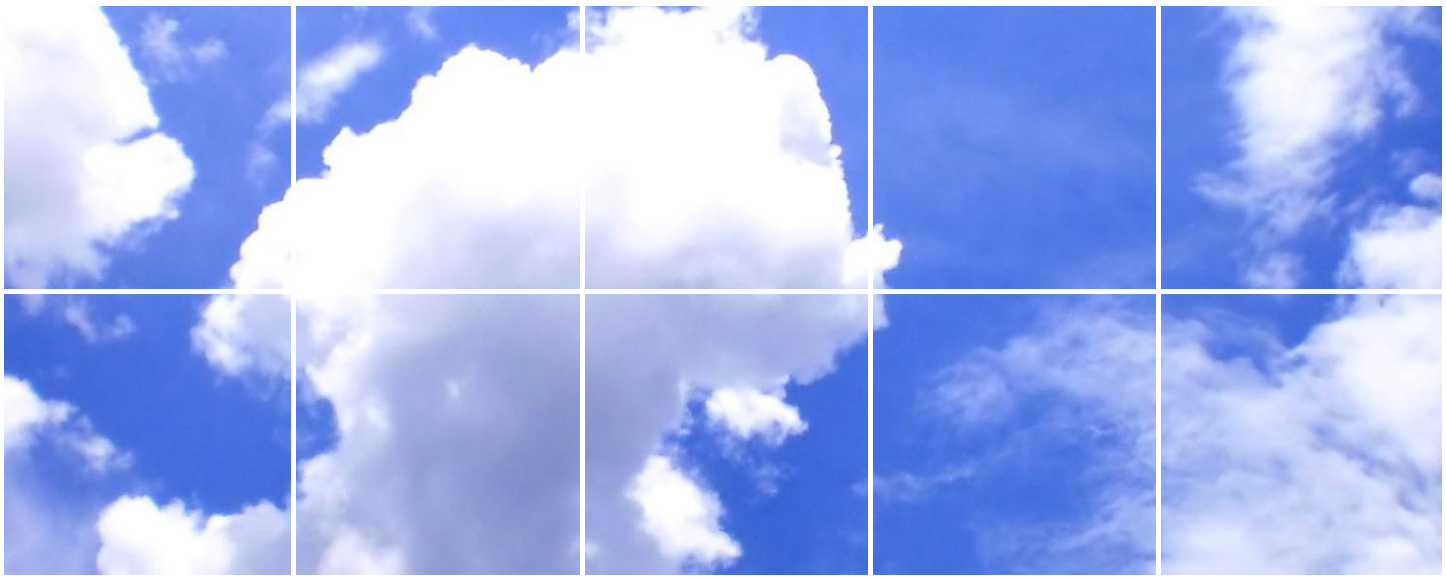
National Atmospheric Emissions Inventory



Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland: 1990 – 2011

Report to the Department of Energy and Climate Change, The Scottish Government, The Welsh Government and The Northern Ireland Department of the Environment.

June 2013

Aether RICARDO-AEA

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Executive Summary

This report presents the latest estimates of greenhouse gas (GHG) emission inventories for the constituent countries of the UK. Separate GHG emission inventories have been estimated for England, Scotland, Wales and Northern Ireland for the years 1990, 1995 and 1998 to 2011. The GHGs reported are:

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxide (N_2O)
- Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)
- Sulphur hexafluoride (SF_6)

The estimates are based on, and consistent with the United Nations Framework Convention on Climate Change (UNFCCC) reporting guidelines and the 2011 UK Greenhouse Gas Inventory (Webb et al., 2013).

Emissions from offshore oil and gas exploration and production activities are not allocated to any country, and are presented as "Unallocated".

Estimates also exclude the Crown Dependencies of Jersey, Guernsey and Isle of Man, and those Overseas Territories joining UK instruments of ratification for the UNFCCC and the Kyoto Protocol namely: Cayman Islands, Falkland Islands, Bermuda, Montserrat and Gibraltar. Consistent with the UK GHG inventory reporting protocol, the Devolved Administration (DA) inventory data presented in this report also excludes emissions from international shipping and aviation. Estimates are reported as "memo items" and are excluded from national totals presented in this report.

The main focus of the report is emissions presented on a *by source* (emissions are allocated to the source sector in which they occur) basis for the DA countries, and figures and percentages within this report refer to this dataset, unless otherwise stated.

Country-Specific Climate Change Commitments

The Climate Change (Scotland) Act (2009), the 'One Wales' Commitment to reduce greenhouse gas emissions and the Climate Change Strategy for Wales (2010), and the Northern Ireland Greenhouse Gas Emissions Action Plan (2011), outline each of the DAs' aims and objectives in reducing GHG emissions.

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 international aviation. In contrast, the Welsh emissions account excludes emissions from the traded sector[1] and international transport sources, with specific sector targets to be established. The Northern Ireland Executive's current Programme for Government target is to continue to work towards a 35% reduction in greenhouse gas emissions by 2025 based on 1990 levels of the by source estimates.

[1] The "traded sector" refers to emissions from installations that operate within the EU ETS, the EU-wide trading scheme that has been operational since 2005 and includes emissions from large energy consumers within the industrial and commercial sectors.

By Source DA GHG Emission Estimates in 2011

The UK distribution of regional net[2] greenhouse gas emissions in 2011, expressed in terms of global warming potentials (GWP), is detailed below, and shows the trends in emissions from the Base Year[3].

- England has a **76.7%** share of total net GHG emissions in **2011** and emissions have declined by **30.9%** since the Base Year.
- Scotland has an **8.9%** share of total net GHG emissions in **2011**, and the trend since the Base Year is a decline of **30.8%**.
- Wales has an **8.0%** share of total net GHG emissions in **2011** and emissions have declined by **20.6%** since the Base Year.
- Northern Ireland has a **3.6%** share of total net GHG emissions in **2011**, and the trend since the Base Year is a decline of **17.5%**.
- **2.8%** of the UK emissions total is unallocated in **2011.** Unallocated emissions have increased by **2.9%** since the Base Year.

Tables ES1.1 to ES1.4 present the time series of emissions for each constituent country.

- 1995 is used as the Base Year (BY) for emissions of HFCs, PFCs and nitrous oxide and 1990 for all other gases in the UK's Climate Change Programme, in accordance with 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 Land Use, Land Use Change and Forestry sectors;
- The percentage changes presented in this chapter are calculated from emission estimates held at full precision within a database. The emissions quoted in Table ES1 and other tables relevant to this Chapter are values rounded from estimates in the database. The percentages and emissions totals that could be calculated from these tables may therefore differ slightly from percentages that have been calculated from the emission estimates held at full precision.
- Emissions data at full precision can be found in the tables that accompany this report "DA_GHGi_1990-2011_Issue 1.xls"

[2] Total net emissions include removals in the LULUCF sector and exclude emissions from international aviation and shipping.

[3] Base years for UK greenhouse gas emissions are: 1990 for carbon dioxide, methane and nitrous oxide, 1995 for the fluorinated gases.

Table ES1.1: England GHG Emissions, Base Year (BY) to 2011 (Mt CO_2e)

	Base Year	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	% Change BY - 2011
By Gas including LULUCF																		
Carbon	486.77	486.77	450.20	452.92	444.92	451.41	463.98	456.59	468.46	471.20	472.26	468.69	467.21	454.69	413.18	420.82	394.55	-19%
CH4	73.72	73.72	62.44	53.17	49.45	46.18	41.73	39.65	36.42	35.07	33.31	32.48	31.64	30.87	29.83	29.14	28.29	-62%
HFCs	15.11	11.38	15.11	16.12	9.38	8.25	9.02	9.35	10.33	9.48	10.23	10.79	11.02	11.50	11.79	12.09	12.31	-18%
N2O	53.56	53.56	43.26	43.22	32.62	32.43	30.03	28.92	28.61	29.58	28.95	27.15	27.16	26.59	24.65	25.02	24.01	-55%
PFCs	0.23	0.97	0.23	0.20	0.18	0.25	0.21	0.13	0.14	0.23	0.18	0.18	0.12	0.09	0.06	0.17	0.27	19%
SF6	1.12	0.94	1.12	1.13	1.28	1.62	1.28	1.35	1.18	0.99	0.96	0.75	0.68	0.61	0.57	0.59	0.52	-54%
LULUCF only by Gas																		
Carbon	5.67	5.67	5.55	4.31	3.96	3.63	3.41	2.98	2.89	2.43	2.22	2.00	1.77	1.52	1.49	1.38	1.48	-74%
CH4	0.01	0.01	0.02	0.01	0.01	0.02	0.01	0.02	0.03	0.01	0.02	0.02	0.02	0.01	0.02	0.01	0.01	-3%
N2O	0.32	0.32	0.33	0.32	0.32	0.31	0.30	0.30	0.31	0.29	0.29	0.28	0.28	0.27	0.27	0.25	0.24	-25%
LULUCF Net Emissions	6.01	6.01	5.90	4.64	4.29	3.96	3.73	3.29	3.23	2.74	2.52	2.30	2.07	1.81	1.78	1.64	1.73	-71%
By National Communication Sector																		
Agriculture	40.45	40.45	39.08	38.36	37.89	36.63	34.29	34.54	34.15	34.37	34.23	32.79	32.32	32.19	31.64	31.93	31.94	-21%
Business	88.04	87.04	84.34	83.83	83.90	85.29	87.86	83.65	85.45	84.16	85.59	83.15	82.32	80.86	72.21	70.75	68.43	-22%
Energy Supply	211.91	211.91	167.86	153.64	144.49	148.69	157.31	158.87	166.96	165.27	164.99	165.61	167.09	160.61	142.84	145.80	138.98	-34%
Industrial Process	50.98	49.14	40.70	39.69	22.15	20.24	18.60	16.53	16.68	16.07	15.13	13.70	15.02	13.58	8.73	9.01	7.57	-85%
Land Use Change	6.01	6.01	5.90	4.64	4.29	3.96	3.73	3.29	3.23	2.74	2.52	2.30	2.07	1.81	1.78	1.64	1.73	-71%
Public	10.69	10.69	10.74	10.61	10.36	9.80	10.18	8.70	8.72	9.46	9.29	8.44	7.80	7.79	6.83	6.96	5.88	-45%
Residential	63.51	63.18	65.08	71.75	71.65	72.36	74.29	71.68	72.83	74.24	71.08	68.67	65.75	67.08	62.60	72.33	55.69	-12%
Transport	101.12	101.12	101.46	105.33	106.11	105.13	105.12	106.94	106.22	107.17	107.55	108.06	108.94	104.04	100.01	98.76	97.45	-4%
Waste Management	37.01	37.01	32.37	27.56	25.50	24.22	21.60	19.99	17.74	16.62	16.20	15.90	15.67	15.24	14.64	14.17	13.70	-63%
Total Net Emissions	609.73	606.57	547.55	535.41	506.33	506.33	512.99	504.20	511.97	510.09	506.58	498.62	496.99	483.20	441.27	451.34	421.38	-31%

Table ES1.2: Scotland GHG Emissions, Base Year (BY) to 2011 (Mt CO_2e)

	Base Year	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	% Change BY - 2011
By Gas including LULUCF																		
Carbon	53.78	53.78	53.47	53.61	51.01	53.66	53.65	49.78	49.86	47.95	47.34	51.03	46.92	45.87	42.22	44.98	39.45	-27%
CH4	12.18	12.18	10.91	9.67	8.87	8.45	7.77	7.15	6.63	6.46	6.41	6.26	6.13	5.94	5.76	5.68	5.63	-54%
HFCs	0.11	0.00	0.11	0.40	0.44	0.55	0.65	0.72	0.82	0.89	0.96	1.02	1.07	1.12	1.15	1.18	1.20	965%
N2O	6.79	6.79	6.34	6.52	6.35	6.15	6.08	6.00	5.87	5.72	5.50	5.45	5.19	5.07	4.98	4.97	4.91	-28%
PFCs	0.09	0.11	0.09	0.11	0.12	0.11	0.06	0.08	0.08	0.07	0.07	0.06	0.06	0.05	0.05	0.05	0.05	-41%
SF6	0.03	0.02	0.03	0.04	0.05	0.05	0.05	0.05	0.05	0.06	0.07	0.06	0.05	0.05	0.05	0.05	0.04	44%
LULUCF only by Gas																		
Carbon	-2.44	-2.44	-3.09	-3.49	-3.69	-3.87	-4.14	-4.53	-4.73	-5.30	-5.32	-5.42	-5.57	-5.78	-5.77	-5.75	-5.50	126%
CH4	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	33%
N2O	0.38	0.38	0.40	0.40	0.40	0.38	0.36	0.35	0.34	0.32	0.31	0.29	0.28	0.27	0.26	0.24	0.22	-41%
LULUCF Net Emissions	-2.05	-2.05	-2.68	-3.08	-3.28	-3.48	-3.77	-4.18	-4.36	-4.97	-5.00	-5.12	-5.28	-5.50	-5.51	-5.51	-5.27	156%
By National Communication Sector																		
Agriculture	9.92	9.92	9.76	9.97	9.78	9.43	9.17	9.16	9.04	8.91	8.73	8.58	8.27	8.08	7.96	7.96	7.93	-20%
Business	11.81	11.69	8.89	9.11	9.25	9.84	10.44	9.60	9.49	9.31	10.06	9.61	9.21	9.67	8.69	8.76	8.79	-26%
Energy Supply	22.41	22.41	26.48	25.50	23.15	26.04	25.33	23.28	23.44	21.78	20.40	24.44	21.07	19.95	18.56	20.74	16.93	-24%
Industrial Process	1.83	1.88	0.56	0.63	0.60	0.58	0.56	0.60	0.62	0.62	0.54	0.55	0.53	0.52	0.40	0.38	0.44	-76%
Land Use Change	-2.05	-2.05	-2.68	-3.08	-3.28	-3.48	-3.77	-4.18	-4.36	-4.97	-5.00	-5.12	-5.28	-5.50	-5.51	-5.51	-5.27	156%
Public	1.23	1.23	1.07	1.12	1.12	1.03	1.10	0.92	0.91	1.03	1.07	0.97	0.92	0.95	0.85	0.87	0.75	-39%
Residential	8.18	8.15	8.14	8.48	8.40	8.28	8.72	8.08	8.06	8.16	7.98	7.76	7.55	7.78	7.30	8.37	6.58	-20%
Transport	10.50	10.50	10.51	10.89	10.99	10.83	10.79	11.10	11.15	11.24	11.37	11.58	11.76	11.31	10.86	10.70	10.47	0%
Waste Management	6.71	6.71	5.79	4.83	4.40	4.12	3.60	3.28	2.88	2.69	2.61	2.55	2.46	2.40	2.32	2.24	2.17	-68%
Total Net Emissions	70.52	70.43	68.53	67.45	64.39	66.67	65.95	61.85	61.22	58.77	57.77	60.92	56.49	55.15	51.43	54.51	48.79	-31%

Table ES1.3: Wales GHG Emissions, Base Year (BY) to 2011 (Mt CO_2e)

	Base Year	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	% Change BY - 2011
By Gas including LULUCF																		
Carbon	44.46	44.46	41.69	44.08	45.00	47.18	44.53	37.88	39.14	43.14	40.93	42.71	40.24	42.69	36.51	39.85	37.56	-16%
CH4	7.41	7.41	6.34	5.86	5.73	5.50	5.04	4.86	4.74	4.66	4.55	4.60	4.28	4.05	3.96	3.98	3.95	-47%
HFCs	0.06	0.00	0.06	0.21	0.23	0.29	0.33	0.36	0.41	0.41	0.49	0.51	0.53	0.55	0.57	0.58	0.59	892%
N2O	4.06	4.06	4.05	3.95	4.02	3.81	3.66	3.47	3.55	3.46	3.55	3.40	3.12	2.93	2.89	3.02	3.00	-26%
PFCs	0.15	0.31	0.15	0.08	0.07	0.10	0.11	0.10	0.05	0.04	0.06	0.06	0.05	0.06	0.03	0.00	0.00	-97%
SF6	0.08	0.07	0.08	0.08	0.10	0.12	0.10	0.10	0.09	0.07	0.07	0.05	0.05	0.04	0.04	0.04	0.04	-54%
LULUCF only by Gas																		
Carbon	-0.09	-0.09	0.06	0.09	0.11	0.03	0.00	-0.08	-0.13	-0.20	-0.18	-0.19	-0.23	-0.23	-0.24	0.08	0.07	-184%
CH4	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.01	0.00	0.01	0.01	49%
N2O	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.07	0.07	0.07	0.07	0.06	0.06	0.06	0.06	-12%
LULUCF Net Emissions	-0.02	-0.02	0.14	0.17	0.19	0.11	0.07	0.00	-0.05	-0.13	-0.11	-0.12	-0.15	-0.16	-0.17	0.15	0.14	-985%
By National Communication Sector																		
Agriculture	7.15	7.15	7.17	7.12	7.24	6.86	6.62	6.41	6.55	6.45	6.49	6.40	5.83	5.52	5.47	5.64	5.64	-21%
Business	13.75	13.70	14.33	15.05	16.40	16.28	13.19	9.27	10.40	11.07	9.75	10.09	10.24	9.62	7.98	9.60	9.33	-32%
Energy Supply	17.50	17.50	12.78	13.72	13.38	16.18	17.15	15.47	14.84	17.74	17.05	18.35	16.07	19.29	16.25	16.55	15.73	-10%
Industrial Process	2.71	2.87	3.05	2.93	3.14	3.18	2.45	1.91	2.49	2.57	2.72	2.71	2.68	2.41	1.49	2.17	2.05	-24%
Land Use Change	-0.02	-0.02	0.14	0.17	0.19	0.11	0.07	0.00	-0.05	-0.13	-0.11	-0.12	-0.15	-0.16	-0.17	0.15	0.14	-985%
Public	0.75	0.75	0.68	0.55	0.54	0.52	0.54	0.45	0.45	0.50	0.52	0.46	0.42	0.42	0.37	0.38	0.32	-58%
Residential	4.98	4.96	5.12	5.55	5.47	5.30	5.40	5.06	5.09	5.18	4.85	4.80	4.53	4.69	4.39	4.98	3.87	-22%
Transport	6.06	6.06	6.05	6.23	6.23	6.14	6.12	6.29	6.29	6.42	6.41	6.47	6.56	6.32	6.06	5.96	5.85	-4%
Waste Management	2.38	2.38	2.09	1.83	1.71	1.63	1.44	1.32	1.17	1.09	1.06	1.05	1.03	1.01	0.98	0.95	0.92	-61%
Total Net Emissions	55.25	55.35	51.42	53.15	54.30	56.20	52.97	46.17	47.25	50.90	48.73	50.21	47.20	49.13	42.81	46.37	43.84	-21%

Table ES1.4: Northern Ireland GHG Emissions, Base Year (BY) to 2011 (Mt CO_2e)

	Base Year	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	% Change BY - 2011
By Gas including LULUCF																		
Carbon	16.95	16.95	17.29	16.85	17.10	17.08	17.61	15.77	15.81	15.81	16.78	17.33	16.14	16.28	14.62	15.36	14.29	-16%
CH4	3.70	3.70	3.56	3.52	3.38	3.26	3.18	3.12	3.05	3.01	3.04	3.00	2.96	2.93	2.86	2.87	2.87	-22%
HFCs	0.04	0.00	0.04	0.13	0.15	0.19	0.20	0.22	0.26	0.32	0.31	0.33	0.35	0.36	0.37	0.38	0.39	906%
N2O	3.72	3.72	4.13	4.01	4.15	3.92	3.83	3.34	3.35	3.26	3.14	3.05	2.93	2.81	2.81	2.88	2.87	-23%
PFCs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-73%
SF6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	124%
LULUCF only by Gas																		
Carbon	0.02	0.02	-0.11	-0.20	-0.20	-0.17	-0.11	-0.09	-0.09	-0.03	-0.01	-0.02	0.04	0.08	0.11	0.08	0.12	392%
CH4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	42%
N2O	0.07	0.07	0.07	0.07	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.06	0.06	-14%
LULUCF Net Emissions	0.10	0.10	-0.04	-0.14	-0.13	-0.11	-0.05	-0.03	-0.02	0.04	0.06	0.04	0.11	0.15	0.18	0.14	0.18	83%
By National Communication Sector																		
Agriculture	6.04	6.04	6.40	6.46	6.40	6.13	6.06	6.05	6.07	5.97	5.91	5.76	5.60	5.45	5.43	5.52	5.55	-8%
Business	2.72	2.70	2.47	2.10	2.27	2.27	2.52	1.95	2.01	2.12	2.43	2.39	2.42	2.31	2.25	2.48	2.28	-16%
Energy Supply	5.31	5.31	6.54	6.16	6.22	6.34	6.57	5.17	4.96	4.85	5.35	5.75	4.66	4.84	3.68	3.94	3.73	-30%
Industrial Process	0.76	0.76	0.78	0.83	0.94	0.68	0.65	0.21	0.22	0.22	0.42	0.43	0.49	0.40	0.18	0.17	0.16	-79%
Land Use Change	0.10	0.10	-0.04	-0.14	-0.13	-0.11	-0.05	-0.03	-0.02	0.04	0.06	0.04	0.11	0.15	0.18	0.14	0.18	83%
Public	0.46	0.46	0.29	0.19	0.18	0.15	0.17	0.12	0.13	0.15	0.17	0.18	0.19	0.20	0.20	0.20	0.19	-58%
Residential	4.17	4.16	3.61	3.83	3.81	3.82	3.78	3.86	3.83	3.77	3.52	3.62	3.26	3.45	3.40	3.81	3.12	-25%
Transport	3.32	3.32	3.56	3.72	3.87	4.00	4.04	4.20	4.36	4.35	4.41	4.44	4.56	4.40	4.28	4.20	4.16	25%
Waste Management	1.14	1.14	1.02	0.88	0.82	0.78	0.69	0.64	0.56	0.53	0.52	0.51	0.51	0.50	0.48	0.48	0.45	-60%
Total Net Emissions	24.03	23.99	24.62	24.04	24.38	24.06	24.44	22.16	22.11	21.99	22.79	23.12	21.78	21.70	20.08	20.94	19.83	-17%

Uncertainties for the By Source Inventory Estimates

The 2011 DA GHG emission estimates are based on a wide range of data sources that are associated with some degree of uncertainty; an overall analysis of the DA inventory totals using a Monte Carlo simulation model indicates that the uncertainty of the 2011 DA inventory totals are in the range of +-15% to +-42% depending on the relative contributions to the DA inventories of individual source estimates. The uncertainties for the 2011 DA estimates are presented below. Uncertainties result from limitations in the data available for deriving the emission estimates. In many cases data are based on assumptions and datasets that are used as proxies for allocating emissions to the different DAs. The DAs with higher contributions to emissions from more uncertain sources (where we understand less about the distribution and/or intensity of emissions), such as LULUCF, Agriculture, solid and liquid fuel combustion, are subject to the greatest uncertainty.

- UK 2011 GHG total (+-17%)
- England 2011 GHG total (+-15%)
- Scotland 2011 GHG total (+-29%)
- Wales 2011 GHG total (+-19%)
- Northern Ireland 2011 GHG total (+-42%)

The carbon dioxide and total GHG uncertainty for Scotland has increased since last year's inventory due to reduced confidence in the accuracy of estimates for source categories where deviations from UK energy statistics are evident, such as Other Petroleum Gas (OPG) use in industrial combustion.

Appendix 1 provides more detail on the uncertainties for 2011 as well as the uncertainty in the trend of the DA GHG inventories.

Non-Traded and Traded GHG Estimates

The 2011 EU Emissions Trading System (EU ETS) data has been analysed and used to derive a split for non-traded estimates for the DA GHG emission inventories. This method takes account of observed data discrepancies for specific IPCC sectors and presents a "Non-Traded" component to the by source estimates. The data for the 2011 dataset show that:

- Across the **UK**, the non-traded share of total GHG emissions is ***59.8 %***.
- **England** has a high share of EU ETS (traded) emissions from a number of categories including iron and steelworks, power generation and public sector. England non-traded emissions are estimated to be around ***62.0%*** of total GHG emissions in **2011**.
- In **Wales** the coverage of the EU ETS is higher than the rest of the UK, reflecting the high share of heavy industry in Wales (e.g. emissions from power stations, refineries and integrated iron and steelworks). As a result, the non-traded share of the total GHG emissions in Wales in **2011** is only ***48.5%***.
- **Scotland** also has a slightly higher than UK-average share of EU ETS emissions, due to a high proportion of emissions from categories such as refineries, upstream oil and gas and chemicals. The non-traded share of the total GHG emissions in Scotland in **2011** is ***58.9%***.
- **Northern Ireland** has much lower share of the EU ETS emissions, reflecting the fact that there are no refineries, iron and steelworks or oil and gas terminals in Northern Ireland. The non-traded share of the Northern Ireland GHG emissions in **2011** is ***77.9%***.

Full details of methods used to separate emissions into Traded and non-Traded are provided in Appendix 4. Detailed emissions data can be found in the tables that accompany this report: "DA_GHGI_2013_Emissions_Issue1.xlsx".

DA GHG Estimates on an End User Basis

Analysis of emissions re-allocated across the DAs to represent energy consumption patterns rather than production patterns are presented within this report. In this analysis, all emissions associated with energy supply (e.g. power generation, coal mining, oil and gas extraction, refineries) are allocated to the end users of the energy. The net[4] greenhouse gas end user emissions in 2011 and emission trends derived from the end user calculations are summarised below[5]. It must be noted that there is a high level of uncertainty in the reported data, due to limited data availability on electricity generation and consumption, especially at the DA-level in 1990. The DA percentage share of UK end user emissions and reported trends since 1990 are all derived from end user estimates excluding emissions associated with exports, such as the generation of electricity subsequently exported from the UK; this is to present the most accurate assessment of changes in DA consumption-based emission levels and trends.

- England has a **79.8%** share of total net end user GHG emissions in **2011** (Compared to a 76.7% share of by source emissions). End user emissions have declined by 29.8**%** since 1990. End user emissions are 1.2% higher than the by source estimates as a result of emissions attributed to England from energy production activities outside England supplying England with fuels and electricity (e.g. electricity generation and the majority share of the unallocated emissions from oil and gas extraction and refining).
- Scotland has a **9.0%** share of total net end user GHG emissions in **2011** (Compared to an 8.9% share of by source emissions). The trend since 1990 is a decline of **35.9%**. End user emissions are 1.9% lower than the by source estimates as a result of a net export of emissions attributed to energy production activities from Scotland (e.g. exported electricity generated in Scotland and used in other DAs).
- Wales has a **7.3%** share of total net end user GHG emissions in **2011** (Compared to an 8.0% share of by source emissions). Emissions have declined by **30.3%** since 1990. End user emissions are 13.0% lower than the by source estimates 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 DAs).
- Northern Ireland has a **3.9%** share of total net end user GHG emissions in **2011** (Compared to a 3.6% share of by source emissions). The trend since 1990 is a decline of **15.8%.** End user emissions are 5.4% higher than the by source estimates as a result of emissions attributed to Northern Ireland from energy production activities outside Northern Ireland supplying Northern Ireland with fuels and electricity (e.g. emissions from collieries, upstream oil and gas extraction and refining of petroleum fuels).

Full details of methods used to estimate end user emissions are provided in Appendix 3. Emissions data can be found in the tables that accompany this report "DA_GHGi_1990-2011_Issue 1.xls".

Data Sources and Inventory Methodology

In the compilation of GHG inventories for the constituent countries of the UK, where possible the same methodology has been used to calculate emission estimates as for the UK Inventory. However, for many

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

[5] The percentages presented in these figures are rounded to one decimal place, 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.

emission sources the data available for constituent country emissions are less detailed than for the UK as a whole, and for some sources country-level data are not available at all.

In particular, complete sets of fuel consumption data (similar to those available for the UK as a whole) are not available for England, Wales, Scotland or Northern Ireland separately. In order to make emission estimates for fuel consumption, the available data has been supplemented with surrogate/proxy statistics which are used to disaggregate UK total consumptions data.

Sub-national energy statistics are published annually by the Department for Energy and Climate Change (DECC) within the quarterly *Energy Trends*[6] publication. These sub-national statistics are limited in their detail when compared to UK-level energy statistics (used in the UK GHG Inventory compilation), but do provide estimated fuel use data for England, Scotland, Wales and Northern Ireland for the following source sectors:

- Industry and Commercial
- Agriculture
- Residential

The DECC sub-national energy statistics have been developed in recent years to provide estimates of fuel use and carbon dioxide emissions data at Local Authority (LA) level across the UK. The latest available data include LA solid and liquid fuel use estimates for 2005 to 2010, with gas and electricity data also available up to 2011.

The DECC data at local and regional level are derived from analysis of gas and electricity meter point data, supplemented by additional surveys to estimate the distribution of solid fuels and petroleum-based fuels across the UK. Since the initial study and presentation of experimental data for 2003 and 2004, each annual revision to the local and regional data has included data improvements through targeted sector research. These DECC sub-national energy statistics continue to evolve and improve, reducing data inaccuracies, but are subject to greater uncertainty and less detail than the UK energy statistics presented within Digest of UK Energy Statistics (DUKES) which are used to underpin the UK GHG inventory. Despite the lack of detail and higher uncertainties, they are regarded as the best dataset available to inform the patterns of fuel use across the DAs. These data are used to underpin the carbon dioxide emission estimates from fuel combustion sources within the inventories presented here, in conjunction with other data sources such as EU ETS fuel use data for large industrial sites and other DA-specific energy data.

For other significant GHG emission sources there are more reliable and complete country level datasets available including (although some of these are less detailed than data used for the UK Inventory):

- Industrial process emissions are based on plant operator estimates reported to environmental agencies under regulatory systems such as Integrated Pollution Prevention and Control (IPPC). Major sources include cement and lime kilns, iron and steel works, aluminium and other non-ferrous metal plant, chemical industries;
- Agricultural emissions are based on UK emission factors and annual survey data across each of the DAs including estimates of arable production and livestock numbers;
- Land Use, Land Use Change and Forestry (LULUCF) estimates are based on emission factors and regional survey data of land use, modelled to calculate GHG emissions and carbon fluxes between sources and sinks;
- Emissions from waste disposal activities are estimated based on modelled emissions from the UK GHG inventory, split out across the DAs based on local authority waste disposal activity reporting which provides an insight into the local shares of UK activity for recycling, landfilling, incineration and other treatment and disposal options.

[6] The latest available data are taken from the December 2012 Energy Trends: http://www.decc.gov.uk/en/content/cms/statistics/publications/trends/trends.aspx

Revisions and Updates to the Greenhouse Gas Inventories

Each year, the GHG inventories for England, Scotland, Wales and Northern Ireland are extended and updated. The time series of the inventories are extended by including a new inventory year – i.e. the previous inventory (published in September 2012) covered the years up to and including 2010, whilst this report gives emission estimates for the years up to and including 2011.

The nature of emission inventories is such that on-going improvements to data collection or estimation techniques will inevitably lead to some revisions of historic data and our understanding of the trends. The inventories are updated to take account of any new and or revised activity or emission factors, and these amendments may result in revisions to emission estimates for a given year. Core energy statistics (mainly provided by DECC in their annual publication "The Digest of UK Energy Statistics") are revised annually and hence the data provided (e.g. for "coal used in energy generation in 2010") may be different in the latest edition of the Digest, compared to that used in the compilation of the previous inventory report.

In addition, there may also be changes 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 regional GVA or population, this methodology may be improved to use data more closely related to the activities producing emissions involved, should more suitable statistics become available.

Data from previous reports are likely to be different to the figures in this report as a result of improvement to underlying activity datasets and methods used to estimate and distribute emissions across DAs.

Since the publication of the 2012 (1990-2010) GHG inventories for England, Scotland, Wales and Northern Ireland, some of the methodologies used to compile the inventories have been revised due to either changes within the UK GHG inventory compilation method, or the use of new or improved DA-specific data sources for a given source sector. Significant revisions have been made to some DA estimates in the following categories:

- Energy production
- Industrial fuel combustion
- Coal mining activities
- Road transport
- Agriculture
- Land Use, Land Use Change & Forestry

Full details of the changes in estimates between the 2012 (1990 – 2010) estimates and the estimates presented in this report (1990 – 2011) are presented in Appendix 6.

Over the last few years a programme of inventory improvement for the DAs has been implemented, with several strands of research commissioned or planned to (i) meet the current and future reporting needs outlined in climate change legislation relevant to each DA, and (ii) improve the accuracy and sensitivity of estimates from source sectors where current GHG emission estimates are known to be most uncertain.

Contacts

This work forms part of the Climate and Energy: Science and Analysis Research Programme of the Department for Energy and Climate Change. The report has been compiled by Aether and Ricardo-AEA based on the UK GHG inventory compiled by the NAEI consortium led by Ricardo-AEA. The land use, land use change and forestry estimates are provided by the Centre for Ecology and Hydrology (CEH) Edinburgh (Contract CPEG 1). Rothamsted Research provides the estimates of agricultural emissions under a separate contract to the Department for Environment, Food and Rural Affairs.

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Tel: +44 (0) 1837 883528, E-mail: laura.cardenas@rothamsted.ac.uk

A copy of this report and related data may be found on the website maintained by Ricardo-AEA for DECC: http://naei.defra.gov.uk/

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Appendices

Figures

Each of the four DA chapters contain DA-specific graphs. These graphs have the same numbering in each chapter, but contain a unique prefix: 1 – England, 2 – Scotland, 3 – Wales, 4 – Northern Ireland.

Tables

Each of the four DA chapters contain DA-specific graphs. These graphs have the same numbering in each chapter, but contain a unique prefix: 1 – England, 2 – Scotland, 3 – Wales, 4 – Northern Ireland.

Report Structure

This report is structured as follows:

Main body of the report: This part of the report presents and discusses the inventories for England, Scotland, Wales and Northern Ireland, providing GHG emissions data for the years 1990, 1995, and 1998 to 2011. DA inventory estimates are presented in National Communications sector format to align with the needs of DA policy analysts; inventory emissions are presented by source sector and on an end user basis. In addition, traded and non-traded inventory estimates are provided through comparison of the by source inventories against EU ETS data reported by installations in each DA. The reasons for any significant trends in emissions, issues regarding data availability and uncertainty estimates are provided for each inventory.

The appendices present more detailed data and information about the methods used.

Appendix 1: Presents details of the uncertainties in the UK and DA estimates.

Appendix 2: Describes in detail the methodology used to derive the by source DA GHG emission estimates for each source, and how the DA inventories relate to the UK GHG Inventory. This includes the approach for international aviation and international shipping sources.

Appendix 3: Contains the methods used for calculating End User emissions.

Appendix 4: Describes the detailed methods used for splitting DA emissions into traded (EU ETS) and non-traded.

Appendix 5: Presents a mapping between NAEI source name, IPCC category and National Communication category.

Appendix 6: Provides details of recalculations between the 1990-2010 DA GHGI estimates (G. Thistlethwaite et al. 2012) and the latest 1990-2011 DA GHGI estimates. The impact of inventory method improvements and revisions to source data on DA estimates for 2010 by source are presented.

1 Introduction

1.1 Policy Background

The United Nations Framework Convention on Climate Change (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 greenhouse gas (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 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, 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 periodically, according to dates established in the Conference of the Parties. The annual inventory reports must comply with UNFCCC requirements, using source data and methods consistent with Inter-governmental Panel on Climate Change (IPCC) inventory reporting guidelines and good practice guidance, to meet underlying data quality objectives: transparency, completeness, consistency, comparability and accuracy. The Kyoto Protocol supplements the UNFCCC by committing parties, who have ratified the protocol, to achieve individual targets established for the reduction of their respective GHG emissions. Under the protocol, the UK is legally bound to reduce emissions of the 'basket of 6' GHGs by 12.5% against baseline emissions over the first commitment period (2008-2012). In the United Kingdom, the National GHG Inventory and associated National Inventory Report (Webb *et al.*, 2013) are prepared to ensure that the UK fulfils its requirements under the UNFCCC and to monitor the legally binding commitments under the Kyoto Protocol to reduce GHG emissions.

The UK Climate Change Act, which received Royal Assent on the 26th November 2008 established new legal requirements to monitor and report UK GHG emission reductions. The Act set a statutory target to reduce emissions of GHGs in the UK by 80% against the 1990 baseline by 2050 with a minimum 34% reduction in carbon dioxide emissions to be achieved by 2020. The Act also introduced a Carbon Budgeting System whereby emission caps are set over 5 year periods, with three budgets established at a time to map out the emission trajectory to 2050. While this Act represents the primary piece of climate change legislation relevant to England, an overview of the main components of UK and DA climate change legislation and strategies is presented in Figures 1.1a and 1.1b below. 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 Devolved Administrations (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 (Scotland) Act (2009)[7]
- the 'One Wales' Commitment to reduce greenhouse gas emissions and the Climate Change Strategy for Wales (2010).
- Northern Ireland Greenhouse Gas Emissions Reduction Action Plan (2011).

The Climate Change (Scotland) Act (2009) creates a statutory framework for greenhouse gas emissions reductions in Scotland by setting an interim target of at least a 42 per cent reduction for 2020, and at least 80 per cent reduction target for 2050. These reductions are based on a 1990 baseline (1995 for the F-Gases). It also requires the Scottish Ministers to set annual targets for emissions at least 12 years in advance. In October 2010, the Scottish Parliament passed legislation setting the first batch of annual targets, for the years

[7] Climate Change (Scotland) Act 2009: http://www.legislation.gov.uk/asp/2009/12/contents

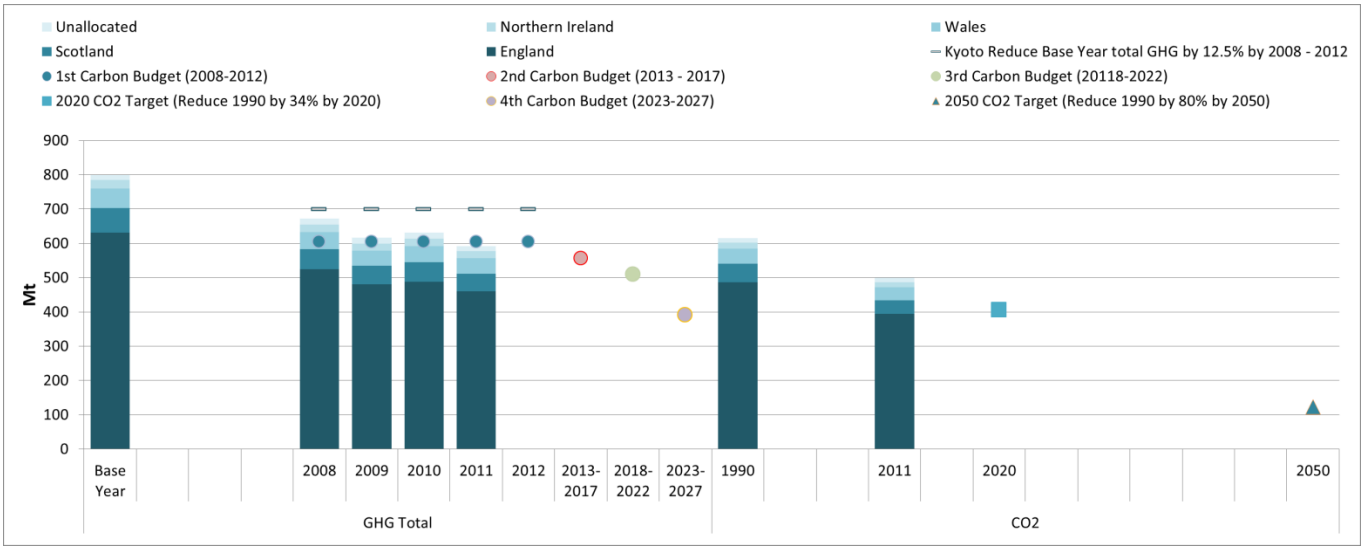
up to 2022[8]. Targets for 2023-2027 were set in October 2011[9], and will continue to be set at 5-year intervals. In reporting emissions reductions against these targets, Scotland is able to take account of emissions trading through the European Union Emissions Trading System (EU ETS). The latest Scottish Government statistics release[10] includes a section on progress towards targets.

The Climate Change (Scotland) Act outlines that the net Scottish GHG emissions account shall include all existing anthropogenic sources and sinks of emissions in Scotland and also a "Scottish share" of GHG emissions from international shipping and international aviation.

The Climate Change Strategy for Wales established emission accounts and targets that include emissions attributed to electricity use in the DA, exclude emissions from the traded sector[11] and (similar to UK targets) do not include emissions from international aviation and shipping (which are reported as memo items to national inventories in line with UNFCCC reporting requirements). The Welsh Government has set 3% annual reductions from 2011 against a baseline of average emissions between 2006 and 2010, as well as a 40% reduction target by 2020 against a 1990 baseline.

The Northern Ireland Executive's current Programme for Government target is to achieve a 35% reduction in greenhouse gas emissions by 2025 based on 1990 levels.

Figure 1.1 UK Greenhouse Gas Emission Reduction Targets: Kyoto, to 2020, to 2050



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, and are a mechanism by which tracking progress towards country-specific GHG emission reduction targets may be achieved. The implementation of new UK and country-specific legislation means that the requirements of the GHG inventories for the constituent countries is evolving, with a much greater focus on (i) sector-specific data accuracy, and (ii) sensitivity to policy impacts.

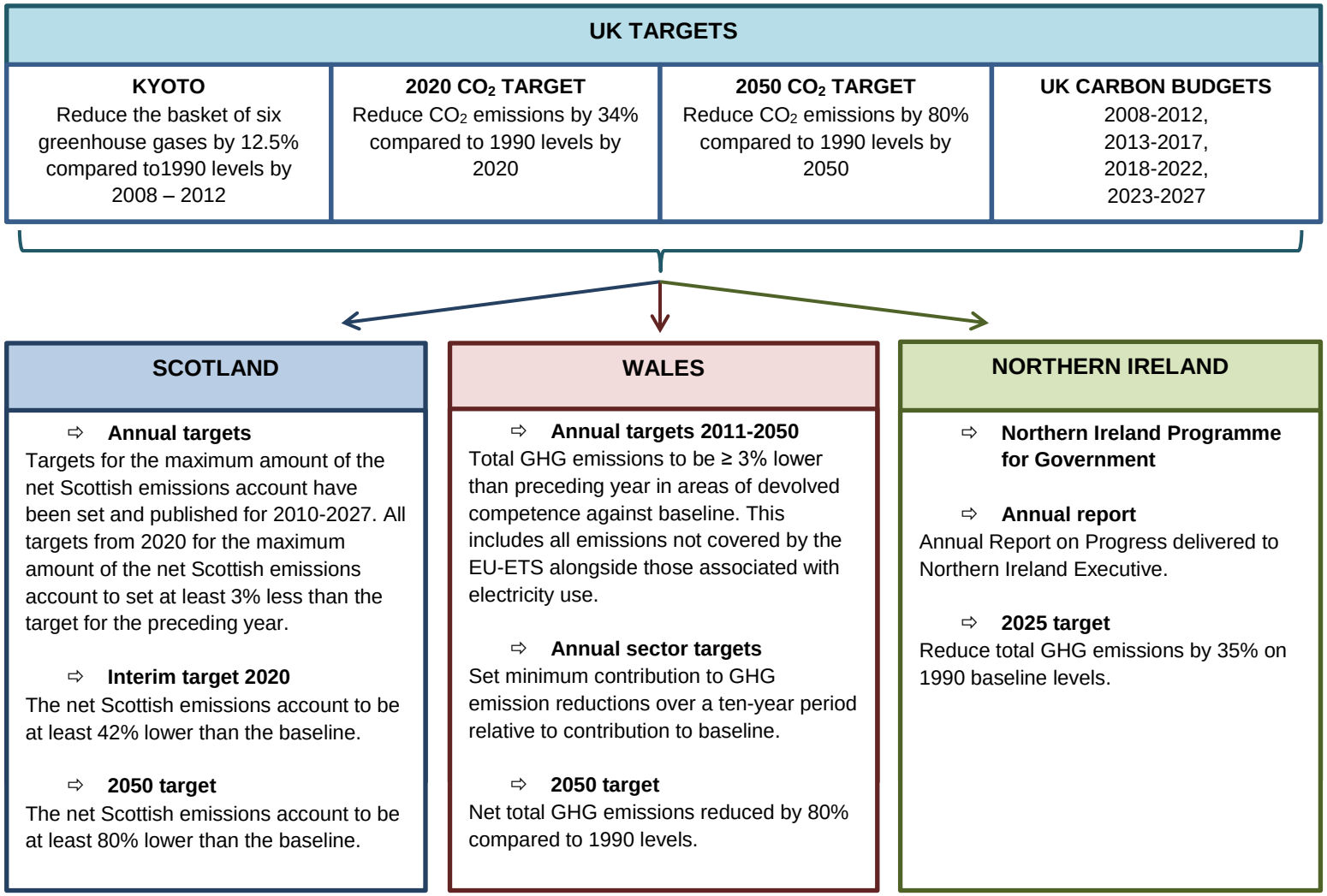
[8] The Climate Change (Annual Targets) (Scotland) Order 2010, SSI 2010 no. 359: http://www.legislation.gov.uk/ssi/2010/359/contents/made

[9] The Climate Change (Annual Targets) (Scotland) Order 2011, SSI 2011 no. 353: http://www.legislation.gov.uk/ssi/2011/353/contents/made

[10] Scottish Greenhouse Gas Emissions 2011: http://www.scotland.gov.uk/ghg11

[11] The "traded sector" refers to emissions from installations that operate within the EU ETS, the EU-wide trading scheme that has been operational since 2005 and includes emissions from large energy consumers within the industrial and commercial sectors.

Figure 1.2 Greenhouse Gas Emission Reduction Targets: UK, Scotland, Wales and Northern Ireland



1.2 About the GHG emissions estimates used for this report

The Department of Energy and Climate Change (DECC) and the DAs commission this annual work programme to compile GHG inventories for the DAs in order to establish GHG emission baselines by source and to track progress towards reduction targets at DA level. This report summarises the findings of the joint research programme for the 1990-2011 GHG inventory cycle, which revises and updates the previous DA inventories that were published in September 2012.

1.2.1 Inventory time series and revisions

This report presents separate GHG Inventories for England, Scotland, Wales and Northern Ireland and "unallocated"[12] for the years 1990, 1995, and 1998 to 2011. It is based on the latest UK GHG inventory which was submitted to the UNFCCC in April 2013 (Webb et al., 2013). The UK emissions are combined with data on the split between the DAs of emissions or activities for each source sector in each year (known as DA 'drivers').

Each year, the GHG inventories for England, Scotland, Wales and Northern Ireland are extended and updated. The time series of the inventories are extended by including a new inventory year – i.e. the previous inventory (published in September 2012) covered the years up to and including 2010, whilst this report gives emission estimates for the years up to and including 2011.

The nature of emission inventories is such that on-going improvements to data collection or estimation techniques will inevitably lead to some revisions of historic data and our understanding of the trends. The inventories are updated to take account of any new and or revised activity or emission factors, and these amendments may result in revisions to emission estimates for a given year. Core energy statistics (mainly provided by DECC in their annual publication "The Digest of UK Energy Statistics") are revised annually and hence the data provided (e.g. for "coal used in energy generation in 2010") may be different in the latest edition of the Digest, compared to that used in the compilation of the previous inventory report.

In addition, there may also be changes 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 regional GVA or population, this methodology may be improved to use data more closely related to the activities producing emissions involved, should more suitable statistics become available.

As a result of this programme of improvement for the UK and DA inventories, data from previous DA inventory reports may be different to the figures in this report as a result of improvement to underlying activity datasets and methods used to estimate and distribute emissions across DAs. Improvements and updates that have been made to the methodology, data sources and assumptions will be evident by revised estimates. Inventory improvements are highlighted at the beginning of each DA section, method details are provided in Appendix 2 and the quantitative impact on the DA inventories is summarised in inventory recalculations tables presented in Appendix 6.

1.2.2 Greenhouse Gases included in the DA inventories

Emissions are reported for the six direct GHGs listed in Table 1.1, where they are presented together with their global warming potentials. Depending upon their molecular weights, radiative properties and residence times in the atmosphere, each GHG has a different capacity to cause global warming. The Global Warming Potential (GWP) is an attempt to encapsulate these parameters and provide a simple measure of the relative radiative effects of the emissions of the relevant GHGs. The GWP is defined as the warming influence over a set time period of a gas relative to that of CO_2. The index is defined as the cumulative radiative forcing between the present and some chosen time horizon caused by a unit mass of gas emitted now, expressed

[12] The component of emissions not attributed to a Devolved Administration such as emissions from the off shore oil and gas industry

relative to that of CO_2. It is necessary to define a time horizon because the gases have different lifetimes in the atmosphere.

Table 1.1 GWPs are defined on a 100-year horizon (IPCC, 1996). The 1996 values were agreed internationally as the values that Parties are required to use for reporting GHG emissions to the UNFCCC and the Kyoto Protocol, although they were updated in 2001. For consistency with international reporting, the 1996 values are also used in this report. A range of GWP values is shown for HFCs and PFCs because these refer to a number of species, each with its own GWP. By weighting the emission of a gas with its GWP it is possible to undertake a comparison of the impacts of the emissions and reductions of different gases and estimate the total contribution to global warming of UK GHG emissions.

Table 1.1 Global Warming Potential of GHGs on a 100-year Horizon (t CO_2 equivalent/ t gas)

Greenhouse Gas	Global Warming Potential (t CO_2 equivalent / t gas)
Carbon Dioxide	1
Methane	21
Nitrous Oxide	310
Hydrofluorocarbons (HFCs)	140-11700
Perfluorocarbons (PFCs)	6500-9200
Sulphur hexafluoride (SF_6)	23900

1.2.3 Inventory Data Presentation by National Communication Format

The GHG inventories for England, Scotland, Wales and Northern Ireland in this report are presented in a different format to the UK GHG inventory, but the sum of the DA inventories are fully consistent with the UK GHG inventory. To provide information that is better aligned to the needs of DA policy teams, this report presents the data according to National Communication (NC) format at the top level, with additional detail by IPCC source category below that. The National Communication format presents the GHG emissions for the following policy areas:

- Energy Supply
- Business
- Industrial Process
- Transport
- Public sector
- Residential
- Agriculture
- Land Use, Land Use Change and Forestry (LULUCF)
- Waste

A table to show the mapping between IPCC sectors and National Communication sectors is provided in Appendix 5.

The data in this report are, unless otherwise stated, presented as emissions estimates at the point of emission, also called “by source” estimates. Emissions are accounted for in the country in which they are emitted. The estimates for each DA include emissions from fuel combustion (Energy), industrial processes, agricultural practices (Agriculture), Land Use, Land Use Change and Forestry (LULUCF) and waste disposal (Waste). National totals for DAs exclude emissions from international aviation and shipping (which are presented as memo items to national inventories, in accordance with UNFCCC reporting requirements) and of carbon dioxide from the burning of biofuels. Emissions of GHGs from offshore oil and gas exploration and production are classified within this report as “Unallocated” emissions and not attributed to any of the DAs.

1.2.4 Uncertainties in Inventory Estimates

Uncertainties provide an indication of the level of confidence that can be put into the inventory estimates; the higher the uncertainty, the less reliable the estimate. Uncertainties can be used to provide a range within which the estimates may change. Decisions based on these data should consider this range and allow for it when defining targets and measures. The levels of uncertainty and the sources and gases responsible for the uncertainty also contribute to the identification and prioritisation of inventory improvements research at UK and DA level.

Uncertainties for estimates of emissions by source for the DAs for the 2011 estimates are presented in figure 1.3 below. UK uncertainties for the GHG estimates in 2011 are (+-17%). Uncertainties in each of the DA inventories vary according to the relative contribution to each DA inventory total of emission sources with high uncertainty:

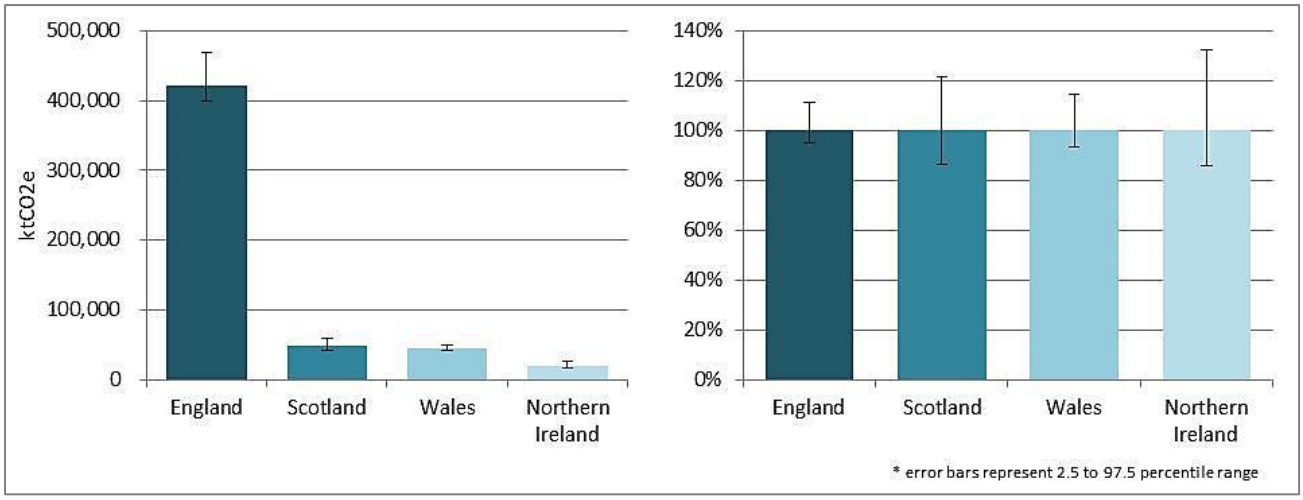
- England inventory uncertainties are (+-15%) as a high proportion of the inventory total is derived from sources with low uncertainty, such as heavy industry where there is extensive emissions monitoring and reporting, and a relatively low contribution from more uncertain sources such as agricultural soils and LULUCF;
- Scotland inventory uncertainties of (+-29%) reflect the fact that there is a much greater contribution to the Scotland total from sources and sinks with significant uncertainties, especially in the LULUCF and agriculture sectors.
- Wales inventory uncertainties of (+-19%) are similar to those for the UK. Similar to England, the Wales inventory has a high contribution from well-documented emission sources, reflecting the high incidence of heavy industry (power generation, oil refining and iron and steel production) in Wales. This is partially off-set by higher uncertainties from agriculture and LULUCF sources in rural Wales;
- Northern Ireland inventory uncertainties of (+-42) are the highest of all DAs due to the relatively high contributions to emissions from LULUCF and agriculture, combined with greater uncertainty in the Energy sector due to high uncertainty in fuel combustion activity. The overall contribution from metered fuels (gas and electricity) is lower in Northern Ireland and there is a greater reliance on solid fuels and oils, the DA estimates for which are more uncertain than for natural gas (which is the main fuel in many sector throughout Great Britain).

Inventory uncertainties can also be considered by gas, where there is a large range in uncertainty due to the different sources that dominate for each specific greenhouse gas:

- Emissions of carbon dioxide are typically associated with the lowest uncertainty due to the high contribution from fuel consumption sources where the carbon content of fuels is generally very well documented and the key source of uncertainty 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 2011 are: +-2% England, +-13% Scotland, +-3% Wales and +-7% Northern Ireland.
- Emissions of nitrous oxide are the least certain (+-262% England, +-272% Scotland, +-277% Wales, +-292% Northern Ireland) due to high uncertainty in estimates for emissions from soils (for fertilizer application and variability of soil types).

Additional details of the uncertainties for each DA by gas can be seen in Figure 4 in each DA chapter. The methodology used to estimate the by source emissions by DA is presented in Appendix 2.

Figure 1.3 Total GHG emissions and uncertainties by DA (2011)



1.2.5 Traded and non-traded emissions

Emissions from the traded (i.e. within the EU ETS) and non-traded sectors represent an important component of emissions reporting in the UK and DA GHG inventories. The EU ETS is a reserved UK Government policy, and the 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. The segregation of emissions between traded and non-traded sectors is especially important for the Welsh Government where the net emissions account for the Wales Climate Change Strategy excludes emissions from the traded sectors. 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.

The EU ETS data are based on returns from operators to UK environmental regulatory agencies which are subject to third party verification as part of the EU ETS quality assurance process. EU ETS data are available since inception of the scheme in 2005, but the analysis presented in this report focuses on the EU ETS data from 2008 onwards as there was a notable change in scope of EU ETS emissions between Phase I (2005 to 2007) and Phase II (2008 to 2012); hence to present trends in non-traded emissions prior to 2008 would be misleading, as there were many more emission sources brought into the EU ETS from 2008 onwards.

The EU ETS reporting format used by operators provides installation-specific emissions and activity data, but does not provide emissions allocated to specific source categories used in the UK and DA inventories. There is not always a one-to-one relationship between installations and emission source categories, and therefore the direct comparison between the GHG inventory data and EU ETS is problematic in some instances. Installations that typically report EU ETS emissions from across more than one National Communication include cement kilns (Business, Industrial Processes) and integrated iron and steel plant (Business, Energy, Industrial Processes). Therefore in the presentation of the traded / non-traded split for each DA, there is some need to aggregate source emission estimates and present “best estimate” traded / non-traded data for the Business, Industrial Process and Energy NC sectors. At the overall DA level, there is no uncertainty from this allocation issue, but at NC level there is some uncertainty as a result of this reporting limitation.

Figures 9 and 10 in each DA chapter show the % traded and non-traded emissions for 2008 – 2011. The methodology used to estimate the split between traded and non-traded emissions by DA is presented in Appendix 4.

1.2.6 End User emission inventories

Emission estimates are also presented in this report on an "end user" basis. The end user basis allocates emissions from energy supply (electricity, refined petroleum fuels, gas and solid fuel production) to the users of the energy (end users: *residential, transport, agriculture, public, business*) of the energy supplied (see Figures 3 and 7 in each DA chapter). 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 energy 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 "Exports" category in the end user inventories.

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 less certain than the 'by source' estimates and should be treated with more caution when making decisions based on them.

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 DECC sub-national energy statistics in the early 2000s. Within the end user inventories, the overall consumption of electricity by DA are reported by DECC whilst the sector allocations of electricity use are based on data from a range of statistical sources. 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 end user inventories are presented in each DA Chapter using National Communication reporting format. The methodology used for estimating the end user emissions for each DA is presented in Appendix 3.

2 Emissions in England

2.1 1990-2011 GHG Inventory Estimates

The greenhouse gas (GHG) emissions for England for 1990 – 2011 are presented in Table 2.1 and in the graph in Figure 2.2 below. Emissions in 2011 are 421,377 $ktCO_2e$ with 33% of emissions in 2011 from Energy Supply, 13% from Residential, 16% from Business and 23% from Transport sources.

Table 2.1: 1990-2011 England GHG Emission Inventory ($ktCO_2e$)

NC Format	Base Year	1990	1995	2000	2005	2009	2010	2011	% of 2011
Agriculture	40,447	40,447	39,082	36,630	34,226	31,638	31,930	31,941	7.6%
Business	88,036	87,039	84,345	85,293	85,594	72,210	70,745	68,426	16.2%
Energy Supply	211,914	211,914	167,860	148,685	164,991	142,840	145,804	138,984	33.0%
Industrial Process	50,982	49,141	40,703	20,242	15,134	8,731	9,006	7,575	1.8%
LULUCF[13]	6,011	6,011	5,899	3,964	2,519	1,776	1,641	1,733	0.4%
Public	10,691	10,691	10,742	9,801	9,293	6,834	6,963	5,884	1.4%
Residential	63,509	63,185	65,077	72,362	71,079	62,596	72,326	55,689	13.2%
Transport	101,122	101,122	101,464	105,131	107,546	100,006	98,758	97,448	23.1%
Waste Management	37,015	37,015	32,373	24,219	16,196	14,635	14,171	13,697	3.3%
Total[14]	**609,728**	**606,566**	**547,546**	**506,327**	**506,578**	**441,267**	**451,343**	**421,377**	**100.0%**

Figure 2.1 and Table 2.2 show the change in emissions from the Base Year and 2010 to the latest year, 2011. Total GHG emissions for England show a decrease of 6.6% between 2010 and 2011, and between the Base Year[15] and 2011 of 30.9%. The 2010 to 2011 trend is driven mostly by the use of less natural gas in the residential sector and in power stations. Carbon dioxide emissions have decreased by 7.4% between 2010 and 2011, and by 23.6% between the Base Year and 2011.

Emission reductions since the Base Year are a result of declining manufacturing (e.g. in iron and steel, bulk chemical production), efficiencies in energy generation and business heating and using natural gas to replace some coal and other fuels as well as abatement in some chemical industries. Emissions for the transport sector have declined by only 3.6% since the Base Year, reflecting the impacts of increasing population and demand for transportation, off-set by improvements in the energy efficiency of the vehicle fleet. Emissions from installations included in the European Union Emissions Trading Scheme (EU ETS) (see Figure 2.7) were relatively constant between 2009 and 2010; however this has been followed by a 5.4% decrease between 2010 and 2011 as power demand in the economy dropped. By comparison emissions from the non-EU ETS sources have reduced by 7.4% between 2010 and 2011.

Detailed analysis of England's emissions in 2011 is presented in Figures 2.4 – 2.9. The dominant emission sources in 2011 include road transport (21% of total GHG emissions), residential combustion for heating and

[13] Land Use, Land Use Change and Forestry (LULUCF)

[14] International aviation and shipping are not included in the data below because these sources are "memo items" and thus not included in the UK emission estimates.

[15] 1995 for fluorinated greenhouse gases (F-Gases) and 1990 for all other gases

cooking (12%), electricity production (28%) and industrial combustion for heat and electricity in the business sector (12%) (See Figure 2.5).

Carbon dioxide is the most common gas emitted for all National Communication (NC) categories except Agriculture, where methane from livestock and nitrous oxide from soils, and for Waste, where methane from landfills, are the most important gases (see Figure 2.4).

Figure 2.4 shows the emissions split by GHG and highlights the 2.5 and 97.5 percentile range. The range of uncertainty is greatest for nitrous oxide emissions. See Appendix 1 for further details on uncertainties.

Traded and Non-Traded Emissions

Emissions from installations in the EU ETS (see Figure 2.9) contribute 38% of total GHG emissions in England in 2011. The main contributors to these traded emissions are the Energy Supply sector (of which 94% total emissions are within the EU ETS, including all power stations) and the Business and Industrial Process sectors (see Figure 2.8) (of which, 38% of the two sector emissions are in the EU ETS). The majority of EU ETS emissions are carbon dioxide emissions from large industrial combustion plant, autogenerators, oil and gas terminals, chemical production (ammonia primarily for fertilizers), cement and lime kilns, iron and steel works, aluminium and brick manufacture plant.

Emissions on an End User Basis

In addition to presenting emissions based on direct emissions from processes or combustion of fuels in England, the emissions from the Energy Supply sector can be attributed to the users of the energy (see Appendix 3 for more details of the end user inventory methodology). Figure 2.7 illustrates the difference between the by source and end user inventory emission estimates and how emissions from energy supply are attributed to the end user NC categories.

This shows that on an end user basis, the contribution to England total emissions in 2011 are: 32% from Business, 25% from Transport sources and 24% from the Residential sector. As illustrated in Figure 2.3 England is a net importer of electricity which results in slightly higher (4%) emissions in England for end user (438,280 kt CO_2e) compared to by source (421,377 kt CO_2e) estimates for 2011.

Emissions from the Land Use, Land Use Change and Forestry (LULUCF) and Waste Management sectors are unchanged between the by source and end user approaches, since there are no emissions from energy use allocated to these sources. The end user increment within the Industrial Process sector is limited to the use of fuels in ammonia production (feedstock use of natural gas), and iron and steel (where emissions are allocated to process use, rather than combustion). For Agriculture, the increase in emissions using the end user approach is limited to the emissions from energy use within the sector.

A more detailed assessment of emissions by sector is presented below for each of the National Communication sectors.

2.1.1 Inventory Recalculations

Revisions to the estimates since the last inventory report (G. Thistlethwaite *et al.,* 2012) have resulted in a 0.6% (2,906 ktCO_2e) increase in the 2010 estimates for England. The most significant revisions to the 2010 estimates have been for the following sectors:

1. **Other manufacturing industry and construction (Business)**: (2,437 ktCO_2e increase) predominantly due to the addition of emissions due to new estimates in the UK inventory for the use of Other Petroleum Gas (OPG) in industrial boilers, following greater scrutiny of the EU ETS data for evidence of use of off-gases from petrochemical production processes being used in boilers on specific industrial sites. There have also been UK-wide revisions to gas oil allocations; a revision to Devolved Administration (DA) allocations of fuel use in industrial off-road machinery to use updated energy mapping analysis consistent with the Department of Energy and Climate Change (DECC) sub-national energy statistics; new UK-wide estimates for emissions from biomass; revisions to gas use in

other industrial combustion across Great Britain as a result of changes in point source analysis across 1A2 and revisions to the Digest of UK Energy Statistics (DUKES) activity data for gas-fired autogeneration; increased UK-wide allocation of fuel oil in industry of around 200%.

2. **Road Transport (Transport)**: (-1,581 ktCO_2e decrease) due to a revision for Heavy Goods Vehicles (HGV) emissions, and a revision to minor road vehicle km data based on more detailed survey information which resulted in lower emission estimated for urban driving (especially cars and Large Goods Vehicles).
3. **Industrial Wastewater Handling (Waste)**: (1,083 kt CO_2e increase) as this is a new sector in this inventory.
4. **Lime Production (Industrial Process)**: (862 kt CO_2e increase) due to revisions to the activity data in the UK GHG inventory, deviating from national statistics from the British Geological Survey (BGS) on mineral extraction and production, to utilise industry data from the EU ETS.

For more details of revisions to GHG emission estimates, see Appendix 6.

Percentage Change in GHG Emissions by NC: Base Year - 2011 and 2010 - 2011

The % changes for LULUCF are based on net change to sink/source across the time series

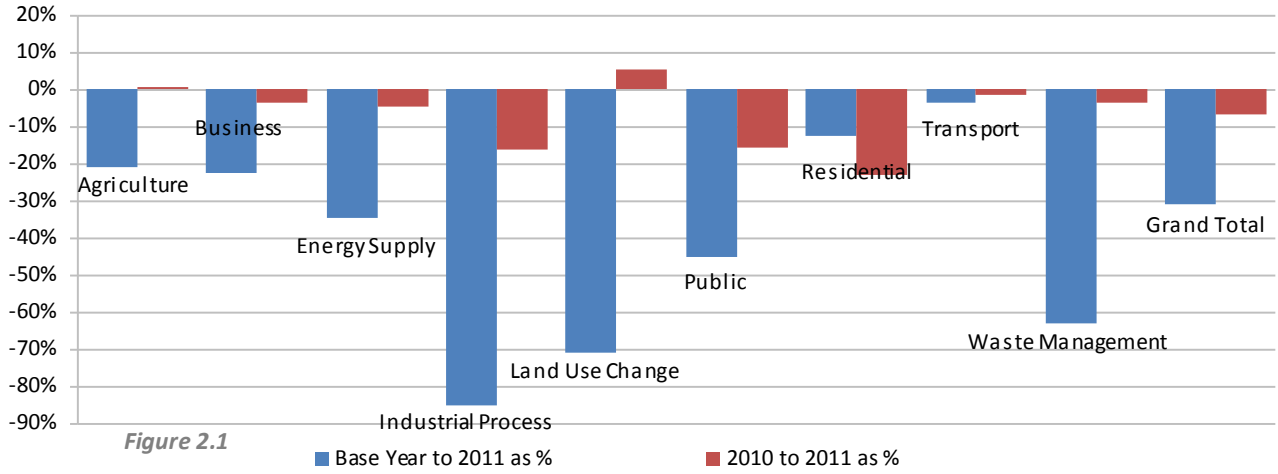


Figure 2.1

Percentage Change in Total GHG and CO2 Emissions by NC: Base Year - 2011 and 2010 - 2011

The % changes for LULUCF are based on net change to sink/source across the time series

Change in emissions from the Base Year to 2011 and 2010 to 2011	Agriculture	Business	Energy Supply	Industrial Process	Land Use Change	Public	Residential	Transport	Waste Management	**Total**	
Base Year to 2011 as %	-21%	-22%	-34%	-85%	-71%	-45%	-12%	-4%	-63%	-31%	**Total GHG as CO2e**
2010 to 2011 as %	0%	-3%	-5%	-16%	6%	-15%	-23%	-1%	-3%	-7%	
Base Year to 2011 as %	-22%	-33%	-29%	-44%	-74%	-45%	-15%	-3%	-79%	-24%	**Total CO2 only**
2010 to 2011 as %	1%	-4%	-5%	-5%	7%	-16%	-24%	-1%	-2%	-7%	
Base Year to 2011 kt	-8,506	-19,609	-72,930	-43,407	-4,278	-4,807	-7,820	-3,674	-23,318	-188,351	**Total GHG as CO2e**
2010 to 2011 kt	12	-2,319	-6,820	-1,431	92	-1,079	-16,637	-1,310	-474	-29,965	
Base Year to 2011 kt	-684	-27,908	-53,981	-5,413	-4,196	-4,758	-9,055	-2,916	-931	-109,843	**Total CO2 only**
2010 to 2011 kt	27	-2,471	-6,633	-344	96	-1,076	-16,603	-1,326	-5	-28,336	

Table 2.2

Total GHG Emissions by NC category for Base Year to 2011, as CO2e

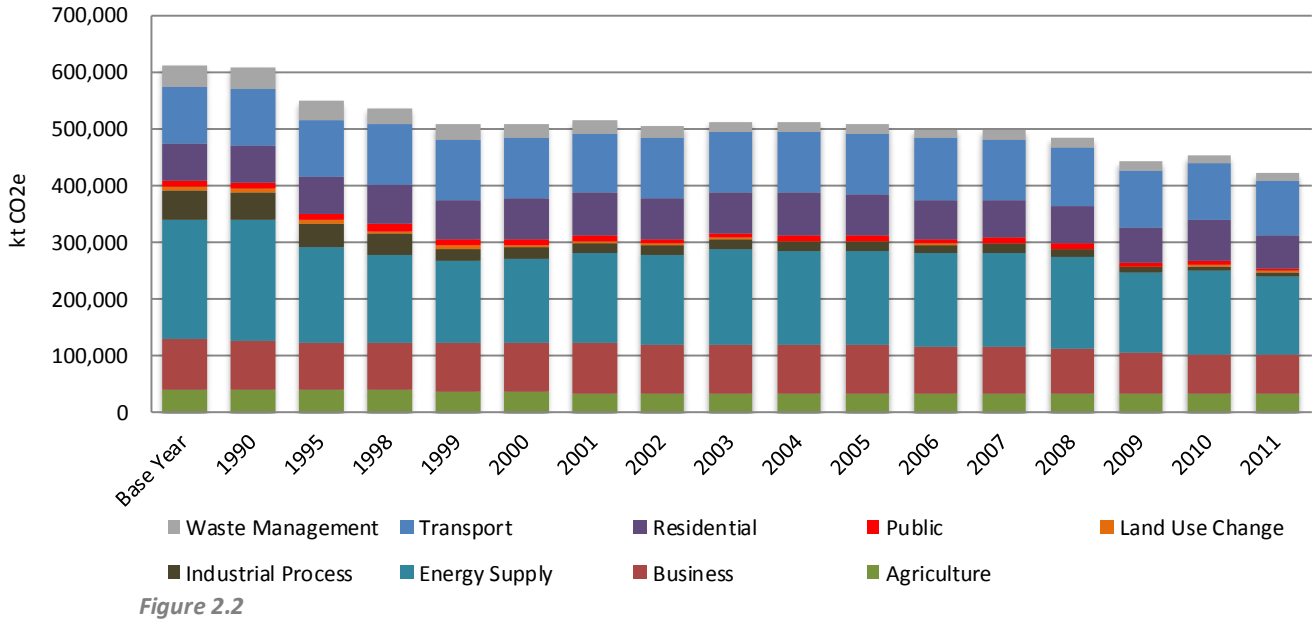
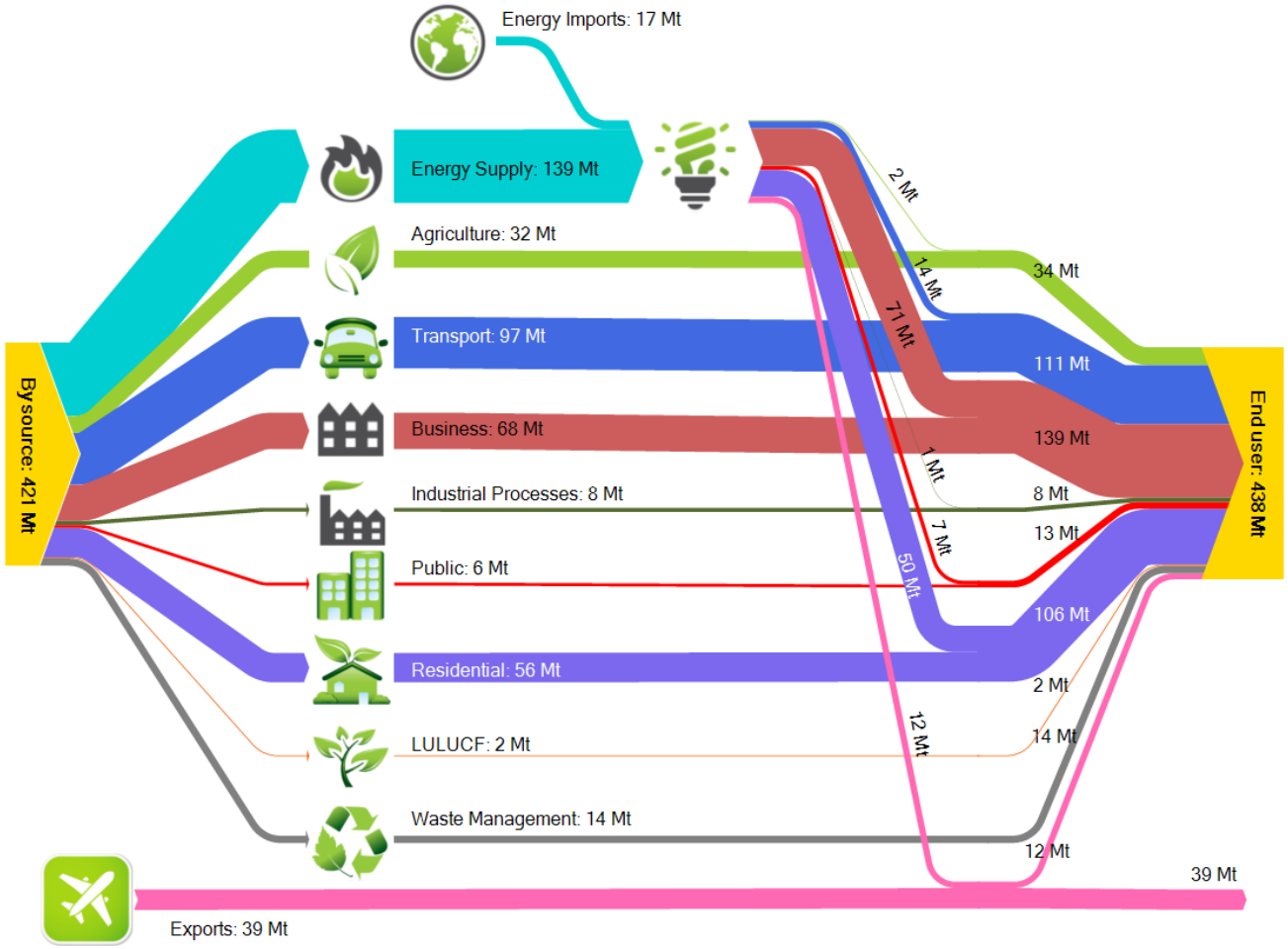


Figure 2.2

Figure 2.3 Sankey diagram showing By Source and End User[16] GHG emission transfers for England in 2011 (Mt CO_2e)[17]



[16] The pink line from 'Energy Supply' to 'End User' represents emissions from energy supply in the production of fuels used in international aviation and shipping.

[17] Exports' equates to emissions from international aviation and shipping.

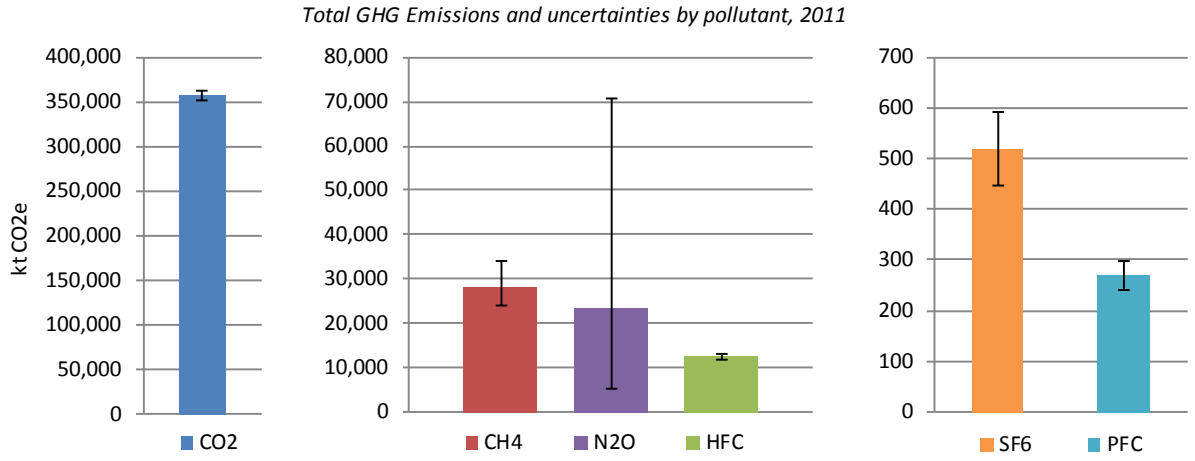


Figure 2.4

** error bars represent 2.5 to 97.5 percentile range*

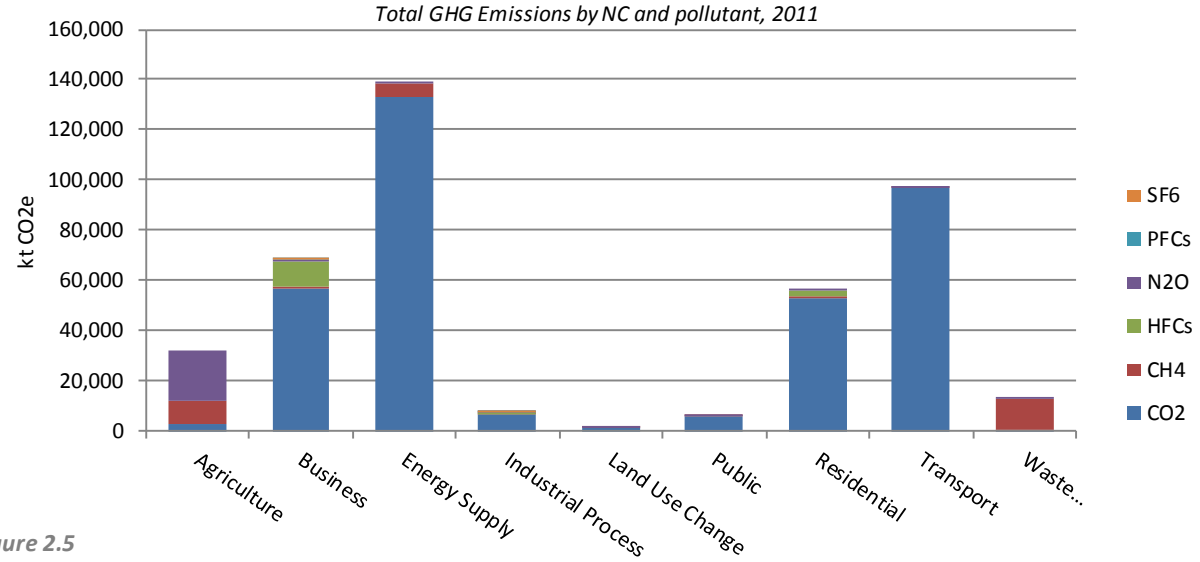


Figure 2.5

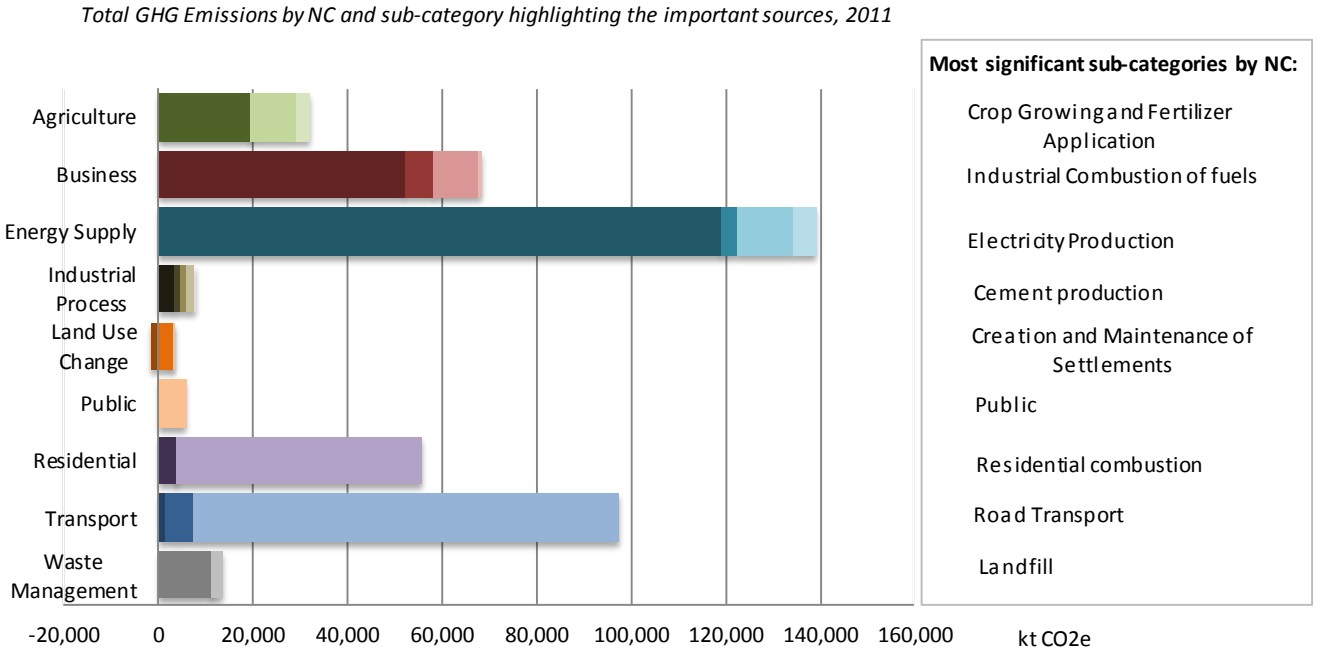


Figure 2.6

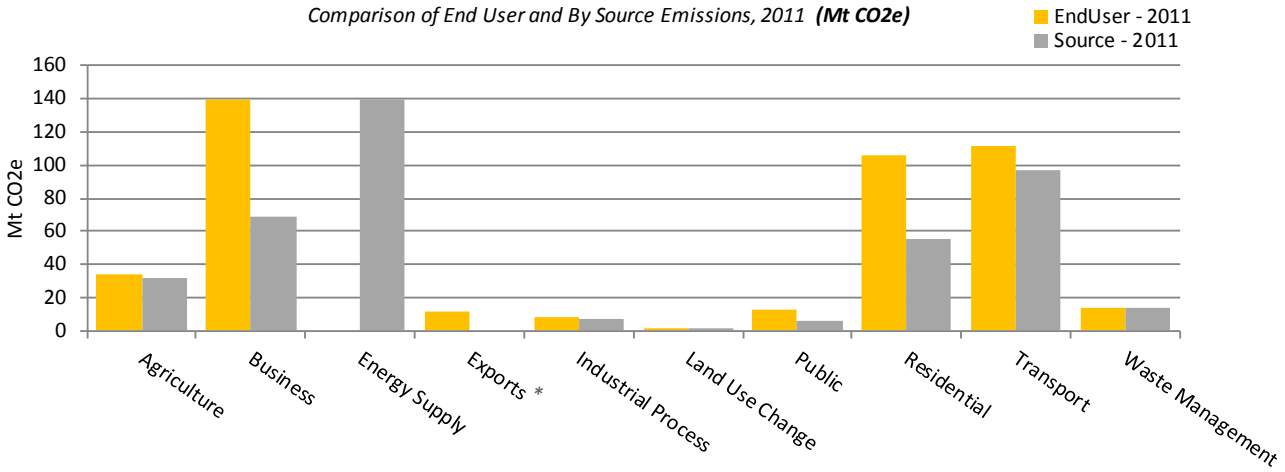


Figure 2.7 * Exports includes emissions from energy production for international aviation, international shipping and exported fuels.

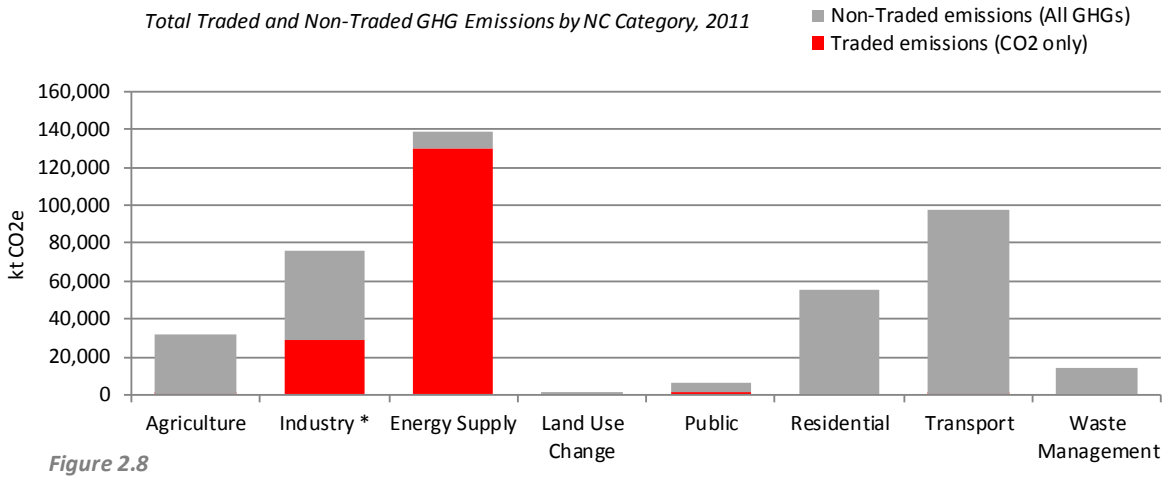


Figure 2.8

* Industry includes emissions from the NC categories: Industrial Process and Business

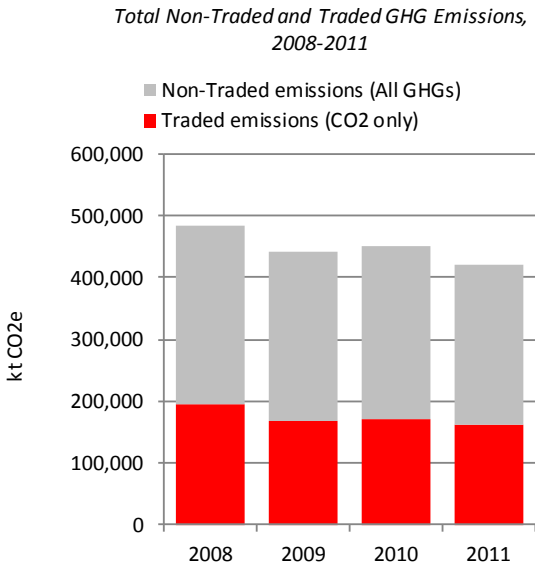


Figure 2.9

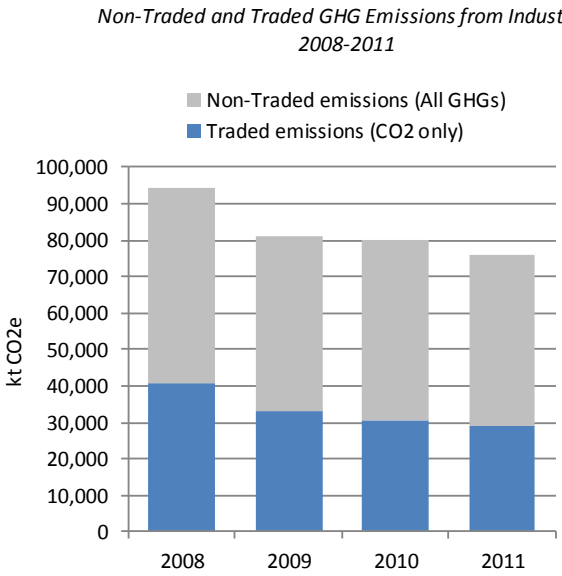


Figure 2.10

* Industry includes emissions from the NC categories: Industrial Process and Business

2.2 Energy Supply

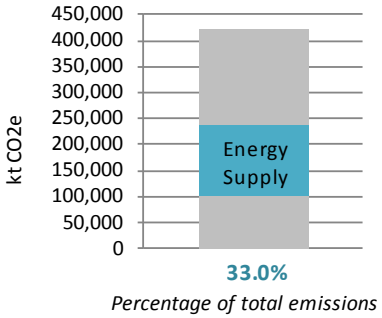


Figure 2.11

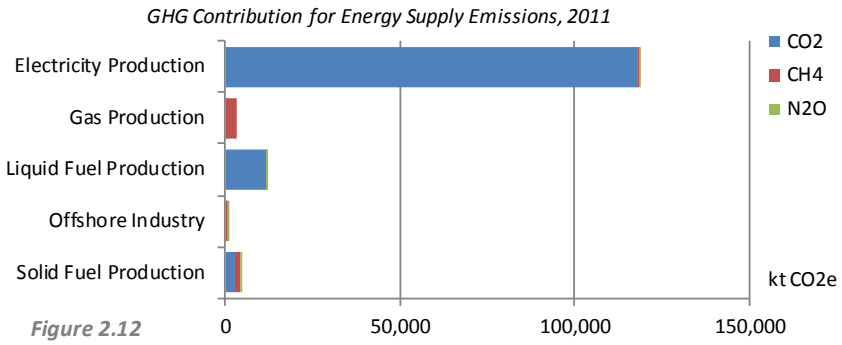


Figure 2.12

Change in GHG Emissions from Base Year (BY) to 2011 and from 2010 to 2011

	BY-2011		2010-2011	
Sub-sector	**%**	**kt CO2e**	**%**	**kt CO2e**
Electricity Production	-31%	-54,339	-6%	-7,427
Gas Production	-53%	-3,888	-6%	-206
Liquid Fuel Production	3%	300	9%	993
Offshore Industry	10%	38	29%	95
Solid Fuel Production	-78%	-15,042	-6%	-275
Total	-34%	-72,930	-5%	-6,820

Table 2.3

NC Category Contribution to End User Inventory by percentage of Electricity Production Emissions

NC Category	End User
Agriculture	1%
Business	55%
Industrial Process	0%
Public	5%
Residential	36%
Transport	2%
Exports*	1%

Table 2.4

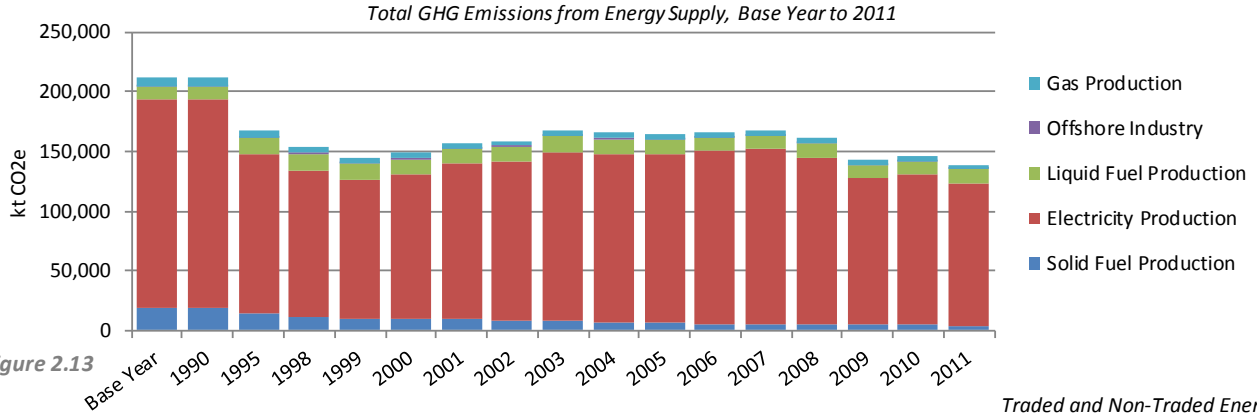


Figure 2.13

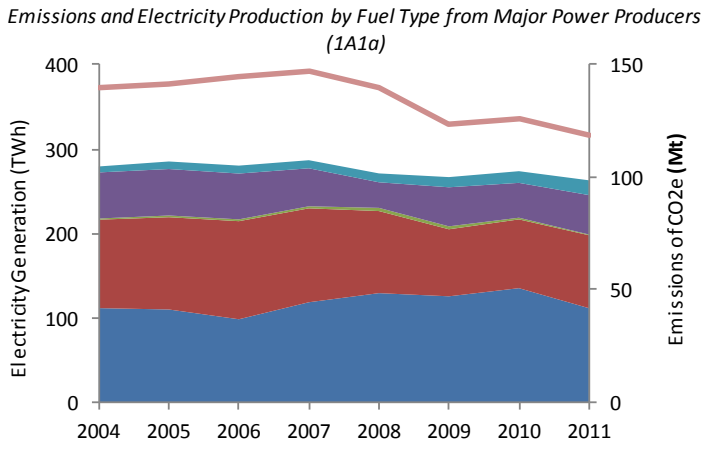


Figure 2.14

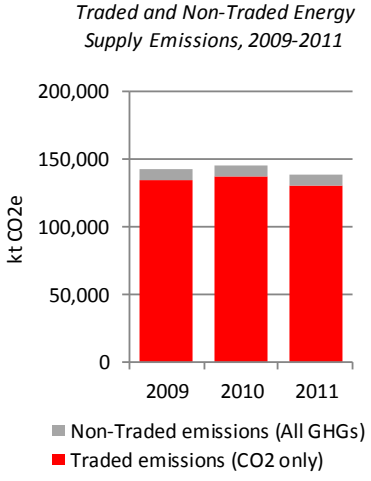


Figure 2.15

* These are emissions associated with the production of exported electricity and electricity used in international aviation and shipping.

Figures 2.11 – 2.15 show detailed emissions and trends for the Energy Supply sector. In England, Energy Supply contributes 33.0% to total 2011 GHG emissions. Energy supply includes emissions from power generation, refineries, coal mines, solid fuel transformation, oil and gas extraction and processing, other energy industries. The main source of emissions in England within the Energy Supply sector is Electricity Production at power stations, which accounts for 85.6% of Energy Supply emissions in 2011; refinery emissions account for a further 8.4% of the Energy Supply sector emissions in 2011.

Table 2.3 shows the change in emissions between the Base Year and 2011, and between 2010 and 2011 for the sector. Energy Supply sector emissions have reduced steadily since 1990 (by 34% between the Base Year and 2011) due to increased efficiency in power generation through a switch from coal-fired to gas- fired combined cycle gas turbines (CCGT) and large reductions in methane emissions from significantly reduced coal mining activities. Emission reductions have also been achieved through an increase in nuclear capacity and utilisation in England and the import of electricity from Wales and Scotland. Energy Supply emissions have decreased by 5% between 2010 and 2011, due mainly to a large reduction in natural gas consumption in power stations, reflecting the impact of cold winters increasing electricity demand in 2010.

Only those emissions arising from on-shore installations in England have been included within the English GHG inventory; emissions from upstream oil & gas exploration and production; emissions from off-shore oil and gas facilities are reported as “Unallocated”.

Carbon dioxide is the predominant gas accounting for over 95% of emissions from the Energy supply sector in 2011 as a result of the combustion of fossil fuels.

The mix of generation capacity in England is shown in Figure 2.14. Power generation in England consists of a high proportion of CCGT stations; a lower proportion of conventional fossil fuel stations; a lower proportion of nuclear generation and no hydroelectricity. In addition, England is a net importer of electricity from both Wales and Scotland[18]. The “by source” inventories presented here allocate emissions to the constituent countries that those emissions occur in, and hence the GHG emissions from the power generated in Wales and Scotland and exported to England are allocated to Wales and Scotland respectively.

Energy Supply Traded and Non-Traded Emissions

Emissions in the Energy Supply sector (Figure 2.15) are dominated by Traded (EU ETS) installations with 94% of emissions in Energy Supply from Traded operations; these traded emissions are primarily from power stations, refineries and coke ovens.

Energy Supply Emissions on an End User Basis

The end user inventory method re-allocates all emissions from the Energy Supply sector on to the final users of the refined / processed fuels, and hence the Energy Supply end user emissions are zero. On an end user basis Business and Residential demand for electricity accounts for 55% and 36% of electricity supply emissions respectively.

[18] For details of regional electricity generation data, see the DECC Energy Trends publication from December 2012, article from page 50.

2.3 Transport

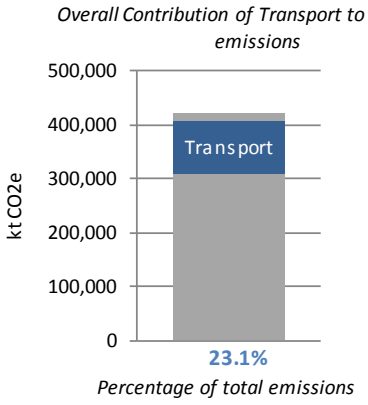


Figure 2.16

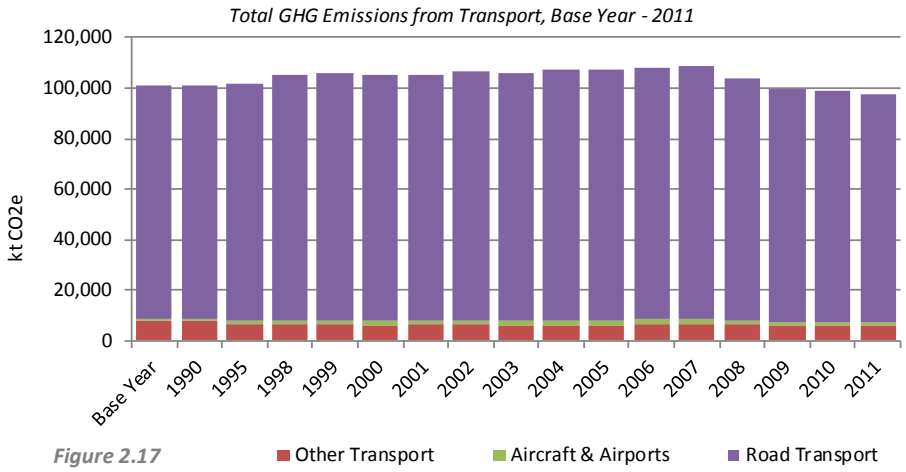


Figure 2.17

Change in GHG Emissions from Base Year (BY) to 2011 and from 2010 to 2011

	BY-2011		2010-2011	
Sub-sector	**%**	**kt CO2e**	**%**	**kt CO2e**
Aircraft & Airports	36%	353	-2%	-29
Other Transport	-23%	-1,819	-1%	-78
Road Transport	-2%	-2,208	-1%	-1,202
Total	-4%	-3,674	-1%	-1,310

Table 2.5

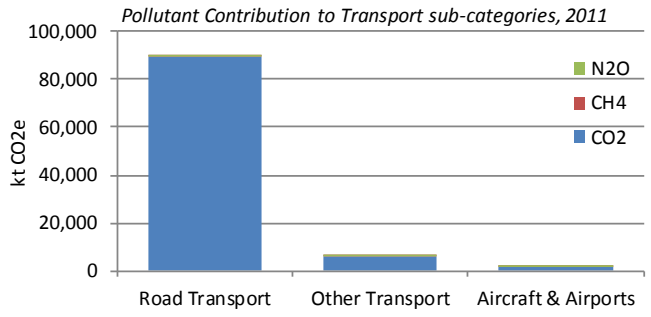


Figure 2.18

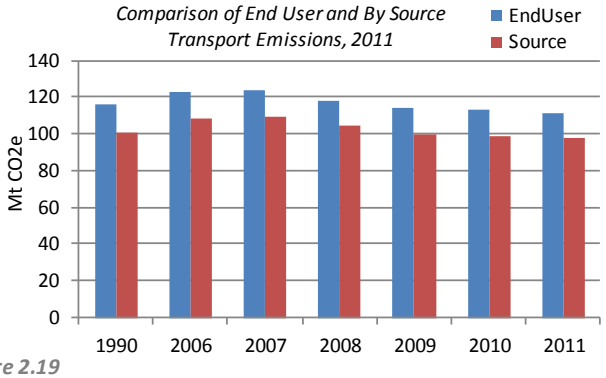


Figure 2.19

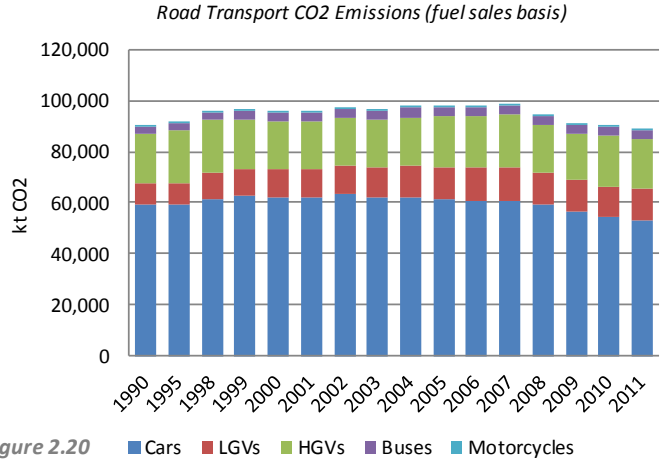


Figure 2.20

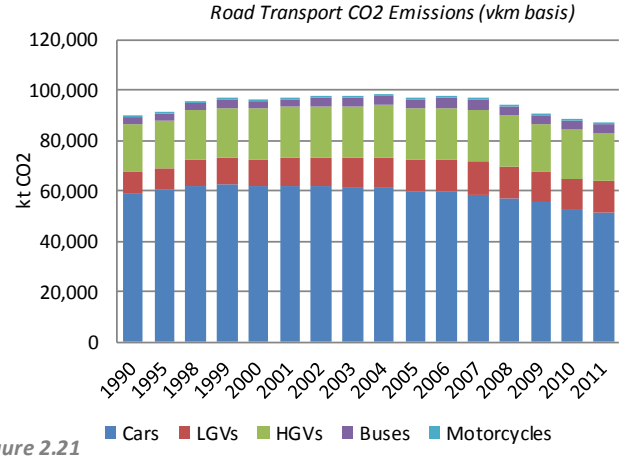


Figure 2.21

Figures 2.16 – 2.21 show detailed emissions and trends for the transport sector. Transport emissions account for 23.1% of England's total GHG emissions in 2011. Transport emissions are dominated by emissions from road transport (92.5% of all Transport emissions in 2011, with 55% of Transport emissions from cars alone). The Transport sector also includes 1.8% from rail (including stationary sources[19]), 1.8% from national navigation and coastal shipping, 1.0% from domestic aviation and 2.4% from military aviation and shipping. Emissions from international aviation are excluded from these estimates.

Table 2.5 shows the change in emissions between the Base Year and 2011, and between 2010 and 2011 for the sector. Total GHG emissions from the Transport sector in England have decreased by only 3.6% between the Base Year and 2011 despite improvements in efficiency of transport vehicles, as a result of strong growth in transport demand and increased affordability of cars over the period. Emissions between 2010 and 2011 have decreased by 1.3%. Recent trends for the sector are driven by the changes in emissions from passenger cars. Although emissions from diesel fuelled cars have increased, emissions from petrol have significantly decreased, which has led to the overall reduction in emissions between 2010 and 2011.

Figures 2.20 and 2.21 show the carbon dioxide emissions from road transport for England based on constrained (to the Digest of UK Energy Statistics (DUKES) fuel sales) and unconstrained (vehicle kilometre, vkm) approaches. Total carbon dioxide emissions from the vkm approach are 0.8% and 2.5% lower than the estimates constrained to DUKES for 1990 and 2011 respectively. The differences between the two approaches fluctuate year on year but they remain within a 2.5% difference for England. These disparities will also be reflected in the trends derived from the two approaches to a different extent. The long term trend (between Base Year and 2011) for each individual vehicle type is generally similar between the two approaches. The vkm approach indicates that the overall carbon dioxide emissions from road transport in 2011 are 3.4% lower than in the Base Year, while the constrained approach indicates that carbon dioxide emissions have decreased by 1.7% between the Base Year and 2011.

Transport Emissions on an End User Basis

The end user estimates in recent years are around 14% higher than the by source estimates, reflecting the additional emissions from upstream oil extraction and the oil refining sector. A small proportion of electricity generation emissions are also attributed to the end user Transport sector from electric rail use.

The trend in end user emissions (Figure 2.19) since 1990 shows a decline of 4.4% to 2011, which is a slightly larger reduction than reported in the by source inventory, reflecting the improved energy efficiency of upstream production and refining of crude oil to produce the fuels used in the transport sector.

[19] Electricity use by the rail sector is not assigned to the transport sector in the by source estimates, but is attributed to the transport sector in the end user estimates.

2.4 Residential

Overall Contribution of Residential sector to 2011 GHG emissions

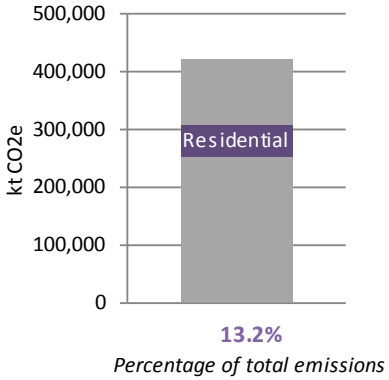


Figure 2.22

Total GHG Emissions by sub-sector, Base Year - 2011

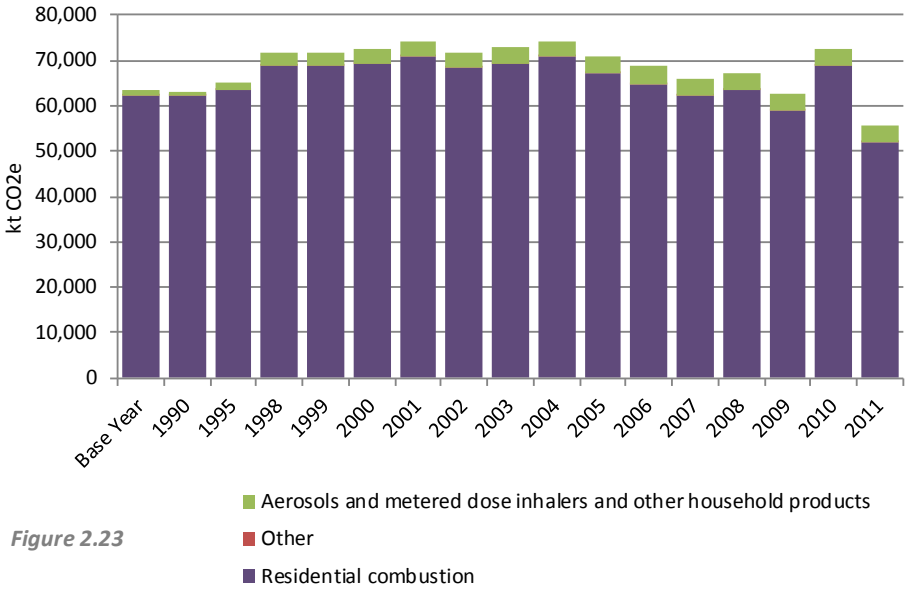


Figure 2.23

Change in GHG Emissions from Base Year (BY) to 2011 and from 2010 to 2011

	BY-2011		2010-2011	
Sub-sector	**%**	**kt CO2e**	**%**	**kt CO2e**
Aerosols and metered dose inhalers and other household products	165%	2231	1%	21
Other	-29%	0	0%	0
Residential combustion	-16%	-10051	-24%	-16,658
Total	-12%	-7820	-23%	-16,637

Table 2.6

Pollutant contribution to Residential Emissions, 2011

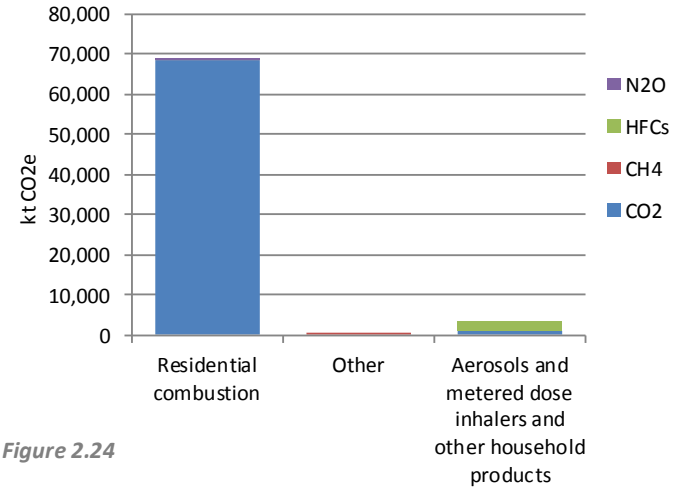


Figure 2.24

*Comparison between End User and By Source Inventory Totals **(Mt CO2e)***

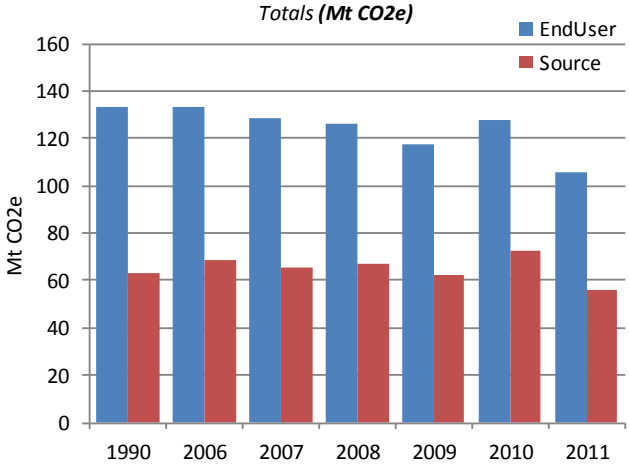


Figure 2.25

Figures 2.22 – 2.25 show detailed emissions and trends for the sector. The residential sector accounts for 13.2% of England's total GHG emissions in 2011. The sector comprises emissions from domestic combustion (94% of emissions for the residential sector) from heating and cooking, household products, accidental vehicle fires and hydrofluorocarbon (HFC) emissions from the use of aerosols and metered dose (usually asthma) inhalers. Over 95% of all residential GHG emissions are from the release of carbon dioxide from the direct combustion of fossil fuels (see Figure 2.24).

Total GHG emissions from the residential sector (Table 2.6) in England have decreased by 12.3% between the Base Year and 2011. There was a large decrease in natural gas consumption[20] in 2011, resulting in a 23% decrease in GHG emissions from the sector between 2010 and 2011. This was primarily due to the cold weather that affected 2010 and therefore significantly increased fuel consumption in the residential sector over this period.

Residential Emissions on an End User Basis

In 2011 England end user emissions for the residential sector are 190% of the by source emission estimates, reflecting the high consumption of electricity in the sector (Figure 2.25). This increases the overall significance of this sector in the end user inventory to 24% of the England total, compared to just 13% of the by source inventory total. The trend in residential end user emissions since 1990 shows a decline of around 21% to 2011 as a result of improvements in energy efficiency of housing combined with the less carbon intensive fuel mix of the electricity generation sector since 1990.

Note that the end user data are uncertain and should be regarded as indicative only due to the limited data on electricity use by source.

[20] Note that the emission estimates in the domestic sector are associated with high uncertainty due to the absence of comprehensive, detailed DA-specific fuel use data, particularly for solid and liquid fuels.

2.5 Business

Overall Contribution to 2011 GHG emissions

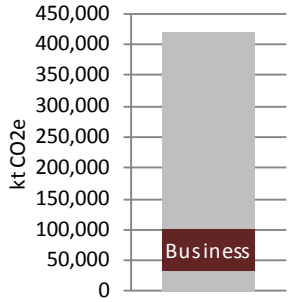


Figure 2.26 **16.24%**

Percentage of total emissions

Total GHG Emissions from Business, Base Year - 2011

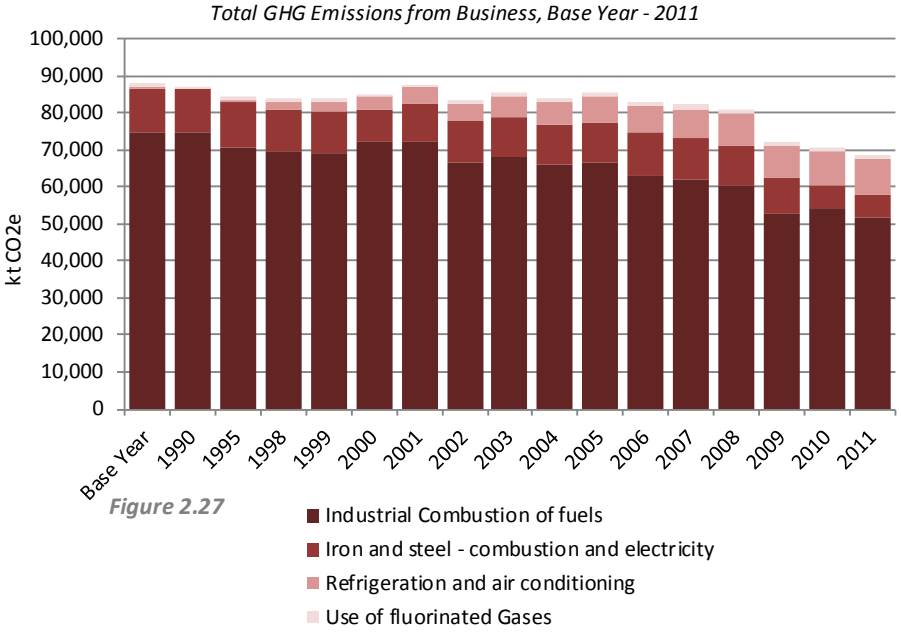


Figure 2.27

Change in GHG Emissions from Base Year (BY) to 2011 and from 2010 to 2011

	BY-2011		2010-2011	
Sub-sector	**%**	**kt CO2e**	**%**	**kt CO2e**
Industrial Combustion of fuels	-31%	-22,943	-4%	-2,253
Iron and steel - combustion and electricity	-48%	-5,530	-4%	-271
Refrigeration and air conditioning	1353%	8,786	2%	211
Use of fluorinated Gases	8%	77	-1%	-6
Total	-22%	-19,609	-3%	-2,319

Table 2.7

Pollutant Contribution for Business Emissions, 2011

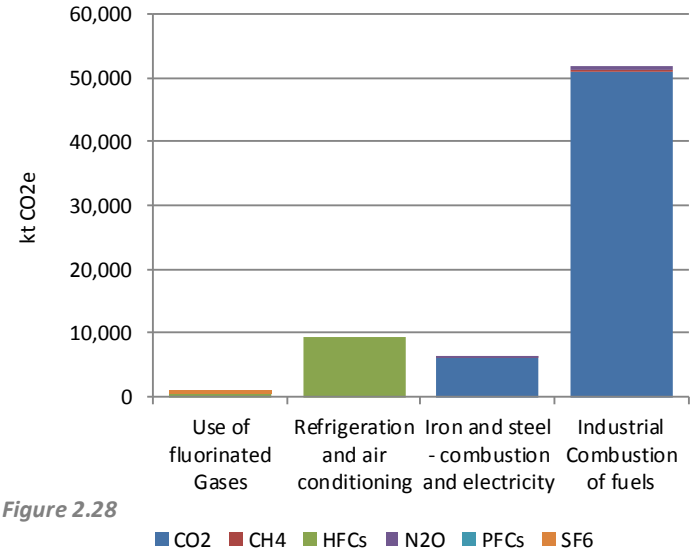


Figure 2.28

Comparison between End User and By Source Inventory for the Business Sector, 1990 and 2006-2011 ***(Mt CO2e)***

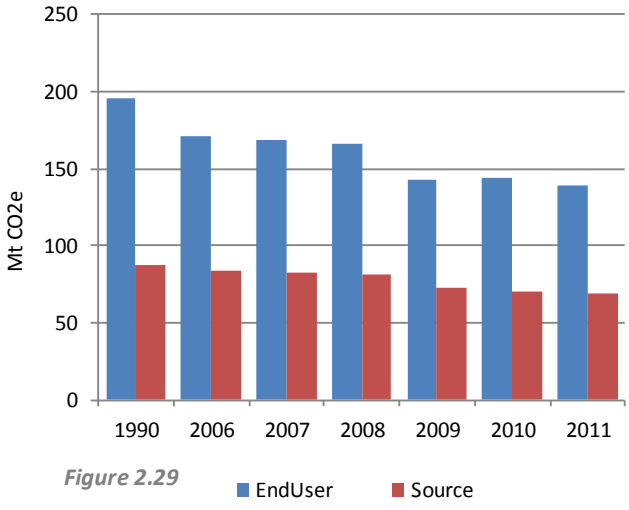


Figure 2.29

Figures 2.26 – 2.29 show detailed emissions and trends for the sector. In England, the business sector contributes 16.2% to total 2011 GHG emissions in England. The sector in 2011 includes emissions from industrial combustion of fuels (75.9% of total GHGs) from manufacturing and construction industry, iron and steel fuel combustion (8.9% of total GHGs), refrigeration & air conditioning (13.8% of total GHGs), arising from losses of HFCs during equipment manufacture, leaks and disposal; as well as HFC emissions from foam production, fire fighting solvents and electronics (1.5% of total GHGs). In 2011, 83% of emissions were carbon dioxide released from the combustion of fossil fuels in the business sector with 15% from the use of fluorinated greenhouse gases (F-Gases), predominantly HFCs.

Overall business sector emissions have reduced steadily since the Base Year, and by 2011 a 22.3% reduction in GHG emissions has been achieved in the sector in England. These reductions have primarily been achieved as a result of declining manufacturing and iron and steel industry emissions. Despite this general decline in emissions, emissions of HFC from refrigeration and air conditioning have risen by over 1300% since 1995; these emissions now account for around 14% of total business emissions in 2011 since the introduction of these gases as replacement to CFCs banned by the Montreal Protocol. Emissions from the sector have decreased by 3.3% between 2010 and 2011, caused by a reduction in the use of gas and fuel oil in the stationary and mobile industrial combustion sectors; a reduction in natural gas consumption in the commercial/institutional sector and reductions in emissions from blast furnace gas, coke oven gas and fuel oil in the iron and steel sector.

Business Traded and Non-Traded Emissions

Emissions in the business sector include significant contributions from installations reporting in the EU ETS. However, due to the lack of detail in the EU ETS dataset, Business, Energy Supply and Industrial Process emissions are not easy to separate. The contribution to total aggregate emissions from the traded and non-traded sector across these NC sectors is presented in Figure 2.8 in the summary section.

Business Emissions on an End User Basis

In 2011, England's end user emissions for the business sector are 203% of the by source emission estimates, reflecting the high consumption of electricity for heating, lighting and operating equipment (and therefore share of emissions from electricity production) in the sector. From this end user perspective, the business sector represents 32% of total emissions for England compared to just 16% of the by source inventory total.

The combustion emission estimates in the business sector are associated with high uncertainty due to the absence of comprehensive, detailed fuel use data specific to each Devolved Administration (DA), particularly for solid and liquid fuels. Non-combustion emissions account for a total of 14% of the total business emissions in England. These data are also uncertain due to the lack of DA-specific data on F-gas sources and the use of proxies such as economic indices and population to estimate the DA share of UK emissions for these sources.

2.6 Public

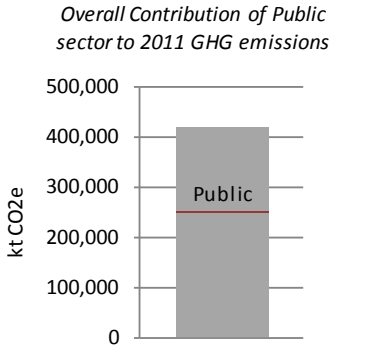


Figure 2.30 **1.40%**

Percentage of total emissions

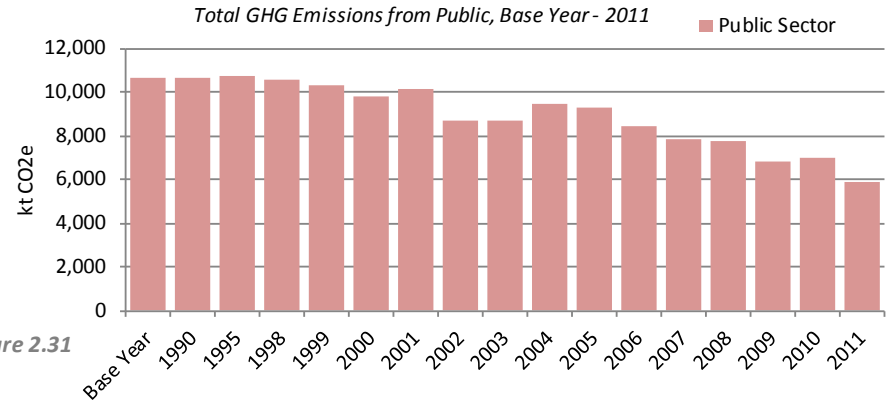


Figure 2.31

Change in GHG Emissions from Base Year (BY) to 2011 and from 2010 to 2011

	BY-2011		2010-2011	
Sub-sector	**%**	**kt CO2e**	**%**	**kt CO2e**
Public	-45%	-4807	-15%	-1079

Table 2.8

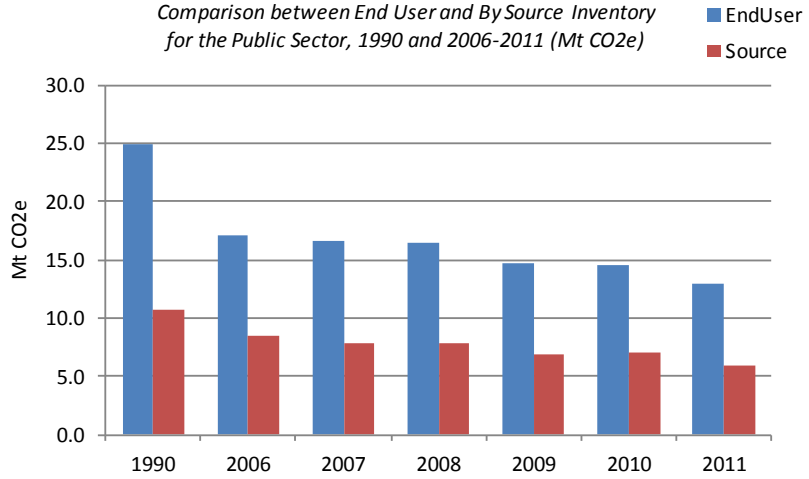


Figure 2.32

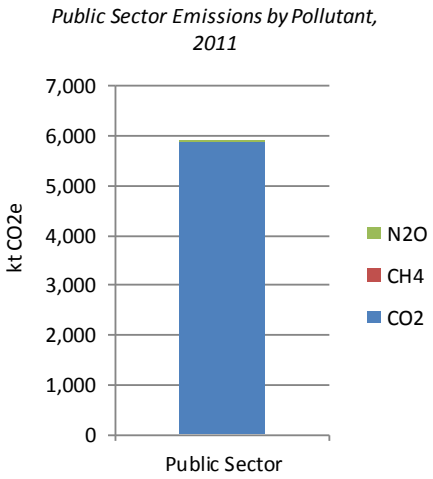


Figure 2.33

Figures 2.30 – 2.33 show detailed emissions and trends for the sector. Emissions from public sector combustion account for 1.4% of GHG emissions in England in 2011. 99.6% of emissions in this sector are from carbon dioxide from the combustion of fossil fuels (predominantly natural gas).

Overall public sector emissions have reduced steadily between the Base Year and 2011, with an overall reduction of 45% over the period (Table 2.8). This has been achieved through more efficient use of fuels and a switch to gas fired heating across England for many public sector buildings since 1990. Public sector GHG emissions decreased by 15.5% between 2010 and 2011, due mainly to cold weather in 2010 that resulted in higher levels of consumption of natural gas over this period.

Public Sector Emissions on an End User Basis

In 2011, England end user emissions for the public sector are 220% of the by source emission estimates (Figure 2.32), reflecting the high consumption of electricity in the sector and increasing the sector's share of total England emissions compared to by source to 2.9% in 2011. The trend in end user emissions since 1990 shows a decline of around 48% to 2011[21].

Note that the emission estimates in the public sector are associated with high uncertainty due to the absence of comprehensive, detailed DA-specific fuel use data, particularly for solid and liquid fuels.

[21] The reported end user trend data are uncertain and should be regarded as indicative only due to the limited data on electricity use by source.

2.7 Industrial Process

Overall Contribution of Industrial Process to 2011 GHG emissions

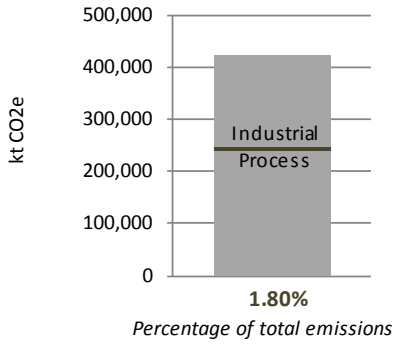


Figure 2.34

Total GHG Emissions from Industrial Process, Base Year - 2011

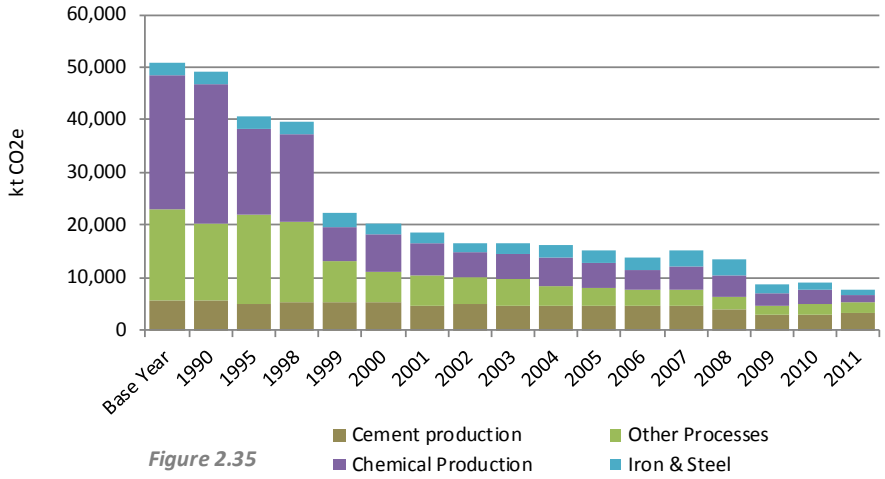


Figure 2.35

Change in GHG Emissions from Base Year (BY) to 2011 and from 2010 to 2011

	BY-2011		2010-2011	
Sub-sector	**%**	**kt CO2e**	**%**	**kt CO2e**
Cement production	-44%	-2537	6%	186
Chemical Production	-94%	-24324	-48%	-1,344
Iron & Steel	-62%	-1471	-22%	-260
Other Processes	-88%	-15075	-1%	-13
Total	-85%	-43407	-16%	-1,431

Table 2.9

Pollutant Contribution for Industrial Process Emissions, 2011

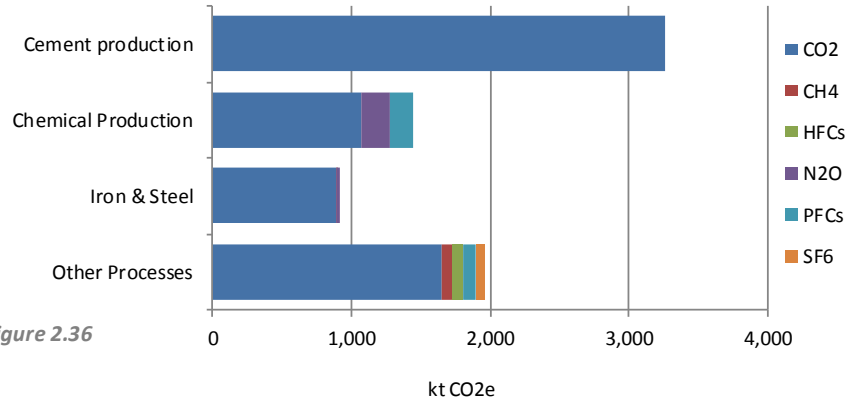


Figure 2.36

Figures 2.34 – 2.36 show detailed emissions and trends for the sector. The Industrial Process sector contributes 1.8% to total 2011 GHG emissions in England. The Industrial Process sector includes non-combustion sources such as the use of limestone in cement production (43% of total sector emissions); Chemical production (19% of sector emissions) including fertilizers and other bulk chemical feedstocks; Iron and Steel processes (12% of sector emissions) excluding the use of electricity and fossil fuels for heating processes; Other processes (26% of sector emissions) including glass & brick making and lime production. Emissions from flue gas cleaning in the electricity production sector accounted for 382 $ktCO_2e$ in 2011.

In 2011, 91% of total GHG emissions for the sector were from emissions of carbon dioxide from processes (primarily cement and iron and steel production), with 3% from nitrous oxide emissions from Nitric acid production. Around 5% of total GHGs emissions are from the use/production of from F-Gases, predominantly PFCs, in industrial processes including: 0.9% of total GHG emissions of sulphur hexafluoride (SF_6) from its application as a cover gas in magnesium production. Emissions of methane from this sector are not significant, accounting for just 1% of total GHG emissions in this sector.

Overall Industrial Process sector emissions in England have reduced by 85% since the Base Year to 2011 (Table 2.9). This large decline in emissions is due to several factors including: improved abatement and subsequent closure of the adipic acid production facilities in England, a decline in manufacturing, bulk chemical and iron and steel industries, and a large reduction in emissions from the manufacture of HFCs through installation of improved abatement systems on HCFC production plant. Between 2010 and 2011, sector emissions decreased by 16% mainly due to new abatement fitted to three of the UK's nitric acid production units, reducing nitrous oxide emissions. Emissions have also decreased from blast furnace gas flaring in the iron and steel sector in England.

Industrial Process Traded and Non-Traded Emissions

Emissions in the Industrial Process sector include significant contributions from installations reporting in the EU ETS. However, due to the lack of detail in the EU ETS dataset, Business, Energy Supply and Industrial Process emissions are not easy to separate. The contribution to total aggregate emissions from the traded and non-traded sector across these NC sectors is presented in Figure 2.8 in the summary section.

Industrial Process Emissions on an End User Basis

As the majority of emissions in the Industrial Process sector are not due to energy consumption, Industrial Process sector emissions on an end user basis are very similar to the emissions by source; in 2011, the end user estimates are only 9.4% higher for the Industrial Process sector, reflecting the relatively low contribution to sector emissions from the use of electricity or fossil fuels as feedstock or for energy.

2.8 Agriculture

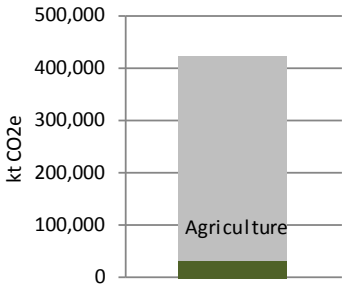


Figure 2.37 **7.58%**

Percentage of total emissions

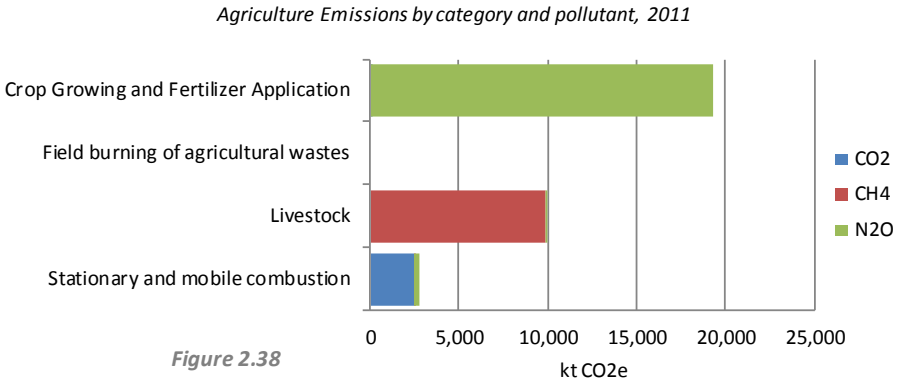


Figure 2.38

Change in GHG Emissions from Base Year (BY) to 2011 and from 2010 to 2011

	BY-2011		2010-2011	
Sub-sector	**%**	**kt CO2e**	**%**	**kt CO2e**
Crop Growing and Fertilizer Application	-18%	-4,258	0%	85
Field burning of agricultural wastes	-100%	-229	-	0
Livestock	-25%	-3,298	-1%	-106
Stationary and mobile combustion	-21%	-721	1%	33
Total	-21%	-8,506	0%	12

Table 2.10

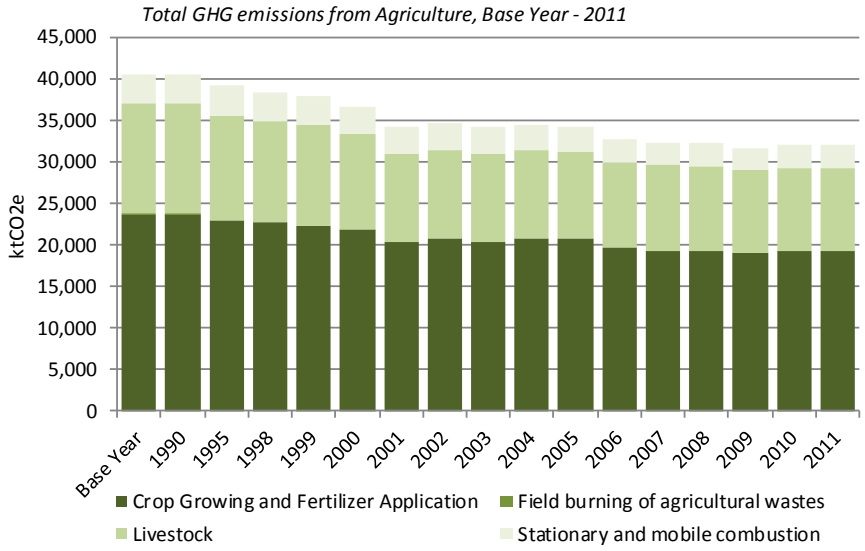


Figure 2.39

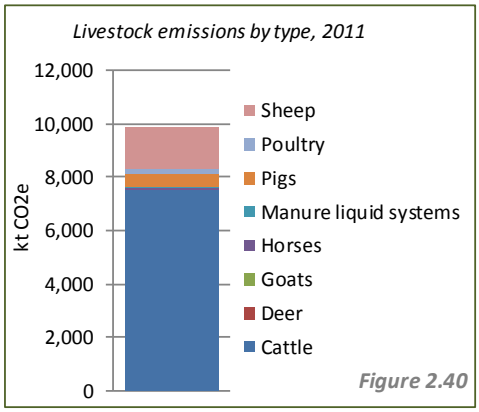


Figure 2.40

Figures 2.37 – 2.40 show detailed emissions and trends for the sector. The agriculture sector contributed 7.6% to total 2011 GHG emissions in England. GHG emissions from agriculture in England comprise mainly of nitrous oxide (61%) from fertilizer application to soils including management of manure (related to handling of manure before it is added to the soil) and methane (31%) from livestock including enteric fermentation and management of manure, with a small amount of carbon dioxide (8%) from agricultural combustion and agrochemical use.

Overall emissions from the agriculture sector have reduced by 21% since the Base Year (Table 2.10). Methane emissions from agriculture are largely dependent on the numbers of livestock and have fallen by 26% from 1990 to 2011, mainly due to a decline in cattle and sheep numbers. There was a small decrease (1%) in total agricultural methane emissions from 2010 to 2011 largely due to a decrease in methane

emissions from enteric fermentation of cattle. Enteric fermentation contributed 83% (8,189 $ktCO_2e$) to the total agricultural methane emissions in England in 2011. Emissions from dairy and beef cattle (enteric and waste management emissions combined) accounted for 76% of the total agricultural methane emissions. Total emissions from sheep were 15.4% of the total methane from agriculture in England.

Nitrous oxide emissions are largely driven by fertiliser nitrogen use, manure applications and grazing returns to soils. Emissions have fallen by 18.3% from 1990 to 2011 resulting from a general decline in livestock numbers and in fertiliser nitrogen use (particularly to grassland). Nitrous oxide emissions increased minimally (by 0.5%) between 2010 and 2011. Most nitrous oxide emissions (93%) arise from the agricultural soils category (see Table 2.11). A relatively small proportion (1,036 $ktCO_2e$) is emitted from the management of animal manure (emissions related to handling of manure before it is added to the soil). Table 2.11 gives a detailed breakdown of nitrous oxide emissions from agriculture for England.

Table 2.11 Emissions of nitrous oxide from agricultural sources in England in 2011 ($ktCO_2e$)[22]

Manure management				1,036
Soils				18,265
	Direct			*12,122*
		Fertiliser		4,546
		Grazing returns		2,875
		Manure application		1,240
		Crop residues		2,463
		Biological fixation		146
		Improved grassland		94
		Histosols		585
		Sewage sludge		174
	Indirect			*6,143*
		Leaching		5,169
			Fertiliser	3,030
			Grazing returns	1,078
			Manure application	930
			Sewage sludge	130
		Deposition		974
			Fertiliser	404
			Grazing returns	287
			Manure application	248
			Sewage sludge	35
Field burning				0
Total				**19,302**

Agriculture Emissions on an End User Basis

As the majority of emissions in the agriculture sector are not due to energy consumption, agriculture sector emissions on an end user basis are very similar to the emissions by source; in 2011, the end user estimates are only 5% higher for the agriculture sector, reflecting the relatively low contribution to sector emissions from the use of oils and electricity, compared to the higher-emitting sources of nitrous oxide and methane from soils and livestock sources.

[22] Total emissions comprise manure management, soils and field burning. Soils include direct and indirect emissions; indirect emissions include leaching and deposition

2.9 Land Use, Land Use Change and Forestry

Overall Contribution to 2011 GHG emissions

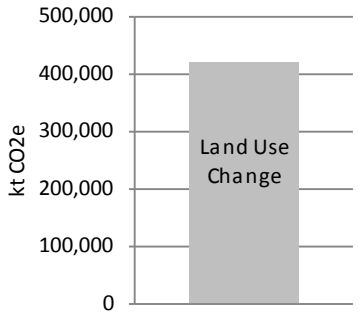


Figure 2.41

0.41%

Percentage of total emissions

Pollutant Contribution to LULUCF GHG Emissions, 2011

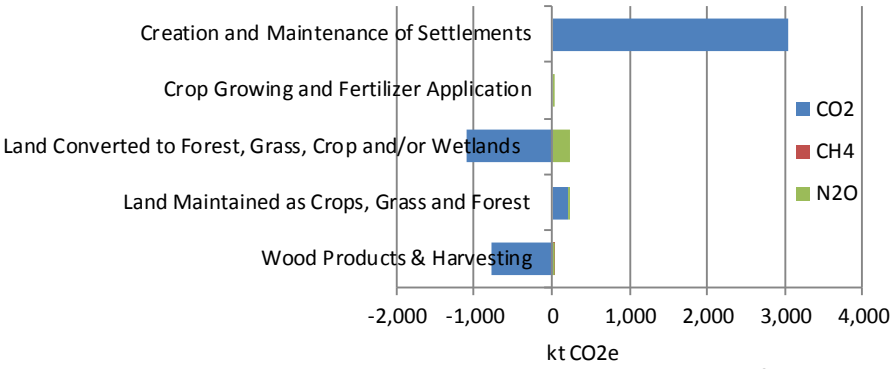


Figure 2.42

Emission Estimates for Base Year (BY), 2010 and 2011; change in GHG Emissions from BY to 2011 and from 2010 to 2011

	BY	2010	2011	BY-2011	2010-2011
Sub-sector	**kt CO2e**	**kt CO2e**	**kt CO2e**	**kt CO2e**	**kt CO2e**
Creation and Maintenance of Settlements	3,791	3,038	3,095	-696	57
Crop Growing and Fertilizer Application	11	12	12	1	0
Land Converted to Forest, Grass, Crop and/or Wetlands	1,639	-851	-886	-2,525	-35
Land Maintained as Crops, Grass and Forest	927	198	46	-881	-152
Wood Products & Harvesting	-357	-757	-534	-177	222
Total	6,011	1,641	1,733	-4,278	92

Table 2.13

Total GHG Emissions from LULUCF, Base Year - 2011

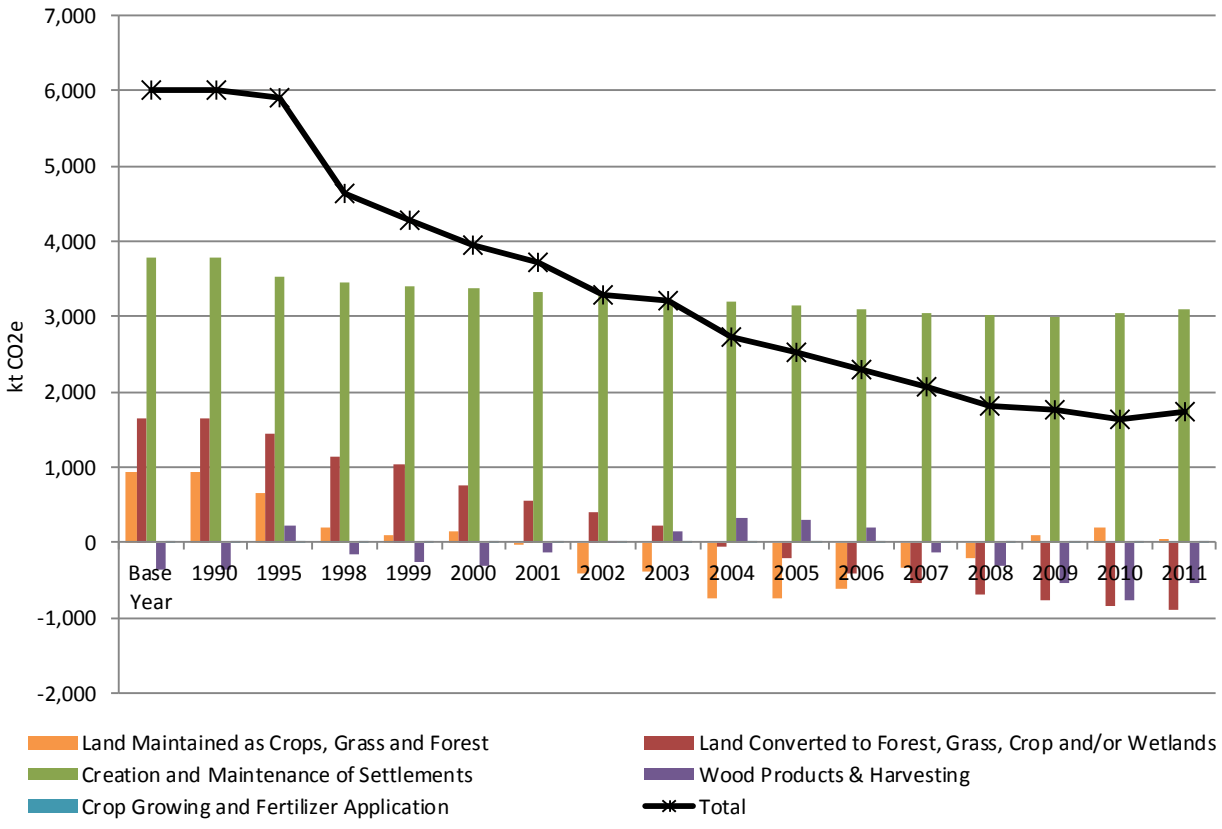


Figure 2.43

Figures 2.41 – 2.43 show detailed emissions and trends for the sector. Net emissions from Land Use, Land Use Change and Forestry (LULUCF) contribute to 0.4% of England emissions in 2011. England is a net source of greenhouse gases from LULUCF activities although the size of this source has diminished by 71% since the Base Year from 6,011 to 1,733 $ktCO_2e$. Emissions arise from the clearing of land (burning and decomposition of material) for the creation of settlements (towns and urban areas), grasslands, croplands and sometimes also for new forest planting. Carbon dioxide is removed from the atmosphere[23] by activities that manage and maintain grass and forest lands encouraging vegetation growth and minimising losses to the atmosphere of carbon dioxide from decomposition of materials. Net emissions have increased from 2010 to 2011 by 5.6% with no major single contributing factor. The changes in emissions between the Base Year and 2011, and between 2010 and 2011 are presented in Table 2.13.

Figure 2.42 and Table 2.13 show a 71% reduction in net emissions of CO_2e from LULUCF and the trends in emissions and removals from important activities in the LULUCF sector. The net emissions in England are dominated by emissions from Creation and Maintenance of Settlements, which have reduced by 11.6% between 1990 and 2011, and are a result of emissions from biomass removal from built up & transport areas, gardens and mineral workings. Emissions from Land Converted to Grass, Crop and Forest has decreased significantly due to a reduction in the amount of land converted from forest/grass land to cropland (which releases carbon from clearing of biomass and from ploughing of soils) while removals as a result of land converted to grassland (which allows carbon to build-up and be stored in the soils) have remained relatively constant. Net removals from Land Maintained as Crops, Grass and Forest (which includes land converted to forest) have generally increased to 2005 with a decreased between 2005 and 2011 as a result of an increase in removals in harvesting of wood products (Wood Products and Harvesting).

Emissions and removals are primarily for carbon dioxide (85% of absolute emissions/removals in 2011) with 14% from nitrous oxide.

A more detailed report of LULUCF emissions in England, Wales, Scotland and Northern Ireland can be found on the National Air Emissions Inventory (NAEI) website (H. Malcolm et al., 2013) and more detailed information is also available in the UK Greenhouse Gas Inventory Report, available on the NAEI website.

LULUCF Emissions on an End User Basis

As emissions and removals from LULUCF do not related to energy supply the end user emissions are the same as emissions by source.

[23] Removals are presented as negative emissions in the inventory tables

2.10 Waste Management

Overall Contribution of Waste Management to 2011 GHG emissions

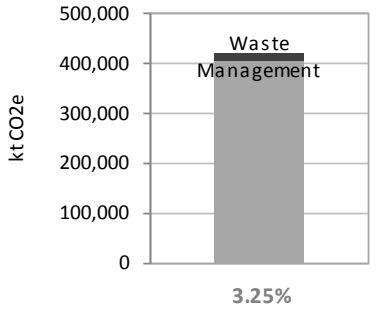


Figure 2.44

Total GHG Emissions from Waste Management, Base Year- 2011

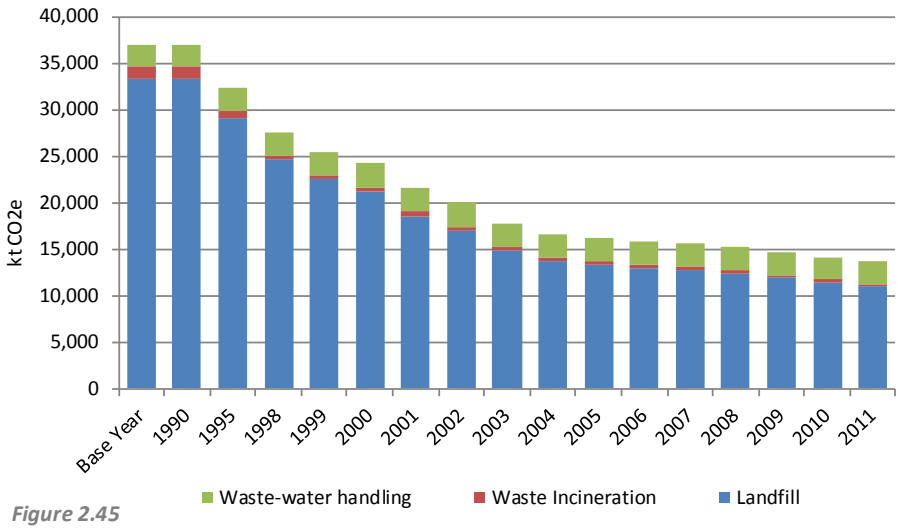


Figure 2.45

Change in GHG Emissions from Base Year (BY) to 2011 and from 2010 to 2011

	BY-2010		2009-2010	
Sub-sector	**%**	**kt CO2e**	**%**	**kt CO2e**
Landfill	-67%	-22,281	-4%	-483
Waste Incineration	-78%	-1,068	-2%	-6
Waste-water handling	1%	31	1%	15
Total	-63%	-23,318	-3%	-474

Table 2.14

Pollutant contribution to Waste Management Emissions, 2011

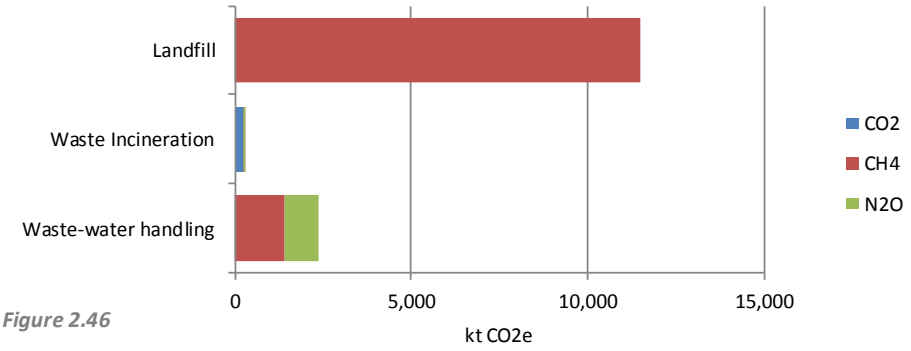


Figure 2.46

Figures 2.44 – 2.46 show detailed emissions and trends for the sector. The waste management sector contributes 3.3% to total GHG emissions in England, and is the largest source sector for methane emissions, representing 44% of total methane emissions. Emissions from this sector are dominated by methane from landfill (80% of total GHGs from the waste sector), with a smaller contribution of emissions of methane and nitrous oxide from wastewater treatment (17.5%). Methane emissions from industrial waste-water treatment have been estimated for the first time for this submission and contribute 3% to 8% of total Waste emissions across the 1990-2011 time series. Emissions from landfill in England constitute approximately 78% of UK landfill emissions.

The majority of total GHG emissions are of methane (91% of total sector GHG emissions in 2011). Nitrous oxide emissions from waste water treatment represent 7.3% of emissions in the sector, and contribute 4.2% to the total emissions of nitrous oxide in England.

Table 2.14 shows the change in emissions between the Base Year and 2011, and between 2010 and 2011 for the sector. Emissions of GHGs from the waste sector in England have shown a significant decline of 63% in total for the sector and by 67% from landfill between 1990 and 2011, due largely to the progressive introduction of methane capture and oxidation systems within landfill management. Sector GHG emissions have decreased between 2010 and 2011 by 3.3%, which is mainly due to UK-wide reductions in methane emission estimates from landfill.

Waste Emissions on an End User Basis

As emissions from the waste sector do not include any energy consumption sources, and no electricity use is allocated to the waste sector (due to lack of data), the end user emission estimates for the sector are unchanged from the emissions presented here on a by source basis.

3 Emissions in Scotland

3.1 1990-2011 GHG Inventory Estimates

The greenhouse gas (GHG) emissions for Scotland for 1990 – 2011 are presented in Table 3.1 and in the graph in Figure 3.2 below. The table below includes a summary of emissions from International Aviation and Shipping; the subsequent tables and figures do not include emissions from these sectors. Emissions in 2011 (excluding international aviation and shipping) were 48,794 $ktCO_2e$ with 35% of net GHG emissions in 2011 from Energy Supply, 21% from Transport sources, 18% from Business, 16% from Agriculture and 13% from Residential.

Table 3.1: 1990-2011 Scotland GHG Emissions ($ktCO_2e$)

NC Format	Base Year[26]	1990	1995	2000	2005	2008	2009	2010	2011	% of 2011
Agriculture	9,922	9,922	9,755	9,427	8,734	8,084	7,956	7,956	7,927	16%
Business	11,810	11,690	8,892	9,843	10,063	9,668	8,694	8,760	8,789	18%
Energy Supply	22,406	22,406	26,483	26,035	20,404	19,950	18,558	20,743	16,929	35%
Industrial Process	1,826	1,884	562	584	536	517	397	385	443	1%
LULUCF[24]	-2,055	-2,055	-2,679	-3,477	-4,998	-5,498	-5,505	-5,509	-5,270	-11%
Public	1,226	1,226	1,072	1,031	1,070	950	848	874	747	2%
Residential	8,181	8,147	8,135	8,280	7,984	7,779	7,301	8,367	6,584	13%
Transport	10,497	10,497	10,514	10,826	11,367	11,306	10,863	10,698	10,471	21%
Waste Management	6,712	6,712	5,794	4,123	2,610	2,399	2,320	2,237	2,174	4%
Total[25]	**70,524**	**70,429**	**68,530**	**66,672**	**57,770**	**55,154**	**51,432**	**54,511**	**48,794**	**100%**
International Aviation & Shipping	2,450	2,450	2,416	2,301	2,568	2,951	2,774	2,399	2,491	
Total + Int. Aviation & Shipping	72,974	72,879	70,946	68,973	60,338	58,105	54,206	56,910	51,285	

Figure 3.1 and Table 3.2 show the change in emissions from the Base Year to 2011, and from 2010 to 2011. Emissions in Scotland have shown a decrease between 2010 and 2011 of 10.5% for all GHGs and 13.2% for carbon dioxide, with emission reductions between the Base Year[26] and 2011 of 30.8% for all GHGs and 28.0% for carbon dioxide. Net emission reductions are the result of many factors from across the economy, including: a decline in manufacturing (e.g. closure of the Ravenscraig steelworks), efficiencies in energy generation and business heating, an increasing carbon sink in the land use sector, the increase in consumption of natural gas to replace more carbon-intensive solid and petroleum-based fuels, and a decline in landfill methane emissions.

[24] Land Use, Land Use Change and Forestry (LULUCF)

[25] Emission estimates from International Aviation and Shipping are not included in this total because these sources are "memo items" and thus not included in the UK emission estimates.

[26] 1995 for fluorinated greenhouse gases (F-Gases) and 1990 for all other gases

All sectors show a decreasing trend between the Base Year and 2011. Emissions for the transport sector have bucked the general trend with only a 0.2% decrease as a result of increasing population and increasing demand for transportation despite improvements in energy efficiency of vehicles. Notably, the cold winters at the start and end of 2010 drove up the residential sector emissions by 15% between 2009 and 2010, but these have decreased by 21% between 2010 and 2011. This is back in line with the steady emissions reduction seen in previous years.

Detailed analysis of Scotland emissions in 2011 is presented in Figures 3.4 – 3.10. The dominant sources of emission in 2011 are displayed in Figure 3.5. These include road transport (19% of total net GHGs), residential combustion for heating and cooking (13% of total net GHGs), electricity production (25% of total net GHGs) and industrial combustion for heat and electricity in the business sector (16% of total net GHGs).

Figure 3.4 shows the emissions split by GHG and highlights the 2.5 and 97.5 percentile range. The range of uncertainty is greatest for nitrous oxide emissions. See Appendix 1 for further details on uncertainties.

Carbon dioxide emissions make up the largest component of all National Communication (NC) sector emissions with two exceptions: agriculture, where methane from livestock and nitrous oxide from soils make large contributions, and waste where methane from landfills is the main GHG emission source (see Figure 3.6).

International Aviation and International Shipping

Emissions from international aviation have increased significantly since 1990 across the UK, ranging from 47% increase in Wales, 109% in England, 148% in Scotland and 175% in Northern Ireland. This reflects the growth in aviation and the increase in international routes at airports in Scotland and Northern Ireland in particular. From 2010 to 2011, emissions have increased in England and Scotland (4% and 8% respectively) and have decreased in Wales and Northern Ireland (-3% and -10% respectively).

Although UK emissions from international shipping have increased by 10% between 1990 and 2011, emissions from Scotland have decreased by 29% over this time period. While the UK shows a rise of 12% between 2010 and 2011, Scotland emissions have only increased by 1%. These trends are primarily due to a continual decrease in Scotland's port freight movements.

Traded and Non-Traded Emissions

Emissions from installations in the European Union Emissions Trading Scheme (EU ETS) (see Figure 3.8) contributed 41% of total net GHG emissions in Scotland in 2011. The main contributors to these traded emissions are the energy supply sector of which 94% of total emissions are within the EU ETS and the business and industrial process sector of which 43% of total sector emissions are in the EU ETS. Figure 3.9 shows emissions from installations included in the EU ETS reduce by 7% between 2008 and 2009 as a result of the reduced demand for energy and products due to the recession. However, the traded sector in Scotland then bounced back with an increase of over 9% between 2009 and 2010, which was a much higher growth than the UK average of 2% due, primarily, to an increase in power generation EU ETS emissions. The trend in 2010-11 reflects the warmer winters in 2011, leading to a fall in power generation emissions and an overall decline in traded sector emissions of 17%.

Emissions on an End User Basis

In addition to presenting emissions based on direct emissions from processes or combustion of fuels in Scotland, the emissions from the Energy Supply sector can be attributed to the users of the energy (see Appendix 3 for more details of the end user inventory methodology). Figure 3.6 illustrates the difference between the by source and end user inventory emission estimates and how emissions from energy supply are attributed to the end user NC categories.

The primary difference in the end user inventory is the significant increase in emissions attributable to the business, residential, transport and public sectors. The end user inventory data illustrate that on an energy consumption basis, the contribution to Scotland total emissions in 2011 are: 33% from business, 25% from the

residential sector and 24% from transport sources. As illustrated in Figure 3.3, Scotland has slightly higher net GHG emissions in Scotland on an end user basis (49,354 ktCO2e), compared to the by source inventory estimates for 2011 (48,794 ktCO2e). However, when emissions associated with exports (i.e. UK-based emissions associated with the generation of fuels – mainly refined oils and electricity – that are ultimately exported from the UK) are discounted from the DA inventories, Scotland end user emissions are slightly lower than the by source estimates, at 47,884 ktCO2e.

The end user model applies a UK-wide GHG emission factor to electricity use, and this has an important impact on the data for Scotland in particular. In 2011, Scotland generated 13.5% of the UK's electricity, exported 26% of the electricity generated, and only consumed 9.1% of total UK electricity. Therefore, the overall end user inventory might be expected to be very much lower for Scotland in 2011, compared to the by source inventory. However, the GHG emissions per unit GWh in Scotland are very much lower than the UK average in 2011 (at about 62% the level of GHG emissions per unit GWh in the UK) due to the higher proportion of renewable and nuclear generation in the Scotland power sector. Applying the much higher GHG electricity grid factor in the end users model leads to a higher GHG allocation for the 9.1% of UK consumption in Scotland, compared to the power sector emissions in Scotland in the by source inventory. Therefore, whilst Scotland is a net exporter of electricity to the rest of the UK in 2011, the application of a UK-wide factor for electricity generation to all UK electricity consumption means that Scotland is a net importer of electricity emissions in the end user inventories.

Emissions from the Land Use, Land Use Change and Forestry (LULUCF), industrial process and waste management sectors in Scotland in 2011 are unchanged between the by source and end user inventories, since there are no emissions from energy use allocated to these sectors.

A more detailed assessment of emissions by sector is presented in the following sections for each of the National Communication sectors.

3.1.1 Inventory Recalculations

Inventory recalculations of source estimates due to new data and/or improved inventory estimation methodologies have led to revisions to the estimates since the last inventory report (G. Thistlethwaite *et al.,* 2012); the impact of these revisions to the Scottish GHG inventory is an increase of 1,266 $ktCO_2e$ (2.2%) primarily due to:

1. **Other manufacturing industry and construction (Business)**: (1,120 $ktCO_2e$ increase) predominantly due to the addition of emissions due to new estimates in the UK inventory for the use of Other Petroleum Gas (OPG) in industrial boilers, following greater scrutiny of the EU ETS data for evidence of use of off-gases from petrochemical production processes being used in boilers on specific industrial sites. There have also been UK-wide revisions to gas oil allocations; a revision to Devolved Administration (DA) allocations of fuel use in industrial off-road machinery to use updated energy mapping analysis consistent with the Department of Energy and Climate Change (DECC) sub-national energy statistics; new UK-wide estimates for emissions from biomass; revisions to gas use in other industrial combustion across GB as a result of changes in point source analysis across 1A2 and revisions to the Digest of UK Energy Statistics (DUKES) activity data for gas-fired autogeneration; increased UK-wide allocation of fuel oil in industry of around 200% in 2010.
2. **Chemical industries (Business)**: (134 $ktCO_2e$ increase) primarily due to the revision to the handling of data for large petrochemical plant, where natural gas was previously assumed to be the fuel, now allocated to 1A2f: "Other manufacturing industry and construction" as Other Petroleum Gas (OPG). This has led to a revision of the allocation of natural gas use in the Industrial Combustion sector.
3. **Land converted to cropland (LULUCF)**: (-101 $ktCO_2e$ decrease) due to a revision to the methodology for emissions of nitrous oxide from the disturbance associated with land use conversion to cropland.

For more details of revisions to GHG emission estimates, see Appendix 6.

Percentage Change in GHG Emissions by NC: Base Year - 2011 and 2010 - 2011

The % changes for LULUCF are based on net change to sink/source across the time series

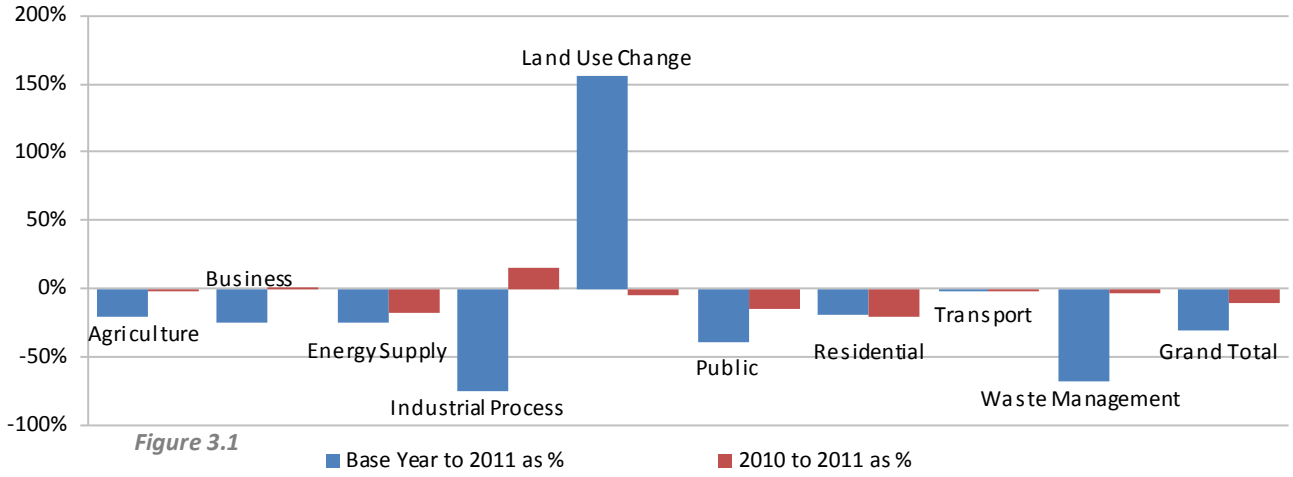


Figure 3.1

Percentage Change in Total GHG and CO2 Emissions by NC: Base Year - 2011 and 2010 - 2011

The % changes for LULUCF are based on net change to sink/source across the time series

Change in emissions from the Base Year to 2011 and 2010 to 2011	Agriculture	Business	Energy Supply	Industrial Process	Land Use Change	Public	Residential	Transport	Waste Management	**Total**	
Base Year to 2011 as %	-20%	-26%	-24%	-76%	156%	-39%	-20%	0%	-68%	-31%	**Total GHG as CO2e**
2010 to 2011 as %	0%	0%	-18%	15%	-4%	-15%	-21%	-2%	-3%	-10%	
Base Year to 2011 as %	-19%	-33%	-21%	-69%	126%	-39%	-20%	0%	-83%	-28%	**Total CO2 only**
2010 to 2011 as %	1%	0%	-19%	16%	-4%	-15%	-22%	-2%	-11%	-13%	
Base Year to 2011 kt	-1,994	-3,021	-5,477	-1,383	-3,215	-479	-1,597	-26	-4,538	-21,730	**Total GHG as CO2e**
2010 to 2011 kt	-28	28	-3,813	58	239	-127	-1,784	-227	-63	-5,717	
Base Year to 2011 kt	-165	-3,845	-4,290	-941	-3,063	-474	-1,599	46	-38	-14,369	**Total CO2 only**
2010 to 2011 kt	9	14	-3,820	59	251	-127	-1,778	-229	-1	-5,623	

Table 3.2

Total GHG Emissions by NC category for Base Year to 2011, as CO2e

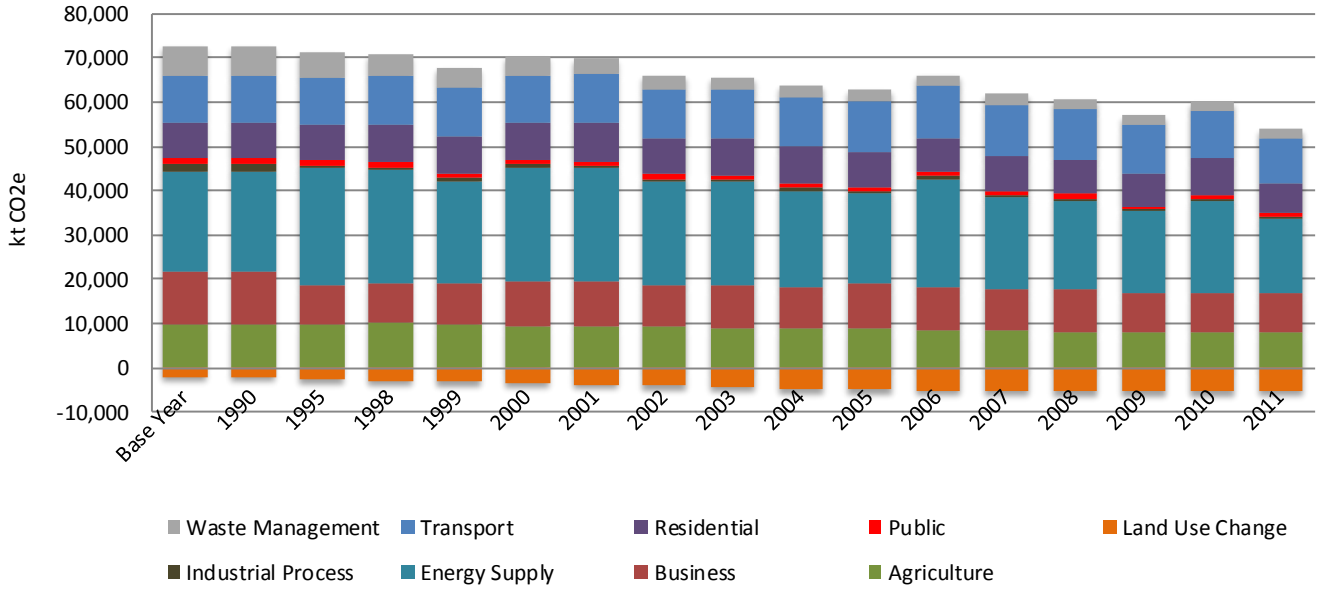
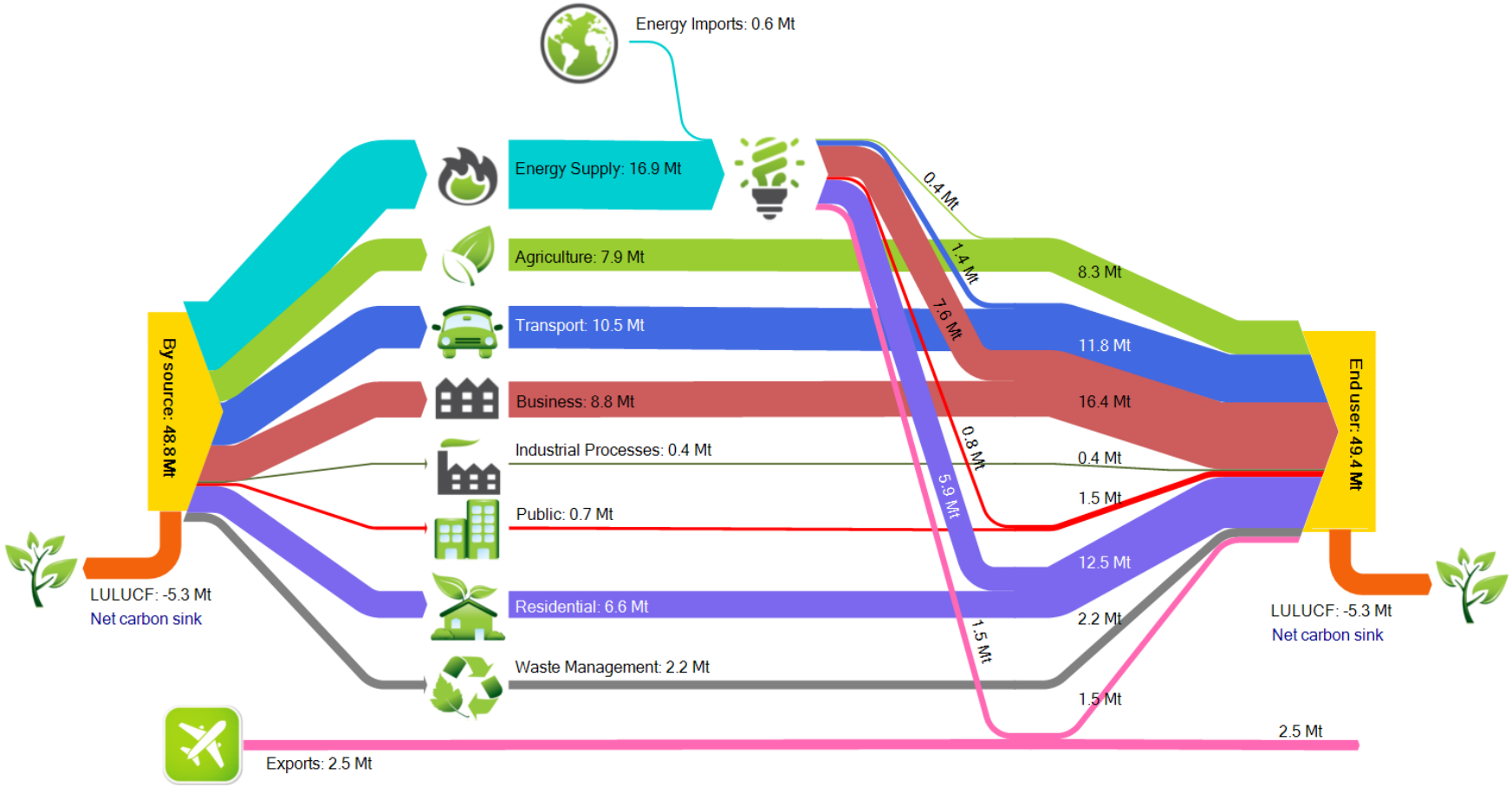


Figure 3.2

Figure 3.3 Sankey diagram showing By Source and End User[27] GHG emission transfers for Scotland in 2011 (Mt CO_2e) [28] [29]



[27] The pink line from 'Energy Supply' to 'End User' represents emissions from energy supply in the production of fuels used in international aviation and shipping.

[28] 'Exports' equates to emissions from international aviation and shipping.

[29] Energy imports (0.6 Mt) represents emissions relating to energy imports/exports. Scotland is a net exporter of electricity but the emissions in the diagram arise due to the use of UK emission efficiencies for electricity production. Scotland produces less GHG emissions per unit of electricity than the UK average.

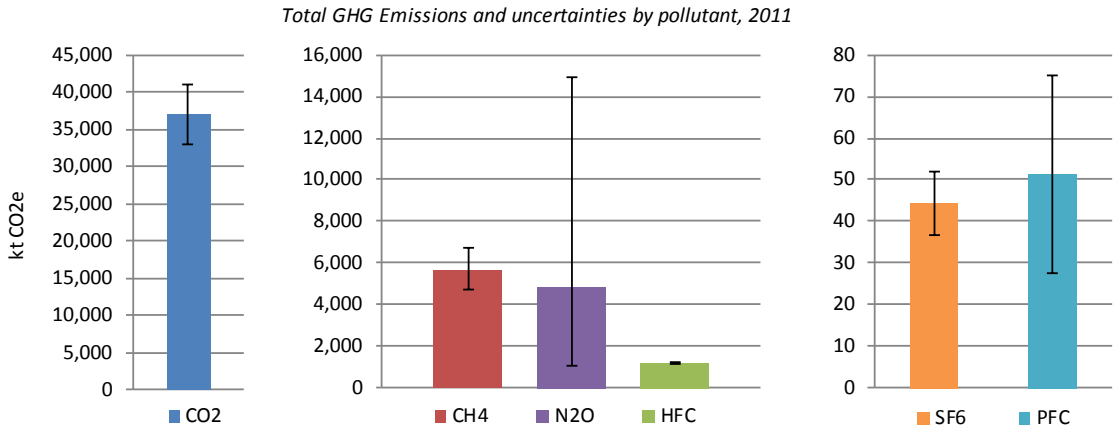


Figure 3.4

** error bars represent 2.5 to 97.5 percentile range*

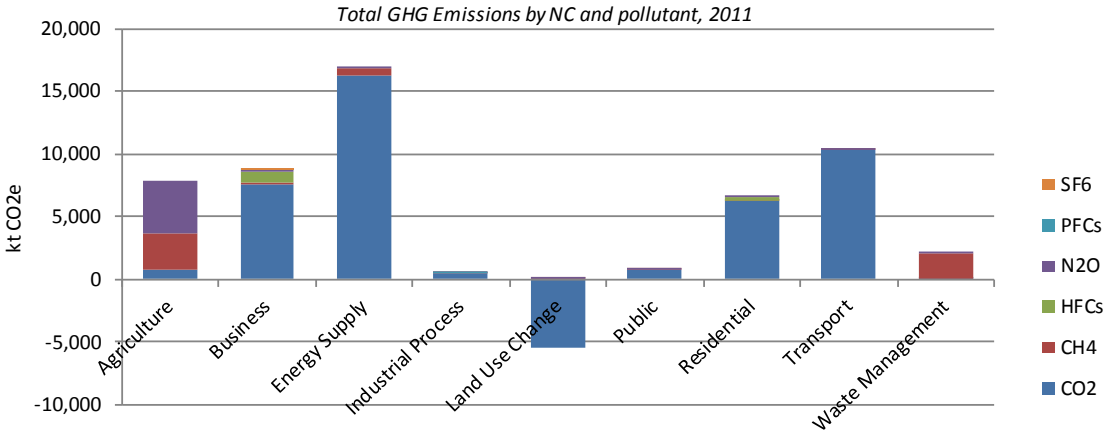


Figure 3.5

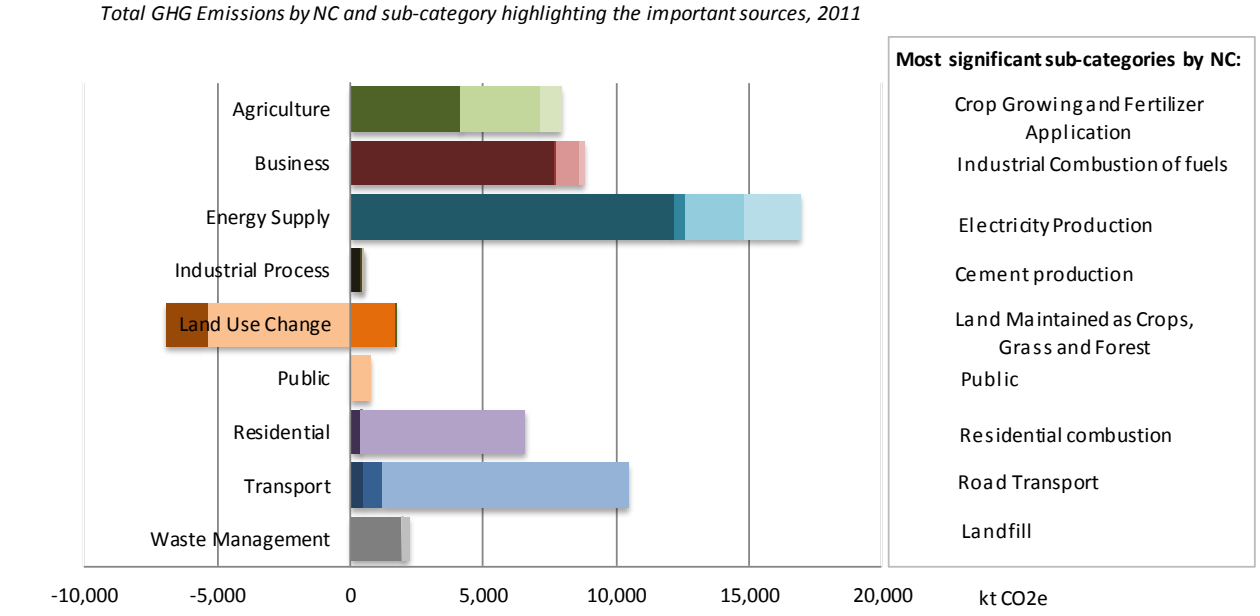


Figure 3.6

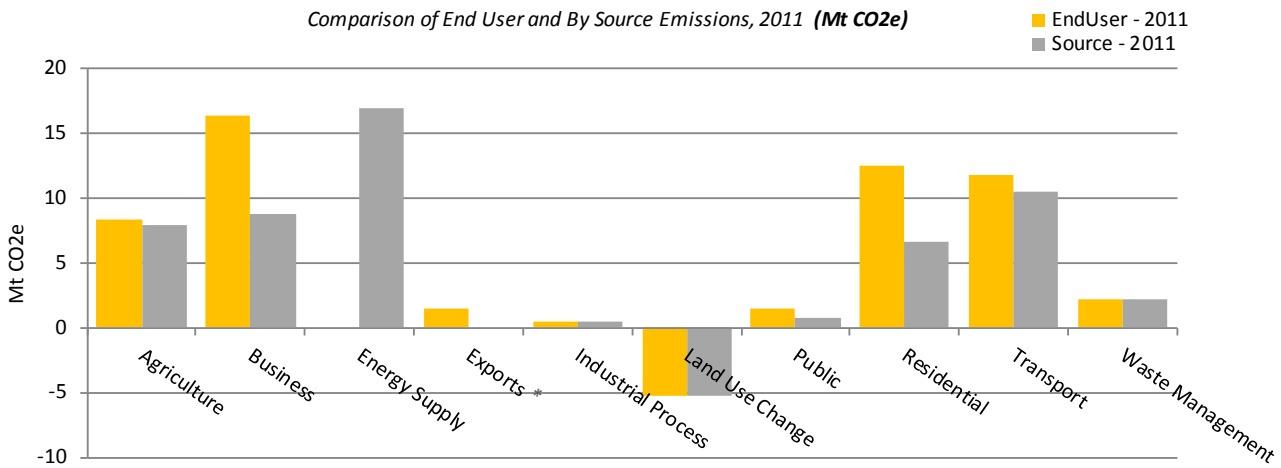


Figure 3.7

** Exports includes emissions from energy production for international aviation, international shipping and exported fuels.*

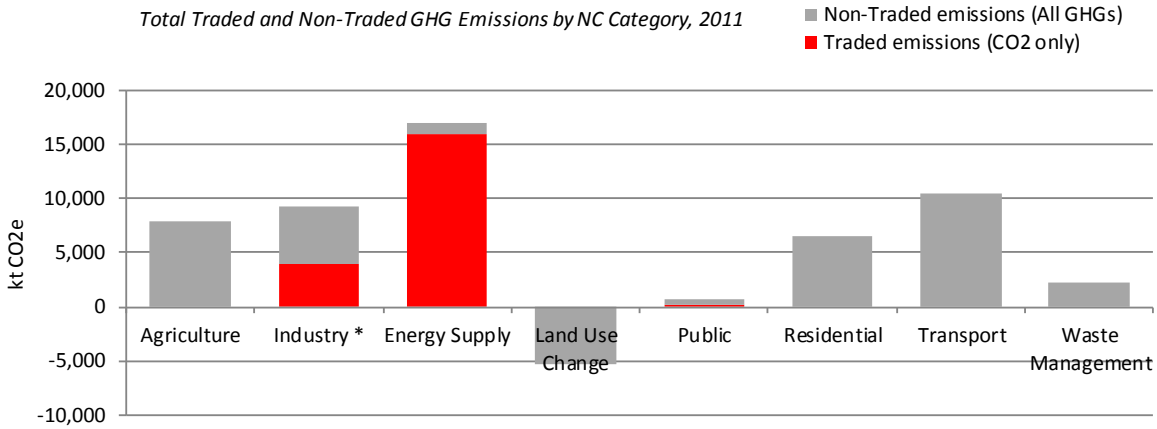


Figure 3.8

** Industry includes emissions from the NC categories: Industrial Process and Business*

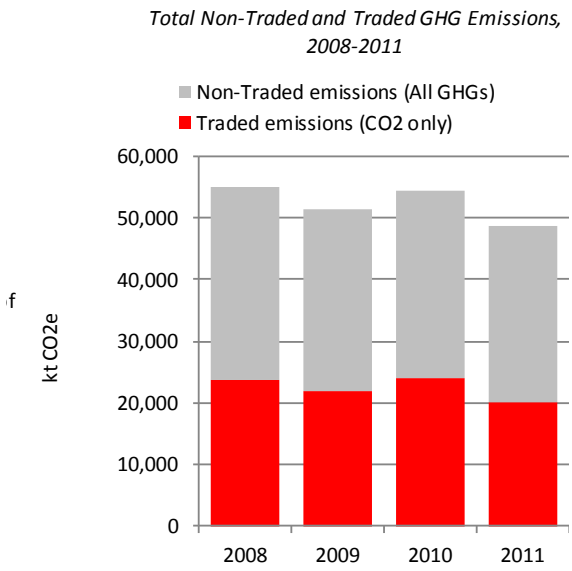


Figure 3.9

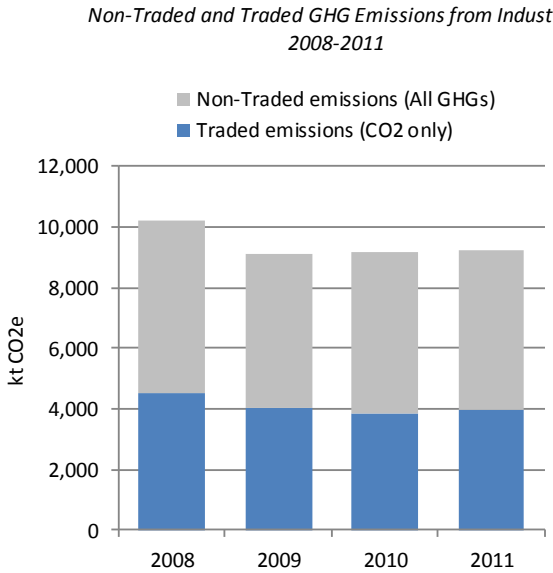


Figure 3.10

** Industry includes emissions from the NC categories: Industrial Process and Business*

3.2 Energy Supply

Overall Contribution of Energy Supply to 2011 GHG emissions

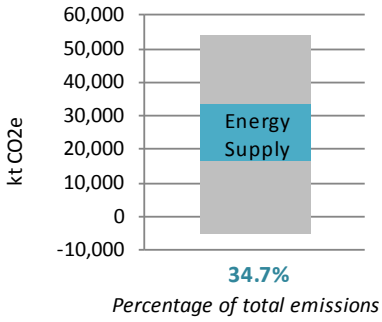


Figure 3.11

GHG Contribution for Energy Supply Emissions, 2011

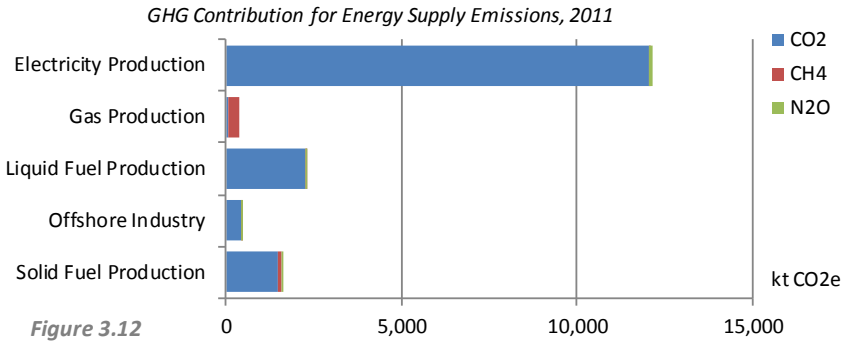


Figure 3.12

Change in GHG Emissions from Base Year (BY) to 2011 and from 2010 to 2011

	BY-2011		2010-2011	
Sub-sector	**%**	**kt CO2e**	**%**	**kt CO2e**
Electricity Production	-18%	-2,636	-23%	-3,679
Gas Production	-59%	-570	3%	11
Liquid Fuel Production	-22%	-642	4%	82
Offshore Industry	-60%	-704	23%	88
Solid Fuel Production	-36%	-924	-16%	-315
Total	-24%	-5,477	-18%	-3,813

Table 3.3

NC Category Contribution to End User Inventory by percentage of Electricity Production Emissions

NC Category	End User
Agriculture	2%
Business	52%
Industrial Process	0%
Public	5%
Residential	40%
Transport	1%
Exports*	0%

Table 3.4

Total GHG Emissions from Energy Supply, Base Year to 2011

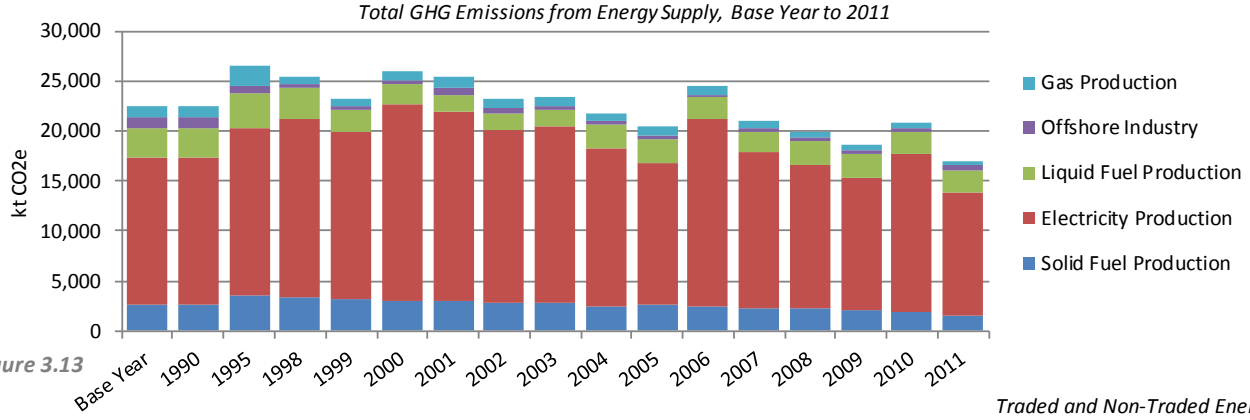


Figure 3.13

Emissions and Electricity Production by Fuel Type from Major Power Producers (1A1a)

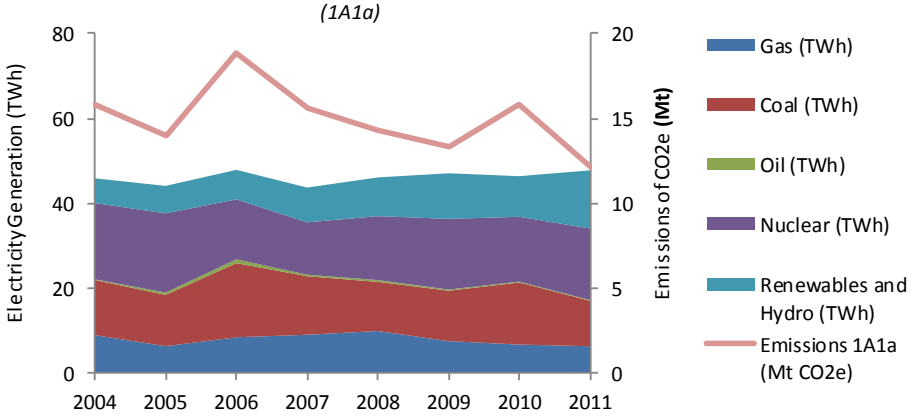


Figure 3.14

Traded and Non-Traded Energy Supply Emissions, 2009-2011

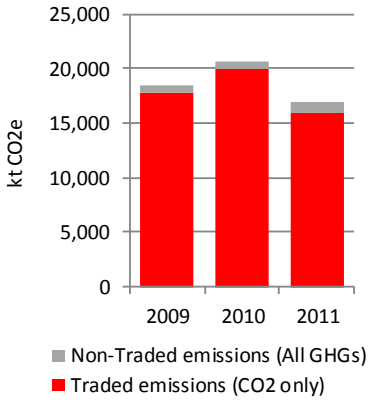


Figure 3.15

* These are emissions associated with the production of exported electricity and electricity used in international aviation and shipping.

Figures 3.11 – 3.15 show detailed emissions and trends for the Energy Supply sector. In Scotland, energy supply sources contribute 35% to total 2011 GHG emissions. Energy supply includes emissions from power generation, refineries, coal mines, solid fuel transformation, oil and gas extraction and processing, other energy industries. The main source of emissions in Scotland within the energy supply sector is electricity generation at power stations, which accounts for 71.8% of energy supply emissions in 2011; refinery emissions account for a further 13.5% of the energy supply sector emissions in 2011.

Table 3.3 shows the change in emissions between the Base Year and 2011, and between 2010 and 2011 for the sector. Energy supply sector emissions have reduced by 24% since the Base Year (Table 3.3), compared to the UK average of 30% reductions. Emissions have declined across many sectors such as coal mining, upstream oil and gas production, coke manufacture (due to closure of Ravenscraig steelworks) and oil refining. Emissions from power stations in Scotland have reduced by 18% between the Base Year and 2011, whereas the UK average is a 29% reduction; this reflects the fact that Scotland generates a high proportion of the UK electricity output and exports the electricity for consumption in England and Northern Ireland.

Energy supply sector emissions reduced by 18% (-3,813 kt CO_2e) between 2010 and 2011. This is primarily due to the reduction of the consumption of coal in power stations, which accounted for 29% of the power generation fuel mix in 2010 and only 21% in 2011. Power generation and consumption data from the Department of Energy and Climate Change (DECC) (DECC, 2012g) indicates that in 2011 around 26% of all electricity generated in Scotland was exported to England and Northern Ireland, with 2011 exports to England at 145% of exports in 2010. The mix of power generation in Scotland is shown in Figure 3.13; the fuel mix is notably different from the rest of the UK with high contribution in 2011 from nuclear power (33%) and renewable sources of energy (27%, mainly hydro-electricity and onshore wind). The remaining generation capacity is predominantly from coal-fired stations (21% of Scottish power generation in 2011), whilst Scotland has a notably lower share of electricity production from gas-fired stations, at only 12% of the Scottish electricity generation total in 2011 compared to a UK average of 38%.

Only those emissions arising from on-shore installations in Scotland have been included within the Scottish GHG inventory; emissions from upstream oil & gas exploration and production off-shore facilities are reported as “Unallocated”. Carbon dioxide from the combustion of fossil fuels is the predominant gas accounting for 96% of total GHG emissions from the energy supply sector in Scotland in 2011.

Energy Supply Traded and Non-Traded Emissions

Emissions in the energy supply sector are dominated by installations within the EU ETS, with 94% of emissions in energy supply from the traded sector (EU ETS); these traded emissions are primarily from power stations, refineries and upstream oil and gas terminals.

Energy Supply Emissions on an End User Basis

The “by source” inventories presented here allocate emissions to the constituent countries in which the emissions occur, and hence the GHG emissions from the power generated in Scotland and subsequently exported to England and Northern Ireland remain allocated to Scotland. In the end user inventories, however, the by source inventory emissions associated with energy production across the UK are re-allocated to the ultimate users of the energy. Therefore, in 2011, as Scotland consumed 9.1% of total electricity in the UK, the Scotland end user inventory includes a total allocation of 9.1% of emissions associated with electricity production.

However, as noted in section 3.1 above, the end user model applies a UK-wide GHG emission factor to electricity use, and therefore whilst Scotland is a net exporter of electricity to the rest of the UK in 2011, the application of a UK-wide factor for electricity generation to all UK electricity consumption means that Scotland is a net importer of electricity emissions in the end user inventories.

End user emissions from the Electricity Production part of the energy supply sector are presented in Table 3.4. On an end user basis, business and residential demand for electricity in Scotland in 2011 accounts for 52% and 40% of electricity supply emissions respectively.

3.3 Transport

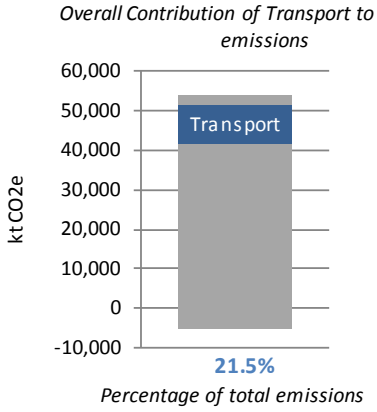


Figure 3.16

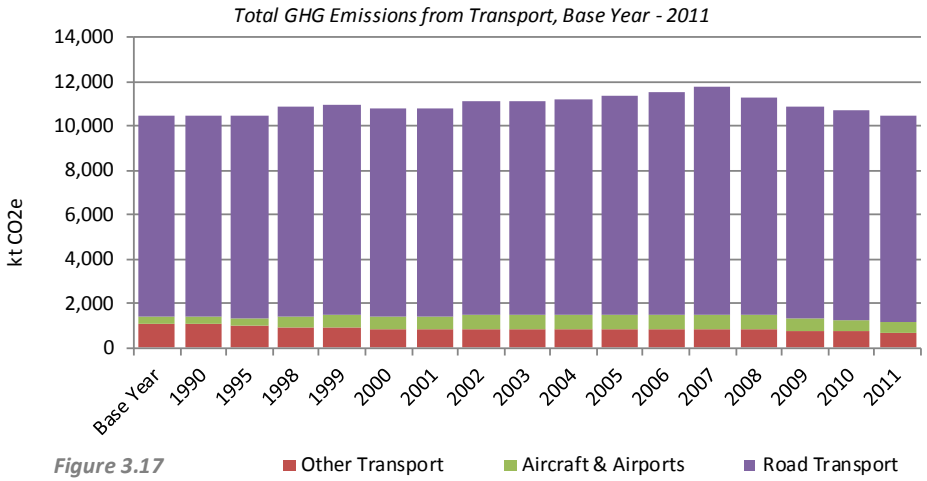


Figure 3.17

Change in GHG Emissions from Base Year (BY) to 2011 and from 2010 to 2011

	BY-2011		2010-2011	
Sub-sector	**%**	**kt CO2e**	**%**	**kt CO2e**
Aircraft & Airports	38%	135	-3%	-16
Other Transport	-32%	-342	-6%	-47
Road Transport	2%	182	-2%	-163
Total	0%	-26	-2%	-227

Table 3.5

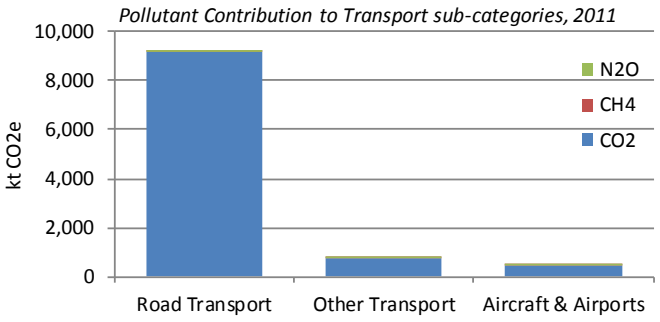


Figure 3.18

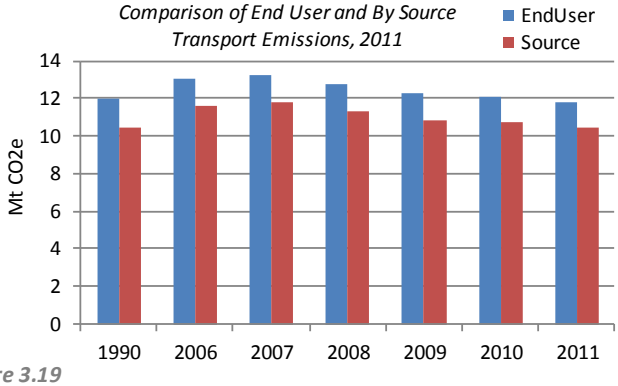


Figure 3.19

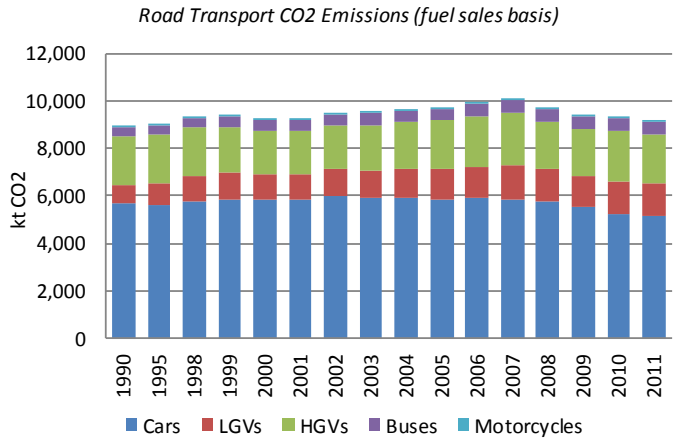


Figure 3.20

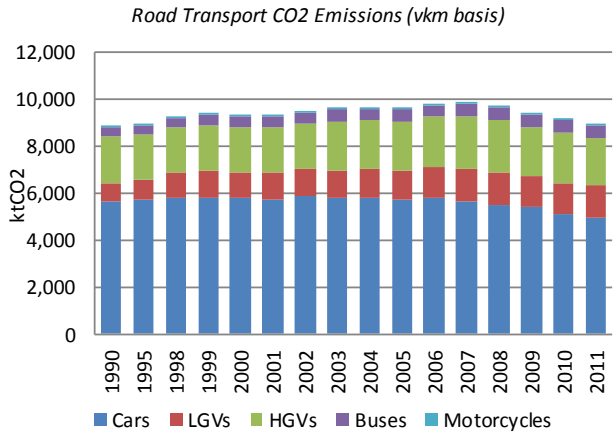


Figure 3.21

Figures 3.16 – 3.21 show detailed emissions and trends for the sector. Note that the transport emissions reported in this section exclude those from international aviation and shipping. Emissions from international aviation and shipping have been included in the Introduction of Scotland's chapter; the methodology is presented in Appendix 2.

Transport emissions accounted for 21.5% of Scotland's total GHG emissions in 2011. Transport emissions were dominated by emissions from road transport (88.5% of all Transport emissions in 2011, with 49.5% of transport emissions from cars alone). The transport sector also includes: 2% from rail (including stationary sources[30]), 3% from national navigation and coastal shipping, 4% from domestic aviation and 2% from military aviation and shipping.

Table 3.5 shows the change in emissions between the Base Year and 2011, and between 2010 and 2011 for the sector. Total GHG emissions from the transport sector in Scotland have only decreased by 0.2% between the Base Year and 2011 despite improvements in efficiency of transport vehicles, as a result of strong growth in transport demand. Emissions between 2010 and 2011 have not seen any significant change, with a small reduction of 2% in total. This sector is driven by the changes in emissions from passenger cars. Although emissions from road diesel (DERV) have increased, emissions from petrol have significantly decreased, which has led to this overall reduction in emissions.

Figures 3.20 and 3.21 show the carbon dioxide emissions from road transport for Scotland based on constrained (DUKES fuel sales) and unconstrained (vehicle kilometre, vkm) approaches. Total carbon dioxide emissions from the vkm approach are 0.8% and 2.4% lower than the estimates constrained to DUKES for 1990 and 2011 respectively. The differences between the two approaches fluctuate year on year but they remain within 2.4% of difference for Scotland. These disparities will also be reflected in the trends derived from the two approaches to a different extent. The long term trend (between Base Year and 2011) for each individual vehicle type is generally similar between the two approaches. The vkm approach indicates that the overall carbon dioxide emissions from road transport have increased by 1.0 % between the Base Year and 2011, while the constrained approach indicates a 2.7% increase.

Transport Emissions on an End User Basis

Figure 3.19 shows the end user estimates in recent years are 13% higher than the by source estimates, reflecting the additional emissions from upstream oil extraction and the oil refining sector. A small proportion of electricity generation emissions are also attributed to the end user transport sector from electric rail use.

The trend in end user emissions since 1990 shows a decrease of 1% to 2011, which is a slightly greater decrease than reported in the by source inventory, reflecting the improved energy efficiency of upstream production and refining of crude oil to produce the fuels used in the transport sector.

[30] Electricity use by the rail sector is not assigned to the transport sector in the by source estimates, but is attributed to the transport sector in the end user estimates.

3.4 Residential

Overall Contribution of Residential sector to 2011 GHG emissions

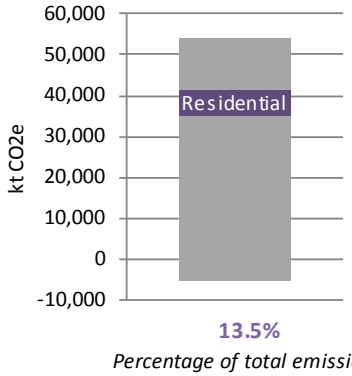


Figure 3.22

Total GHG Emissions by sub-sector, Base Year - 2011

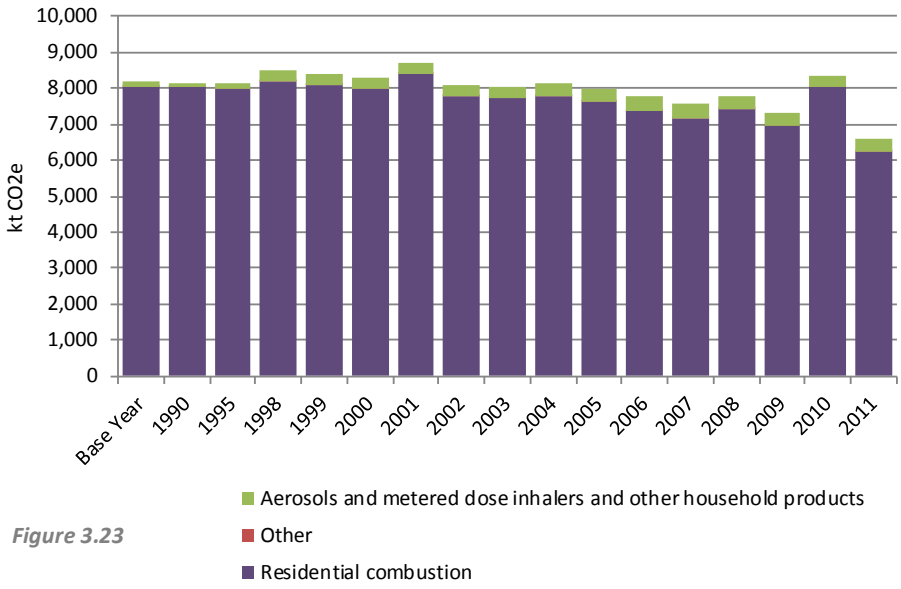


Figure 3.23

Change in GHG Emissions from Base Year (BY) to 2011 and from 2010 to 2011

	BY-2011		2010-2011	
Sub-sector	**%**	**kt CO2e**	**%**	**kt CO2e**
Aerosols and metered dose inhalers and other household products	147%	211	0%	1
Other	-34%	0	0%	0
Residential combustion	-22%	-1808	-22%	-1,785
Total	-20%	-1597	-21%	-1,784

Table 3.6

Pollutant contribution to Residential Emissions, 2011

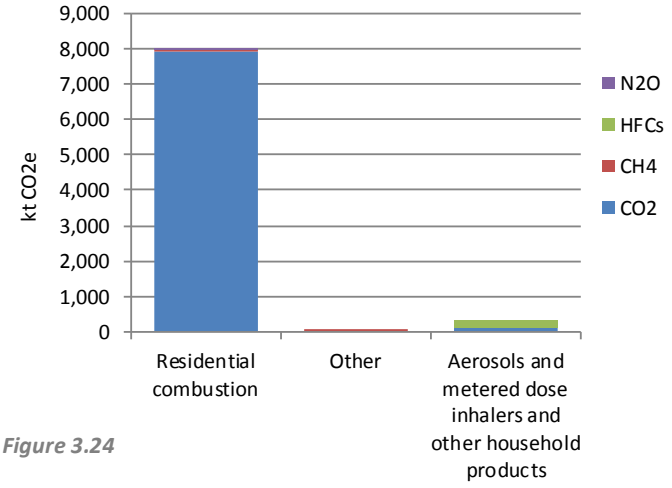


Figure 3.24

*Comparison between End User and By Source Inventory Totals **(Mt CO2e)***

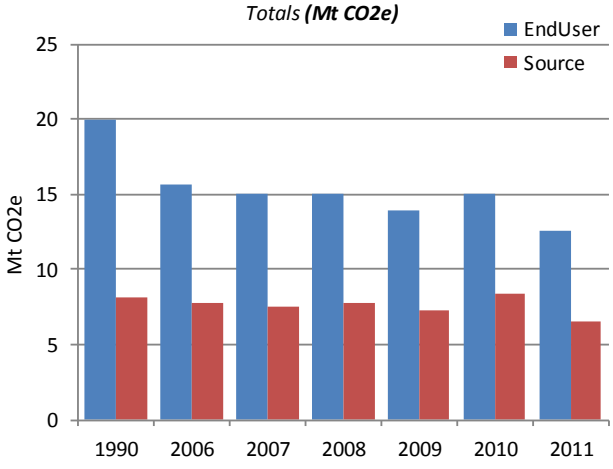


Figure 3.25

Figures 3.22 – 3.25 show detailed emissions and trends for the sector. The residential sector accounts for 13.5% of Scotland's total net GHG emissions in 2011. The sector comprises emissions from domestic combustion (95% of emissions for the residential sector) from heating and cooking, household products, accidental vehicle fires and HFC emissions from the use of aerosols and metered dose (usually asthma) inhalers. Over 95% of all residential sector GHG emissions are from the release of carbon dioxide from the direct combustion of fossil fuels (see Figure 3.24).

Table 3.6 shows the change in emissions between the Base Year and 2011, and between 2010 and 2011 for the sector. Total GHG emissions from the residential sector in Scotland have decreased by 20% between the Base Year and 2011. There was a large increase in fuel use and GHG emissions from the sector in 2010 (15% increase in emissions between 2009 and 2010) primarily driven by two successive cold winters and a resultant high demand for fossil[31] fuel heating in many parts of Scotland. In 2011, emissions from this sector decreased by 21% between 2010 and 2011 resulting in an overall decrease of emissions from 2009 to 2011 of 10%. This reduction was due to a decrease in the consumption of natural gas.

Residential Emissions on an End User Basis

Figure 3.25 shows that in 2011 Scotland end user emissions for the residential sector are 190% of the by source emission estimates, reflecting the high consumption of electricity in the sector. This increases the overall significance of this sector in the end user inventory to 25% of the Scotland total, compared to just 13% of the by source inventory total. The trend in residential sector end user emissions since 1990 shows a decline of around 37% to 2011; these GHG reductions have been achieved through improvements in housing energy efficiency and lower carbon intensity of the UK electricity generation sector since 1990. However, the reported trends are uncertain and should be regarded as indicative only due to the limited data on electricity use by source (particularly in early years) and also the high uncertainty in the by source estimates for the sector.

[31] Note that the emission estimates in the domestic sector are associated with high uncertainty due to the absence of comprehensive, detailed DA-specific fuel use data, particularly for solid and liquid fuels.

3.5 Business

Overall Contribution to 2011 GHG emissions

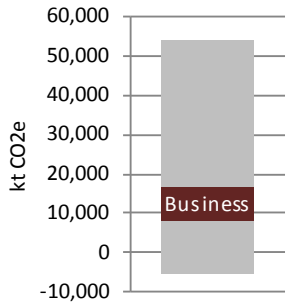


Figure 3.26

18.01%

Percentage of total emissions

Total GHG Emissions from Business, Base Year - 2011

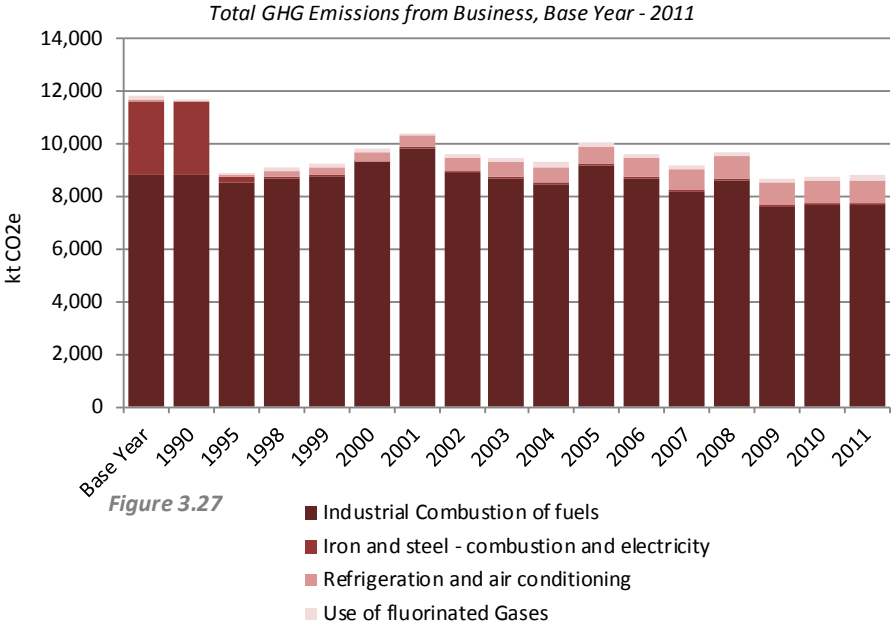


Figure 3.27

Change in GHG Emissions from Base Year (BY) to 2011 and from 2010 to 2011

	BY-2011		2010-2011	
Sub-sector	**%**	**kt CO2e**	**%**	**kt CO2e**
Industrial Combustion of fuels	-13%	-1,168	0%	5
Iron and steel - combustion and electricity	-98%	-2,761	8%	4
Refrigeration and air conditioning	1379%	860	2%	19
Use of fluorinated Gases	50%	49	0%	0
Total	-26%	-3,021	0%	28

Table 3.7

Pollutant Contribution for Business Emissions, 2011

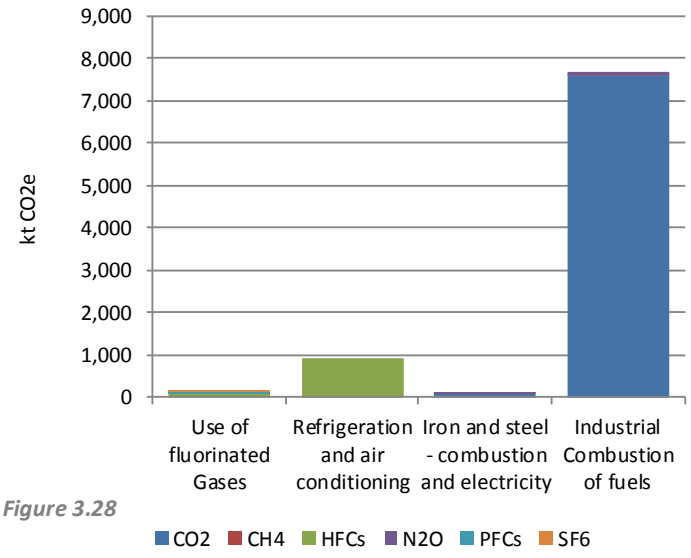


Figure 3.28

Comparison between End User and By Source Inventory for the Business Sector, 1990 and 2006-2011 ***(Mt CO2e)***

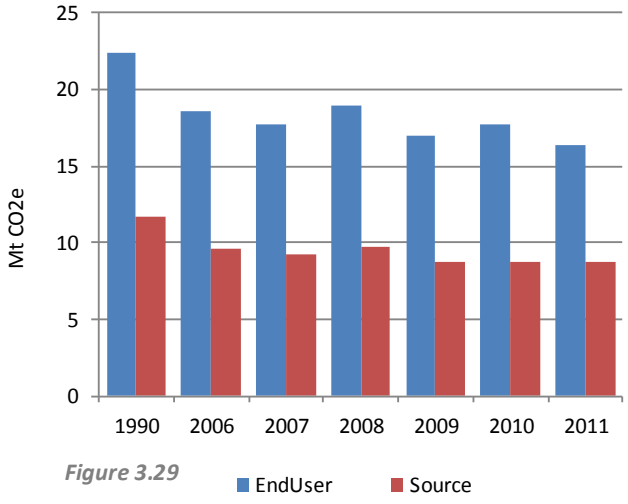


Figure 3.29

Figures 3.26 – 3.29 show detailed emissions and trends for the sector. In Scotland, the business sector contributes 18% to 2011 total net GHG emissions in Scotland. The business sector in 2011 includes emissions from industrial combustion of fuels (87% of business emissions) from manufacturing and construction industry; refrigeration & air conditioning (10% of business emissions), arising from losses of HFCs during equipment manufacture, leaks and disposal; as well as F-gas emissions from foam production, fire fighting solvents and electronics (2% of business emissions) and combustion emissions from the iron and steel sector (1% of business emissions). In 2011, 87% of the Scottish business sector GHG emissions were carbon dioxide, primarily released from the combustion of fossil fuels, with 12% from the use of fluorinated greenhouse gases (F-Gases), predominantly HFCs.

Table 3.7 shows the change in emissions between the Base Year and 2011, and between 2010 and 2011 for the sector. Total business sector GHG emissions in Scotland have reduced by 26% since the Base Year. These reductions have primarily been achieved as a result of declining manufacturing and iron and steel industry emissions. Contrary to the overall decline in emissions from the sector, emissions of fluorinated gases and especially HFC from refrigeration and air conditioning have risen by over 1300% since 1995 with the introduction of these gases as replacements to CFCs banned by the Montreal Protocol; these emissions now account for 10% of total business emissions in 2011.

Business emissions increased by 0.3% between 2010 and 2011 due to an increase in natural gas consumption within the chemicals and food & drink sectors, which was partly off-set by a reduction in natural gas consumption within the industrial/commercial sector.

The combustion emission estimates in the business sector are associated with high uncertainty due to the absence of comprehensive, detailed DA-specific fuel use data, particularly for solid and liquid fuels. Non-combustion emissions account for around 11% of the total business emissions in Scotland. These data are also uncertain due to the lack of DA-specific data on F-gas sources and the use of proxy data such as economic indices and population to estimate the DA share of UK emissions for these sources.

Business Traded and Non-Traded Emissions

Emissions in the business sector include significant contributions from installations reporting in the EU ETS. However, due to the lack of detail in the EU ETS dataset, business, energy supply and industrial process emissions are not easy to separate. The contribution to total aggregate emissions from the traded and non-traded sector across these NC sectors is presented in Figure 3.9 in the summary section.

A high proportion of total emissions in the business sector are from installations that are included in the EU ETS; traded emissions have accounted for between 42-45% of total business and industrial process sector emissions in Scotland during 2008 to 2011, and comprise cement kiln emissions and fuel combustion emissions from large industrial combustion plant and autogenerators.

Business Emissions on an End User Basis

As shown in Figure 3.29, 2011 Scotland end user emissions for the business sector are 186% of the by source emission estimates, reflecting the high consumption of electricity for heating, lighting and operating equipment (and therefore share of emissions from electricity production) in the sector. From this end user perspective, the business sector represents 33% of total emissions for Scotland compared to just 18% of the by source inventory total.

3.6 Public

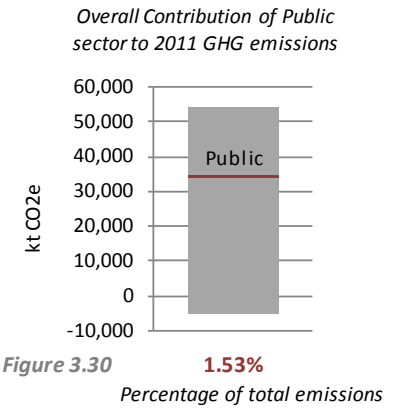


Figure 3.30

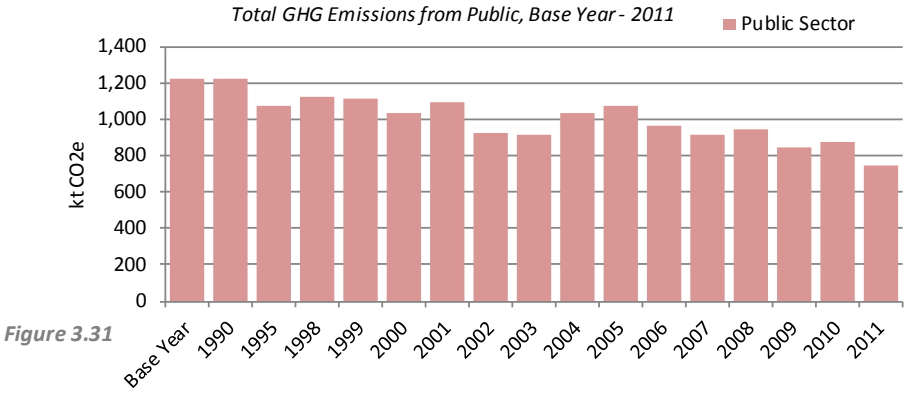


Figure 3.31

Change in GHG Emissions from Base Year (BY) to 2011 and from 2010 to 2011

	BY-2011		2010-2011	
Sub-sector	**%**	**kt CO2e**	**%**	**kt CO2e**
Public	-39%	-479	-15%	-127

Table 3.8

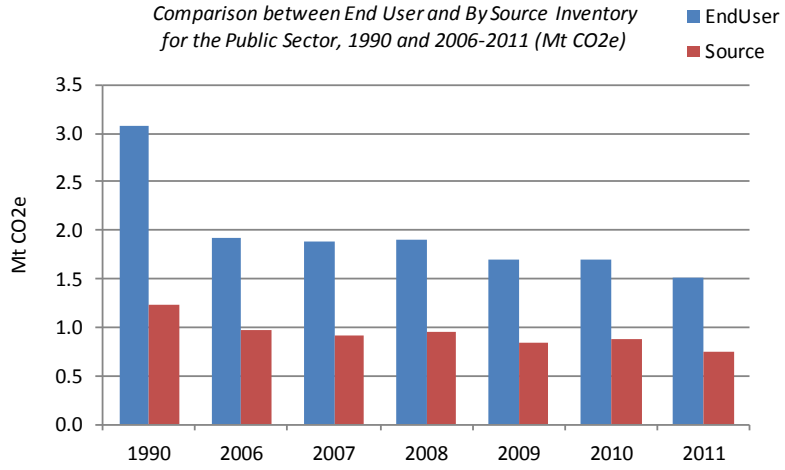


Figure 3.32

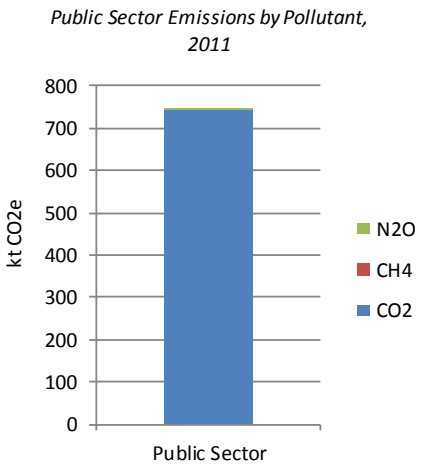


Figure 3.33

Figures 3.30 – 3.33 show detailed emissions and trends for the sector. Emissions from public sector combustion account for 2% of GHG emissions in Scotland in 2011. 99.7% of emissions in this sector are from carbon dioxide from the combustion of fossil fuels (predominantly natural gas).

Table 3.8 shows the change in emissions between the Base Year and 2011, and between 2010 and 2011 for the sector. Public sector GHG emissions have reduced by 39% since the Base Year; these reductions have been achieved through improvements to building energy efficiency and a trend to convert to the use of gas-fired boilers and heating across Scotland for many public sector buildings since 1990. Emissions between 2010 and 2011 decreased by 15%, primarily due to the cold 2010 winter weather at the start and end of 2010 increasing the heating demand, which has led to a decrease in consumption of natural gas in 2011.

Public Emissions on an End User Basis

As illustrated in Figure 3.32, 2011 Scotland end user emissions for the public sector are 202% of the by source emission estimates, reflecting the high consumption of electricity in the sector and increasing the sectors share of total Scotland emissions from 1.5% to 3.1% in 2011. The trend in end user emissions since 1990 shows a decline of around 51% to 2011[32],

Note that the emission estimates in the public sector are associated with high uncertainty due to the absence of comprehensive, detailed DA-specific fuel use data, particularly for solid and liquid fuels and rely on estimates modelled on employment and GDP.

[32] the trend data are uncertain and should be regarded as indicative only due to the limited data on electricity use by source.

3.7 Industrial Process

Overall Contribution of Industrial Process to 2011 GHG emissions

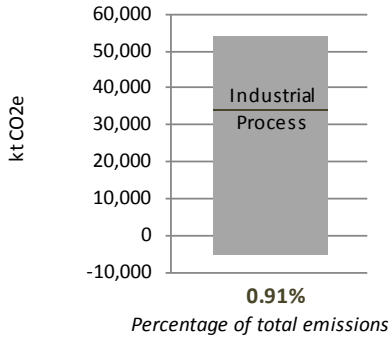


Figure 3.34

Total GHG Emissions from Industrial Process, Base Year - 2011

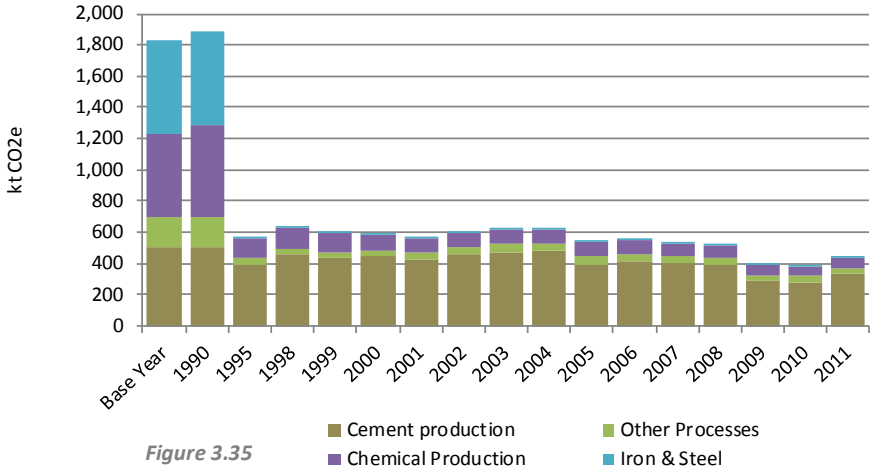


Figure 3.35

Change in GHG Emissions from Base Year (BY) to 2011 and from 2010 to 2011

	BY-2011		2010-2011	
Sub-sector	**%**	**kt CO2e**	**%**	**kt CO2e**
Cement production	-34%	-175	19%	54
Chemical Production	-87%	-459	9%	6
Iron & Steel	-100%	-595	-1%	0
Other Processes	-81%	-155	-4%	-2
Total	-76%	-1383	15%	58

Table 3.9

Pollutant Contribution for Industrial Process Emissions, 2011

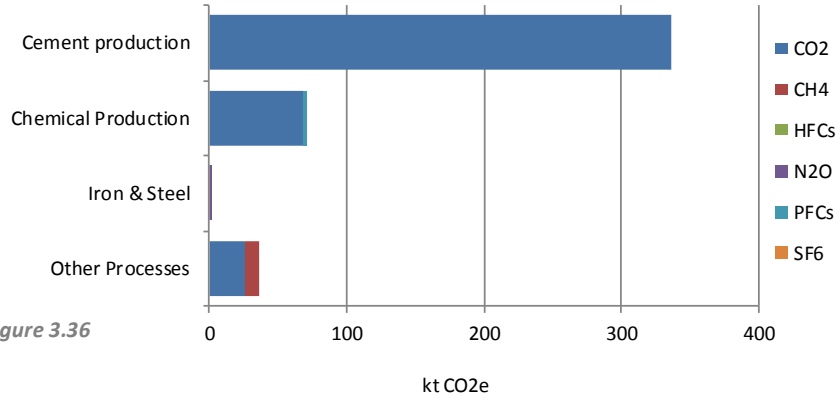


Figure 3.36

Figures 3.34 – 3.36 show detailed emissions and trends for the sector. In 2011, the industrial process sector contributed 1% to total GHG emissions in Scotland. The industrial process sector emissions arise from non-combustion sources and in Scotland comprised three main sources in 2011: 76% of total sector emissions come from cement decarbonisation of limestone, with 11% from process sources in the glass industry and 11% from primary aluminium production (decarbonisation of anodes and a small emission of PFCs). Emissions of methane accounted for only 2% of total GHG emissions from the industrial process sector, while emissions of carbon dioxide accounted for 97% of total GHG emissions in 2011.

Table 3.9 shows the change in emissions between the Base Year and 2011, and between 2010 and 2011 for the sector. Overall industrial process sector emissions in Scotland have reduced by 76% between the Base Year and 2011. This large decline in emissions is primarily due to the closure of the nitric acid plant, closure of Ravenscraig iron and steel works, and a reduction in emissions from the chemicals and cement sectors. However, emissions have increased between 2010 and 2011 by 15%, primarily due to increasing emissions from cement production.

Industrial Process Traded and non-traded emissions

Emissions in the industrial process sector include significant contributions from installations reporting in the EU ETS. However, due to the lack of detail in the EU ETS dataset, business, energy supply and industrial process emissions are not easy to separate. The contribution to total aggregate emissions from the traded and non-traded sector across these National Communication (NC) sectors is presented in Figure 3.9 in the summary section.

Industrial Process Emissions on an End User Basis

As the majority of emissions in the industrial process sector are not due to energy consumption, Industrial process sector emissions on an end user basis are very similar to the emissions by source. In 2011, the end user estimates are less than 0.1% higher than those in the by source industrial process inventory, reflecting a very low contribution to sector emissions from the use of electricity or fossil fuels as feedstock or for energy.

3.8 Agriculture

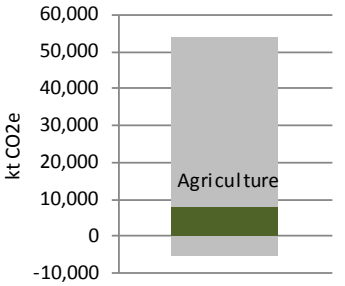


Figure 3.37

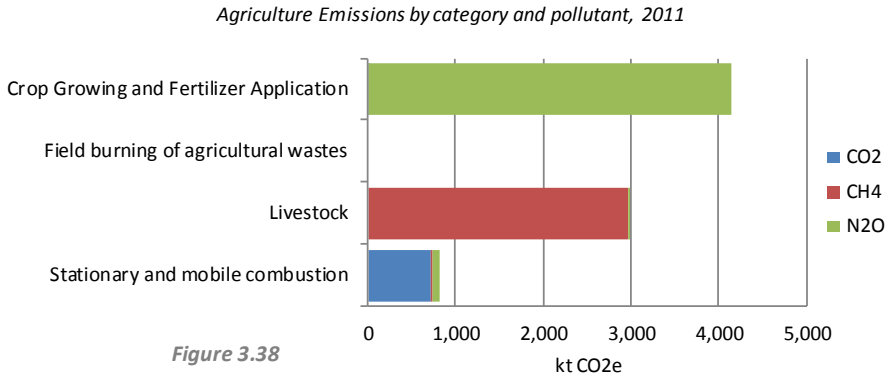


Figure 3.38

Change in GHG Emissions from Base Year (BY) to 2011 and from 2010 to 2011

	BY-2011		2010-2011	
Sub-sector	**%**	**kt CO2e**	**%**	**kt CO2e**
Crop Growing and Fertilizer Application	-22%	-1,144	-1%	-24
Field burning of agricultural wastes	-100%	-94	-	0
Livestock	-16%	-578	-1%	-15
Stationary and mobile combustion	-18%	-178	1%	11
Total	-20%	-1,994	0%	-28

Table 3.10

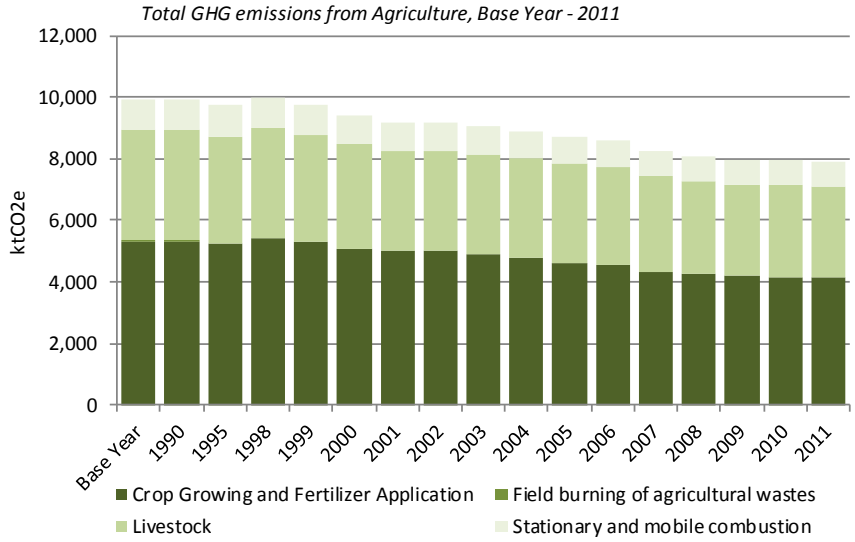


Figure 3.39

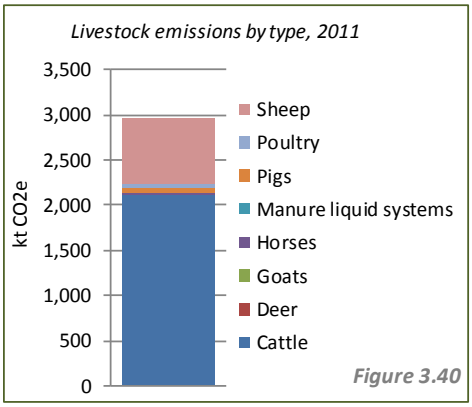


Figure 3.40

Figures 3.37 – 3.40 show detailed emissions and trends for the sector. GHG emissions from agriculture under the Intergovernmental Panel on Climate Change (IPCC) reporting format comprise entirely of methane and nitrous oxide. However, within the NC sector for agriculture there are also carbon dioxide emissions from fuel combustion in stationary (e.g. boilers) and mobile units (e.g. tractors and other machinery). Emissions from the agriculture NC sector contribute 16% to total greenhouse gas emissions in Scotland in 2011. These emissions arise primarily from livestock (enteric fermentation and waste management) and agricultural soils. In 1990, a small emission was also included from field burning, but this practice has now ceased in the UK and is therefore no longer a source.

Table 3.10 shows the change in emissions between the Base Year and 2011, and between 2010 and 2011 for the sector. Agriculture is the largest source of methane emissions in Scotland in 2011. Enteric fermentation

contributed 90% (2,671 $ktCO_2e$) to total agricultural methane in Scotland in 2011. Total cattle emissions (dairy and beef enteric and waste management) accounted for 71% of the total agricultural methane emissions, whilst emissions from sheep accounted for a further 25% of the total. Total agriculture GHG emissions decreased by 0.01% between 2009 and 2010 and then further decreased by 0.4% between 2010 and 2011.

Methane emissions are largely dependent on the numbers of livestock and have fallen by 18% between the Base Year and 2011, due to a decline in cattle and sheep numbers. Scotland accounted for 17% of UK agricultural methane emissions with methane emissions decreasing by 0.5% in 2011 compared to 2010. Agriculture is also by far the largest source of nitrous oxide in Scotland, accounting for 87% of total national emissions in 2011. The largest source of nitrous oxide emissions is releases from agricultural soils (3,891 $ktCO_2e$) which accounts for 92% of total nitrous oxide emissions in the agriculture sector and 80% of nitrous oxide emissions from all sources in Scotland in 2011. Emissions from the agricultural soils sector are broken down in Table 3.11.

Nitrous oxide emissions are largely driven by fertiliser nitrogen use, manure applications and grazing returns to soils. Scottish emissions of nitrous oxide have declined by 22% between the Base Year and 2011 due to a decline in livestock numbers and in nitrogen fertiliser use (particularly to grassland). Emissions decreased by 0.5% in 2011 relative to 2010.

Table 3.11 Emissions of nitrous oxide from agricultural sources in Scotland in 2011 ($ktCO_2e$)[33]

Manure management				252
Soils				3,891
	Direct			*2,498*
		Fertiliser		850
		Grazing returns		1,020
		Manure application		271
		Crop residues		307
		Biological fixation		7
		Improved grassland		33
		Histosols		0
		Sewage sludge		9
	Indirect			*1,393*
		Leaching		1,160
			Fertiliser	567
			Grazing returns	383
			Manure application	203
			Sewage sludge	7
		Deposition		234
			Fertiliser	76
			Grazing returns	102
			Manure application	54
			Sewage sludge	2
Field burning				0
Total				**4,143**

Agriculture Emissions on an End User Basis

As the majority of emissions in the agriculture sector are not due to energy consumption, Agriculture sector emissions on an end user basis are very similar to the emissions by source. In 2011, the end user estimates were only 5% higher for the agriculture sector, reflecting the relatively low contribution to sector emissions from the use of oils and electricity, compared to the higher-emitting sources of nitrous oxide and methane from soils and livestock sources.

[33] Total emissions comprise manure management, soils and field burning. Soils include direct and indirect emissions; indirect emissions include leaching and deposition.

3.9 Land Use, Land Use Change and Forestry

Overall Contribution to 2011 GHG emissions

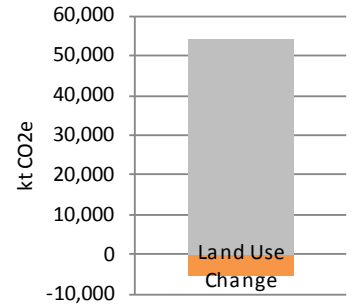


Figure 3.41

Percentage of total emissions

Pollutant Contribution to LULUCF GHG Emissions, 2011

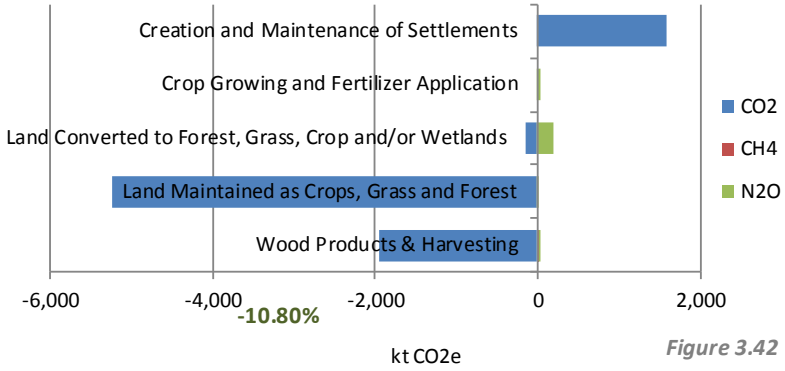


Figure 3.42

Emission Estimates for Base Year (BY), 2010 and 2011; change in GHG Emissions from BY to 2011 and from 2010 to 2011

	BY	2010	2011	BY-2011	2010-2011
Sub-sector	**kt CO2e**	**kt CO2e**	**kt CO2e**	**kt CO2e**	**kt CO2e**
Creation and Maintenance of Settlements	1,736	1,600	1,630	-106	31
Crop Growing and Fertilizer Application	25	29	29	4	0
Land Converted to Forest, Grass, Crop and/or Wetlands	-466	48	-60	406	-108
Land Maintained as Crops, Grass and Forest	-2,671	-5,240	-5,280	-2,609	-40
Wood Products & Harvesting	-678	-1,946	-1,589	-911	357
Total	-2,055	-5,509	-5,270	-3,215	239

Table 3.13

Total GHG Emissions from LULUCF, Base Year - 2011

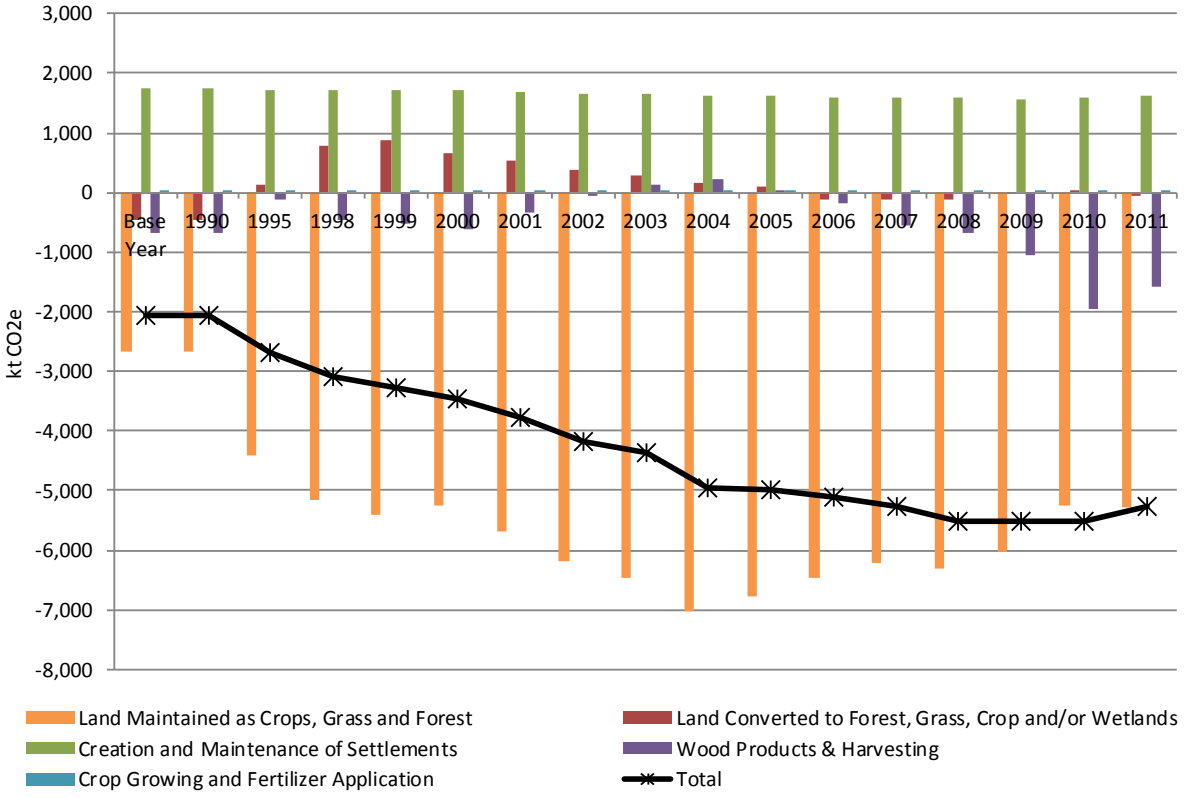


Figure 3.43

Figures 3.41 – 3.43 and Table 3.13 show detailed emissions and trends for the Land Use, Land Use Change and Forestry (LULUCF) sector. Scotland is a large net sink of greenhouse gases from LULUCF activities and the size of this sink (CO_2e removal) has grown by 156% between 1990 and 2011 from -2,055 to -5,270 $ktCO_2e$. This increase in net removals is primarily as a result of less conversion of grassland and forests to cropland over the period. Net removals from the maintenance of, and conversion to, forestland during this period have also increased (contributing to the increase in net removals for the sector (Land Maintained as Crop, Grass and Forest)). This is as a result of long-term forest management (the extensive conifer plantations established in the mid-20^{th} century are now reaching felling age, with reduced removals from forest but with increased carbon stocks in harvested wood products in recent years).

Net emissions/removals in Scotland are dominated by removals from forest land (including land maintained as forest, converted to forest and converted from forest to other uses) (-7,348 $ktCO_2e$ in 2011). The largest source of emissions is Cropland (4,684 $ktCO_2e$ in 2011) (including maintenance and conversion to) which releases carbon from clearing of biomass and from ploughing of soils.

A more detailed report of LULUCF emissions in England, Wales, Scotland and Northern Ireland can be found on the National Air Emissions Inventory (NAEI) website (H. Malcolm et al., 2013) and more detailed information is also available in the UK Greenhouse Gas Inventory Report, available on the NAEI website.

LULUCF Emissions on an End User Basis

As emissions and removals from LULUCF do not related to energy supply the end user GHG inventory emissions are the same as emissions reported in the by source GHG inventory.

3.10 Waste Management

Overall Contribution of Waste Management to 2011 GHG emissions

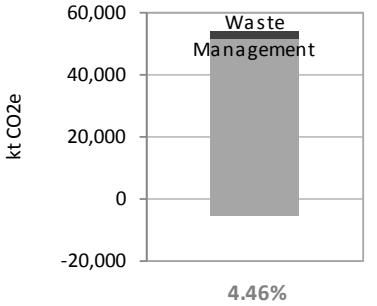


Figure 3.44

Total GHG Emissions from Waste Management, Base Year- 2011

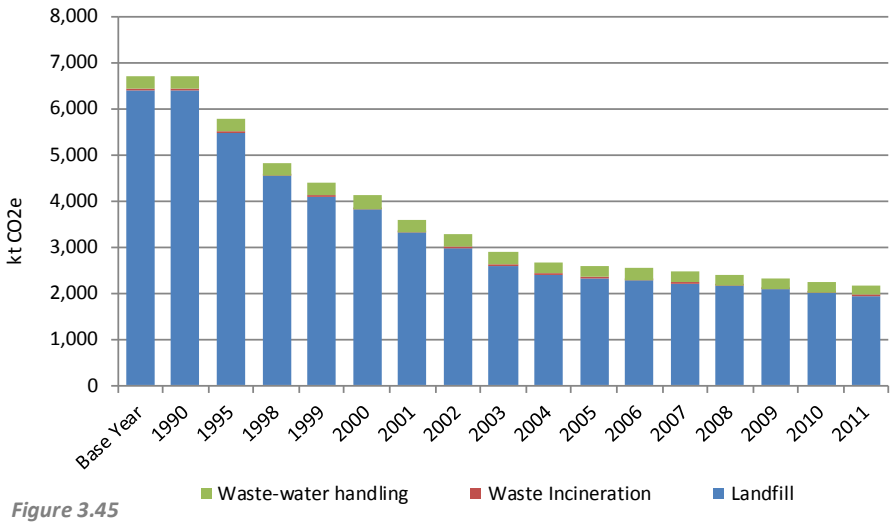


Figure 3.45

Change in GHG Emissions from Base Year (BY) to 2011 and from 2010 to 2011

	BY-2010		2009-2010	
Sub-sector	**%**	**kt CO2e**	**%**	**kt CO2e**
Landfill	-69%	-4,439	-3%	-69
Waste Incineration	-78%	-40	-9%	-1
Waste-water handling	-22%	-59	3%	7
Total	-68%	-4,538	-3%	-63

Table 3.14

Pollutant contribution to Waste Management Emissions, 2011

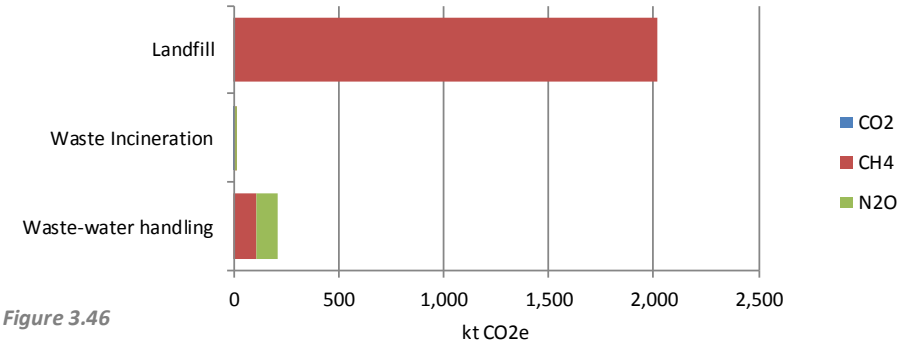


Figure 3.46

Figures 3.44 – 3.46 show detailed emissions and trends for the sector. The waste sector contributes 4.5% to total GHG emissions in Scotland in 2011, and is the second largest source sector for methane emissions, representing 37% of total methane emissions in 2011. Emissions from this sector in 2011 are dominated by methane from landfill (90% of total GHGs from the Waste sector), with a smaller contribution of emissions of methane and nitrous oxide from wastewater treatment (10%). Methane emissions from industrial waste-water treatment have been estimated for the first time for this submission and contribute 2% to 5% of total Waste emissions across the 1990-2011 time series. Emissions from landfill in Scotland constitute approximately 14% of UK landfill emissions.

Nitrous oxide emissions from waste water treatment represent 4.6% of emissions in the sector in 2011, and contribute 2.1% to the total emissions of nitrous oxide in Scotland.

Table 3.14 shows the change in emissions between the Base Year and 2011, and between 2010 and 2011 for the sector. Emissions from the waste sector in Scotland have reduced by 68% since the Base Year, driven by reductions of emissions from landfill of 69% between the Base Year and 2011; these reductions have been achieved by the progressive introduction of methane capture and oxidation systems within landfill management.

Waste sector emissions have reduced by 2.8% between 2010 and 2011. This was due to a decline in methane emission estimates from landfill, which were partly offset by small increases in methane emissions from industrial and municipal waste water treatment.

Waste Management Emissions on an End User Basis

There are no energy consumption sources reported in the waste sector, and no electricity use is allocated to the waste sector in the UK and DA end user inventories. Hence the waste sector emissions on an end user basis are identical to those presented on a by source basis.

4 Emissions in Wales

4.1 1990-2011 GHG Inventory Estimates

The greenhouse gas (GHG) emissions for Wales for 1990 – 2011 are presented in Table 4.1 1 and in the graph in Figure 4.2 below. Emissions in 2011 are 43,844 $ktCO_2e$ with 36% of emissions in 2011 from Energy Supply, 21% from Business, 13% from Transport, 13% from Agriculture and 9% from Residential sources.

Table 4.1: 1990-2011 Wales GHG Emission Inventory ($ktCO_2e$)

NC Format	Base Year	1990	1995	2000	2005	2008	2009	2010	2011	% of 2011
Agriculture	7,146	7,146	7,173	6,860	6,487	5,518	5,467	5,642	5,644	13%
Business	13,749	13,700	14,335	16,278	9,753	9,625	7,977	9,595	9,330	21%
Energy Supply	17,495	17,495	12,785	16,184	17,046	19,290	16,247	16,546	15,726	36%
Industrial Process	2,709	2,871	3,046	3,180	2,719	2,405	1,493	2,175	2,054	5%
LULUCF[34]	-16	-16	143	107	-110	-161	-175	151	141	0%
Public	752	752	681	522	516	425	375	381	320	1%
Residential	4,982	4,963	5,120	5,295	4,855	4,693	4,392	4,976	3,868	9%
Transport	6,061	6,061	6,053	6,140	6,408	6,323	6,058	5,956	5,846	13%
Waste Management	2,376	2,376	2,090	1,630	1,062	1,010	978	949	916	2%
Total	55,253	55,347	51,424	56,197	48,735	49,128	42,811	46,370	43,844	100%

Figure 4.1 and Table 4.2 show the change in emissions from the Base Year and 2010 to the latest year 2011. Total GHG emissions from Wales have reduced between the Base Year[35] and 2011 by 21%, whilst carbon dioxide emissions have fallen by 17%. These emission reductions are a result of a decline in manufacturing emissions (e.g. in iron and steel, bulk chemical production) in the business and industrial process sectors, efficiencies in energy generation and business sector heating, the use of natural gas to replace some coal and other fuels as well as abatement in some chemical industries. Transport emissions have reduced slightly (-4%) since the Base Year due to increasing population and increasing demand for transportation off-set by improvements in energy efficiency of vehicles.

Total GHG emissions have reduced between 2010 and 2011 by 5%. Emissions from business and industrial process sectors have shown a small decrease between 2010 and 2011 of 3% and 6% respectively after large increases of 20% and 46% between 2009 and 2010 due to increased production from iron and steel sites. The cold winters at the start and end of 2010 impacted upon recent trends in the residential sector, emissions from which decreased by 22% between 2010 and 2011.

Detailed analysis of Wales GHG emissions in 2011 is presented in Figures 4.4 – 4.9. The largest sources of emission in 2011 include electricity production (24% of total emissions), road transport (12% of total emissions), residential combustion for heating and cooking (8% of total emissions), and industrial combustion for heat and electricity in the business sector (8% of total emissions).

[34] Land Use, Land Use Change and Forestry (LULUCF)

[35] 1995 for fluorinated greenhouse gases (F-Gases) and 1990 for all other gases

Figure 4.4 shows the emissions split by GHG and highlights the 2.5 and 97.5 percentile range. The range of uncertainty is greatest for nitrous oxide emissions. See Appendix 1 for further details on uncertainties.

Carbon dioxide is the most common gas emitted for all National Communication (NC) categories except agriculture, where methane from livestock and nitrous oxide from soils, and waste, where methane from landfills, are the most important gases (see Figure 4.5).

Traded and Non-Traded Emissions

Total GHG emissions from installations that operate within the European Union Emissions Trading Scheme (EU ETS) (see Figure 4.9) increased by 10% between 2009 and 2010, driven by economic recovery and a colder winter in 2010. This was followed by a 6% decrease between 2010 and 2011. Across the two years the traded sector emissions are around 3% higher in 2011 compared to 2009, whilst emissions from the non-traded sources in Wales only increased by around 1% during that time. Emissions from installations in the EU ETS (see Figure 4.9) account for 52% of total GHG emissions in Wales in 2011; the main contributors to these traded emissions are the Energy Supply sector (of which 92% total emissions are within the EU ETS, including all power stations) and the Business and Industrial Process sector (see Figure 4.8) (of which, 72% of total sector emissions are in the EU ETS).

Emissions on an End User Basis

In addition to presenting emissions based on direct emissions from processes or combustion of fuels in Wales, the emissions from the Energy Supply sector can be attributed to the users of the energy (see Appendix 3 for more details of the end user inventory methodology).

Figure 4.7 illustrates the difference between the by source and end user inventory emission estimates and how emissions from energy supply are allocated to the end user National Communication (NC) sectors. The primary difference in the end user perspective is the significant increase in emissions attributable to the business, residential, transport and public sectors. The end user inventory data illustrate that on an energy consumption basis, the contribution to Wales total emissions in 2011 are: 37% from Business, 17% from the Residential sector and 16% from Transport sources. As illustrated in Figure 4.3 Wales is a net exporter of electricity which resulted in lower (-8.3%) emissions in Wales on an end user basis (40,203 $ktCO_2e$) compared to the by source (43,844 $ktCO_2e$) inventory estimates.

Emissions from the Land Use, Land Use Change and Forestry (LULUCF) and waste management sectors are unchanged between the by source and end user inventories, since there are no emissions from energy use allocated to these sources. The end user increment within the industrial process sector is limited to the use of fuels in the iron and steel sector, whilst in the agriculture NC sector a small additional end user emission allocation is evident to reflect the fuel use in stationary and mobile combustion units within the sector.

A more detailed assessment of emissions by sector is presented below for each of the NC sectors.

4.1.1 Inventory Recalculations

Revisions to the estimates since the last inventory report (G. Thistlethwaite *et al.,* 2012) have resulted in a 0.58% (-269 $ktCO_2e$) decrease in the 2010 estimate for Wales). The most significant revisions to the 2010 estimates have been for the following sectors:

1. **Biomass Burning of Forest Land (LULUCF)**: (221 $ktCO_2e$ increase) due to revised activity data on wildfires, which now uses Earth Observation data with the support of fire station reports, and the inclusion of dead organic matter (DOM) in biomass burning.
2. **Combustion within Iron and Steel industry (Energy Supply)**: (-196 $ktCO_2e$ decrease) due to revisions to Digest of UK Energy Statistics (DUKES) for blast furnace gas in blast furnaces.
3. **Road Transport (Transport)**: (-96 $ktCO_2e$ decrease) due to a revision for Heavy Goods Vehicles (HGV) emissions, and a revision to minor road vehicle km data based on more detailed survey

information which resulted in lower emission estimated for urban driving, especially cars and Large Goods Vehicles (LGVs).

4. **Railways (Transport)**: (-80 ktCO_2e decrease) due to DUKES gas oil revisions for the rail sector and an improvement in the methodology which now uses analyses from the DfT's Rail Emissions Model for the first time.

For more details of revisions to GHG emission estimates, see Appendix 6.

Percentage Change in GHG Emissions by NC: Base Year - 2011 and 2010 - 2011

The % changes for LULUCF are based on net change to sink/source across the time series

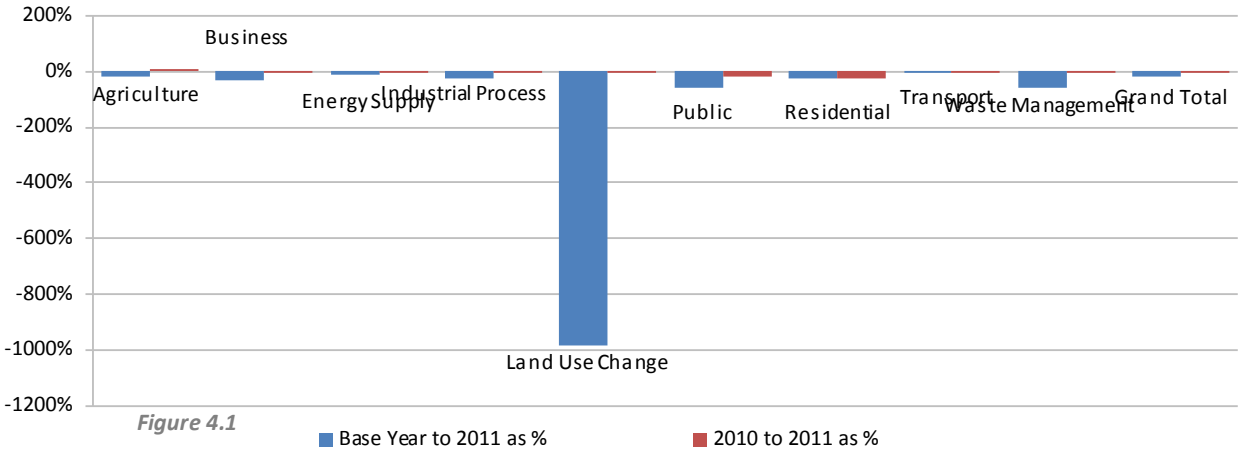


Figure 4.1

Percentage Change in Total GHG and CO2 Emissions by NC: Base Year - 2011 and 2010 - 2011

The % changes for LULUCF are based on net change to sink/source across the time series

Change in emissions from the Base Year to 2011 and 2010 to 2011	Agriculture	Business	Energy Supply	Industrial Process	Land Use Change	Public	Residential	Transport	Waste Management	**Total**	
Base Year to 2011 as %	-21%	-32%	-10%	-24%	-985%	-58%	-22%	-4%	-61%	-21%	**Total GHG as CO2e**
2010 to 2011 as %	0%	-3%	-5%	-6%	-7%	-16%	-22%	-2%	-3%	-5%	
Base Year to 2011 as %	-18%	-35%	-2%	-19%	-184%	-57%	-23%	-3%	-88%	-17%	**Total CO2 only**
2010 to 2011 as %	1%	-3%	-5%	-5%	-6%	-16%	-23%	-2%	-8%	-6%	
Base Year to 2011 kt	-1,502	-4,418	-1,769	-654	156	-433	-1,114	-215	-1,460	-11,409	**Total GHG as CO2e**
2010 to 2011 kt	2	-265	-820	-120	-11	-61	-1,108	-110	-33	-2,526	
Base Year to 2011 kt	-112	-4,744	-297	-471	163	-428	-1,126	-170	-45	-7,231	**Total CO2 only**
2010 to 2011 kt	5	-270	-815	-114	-5	-61	-1,105	-110	-1	-2,476	

Table 4.2

Total GHG Emissions by NC category for Base Year to 2011, as CO2e

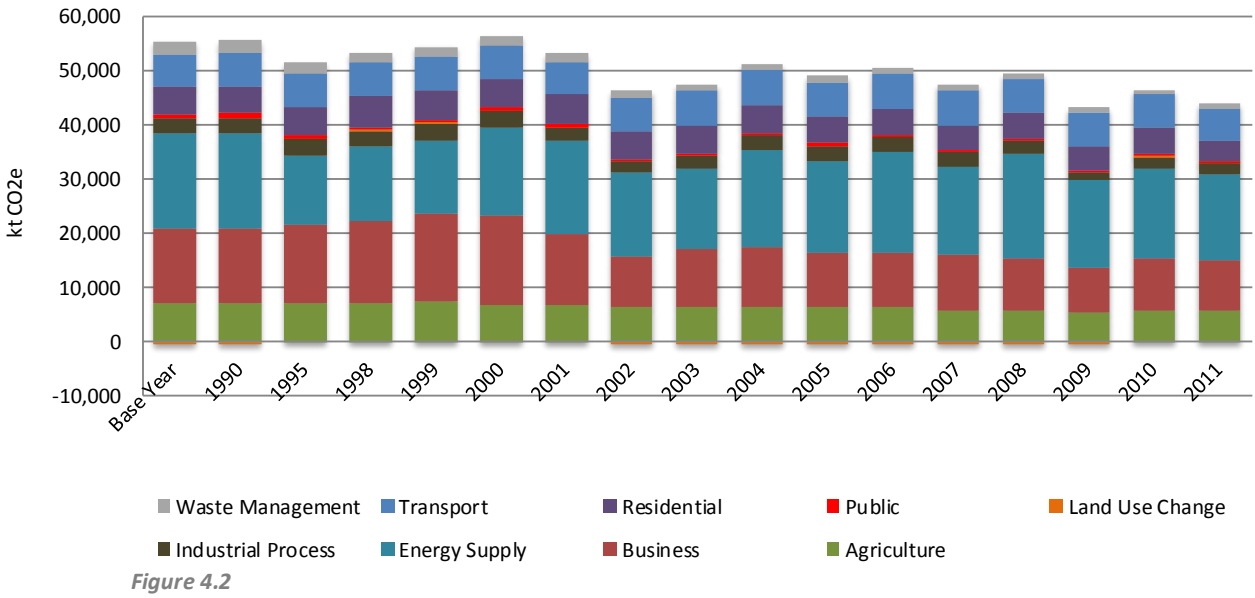
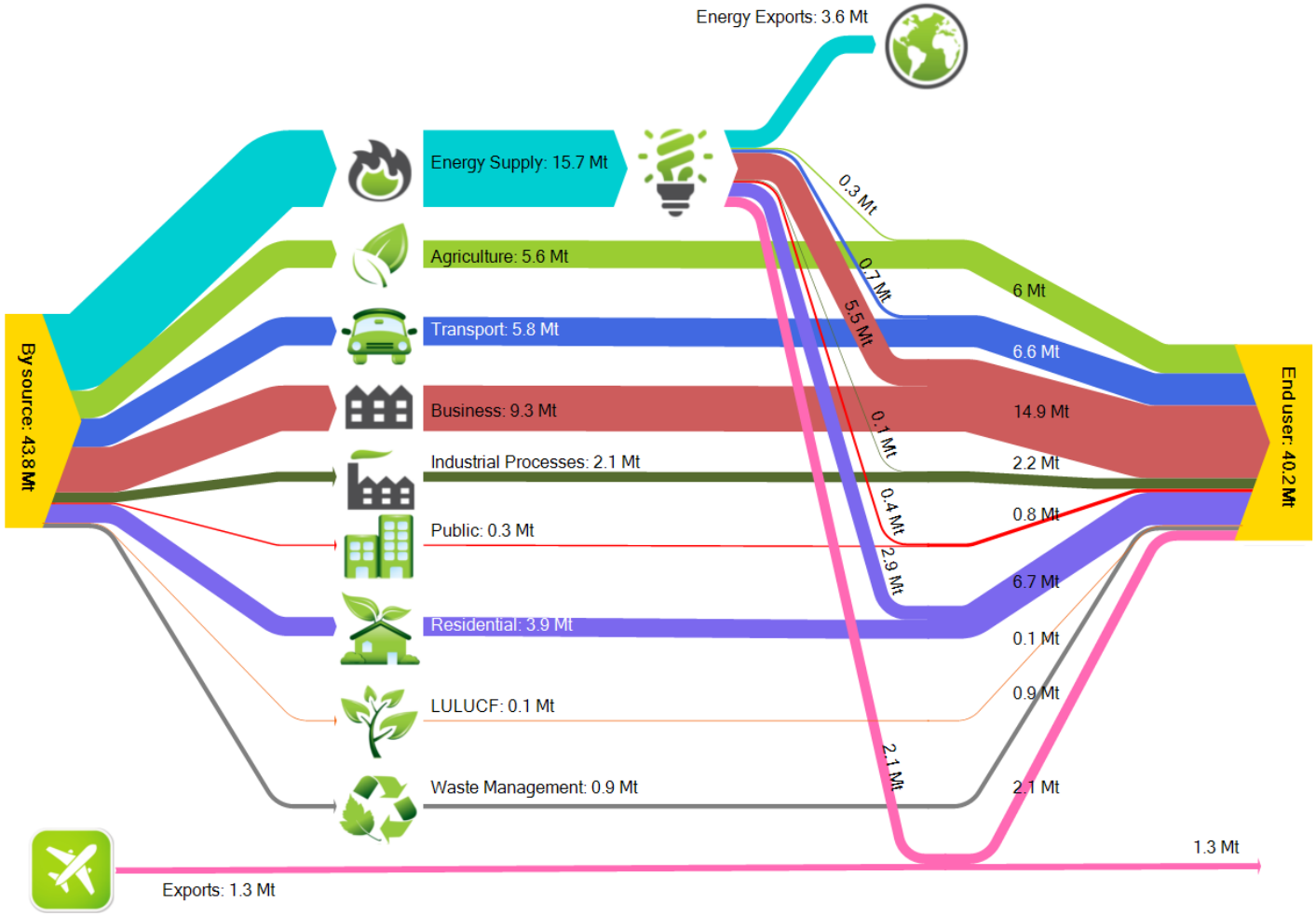


Figure 4.2

Figure 4.3 Sankey diagram showing By Source and End User[36] GHG emission transfers for Wales in 2011 (Mt CO_2e)[37]



[36] The pink line from 'Energy Supply' to 'End User' represents emissions from energy supply in the production of fuels used in international aviation and shipping.

[37] Exports' equates to emissions from international aviation and shipping.

Total GHG Emissions and uncertainties by pollutant, 2011

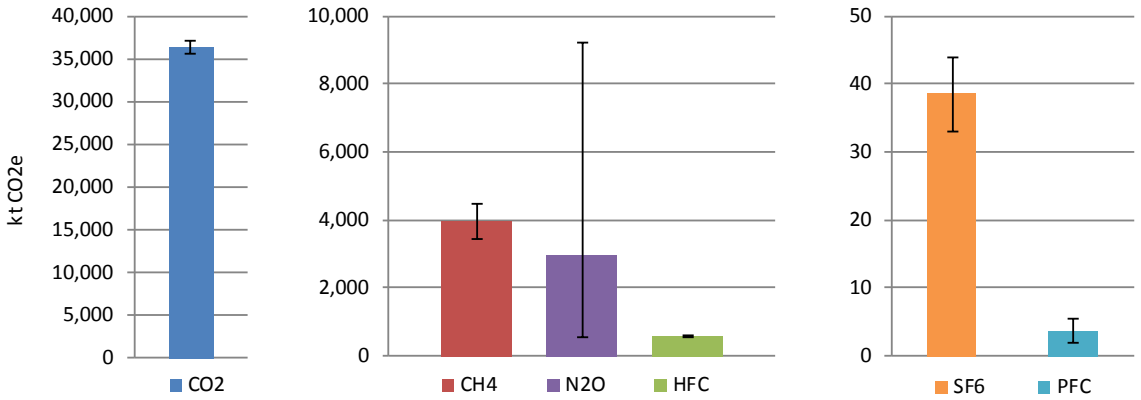


Figure 4.4

** error bars represent 2.5 to 97.5 percentile range*

Total GHG Emissions by NC and pollutant, 2011

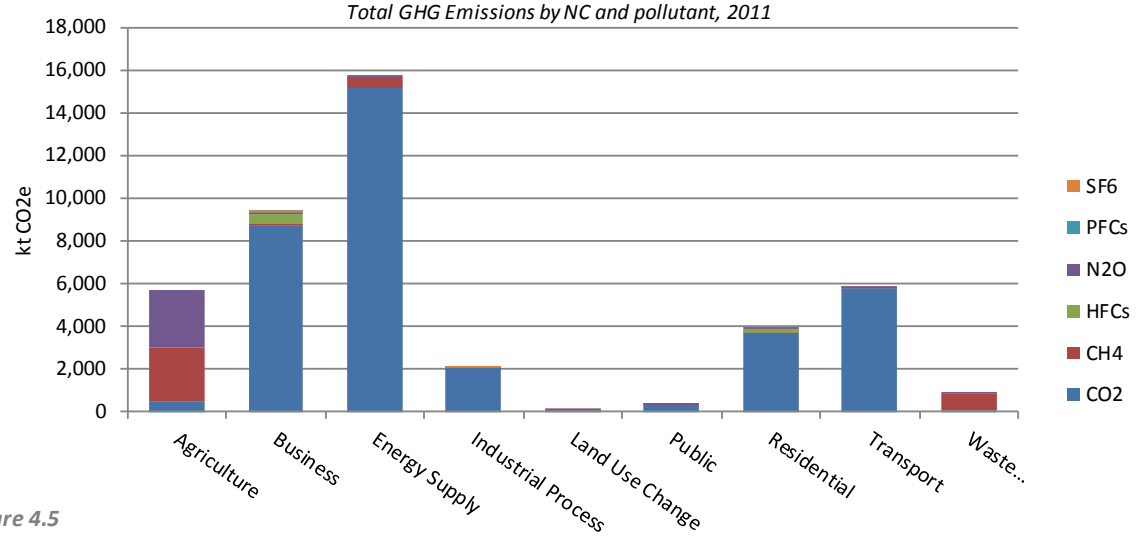


Figure 4.5

Total GHG Emissions by NC and sub-category highlighting the important sources, 2011

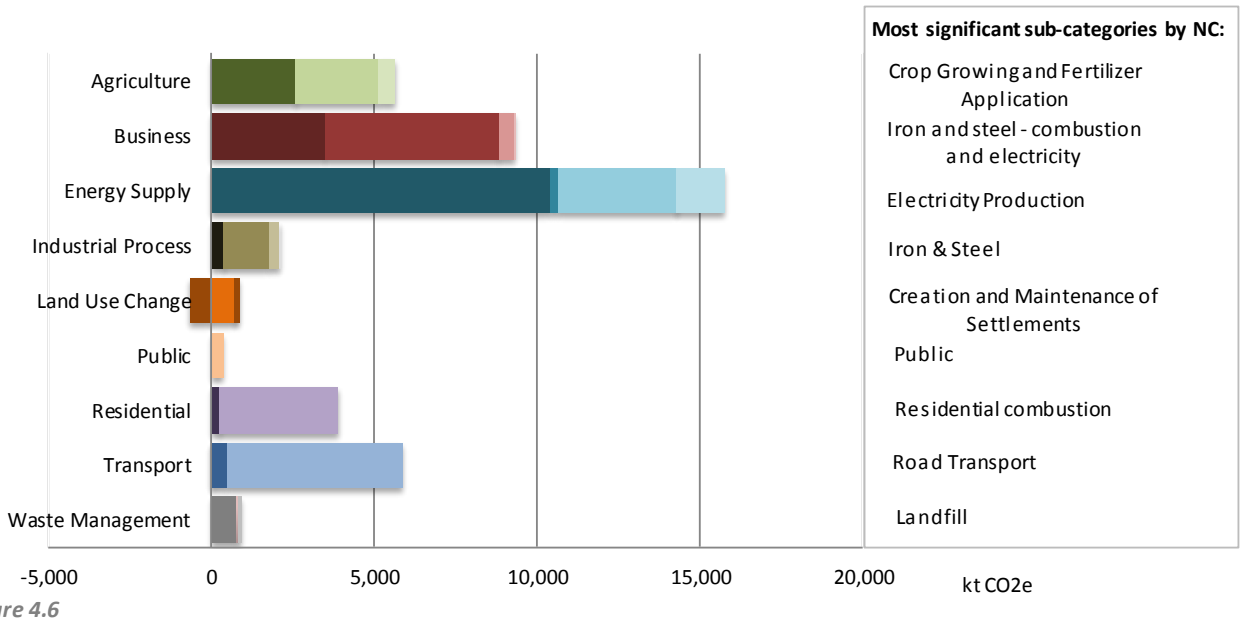


Figure 4.6

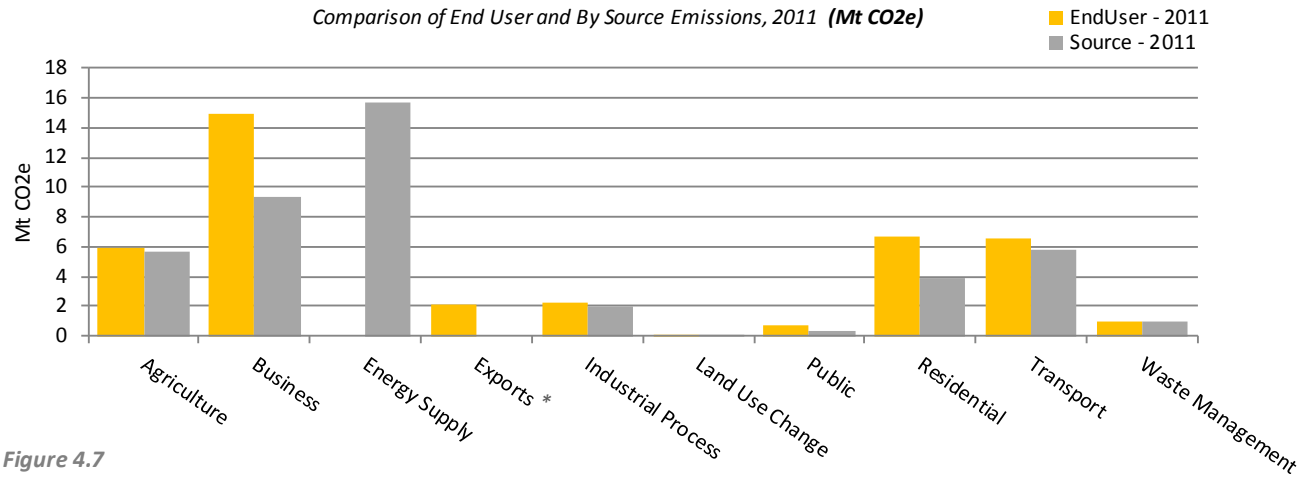


Figure 4.7

** Exports includes emissions from energy production for international aviation, international shipping and exported fuels.*

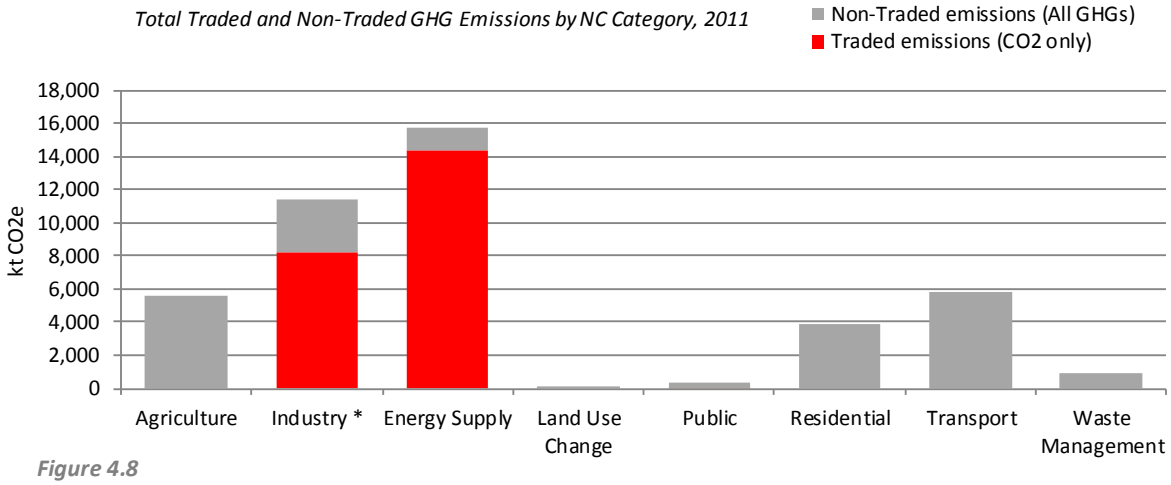


Figure 4.8

** Industry includes emissions from the NC categories: Industrial Process and Business*

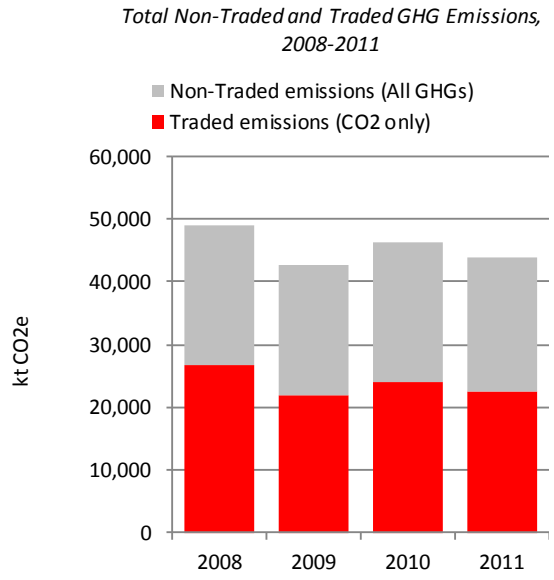


Figure 4.9

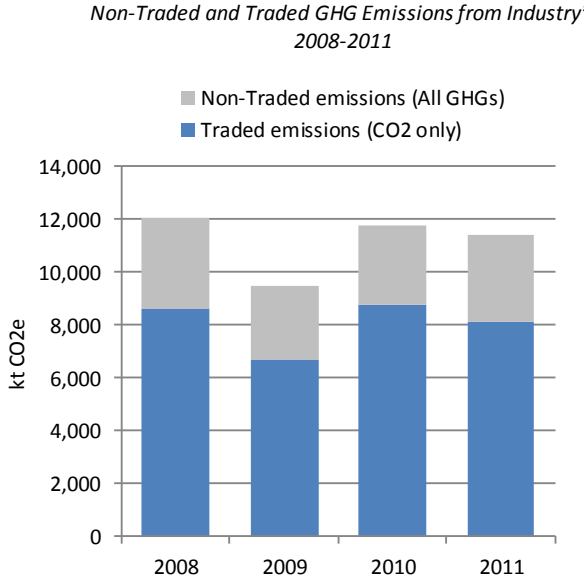


Figure 4.10

** Industry includes emissions from the NC categories: Industrial Process and Business*

4.2 Energy Supply

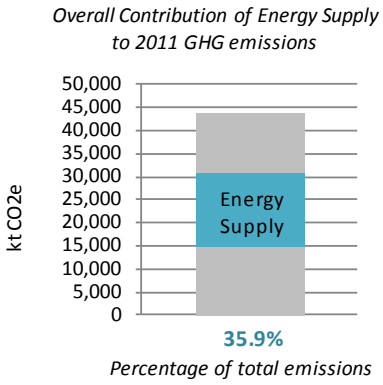


Figure 4.11

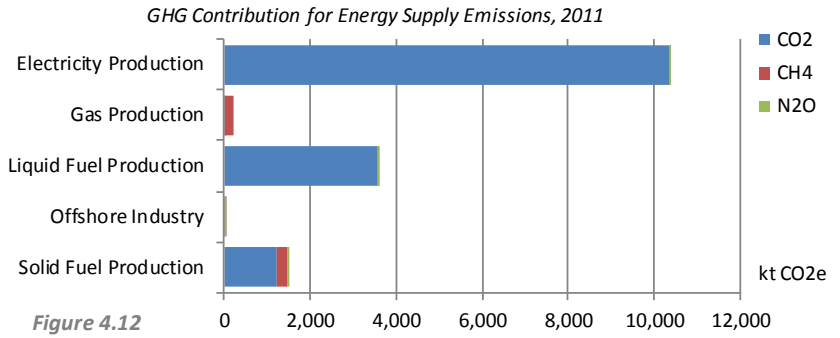


Figure 4.12

Change in GHG Emissions from Base Year (BY) to 2011 and from 2010 to 2011

	BY-2011		2010-2011	
Sub-sector	**%**	**kt CO2e**	**%**	**kt CO2e**
Electricity Production	-8%	-849	-9%	-1,036
Gas Production	-36%	-128	-6%	-15
Liquid Fuel Production	3%	112	7%	221
Offshore Industry	-	1	0%	0
Solid Fuel Production	-38%	-905	1%	11
Total	-10%	-1,769	-5%	-820

Table 4.3

NC Category Contribution to End User Inventory by percentage of Electricity Production Emissions

NC Category	End User
Agriculture	3%
Business	61%
Industrial Process	0%
Public	5%
Residential	31%
Transport	0%
Exports *	0%

Table 4.4

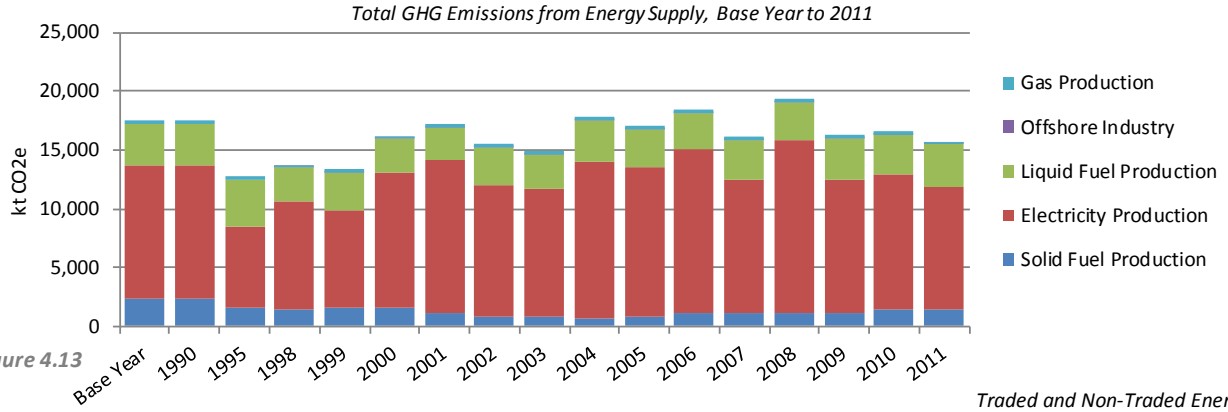


Figure 4.13

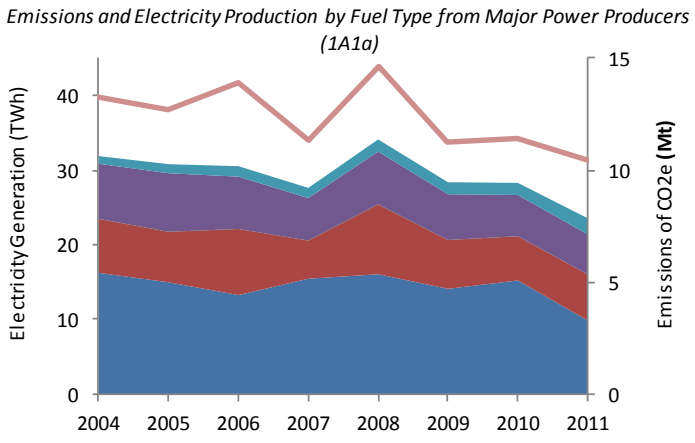


Figure 4.14

Traded and Non-Traded Energy Supply Emissions, 2009-2011

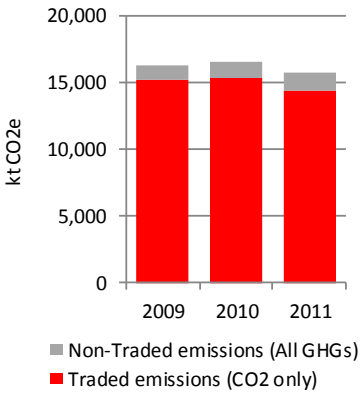


Figure 4.15

* These are emissions associated with the production of exported electricity and electricity used in international aviation and shipping.

In Wales, energy supply sources contributed 36% to total 2011 GHG emissions. Energy supply includes emissions from power generation, refineries, solid fuel transformation, oil and gas extraction and processing and other energy industries. The main source of emissions in Wales within the energy supply sector was electricity production at power stations, which accounted for 66% of energy supply emissions in 2011 and refinery emissions which accounted for a further 23%.

Energy supply sector emissions have reduced by 10% between the Base Year and 2011 due to reductions in the production of coke in the iron and steel industry despite an increase in emissions from power stations over the period.

Emissions have reduced by 5% (-820 kt CO_2e) between 2010 and 2011. Although there has been an increase in emissions from refineries and a 4% increase in coal consumption in power stations, there has been a significant decrease of 35% in the consumption of natural gas in power stations. This has led to the small reduction seen in this sector.

The mix of generation capacity in Wales is shown in Figure 4.14. Natural gas combustion accounts for 36% of total generation, with coal power stations generating 23% compared to the UK-average of 30% of electricity generation. Nuclear generation and renewable sources produce 28% of electricity. In addition, Wales is a net exporter of electricity (see Figure 4.3).

Only those emissions arising from on-shore installations in Wales have been included within the Welsh GHG inventory; emissions from upstream oil & gas exploration and production off-shore facilities are reported as “Unallocated”.

Carbon dioxide is the predominant gas accounting for over 97% of emissions from the energy supply sector in 2011, released through the combustion of fossil fuels.

Energy Supply Traded and Non-Traded Emissions

Emissions in the energy supply sector are dominated by installations that operate within the EU ETS, with 92% of emissions in energy supply from traded (EU ETS) operations in 2011; these traded emissions are primarily from power stations, refineries and coke ovens.

End user emissions from the Energy Supply sector

End user emissions from electricity are presented in Table 4.4. In the end user inventory, the emissions from the energy supply sector are passed on to the end users of the electricity, refined oils, gas and solid fuels. The most significant re-allocation is to pass on the emissions from electricity generation to end users, and in Wales in 2011 the business sector was estimated to use 61% of electricity whilst the residential sector accounts for 31% of electricity demand, and hence these sectors have the largest additional emissions allocation on an end user basis.

4.3 Transport

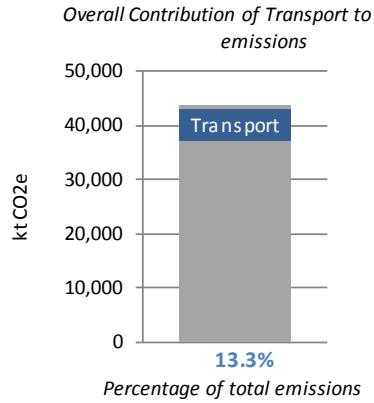


Figure 4.16

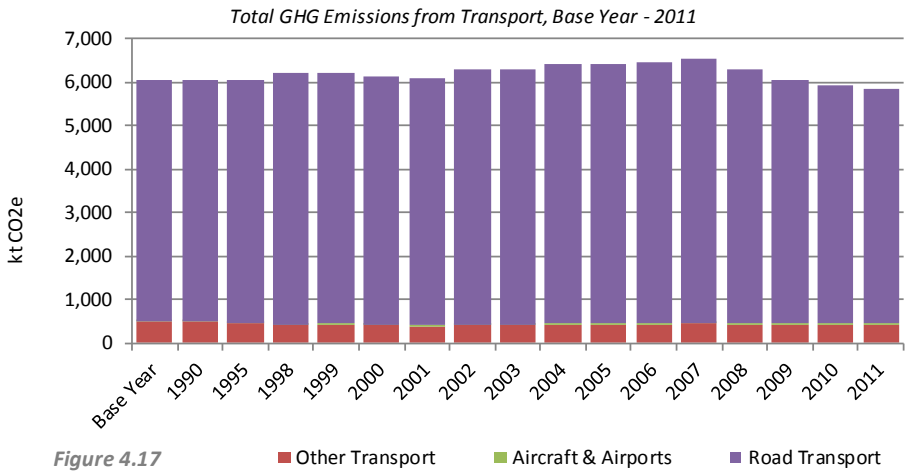


Figure 4.17

Change in GHG Emissions from Base Year (BY) to 2011 and from 2010 to 2011

	BY-2011		2010-2011	
Sub-sector	**%**	**kt CO2e**	**%**	**kt CO2e**
Aircraft & Airports	126%	10	-6%	-1
Other Transport	-13%	-69	0%	-1
Road Transport	-3%	-156	-2%	-108
Total	-4%	-215	-2%	-110

Table 4.5

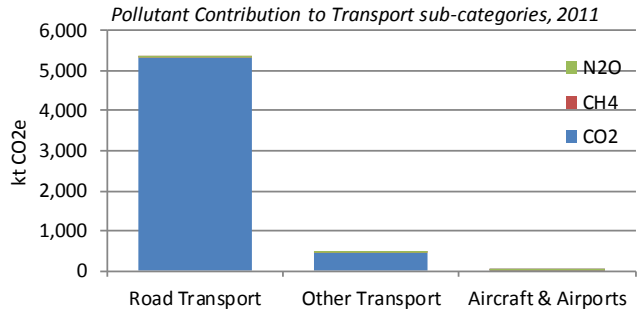


Figure 4.18

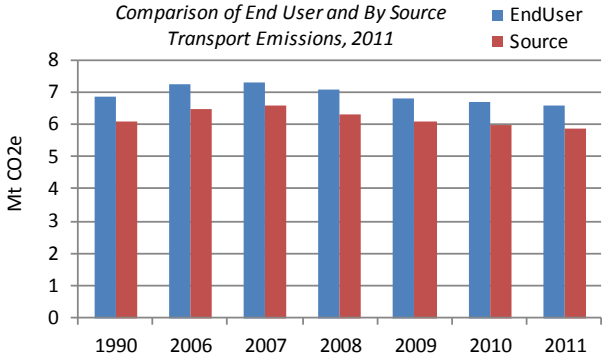


Figure 4.19

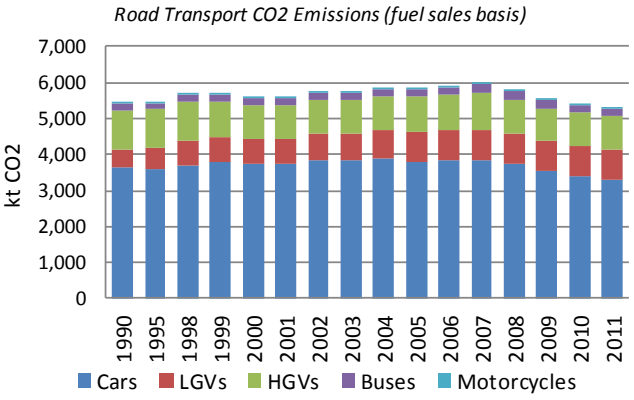


Figure 4.20

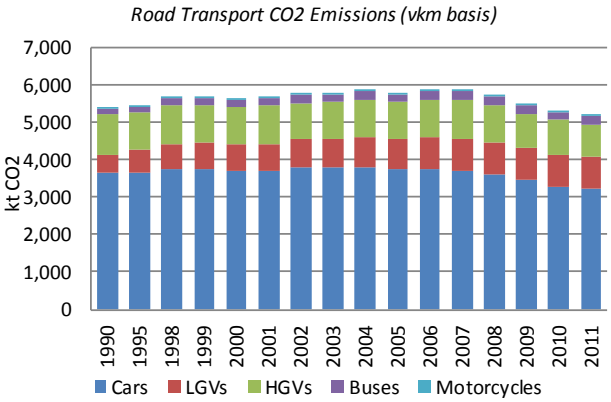


Figure 4.21

Transport emissions account for 13% of Wales' total GHG emissions in 2011. Transport emissions are dominated by emissions from road transport (92% of all transport emissions in 2011, with 57% of transport emissions from cars alone) (see Figures 4.17 and 4.18). The transport sector also includes: 2% from rail (including stationary sources[38]), 4% from national navigation and coastal shipping, 0.2% from domestic aviation and 2% from military aviation and shipping. Emissions from international aviation are excluded from these estimates.

Total emissions from the transport sector in Wales have decreased by only 4% between the Base Year and 2011 despite improvements in efficiency of transport vehicles, as a result of strong growth in transport demand and increased affordability of cars over the period. Emissions between 2010 and 2011 have reduced by around 2% (see Table 4.5). This sector is driven by the changes in emissions from passenger cars. Although emissions from road diesel (DERV) have increased between 2010 and 2011, emissions from petrol have significantly decreased, which has led to an overall reduction in emissions in the transport sector.

Figure 4.19 shows the carbon dioxide emissions from road transport for Wales based on constrained (DUKES fuel sales) and unconstrained (vehicle kilometre, vkm) approaches. Total carbon dioxide emissions from the vkm approach are 0.7% and 2.3% lower than the estimates constrained to DUKES for 1990 and 2011 respectively. The differences between the two approaches fluctuate year on year but they remain within 2.3% of difference for Wales. These disparities will also be reflected in the trends derived from the two approaches to a different extent. The long term trend (between Base Year and 2011) for each individual vehicle type is generally similar between the two approaches. The vkm approach indicates that the overall carbon dioxide emissions from road transport in 2011 are 3.9% lower than in the Base Year, while the constrained approach indicates that carbon dioxide emissions have decreased by 2.3% between the Base Year and 2011.

Transport Emissions on an End User Basis

The end user estimates in recent years are 12% higher than the by source estimates, reflecting the additional emissions from upstream oil extraction and the oil refining sector (see Figure 4.19).

Wales is estimated to account for 5% of the UK 2011 end user emissions in the transport sector, which is the same as the reported share of the by source estimates.

The trend in end user emissions since 1990 shows a decline of around 4% to 2011 and is a slightly larger reduction than reported in the by source inventory, reflecting the improved energy efficiency of upstream production and refining of crude oil to produce the fuels used in the transport sector.

[38] Electricity use by the rail sector is not assigned to the transport sector in the by source estimates, but is attributed to the transport sector in the end user estimates.

4.4 Residential

Overall Contribution of Residential sector to 2011 GHG emissions

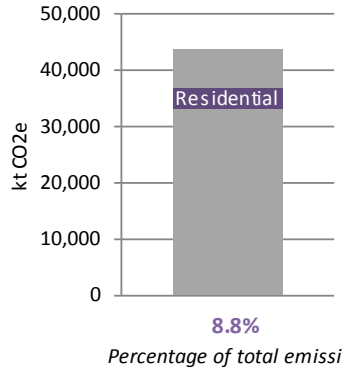


Figure 4.22

Total GHG Emissions by sub-sector, Base Year - 2011

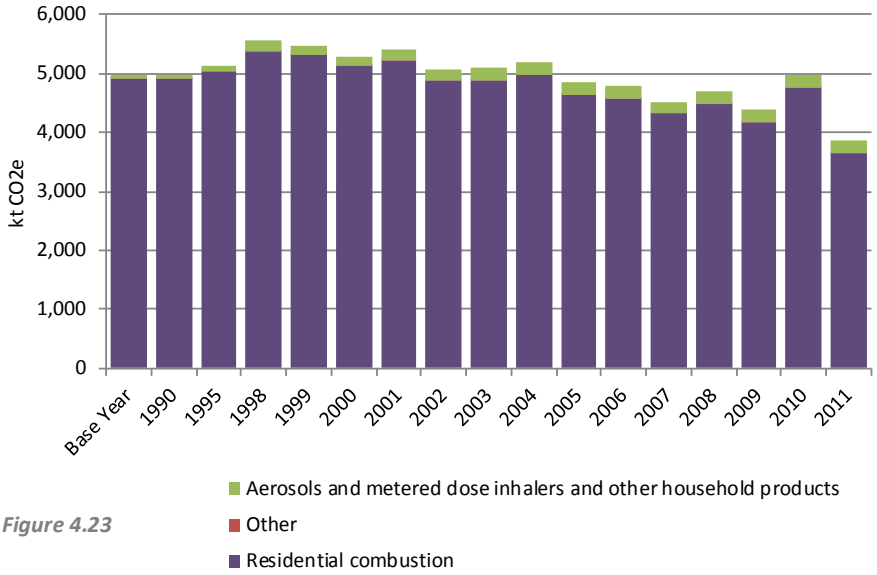


Figure 4.23

Change in GHG Emissions from Base Year (BY) to 2011 and from 2010 to 2011

	BY-2011		2010-2011	
Sub-sector	**%**	**kt CO2e**	**%**	**kt CO2e**
Aerosols and metered dose inhalers and other household products	155%	126	0%	0
Other	-32%	0	0%	0
Residential combustion	-25%	-1240	-23%	-1,108
Total	-22%	-1114	-22%	-1,108

Table 4.6

Pollutant contribution to Residential Emissions, 2011

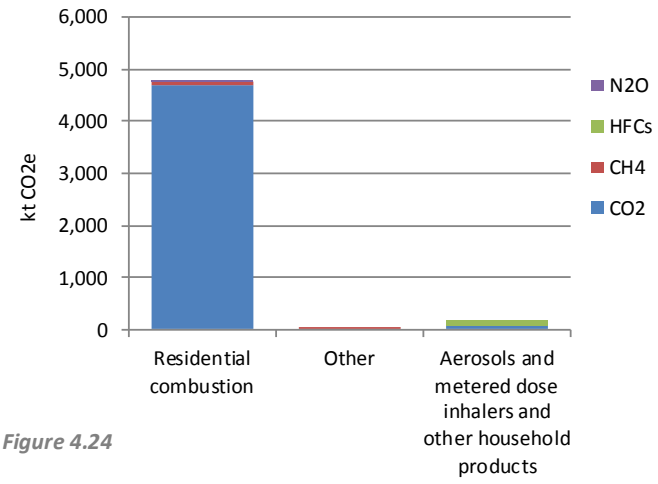


Figure 4.24

*Comparison between End User and By Source Inventory Totals **(Mt CO2e)***

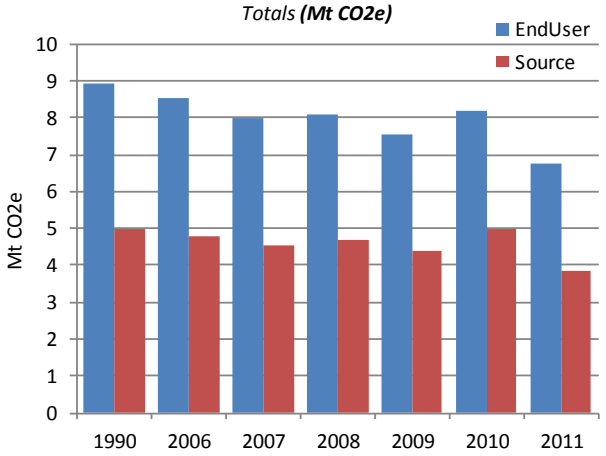


Figure 4.25

Figures 4.22 – 4.25 show detailed emissions and trends for the sector. The residential sector accounts for 9% of Wales' total emissions in 2011. The sector comprises emissions from domestic combustion (95% of emissions for the residential sector) from heating and cooking, household products (see Figure 4.23). The remaining 5% of emissions were from house and garden machinery, and HFC emissions from aerosols, metered-dose inhalers (MDIs) and other household products.

Total GHG emissions from the residential sector in Wales have decreased by 22% between the Base Year and 2011 (see Table 4.6). Emissions significantly decreased by 22% between 2010 and 2011, primarily due to the cold winter in 2010, resulting in high demand for natural gas and burning oil (fuel for heating) in many parts of Wales[39] and therefore increased emissions for the period.

Residential Emissions on an End User Basis

In 2011, Wales end user emissions for the residential sector are 174% higher compared to the by source emission estimates reflecting the high consumption of electricity in the sector. This increases the overall significance of this sector in the end user inventory to 17% of the Wales total, compared to just 9% of the by source inventory total (see Figure 4.25). The trend in residential end user emissions since the Base Year shows a decline of around 25% to 2011 as a result of improvements in the energy efficiency of housing in Wales and also the reduction in GHG intensity of the UK electricity generation sector since 1990. However, the trend data are uncertain and should be regarded as indicative only, due to the limited data on electricity use by source.

[39] Note that the emission estimates in the domestic sector are associated with high uncertainty due to the absence of comprehensive, detailed DA-specific fuel use data, particularly for solid and liquid fuels.

4.5 Business

Overall Contribution to 2011 GHG emissions

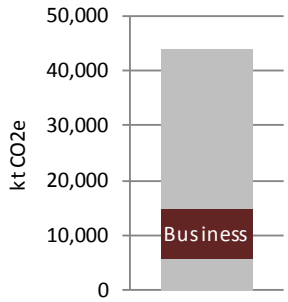


Figure 4.26

21.28%

Percentage of total emissions

Total GHG Emissions from Business, Base Year - 2011

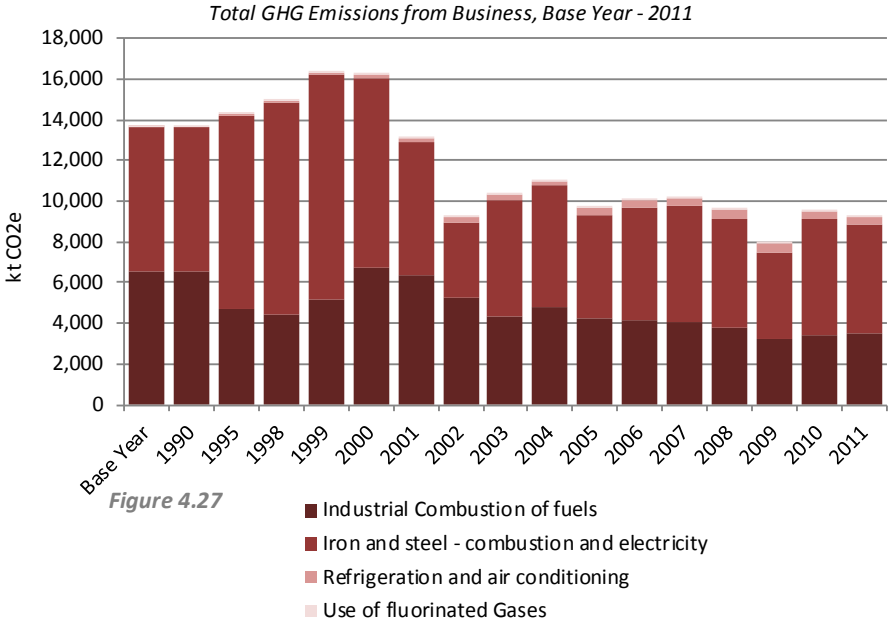


Figure 4.27

Change in GHG Emissions from Base Year (BY) to 2011 and from 2010 to 2011

	BY-2011		2010-2011	
Sub-sector	**%**	**kt CO2e**	**%**	**kt CO2e**
Industrial Combustion of fuels	-47%	-3,085	1%	25
Iron and steel - combustion and electricity	-24%	-1,734	-5%	-299
Refrigeration and air conditioning	1275%	399	2%	10
Use of fluorinated Gases	3%	2	-1%	0
Total	-32%	-4,418	-3%	-265

Table 4.7

Pollutant Contribution for Business Emissions, 2011

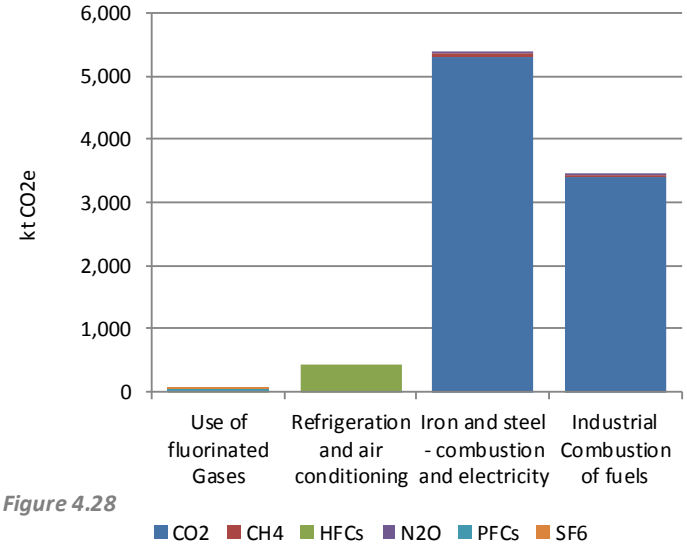


Figure 4.28

Comparison between End User and By Source Inventory for the Business Sector, 1990 and 2006-2011 ***(Mt CO2e)***

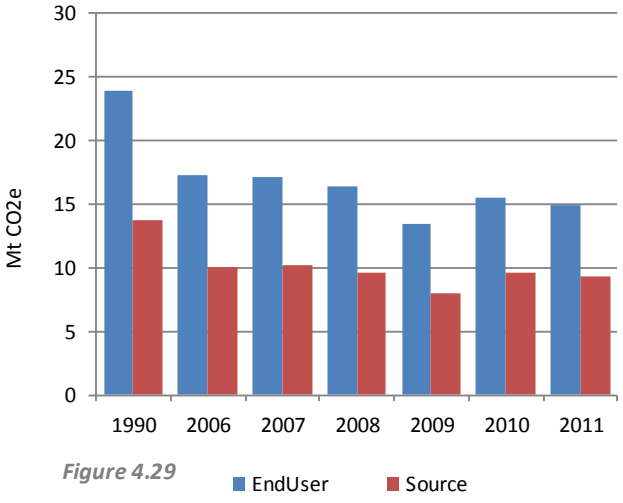


Figure 4.29

Figures 4.26 – 4.29 show detailed emissions and trends for the sector. In Wales, the business sector contributes 21% to total 2011 GHG emissions in Wales. The business sector in 2011 included emissions from industrial combustion of fuels (37% of total emissions); iron and steel combustion (57% of total emissions); refrigeration & air conditioning (5% of total emissions), arising from losses of HFCs during equipment manufacture, leaks and disposal; as well as HFC emissions from foam production, fire fighting solvents and electronics (1% of total emissions). In 2011, 93% of emissions were carbon dioxide released from the combustion of fossil fuels in the business sector with 5% from the use of fluorinated greenhouse gases (F-Gases), predominantly HFCs in refrigeration and air conditioning and sulphur hexafluoride (SF_6) in electrical insulation systems).

Total GHG emissions from the business sector have declined by 32% since the Base Year (see Table 4.7). These reductions have primarily been achieved as a result of declining manufacturing and iron and steel industry emissions. Despite this general decline in emissions, emissions of HFC from refrigeration and air conditioning have risen by over 1200% since 1995; these emissions now account for 5% of total business emissions in 2011 since the introduction of these gases as replacement to CFCs banned by the Montreal Protocol.

Emissions have decreased by 3% between 2010 and 2011 (-265 ktCO_2e). Despite a small increase in emissions from industrial combustion, an overall reduction between 2010 and 2011 has been driven by lower emissions from blast furnace gas, coke oven gas and fuel oil in the iron and steel sector.

Business Traded and Non-Traded Emissions

Emissions in the business sector include significant contributions from installations reporting in the EU ETS. However, due to the lack of detail in the EU ETS dataset, business, energy supply and industrial process emissions are not easy to separate. The contribution to total aggregate emissions from the traded and non-traded sector across these NC sectors is presented in Figure 4.9 in the summary section.

Business Emissions on an End User Basis

In 2011, Wales' end user emissions for the business sector were 159% higher than the by source emission estimates, reflecting the high consumption of electricity for heating, lighting and operating equipment in the sector (see Figure 4.29). On an end user basis, therefore, business sector represents 37% of total emissions for Wales compared to just 21% of the by source inventory total.

The trend since 1990 shows a decline of 38% to 2011, but the trend data are uncertain and should be regarded as indicative only due to the limited data on electricity use by source.

The combustion emission estimates in the business sector are associated with high uncertainty due to the absence of comprehensive, detailed fuel use data specific to each Devolved Administration (DA), particularly for solid and liquid fuels.

4.6 Public

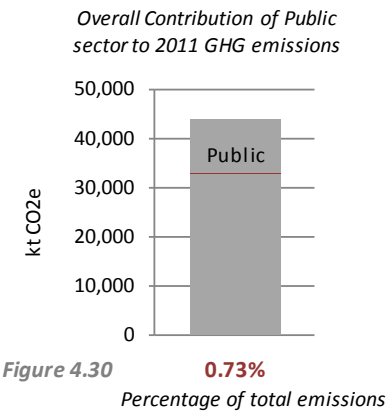


Figure 4.30

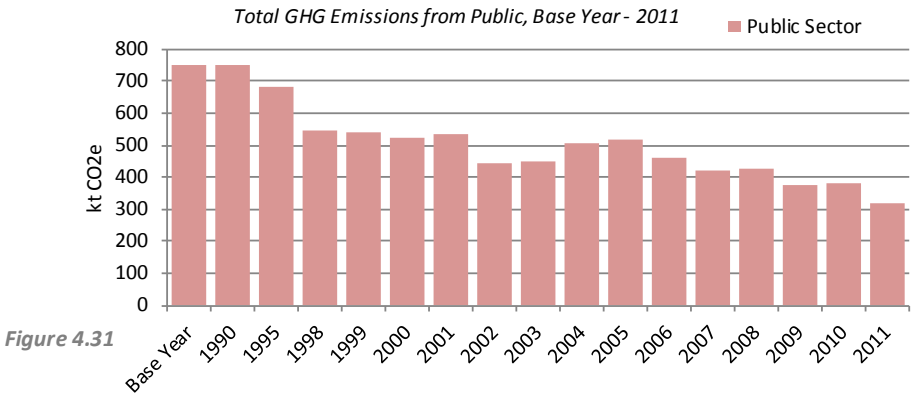


Figure 4.31

Change in GHG Emissions from Base Year (BY) to 2011 and from 2010 to 2011

	BY-2011		2010-2011	
Sub-sector	**%**	**kt CO2e**	**%**	**kt CO2e**
Public	-58%	-433	-16%	-61

Table 4.8

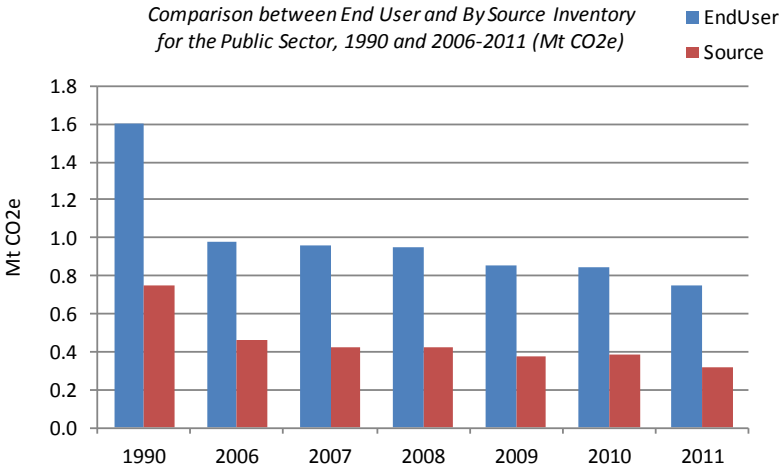


Figure 4.32

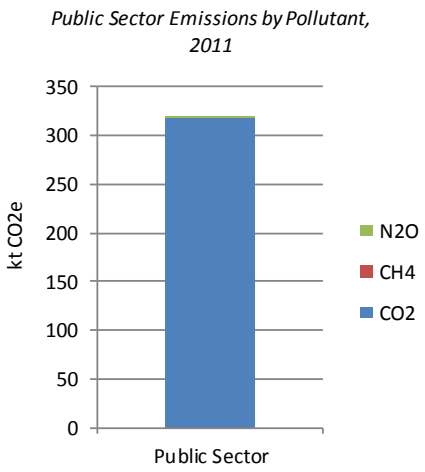


Figure 4.33

Emissions from public sector combustion account for 1% of GHG emissions in Wales in 2011. Carbon dioxide emissions from the combustion of fossil fuels accounts for 99.6% of emissions in 2011. These emissions are primarily from the combustion of natural gas to heat buildings.

Public sector emissions have reduced by 58% since the Base Year (see Table 4.8); this has been achieved through more efficient use of fuels and a switch to gas fired heating across Wales for many public sector buildings since 1990.

Emissions between 2010 and 2011 decreased significantly by 16% primarily due to the cold winters at the start and end of 2010, which led to a reduction in the consumption of natural gas. Note that the emission estimates in the public sector are associated with high uncertainty due to the absence of comprehensive, detailed DA-specific fuel use data, particularly for solid and liquid fuels.

Public Emissions on an End User Basis

In 2011, Wales' end user emissions for the public sector are 235% higher than the by source emission estimates, reflecting the high consumption of electricity in the sector and increasing the sector's share of total Wales emissions to 2% in 2011 compared to 0.7% of the by source estimates (see Figure 4.32). The trend in end user emissions since 1990 shows a decline of 53% to 2011[40].

[40] the trend data are uncertain and should be regarded as indicative only due to the limited data on electricity use by source.

4.7 Industrial Process

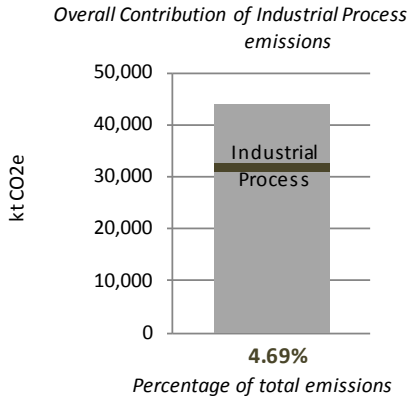


Figure 4.34

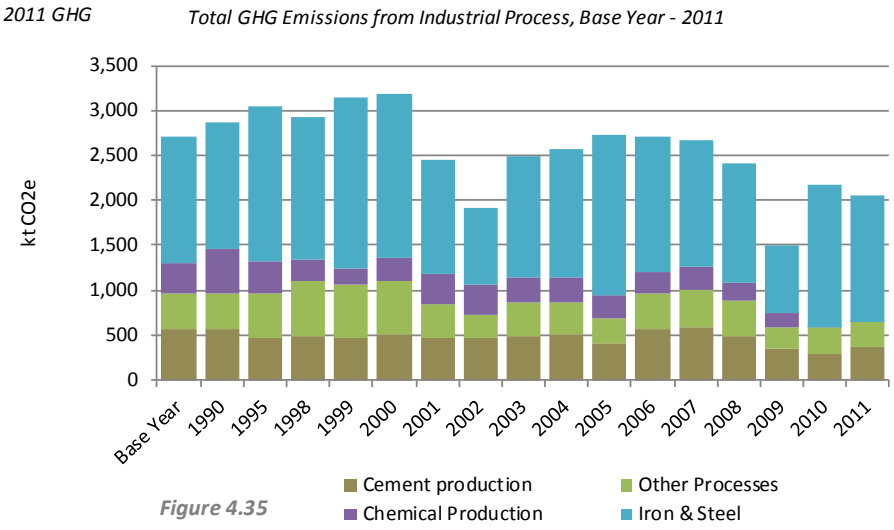


Figure 4.35

Change in GHG Emissions from Base Year (BY) to 2011 and from 2010 to 2011

	BY-2011		2010-2011	
Sub-sector	**%**	**kt CO2e**	**%**	**kt CO2e**
Cement production	-37%	-211	24%	71
Chemical Production	-99%	-331	5%	0
Iron & Steel	0%	-4	-12%	-182
Other Processes	-28%	-108	-3%	-10
Total	-24%	-654	-6%	-120

Table 4.9

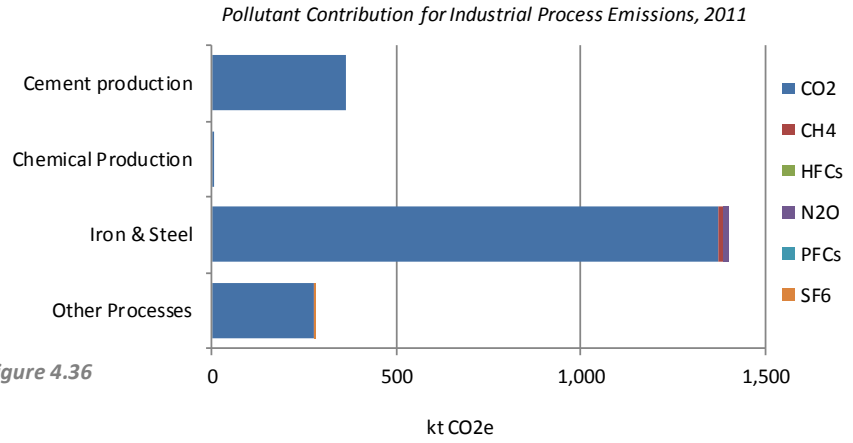


Figure 4.36

In Wales in 2011, the industrial process sector contributed 5% to total GHG emissions. The industrial process sector includes non-combustion sources such as iron and steel processes (68% of total GHGs) excluding the use of electricity and fossil fuels for heating processes; the use of limestone in cement production (18% of total sector GHG emissions) and other processes (14% of total GHGs) including fertilizers & other bulk chemical feedstocks, glass & brick making and lime production (see Figure 4.35).

In 2011, 98% of total GHGs emissions were from emissions of carbon dioxide from processes (primarily cement and iron and steel production). Less than 1% of total GHGs emissions are from the use of fluorinated greenhouse gases (F-Gases), predominantly HFCs, in industrial processes including sulphur hexafluoride (SF_6) from its application as a cover gas in magnesium production (see Figure 4.36). Emissions of methane and nitrous oxide from this sector are not significant, accounting for 1.5% of total GHG emissions in this sector.

Overall, industrial process emissions in Wales have reduced by 24% between the Base Year and 2011 (see Table 4.9). This decline in emissions is due to several factors including a decline in manufacturing, cement, aluminium production, bulk chemical and iron and steel industries.

Total GHG emissions have decreased by 6% between 2010 and 2011 (-120 $ktCO_2e$). Although there has been a slight increase in emissions from cement production, there has been a significant decrease in carbon dioxide emissions from blast furnace gas flaring in the iron and steel sector.

Industrial Process Traded and non-traded emissions

Emissions in the industrial process sector include significant contributions from installations reporting in the EU ETS. However, due to the lack of detail in the EU ETS dataset, business, energy supply and industrial process emissions are not easy to separate. The contribution to total aggregate emissions from the traded and non-traded sector across these NC sectors is presented in Figure 4.9 in the summary section.

Industrial Process Emissions on an End User Basis

As the majority of emissions in the industrial process sector are not due to energy consumption, industrial process sector emissions on an end user basis are very similar to the emissions by source. In 2011, the end user estimates are only 7% higher for the industrial process sector, reflecting the relatively low contribution to sector emissions from the use of electricity or fossil fuels as feedstock or for energy.

4.8 Agriculture

Overall Contribution to 2011 GHG emissions

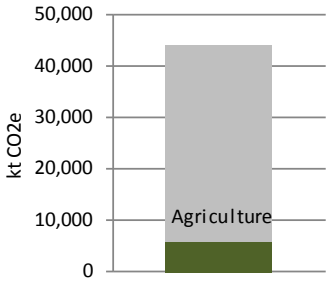


Figure 4.37

12.87%

Percentage of total emissions

Agriculture Emissions by category and pollutant, 2011

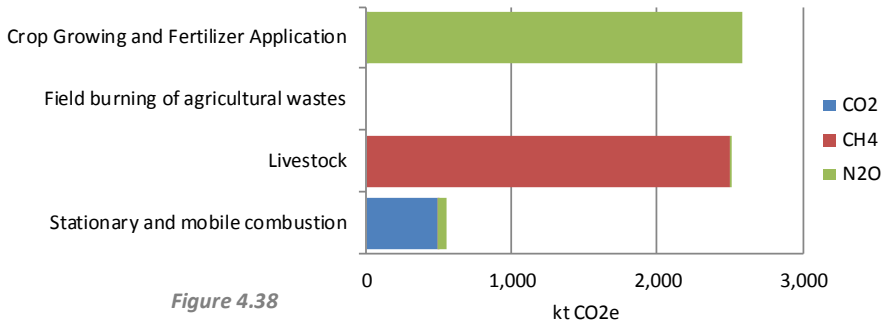


Figure 4.38

Change in GHG Emissions from Base Year (BY) to 2011 and from 2010 to 2011

	BY-2011		2010-2011	
Sub-sector	**%**	**kt CO2e**	**%**	**kt CO2e**
Crop Growing and Fertilizer Application	-26%	-906	-1%	-20
Field burning of agricultural wastes	-100%	-15	-	0
Livestock	-15%	-457	1%	16
Stationary and mobile combustion	-18%	-124	1%	6
Total	-21%	-1,502	0%	2

Table 4.10

Total GHG emissions from Agriculture, Base Year - 2011

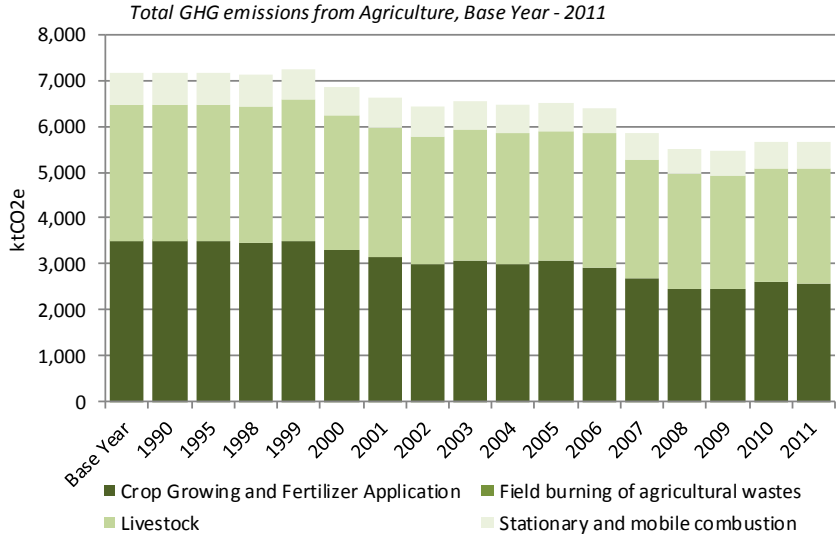


Figure 4.39

Livestock emissions by type, 2011

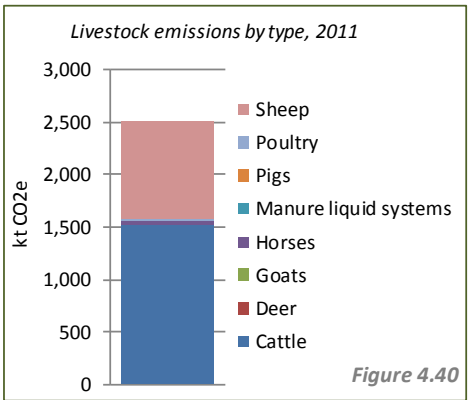


Figure 4.40

GHG emissions from agriculture are primarily methane and nitrous oxide from livestock and agricultural soils respectively, but there are also carbon dioxide emissions from fuel combustion in mobile and stationary units in the sector (see Figure 4.38). Agriculture accounts for 13% of total greenhouse gas emissions in Wales in 2011, and is the most significant source sector for methane and nitrous oxide, accounting for 44% and 47% of total Welsh emissions of these two gases, respectively.

Emissions from agriculture have slightly increased by 0.04% between the Base Year and 2011. The increases in methane emissions from sheep enteric fermentation and carbon dioxide from gas oil use in mobile machinery just exceed a number of reductions from nitrous oxide from agricultural soils and enteric fermentation in cattle.

Enteric fermentation contributed 91% (2,264 $ktCO_2e$) to total agricultural methane in Wales in 2011. Total methane emissions from beef and dairy cattle (enteric and waste management sources combined) accounted for 61% of the all Welsh agricultural methane emissions. Total emissions from sheep were 37% of the total methane from agriculture in 2011.

Agriculture is the most important source of nitrous oxide in Wales and 92% (2,445 $ktCO_2e$) of the sector total arose from agricultural soils. This source accounted for 82% of total nitrous oxide emissions in 2011. A further breakdown of these emissions is shown in Table 4.11.

Nitrous oxide emissions are largely driven by fertiliser nitrogen use, manure applications and grazing returns to soils. Nitrous oxide emissions declined by 26% between the Base Year and 2011 due to a general decline in livestock numbers and fertiliser nitrogen use (particularly to grassland).

Table 4.11: Emissions of nitrous oxide from agricultural sources in Wales in 2011 ($ktCO_2e$)[41]

Manure management				143
Soils				2,445
	Direct			*1,537*
		Fertiliser		402
		Grazing returns		868
		Manure application		189
		Crop residues		38
		Biological fixation		0
		Improved grassland		28
		Histosols		0
		Sewage sludge		12
	Indirect			*907*
		Leaching		744
			Fertiliser	268
			Grazing returns	325
			Manure application	142
			Sewage sludge	9
		Deposition		163
			Fertiliser	36
			Grazing returns	87
			Manure application	38
			Sewage sludge	2
Field burning				0
TOTAL				**2,587**

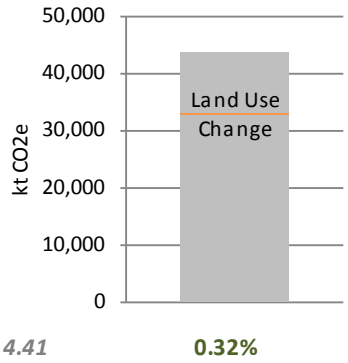
Agriculture Emissions on an End User Basis

As the majority of emissions in the agriculture sector are not due to energy consumption, agriculture sector emissions on an end user basis are very similar to the emissions by source. In 2011, the end user estimates were only 6% higher for the agriculture sector, reflecting the relatively low contribution to sector emissions from the use of oils and electricity, compared to the higher-emitting sources of nitrous oxide and methane from soils and livestock sources.

[41] Total emissions comprise manure management, soils and field burning. Soils include direct and indirect emissions; indirect emissions include leaching and deposition

4.9 Land Use, Land Use Change and Forestry

Overall Contribution to 2011 GHG emissions



0.32%

Percentage of total emissions

Figure 4.41

Pollutant Contribution to LULUCF GHG Emissions, 2011

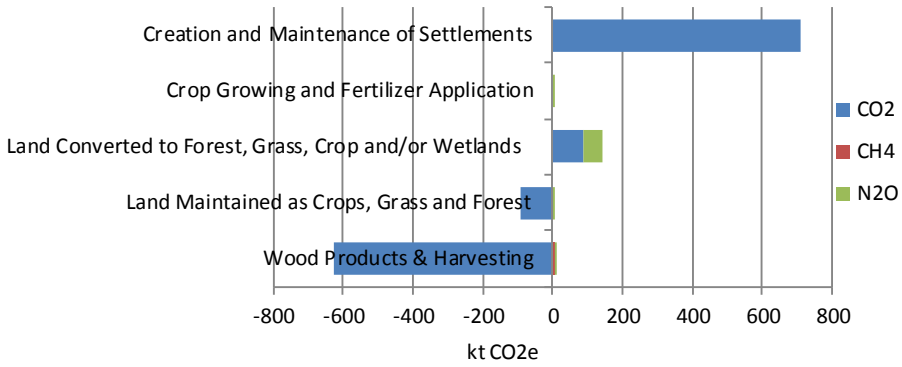


Figure 4.42

Emission Estimates for Base Year (BY), 2010 and 2011; change in GHG Emissions from BY to 2011 and from 2010 to 2011

	BY	2010	2011	BY-2011	2010-2011
Sub-sector	**kt CO2e**	**kt CO2e**	**kt CO2e**	**kt CO2e**	**kt CO2e**
Creation and Maintenance of Settlements	769	708	705	-63	-2
Crop Growing and Fertilizer Application	4	4	4	0	0
Land Converted to Forest, Grass, Crop and/or Wetlands	73	142	124	51	-18
Land Maintained as Crops, Grass and Forest	-541	-94	-67	474	27
Wood Products & Harvesting	-321	-609	-627	-306	-18
Total	-16	151	141	156	-11

Table 4.13

Total GHG Emissions from LULUCF, Base Year - 2011

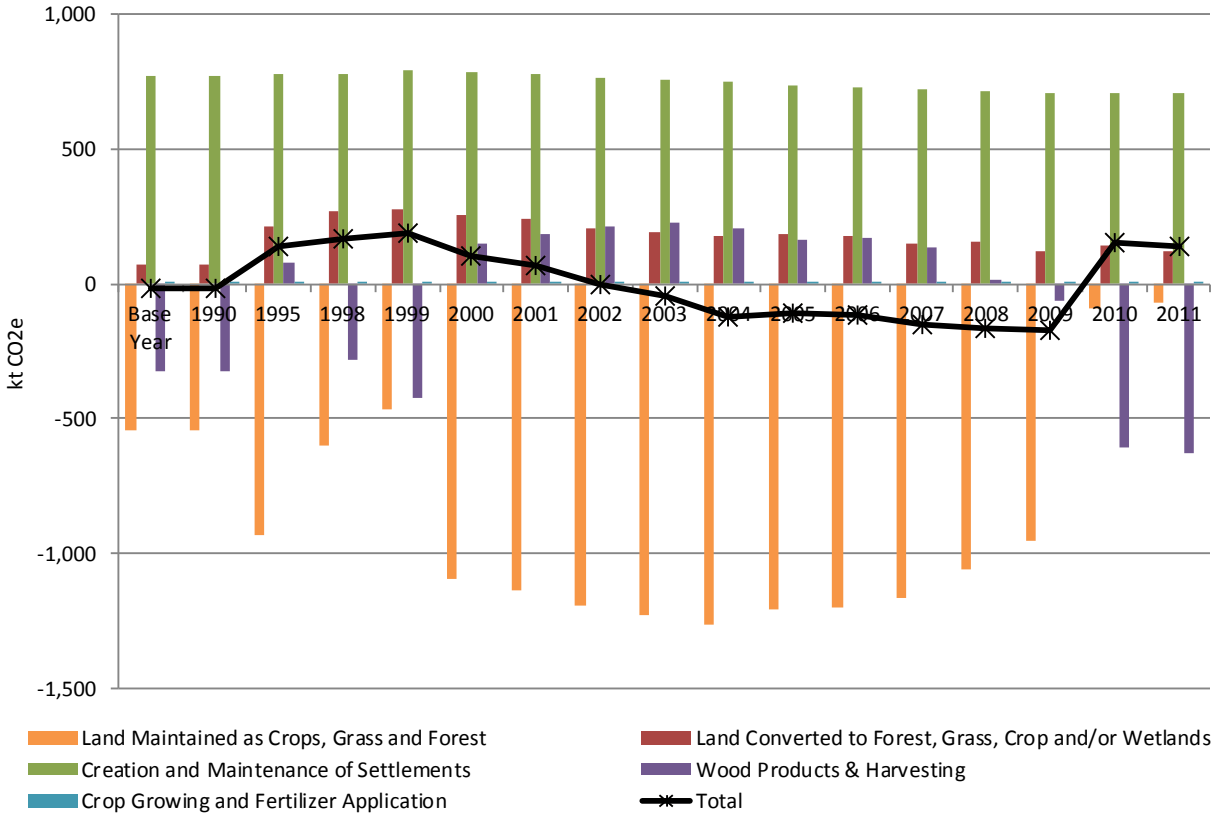


Figure 4.43

Figures 4.41 – 4.43 and Table 4.13 show detailed emissions and trends for the Land Use, Land Use Change and Forestry (LULUCF) sector. Wales has been a small net source of GHG emissions between 1990 and 2002 after which it was a small net sink until 2010. In 2010 and 2011, Wales was a small net source of GHG emissions.

The net change from sink to source seen between 2009 and 2010 was primarily due to an increase in net emissions from land maintained as crops, grass and forests resulting in a smaller sink for this sub-sector. Although there was a significant increase in the sink from wood products and harvesting, the overall effect of these two changes led to a rise in emissions resulting in a small net source of GHG emissions from 2010 onwards.

Wales had significant forest planting during 1950s through to mid-1970s. The steady decrease in the sink from "Land Maintained as Crops, Forest and/or Wetland" reflects the maturation of these forest stocks. From 2010 onwards, those forests are considered to be near maturity and therefore no longer sequestering significant carbon. There was a decline in new planting mid-1970s with no further significant replanting after that. This also affects emissions from "Wood Products and Harvesting" which is why there is a significant increase in the sink from 2009 to 2010. The maturation of Wales' forest stock is, therefore, the primary driver for the change of net GHG emissions from a small net sink to small net source between 2009 and 2010.

Total LULUCF emissions have decreased by 7% between 2010 and 2011. Although there has been a reduced sink in harvested wood products, there has also been a reduction in emissions from forest land wildfires leading to a slight reduction in overall emissions.

A more detailed report of LULUCF emissions in England, Wales, Scotland and Northern Ireland can be found on the National Air Emissions Inventory (NAEI) website (H. Malcolm *et al*. 2013) and more detailed information is also available in the UK Greenhouse Gas Inventory Report, available on the NAEI website.

LULUCF Emissions on an End User Basis

As emissions and removals from LULUCF do not related to energy supply the end user GHG inventory emissions are the same as emissions reported in the by source GHG inventory.

4.10 Waste Management

Overall Contribution of Waste Management to 2011 GHG emissions

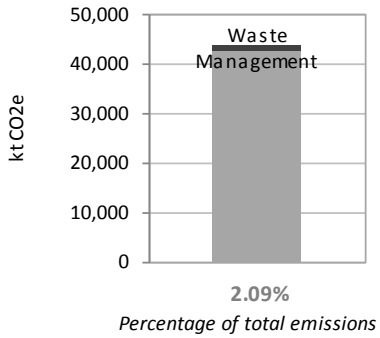


Figure 4.44

Total GHG Emissions from Waste Management, Base Year- 2011

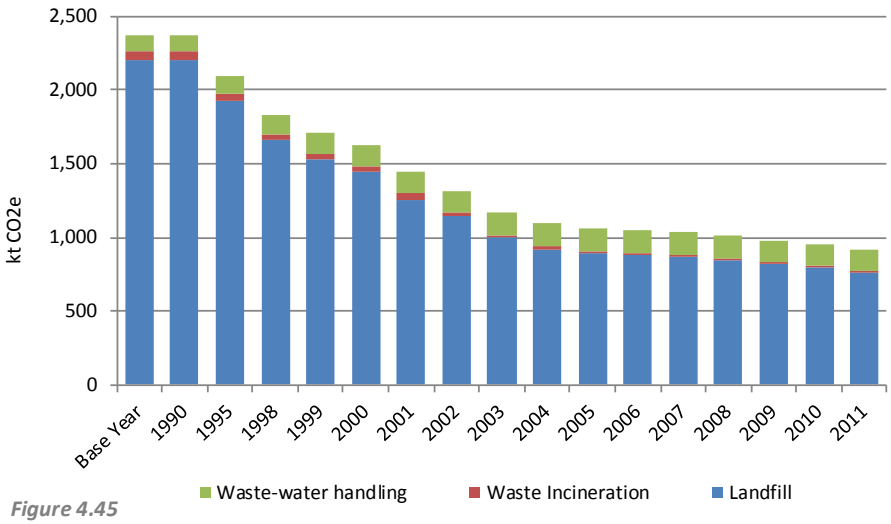


Figure 4.45

Change in GHG Emissions from Base Year (BY) to 2011 and from 2010 to 2011

	BY-2010		2009-2010	
Sub-sector	**%**	**kt CO2e**	**%**	**kt CO2e**
Landfill	-65%	-1,439	-4%	-29
Waste Incineration	-84%	-45	-7%	-1
Waste-water handling	21%	24	-2%	-3
Total	-61%	-1,460	-3%	-33

Table 4.14

Pollutant contribution to Waste Management Emissions, 2011

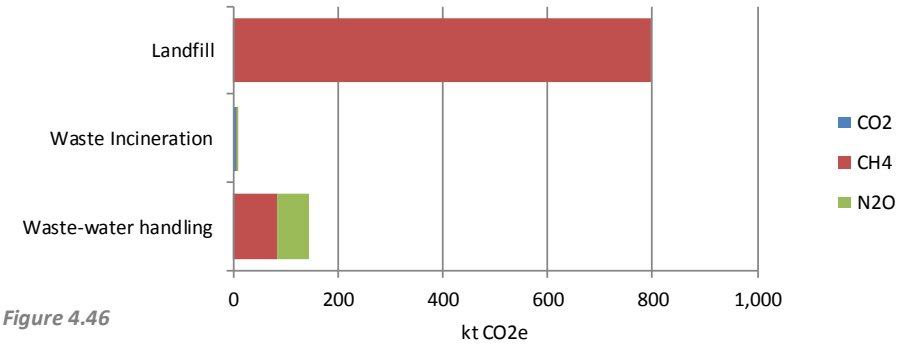


Figure 4.46

In 2011, the waste management sector contributed 2% to total GHG emissions in Wales. It was the second largest source for methane emissions, representing 22% of total methane emissions. Emissions from this sector are dominated by methane from landfill (84% of emissions) with a smaller contribution of methane and nitrous oxide emissions from wastewater treatment (15% of emissions) and the remaining 1% of emissions from waste incineration (see Figure 4.45). Methane emissions from industrial waste-water treatment have been estimated for the first time for this submission and contribute 2% to 8% of total Waste emissions across the 1990-2011 time series.

Nitrous oxide emissions from wastewater treatment represented 6% of emissions in the sector, and contributed 2% to the total emissions of nitrous oxide in Wales.

Total GHG emissions from the waste management sector in Wales have shown a significant decline of 61% in total for the sector and by 65% for landfill between the Base Year and 2011, as shown in Table 4.14, due largely to the progressive introduction of methane capture and oxidation systems within landfill management.

There has been a decline in methane emission estimates from landfill between 2010 and 2011, which has been the primary driver for the overall decrease (-3.5%) in emissions from the waste management sector. There were also further, small reductions in the methane emission estimates from industrial and municipal waste water treatment.

Waste Management Emissions on an End User Basis

As emissions from the waste sector do not include any energy consumption sources, and no electricity use is allocated to the waste sector (due to lack of data), the end user emission estimates for the sector are unchanged from the emissions presented here on a by source basis.

5 Emissions in Northern Ireland

5.1 1990-2011 GHG Inventory Estimates

The greenhouse gas (GHG) emissions for Northern Ireland for 1990-2011 are presented in Table 5.1 and in the graph in Figure 5.2 below. Emissions in 2011 are 19,827 $ktCO_2e$ with 28% from Agriculture, 21% from Transport, 19% from Energy Supply and 16% from the Residential sector.

Table 5.1: 1990-2011 Northern Ireland GHG Emission Inventory ($ktCO_2e$)

NC Format	Base Year	1990	1995	2000	2005	2009	2010	2011	% of 2011
Agriculture	6,039	6,039	6,397	6,130	5,914	5,428	5,518	5,550	28.0%
Business	2,725	2,699	2,471	2,273	2,426	2,251	2,479	2,283	11.5%
Energy Supply	5,315	5,315	6,541	6,341	5,349	3,681	3,944	3,731	18.8%
Industrial Process	761	761	779	682	418	178	170	162	0.8%
LULUCF[42]	98	98	-41	-107	63	181	141	180	0.9%
Public	461	461	288	147	173	200	200	192	1.0%
Residential	4,169	4,158	3,608	3,819	3,524	3,396	3,813	3,118	15.7%
Transport	3,325	3,325	3,558	3,997	4,409	4,277	4,201	4,158	21.0%
Waste Management	1,135	1,135	1,019	780	519	483	476	454	2.3%
Total[43]	**24,028**	**23,991**	**24,621**	**24,063**	**22,795**	**20,075**	**20,942**	**19,827**	**100.0%**

Figure 5.1 and Table 5.2 show the change in emissions from the Base Year and 2010 to the latest year 2011. Total GHG emissions for Northern Ireland show a decrease of 5.3% between 2010 and 2011, and between the Base Year[44] and 2011 of 17.5%. The 2010 to 2011 reduction is mainly due to the large reduction in burning oil use in the residential and business sector, along with a reduction of emissions from coal consumption at power stations. Carbon dioxide emissions have reduced by 17.3% since the Base Year. Transport and LULUCF emissions have, however, increased since the Base Year with the transport sector emitting 25% more GHG emissions in 2011 than the Base Year.

Emissions from the transport sector continued to buck the general trend as a result of increasing population and increasing demand for transportation despite improvements in energy efficiency of vehicles; across the UK emissions from the Transport sector have shown a small increase since 1990, whereas in Northern Ireland the increase is notably larger, which reflects the growth in the Northern Ireland economy during the 2000's. Northern Ireland has seen a marked reduction in emissions from the residential sector due to its changing fuel profile away from oil and towards gas.

Detailed analysis of Northern Ireland emissions in 2011 is presented in Figures 5.4-5.10. The largest sources of emissions in 2011 include road transport (19.1% of total GHGs), electricity production (18.8% of total GHGs), residential combustion for heating and cooking (15.1% of total GHGs), crop growing and fertilizer application (13.1% of total GHGs) and livestock emissions (12.2% of total GHGs) (See Figure 5.6).

[42] Land Use, Land Use Change and Forestry (LULUCF)

[43] International aviation and shipping are not included in the data below because these sources are "memo items" and thus not included in the UK emission estimates.

[44] 1995 for fluorinated greenhouse gases (F-Gases) and 1990 for all other gases

Figure 5.4 shows the emissions split by GHG and highlights the 2.5 and 97.5 percentile range. The range of uncertainty is greatest for nitrous oxide emissions. See Appendix 1 for further details on uncertainties.

Carbon dioxide is the most common gas emitted for all National Communication (NC) categories except agriculture, where methane from livestock and nitrous oxide from soils, and for waste, where methane from landfills are the most important gases (see Figure 5.5).

Traded and Non-Traded Emissions

Emissions from installations included in the European Union Emissions Trading Scheme (EU ETS) (see Figure 5.9) reduced by 26% between 2008 and 2009 as power demand in the economy dropped, whilst traded emissions then increased by nearly 7% between 2009 and 2010. Emissions from installations in the EU ETS (see Figure 5.7) accounted for 22% of total GHG emissions in Northern Ireland in 2011; the main contributors to these traded emissions are the energy supply sector (of which 100% total emissions are within the EU ETS, including all power stations) and the business and industrial process sectors (see Figure 5.8) of which, 25% of total sector emissions are in the EU ETS.

Emissions on an End User Basis

In addition to presenting emissions based on direct emissions from processes or combustion of fuels in Northern Ireland, the emissions from the Energy Supply sector can be attributed to the users of the energy (see Appendix 3 for more details of the end user inventory methodology).

Figure 5.7 illustrates the difference between the by source and end user inventory emission estimates and how emissions from energy supply are allocated to the end user NC categories. The primary difference in the end user perspective is the significant increase in emissions attributable to the business, residential, transport and public sectors. The end user inventory data illustrate that on an end user basis, the contribution to Northern Ireland total emissions in 2011 are: 23% from the residential sector, 22% from transport sources and 20% from business. As illustrated in Figure 5.3, Northern Ireland is a net importer of electricity which results in higher (+7.1% all GHGs) emissions in Northern Ireland on an end user basis (21,228 $ktCO_2e$) compared to by source (19,827 $ktCO_2e$) inventory estimates for 2011.

Emissions from the Land Use, Land Use Change and Forestry (LULUCF) and waste management sectors are unchanged between the by source and end user approaches, since there are no emissions from energy use allocated to these sources. For agriculture, the increase in emissions using the end user approach is limited to the emissions from energy use within the sector.

A more detailed assessment of emissions by sector is presented below for each of the National Communication sectors.

5.1.1 Inventory Recalculations

Revisions to the estimates since the last inventory report (G. Thistlethwaite *et al.,* 2012) have resulted in a 2.3% (482 $ktCO_2e$) increase in the 2010 estimates for Northern Ireland. The most significant revisions to the 2010 estimates have been for the following sectors:

1. **Agricultural Soils (Agriculture)**: (280 $ktCO_2e$ increase) due to an updated crop area time series with data supplied from Northern Ireland, an updated crop area and fertiliser N rate time series and changes to grassland areas (grass >5 years now includes rough grazing).
2. **Other manufacturing industry and construction (Business)**: (176 $ktCO_2e$ increase) predominantly due to the addition of emissions due to new estimates in the UK inventory for the use of Other Petroleum Gas (OPG) in industrial boilers, following greater scrutiny of the EU ETS data for evidence of use of off-gases from petrochemical production processes being used in boilers on specific industrial sites. There have also been UK-wide revisions to gas oil allocations; a revision to Devolved Administration (DA) allocations of fuel use in industrial off-road machinery to use updated energy mapping analysis consistent with the Department of Energy and Climate Change (DECC) sub-

national energy statistics; new UK-wide estimates for emissions from biomass; revisions to gas use in other industrial combustion across GB as a result of changes in point source analysis across 1A2 and revisions to the Digest of UK Energy Statistics (DUKES) activity data for gas-fired autogeneration; increased UK-wide allocation of fuel oil in industry of around 200% in 2010.

3. **Industrial Wastewater Handling (Waste)**: (36 kt CO_2e increase) as this is a new sector in this inventory.
4. **Land converted to cropland (LULUCF)**: (25 ktCO_2e increase) due to a revision to the methodology for emissions of nitrous oxide from the disturbance associated with land use conversion to cropland.

For more details of revisions to GHG emission estimates, see Appendix 6.

Percentage Change in GHG Emissions by NC: Base Year - 2011 and 2010 - 2011

The % changes for LULUCF are based on net change to sink/source across the time series

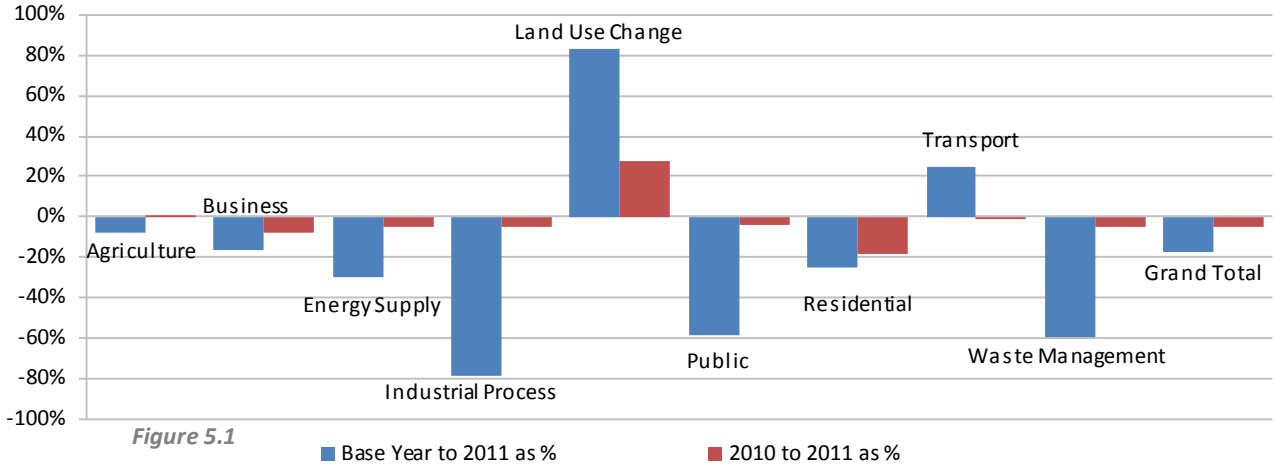


Figure 5.1

Percentage Change in Total GHG and CO2 Emissions by NC: Base Year - 2011 and 2010 - 2011

The % changes for LULUCF are based on net change to sink/source across the time series

Change in emissions from the Base Year to 2011 and 2010 to 2011	Agriculture	Business	Energy Supply	Industrial Process	Land Use Change	Public	Residential	Transport	Waste Management	**Total**	
Base Year to 2011 as %	-8%	-16%	-30%	-79%	83%	-58%	-25%	25%	-60%	-17%	**Total GHG**
2010 to 2011 as %	1%	-8%	-5%	-5%	28%	-4%	-18%	-1%	-5%	-5%	**as CO2e**
Base Year to 2011 as %	-11%	-27%	-30%	-61%	392%	-58%	-24%	26%	-67%	-17%	**Total CO2**
2010 to 2011 as %	2%	-9%	-5%	-5%	53%	-4%	-19%	-1%	-11%	-7%	**only**
Base Year to 2011 kt	-489	-442	-1,584	-599	82	-270	-1,051	833	-682	-4,201	**Total GHG**
2010 to 2011 kt	33	-196	-213	-8	39	-9	-695	-44	-22	-1,114	**as CO2e**
Base Year to 2011 kt	-59	-713	-1,571	-254	92	-265	-944	848	-5	-2,871	**Total CO2**
2010 to 2011 kt	11	-200	-210	-8	40	-9	-690	-45	0	-1,110	**only**

Table 5.2

Total GHG Emissions by NC category for Base Year to 2011, as CO2e

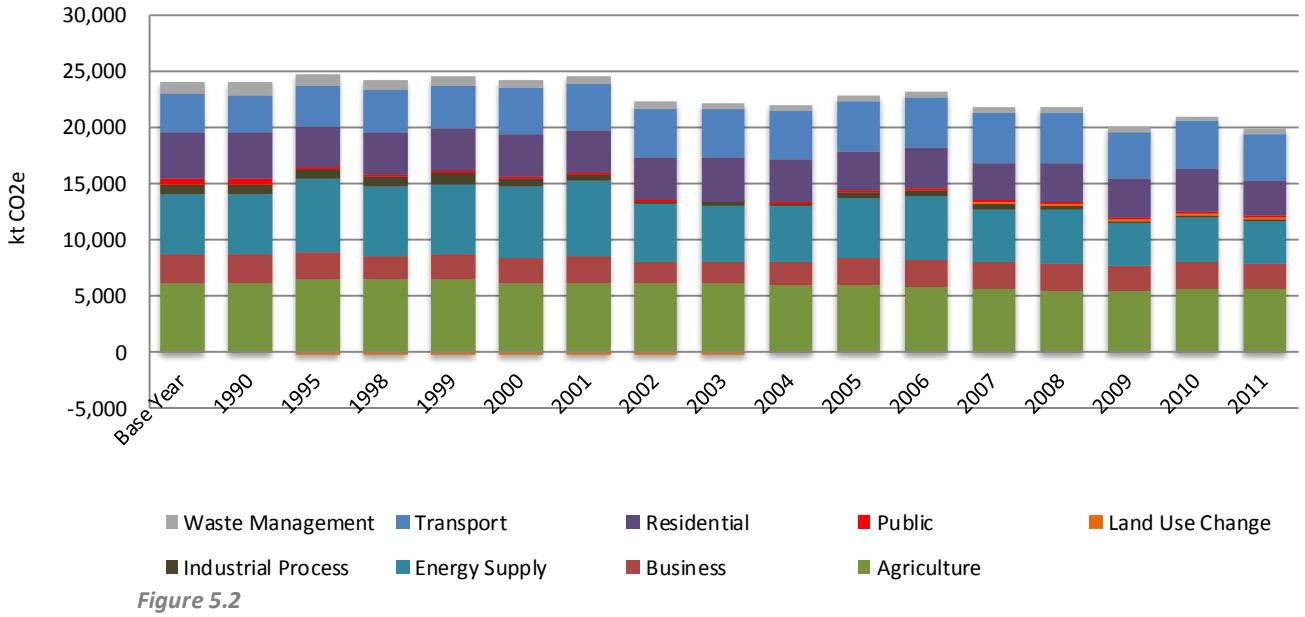
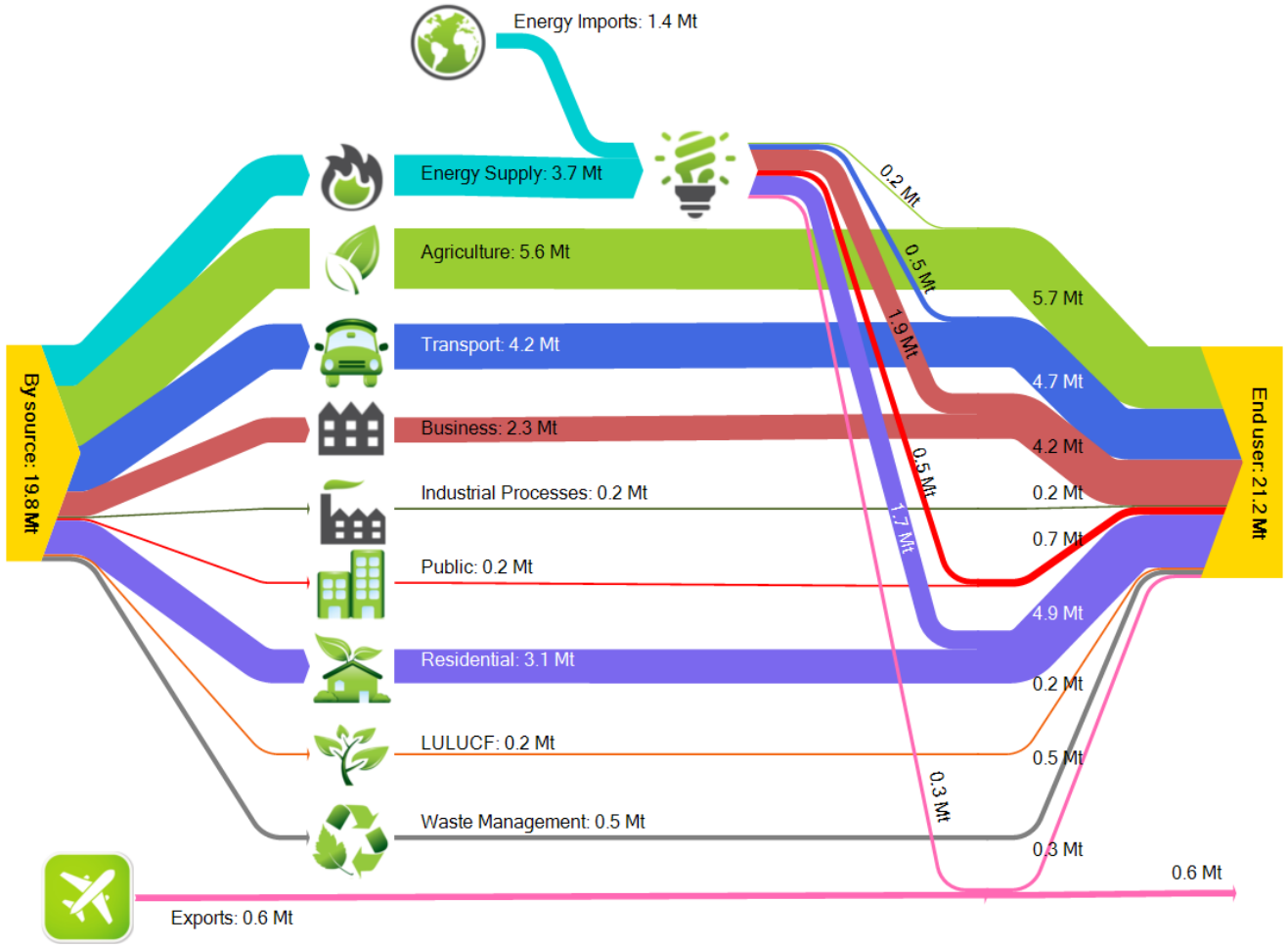


Figure 5.2

Figure 5.3 Sankey diagram showing By Source and End User[45] GHG emission transfers for Northern Ireland in 2011 (Mt CO_2e)[46]



[45] The pink line from 'Energy Supply' to 'End User' represents emissions from energy supply in the production of fuels used in international aviation and shipping.

[46] Exports' equates to emissions from international aviation and shipping.

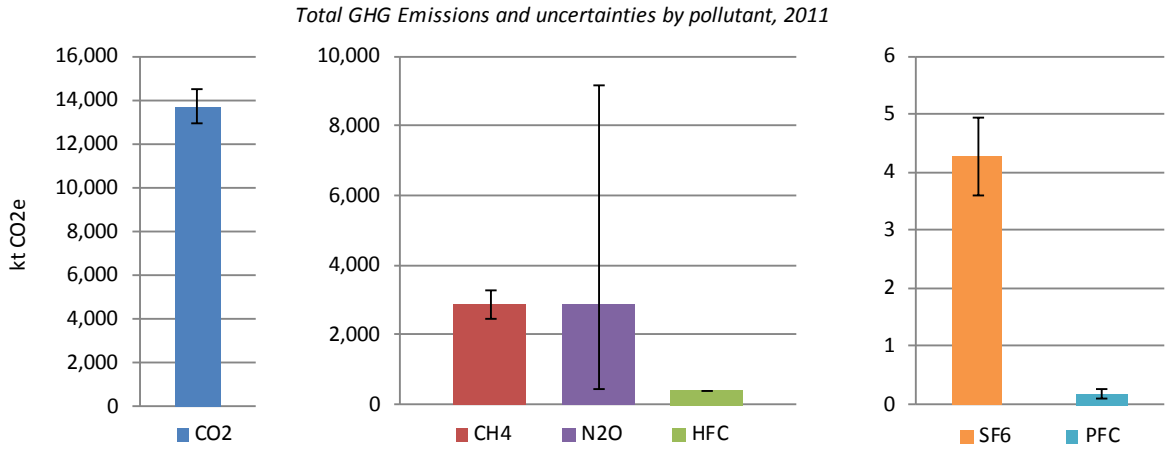


Figure 5.4

** error bars represent 2.5 to 97.5 percentile range*

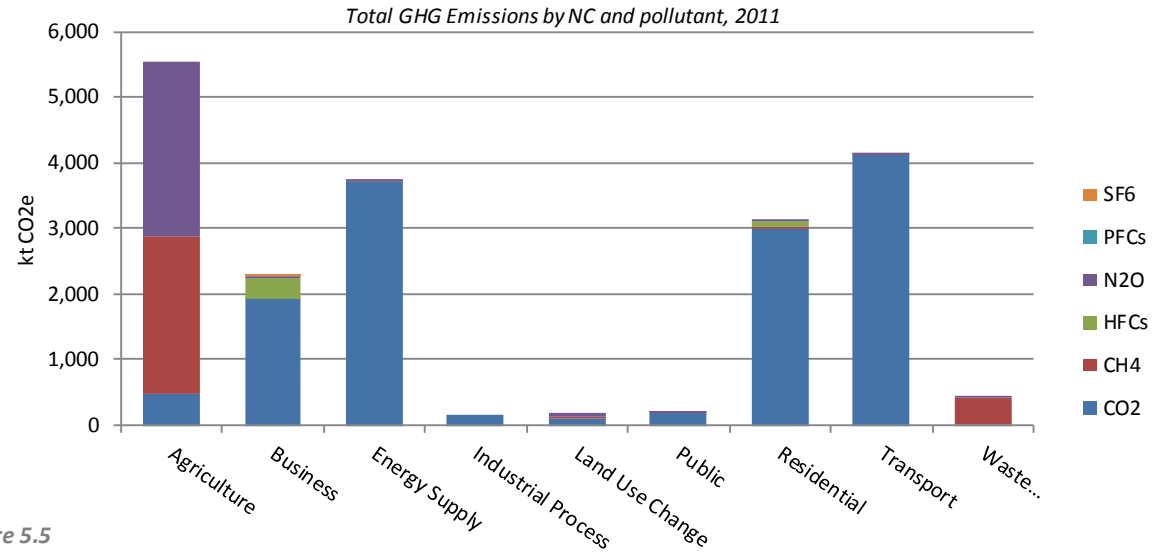


Figure 5.5

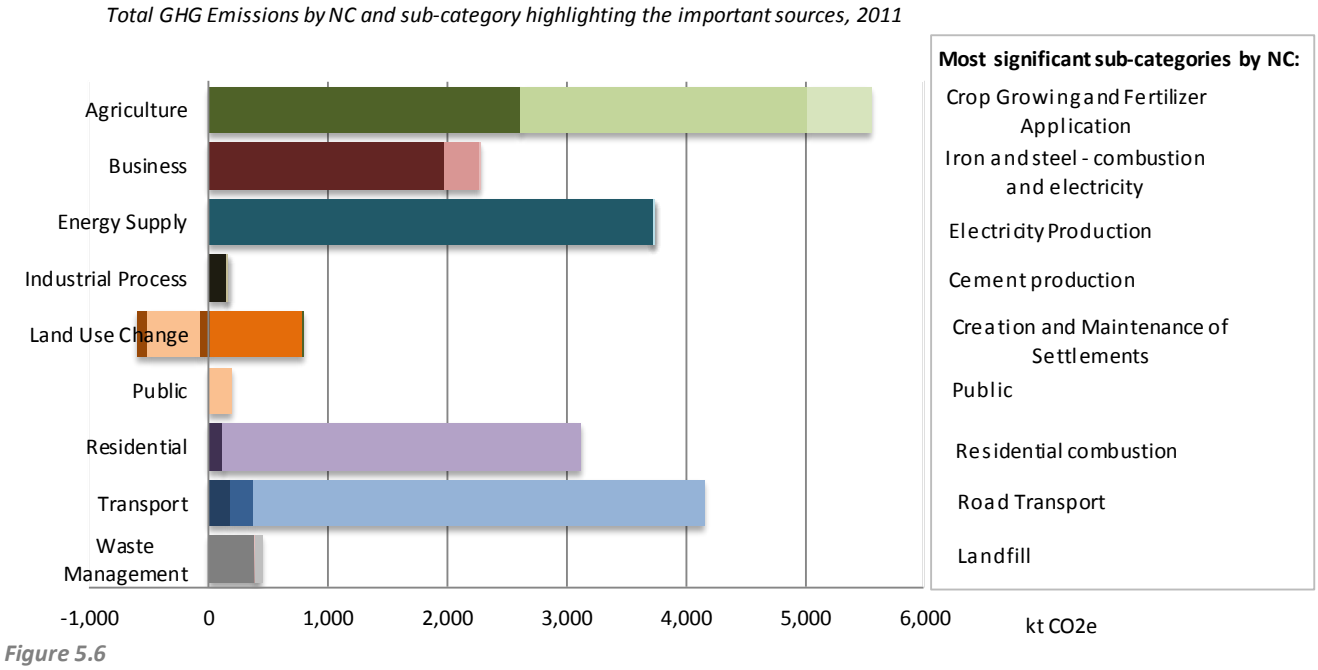


Figure 5.6

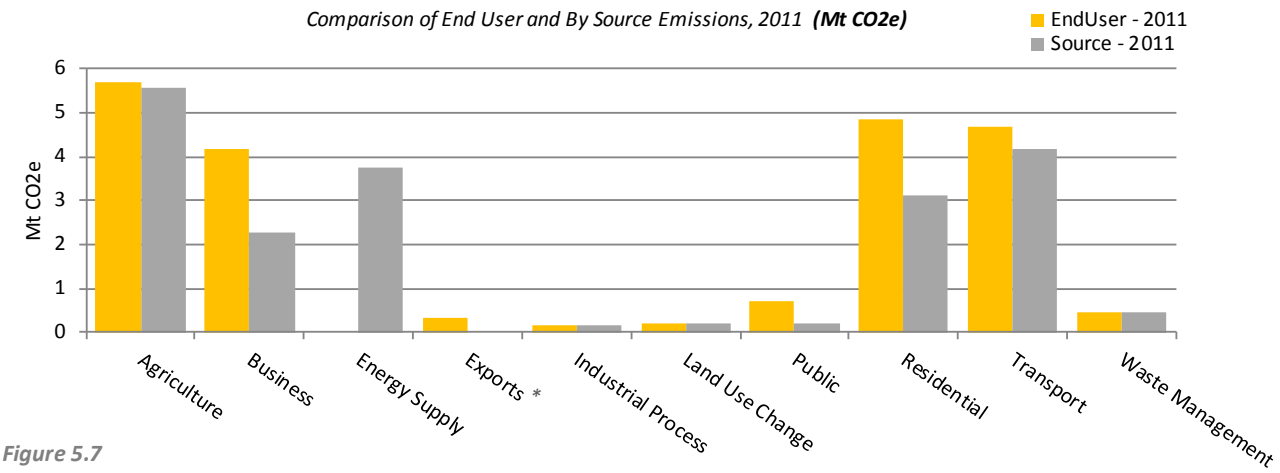


Figure 5.7

** Exports includes emissions from energy production for international aviation, international shipping and exported fuels.*

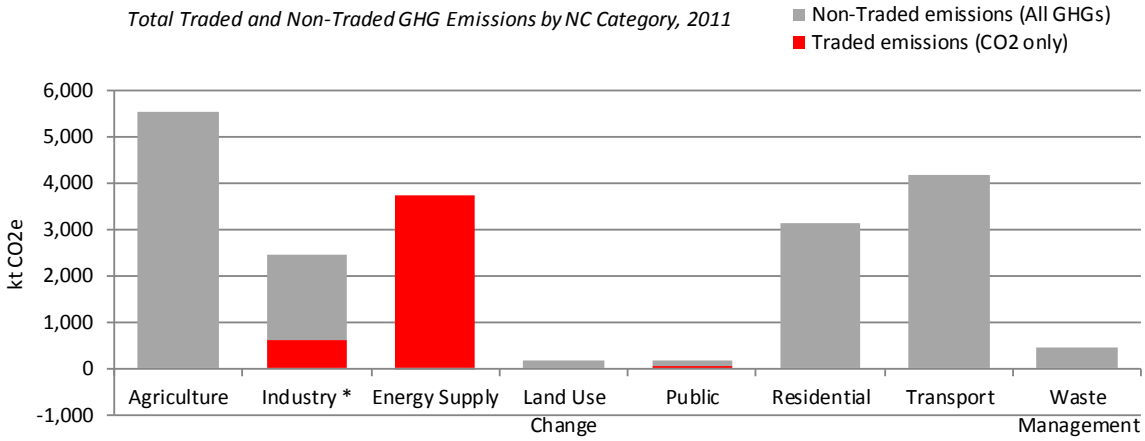


Figure 5.8

** Industry includes emissions from the NC categories: Industrial Process and Business*

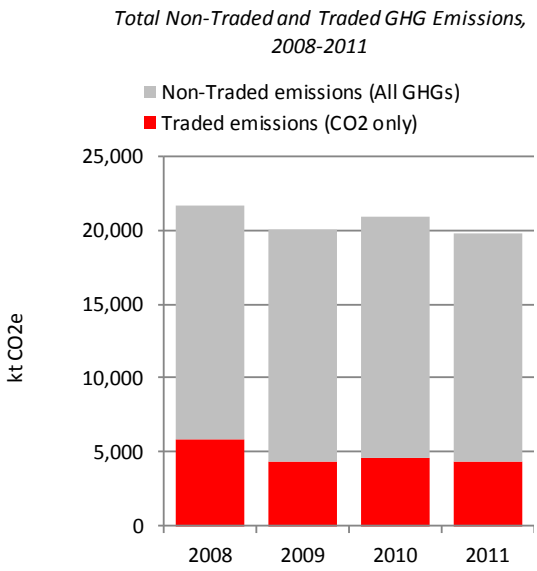


Figure 5.9

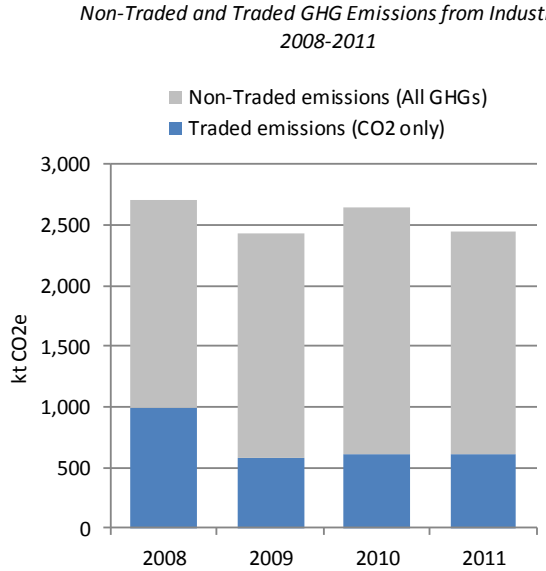


Figure 5.10

** Industry includes emissions from the NC categories: Industrial Process and Business*

5.2 Energy Supply

Overall Contribution of Energy Supply to 2011 GHG emissions

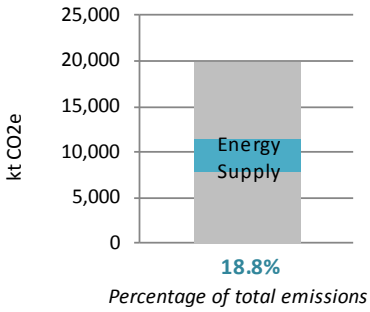


Figure 5.11

GHG Contribution for Energy Supply Emissions, 2011

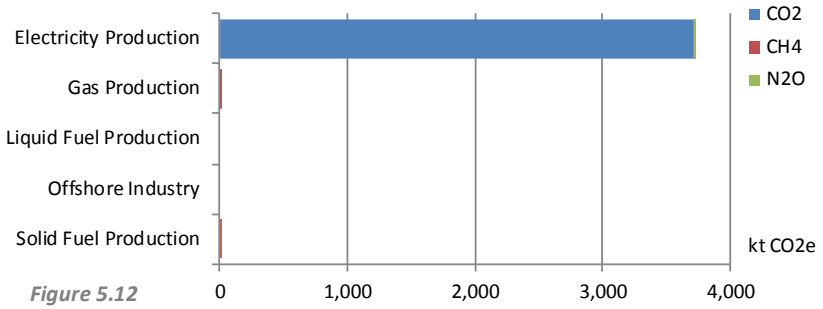


Figure 5.12

Change in GHG Emissions from Base Year (BY) to 2011 and from 2010 to 2011

	BY-2011		2010-2011	
Sub-sector	**%**	**kt CO2e**	**%**	**kt CO2e**
Electricity Production	-30%	-1,584	-5%	-213
Gas Production	-	0	-4%	0
Liquid Fuel Production	-	0	-	0
Offshore Industry	-	0	-	0
Solid Fuel Production	-	0	0%	0
Total	-30%	-1,584	-5%	-213

Table 5.3

NC Category Contribution to End User Inventory by percentage of Electricity Production Emissions

NC Category	End User
Agriculture	2%
Business	43%
Industrial Process	0%
Public	13%
Residential	35%
Transport	0%
Exports*	7%

Table 5.4

Total GHG Emissions from Energy Supply, Base Year to 2011

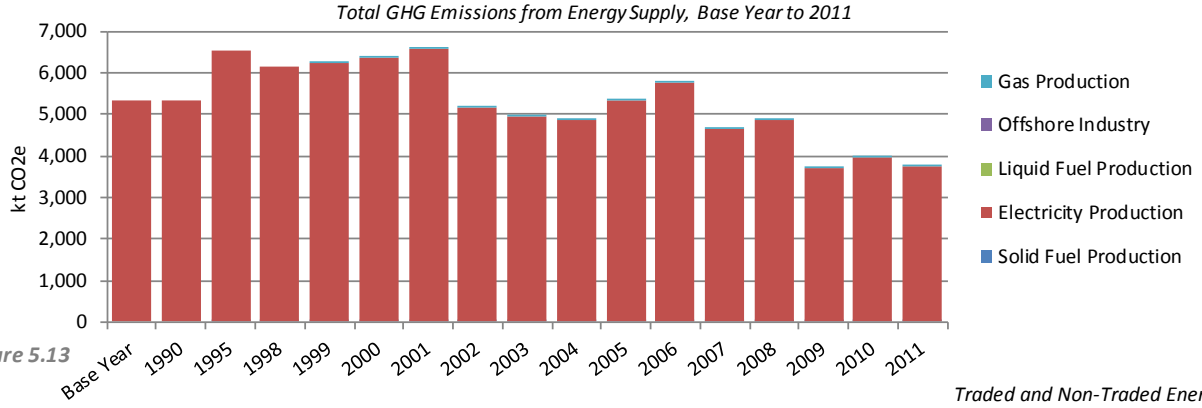


Figure 5.13

Emissions and Electricity Production by Fuel Type from Major Power Producers (1A1a)

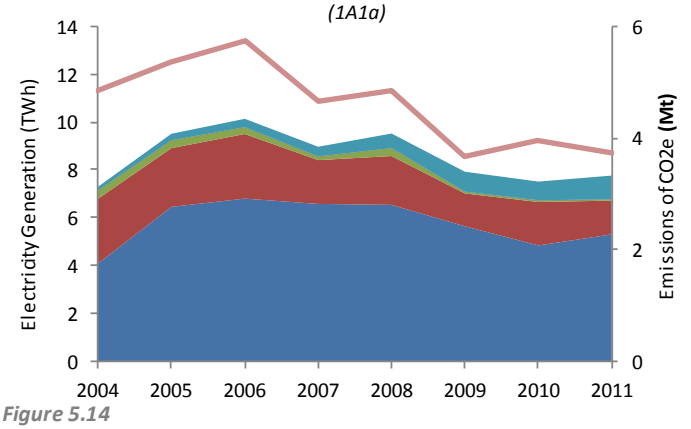


Figure 5.14

Traded and Non-Traded Energy Supply Emissions, 2009-2011

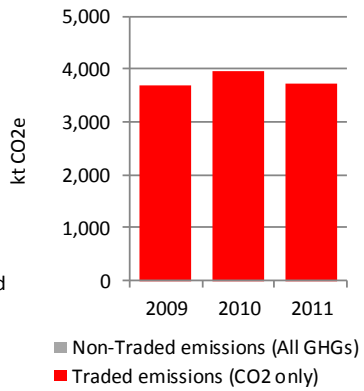


Figure 5.15

* These are emissions associated with the production of exported electricity and electricity used in international aviation and shipping.

In Northern Ireland the energy supply contributes 18.8% to total 2011 GHG emissions (see Figure 5.11). Northern Ireland has a much lower contribution from this sector than the UK average because, unlike the other Devolved Administrations (DAs), Northern Ireland does not have any refineries, iron and steel industry (producing coke), oil and gas terminals or coal mining. In addition, leakage from the gas supply network in Northern Ireland is minimal due to the relatively new infrastructure in the developing network.

The main source of emissions in Northern Ireland within the energy supply sector is electricity production at power stations, which accounts for more than 99% of energy supply emissions in 2011; gas production accounts for approximately 0.01% of emissions (see Figure 5.13). Energy supply sector emissions have reduced since 1990 (by 30% between the Base Year and 2011) and between 2010 and 2011 (by 5%), with the 2010 to 2011 decrease caused mainly by a significant reduction of coal consumption in power stations. Carbon dioxide is the predominant gas accounting for 99.6% of emissions from the energy supply sector in 2011 as a result of the combustion of fossil fuels (see Figure 5.12).

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 time-series. The emission of carbon dioxide per unit energy produced is lower for natural gas than other fossil fuels. 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.

Northern Ireland generates electricity that can be subsequently exported and sold into the Republic of Ireland electricity grid, whilst the country also imports electricity from Scotland via the Moyle interconnector. All emissions from electricity production in the energy supply sector originate from Traded (EU ETS) installations (see Figure 5.15).

Energy Supply Emissions on an End User Basis

End user emissions from electricity production in the energy supply sector are presented in Table 5.4. On an end user basis, business and residential demand for electricity accounts for 43% and 35% of electricity supply emissions respectively.

5.3 Transport

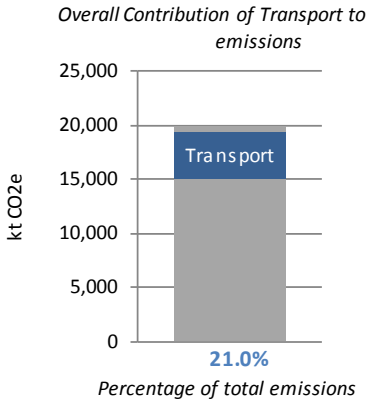


Figure 5.16

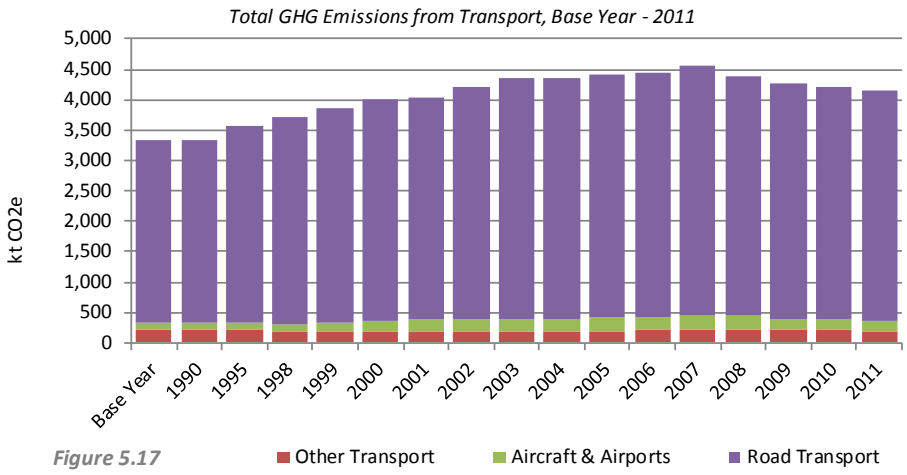


Figure 5.17

Change in GHG Emissions from Base Year (BY) to 2011 and from 2010 to 2011

	BY-2011		2010-2011	
Sub-sector	**%**	**kt CO2e**	**%**	**kt CO2e**
Aircraft & Airports	54%	62	-5%	-10
Other Transport	-9%	-20	-3%	-7
Road Transport	26%	791	-1%	-27
Total	25%	833	-1%	-44

Table 5.5

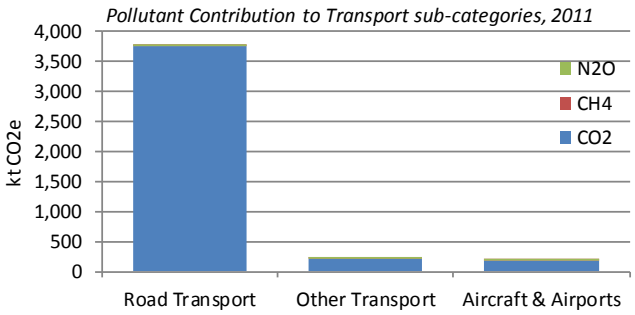


Figure 5.18

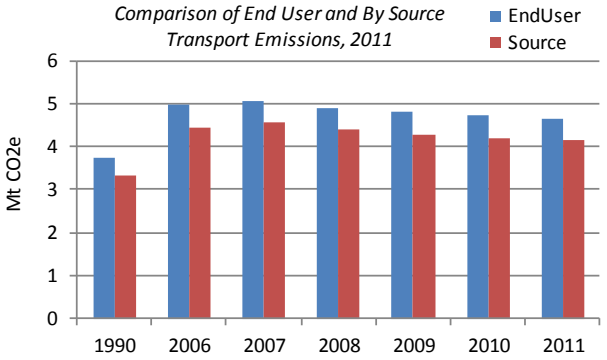


Figure 5.19

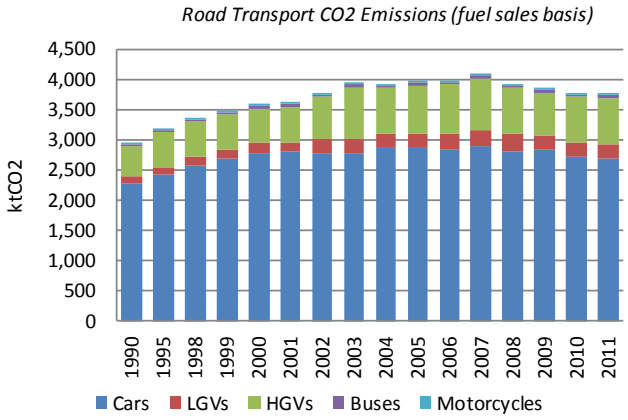


Figure 5.20

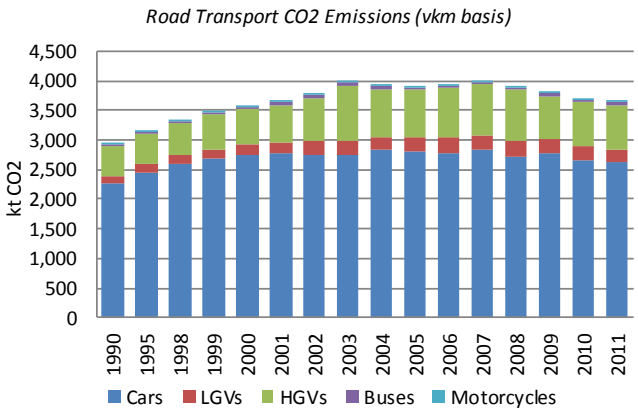


Figure 5.21

Transport emissions account for 21% of Northern Ireland's total GHG emissions in 2011. Transport emissions are dominated by emissions from road transport (91% of all transport emissions in 2011, with 65% of transport emissions from cars alone (see Figures 5.20 and 5.21). The transport sector also includes 0.9% from rail (including stationary sources[47]), 2.2% from national navigation and coastal shipping, 3.8% from domestic aviation and 1.5% from military aviation and shipping. Emissions from international aviation are excluded from these estimates. Details of these emissions are included in Appendix 6.

Total GHG emissions from the transport sector in Northern Ireland have increased by 25% between the Base Year and 2011 despite improvements in efficiency of transport vehicles, as a result of strong growth in transport demand. Emissions between 2010 and 2011 have not seen any significant change – decreasing by 1% (see Table 5.5).

Figures 5.20 and 5.21 show the carbon dioxide emissions from road transport for Northern Ireland based on constrained (DUKES fuel sales) and unconstrained (vehicle kilometre, vkm) approaches. Total carbon dioxide emissions from the vkm approach are 0.6% and 2.4% lower than the estimates constrained to DUKES for 1990 and 2011 respectively. The differences between the two approaches fluctuate year on year but they remain within 2.4% of difference for Northern Ireland. These disparities will also be reflected in the trends derived from the two approaches to a different extent. The long term trend (between Base Year and 2011) for each individual vehicle type is generally similar between the two approaches. The vkm approach indicates that the overall carbon dioxide emissions from road transport have increased by 25.0 % between the Base Year and 2011, while the constrained approach indicates a 27.3% increase.

Transport Emissions on an End User Basis

The end user estimates for 2011 are a 12% higher than the by source estimates, reflecting the additional emissions from upstream oil extraction and the oil refining sector (see Figure 5.19).

The trend in end user emissions since 1990 shows an increase of 24.2% to 2011, which is a slightly smaller increase than in the by source inventory, reflecting the improved energy efficiency of upstream production and refining of crude oil to produce the fuels used in the transport sector.

[47] Electricity use by the rail sector is not assigned to the transport sector in the by source estimates, but is attributed to the transport sector in the end user estimates.

5.4 Residential

Overall Contribution of Residential sector to 2011 GHG emissions

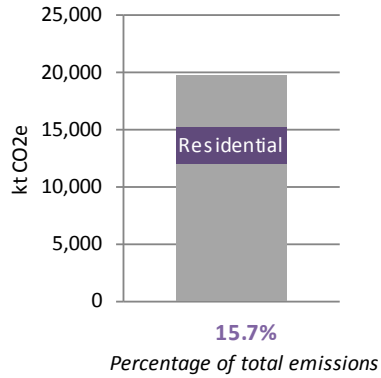


Figure 5.22

Total GHG Emissions by sub-sector, Base Year - 2011

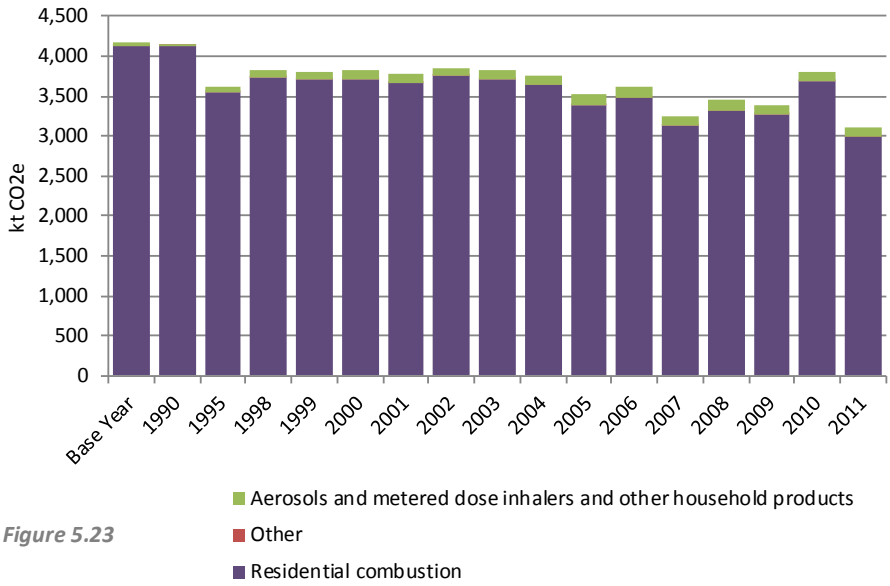


Figure 5.23

Change in GHG Emissions from Base Year (BY) to 2011 and from 2010 to 2011

	BY-2011		2010-2011	
Sub-sector	**%**	**kt CO2e**	**%**	**kt CO2e**
Aerosols and metered dose inhalers and other household products	168%	76	0%	0
Other	-28%	0	0%	0
Residential combustion	-27%	-1127	-19%	-695
Total	-25%	-1051	-18%	-695

Table 5.6

Pollutant contribution to Residential Emissions, 2011

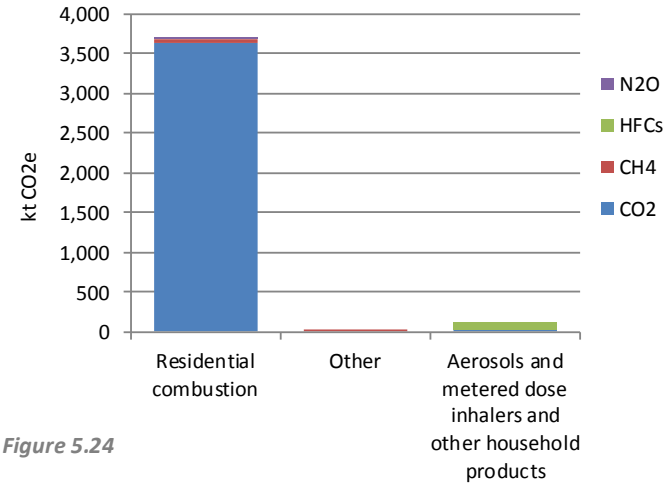


Figure 5.24

*Comparison between End User and By Source Inventory Totals **(Mt CO2e)***

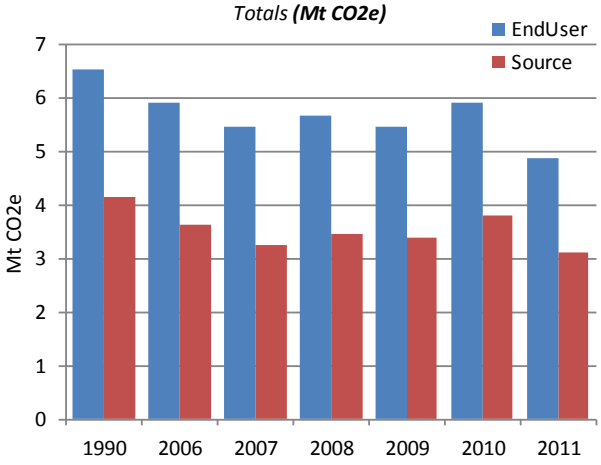


Figure 5.25

The residential sector accounts for 15.7% of Northern Ireland's total GHG emissions in 2011. The sector comprises emissions from residential combustion (96% of emissions for the residential sector) from heating and cooking, household products, accidental vehicle fires and HFC emissions from the use of aerosols and metered dose (usually asthma) inhalers. 96% of all residential GHG emissions are from the release of carbon dioxide from the direct combustion of fossil fuels (see Figure 5.24).

As a proportion of UK domestic emissions, Northern Ireland represents a higher share considering Northern Ireland's share of UK population. The reason for this is the very limited availability of natural gas resulting in the high consumption of coal, burning oil and gas oil in the residential sector, although natural gas is becoming more widely available and residential carbon dioxide emissions have shown a decrease of 24% since 1990 (see Table 5.6).

Total GHG emissions from the residential sector in Northern Ireland have decreased by 25% between the Base Year and 2011. There was a large decrease in GHG emissions from the sector in 2011 (18% decrease in emissions between 2010 and 2011) primarily driven by the exceptionally cold weather observed in 2010, which increased the consumption of fossil fuels in this sector. The decrease in emissions was mainly due to a reduced consumption of burning oil[48].

Residential Emissions on an End User Basis

In 2011, Northern Ireland end user emissions for the residential sector are 156% of the by source emission estimates (see Figure 5.25), reflecting the high consumption of electricity in the sector. This increases the overall significance of this sector in the end user inventory to 23% of the Northern Ireland total, compared to just 16% of the by source inventory total. The trend in residential end user emissions since 1990 shows a decline of around 26% to 2011 as a result of improvements in the electricity generation sector since 1990. The trend data are uncertain and should be regarded as indicative only due to the limited data on electricity use by source.

[48] Note that the emission estimates in the domestic sector are associated with high uncertainty due to the absence of comprehensive, detailed DA-specific fuel use data, particularly for solid and liquid fuels.

5.5 Business

Overall Contribution to 2011 GHG emissions

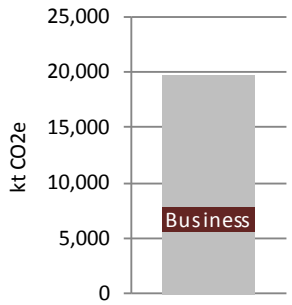


Figure 5.26

11.51%

Percentage of total emissions

Total GHG Emissions from Business, Base Year - 2011

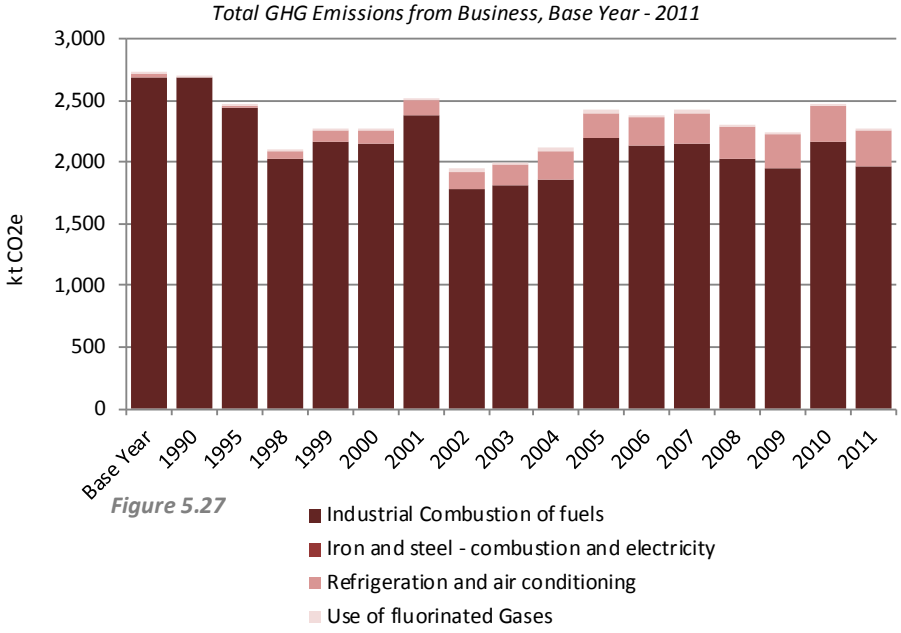


Figure 5.27

Change in GHG Emissions from Base Year (BY) to 2011 and from 2010 to 2011

	BY-2011		2010-2011	
Sub-sector	**%**	**kt CO2e**	**%**	**kt CO2e**
Industrial Combustion of fuels	-27%	-727	-9%	-202
Iron and steel - combustion and electricity	-	0	-	0
Refrigeration and air conditioning	1212%	270	2%	6
Use of fluorinated Gases	201%	15	-1%	0
Total	-16%	-442	-8%	-196

Table 5.7

Pollutant Contribution for Business Emissions, 2011

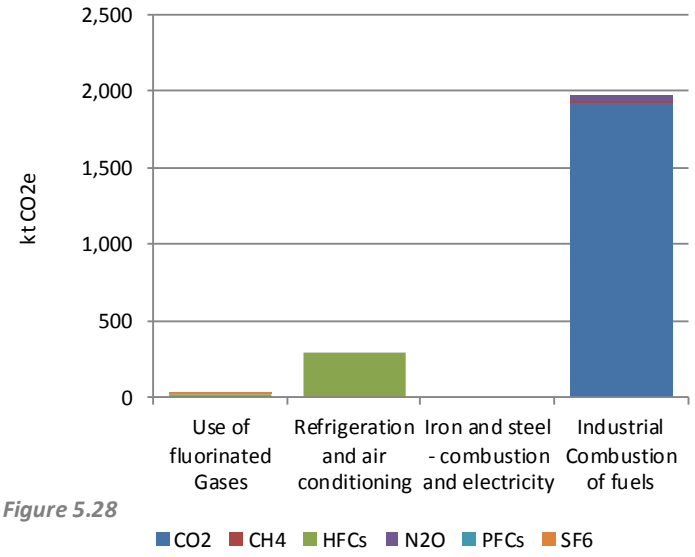


Figure 5.28

Comparison between End User and By Source Inventory for the Business Sector, 1990 and 2006-2011 ***(Mt CO2e)***

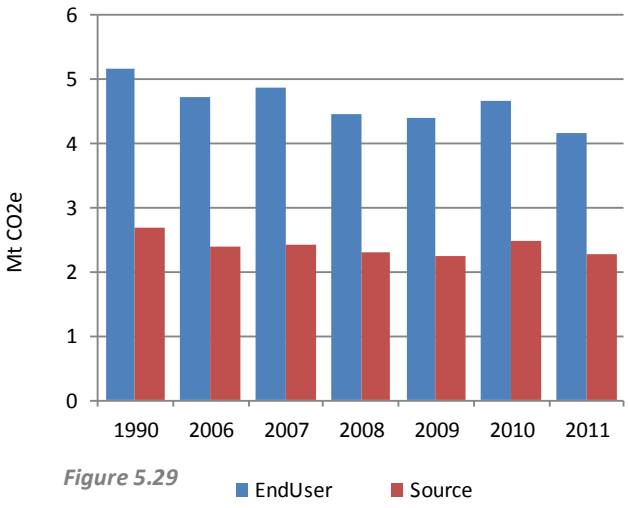


Figure 5.29

In Northern Ireland, the business sector contributes 11.5% to total 2011 GHG emissions. Combustion emissions from manufacturing industry and construction account for 14% of the total Northern Ireland carbon dioxide emission in 2011. There is no iron and steel production in Northern Ireland, so the category is entirely 'Other Industry'. Emissions from the business sector for Northern Ireland have decreased by an estimated 16% over the period 1990-2011. This reflects the impacts of a gradual growth in access to the gas network over the last 10 years in Northern Ireland, enabling fuel-switching from more carbon-intensive oil- and coal-fired boilers to gas. Business sector GHG emissions have decreased by 7.9% between 2010 and 2011 due to reduced consumption of oil in the industrial sector, lower reported natural gas consumption in the industrial and commercial sectors and lower coal use in the chemical sector.

Sulphur hexafluoride (SF_6) constitutes 0.2% of total GHG emissions from the business sector in Northern Ireland, with the main sources of SF_6 emissions coming from its application in electrical insulation. The business sector accounts for all SF_6 emissions in Northern Ireland.

The main sources of HFC emissions come from refrigeration and air conditioning equipment, arising from losses during manufacture and the lifetime of equipment, which accounted for 75% of HFC emissions in Northern Ireland in 2011 (see Figure 5.27). Emissions from these sectors have risen by over 1200% in Northern Ireland since the 1995 Base Year.

Business Emissions on an End User Basis

In 2011 Northern Ireland end user emissions for the business sector are 183% of the by source emission estimates, reflecting the high consumption of electricity for heating, lighting and operating equipment (and therefore share of emissions from electricity production) in the sector. From this end user perspective, business sector represents 20% of total emissions for Northern Ireland compared to just 12% of the by source inventory total (see Figure 5.29).

The combustion emission estimates in the business sector are associated with high uncertainty due to the absence of comprehensive, detailed DA-specific fuel use data, particularly for solid and liquid fuels. Non-combustion emissions account for a total of 13% of the total business emissions in Northern Ireland. These data are also uncertain due to the lack of DA-specific data on fluorinated greenhouse gases (F-Gases) sources and the use of proxies such as economic indices and population to estimate the DA share of UK emissions for these sources.

5.6 Public

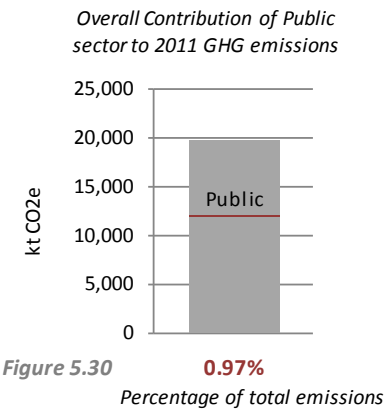


Figure 5.30

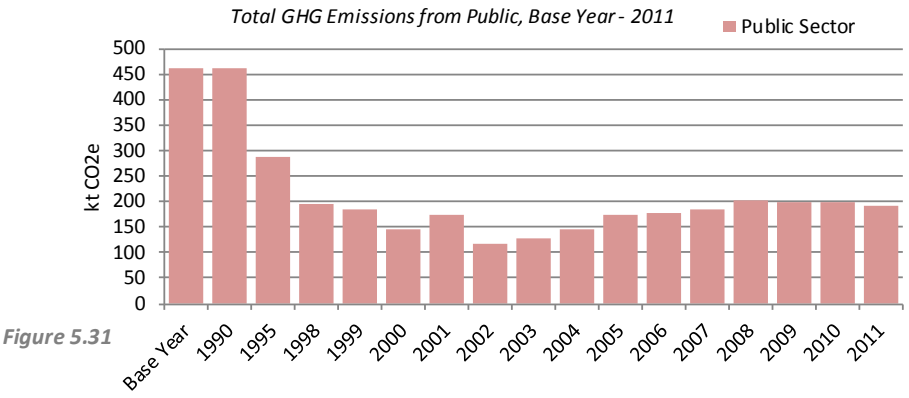


Figure 5.31

Change in GHG Emissions from Base Year (BY) to 2011 and from 2010 to 2011

	BY-2011		2010-2011	
Sub-sector	**%**	**kt CO2e**	**%**	**kt CO2e**
Public	-58%	-270	-4%	-9

Table 5.8

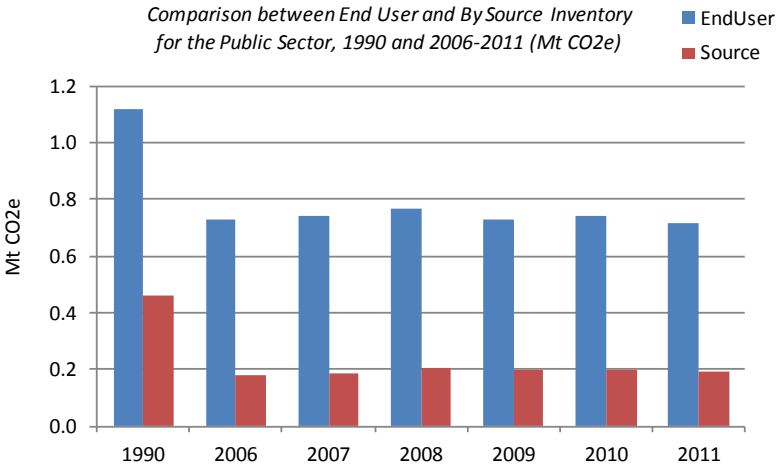


Figure 5.32

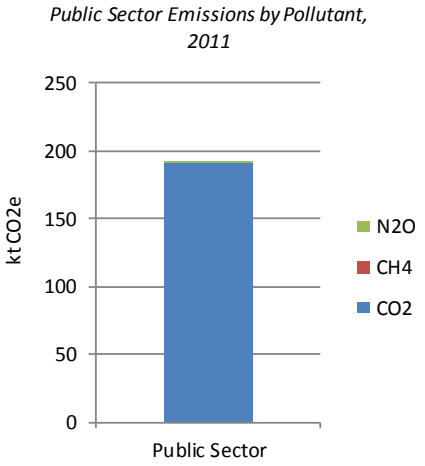


Figure 5.33

Emissions from public sector combustion account for 1.0% of GHG emissions in Northern Ireland in 2011. 99.5% of emissions in this sector are of carbon dioxide from the combustion of fossil fuels. See Figure 5.30 and 5.33.

Overall public sector emissions have reduced steadily since the Base Year up to 2002, then steadily increasing from 2002 to 2010. Emissions have since decreased from 2010 to 2011 by 4.4% due to reductions in gas oil and natural gas consumption (see Table 5.8 and Figure 5.31). The overall reduction from the Base Year to 2011 is 58%. This has been achieved through more efficient use of fuels and a switch to gas fired heating across Northern Ireland for many public sector buildings since 1990.

Public Emissions on an End User Basis

In 2011 Northern Ireland end user emissions for the public sector are 374% of the by source emission estimates, reflecting the high consumption of electricity in the sector and increasing the sector's share of total Northern Ireland emissions to 3.4% in 2011 (see Figure 5.32). The trend in end user emissions since 1990 shows a decline of around 36% to 2011[49].

Note that the emission estimates in the public sector are associated with high uncertainty due to the absence of comprehensive, detailed DA-specific fuel use data, particularly for solid and liquid fuels.

[49] the trend data are uncertain and should be regarded as indicative only due to the limited data on electricity use by source.

5.7 Industrial Process

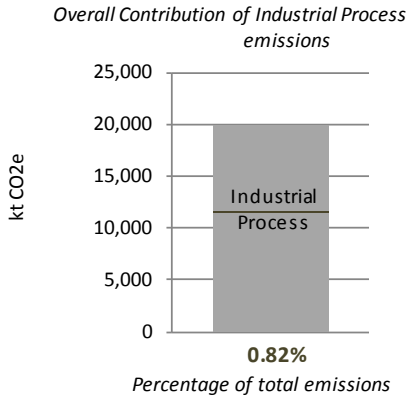


Figure 5.34

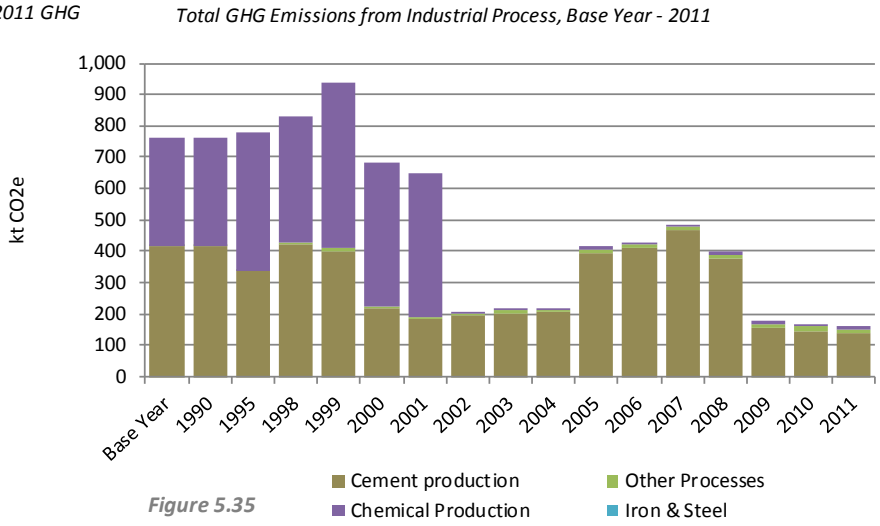


Figure 5.35

Change in GHG Emissions from Base Year (BY) to 2011 and from 2010 to 2011

	BY-2011		2010-2011	
Sub-sector	**%**	**kt CO2e**	**%**	**kt CO2e**
Cement production	-66%	-277	-5%	-8
Chemical Production	-97%	-334	-2%	0
Iron & Steel	-	0	-	0
Other Processes	50726%	12	-3%	0
Total	-79%	-599	-5%	-8

Table 5.9

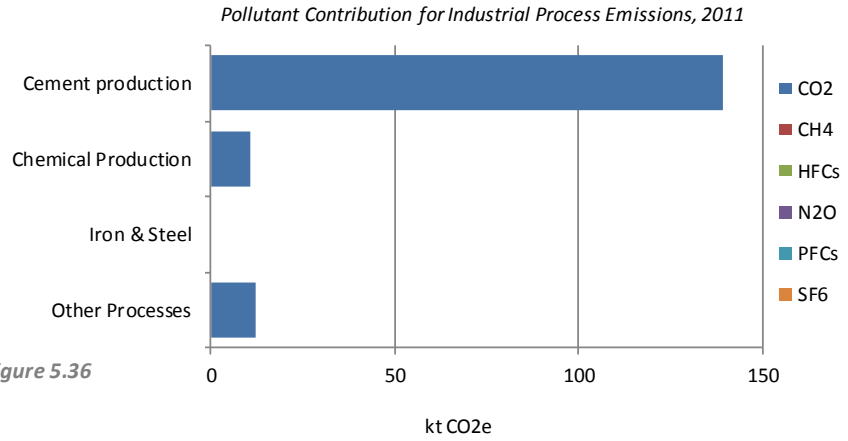


Figure 5.36

In Northern Ireland in 2011, the industrial process sector contributes 0.8% to total 2011 GHG emissions in Northern Ireland. The industrial process sector includes cement production (86% of sector GHG emissions) and glass production (14% of sector GHG emissions) and all emissions in 2011 from this sector are carbon dioxide emissions (see Figure 5.36).

In 2011 the sector emissions are 79% lower than in 1990 (see Figure 5.35 and Table 5.9), partly due to the 2008-2009 down-turn in cement production in Northern Ireland which decreased by 58% over this period, but also due to the closure of a nitric acid plant in 2001 and the consequent reduction in nitrous oxide emissions from the chemical industry sector. 2011 GHG emissions from cement production and glass production in Northern Ireland are both lower than those reported in 2010, which is a reverse of the overall UK trend of increasing emissions from mineral processes. This contributes to the 4.9% 2010 to 2011 decrease in GHG emissions for the sector.

Industrial Process traded and non-traded emissions

Emissions in the industrial process sector include significant contributions from installations reporting in the EU ETS. However, due to the lack of detail in the EU ETS dataset, business, energy supply and industrial process emissions are not easy to separate. The contribution to total aggregate emissions from the traded and non-traded sector across these NC sectors is presented in Figure 5.9 in the summary section.

Industrial Process Emissions on an End User Basis

As all emissions in the industrial process sector in Northern Ireland are not related to energy consumption or use of fuels as feedstock, the industrial process sector emissions on an end user basis are the same as the emissions in the by source inventory.

5.8 Agriculture

Overall Contribution to 2011 GHG emissions

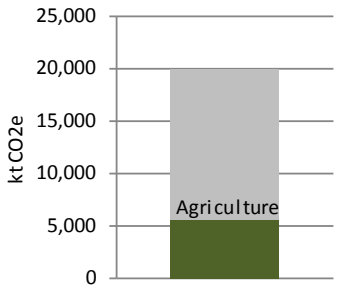


Figure 5.37

27.99%

Percentage of total emissions

Agriculture Emissions by category and pollutant, 2011

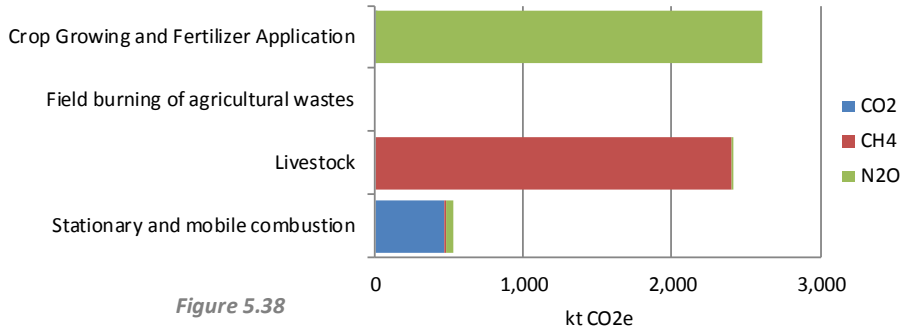


Figure 5.38

Change in GHG Emissions from Base Year (BY) to 2011 and from 2010 to 2011

	BY-2011		2010-2011	
Sub-sector	**%**	**kt CO2e**	**%**	**kt CO2e**
Crop Growing and Fertilizer Application	-14%	-424	0%	1
Field burning of agricultural wastes	-100%	-8	-	0
Livestock	0%	11	1%	19
Stationary and mobile combustion	-12%	-69	2%	12
Total	-8%	-489	1%	33

Table 5.10

Total GHG emissions from Agriculture, Base Year - 2011

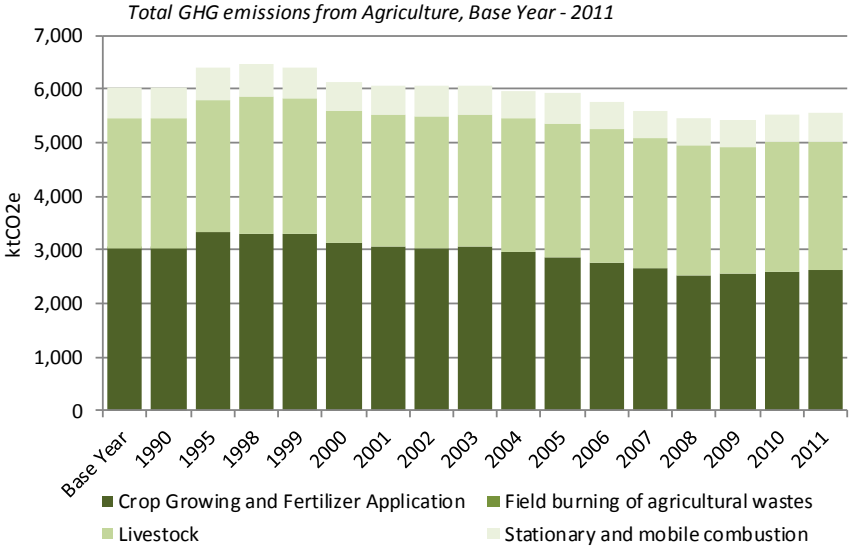


Figure 5.39

Livestock emissions by type, 2011

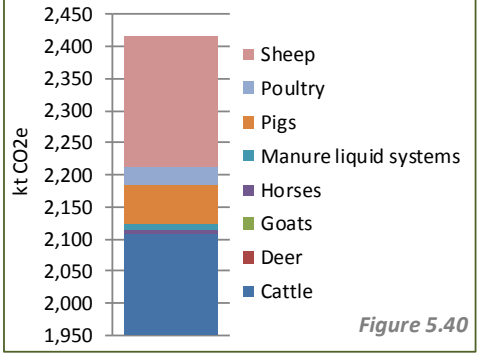


Figure 5.40

The agricultural sector contributes 28% to total 2011 GHG emissions in Northern Ireland. GHG emissions from agriculture under the Intergovernmental Panel on Climate Change (IPCC) reporting format comprise entirely of methane and nitrous oxide. Stationary and mobile combustion within the agriculture sector emit all the carbon dioxide emissions from the sector (see Figure 5.38). Emissions from agriculture represent a much higher proportion in Northern Ireland than the UK average because there is less industry and energy related emission sources in Northern Ireland than elsewhere in the UK, and hence agriculture emissions are comparatively more important.

Agriculture is the largest source of methane emissions in Northern Ireland. Enteric fermentation contributed 86% (2,065 $ktCO_2e$) to total agricultural methane in Northern Ireland in 2011. Cattle (dairy and beef enteric and waste management) were responsible for 88% of the total agricultural methane emissions (enteric and waste management). Total emissions from sheep were 8.5% of the total methane from agriculture in Northern Ireland.

Methane emissions are dependent on livestock numbers, and have increased by 0.2% since 1990, mainly influenced by an increase in dairy cattle numbers. Total methane emissions increased relative to 2010 by 0.8% due to small increases from cattle enteric fermentation, cattle wastes and from other manure management systems. Agriculture is the most important source of nitrous oxide in Northern Ireland. Emissions from agricultural soils account for 84% (2,399 $ktCO_2e$) of the total Northern Irish nitrous oxide emission in 2011. A further breakdown of the agricultural soils sector emission is shown in Table 5.11.

Nitrous oxide emissions are largely driven by fertiliser nitrogen use, manure applications and grazing returns to soils. Northern Irish agricultural nitrous oxide emissions have fallen by 14% between 1990 and 2011 due to a decline in total livestock numbers and in fertiliser nitrogen use (particularly to grassland). There was no significant change in emissions for 2011 relative to 2010 (0.1% increase).

Table 5.11 Emissions of nitrous oxide from agricultural sources in Northern Ireland in 2011 ($ktCO_2e$)[50]

Manure management				215
Soils				2,399
	Direct			*1,465*
		Fertiliser		430
		Grazing returns		691
		Manure application		286
		Crop residues		25
		Biological fixation		0
		Improved grassland		22
		Histosols		0
		Sewage sludge		9
	Indirect			*934*
		Leaching		768
			Fertiliser	287
			Grazing returns	259
			Manure application	215
			Sewage sludge	7
		Deposition		167
			Fertiliser	38
			Grazing returns	69
			Manure application	57
			Sewage sludge	2
Field burning				0
TOTAL				**2,614**

Agriculture Emissions on an End User Basis

As the majority of emissions in the agriculture sector are not due to energy consumption, agriculture sector emissions on an end user basis are very similar to the emissions by source; in 2011, the end user estimates are only 3% higher for the agriculture sector, reflecting the relatively low contribution to sector emissions from the use of oils and electricity, compared to the higher-emitting sources of nitrous oxide and methane from soils and livestock sources.

[50] Total emissions comprise manure management, soils and field burning. Soils include direct and indirect emissions; indirect emissions include leaching and deposition.

5.9 Land Use, Land Use Change and Forestry

Overall Contribution to 2011 GHG emissions

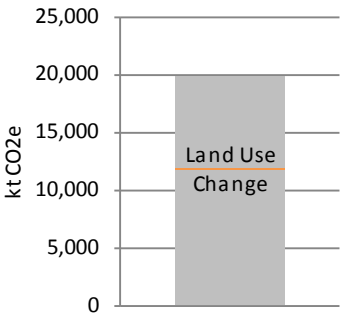


Figure 5.41

0.91%

Percentage of total emissions

Pollutant Contribution to LULUCF GHG Emissions, 2011

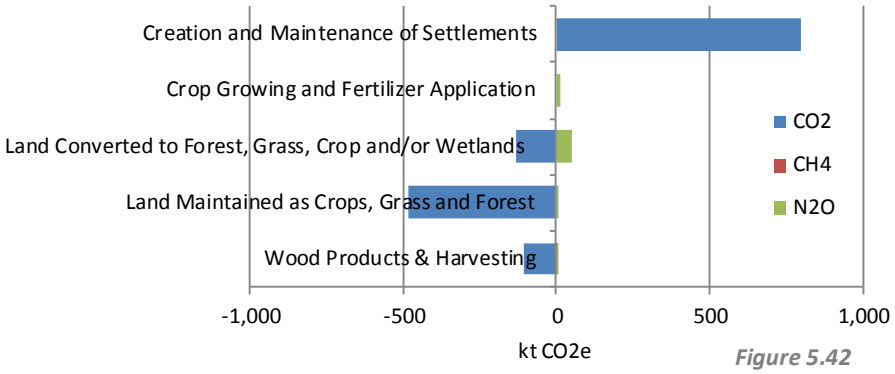


Figure 5.42

Emission Estimates for Base Year (BY), 2010 and 2011; change in GHG Emissions from BY to 2011 and from 2010 to 2011

	BY	2010	2011	BY-2011	2010-2011
Sub-sector	**kt CO2e**	**kt CO2e**	**kt CO2e**	**kt CO2e**	**kt CO2e**
Creation and Maintenance of Settlements	547	796	778	231	-18
Crop Growing and Fertilizer Application	9	11	11	2	0
Land Converted to Forest, Grass, Crop and/or Wetlands	26	-79	-74	-100	6
Land Maintained as Crops, Grass and Forest	-500	-483	-453	48	30
Wood Products & Harvesting	16	-104	-83	-99	21
Total	98	141	180	82	39

Table 5.13

Total GHG Emissions from LULUCF, Base Year - 2011

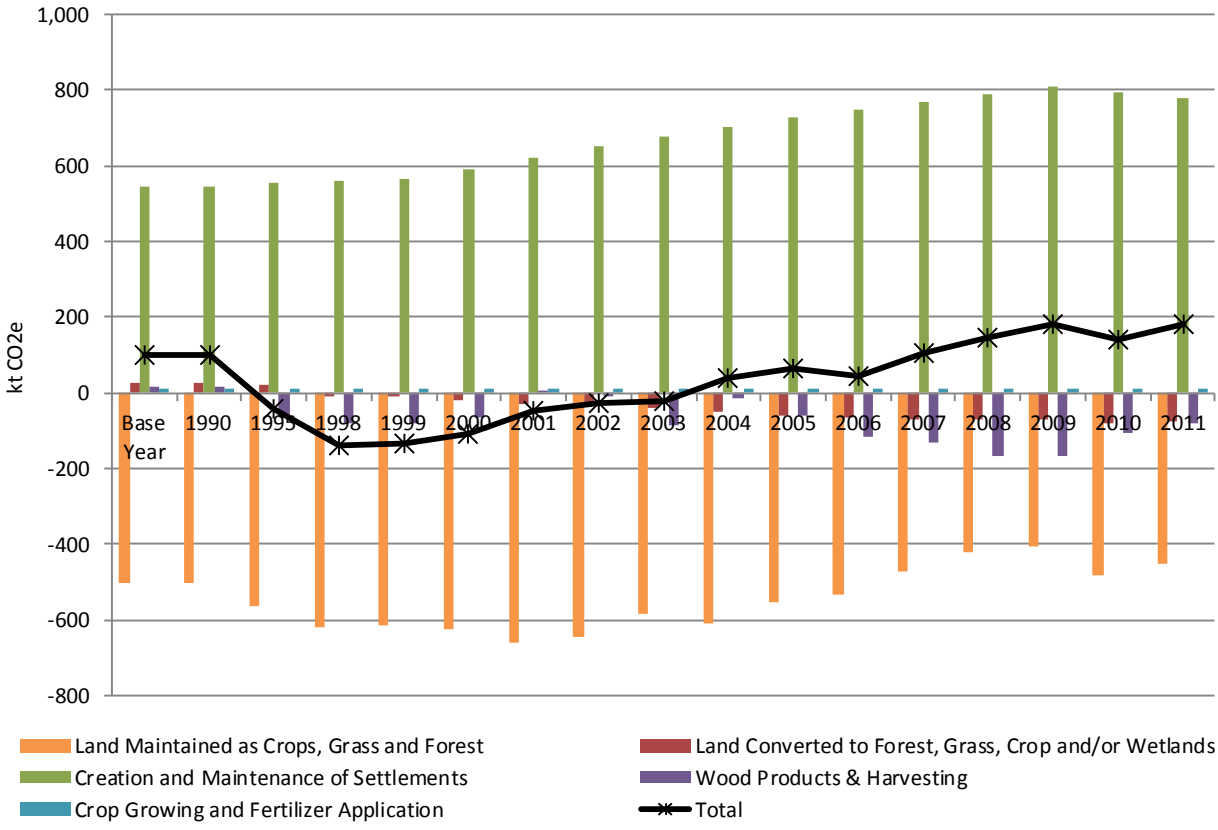


Figure 5.43

Net emissions from Land Use, Land Use Change and Forestry (LULUCF) contribute to 0.9% of Northern Ireland emissions in 2011. Net emissions have increased between 2010 and 2011 by 28% with no major single contributing factor. Northern Ireland was a small net source of greenhouse gases from LULUCF activities in 1990 of 98 $ktCO_2e$, becoming a small net sink between 1992 and 2003 (reaching -139 $ktCO_2e$ in 1998), and has now returned to being a small net source (Figure 5.43) of 180 $ktCO_2e$ in 2011.

Emissions arise from the clearing of land (burning and decomposition of material) for the maintenance and creation of settlements (towns and urban areas) and croplands. Carbon dioxide is removed from the atmosphere[51] (1718 $ktCO_2e$ removal in 2011) by activities that manage and maintain, grass and forest lands encouraging vegetation growth and the storage of carbon in wood products. Emissions occur from cropland and conversion to cropland (emissions of 932 $ktCO_2e$ in 2011) and from the creation and maintenance of settlements (778 $ktCO_2e$ in 2011), from biomass removal in built up & transport areas, gardens and mineral workings.

Emissions and removals are primarily for carbon dioxide (64% of net emissions/removals in 2011) with 35% from nitrous oxide.

A more detailed report of LULUCF emissions in England, Wales, Scotland and Northern Ireland can be found on the National Air Emissions Inventory (NAEI) website (H. Malcolm et al. 2013) and more detailed information is also available in the UK Greenhouse Gas Inventory Report, available on the NAEI website.

LULUCF Emissions on an End User Basis

As emissions and removals from LULUCF do not related to energy supply, the end user GHG inventory emissions are the same as emissions reported in the by source GHG inventory.

[51] Removals are presented as negative emissions in the inventory tables

5.10 Waste Management

Overall Contribution of Waste Management to 2011 GHG emissions

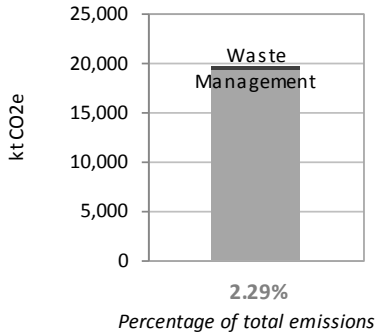


Figure 5.44

Total GHG Emissions from Waste Management, Base Year- 2011

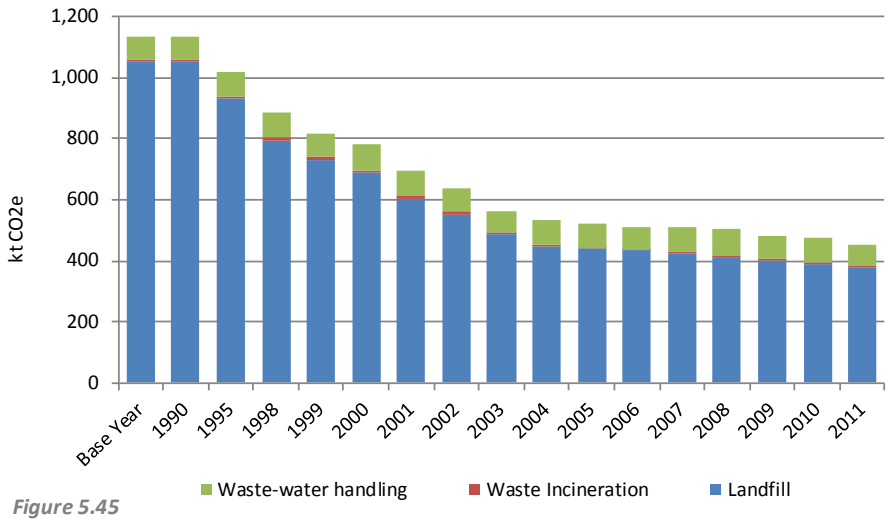


Figure 5.45

Change in GHG Emissions from Base Year (BY) to 2011 and from 2010 to 2011

	BY-2010		2009-2010	
Sub-sector	**%**	**kt CO2e**	**%**	**kt CO2e**
Landfill	-64%	-673	-4%	-14
Waste Incineration	-55%	-5	-9%	0
Waste-water handling	-5%	-4	-9%	-8
Total	-60%	-682	-5%	-22

Table 5.14

Pollutant contribution to Waste Management Emissions, 2011

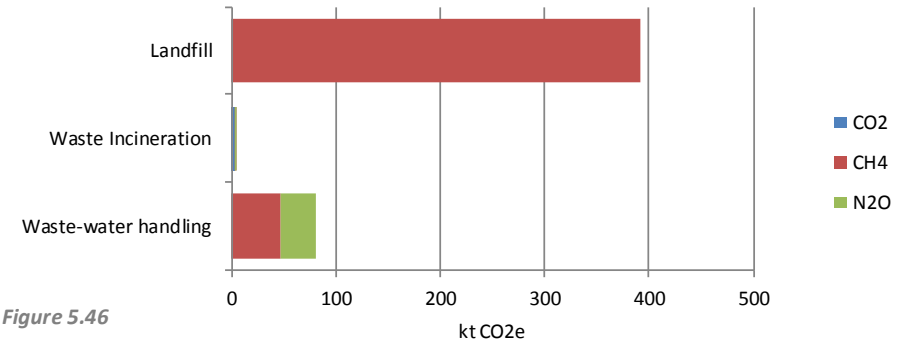


Figure 5.46

The waste management sector contributes 2.3% to total GHG emissions in Northern Ireland, and represents 14.5% of total methane emissions. Emissions from this sector are dominated by methane from landfill (83% of total GHGs from the waste sector – see Figure 5.45), with a smaller contribution of emissions of methane and nitrous oxide from wastewater treatment (16%). Methane emissions from industrial waste-water treatment have been estimated for the first time for this submission and contribute 3% to 8% of total Waste emissions across the 1990-2011 time series. Emissions from landfill in Northern Ireland constitute approximately 3% of UK landfill emissions.

The majority of total GHG emissions are of methane (92% of total sector GHG emissions in 2011). Nitrous oxide emissions from waste water treatment represent 7.6% of emissions in the sector, and contribute 1.2% to the total emissions of nitrous oxide in Northern Ireland. See Figure 5.46 for the pollutant contribution within the waste management sector.

Emissions of GHGs from the waste sector in Northern Ireland have shown a significant decline of 60% in total for the sector and by 64% for landfill between 1990 and 2011, as shown in Table 5.14, due largely to the progressive introduction of methane capture and oxidation systems within landfill management. Between 2010 and 2011 waste management sector GHG emissions decreased by 4.6%, which is mainly due to UK-wide reductions in methane emission estimates from landfill, along with further (smaller) reductions in the methane emission estimates from industrial and municipal waste water treatment in Northern Ireland.

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7 Appendices