

# Scotland's Carbon Footprint 1998 – 2010

## An Official Statistics Publication for Scotland

This publication provides estimates of Scotland's greenhouse gas emissions on a consumption basis; that is emissions that 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.

### Key points

- Scotland's carbon footprint (including emissions from all greenhouse gases) rose in 2010, after falling from a peak in 2007.
- Between 2009 and 2010, Scotland's carbon footprint increased by 4 per cent following a 19 per cent fall in 2009. From 1998, the footprint rose by 15 per cent to a peak of 101.1 million tonnes carbon dioxide equivalent<sup>1</sup> (MtCO<sub>2</sub>e) in 2007 before falling to 78.7 MtCO<sub>2</sub>e in 2009. In 2010, Scotland's carbon footprint was 82.2 MtCO<sub>2</sub>e, 6 per cent less than in 1998 (87.9 MtCO<sub>2</sub>e).
- Similarly GHG emissions relating to Scottish final consumption of imports rose 34 per cent between 1998 and a peak in 2007. Since 2007, emissions from imports fell to a low in 2009 before increasing in 2010 to a level 4 per cent less than in 1998.
- Emissions relating to Scottish consumption of goods and services produced in the UK decreased by 12 per cent between 1998 and 2010 while emissions relating to Scottish residents direct consumption of fuel increased by 2%.
- Whilst Scotland's carbon footprint has fallen by 6 per cent between 1998 and 2010, comparable emissions on a territorial basis (Scotland's production emissions) have fallen by 15 per cent.

The carbon footprint of Scotland includes the six main greenhouse gases (GHGs) including carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O) and fluorinated compounds (hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride).

The estimates for all greenhouse gases are less robust than estimates for CO<sub>2</sub> only, largely because of inherent uncertainties in the estimation of non-CO<sub>2</sub> emissions. The carbon dioxide footprint relates just to CO<sub>2</sub> emissions. Scotland's carbon dioxide footprint rose by 3 per cent between 1998 and 2010, with a peak in 2007.

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<sup>1</sup> A carbon dioxide equivalent is a metric 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 with the same 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.

The carbon footprint refers to emissions that are associated with the spending of Scottish residents on goods and services, wherever in the world these emissions arise along the supply chain, and those which are directly generated by Scottish households through private motoring etc. These 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. To find out what effect Scottish consumption has on GHG emissions we need to take into account where the goods we buy come from and their associated supply chains.

Since 1990, the UK’s economy has continued to move from a manufacturing base towards the services sector. One of the consequences of this is that more of the goods and services we buy and use are now produced outside the UK. The current data breaks down emissions into those generated by households, those produced in the UK and imports either from the rest of the EU, China or the rest of the World.

Inherently the 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 GHG emissions generated domestically. The methodology and data for calculating these emissions resulting from imports have been substantially revised since the last release.

This statistical report meets the requirements under Section 37 of the Climate Change (Scotland) Act 2009. The data contained within this report are also used to inform National Indicator 47: “Reduce Scotland’s Carbon Footprint”.

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## Greenhouse gas emissions associated with Scottish consumption

Scotland's carbon footprint can be separated into a number of components: those generated directly by Scottish households through heating and private motoring, those emissions relating to goods and services produced by UK business, and those emissions relating to imported goods and services, broken down into imports from the EU, China and the Rest of the World. These are often referred to as emissions that are "embedded" in imports.

**Figure 1 GHG emissions associated with Scottish consumption 1998 to 2010**

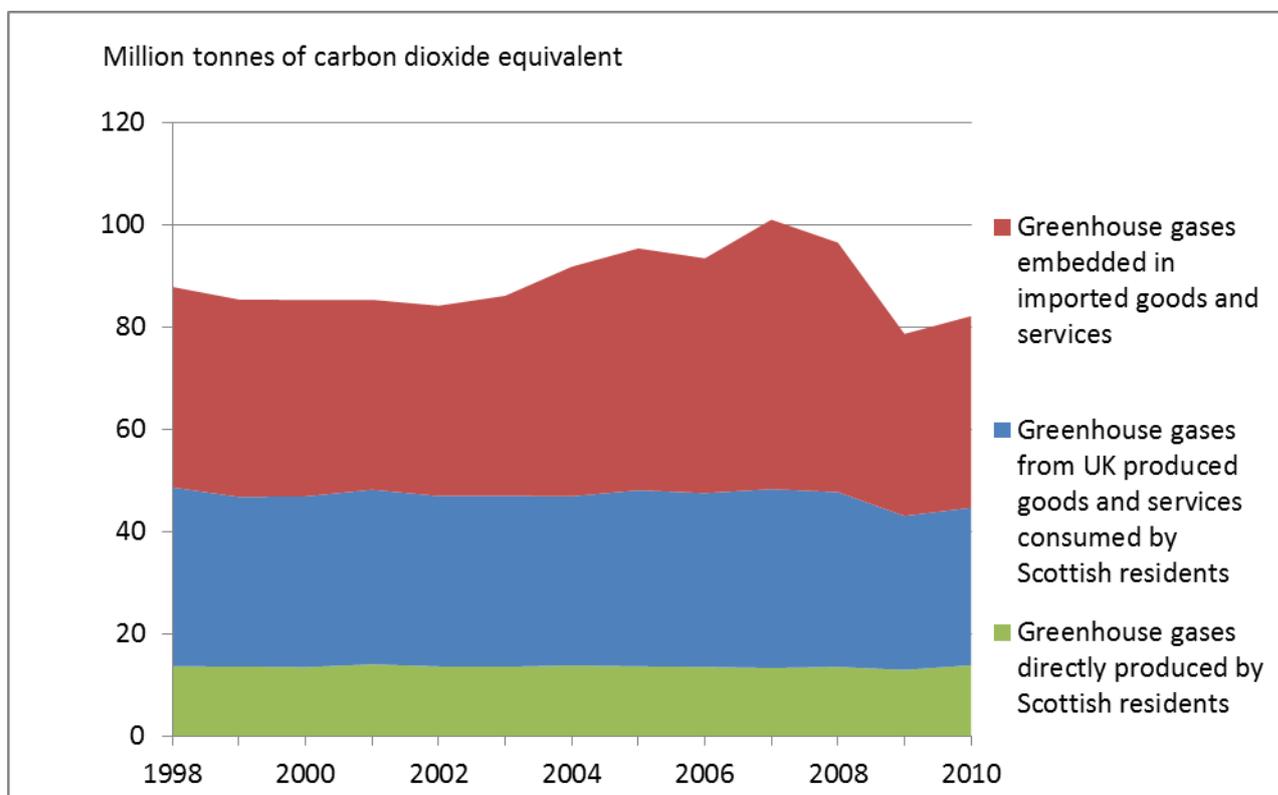
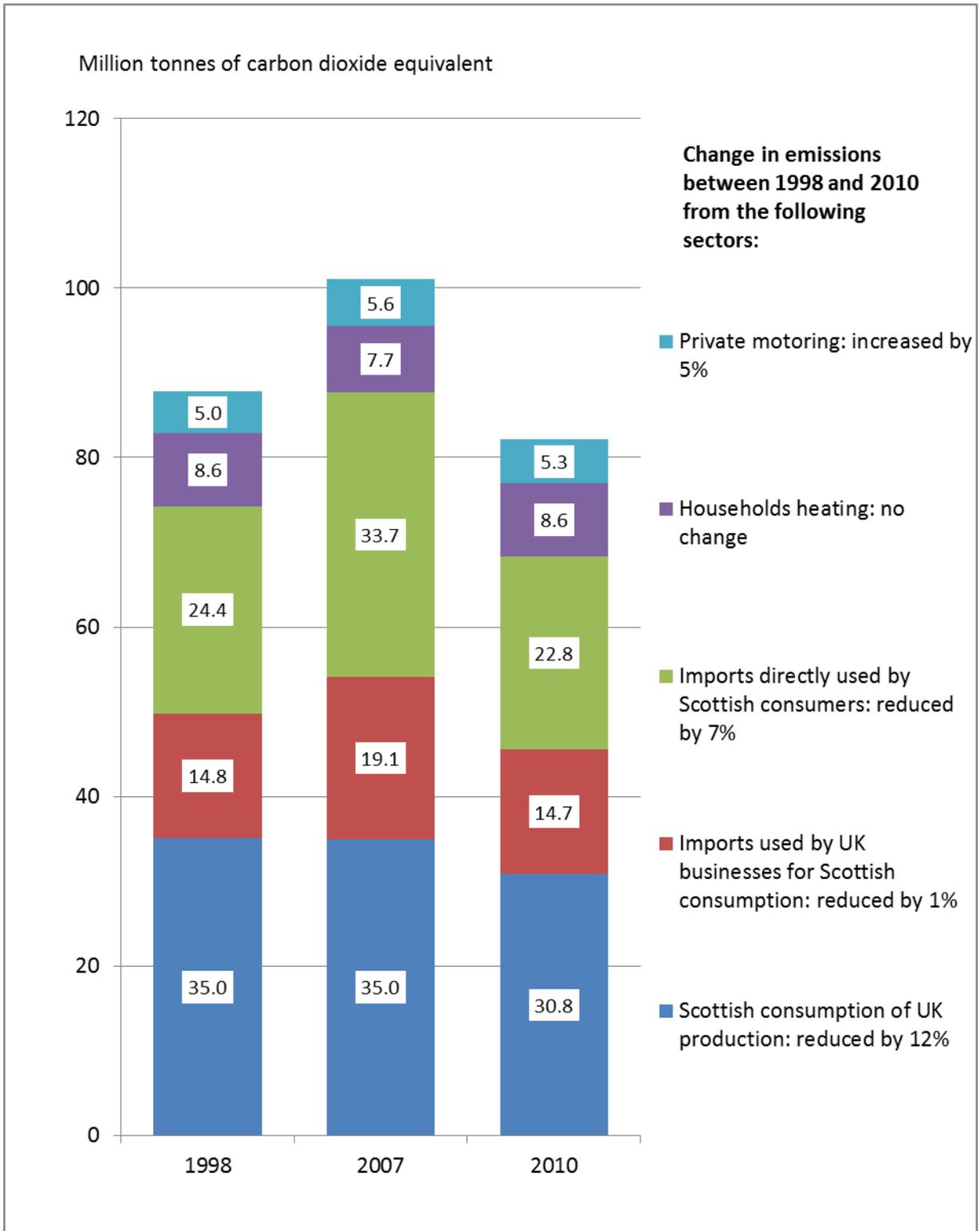


Figure 1 shows that Scotland's carbon footprint rose from in 1998 to a peak in 2007 at 101.1 MtCO<sub>2</sub>e and since then has fallen 19 per cent to 82.2 MtCO<sub>2</sub>e, with a notably large dip occurring in 2009 before a slight rise in 2010. GHG emissions associated with imported goods and services accounted for around 45 per cent of Scotland's carbon footprint in 1998 (39.2 MtCO<sub>2</sub>e); by 2007 their share had increased to 52 per cent but by 2010 the share had fallen back to 46 per cent (37.5 MtCO<sub>2</sub>e). Indirect GHG emissions relating to Scottish residents consumption of UK produced goods and services fell 12 per cent from 35.0 MtCO<sub>2</sub>e to 30.8 MtCO<sub>2</sub>e between 1998 and 2010. GHG emissions generated directly by Scottish residents have remained relatively constant at around 13.5 MtCO<sub>2</sub>e, with a 2% increase between 1998 and 2010; the rise in 2010 being linked to the increased use of heating in a cold year.

**Figure 2 Comparison of consumption based GHG emissions in 1998, 2007 and 2010**



**Table 1 Description of the main activities shown in Figure 2**

<b>Activity</b>	<b>Description</b>
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.
Imports used by UK businesses for Scottish consumption	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	Emissions associated with the production of imports which are used by Scottish final consumers
Private motoring	Emissions generated directly by households through private motoring.
Household heating	Emissions arising from households' use of fossil fuels for heating, households use of aerosols, etc.

Between 1998 and 2010 there was a 6 per cent reduction in the Scottish GHG footprint. Figure 2 sets out the changes in each of five main activities that make up the total.

**Emissions associated with UK production**, (which excludes those directly generated by households), decreased by 12 per cent between 1998 and 2010. UK produced goods and services accounted for 37 per cent of the total Scottish GHG footprint in 2010, compared with 40 per cent in 1998.

**Emissions associated with imports**, both those directly used by consumers and those used by businesses, largely account for the increase in Scotland's carbon footprint between 1998 and 2007. Over this period emissions embedded in imports used by UK businesses for Scottish consumption increased by 29 per cent while emissions associated with the production of imports used directly by Scottish consumers increased by 38 per cent. However between 2007 and 2010, emissions associated with both categories have fallen to below 1998 levels. Overall embedded emissions from imports increased from 39.2 MtCO<sub>2</sub>e in 1998 to a peak of 52.8 MtCO<sub>2</sub>e in 2007 but have since fallen by 29 per cent to 37.5 MtCO<sub>2</sub>e in 2010.

The absolute amount of **emissions generated directly by households** has remained fairly constant at around 13.5 MtCO<sub>2</sub>e. Within the category, emissions from heating have fluctuated around 7.5 – 8.5 MtCO<sub>2</sub>e, depending largely upon the severity of the winter. Private motoring emissions increased between 1998 and 2006 due to an increase in travel by car. Reductions since then are in part due to the introduction of more fuel efficient vehicles.

**Figure 3 Breakdown of consumption emissions by region of import**

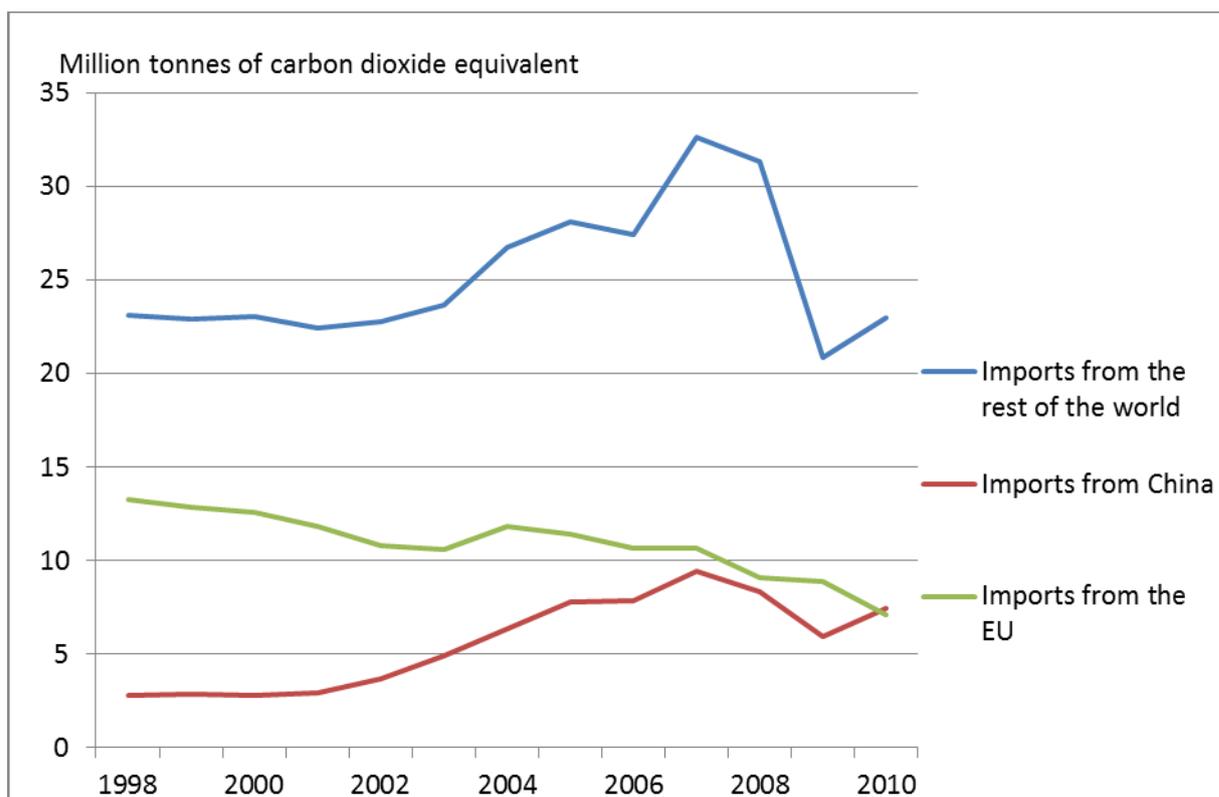


Figure 3 shows that emissions associated with imports from China have increased 164 per cent since 1998, from 2.8 MtCO<sub>2</sub>e in 1998 to 7.4 MtCO<sub>2</sub>e in 2010, and now account for 9 per cent of Scotland’s carbon footprint as opposed to 3 per cent in 1998. Since 1998, emissions relating to EU imports have decreased 47 per cent to 7.1 MtCO<sub>2</sub>e in 2010, below the level for China. The absolute amount of emissions embedded in imports from the Rest of the World has reduced by 1 per cent since 1998 to 23.0 MtCO<sub>2</sub>e in 2010. These emissions have accounted for around 60% of embedded emissions in imports across the time period.

**Contribution of carbon dioxide emissions to Scottish consumption**

CO<sub>2</sub> is the main greenhouse gas, accounting for 73 per cent of Scotland’s total carbon footprint in 2010, up from 67 per cent in 1998.

**Background to the statistics**

The University of Leeds has been contracted for five years 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. It uses a multi-region input-output (MRIO) model, to link the flows of goods and services described in monetary terms, with the emissions generated in the process of production. The latest estimates benefit from recent modelling developments at the University of Sydney where data from their “Eora” model feeds directly into the Scottish model. In brief, this is a sophisticated computer model that can assimilate data on emissions and product flows from

different countries and years in different classifications and valuations, dealing with the data gaps and reconciling inconsistencies. Data relating to pre-1998 was assessed as being less reliable and consequently the time series used for this release is limited to 1998-2010.

The methods and data sources used in this research remain consistent with those used in the previously published results that are documented in Wiedmann et al (2008i) with the differences relating to country coverage and sector breakdown. Due to a change in the Standard Industrial Classification (SIC) used in some of the source data, additional effort has been needed to re-allocate estimates from the more recent classification covering 110 sectors to the previous coverage of 123 sectors.

### **Revisions to the data since previous release**

Provisional results for 1998-2009 were published on the Scottish Government website as “data being developed” (Scottish Government, 2012). Since then, the model has been further refined by the University of Leeds. It now separates imports into three regions: China, the EU and the Rest of the World and provides consistent time series over the whole period – previously results prior to 2004 did not reflect the technology of every country along the supply chain. These refinements are able to capture emissions that occurred in these regions across all stages of the supply chain. Whilst the trends remain consistent with previous estimates, the recent refinements have resulted in GHG estimates that are generally higher than previously estimated. In addition the latest figures make use of updated Scottish Input-Output tables which use the 2007 Standard Industrial Classification (SIC). A methodological note is available on request further detailing the revisions.

### **Greenhouse gas emissions uncertainty**

Defra published research on the uncertainty in the estimates as part of a previous report on consumption-based CO<sub>2</sub> emissions between 1992 and 2004 (Wiedmann et al, 2008ii). The research showed that the relative standard error for total UK CO<sub>2</sub> consumption emissions in any one year lies within the range of 3.3 per cent for 1994 and 5.5 per cent for 2004.

Based on the uncertainty estimates mentioned above further research undertaken for the Scottish Government (Stockholm Environment Institute, 2009 ) estimated that the time series of GHG footprint for Scotland had a relative standard error (RSE) for annual estimates in the region of  $\pm 5\%$  for CO<sub>2</sub> and in the region of up to  $\pm 10\%$  for other GHGs. This gave an RSE for all GHGs in the region of  $\pm 7\%$ . Since then there have been a number of improvements in the model which should have reduced the range of errors in recent years.

### **Relationship with territorial emissions**

Scotland’s carbon emissions are measured in different ways for different purposes. Each basis of measurement is published by the government. The different bases should be viewed as complementary ways of accounting for carbon emissions.

#### *Territorial basis*

Emission estimates are published on the NAEI website on behalf of the Scottish Government, the Department for Energy and Climate Change (DECC), the Welsh Assembly Government and the department of Environment for Northern Ireland in the report “Greenhouse gas inventories for England, Scotland, Wales and Northern

Ireland”. This is a disaggregation of the UK inventory which is used as the basis for reporting UK emissions to the EC and United Nations Framework Convention on Climate Change (UNFCCC). The figures for Scotland form the basis for reporting on progress towards our domestic reduction targets. The Scottish GHG inventory measures emissions on a territorial basis, so only includes emissions which occur within Scottish borders, though it also includes estimates of GHG emissions emitted 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. Since these are not accounted for in the carbon footprint they have been subtracted from the territorial emissions in the comparison.

**Figure 4 Relationship of a consumption measure of Scotland’s GHG emissions with a territorial basis: 1998 to 2010**

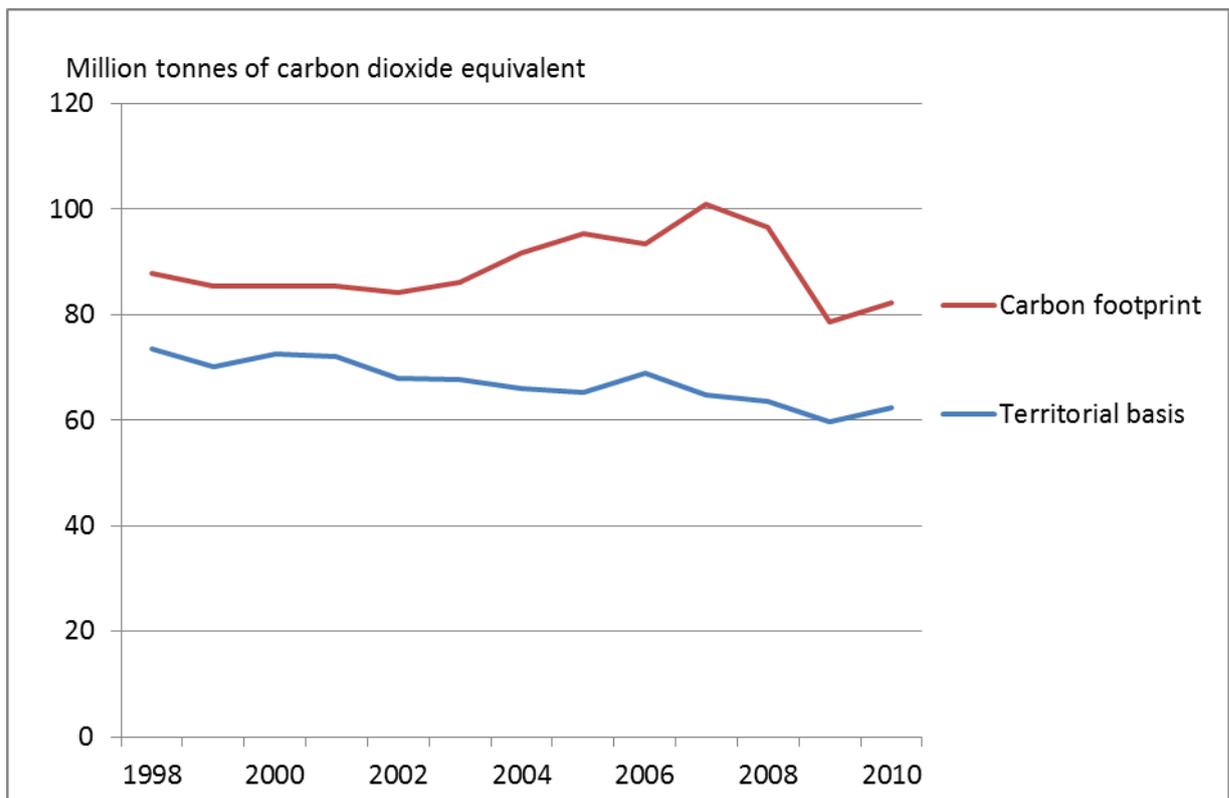


Figure 4 shows the relationship between the two different measures of GHG emissions relating to Scotland. The carbon footprint is notably biggest due to the impact of embedded emissions from imports. Whilst the carbon footprint has fallen by 6 per cent over the time period, comparable emissions on a territorial basis have decreased by 15 per cent. These contrasting trends may be due to the UK economy further moving from a manufacturing base to a service base with a greater dependence upon imports and their associated embedded emissions.

## References

### Previous reports on Scotland's consumption emissions

Stockholm Environment Institute (2009) [Production of a Time Series of Scotland's Ecological and Greenhouse Gas Footprints](#). Scottish Government, Edinburgh, UK.

Scottish Government (2012) [Scottish Greenhouse Gas Emissions on a Consumption Basis](#)

### Methodological papers

Wiedmann, T., Wood, R., Lenzen, M., Minx, J., Guan, D. and Barrett, J. (2008i) [Development of an Embedded Carbon Emissions Indicator – Producing a Time Series of Input-Output Tables and Embedded Carbon Dioxide Emissions for the UK by Using a MRIO Data Optimisation System](#), Report to the UK Department for Environment, Food and Rural Affairs by Stockholm Environment Institute at the University of York and Centre for Integrated Sustainability Analysis at the University of Sydney, June 2008. Defra, London, UK

Wiedmann, T., Lenzen, M. and Wood, R. (2008ii) [Uncertainty Analysis of the UK-MRIO Model – Results from a Monte-Carlo Analysis of the UK Multi-Region Input-Output Model \(Embedded Emissions Indicator\)](#); Report to the UK Department for Environment, Food and Rural Affairs by Stockholm Environment Institute at the University of York and Centre for Integrated Sustainability Analysis at the University of Sydney. Defra, London, UK.

### Scotland's territorial emissions

Salisbury, E, Claxton, R, Goodwin, J, Thistlethwaite, G, MacCarthy, J, Pang, Y, Thomson, A and Cardenas, L. (2013) [Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland: 1990 - 2011](#) A report to the Department of Energy and Climate Change, the Scottish Government, the Welsh Government and the Northern Ireland Department of the Environment by Ricardo-AEA and Aether.

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