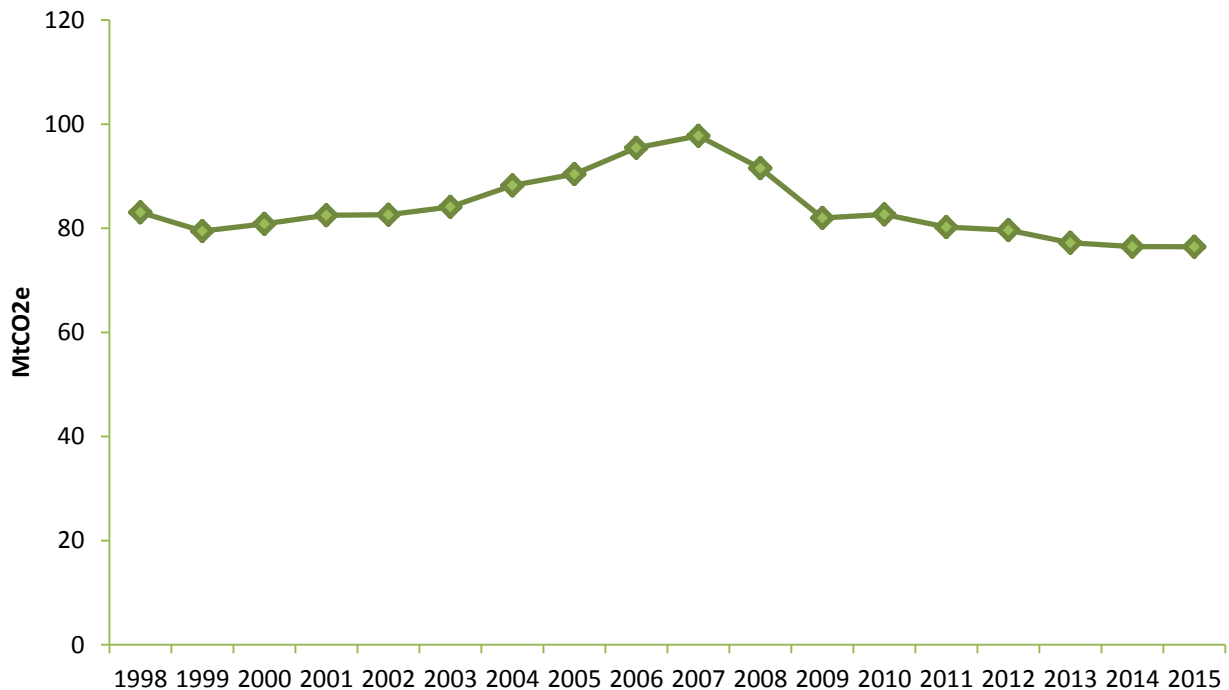


AGRICULTURE, ENVIRONMENT AND MARINE

Scotland's Carbon Footprint 1998 - 2015

Chart 1. Scotland's Carbon Footprint, 1998-2015. Values in MtCO₂e



Key points

- Between 2014 and 2015, Scotland's carbon footprint (emissions from all greenhouse gases) remained constant at 76.5 million tonnes of carbon dioxide equivalent (MtCO₂e).
- Between 1998 and 2015, Scotland's carbon footprint fell by 8.0 per cent, from 83.1 MtCO₂e in 1998 to 76.5 MtCO₂e in 2015.
- Scotland's carbon footprint rose steadily from 1999 to a peak of 97.7 MtCO₂e in 2007 before falling sharply in the following years (coinciding with the recession) and has generally fallen gradually in more recent years. The overall reduction between this 2007 peak, and 2015 is 21.8 per cent.

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We would like to thank John Barrett, Anne Owen and Jannik Giesekam of the Sustainability Research Institute (SRI) at Leeds University for their invaluable support in compiling the figures and for continually improving the methodologies and data used in the Scottish Carbon Footprint statistics release.

What is Scotland’s Carbon Footprint?

Scotland’s Carbon Footprint refers to estimates of Scotland’s greenhouse gas emissions on a consumption basis. This refers to greenhouse gas emissions which are associated with the spending of Scottish residents on goods and services, wherever in the world these emissions arise together with emissions directly generated by Scottish households, through private heating and motoring. These greenhouse gas emissions are often referred to as “consumption emissions” to distinguish them from estimates relating to the emissions “produced” within a country’s territory or economic sphere. Scotland’s Carbon Footprint is also sometimes referred to as its Consumption Based Account. Information on the different reporting bases can be found in the section [Comparison of Scotland’s carbon footprint and its territorial emissions](#) within this publication.

To find out what effect Scottish consumption has on greenhouse gas emissions we need to take into account where the goods we buy come from and their associated supply chains. More information on the methods used can be found in the section [“How has Scotland’s Carbon Footprint been calculated?”](#)

The carbon footprint of Scotland includes the six main greenhouse gases including carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O) and fluorinated compounds (hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride). Unless otherwise specified, these emissions are presented in this publication in units of million tonnes of carbon dioxide equivalent (MtCO₂e)¹.

This statistical report meets the requirements under Section 37 of the [Climate Change \(Scotland\) Act 2009](#) and is used to inform the [Scotland Performs National Indicator 47: Reduce Scotland's Carbon Footprint](#)

- Scotland's greenhouse gas emissions can be broken up into three main categories: emissions embedded in imported goods and services, those embedded in UK produced goods and services and those directly produced by Scottish residents, through activities such as heating and motoring. More information on these categories can be found in the section "[Breakdown of Scotland's Carbon Footprint 1998-2015](#)".
- Whilst Scotland's carbon footprint has fallen by 8.0 per cent between 1998 and 2015, equivalent greenhouse gas emissions on a territorial basis have fallen by 42.0 per cent over the same time period².
- Similarly, Scotland's carbon dioxide footprint is measured on the same basis as the carbon footprint although it relates only to carbon dioxide (CO₂) emissions. Scotland's carbon dioxide footprint decreased by 2.6 per cent between 1998 and 2016 whilst reaching its peak in 2007.

Since 1990, the UK's economy has continued to shift from manufacturing to having a greater reliance upon the services sector. One of the consequences of this is that more of the goods we buy and use are now produced outside Scotland and the rest of the UK. The current data in this publication breaks down greenhouse gas emissions into those generated by households and businesses, those produced in the UK and imports either from the rest of the EU, China or the Rest of the World.

Inherently the greenhouse gas emissions relating to the overseas production of imports to Scotland are not as easily measured as emissions generated within Scotland's borders. There are general conventions on how to do this, using shares of production based on financial data, but the results cannot be viewed as being as robust as the estimates of greenhouse gas emissions generated domestically. The methodology and data for calculating these emissions resulting from imports have been revised since the last release. More information can be found in the [revisions](#) section of the publication.

¹ Carbon dioxide equivalent is a measure used to compare the emissions from various greenhouse gases on the basis of their global warming potential by converting amounts of other gases to the equivalent amount of carbon dioxide based on their global warming potential. Global warming potential describes the relative potency, molecule for molecule, of a greenhouse gas, taking account of how long it remains active in the atmosphere.

² [Scottish Greenhouse Gas Emissions 2016](#)

Breakdown of Scotland's Carbon Footprint, 1998-2015

Table 1 outlines how the Carbon Footprint has been categorised for this publication.

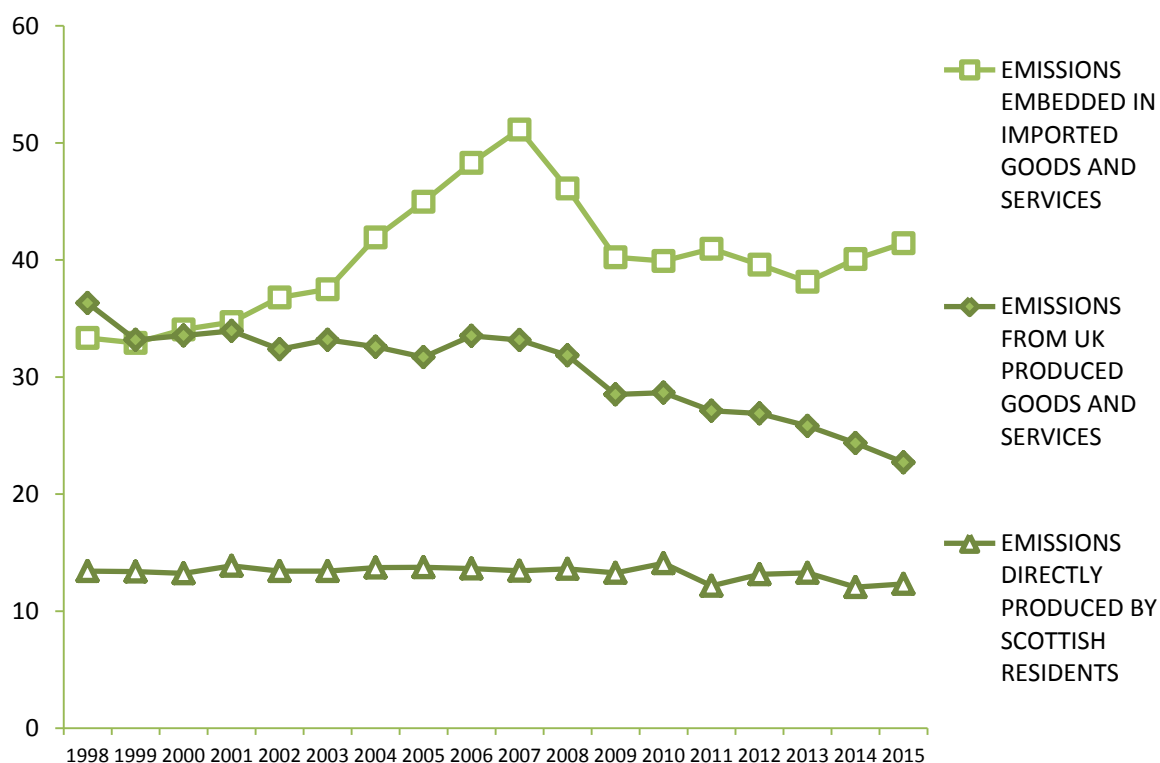
Table 1. Categorisation of Scotland's Carbon Footprint

Main Category	Activity	Description
Greenhouse Gas Emissions from UK Produced Goods and Services	Scottish consumption of UK production	UK production emissions attributable to Scottish final consumption, including manufacturing and transport, international aviation and shipping provided by Scottish operators.
Greenhouse Gas Emissions Embedded in Imported Goods and Services – By Region of Import <ul style="list-style-type: none"> • EU • China • Rest of the World 	Imports used by UK businesses for Scottish consumption	Greenhouse Gas Emissions associated with the production of imports which are used by UK industry and attributable to Scottish final consumption
	Imports directly used by Scottish consumers	Greenhouse Gas Emissions associated with the production of imports which are used by Scottish final consumers
Greenhouse Gas Emissions Directly Produced By Scottish Residents	Private motoring	Greenhouse Gas Emissions generated directly by households through private motoring.
	Household heating	Greenhouse Gas Emissions arising from households' use of fossil fuels for heating, households use of aerosols, etc.

Chart 2 shows Scotland's carbon footprint, broken down into three main components, from 1998 to 2015.

- Greenhouse gas emissions embedded in imported goods and services from overseas. These accounted for 54.2 per cent of Scotland's carbon footprint in 2015; up from 40.1 per cent in 1998.
- Greenhouse gas emissions embedded in UK produced goods and services. These accounted for 29.7 per cent of Scotland's carbon footprint in 2015; down from 43.7 per cent in 1998.
- Greenhouse gas emissions directly produced by Scottish residents. These account for 16.1 per cent of Scotland's carbon footprint in 2015; essentially equal to their emissions share in 1998 at 16.2 per cent of total consumption-based emissions.

Chart 2. Scotland's Carbon Footprint, by main component, 1998 to 2015.
Values in MtCO₂e



Additionally, Chart 2 shows that:

- Greenhouse gas emissions associated with imported goods and services increased from 33.3 MtCO₂e in 1998 to 51.1 MtCO₂e in 2007 (an increase of 53.4 per cent over this time period). These emissions accounted for 52.3 per cent of Scotland's carbon footprint in 2007.
- Between 2007 and 2015, greenhouse gas emissions embedded in imported goods and services fell by 19.0 per cent; this compares with a

24.3 per cent increase in emissions embedded in imports over the whole time period from 1998 to 2015.

- Greenhouse gas emissions relating to the consumption of UK produced goods and services by Scottish residents fell from 36.3 MtCO₂e in 1998 to 22.7 MtCO₂e in 2015 – a fall of 37.5 per cent. There was a general fall in greenhouse gas emissions from this category over the time period.
- Greenhouse gas emissions generated directly by Scottish residents have fallen from 13.4 MtCO₂e in 1998 to 12.3 MtCO₂e in 2015 – a fall of 8.1 per cent over this time period.

Chart 3 shows how Scotland’s carbon footprint fell by 6.6 MtCO₂e (8.0 per cent) between 1998 and 2015.

Chart 3. Change in Scotland's Carbon Footprint between 1998 and 2015 - in MtCO₂e, and percentage changes

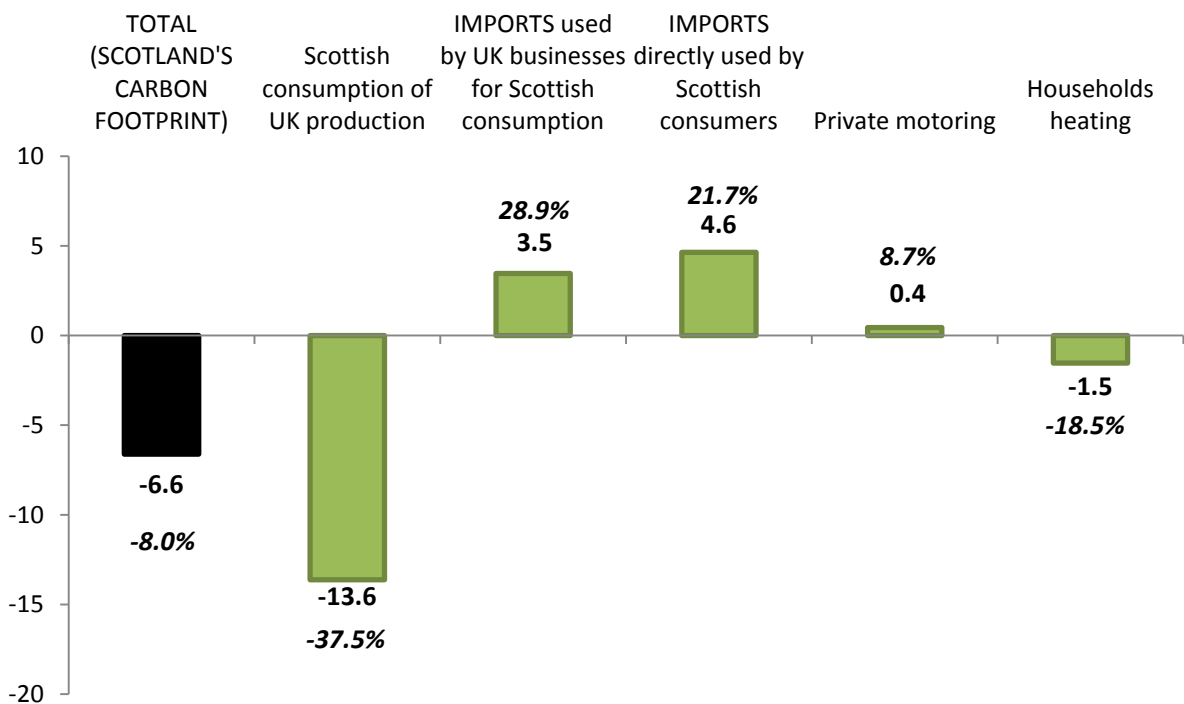


Chart 3 also shows that between 1998 and 2015:

- Greenhouse gas emissions from Scottish consumption of UK production have seen the greatest absolute reduction over this time period (13.6 MtCO₂e; a 37.5 per cent reduction).
- Greenhouse gas emissions embedded in imports directly used by Scottish consumers have increased by 4.6 MtCO₂e (a 21.7 per cent increase). Emissions embedded in imports used by UK businesses for Scottish consumption have increased by 3.5 MtCO₂e (a 28.9 per cent increase).

- Greenhouse gas emissions resulting from households heating have decreased by 1.5 MtCO₂e (an 18.5 per cent decrease) whilst private motoring emissions have increased by 0.4 MtCO₂e (an 8.7 per cent increase).

Chart 4 shows how Scotland's carbon footprint has changed from 2007 to 2015. The year 2007 has been chosen as the base year for this chart as it represents the peak value in the series. Scotland's carbon footprint has fallen by 21.3 MtCO₂e (21.8 per cent) over this time period.

Chart 4. Change in Scotland's Carbon Footprint between 2007 and 2015 - in MtCO₂e, and percentage changes

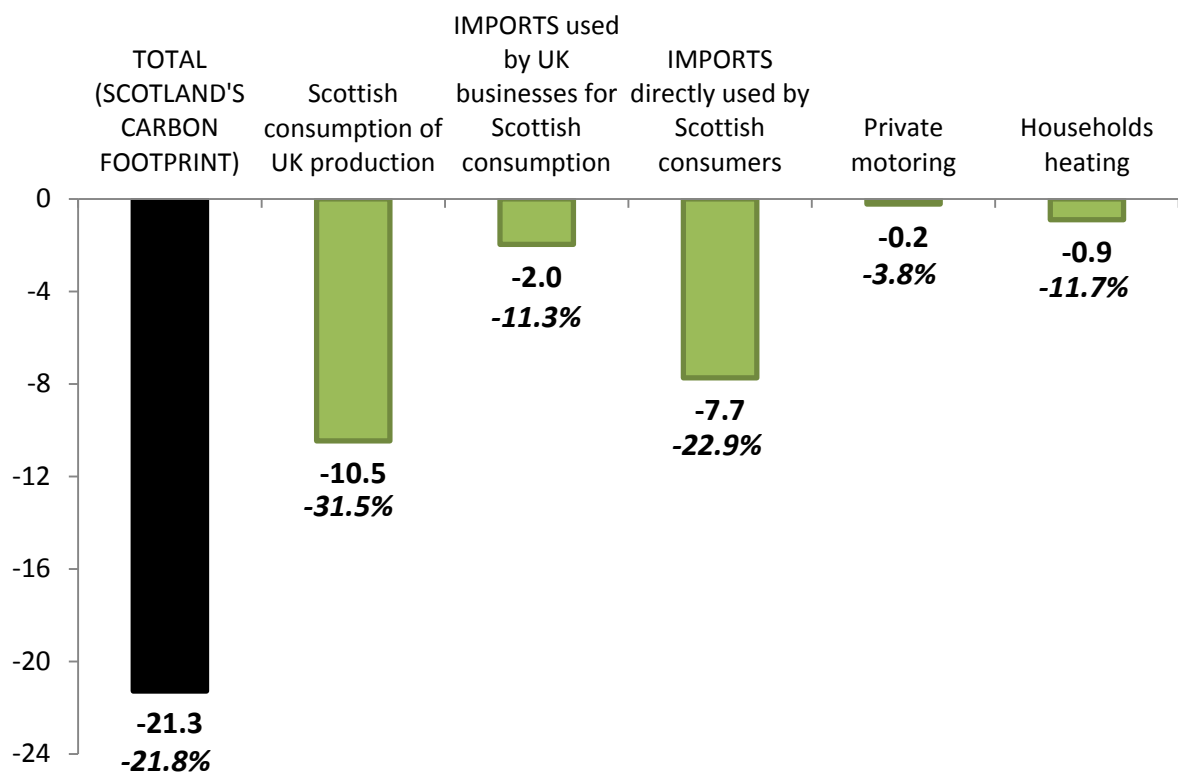


Chart 4 also shows that between 2007 and 2015:

- Greenhouse gas emissions embedded in Scottish consumption of UK production fell by the greatest amount, both in absolute and percentage terms (a reduction of 10.5 MtCO₂e; 31.5 per cent).
 - There were also considerable falls in greenhouse gas emissions attributed to imports directly used by Scottish consumers (7.7 MtCO₂e; 22.9 per cent).
 - Imports used by UK businesses for Scottish consumption fell slightly (a reduction of 2.0 MtCO₂e; 11.3 per cent).
- Greenhouse gas emissions attributed to private motoring and household heating have seen smaller absolute falls (0.2 MtCO₂e for private motoring; 0.9 MtCO₂e for households heating).

Chart 5 shows that Scotland's carbon footprint has maintained the same level between 2014 and 2015.

Chart 5. Change in Scotland's Carbon Footprint between 2014 and 2015 - in MtCO₂e, and percentage changes

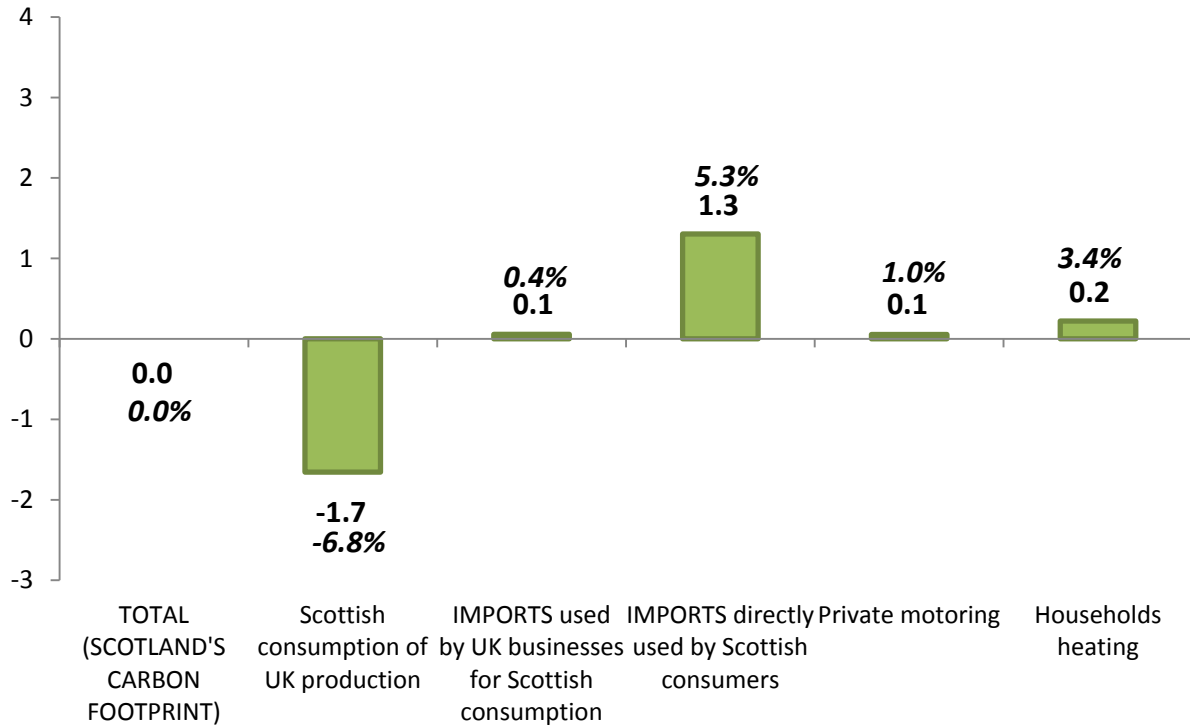


Chart 5 also shows that between 2014 and 2015:

- Emissions embodied in Scottish consumption of UK production fell by 1.7 MtCO₂e (6.8 per cent).
- Conversely, embedded emissions in imports consumed in Scotland rose by 1.3 MtCO₂e (5.3 per cent).
- There were relatively minor increases in the level of absolute emissions in Imports used by UK businesses (0.1 MtCO₂e), private motoring (0.1 MtCO₂e), and household heating (0.2 MtCO₂e).

Chart 6 presents a breakdown of Scotland's embedded greenhouse gases by region of import.

Chart 6. Breakdown of Scotland's embedded greenhouse gas emissions by region of import, 1998 to 2015. Values in MtCO₂e

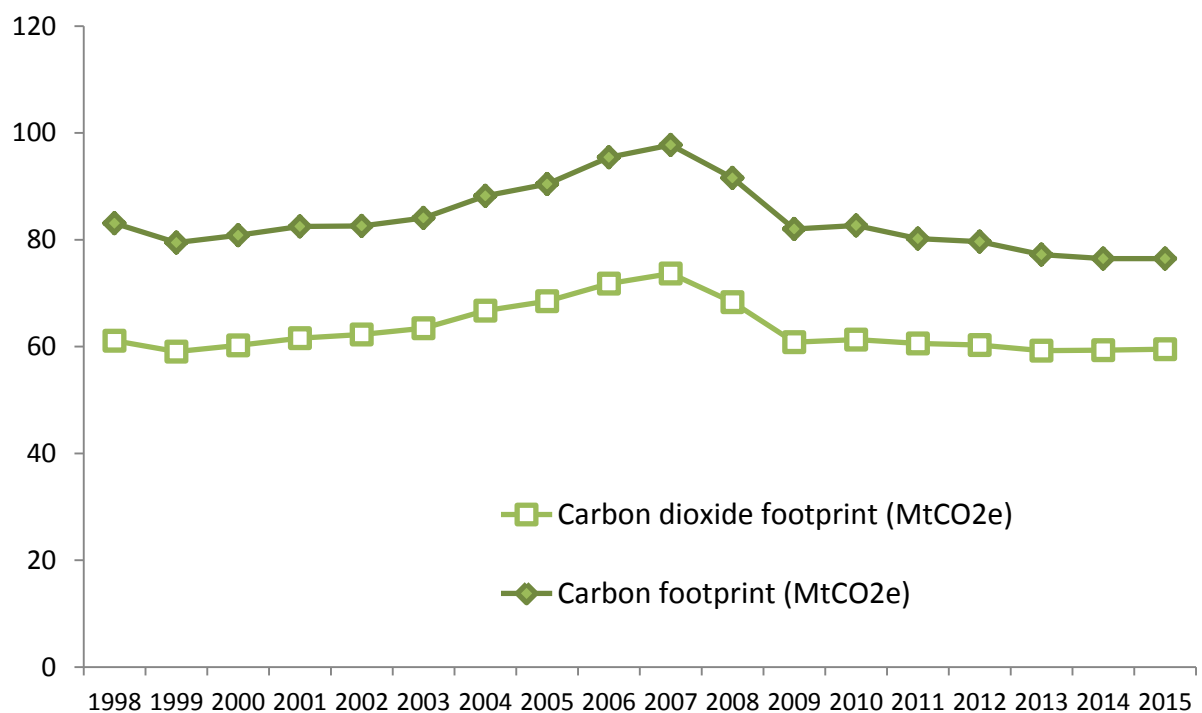


- Consistently over the entire time-series, over half of greenhouse gas emissions embedded in imported goods and services originate from areas other than the EU and China. Greenhouse gas emissions associated with these “rest of world” imports increased from 21.9 MtCO₂e in 1998 to 28.8 MtCO₂e in 2007 (a 31.5 per cent increase). They then fell sharply to 23.3 MtCO₂e in 2009. Following 2009, these embodied emissions have been comparatively stable, initially falling and then rising slightly over this period to their 2015 level of 23.8 MtCO₂e.
- Greenhouse gas emissions embedded in EU imports increased slightly from 8.0 MtCO₂e in 1998 to 9.0 MtCO₂e in 2007 before falling to their lowest point of 7.9 MtCO₂e in 2009. Over the entire time-series, these embodied emissions show a modest overall increase of 5.7 per cent from 1998 to 2015.
- Greenhouse gas emissions embedded from imports to Scotland from China have increased from 2.4 MtCO₂e in 1998 to 12.3 MtCO₂e in 2007 (a five-fold (518 per cent) increase)). Emissions embedded in these imports fell for 3 consecutive years following the 2007 peak and have remained comparatively stable since that time. Over the entire time-series, embodied emissions associated with imports from China have increased by 240 per cent (1998-2015).

Contribution of carbon dioxide (CO₂) emissions to Scotland's carbon footprint

CO₂ is the main greenhouse gas in Scotland's carbon footprint. It accounted for 77.8 per cent of Scotland's total carbon footprint in 2015, up from 73.6 per cent in 1998. Between 2014 and 2015, Scotland's carbon dioxide footprint from all sources rose marginally by 0.3%.

Chart 7. Scottish Carbon Footprint. Comparison of Carbon and CO₂ footprint. Values in MtCO₂e



Data tables

Table 2. Detailed breakdown of Scotland's carbon footprint, 1998 to 2014. Values in MtCO₂e

Main Category	Activity	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
TOTAL - SCOTLAND'S CARBON FOOTPRINT		83.1	79.5	80.8	82.5	82.6	84.1	88.2	90.4	95.4	97.7	91.6	82.0	82.7	80.2	79.6	77.2	76.5	76.5
Greenhouse gas emissions from UK Produced Goods and Services	Scottish consumption of UK production	36.3	33.2	33.5	33.9	32.4	33.2	32.6	31.7	33.5	33.2	31.9	28.5	28.7	27.1	26.9	25.8	24.4	22.7
Greenhouse gas emissions embedded in Imported Goods and Services	Imports used by UK businesses for Scottish consumption	12.0	11.2	11.4	11.6	11.6	11.7	13.1	12.9	16.2	17.4	16.0	14.1	14.3	14.4	13.6	14.7	15.4	15.4
	Imports directly used by Scottish consumers	21.4	21.7	22.6	23.1	25.2	25.8	28.9	32.0	32.1	33.7	30.1	26.1	25.6	26.6	26.0	23.5	24.7	26.0
Greenhouse gas emissions Directly Produced By Scottish Residents	Private motoring	5.1	5.2	5.2	5.3	5.5	5.5	5.7	5.7	5.8	5.8	5.7	5.6	5.5	5.4	5.5	5.5	5.5	5.6
	Household heating	8.3	8.2	8.1	8.6	7.9	7.9	8.1	8.1	7.9	7.6	7.9	7.6	8.6	6.7	7.7	7.8	6.5	6.7

Table 3. Breakdown of Scotland's embedded greenhouse gas emissions by region of import, 1998 to 2015. Values in MtCO₂e

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
TOTAL IMPORTS	33.3	32.9	34.1	34.7	36.8	37.5	41.9	45.0	48.3	51.1	46.1	40.2	39.9	41.0	39.6	38.1	40.1	41.4
Imports from the EU	9.0	9.0	9.2	9.2	9.7	9.0	9.2	9.3	9.5	10.0	8.8	7.9	8.5	8.4	8.6	8.5	8.7	9.5
Imports from China	2.4	2.3	3.5	3.7	4.5	6.2	8.1	10.1	11.5	12.3	11.0	9.0	8.4	8.5	7.9	7.8	8.1	8.1
Imports from the rest of the world	21.9	21.6	21.4	21.8	22.6	22.2	24.6	25.6	27.3	28.8	26.3	23.3	23.0	24.1	23.1	21.8	23.3	23.8

Table 4. Comparison of Scotland's carbon footprint and carbon dioxide footprint, 1998-2015

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Carbon footprint (MtCO ₂ e)	83.1	79.5	80.8	82.5	82.6	84.1	88.2	90.4	95.4	97.7	91.6	82.0	82.7	80.2	79.6	77.2	76.5	76.5
Carbon dioxide footprint (MtCO ₂ e)	61.1	59.0	60.2	61.6	62.3	63.4	66.7	68.5	71.8	73.7	68.3	60.8	61.3	60.6	60.3	59.2	59.3	59.5

How has Scotland's Carbon Footprint been calculated?

Step 1. Develop an Input-output (IO) model

Input-output models are used by environmental researchers to make the link between the environmental impacts associated with production techniques and the consumption of products. The Leontief Input-Output model is constructed from economic data and shows the interrelationships between the industries that produce goods (outputs) and those that consume goods (inputs) from other industries in the process of making their own product. Further information on the Input-Output (IO) model and a User Guide can be found on the [Input-Output](#) webpages of the Scottish Government website.

Within the IO model, greenhouse gas emissions are reallocated from the industries that produce them to the final consumption activities that are assumed to ultimately have been their drivers. The emissions of each industry required in the production of a product are reallocated to the demand of this product, rather than the supply. In other words, we can show the greenhouse gas emissions associated with consumption. Adding an exogenous environmental variable to an IO framework produces an Environmentally Extended Input-Output model (EEIOM). The Greenhouse Gas model, also known as a Carbon Footprint, is one such example of a model.

Step 2. Develop a Multi-Regional Input-Output (MRIO) model

The University of Leeds has been contracted by the Scottish Government to provide estimates of Scotland's carbon footprint. The project updates previous work carried out by the Stockholm Environment Institute (SEI) published by the Scottish Government in 2009. A Multi-Regional Input-Output (MRIO) model allows the greenhouse gas emissions embodied to be estimated within traded goods and services. An MRIO model is used to link the flows of goods and services described in monetary terms, with the greenhouse gas emissions generated in the process of production.

Data relating to pre-1998 were assessed as being less reliable and consequently the time series used for this release is limited to 1998-2015. The system assumes a linear relationship between greenhouse gas emissions and changes in final demand, meaning that if all final demand doubled for a particular commodity, emissions would double too.

Step 3. Develop UK Based MRIO Model

In 2012, researchers from the Sustainable Research Institute at the University of Leeds constructed a UK MRIO model for DEFRA. The model uses the Office for National Statistics UK supply and use tables in 106 sectors and data from the Eora MRIO to trace the trade with the EU, China and Rest of the World to complete the MRIO.

Step 4. Develop the Scottish Consumption Based Account (the Scottish Carbon Footprint)

To calculate a consumption based account for Scotland, we use the UK MRIO model and replace the UK final demand with the Scottish final demand taken from the Scottish Input-Output tables.

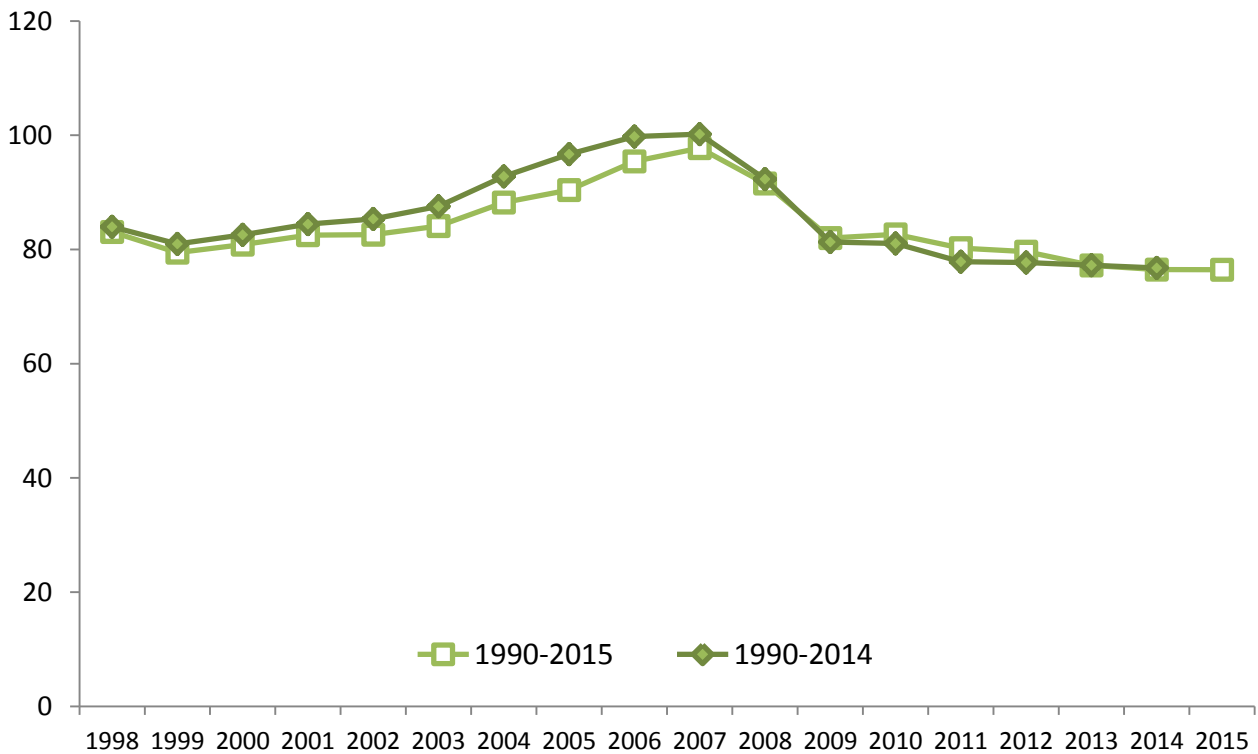
The consumption based account also contains data on direct greenhouse gas emissions from households and is broken down into those from home heating and travel. Data from the [UK Environmental Accounts](#) produced by the Office for National Statistics at a UK level have been used to calculate residential heating and private motoring consumption based emissions. Scotland's share of these UK greenhouse gas emissions are calculated using data from the [National Atmospheric Emissions Inventory](#) website.

Revisions since the previous Carbon Footprint for Scotland

There have been six releases of the model used to estimate Scotland's Carbon Footprint.

Chart 8 shows the differences between the 2014 and 2015 releases of the carbon footprint. Revisions to previously published estimates in this release are comparatively small and relate to revisions to the global emissions and trade data used to construct the multi-regional input-output model used in this carbon footprint.

Chart 8. Scotland's Carbon Footprint. Comparison of 1990-2014 and 1990-2015 series. Values in MtCO₂e



Revisions between the 1990-2012 and 1990-2015 publications

Since the carbon footprint was first published, successive releases have used different versions of the UK MRIO model. The 2012 release used a 2-region model which only distinguished the UK and the Rest of the World as trade regions. The 2013, 2015 and 2016 releases used a four region model, distinguishing imports from Europe, China and the Rest of World, using trade data from the Eora global MRIO. The 2017 model adopted the same four regions but used trade data from a source called EXIOBASE MRIO. The 2018 model used in this release contains no

further changes to the underlying model structure but does incorporate updated/revised data on global emissions and trade. The 2018 model presents the most accurate calculation to date.

Comparison of Scotland's carbon footprint and its territorial emissions

In addition to Scotland's carbon footprint, Scotland's carbon emissions are measured on a territorial basis. The different bases should be viewed as complementary ways of accounting for carbon emissions.

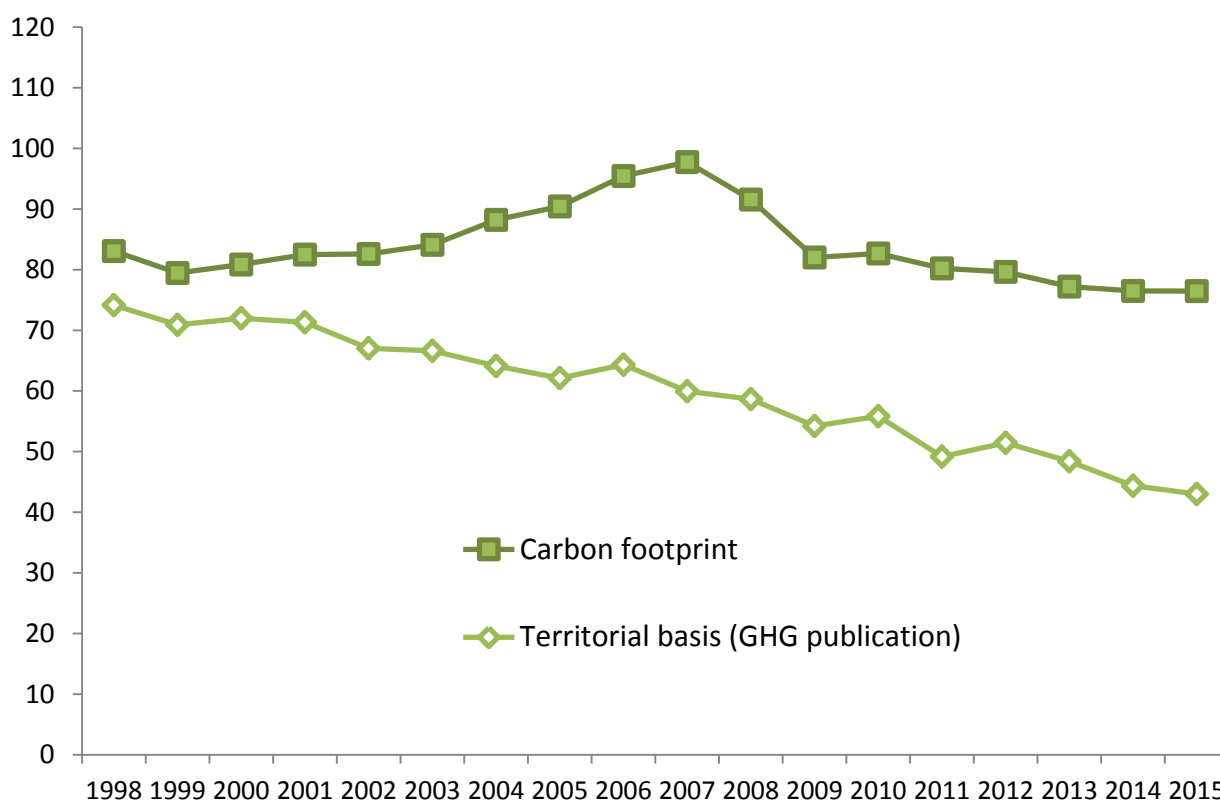
What are Territorial Emissions?

Territorial greenhouse gas emissions are those which occur within a country's or region's borders. The Scottish Government publishes emissions on a territorial basis from the Scottish greenhouse gas inventory as part of the Official Statistics publication [Scottish Greenhouse Gas Emissions 2016](#). The Scottish greenhouse gas inventory measures greenhouse gas emissions on a territorial basis, so only includes emissions within Scottish borders, though it also includes estimates of greenhouse gas emissions from international aviation and shipping based on Scotland's share of fuel sales from aviation and marine bunkers. The inventory also includes emissions and removals resulting from land use, land use change and forestry, which have been removed from the Carbon Footprint. Data from the Scottish Greenhouse Gas Inventory are used for reporting progress against the [Climate Change \(Scotland\) Act 2009](#) and for progress against the [Scottish Government's Sustainability Purpose Target](#).

The Scottish greenhouse gas inventory is a disaggregation of the UK's greenhouse gas inventory, which is used for reporting UK emissions to the EC and United Nations Framework Convention on Climate Change (UNFCCC). The [National Atmospheric Emissions Inventory](#) website contains direct comparisons between the Scottish and UK greenhouse gas inventory.

Chart 8 shows the relationship between the two different measures of greenhouse gas emissions relating to Scotland. The carbon footprint is notably bigger due to the impact of embedded greenhouse gas emissions from imports. Whilst the carbon footprint has fallen by 8.0 per cent between 1998 and 2015, equivalent greenhouse gas emissions on a territorial basis have fallen by 42.0 per cent (territorial emissions figures from the Scottish Greenhouse Gas Emissions 2016 publication) over the same time period.

Chart 9. Comparison of Scotland’s Carbon Footprint with its territorial greenhouse gas emissions: 1998 to 2015. Values in MtCO₂e



Access to Background Data and Charts

All the data which underpin the charts are available from an Excel workbook accompanying this release. This Excel workbook also contains the underlying outputs from the MRIO model with data for each year from 1998 to 2015 with information on greenhouse gas and carbon dioxide emissions for each economic sector.

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Correspondence and enquiries

For enquiries about this publication please contact:

Andrew Mortimer

Office of the Chief Economic Advisor

Telephone: 0131 244 0093

e-mail: andrew.mortimer@gov.scot

For general enquiries about Scottish Government statistics please contact:

Office of the Chief Statistician

Telephone: 0131 244 0442

email: statistics.enquiries@gov.scot

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