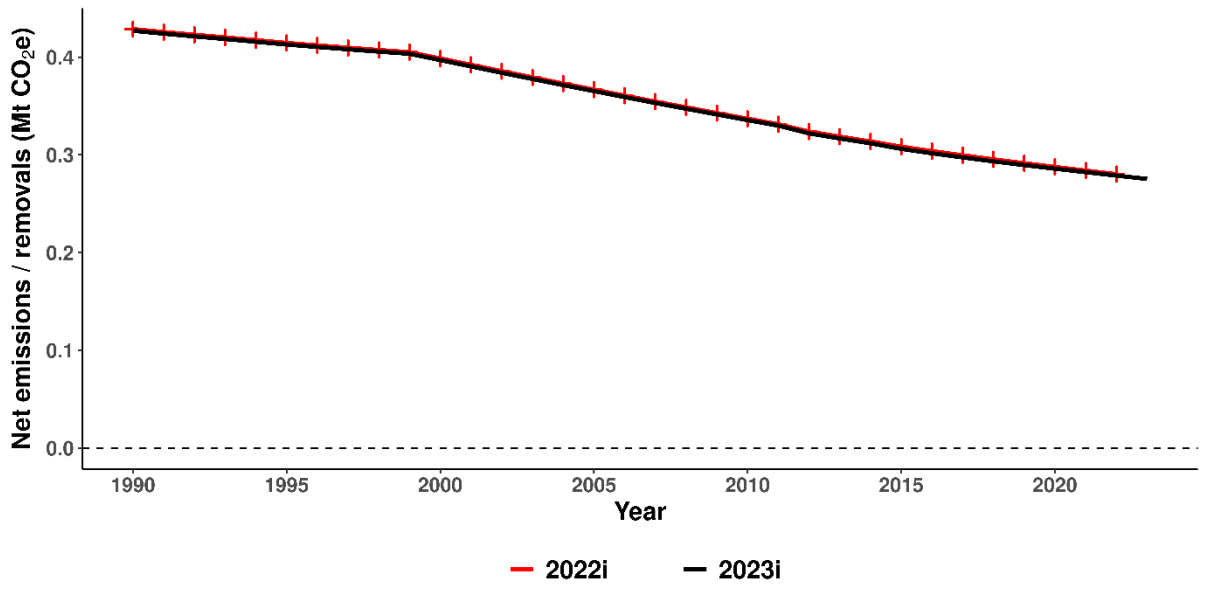
Figure 22 – Net emissions/removals within the Forestry category $MtCO_2e$.



Peatland

Minor changes in the estimate of net emissions from Peatland of -0.002 $MtCO_2e$ in 1990 and -0.001 $MtCO_2e$ in 2022 (Figure 23). This is due to minor changes in planting areas and splitting rewetted fen areas between grassland and wetland to ensure these areas end up in the right LULUCF categories after 20 years. This is the first year this split has been implemented.

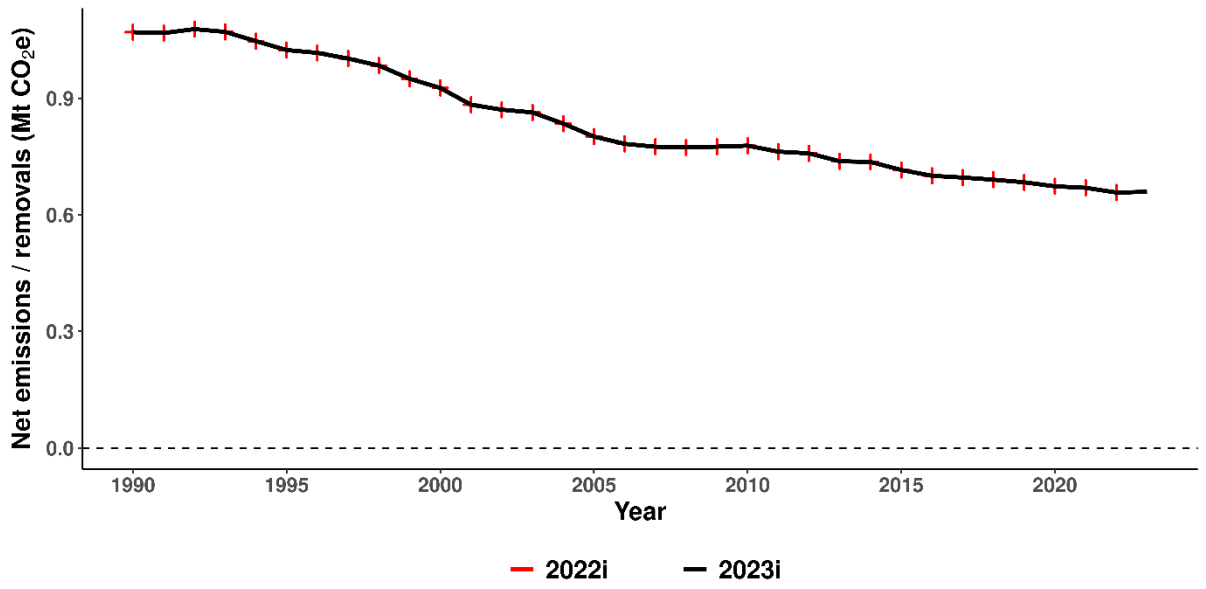
Figure 23 – Net emissions/removals within the Peatland category $MtCO_2e$.



Cropland Mineral Soils under LUC

There was no change to the estimates of net emissions from cropland mineral soils undergoing land use change.

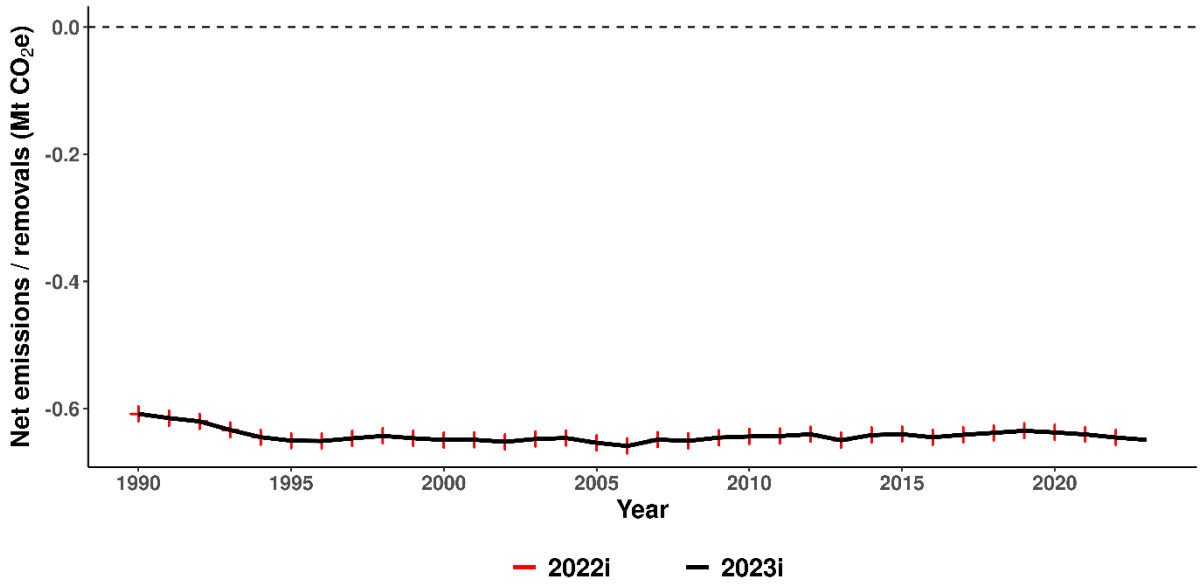
Figure 24 – Net emissions/removals within the Cropland category $MtCO_2e$.



Grassland Mineral Soils under LUC

There was no change to the estimates of net removals from grassland mineral soils undergoing land use change.

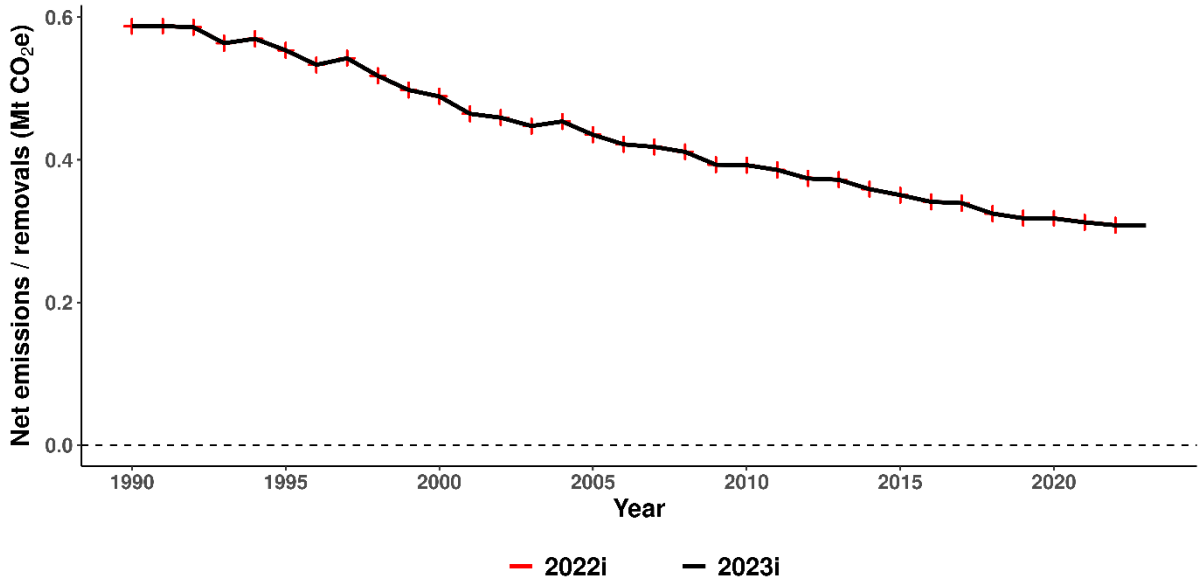
Figure 25 – Net emissions/removals within the Grassland mineral soils category $MtCO_2e$.



Settlement

There was no change to the estimates of net emissions from settlement.

Figure 26 – Net emissions/removals within the Settlement category $MtCO_2e$.



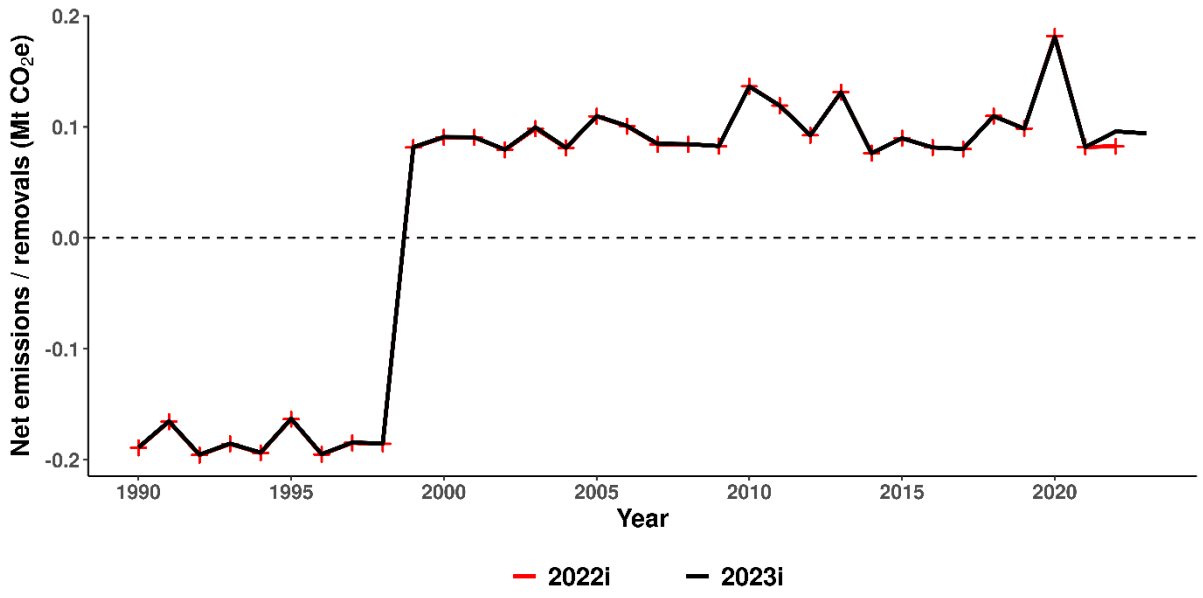
Bioenergy

There are zero emissions/removals in the bioenergy category for Wales (activity data for areas of bioenergy crops are not available and are thought to be very small).

Other LULUCF

Minor changes in the other LULUCF category at the end of the timeseries. There is an increase in net emissions of 0.013 $MtCO_2e$ in 2022. This is due to inclusion of a new year of wildfire activity data where previously this had been rolled over from the last available year. Detailed information of what is included in this category is provided in Annex 1.

Figure 27 – Net emissions/removals within the Other LULUCF category $MtCO_2e$.



Recalculations Overview

Table 14 – Changes to emissions estimates from LULUCF in Wales between the previous and current submissions presented in $MtCO_2e$

Wales LULUCF Inventory – Differences between the 1990-2022 (previous) and 1990-2023 (current) submissions							
Source category	Difference between previous and current submission 1990 $MtCO_2e$	Difference between previous and current submission 2022 $MtCO_2e$	Previous submission 1990 $MtCO_2e$	Current submission 1990 $MtCO_2e$	Previous submission 2022 $MtCO_2e$	Current submission 2022 $MtCO_2e$	**Comments**
Forestry	-0.018	0.041	-1.649	-1.667	-1.537	-1.497	Updates to CARBINE. Minor updates to forest planting and activity data. Updates to HWP input proportions.
Peatland	-0.002	-0.001	0.429	0.427	0.280	0.279	Splitting of rewetted fen areas between grassland and wetland for the first time.
Cropland mineral soils under LUC	0.000	0.000	1.070	1.070	0.658	0.658	No change.
Grassland mineral soils under LUC	0.000	0.000	-0.608	-0.608	-0.645	-0.645	No change.
Settlement	0.000	0.000	0.587	0.587	0.308	0.308	No change.

Wales LULUCF Inventory – Differences between the 1990-2022 (previous) and 1990-2023 (current) submissions							
Bioenergy crops	0.000	0.000	0.000	0.000	0.000	0.000	Zero emissions / removals.
Other LULUCF	0.000	0.013	-0.189	-0.189	0.083	0.096	Inclusion of new year of wildfire activity data where previously this has been rolled over from the latest available year.

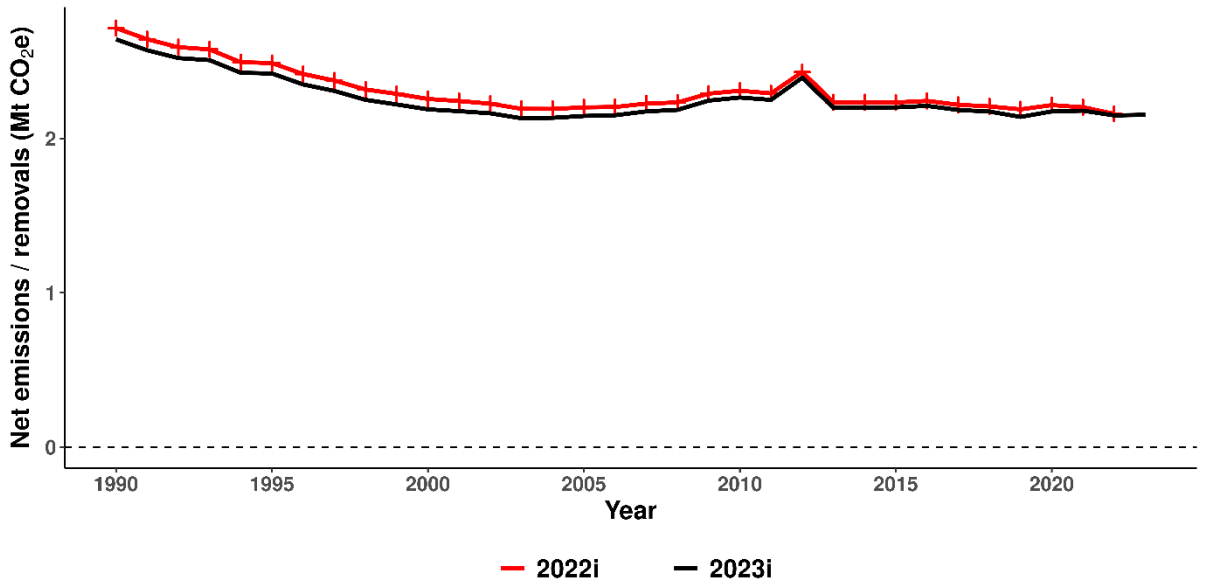
NORTHERN IRELAND

LULUCF Sector Total

Recalculations to greenhouse gas emissions from the LULUCF sector – Northern Ireland

Revisions since the previous inventory resulted in a decrease in reported GHG emissions from the LULUCF sector in Northern Ireland across the timeseries (Figure 28). For 1990 there is a decrease of -0.073 $MtCO_2e$ (from 2.715 to 2.643 $MtCO_2e$), and for the most recent comparable year, 2022, there is a decrease of -0.015 $MtCO_2e$ (from 2.160 to 2.145 $MtCO_2e$).

Figure 28 – Net emissions/removals in Total LULUCF Sector $MtCO_2e$.



There have been several methodological changes contributing to these revisions. The most important changes and recalculations for Northern Ireland are outlined below. Note that the scales of the graphs vary. This should be borne in mind when assessing the impact of the recalculation on the LULUCF total.

Forestry

An increase in net removals from Forestry of -0.081 $MtCO_2e$ in 1990 and -0.003 $MtCO_2e$ in 2022 (Figure 29). The changes are due to both model and activity data improvements, which include:

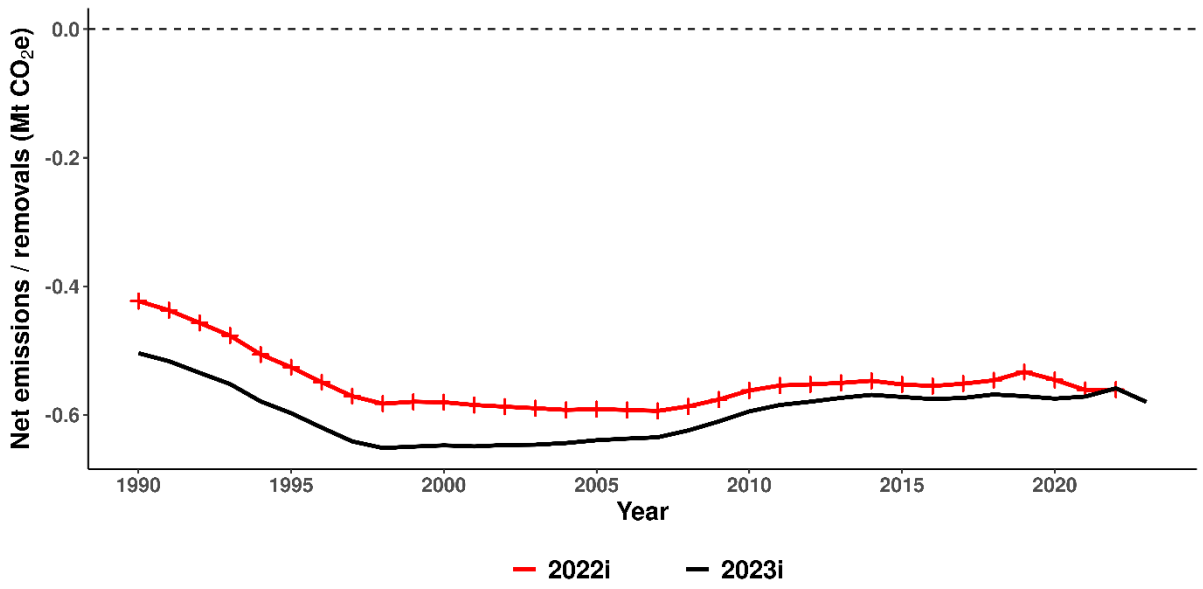
I. Updates to the CARBINE model including: improved early growth rate estimates, incorporation of carbon from branches on dead trees into soil, update of branch decay rate from 4% to 14% and fix of anaerobic conditions soil water availability modifier calculation in Scotia.

II. Fix to Northern Ireland reconcile process to improve estimation of harvest intensity for private forests.

III. Minor changes to forest planting statistics and updated deforestation areas based on new rewetting data.

IV. Updates to HWP: estimate of sawmill input going to sawn wood improved, also affecting proportions going to other products. This affects the whole timeseries due to overlap method used to ensure consistency.

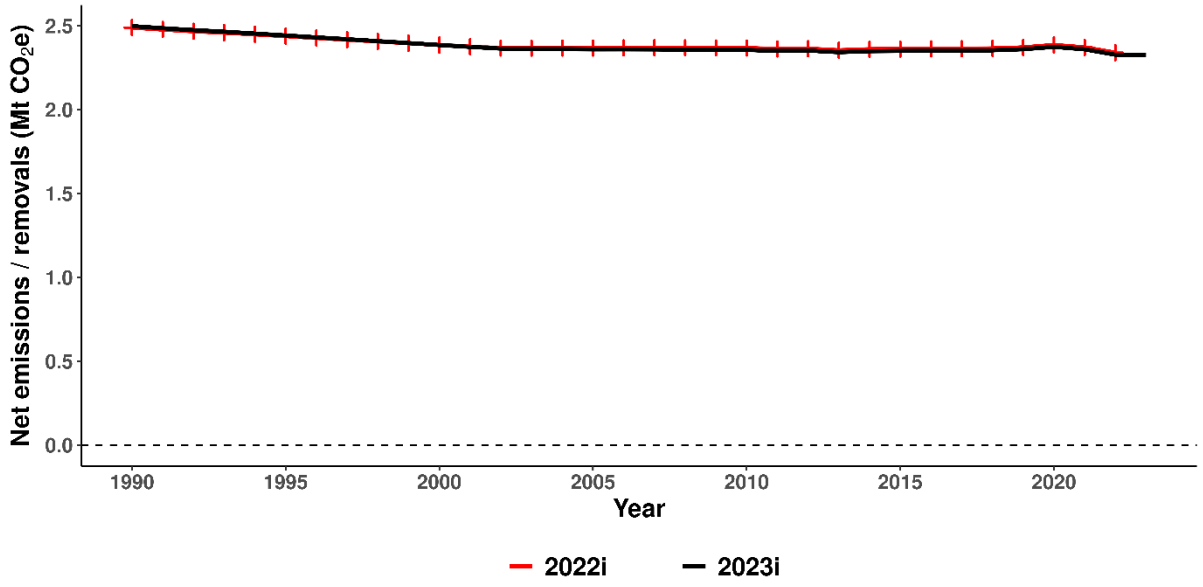
Figure 29 – Net emissions/removals within the Forestry category $MtCO_2e$.



Peatland

Changes in the estimate of net emissions from Peatland from an increase of 0.009 $MtCO_2e$ in 1990 to a decrease of -0.012 $MtCO_2e$ in 2022 (Figure 30). This is due to updates to deforestation data, including new forest to wetland areas from 2020. This is the first year that forest to wetland data has been available for Northern Ireland. Additionally, updated rewetted data has been included for Modified Bog from 2020, and rewetted fen has been split to grassland and wetland to ensure that these end up in the correct LULUCF categories after 20 years. This is the first year this split has been implemented.

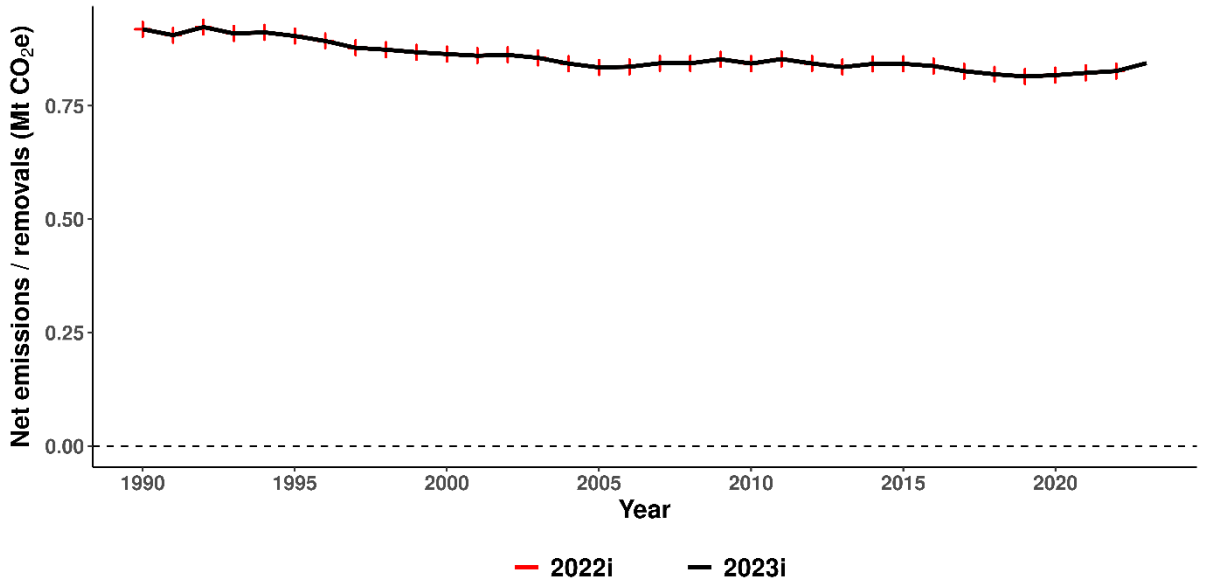
Figure 30 – Net emissions/removals within the Peatland category $MtCO_2e$



Cropland Mineral Soils under LUC

There was no change to the estimates of net emissions from cropland mineral soils undergoing land use change.

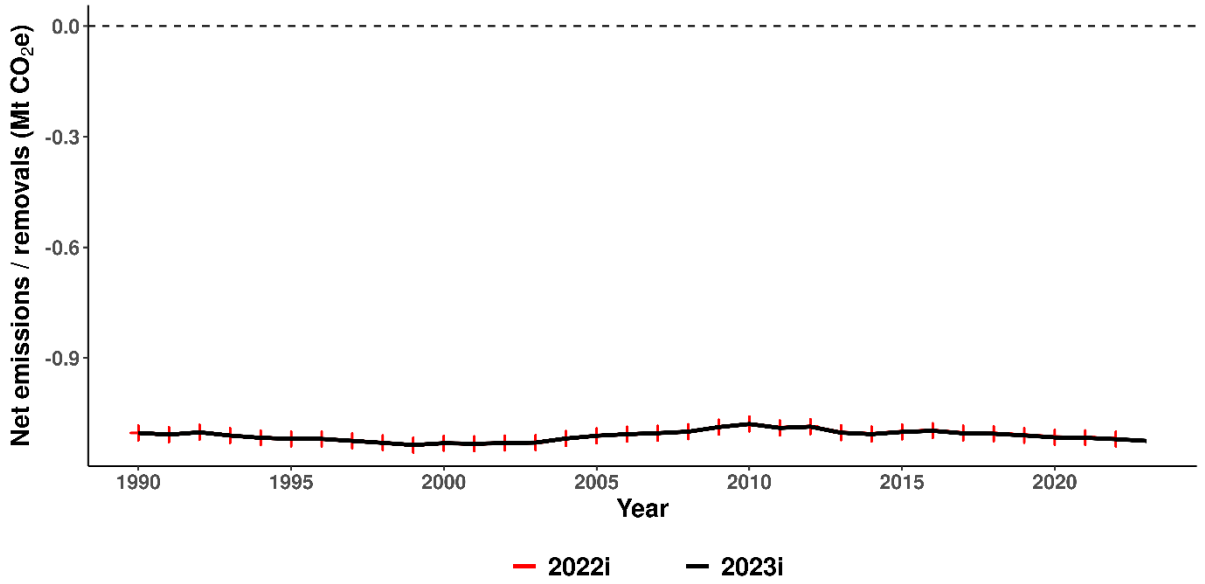
Figure 31 – Net emissions/removals within the Cropland mineral soils category $MtCO_2e$.



Grassland Mineral Soils under LUC

There was no change to the estimates of net removals from grassland mineral soils undergoing land use change.

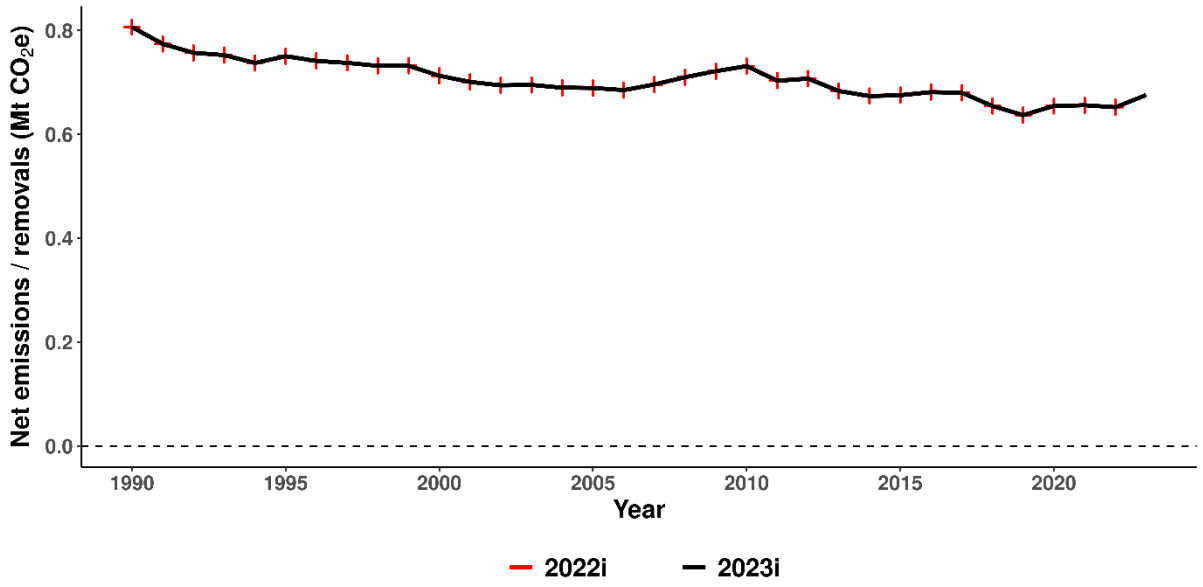
Figure 32 – Net emissions/removals within the Grassland mineral soils category $MtCO_2e$.



Settlement

There was no change to the estimates of net emissions from settlement.

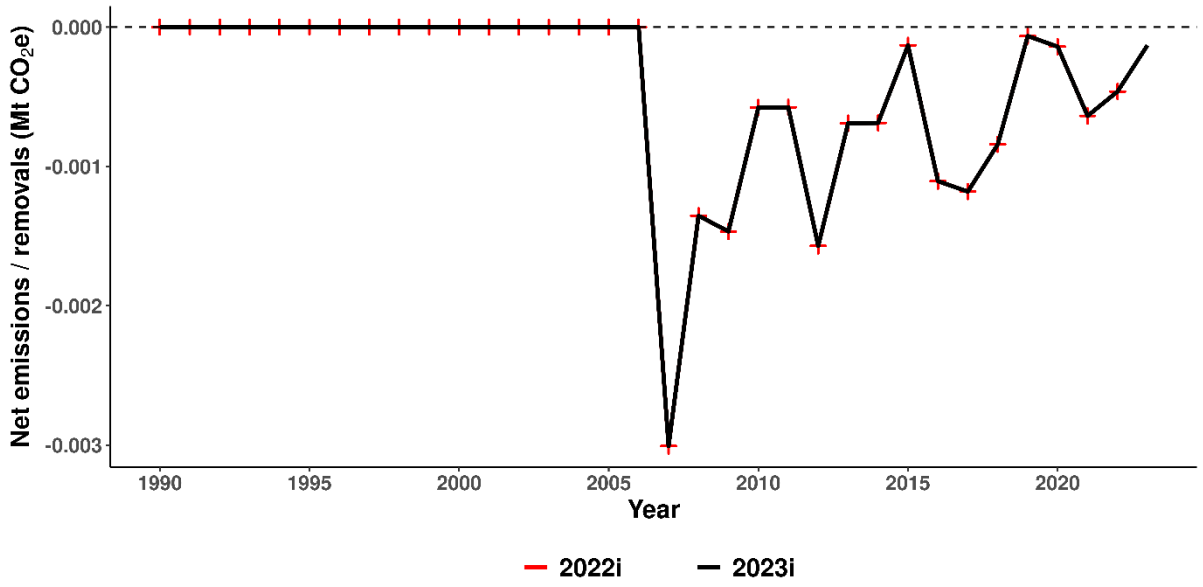
Figure 33 – Net emissions/removals within the Settlement category $MtCO_2e$.



Bioenergy

There were no changes to the net emissions/removals from bioenergy.

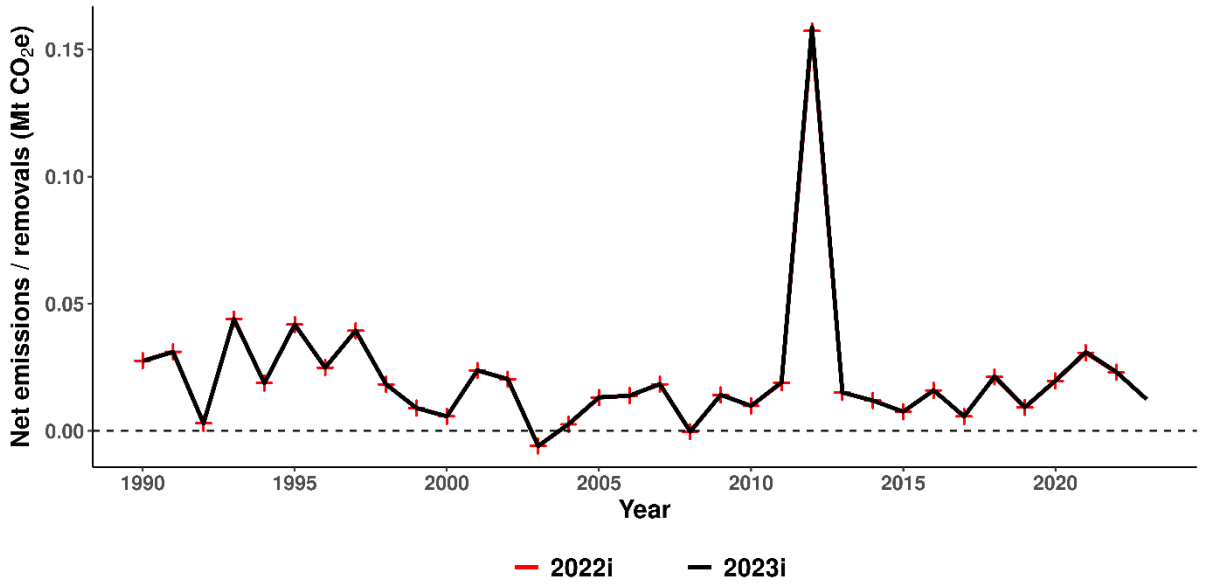
Figure 34 – Net emissions/removals within the Bioenergy category $MtCO_2e$



Other LULUCF

There were no changes in the other LULUCF category. Information of what is included in this category is provided in Annex 1.

Figure 35 – Net emissions/removals within the Other LULUCF category $MtCO_2e$.



6.1.1.1 Recalculations Overview

Table 15 – Changes to emissions estimates from LULUCF in Northern Ireland between the previous and current submissions presented in $MtCO_2e$

Northern Ireland LULUCF Inventory – Differences between the 1990-2022 (previous) and 1990-2023 (current) submissions							
Source category	Difference between previous and current submission 1990 MtCO2e	Difference between previous and current submission 2022 MtCO2e	Previous submission 1990 MtCO2e	Current submission 1990 MtCO2e	Previous submission 2022 MtCO2e	Current submission 2022 MtCO2e	**Comments**
Forestry	-0.081	-0.003	-0.423	-0.504	-0.561	-0.564	Updates to CARBINE. Minor updates to forest planting and updated deforestation activity data including forest to wetland areas for the first time. Improvements to the estimation of harvest intensity for private forests. Updates to HWP input proportions.
Peatland	0.009	-0.012	2.489	2.498	2.339	2.327	Inclusion of new rewetted peatland areas (including forest to wetland). Split of rewetted fen to grassland and wetland for the first time.
Cropland mineral soils under LUC	0.000	0.000	0.919	0.919	0.826	0.826	No change.
Grassland mineral soils under LUC	0.000	0.000	-1.104	-1.104	-1.120	-1.120	No change.
Settlement	0.000	0.000	0.807	0.807	0.652	0.652	No change.
Bioenergy crops	0.000	0.000	0.000	0.000	0.000	0.000	No change.
Other LULUCF	0.000	0.000	0.028	0.027	0.023	0.023	No change.

UK GREENHOUSE GAS INVENTORY IMPROVEMENT PROJECT CHANGES

Improvements to the DA inventories were identified under the DESNZ Greenhouse Gas Inventory Improvement Programme (GHGIIP). The aim of the GHGIIP is to maintain a scientifically robust UK National Atmospheric Emissions Inventory (NAEI) and to improve the transparency, accuracy, consistency, comparability, and completeness of the inventory.

GHGIIP Reports are available on the NAEI website:

https://naei.energysecurity.gov.uk/reports?title=&field_categories_target_id=13

GHGIIP Project 9: DAs Energy Balances

The DAs Specific Energy Balances project (Project 9) was an initiative under the GHGIIP. This project aimed to enhance the accuracy and granularity of energy data used in the DA GHG and air pollutant inventories of England, Scotland, Wales and Northern Ireland. One of the key outcomes from this project was the direct incorporation of the modelled estimated gas use data from 2005-2014 for England, Scotland and Wales.

The Regional and Local Authority gas consumption statistics[29] are available as “non-weather-corrected” (henceforth referred to as “estimated actual”) statistics from 2015 and as “weather corrected” statistics from 2005 for England, Scotland and Wales. In the inventory, actual gas use data provides better estimates of emissions as these reflect the actual amount of gas used. This improvement ensures better timeseries consistency between the 2005-2014 and 2015-2023 datasets.

To create modelled estimated gas use data for 2005-2014, a DA specific heating degree day analysis was used. For years where both estimated actual and weather corrected data were available (2015-2022), the DA weather correction factor was correlated with heating degree days. From this analysis, heating degree days for 2005-2014 were used to model the estimated actual gas use data by DA and by domestic and non-domestic sectors. This resulted in recalculations for England, Scotland and Wales in the commercial/ institutional fuel combustion (CRT Category 1A4a) and residential fuel combustion (CRT Category 1A4b) categories. Note that there were no recalculations to Northern Ireland driven by this improvement as the Northern Ireland gas use data continues to be obtained directly from suppliers.

GHGIIP Project 17: DA General Improvements

Following a consultation with DA inventory contacts, the use of DA-specific data within the inventory was identified as a key priority.

Under this project, a review was conducted of all drivers currently using Gross Domestic Product (GDP) to identify whether more sector-specific economic data can be used. Gross Value Added (GVA) is defined as the value generated by any unit engaged in the production of goods and services. GVA is used in the estimation of GDP, but it is estimated on a workplace basis, i.e. allocated to the location where the economic activity takes place. This is ideal for the DA inventories compiled as emissions allocated ‘By-source’. This improves the accuracy of the inventory, as currently GDP provides one aggregated number across all sectors. GVA is now used for the following sources:

- 1A1bi: Charcoal production
- 1A5b: Military Aircraft
- 2D3d: Non-Energy Petroleum Coke
- 2D1: Industrial engines (lubricants)
- 2F1e: Mobile air conditioning (MAC) systems in cars, vans and cabs
- 2F1c: Industrial Refrigeration
- 2F5: Precision Cleaning
- 2G2e: Tracer gas

A new driver was also developed for refrigerants in supermarkets, using the Inter-Departmental Business Register (IDBR) dataset to estimate the size of businesses using refrigerants. This impacts CRT category 2F1a Commercial Refrigeration.

[29] https://www.gov.uk/government/statistics/regional-and-local-authority-gas-consumption-statistics

In addition, the project reviewed all drivers where values had not changed across the last 10 years of the inventory timeseries, to review whether the constant split of emissions was correct, or where it was due to a lack of recent data. However, no better data were identified for these sources, so no improvements were made for these drivers. In addition, a review of drivers where all emissions were allocated to England were reviewed. Three sources were found to also have emissions in Scotland, so new drivers were developed to allocate emissions to Scotland for:

- Power stations – Flue Gas Desulphurisation (FGD) for gypsum produced;
- Onshore oil production: gas flaring for non-fuel consumption; and
- Onshore oil production (conventional) for crude oil.
- Aircraft between UK and Gibraltar – Take-off and Landing (TOL)

APPENDIX 3. DA GHG BY-SOURCE INVENTORY DATA SOURCES

There are three ways to generate GHG emission estimates for the DA by-source inventory:

- **Bottom-up estimates**, which is the most robust method and subject to lower uncertainties. Usually associated with well-regulated sources (e.g. power stations). If completeness of known sites is good, we can sum the emissions in each DA and derive a % of the UK total.
- **Top down estimates**, where there are no regular source of emissions data or fuel use data available, so proxy data are used to split up the UK total, such as population, GDP, or periodic surveys. This is less accurate, but often the only option for less regulated sectors.
- **Hybrid**, where bottom-up data are used as far as possible, with proxy data used to derive remaining emissions.

This appendix sets out the key data sources and publishers/ providers used to compile the DA inventories. Citation and links to the data sources mentioned are provided in **Section 6. References**.

It should be noted that this appendix does not intend to duplicate information on data sources which are also used in the UK inventory (e.g. data for well-regulated sources such as power stations). There is extensive documentation on these data; please refer to Table 1.4 in the NID and other published NAEI reports.

This appendix focuses on data sources used specifically for the compilation of the DA inventories, and therefore only briefly references national level sources. This appendix should be read in conjunction with the NID (Brown, et al., 2025).

Table 16 – DA By-Source Inventory data sources 2023

Data Source Name	**Citation** (Publisher, Date)	**Description**
NAEI Points Database	Ricardo, 2025	Covers large industrial and commercial sources that are well regulated. The NAEI Points Database is compiled from several regulatory sources, including (but not limited to): • UK and EU Emissions Trading Scheme • Pollution Inventory (Environment Agency and Natural Resources Wales), Scottish Pollutant Release Inventory (Scottish Environment Protection Agency) and Inventory of Statutory Releases (Department of Agriculture, the Environment and Rural Affairs) Further data on point sources used in the inventory can be found here: https://naei.energysecurity.gov.uk/data/maps/emissions-point-sources
NAEI Mapping Grids	Ricardo, 2025	For diffuse emission sources, distribution maps are generated using appropriate surrogate statistics that indirectly indicate the spatial distribution of emissions for each sector. The method used for each source sector varies according to the data available. An explanation of the mapping grid methodology and relevant data can be found here: https://uk-air.defra.gov.uk/assets/documents/reports/cat05/2501171412_UK_Spatial_Emissions_Methodology_for_NAEI_2022.pdf
NAEI Output	Ricardo, 2025	The DA inventories use the UK inventory as a basis
Annual airport data 2023	Civil Aviation Authority, 2023	Number of flights per airport
Coal mining production and manpower returns statistics 2023	Coal Authority, 2024	Regional coal production for deep mining and open mining

Data Source Name	Citation (Publisher, Date)	Description
Northern Ireland Waste Data Interrogator	DAERA, 2024	Landfill waste data and landfill gas collection data for Northern Ireland
Agricultural Workforce in the UK	Defra, 2024	Statistics on the number of agriculture workers (seasonal and total labour) per DA
Port and domestic waterborne freight statistics: data tables (POT)	Department for Transport, 2024	Data about the international and domestic movement of freight by water
Sea passenger statistics: data tables (SPAS)	Department for Transport, 2025	Data on UK international and domestic sea passengers
Digest of UK Energy Statistics	DESNZ, 2024a	Energy trends: Electricity and generation supplied per DA, including electricity generated for own use and consumption, transfers to public supply and imported/ exported internationally Agriculture commodity balance of final consumption of electricity.
Regional and Local Authority gas consumption statistics	DESNZ, 2024b	Total gas consumption data for domestic use consumption (GWh) for Great Britain
Regional and Local Authority electricity consumption statistics	DESNZ, 2024c	Estimates of electricity consumption at region and Local Authority levels in Great Britain
Sub-national electricity consumption statistics in Northern Ireland	DESNZ, 2024d	Sub-national domestic and non-domestic electricity consumption statistics in Northern Ireland
Subnational Residual Fuel Statistics	DESNZ, 2025	Sub-national estimates of non-gas, non-electricity and non-road transport fuel consumption (in thousand tonnes of oil equivalent (ktoe))
England Waste Data Interrogator	EA, 2024	Landfill waste data and landfill gas collection data for England
UK sea fisheries annual statistics	Marine Management Organisation, 2024	Landings by port
Wales Waste Data Interrogator	NRW, 2024	Landfill waste data and landfill gas collection data for Wales
Regional gross value added (balanced) by industry: all ITL regions	ONS, 2025a	Table 1, ITL1 & UK current price estimates, pounds million
Regional gross domestic product: all ITL regions	ONS, 2025b	Gross Domestic Product per DA
Dwelling stock by tenure, UK	ONS, 2025c	Number of dwellings per DA
Population statistics	ONS, 2025d	Mid-Year population statistics by DA
Oil and gas production statistics	Scottish Government, 2023	Oil and gas production volumes

Data Source Name	**Citation** (Publisher, Date)	**Description**
Scotland Waste Data Interrogator	SEPA, 2024	Landfill waste data and landfill gas collection data for Scotland
Compliance Report Emissions and Surrenders	UK Emissions Trading Registry	Emissions reported by Iron & Steel plants
Abandoned mine methane emissions	WSP, 2011	Modelled projected deep mine and open cast mine methane emissions estimates

APPENDIX 4. UNCERTAINTIES

INTRODUCTION

The uncertainties in the UK Inventory are estimated using a Monte Carlo simulation. The UK NID describes this approach in detail (NID Annex 2). The method involves estimating the uncertainties in activity data and EFs for all emission source categories and then using a Monte Carlo simulation package to calculate the uncertainty in the emission totals.

In order to apply a similar approach to the DA GHG inventories, it is necessary to estimate uncertainties for the DA activity data (i.e. fuel consumption, production data). The same EFs are used in the DA inventories as in the UK Inventory, so it is assumed that the emission factor uncertainties are the same as for the UK.

In the UK Inventory, uncertainties in the activity data are estimated on the basis of expert judgement. Making similar expert judgments for each DA would be a time-consuming activity and would be prone to inconsistencies with the UK uncertainties. Moreover, for some sources, no direct activity data is available at all, and it has been necessary to distribute the UK data using surrogate data (e.g. employment statistics). In such cases, it is impossible to say whether the surrogate statistics are an accurate indicator. The uncertainties for activity in the individual DAs when expressed as a percentage should be higher than that of the total UK uncertainty. This is due to a statistical principle where, if the elements of a group have any independence from one another and are positive, the uncertainty of the sum of a group is less than the sum of the uncertainties of each element in the group.

UNCERTAINTY ANALYSIS METHODOLOGY

The uncertainties in the DA GHG inventories are also estimated using a Monte Carlo simulation. For simplicity and consistency, the source categories used are the same as those used in the UK GHGI simulation. For each of these source categories, activity uncertainties are derived for England, Scotland, Wales, Northern Ireland, and Unallocated based on the uncertainty for the UK total and the relative contributions to emissions from each of the DAs for this source category using the following equation:

$$U_{A_i} = U_A w_i \frac{\sum_i |E_i|}{\sqrt{\sum_i {w_i}^2 {E_i}^2}}$$

Where U_A is the uncertainty in the UK activity,

i is the DA,

U_{A_i} is the uncertainty in activity for DA i,

w_i is a weighting factor for DA i representing the relative uncertainty in the activity,

E_i is the emission for each of the DA i.

When independence is assumed between the DAs' activity estimates then this equation ensures that the sum of the DAs uncertainty is consistent with the UK uncertainty. For the simplest case of $w_i = 1$ for all i this equation gives the DAs the same % uncertainty each, but opting to use a weighting function attributes higher % uncertainties for small contributors and lower uncertainties to large contributors using the following equation:

$$w_i = \frac{1}{\sqrt[4]{E_i}}$$

For some key sources the calculated uncertainty was overwritten with expert judgement.

In order to estimate the uncertainty on the trend, it was necessary to make an estimate of the uncertainty in the base year (1990 for carbon dioxide, methane and nitrous oxide, and 1995 for the F-gases). This estimate is made for the UK Inventory, as part of the analysis presented in the NID. Therefore, it was possible to make the DA uncertainty estimates using the method described above in conjunction with the UK estimates for the base year.

In addition to the estimation of the uncertainty in each year, it was also necessary to consider correlations between sources across years. Similar to the UK assessment of uncertainties EFs are assumed to be correlated between years and activity data is uncorrelated between years.

UNCERTAINTY ANALYSIS RESULTS

As UK emissions are the sum of the DA's emissions, the estimates for the individual DAs will be more uncertain than for the UK total. The DA uncertainties are estimated independently of the UK inventory uncertainties and there are subtle differences in the calculations and assumptions made between these models, additionally any two runs of a Monte Carlo analysis will always give slightly different results (the difference reducing with more iterations). This means that the uncertainties calculated for the UK in the DA inventories will be slightly different than that for the UK in the UK inventory. Overall data quality and sector allocations are improving, but for some source sectors, significant uncertainties remain, even at UK level.

The uncertainty estimates for the 1990-2023 DA GHG inventories are reported in **Table 17** below. The table presents the central estimate from the Monte Carlo simulation for each GHG and for each DA, for the Base Year (1990 or 1995) and the latest year and the estimated uncertainty on the total. In addition, the central estimate of the trend (expressed as the percentage change from the Base Year) is presented together with the 2.5 and 97.5 percentile estimates.

It has been observed that relative to the year specific uncertainty ranges, that the reported trend uncertainty range may be an overestimate, i.e., the correlation of uncertainties within the modelling over time may warrant review.

Please note, the totals below may not exactly match the sum of the values, due to minor rounding values.

Table 17 – Estimated Uncertainties[a] in the DA GHG Inventories: Base Year, 2023 and Trend

Gas (*ktCO_2e*)	Base Year[b]		2023		Base Year to 2023 Trend		
	Central Estimate[cd]	Uncertainty	Central Estimate	Uncertainty	Central Estimate	2.5 Percentile	97.5 Percentile
England							
CO_2	469,551	2%	231,612	2%	-237,939	-52%	-49%
CH_4	111,620	25%	34,894	18%	-76,726	-90%	-49%
N_2O	35,910	50%	12,365	21%	-23,544	-128%	-32%
HFC	15,365	9%	5,545	12%	-9,821	-74%	-53%
PFC	278	20%	99	16%	-179	-87%	-45%
SF_6	1,165	4%	239	6%	-926	-84%	-75%
NF_3	0	77%	0	92%	0	-180%	-25%
Total	633,889	5%	284,754	3%	-349,135	-60%	-51%
Scotland							
CO_2	57,681	5%	23,952	7%	-33,729	-63%	-54%
CH_4	17,811	24%	10,290	14%	-7,521	-66%	-23%
N_2O	4,189	14%	2,912	20%	-1,277	-45%	-16%
HFC	64	23%	566	28%	502	543%	1,039%
PFC	101	46%	43	52%	-57	-115%	-11%
SF_6	37	24%	37	31%	0	-37%	41%
NF_3	0	60%	0	55%	0	-144%	-21%
Total	79,883	6%	37,800	6%	-42,083	-59%	-47%
Wales							
CO_2	42,109	4%	26,359	3%	-15,750	-42%	-33%
CH_4	10,562	26%	5,716	12%	-4,846	-76%	-27%
N_2O	1,807	14%	1,292	19%	-515	-43%	-14%
HFC	33	33%	308	36%	275	507%	1,195%
PFC	155	28%	3	213%	-152	-127%	-70%

Gas (*ktCO_2e*)	Base Year[b]		2023		Base Year to 2023 Trend		
	Central Estimate[cd]	Uncertainty	Central Estimate	Uncertainty	Central Estimate	2.5 Percentile	97.5 Percentile
SF_6	85	14%	19	23%	-66	-92%	-62%
NF_3	0	262%	0	219%	0	-394%	99%
Total	54,751	6%	33,697	3%	-21,054	-45%	-33%
Northern Ireland							
CO_2	18,314	7%	11,190	6%	-7,124	-46%	-33%
CH_4	6,338	30%	5,501	11%	-836	-50%	8%
N_2O	1,877	19%	1,332	28%	-545	-55%	-2%
HFC	19	43%	179	49%	160	489%	1,428%
PFC	1	605%	-	-	-1	-626%	-3%
SF_6	3	71%	7	30%	4	-1%	189%
NF_3	-	-	-	-	-	-	-
Total	26,552	9%	18,209	6%	-8,343	-41%	-24%
Unallocated							
CO_2	15,628	2%	9,692	4%	-5,936	-41%	-35%
CH_4	2,191	45%	606	77%	-1,585	-104%	-50%
N_2O	265	87%	194	90%	-72	-55%	-12%
HFC	-	-	-	-	-	-	-
PFC	-	-	-	-	-	-	-
SF_6	-	-	-	-	-	-	-
NF_3	-	-	-	-	-	-	-
Total	18,084	6%	10,492	6%	-7,592	-47%	-38%
UK							
CO_2	603,284	2%	302,806	2%	-300,478	-51%	-48%
CH_4	148,521	22%	57,007	14%	-91,514	-81%	-44%
N_2O	44,049	41%	18,096	19%	-25,953	-110%	-31%
HFC	15,480	9%	6,597	11%	-8,884	-68%	-47%
PFC	534	16%	145	19%	-389	-90%	-57%
SF_6	1,291	4%	302	6%	-989	-81%	-72%
NF_3	0	46%	0	46%	0	-130%	-35%
Total	813,160	5%	384,952	3%	-428,207	-57%	-49%

Notes

a) Uncertainty is defined as ± 1.96×(standard deviation)/mean %, which closely approximates the 95% confidence interval.

b) Base Years are 1990 for CO_2, CH_4 and N_2O; 1995 for NF_3, HFCs, PFCs and SF_6.

c) The uncertainty model takes emission estimates by gas for each source, applies an uncertainty distribution for that source and calculates a statistical mean, presented above as the central estimate. The emissions data in this table are taken from the Monte Carlo model output. The central estimates by gas for the Base Year and the latest inventory year are very similar but not identical to the emission estimates in the DA inventories.

d) Where the central estimate says '0' this does not mean that there are no emissions, but that emissions are rounded to 0. '-' is used to represent no emissions.

APPENDIX 5. END-USER EMISSIONS

INTRODUCTION

Emissions of GHGs reported under international conventions are typically on a “by-source” basis. This means that the emissions are allocated to the source sector at the point of their release. For example, emissions from refining oils are allocated to the refineries, and emissions from the combustion of fuel in vehicles are allocated to the relevant transport sector.

This section of the report presents emissions on an “end-user” basis. In this case, all emissions associated with energy supply (e.g. power generation, coal mining, oil and gas extraction, refineries) are allocated to the final users of the energy. In the above example, the emissions from the refineries would be reallocated to all oil users, including within the transport sector. Therefore, the main usefulness of end-user emission inventories is to present a more representative picture of emissions due to consumption, rather than production. End-user inventories are needed to reflect the full impact of energy efficiency policies as they show the emissions associated with sector consumption of all fuels, including emissions associated with electricity use.

The scope of the emissions allocated within these DA end-user inventories is bounded by the definition of the “UK” emissions, as applied in the main DA by-source inventories. The sum of all DA end-user emissions equals the sum of all DA by-source emissions, which matches the UK total. GHG emissions associated with fuel imports (e.g. electricity imported from the EU and consumed in the UK) are not reported within these data. However, the emissions of GHGs associated with the refining of fuels that are subsequently exported are included in these DA inventories, as the emissions are produced at source within the UK energy supply industry. An example of this is for international aviation and shipping; whilst the GHG emissions from the direct use of petroleum fuels in those “memo item” sources are excluded from the end-user inventories, the emissions associated with the supply of fuels to those sectors (i.e. upstream oil extraction and refinery emissions within the UK) are included in the DA end-user inventories.

END USER METHODOLOGY

The End User estimates are derived from the By Source emission inventories, applying a secondary set of calculations based on additional data such as electricity use estimates by DA by sector. For some sectors, the DA estimates of electricity use are based on proxy data, and introduce additional uncertainty to the End User inventories. As a result, the DA End User inventory estimates are associated with greater uncertainty than the By Source estimates and Policy makers must consider this when using the End User inventory data.

In particular, the End User emission estimates for each country are associated with higher uncertainty for 1990 due to the lack of detailed electricity consumption data by country available for that year, whereas the estimates of total emissions from 2003 onwards are subject to lower uncertainty due to the development of the DESNZ sub-national energy statistics in the early 2000s. Within the End User inventories, the overall consumption of electricity by DA are reported by DESNZ whilst the sector allocations of electricity use are based on data from a range of statistical sources.

The revisions to the DA GHGI by-source data also affect the DA end-users data, and hence impacts such as the revisions to LULUCF and agriculture estimates (see **Appendix 2**) also have a notable impact on the reported inventory estimates and trends on an end-user basis.

END USER RESULTS

The results of the DA end-users analysis for the 1990-2023 inventory cycle are presented in the spreadsheet that accompanies this report, and this includes the data resolved at the TES Sector level.

The country-specific trends of end-user emissions, once the emissions attributable to exports are excluded from the totals (to give a more accurate representation of “consumption” emission trends in each DA) are as follows:

- England
    - 1990-2023 trend, emissions down 54%
    - 2022-2023 trends, emissions down 5.6%
- Scotland

  - 1990-2023 trend, emissions down 54%
  - 2022-2023 trends, emissions down 2.1%
- Wales
  - 1990-2023 trend, emissions down 45%
  - 2022-2023 trends, emissions down 1.7%
- Northern Ireland
  - 1990-2023 trend, emissions down 33%
  - 2022-2023 trends, emissions down 4.0%

END USER DATA FOR WALES “ELECTRICITY ONLY” EMISSIONS

The allocation of emissions from electricity use in the end-user inventories was historically of specific interest for the reporting of progress against GHG reduction targets for the Welsh Government; the Climate Change Strategy for Wales (2010) established emission reduction targets that address the scope of devolved powers for the Welsh Government, and this required analysis of the impact of the operation of the UK electricity supply grid. The table below presents the end-user emissions that are allocated from the use of electricity in Wales during 2006 to 2023, as the Welsh Government targets used a baseline from 2006 onwards. Note that these data exclude the by-source emission estimates and the component of the end-user dataset that relates to the use of solid fuels, natural gas, and petroleum fuels.

Table 18 – Summary of Wales End-user Electricity Only Emissions, 2006-2023, $MtCO_2e$

TES Sector	2006	2010	2015	2020	2021	2022	2023
Agriculture	0.30	0.28	0.20	0.10	0.10	0.09	0.07
Buildings and product uses	5.64	4.95	3.28	1.59	1.72	1.58	1.32
Domestic transport	0.00	0.00	0.00	0.01	0.03	0.05	0.07
End use outside UK	0.00	0.00	0.58	0.14	0.23	0.08	0.36
Industry	4.82	3.83	2.28	1.83	1.53	1.82	1.47
Wales Total	10.76	9.07	6.34	3.67	3.61	3.62	3.29

APPENDIX 6. TRADED NON-TRADED METHODOLOGY

METHODOLOGY OVERVIEW

For the UK to achieve progress in emission reductions across the economy, a detailed understanding of the scope, level and trend of non-traded GHG emissions (i.e. those emission sources that are not within the UK Emissions Trading Scheme (ETS) is needed to support evidence-based policy development within the climate change strategies and programmes implemented by the DAs; good quality GHG emissions data by source will enable the DAs to design and implement devolved policy mechanisms that are effective and cost-effective in achieving GHG reduction targets, to complement the actions through reserved UK-level policies and measures.

Non-traded GHG emission sources in the UK comprise:

- Small-scale fuel combustion sources in the industrial, agricultural, commercial, public and residential sectors;
- transport emissions;
- Agricultural process emissions;
- LULUCF emissions / sinks; and
- Waste sector emissions.

The small-scale fuel combustion sources are usually sources where comprehensive accurate data on energy use and / or emissions are not available at DA level. DA emissions in the traded sector are much more certain, since the mechanism for trading requires site-specific reporting of detailed emissions, activity and emission factor data. The current approach to deriving the non-traded fuel combustion emission estimates is therefore by difference from the total DA GHGI for energy emissions and the ETS emissions data:

Non-traded emissions = total emissions – traded emissions

The DA GHGI data are derived from the UK GHGI data, which in turn is linked directly (for high emitting, energy-intensive sites, such as those within the ETS) to industry-specific fuel allocations within the DUKES. The UK GHGI integrates ETS activity and emission factor data into national energy statistics and GHGI estimates so close consistency can be achieved in the UK between the ETS and GHGI. However, some inconsistencies between the inventory and ETS remain for a number of sources.

The estimates derived for the traded and non-traded sectors of the DA GHG inventories presented in this report are for the years 2008 to 2023, as the earlier years of EU data covering 2005 to 2007 were during Phase I of the European Union (EU) scheme when a more limited scope of installations was included. Comparison of data from Phase I and Phase II/III is therefore of little value. Phase III of the EU ETS started in 2013, with a slightly increased scope of reporting compared with Phase II (2008-12). As a result, EU ETS data for 2013 onwards included emissions from some additional industrial combustion installations (e.g. roadstone coating plant) and certain industrial process sources were also included for the first time.

The UK ETS replaced the UK's participation in the EU ETS on 1 January 2021, which marks the start of Phase IV. UK based operators (except for electricity generators in Northern Ireland, who will remain in EU ETS in accordance with the terms of the Protocol on Ireland/Northern Ireland to the Withdrawal Agreement) will now report their emissions under the UK ETS. For the purposes of calculating UK emissions statistics, teams should use EU ETS data for emissions arising up to December 31st, 2020, and use UK ETS data for emissions emitted from 1st January 2021. As the UK ETS was initially designed to provide a smooth transition for relevant sectors from the EU to the UK scheme, the two data sets are compatible.

The traded and non-traded emission estimates for each of the DAs presented in the DA GHGI include:

- Annual total traded GHG emissions;
- Annual total non-traded GHG emissions;
- Annual total traded and non-traded GHG emissions per TES Sector;
- Annual total GHGI emissions; and

- Non-traded sector percentage share of the total GHGI.

DATA QUALITY AND REPORT FORMATTING

Sector activity data (fuel use, mineral use) from the ETS are analysed against the data reported in the national energy statistics from DUKES, and ETS fuel quality information by sector are used within the derivation of UK GHGI estimates for several high-emitting sectors. However, direct comparison of ETS data and alignment with DUKES sectors and the DA GHGI exposes a disparity between ETS and national activity statistics.

The activity data from ETS are generally considered to be of good quality, having been subject to a rigorous data checking and verification process. Comparisons with UK energy statistics are therefore potentially very useful in revealing any areas of under- or over-estimation in the national statistics. However, for most economic sectors, the ETS does not cover 100% of sites and fuel use in the UK, and therefore the sum of ETS activity data for most sectors is expected to be lower than the national statistics published by DUKES (for energy use). This is indeed what is generally found, and so we conclude there is no evidence of any problems in DUKES for these sectors. The comparison between ETS and DUKES is more informative in the case of sectors where we expect all, or nearly all sites to be covered by ETS e.g. for power stations, refineries etc. Here the ETS data should be the same or similar to that given in the UK energy statistics. In fact, there are a number of instances where the ETS fuel use data are higher than the data reported within DUKES, and so ETS data are therefore used within the UK and DA GHGI compilation, deviating from the national statistics. Examples include refinery and industrial use of other petroleum gases (OPG), upstream oil and gas use of liquefied petroleum gas (LPG) and OPG.

As a result of these data format and data quality issues, the derivation of traded and non-traded emission estimates requires calculation of non-traded DA GHGI data such that the data inconsistencies between DUKES and ETS fuel use are minimised, removing the inconsistencies by (in most cases) assuming that the ETS data for a given sector are the more accurate estimates.

APPENDIX 7. AVIATION DATA IN THE ETS

GHG emissions from civil aviation are reported within the UK GHGI and within GHG inventories prepared for the constituent countries of the UK: Scotland, Wales, Northern Ireland, and England. The emissions from domestic flights are accounted within national inventory totals, whilst emissions from international flights are reported as memo items to the UK inventory.

Each of the devolved Governments tailors their climate change policy legislation and policies to focus on specific local and regional priorities. The Climate Change (Scotland) Act identifies that the scope of net Scottish GHG emissions account shall include all existing anthropogenic sources and sinks of emissions in Scotland, as well as a "Scottish share" of GHG emissions from international shipping and from international aviation. Similarly, the scope of the Welsh statutory targets and carbon budgets include a "Welsh share" of emissions from international aviation and shipping.

The UK and DA aviation emission estimates for both domestic and international flights are based on flight data from the Civil Aviation Authority (CAA) and fuel use in the aviation sector reported within the UK energy statistics (DUKES), published annually by DESNZ.

Since 2012, aviation emissions are included within the scope of the UK Emissions Trading Scheme[30] (ETS). The scope of ETS for aviation includes flights within the UK zone to and from a wide range of countries, not only flights that originate and land within the UK.

The tables below present analysis of the baseline level and trend of aviation emissions in the UK and Scottish inventories, including specific analysis for those flights that fall within the scope of the ETS.

UK Aviation Summary

The UK aviation emissions are presented below in **Table 19** for the Stop the Clock scope and **Table 20** for the 2014 Regulation scope.

- From 2010 onwards the *Stop the Clock* scope is between 32 - 37% of the UK aviation inventory total, with slightly variable and higher percentages in later years.
- Since 2010 the 2014 Regulation scope is around 28 - 29% of the UK total until 2021 and 2022 where the 2014 Regulation scope is around 31% of the UK total. This decreases to 29% in 2023.

Table 19 – UK aviation emissions under the Stop the Clock Scope ($MtCO_2e$)

	GHG	2000	2005	2010	2015	2018	2019	2020	2021	2022	2023
Stop the Clock	Carbon dioxide	11.232	13.691	11.556	11.42	12.908	12.459	5.03	5.247	10.942	11.543
	Methane	0.008	0.007	0.005	0.004	0.004	0.004	0.001	0.002	0.003	0.003
	Nitrous oxide	0.095	0.115	0.097	0.096	0.109	0.105	0.042	0.044	0.092	0.098
UK GHGI	Carbon dioxide	32.442	37.766	35.214	34.981	38.061	37.415	15.78	14.519	29.461	34.376
	Methane	0.01	0.009	0.006	0.005	0.005	0.005	0.002	0.002	0.004	0.004
	Nitrous oxide	0.273	0.318	0.296	0.294	0.32	0.315	0.133	0.123	0.249	0.292
Stop the clock % share	Total GHGs	34.6%	36.3%	32.8%	32.7%	33.9%	33.3%	31.9%	36.1%	37.1%	33.6%

[30] Prior to 2021, UK organisations reported emissions to the EU ETS.

Table 20 – UK aviation emissions under the Stop the Clock Scope ($MtCO_2e$)

	GHG	2000	2005	2010	2015	2018	2019	2020	2021	2022	2023
2014 Regulation	Carbon dioxide	9.687	12.042	9.871	9.859	11.131	10.783	4.363	4.524	9.266	9.788
	Methane	0.008	0.006	0.004	0.003	0.004	0.003	0.001	0.002	0.003	0.003
	Nitrous oxide	0.082	0.101	0.083	0.083	0.094	0.091	0.037	0.038	0.078	0.083
UK GHGI	Carbon dioxide	32.442	37.766	35.214	34.981	38.061	37.415	15.78	14.519	29.461	34.376
	Methane	0.01	0.009	0.006	0.005	0.005	0.005	0.002	0.002	0.004	0.004
	Nitrous oxide	0.273	0.318	0.296	0.294	0.32	0.315	0.133	0.123	0.249	0.292
2014 Regulation % share	Total GHGs	29.9%	31.9%	28.0%	28.2%	29.3%	28.8%	27.7%	31.2%	31.5%	28.5%

Scottish Aviation Summary

The Scotland aviation emissions are presented below in **Table 21** for the *Stop the Clock* scope and **Table 22** for the *2014 Regulation* scope.

- From 2010-2020 the *Stop the Clock* scope is between 71 - 78% of the Scotland aviation inventory total. In 2022, there was step change in the percentage share of Stop the Clock emissions to 85%, however in 2022 and 2023 this as returned to pre COVID-19 levels.
- From 2010-2020 the *2014 Regulation* scope has been between 63 - 71% of the Scotland total, which had shown steady decline until 2020, a result of the significantly impacted aviation market during the early stages of the COVID pandemic. 2021 values also show a step-change between 2020 and 2021, with a share of emissions at 76%. In 2022 and 2023, the share returned to pre-pandemic levels at 66% and 61% respectively.

Table 21 – Scotland aviation emissions under the Stop the Clock Scope ($MtCO_2e$)

	GHG	2000	2005	2010	2015	2018	2019	2020	2021	2022	2023
Stop the Clock	Carbon dioxide	1.258	1.533	1.27	1.328	1.47	1.373	0.54	0.553	1.181	1.351
	Methane	0.0012	0.0013	0.0009	0.0008	0.0008	0.0007	0.0002	0.0004	0.0005	0.0004
	Nitrous oxide	0.009	0.011	0.008	0.007	0.007	0.006	0.003	0.003	0.005	0.005
Scotland GHGI	Carbon dioxide	1.496	1.946	1.635	1.854	2.033	1.934	0.698	0.652	1.542	1.867
	Methane	0.0008	0.0008	0.0006	0.0006	0.0006	0.0005	0.0002	0.0003	0.0004	0.0004
	Nitrous oxide	0.013	0.016	0.014	0.016	0.017	0.016	0.006	0.006	0.013	0.016
Stop the Clock % share	Total GHGs	84.0%	78.7%	77.5%	71.4%	72.1%	70.7%	77.1%	84.5%	76.3%	72.0%

Table 22 – Scotland aviation emissions under the 2014 Regulation Scope ($MtCO_2e$)

	GHG	2000	2005	2010	2015	2018	2019	2020	2021	2022	2023
2014 Regulation	Carbon dioxide	1.166	1.43	1.161	1.187	1.297	1.218	0.485	0.494	1.011	1.142
	Methane	0.0008	0.0008	0.0006	0.0005	0.0006	0.0005	0.0002	0.0003	0.0004	0.0003
	Nitrous oxide	0.01	0.012	0.01	0.01	0.011	0.01	0.004	0.004	0.009	0.01
Scotland GHGI	Carbon dioxide	1.496	1.946	1.635	1.854	2.033	1.934	0.698	0.652	1.542	1.867
	Methane	0.0008	0.0008	0.0006	0.0006	0.0006	0.0005	0.0002	0.0003	0.0004	0.0004
	Nitrous oxide	0.013	0.016	0.014	0.016	0.017	0.016	0.006	0.006	0.013	0.016
2014 Regulation % share	Total GHGs	77.9%	73.5%	71.0%	64.0%	63.8%	63.0%	69.5%	75.7%	65.6%	61.2%


National Atmospheric
Emissions Inventory