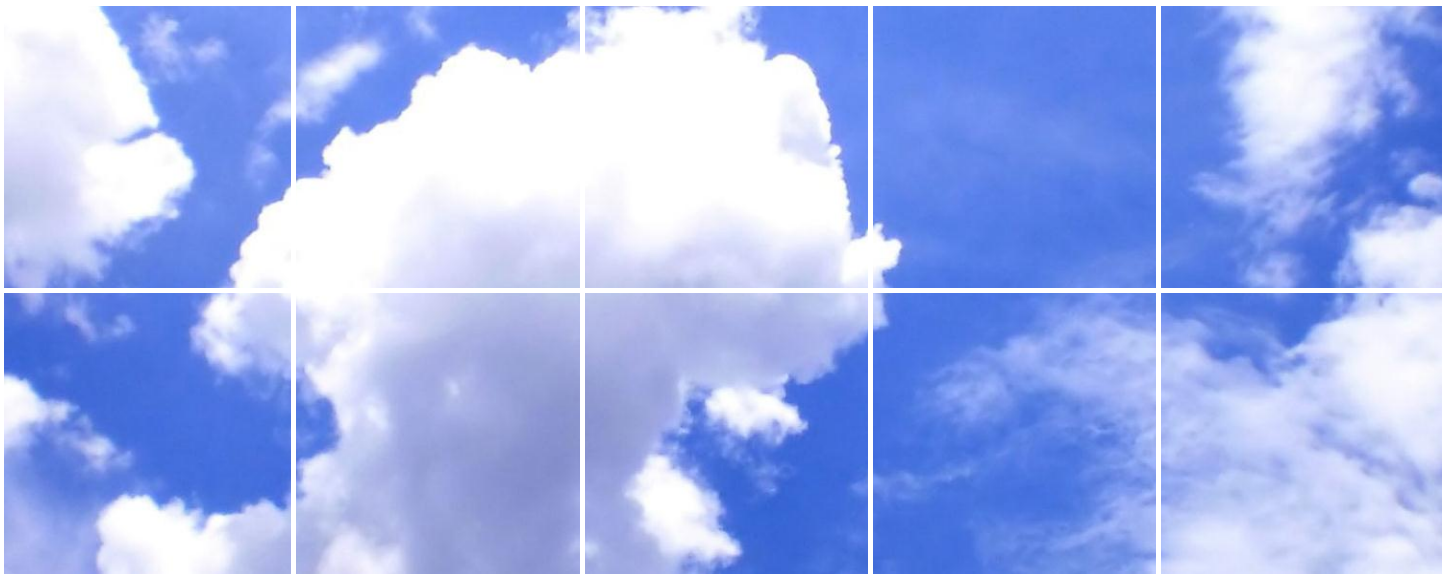
National Atmospheric Emissions Inventory



Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland: 1990 – 2012

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

June 2014

Aether RICARDO-AEA

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

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Tables in Devolved Administrations' Chapters

Executive Summary

This report presents the latest estimates of greenhouse gas (GHG) emissions for the UK Devolved Administrations (DAs): England, Scotland, Wales and Northern Ireland. Separate GHG emission inventories have been estimated for the years 1990, 1995 and 1998 to 2012. The estimates are expressed in terms of global warming potentials (GWPs) defined on a 100-year horizon (IPCC, 1996a). The estimates and the GWPs are consistent with the United Nations Framework Convention on Climate Change (UNFCCC) reporting guidelines and based on the 1990-2012 UK Greenhouse Gas Inventory (Webb *et al.*, 2014).

Table ES 1 Global Warming Potential of GHGs on a 100-year Horizon (t CO_2 equivalent/ t gas) (IPCC, 1996a)

Greenhouse Gas		Global Warming Potential (t CO_2 equivalent / t gas)
Carbon Dioxide	CO_2	1
Methane	CH_4	21
Nitrous Oxide	N_2O	310
Hydrofluorocarbons	HFCs	140-11700
Perfluorocarbons	PFCs	6500-9200
Sulphur hexafluoride	SF_6	23900

Consistent with international and UK GHG inventory reporting protocol, the Devolved Administration (DA) inventory totals presented in this report excludes emissions from international shipping and aviation, which are reported as "memo items". There are some exceptions to this, which are clearly stated, due to Scotland's requirements for reporting against national mitigation targets. Emissions from offshore oil and gas exploration and production activities are not allocated to any country, and are presented as "Unallocated".

Estimates 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.

The main focus of the report is emissions presented on a *by source* basis (emissions are allocated to the source sector in which they occur) and figures and percentages within this report refer to this dataset, unless otherwise stated. Data showing End User emissions (where energy supply emissions are allocated to energy users) and a breakdown of traded/non traded sources, derived from the by source estimates, are also included in the analysis in this report to provide additional perspectives on trends and "ownership" of emissions.

Devolved Administrations' Climate Change Commitments

The Climate Change (Scotland) Act (2009), the 'One Wales' Commitment to reduce greenhouse gas emissions together with the Climate Change Strategy for Wales (2010), and the Northern Ireland Greenhouse Gas Emissions Action Plan (2011) outline each of the Devolved Administrations' aims and objectives in reducing greenhouse gas 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 relating to the annual targets (2011-2020) excludes emissions from the traded sector[1] and international transport sources. The Northern Ireland Executive's current Programme for Government target is to continue to work towards a 35% reduction in greenhouse gas emissions (on the by-source basis presented in this report) by 2025 based on 1990 levels of the by source estimates.

By Source Inventory Estimates for 2012

The UK distribution of regional net[2] greenhouse gas emissions in 2012, expressed in terms of global warming potentials (GWP), is detailed below.

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

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

England has a **77%** share of total net GHG emissions in **2012**. **England** has seen a decrease of 28% in greenhouse gas emissions between the Base Year[3] and 2012. However, emissions between 2011 and 2012 have increased slightly (by 3.8%). This increase of emissions is predominantly driven by a shift from natural gas to coal (which has a higher carbon content per unit of energy) in the power generation sector due to the impact of changes in global fuel prices, and an increase in the consumption of natural gas in the Residential sector due to colder average temperatures.

Scotland has an **8.8%** share of total net GHG emissions in **2012**. **Scotland** has seen a decrease of 31% in greenhouse gas emissions between the Base Year and 2012. However, emissions between 2011 and 2012 have increased slightly (by 1.3%). As with the recent trends elsewhere in the UK, this increase is predominantly driven by a shift from natural gas to coal (which has a higher carbon content per unit of energy) in the power generation sector due to the impact of changes in global fuel prices, and an increase in the consumption of natural gas in the Residential sector due to colder average temperatures.

Wales has an **8.0%** share of total net GHG emissions in **2012**. **Wales** has seen a decrease of 18% in greenhouse gas emissions between the Base Year and 2012. However, emissions between 2011 and 2012 have increased by 5%. The increase is predominantly driven by a shift from natural gas to coal combustion (which has a higher carbon content per unit of energy) in the energy sector due to global fuel prices. Increases have been offset by a decrease in emissions from iron and steel production in Wales during 2012, as the No.4 Blast Furnace re-build began in July 2012.

Northern Ireland has a **3.7%** share of total net GHG emissions in **2012**. **Northern Ireland** has seen a decrease of 16% in greenhouse gas emissions between the Base Year and 2012. However, emissions between 2011 and 2012 have increased by 2%. This increase is predominantly driven by the forest fires that occurred in 2012 and the shift from natural gas to coal in the Energy Supply sector.

2.5% of the UK emissions total is unallocated in **2012** and these net emissions have decreased by 2.6% since the Base Year. These emissions from offshore oil and gas installations decreased by 5% between 2011 and 2012 due to the continued decline in UK oil and gas production. This trend is also evident within the oil and gas terminal emissions in England and Scotland.

Tables ES 2 - ES 5 present the time series of emissions for each Devolved Administration.

- 1995 is used as the Base Year (BY) for emissions of HFCs, PFCs and SF_6, and 1990 for all other gases (carbon dioxide (CO2), Methane (CH_4) and nitrous oxide (N_2O)), 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 the Land Use, Land Use Change and Forestry (LULUCF) sector;
- The percentage changes presented in this chapter are calculated from estimates held at full precision within a database. The estimates quoted in Table ES 2-5 and other tables relevant to this Chapter are values rounded from data 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 i.e. data that have not been rounded, can be found in the tables that accompany this report: "DA_GHGI_1990-2012_Issue1.xlsx".

Uncertainties

The 2012 Devolved Administration GHG emission estimates are based on a wide range of data sources and include statistical differences, assumptions, proxy datasets and some expert judgement. In addition, the natural variability in processes (e.g. emissions from farming practices under different climatic conditions and across soil types, carbon content of fuels, and performance of industrial production plant and abatement plant) that are being "modelled" introduces a degree of uncertainty. An overall analysis of the uncertainty in Devolved Administration inventory totals indicates that the uncertainties are in the range of +-5% to +-15% depending on the relative contributions to the Devolved Administration inventories of more uncertain categories where we understand less about the distribution and intensity of the estimates (e.g. nitrous oxide from agricultural soils, carbon dioxide from Land Use, Land Use Change and Forestry, solid and liquid fuel combustion). The uncertainties for the 2012 DA estimates are presented below.

- UK 2012 GHG total (+-6%): low uncertainty due to a high proportion of large industrial sources with estimates with low uncertainty.
- England 2012 GHG total (+-5%): low uncertainty due to a high proportion of large industrial sources with estimates with low uncertainty.
- Scotland 2012 GHG total (+-14%): much greater contribution to the Scotland total from sources and sinks with significant uncertainties. A sensitivity analysis has been carried out which indicates that the contribution of LULUCF, and emissions from the

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

combustion of OPG, make a large contribution to the uncertainty in carbon dioxide emissions, which in turn impacts on the total uncertainty for the Scottish inventory.

- Wales 2012 GHG total (+-7%): relatively low uncertainty due to high contribution from well-documented emission sources including of heavy industry (power generation, oil refining and iron and steel production).
- Northern Ireland 2012 GHG total (+-15%): relatively high uncertainty due to contributions to emissions from LULUCF and agriculture, combined with greater uncertainty due to greater fuel combustion of solid and liquid fuels.

Appendix 1 provides more detail on the uncertainties for 2012 as well as the uncertainty in the trend of the DA GHG inventories.

Table ES 2: Summary of By Source Emission Estimates for England, Base Year to 2012 (Mt CO_2e)

	Base Year	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	% Change Base Year - 2012
By Gas including LULUCF																			
Carbon Dioxide	483.79	483.79	446.56	449.87	443.08	449.16	461.27	453.87	465.68	468.24	470.27	467.20	467.27	451.15	410.92	418.93	391.74	407.21	-16%
Methane	77.42	77.42	71.26	65.00	60.40	56.08	53.32	53.02	49.22	45.83	43.53	42.70	41.18	40.53	38.78	36.10	35.40	34.46	-55%
HFCs	15.11	11.38	15.11	15.93	9.08	7.86	8.59	8.86	9.78	8.86	9.55	10.10	10.31	10.78	11.12	11.46	11.67	11.81	-22%
Nitrous oxide	54.65	54.65	44.35	44.54	34.00	33.71	31.30	30.14	29.77	30.72	30.09	28.27	28.26	27.72	25.65	26.34	25.05	24.76	-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	0.15	-33%
SF6	1.09	0.90	1.09	1.14	1.30	1.61	1.25	1.29	1.12	0.91	0.85	0.64	0.65	0.51	0.49	0.56	0.48	0.47	-57%
LULUCF only by Gas																			
Carbon Dioxide	2.19	2.19	2.27	1.80	1.70	0.86	0.37	-0.14	-0.25	-0.75	-1.01	-1.27	-1.42	-1.60	-1.64	-1.62	-1.50	-1.31	-160%
Methane	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.02	0.03	0.01	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.02	81%
Nitrous oxide	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	0.24	-27%
LULUCF Net Emissions	2.52	2.52	2.61	2.13	2.03	1.19	0.68	0.18	0.09	-0.45	-0.71	-0.97	-1.12	-1.31	-1.35	-1.36	-1.25	-1.05	-142%
By National Communication Sector																			
Agriculture	45.49	45.49	44.17	44.01	43.45	41.78	39.12	39.16	38.50	38.71	38.38	36.85	36.36	36.24	35.62	36.18	35.92	35.39	-22%
Business	88.83	87.83	84.59	83.97	84.85	86.19	88.52	84.24	86.01	84.59	86.18	83.64	82.84	79.62	71.27	69.86	66.03	67.90	-24%
Energy Supply	211.88	211.88	167.82	153.59	144.39	148.66	157.30	158.85	166.93	165.20	165.52	166.99	168.39	160.68	143.00	145.94	138.97	147.17	-31%
Industrial Process	51.06	49.22	40.77	39.71	22.30	20.35	18.73	16.63	16.81	16.22	15.30	13.89	15.26	13.85	8.84	9.10	7.65	7.64	-85%
Land Use Change	2.52	2.52	2.61	2.13	2.03	1.19	0.68	0.18	0.09	-0.45	-0.71	-0.97	-1.12	-1.31	-1.35	-1.36	-1.25	-1.05	-142%
Public	10.27	10.27	10.06	10.01	9.82	9.26	9.63	8.21	8.21	8.96	8.85	8.04	7.47	7.93	7.81	8.42	7.82	8.14	-21%
Residential	63.52	63.19	65.08	71.57	71.35	71.98	73.86	71.20	72.27	73.62	70.40	67.99	65.05	66.38	61.96	71.72	55.15	62.44	-2%
Transport	101.16	101.16	101.47	105.37	106.14	105.17	105.15	106.97	106.25	107.20	107.76	108.00	110.36	104.06	100.03	98.80	97.52	97.04	-4%
Waste Management	36.93	36.93	37.41	35.23	32.42	30.40	29.80	30.12	27.52	24.34	23.52	23.28	22.39	22.07	20.71	18.29	17.95	17.10	-54%
Total Net Emissions	611.67	608.50	553.98	545.58	516.74	514.97	522.78	515.57	522.58	518.38	515.21	507.71	506.99	489.53	447.89	456.95	425.74	441.78	-28%

Table ES 3: Summary of By Source Emission Estimates for Scotland, Base Year to 2012 (Mt CO_2e)

	Base Year	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	% Change Base Year - 2012
By Gas including LULUCF																			
Carbon Dioxide	55.55	55.55	55.96	55.06	52.24	54.62	54.32	50.22	50.56	48.89	47.87	51.73	47.64	45.91	42.44	44.84	39.11	39.80	-28%
Methane	12.82	12.82	12.62	11.91	10.90	10.35	9.99	9.68	9.08	8.54	8.41	8.25	7.98	7.80	7.46	7.07	7.02	6.80	-47%
HFCs	0.11	0.00	0.11	0.38	0.41	0.51	0.60	0.67	0.76	0.83	0.89	0.95	0.99	1.04	1.08	1.10	1.13	1.13	908%
Nitrous oxide	6.99	6.99	6.55	6.75	6.58	6.40	6.33	6.27	6.14	5.99	5.78	5.73	5.47	5.34	5.25	5.23	5.15	5.08	-27%
PFCs	0.087	0.113	0.087	0.110	0.115	0.109	0.062	0.080	0.081	0.071	0.066	0.063	0.057	0.055	0.051	0.049	0.052	0.051	-41%
SF6	0.030	0.019	0.030	0.041	0.052	0.054	0.048	0.051	0.050	0.055	0.062	0.046	0.045	0.037	0.036	0.038	0.036	0.035	16%
LULUCF only by Gas																			
Carbon Dioxide	-1.21	-1.21	-1.32	-2.57	-2.89	-2.99	-3.47	-3.84	-3.96	-4.35	-4.57	-4.80	-5.01	-5.19	-5.20	-5.60	-5.82	-6.01	397%
Methane	0.006	0.006	0.012	0.008	0.007	0.019	0.017	0.018	0.031	0.025	0.027	0.024	0.027	0.022	0.022	0.020	0.022	0.029	352%
Nitrous oxide	0.38	0.38	0.40	0.41	0.41	0.40	0.39	0.38	0.39	0.37	0.36	0.36	0.35	0.34	0.33	0.32	0.31	0.30	-20%
LULUCF Net Emissions	-0.82	-0.82	-0.91	-2.16	-2.48	-2.57	-3.07	-3.45	-3.54	-3.96	-4.18	-4.42	-4.63	-4.82	-4.84	-5.26	-5.49	-5.68	589%
By National Communication Sector																			
Agriculture	10.81	10.81	10.71	11.02	10.77	10.43	10.15	10.13	9.98	9.84	9.66	9.48	9.15	8.95	8.79	8.79	8.74	8.60	-20%
Business	11.76	11.64	8.79	8.84	8.97	9.32	9.82	8.83	8.88	8.77	9.25	8.97	8.58	8.54	7.68	7.77	8.03	8.08	-31%
Energy Supply	22.40	22.40	26.48	25.50	23.14	26.03	25.33	23.27	23.44	21.77	20.51	24.74	21.32	19.98	18.58	20.73	16.90	17.13	-24%
Industrial Process	1.84	1.90	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	0.44	-76%
Land Use Change	-0.82	-0.82	-0.91	-2.16	-2.48	-2.57	-3.07	-3.45	-3.54	-3.96	-4.18	-4.42	-4.63	-4.82	-4.84	-5.26	-5.49	-5.68	589%
Public	1.66	1.66	1.76	1.73	1.70	1.58	1.66	1.42	1.42	1.55	1.52	1.37	1.27	1.36	1.33	1.43	1.31	1.37	-18%
Residential	8.19	8.15	8.14	8.46	8.37	8.24	8.68	8.03	8.01	8.10	7.92	7.70	7.49	7.72	7.25	8.32	6.55	7.28	-11%
Transport	10.53	10.53	10.54	10.91	11.00	10.85	10.82	11.12	11.17	11.26	11.40	11.59	11.90	11.31	10.87	10.69	10.49	10.54	0%
Waste Management	6.70	6.70	6.75	6.25	5.66	5.23	5.06	5.07	4.60	4.04	3.89	3.83	3.63	3.59	3.38	2.96	2.92	2.77	-59%
Total Net Emissions	73.06	72.97	72.82	71.17	67.72	69.71	69.02	65.03	64.57	62.00	60.50	63.80	59.24	57.13	53.43	55.82	49.90	50.53	-31%

Table ES 4: Summary of By Source Emission Estimates for Wales, Base Year to 2012 (Mt CO_2e)

	Base Year	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	% Change Base Year - 2012
By Gas including LULUCF																			
Carbon Dioxide	44.56	44.56	41.81	43.72	45.17	47.43	44.60	37.72	39.17	43.25	41.15	43.17	40.82	42.69	36.43	39.55	36.76	38.58	-13%
Methane	7.79	7.79	7.04	6.76	6.58	6.28	5.98	5.94	5.78	5.57	5.41	5.48	5.06	4.83	4.70	4.57	4.53	4.50	-42%
HFCs	0.06	0.00	0.06	0.20	0.22	0.27	0.30	0.33	0.38	0.37	0.45	0.48	0.49	0.51	0.53	0.54	0.56	0.56	846%
Nitrous oxide	4.18	4.18	4.16	4.09	4.16	3.94	3.80	3.60	3.69	3.60	3.68	3.54	3.25	3.03	2.99	3.12	3.10	3.15	-25%
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	0.003	0.004	0.004	-97%
SF6	0.08	0.07	0.08	0.08	0.10	0.12	0.09	0.10	0.08	0.07	0.06	0.05	0.05	0.04	0.04	0.04	0.04	0.03	-57%
LULUCF only by Gas																			
Carbon Dioxide	0.00	0.00	-0.19	-0.43	-0.50	-0.52	-0.58	-0.63	-0.63	-0.66	-0.67	-0.67	-0.69	-0.63	-0.66	-0.55	-0.70	-0.56	1769406%
Methane	0.003	0.003	0.004	0.003	0.003	0.005	0.004	0.004	0.007	0.004	0.005	0.006	0.006	0.005	0.004	0.008	0.006	0.008	198%
Nitrous oxide	0.067	0.067	0.072	0.072	0.073	0.072	0.069	0.068	0.072	0.066	0.066	0.065	0.065	0.062	0.061	0.062	0.0595	0.059	-12%
LULUCF Net Emissions	0.07	0.07	-0.11	-0.36	-0.42	-0.45	-0.51	-0.55	-0.55	-0.59	-0.60	-0.60	-0.61	-0.56	-0.59	-0.48	-0.63	-0.49	-803%
By National Communication Sector																			
Agriculture	7.75	7.75	7.77	7.77	7.90	7.49	7.23	6.97	7.14	7.03	7.04	6.97	6.35	6.01	5.95	6.12	6.13	6.14	-21%
Business	13.62	13.57	14.56	15.11	16.95	16.86	13.69	9.58	10.80	11.50	10.14	10.49	10.63	9.80	8.10	9.71	9.10	7.98	-41%
Energy Supply	17.48	17.48	12.77	13.69	13.38	16.18	17.14	15.46	14.84	17.74	17.20	18.75	16.50	19.32	16.28	16.56	15.72	19.07	9%
Industrial Process	2.75	2.91	3.09	2.94	3.25	3.28	2.52	1.96	2.57	2.65	2.80	2.79	2.75	2.45	1.50	2.17	2.02	1.55	-43%
Land Use Change	0.07	0.07	-0.11	-0.36	-0.42	-0.45	-0.51	-0.55	-0.55	-0.59	-0.60	-0.60	-0.61	-0.56	-0.59	-0.48	-0.63	-0.49	-803%
Public	0.75	0.75	0.67	0.54	0.53	0.52	0.53	0.44	0.44	0.50	0.51	0.45	0.41	0.43	0.42	0.45	0.41	0.44	-41%
Residential	4.98	4.96	5.12	5.54	5.46	5.28	5.38	5.04	5.06	5.15	4.82	4.76	4.50	4.66	4.36	4.95	3.85	4.23	-15%
Transport	6.06	6.06	6.05	6.22	6.22	6.13	6.11	6.28	6.29	6.41	6.42	6.47	6.63	6.32	6.06	5.95	5.84	5.77	-5%
Waste Management	2.37	2.37	2.42	2.35	2.18	2.05	2.00	2.00	1.83	1.61	1.56	1.55	1.49	1.48	1.40	1.23	1.20	1.14	-52%
Total Net Emissions	55.83	55.92	52.35	53.80	55.44	57.34	54.10	47.18	48.42	52.01	49.90	51.64	48.65	49.92	43.48	46.66	43.63	45.83	-18%

Table ES 5: Summary of By Source Emission Estimates for Northern Ireland, Base Year to 2012 (Mt CO_2e)

	Base Year	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	% Change Base Year - 2012
By Gas including LULUCF																			
Carbon Dioxide	17.07	17.07	17.36	16.83	17.10	17.05	17.55	15.69	15.72	15.67	16.62	17.14	15.98	16.04	14.38	15.26	14.13	14.46	-15%
Methane	4.35	4.35	4.40	4.51	4.28	4.10	4.08	4.09	4.02	3.91	3.91	3.87	3.79	3.75	3.67	3.61	3.61	3.63	-17%
HFCs	0.04	0.0003	0.04	0.13	0.14	0.17	0.19	0.20	0.24	0.30	0.28	0.31	0.33	0.34	0.35	0.36	0.36	0.36	848%
Nitrous oxide	3.89	3.89	4.32	4.22	4.36	4.11	4.02	3.54	3.55	3.46	3.34	3.24	3.11	2.99	2.97	3.04	3.03	3.06	-21%
PFCs	0.00066	0.00239	0.00066	0.00008	0.00010	0.00011	0.00011	0.00011	0.00010	0.00009	0.00007	0.00005	0.00003	0.00001	0.00001	0.00	0.00018	0.00026	-60%
SF6	0.002	0.001	0.002	0.004	0.005	0.005	0.005	0.005	0.006	0.009	0.012	0.007	0.006	0.005	0.004	0.004	0.004	0.003	79%
LULUCF only by Gas																			
Carbon Dioxide	0.05	0.05	-0.14	-0.31	-0.31	-0.31	-0.27	-0.27	-0.28	-0.25	-0.25	-0.28	-0.25	-0.24	-0.23	-0.22	-0.19	0.15	198%
Methane	0.0013	0.0013	0.0006	0.0007	0.0011	0.0011	0.0017	0.0018	0.0016	0.0019	0.0019	0.0012	0.0019	0.0015	0.0013	0.0012	0.0021	0.010	651%
Nitrous oxide	0.073	0.073	0.068	0.065	0.065	0.065	0.066	0.066	0.066	0.066	0.066	0.066	0.067	0.067	0.067	0.064	0.063	0.067	-9%
LULUCF Net Emissions	0.13	0.13	-0.07	-0.24	-0.25	-0.24	-0.21	-0.20	-0.21	-0.18	-0.18	-0.22	-0.18	-0.17	-0.16	-0.15	-0.12	0.23	83%
By National Communication Sector																			
Agriculture	6.86	6.86	7.27	7.41	7.28	6.97	6.89	6.89	6.92	6.81	6.75	6.57	6.39	6.23	6.20	6.28	6.31	6.32	-8%
Business	2.81	2.78	2.58	2.20	2.38	2.36	2.61	2.03	2.09	2.20	2.50	2.45	2.49	2.36	2.30	2.64	2.41	2.40	-15%
Energy Supply	5.31	5.31	6.54	6.16	6.22	6.34	6.57	5.17	4.96	4.84	5.35	5.75	4.66	4.84	3.68	3.94	3.74	3.83	-28%
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	0.16	-79%
Land Use Change	0.13	0.13	-0.07	-0.24	-0.25	-0.24	-0.21	-0.20	-0.21	-0.18	-0.18	-0.22	-0.18	-0.17	-0.16	-0.15	-0.12	0.23	83%
Public	0.46	0.46	0.29	0.19	0.19	0.15	0.17	0.12	0.13	0.15	0.17	0.18	0.19	0.20	0.20	0.20	0.20	0.20	-57%
Residential	4.18	4.17	3.61	3.82	3.81	3.81	3.77	3.85	3.82	3.75	3.51	3.60	3.24	3.43	3.39	3.81	3.12	3.16	-24%
Transport	3.33	3.33	3.56	3.72	3.87	4.00	4.04	4.20	4.36	4.36	4.42	4.44	4.62	4.40	4.28	4.21	4.11	4.10	23%
Waste Management	1.13	1.13	1.18	1.13	1.04	0.98	0.96	0.97	0.88	0.78	0.76	0.76	0.73	0.73	0.69	0.62	0.60	0.58	-49%
Total Net Emissions	24.97	24.93	25.73	25.23	25.48	25.06	25.46	23.23	23.17	22.93	23.69	23.96	22.62	22.42	20.76	21.70	20.52	20.97	-16%

Traded/Non-Traded Inventory Estimates for 2012

The 2012 EU Emissions Trading System (EU ETS) data has been analysed and used to derive a split for non-traded estimates for the By Source 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 2012 emission estimates show that:

- Across the **UK**, the non-traded share of total GHG emissions is **60%** of total GHG emissions in **2012**.
- **England**'s share of EU ETS (traded) emissions comes from a number of categories including iron and steel works, power generation and public sector. England non-traded emissions are estimated to be around **62%** of total GHG emissions in **2012**.
- **Scotland** has a similar 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 **2012** is **60%**.
- 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 steel works) and as a result, the non-traded share of the total GHG emissions in Wales in **2012** is only **46%**.
- **Northern Ireland** has much lower share of the EU ETS emissions, reflecting the fact that there are no refineries, iron and steel works or oil and gas terminals in Northern Ireland. The non-traded share of the Northern Ireland GHG emissions in **2012** is **79%**.

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_21990-2012_EmissionsData_Issue1.xlsx".

End User Inventory Estimates for 2012

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 (consumers). Estimates are presented excluding emissions associated with exports, (such as the generation of electricity subsequently exported from the UK) unless otherwise stated; this is to present the most accurate assessment of changes in DA consumption-based emission levels and trends. 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 net[4] greenhouse gas End User emissions in 2012 and emission trends derived from the End User calculations are summarised below[5].

- England has an **80%** share of total net End User GHG emissions in **2012** (compared to a 77% share of by source emissions). End User emissions have declined by **26%** since 1990. End User emissions are 1.6% higher than the by source estimates as a result of emissions attributed to England from energy production activities (e.g. electricity generation) outside England.
- Scotland has a **9.0%** share of total net End User GHG emissions in **2012** (compared to an 8.8% share of by source emissions). The trend since 1990 is a decline of **35%**. End User emissions are slightly (0.1%) higher than the by source estimates as a result of a net import of emissions attributed to energy production activities from Scotland. Although Scotland is a net exporter (from Scotland to other DAs) of electricity, the Scottish power generation mix has a lower carbon intensity than the rest of the UK, so by allocating total UK emissions from electricity generation based on electricity used (effectively using the same emission factor across all DAs), Scottish end user emissions are higher. Scottish power generation emissions are 12.7 Mt CO_2e, compared with emissions allocated to Scottish electricity use of 15.2 Mt CO_2e.
- Wales has a **6.7%** share of total net End User GHG emissions in **2012** (compared to an 8.0% share of by source emissions). Emissions have declined by **32%** since 1990. End User emissions are 18% 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 **4.0%** share of total net End User GHG emissions in **2012** (compared to a 3.7% share of by source emissions). The trend since 1990 is a decline of **13%.** End User emissions are 6.9% 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 associated with imported electricity and emissions from collieries, upstream oil and gas extraction and refining of petroleum fuels).

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.

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_1990-2012_Issue 1.xlsx".

Data Sources and Inventory Methodology

In the compilation of GHG inventories for the Devolved Administrations, where possible the same methodology has been used to calculate emission estimates as for the UK Inventory. However, the structure of the DA and UK statistical datasets and data collection processes mean that for many emission sources the data available for Devolved Administrations emissions are less detailed than for the UK as a whole, and for some sources DA-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 publication (DECC, 2013a; DECC, 2014). 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 a Local Authority level across the UK. The latest available data include Local Authority solid and liquid fuel use estimates for 2005 to 2011, with gas and electricity data also available up to 2012.

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 remain subject to greater uncertainty and less detail than the UK energy statistics presented within Digest of UK Energy Statistics (DUKES) (DECC, 2013b) 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.

Revisions and Updates to the 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 (Salisbury *et al.*, 2013) covered the years up to and including 2011, whilst this report gives emission estimates for the years up to and including 2012.

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 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" (DECC, 2013b), are revised annually and hence the data provided (e.g. for "coal used in energy generation in 2011") 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 these improvements to underlying activity datasets and methods used to estimate and distribute emissions across DAs, data in this report are likely to differ from figures presented in previous DA inventory reports. Significant revisions have been made to some DA estimates since the publication of the previous Devolved Administrations' GHG inventory (Salisbury *et al.*, 2013) in the following categories:

- Industrial fuel combustion – due to recalculations in DUKES (DECC, 2013b);
- Agriculture – due to improved allocation within manure management systems and improved activity data;
- Waste Management – revision of estimates of methane burned in landfill gas flares and landfill gas engines, based on new research by Defra and the Environment Agency;
- Land Use, Land Use Change & Forestry – due to the implementation of the CARBINE model to replace a previous carbon flow model, and improvements to the detail and application of available activity data.

Full details of the changes in estimates between the previous inventory (1990-2011) and the estimates presented in this report (1990-2012) 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.

1 Introduction

1.1 Policy Background

The Greenhouse Gas (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 Devolved Administrations (DAs) is evolving, with a much greater focus on (i) sector-specific data accuracy, and (ii) sensitivity to policy impacts.

The United Nations Framework Convention on Climate Change (UNFCCC)

The UNFCCC was ratified by the United Kingdom in December 1993 and came into force on the 21st March 1994. The objective of the Convention is to stabilise 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, which requires accurate information on trends of emissions of GHGs, and the collective ability to alter these trends.

The UK, as an Annex I Party to the Convention, having ratified the Kyoto Protocol, 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.

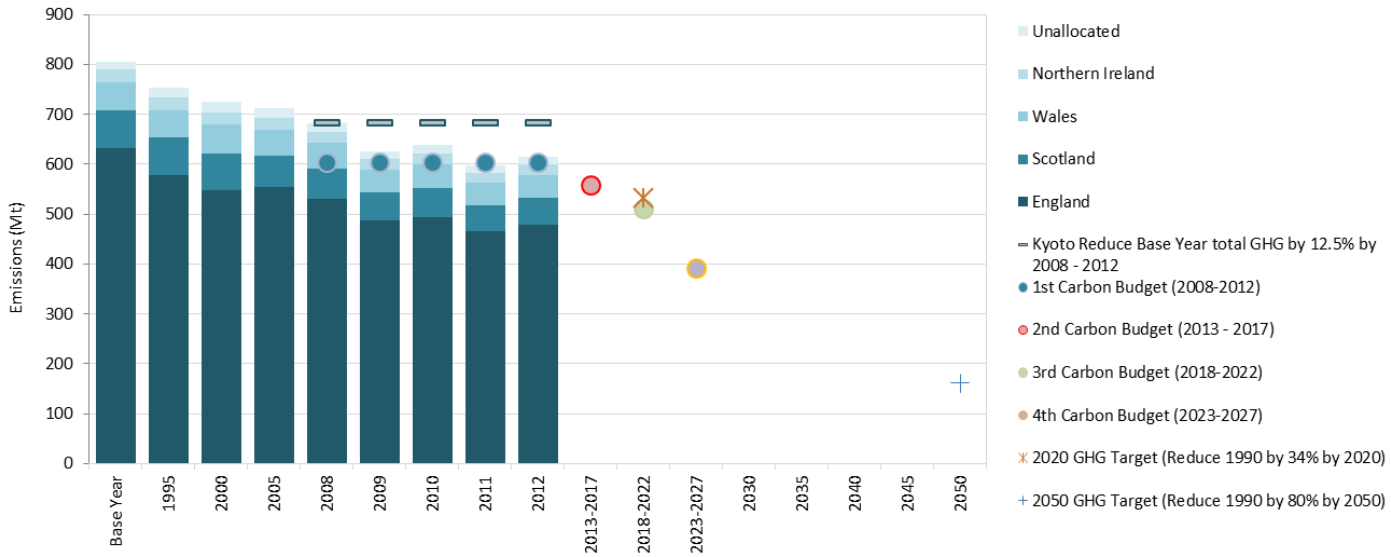
The Kyoto Protocol supplements the UNFCCC by committing parties, who have ratified the protocol, to achieve individual targets established for the reduction of their respective GHG emissions. Under the protocol, the UK is legally bound to reduce emissions of the 'basket of 6' GHGs by 12.5% against baseline emissions over the first commitment period (2008-2012). In the United Kingdom, the National GHG Inventory and associated National Inventory Report (Webb *et al.*, 2014) 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

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 greenhouse gas emissions to be achieved by 2020. The Act also introduced a Carbon Budgeting System whereby emission caps are set over 5 year periods, to map out the emission trajectory to 2050. The Government set the first three carbon budgets in May 2009, covering the periods 2008-12, 2013-17 and 2018-2022. The fourth carbon budget, covering the period 2023-27, was set in June 2011.

While this Act represents the primary piece of climate change legislation relevant to England, an overview of the main components of UK and Devolved Administrations (DAs) climate change legislation and strategies is presented in Figure 1.1 below.

Figure 1.1 UK Greenhouse Gas Emission Reduction Targets



Devolved Administrations' Climate Change Commitments

Powers to implement measures to deliver reductions in emissions of GHGs in Scotland, Wales and Northern Ireland are devolved to the Scottish Government, Welsh Government and the Northern Ireland Executive. Each of the 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)[6]
- 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)

A summary of the greenhouse gas emission reduction targets for the UK and all Devolved Administrations can be found in Figure 1.2 below.

Scotland

The Climate Change (Scotland) Act (2009) creates a statutory framework for greenhouse gas emissions reductions in Scotland by setting two targets: an interim target of at least a 42 per cent reduction for 2020, and a target of at least an 80 per cent reduction for 2050. These reductions are based on a 1990 baseline (1995 for the fluorinated 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 up to 2022[7]. Targets for 2023-2027 were set in October 2011[8], 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[9] 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.

Wales

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[10] and (similar to UK targets) do not include emissions from international aviation and

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

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

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

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

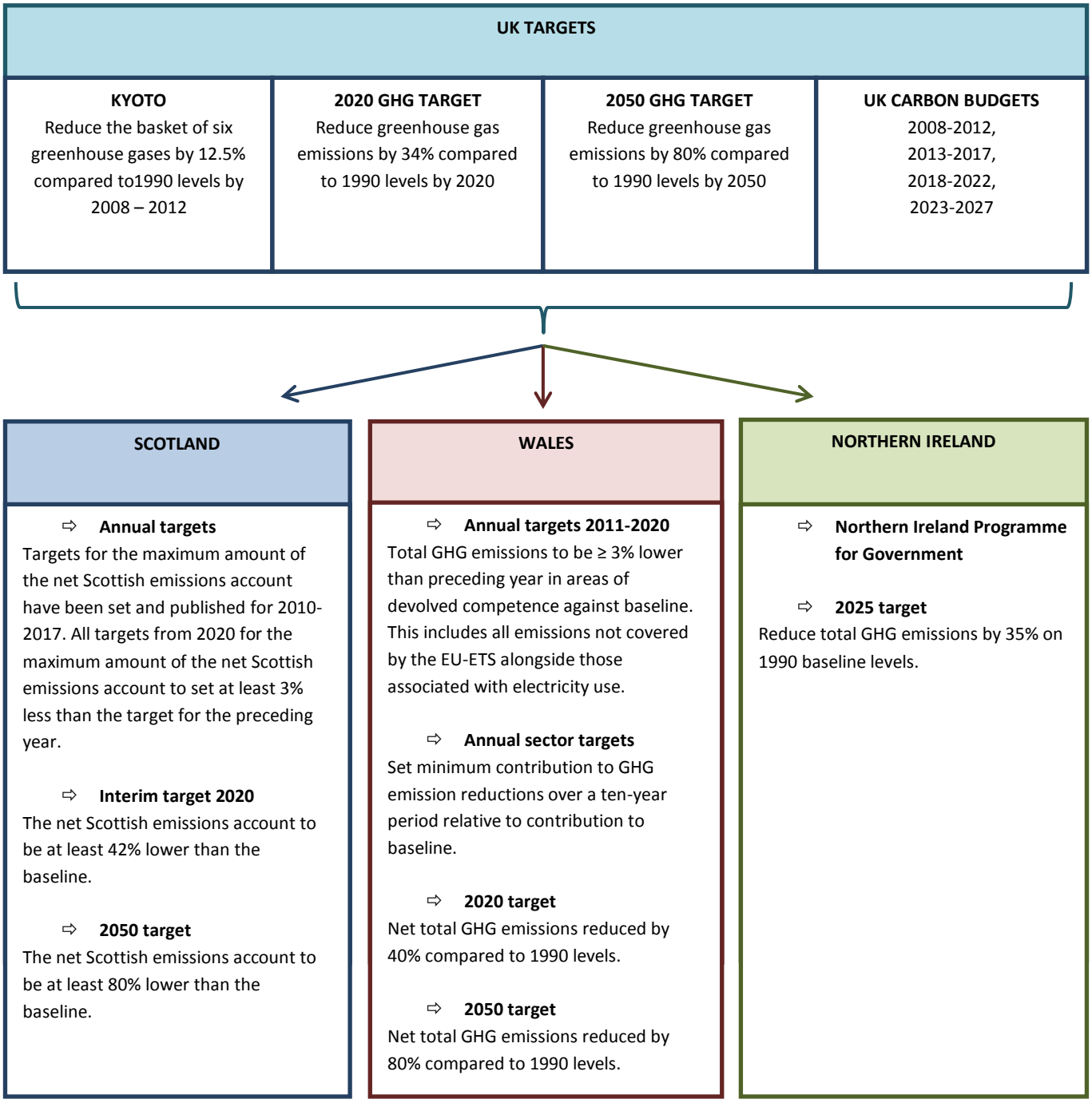
[10] The "traded sector" refers to emissions from installations that operate within the EU ETS, the EU-wide trading system that has been operational since 2005 and includes emissions from large energy consumers within the industrial and commercial sectors.

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, and an 80% reduction target for total GHGs by 2050 against a 1990 baseline.

Northern Ireland

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



1.2 About the Greenhouse Gas Emission Estimates

The Department of Energy and Climate Change (DECC) and the Devolved Administrations (DAs) commission this annual work programme to compile greenhouse gas (GHG) inventories for the DAs in order to establish GHG emission baselines by source and to track progress towards reduction targets at the DA level. This report summarises the findings of the joint research programme for the 1990-2012 GHG inventory cycle, which revises and updates the previous DA GHG inventories that were published in June 2013.

Inventory Time Series and Revisions

This report presents separate GHG Inventories for England, Scotland, Wales and Northern Ireland and "unallocated"[11] for the years 1990, 1995, and 1998 to 2012. It is based on the latest UK GHG inventory, which was submitted to the UNFCCC in April 2014 (Webb et al., 2014). 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 (Salisbury *et al.*, 2013) covered the years up to and including 2011, whilst this report gives emission estimates for the years up to and including 2012.

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 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" (DECC, 2013b), are revised annually and hence the data provided (e.g. for "coal used in energy generation in 2011") 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 improvements for the UK and DA inventories, data from previous DA inventory reports may be different to the figures in this report due to improvements 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.

Greenhouse Gases Included in the Inventories

Emissions are reported for the six direct greenhouse gases listed in Table 1.1 below, 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 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 relative to that of carbon dioxide. 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, 1996a). 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 hydrofluorocarbons (HFCs) and perfluorocarbons (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.

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

Table 1.1 Global Warming Potential of GHGs on a 100-year Horizon (t CO_2 equivalent/ t gas) (IPCC, 1996a)

Greenhouse Gas		Global Warming Potential (t CO_2 equivalent / t gas)
Carbon Dioxide	CO_2	1
Methane	CH_4	21
Nitrous Oxide	N_2O	310
Hydrofluorocarbons	HFCs	140-11700
Perfluorocarbons	PFCs	6500-9200
Sulphur hexafluoride	SF_6	23900

Inventory Sector Definitions

The GHG inventories for England, Scotland, Wales and Northern Ireland in this report are presented in the same format as DECC's UK GHG inventory National Statistics. The sum of the DA inventories is fully consistent with the UK GHG inventory. To provide information that is 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 Management

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

Types of Inventory

This report presents DA emission estimates in three different ways.

By Source Inventory

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 and source sector in which they are emitted.

Traded/Non-Traded Inventory

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

- Traded sector – emissions that are controlled under the EU Emissions Trading System (EU ETS)
- Non-Traded sector – all emissions that are outside of the scope of the EU ETS

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 7 and 8 in each DA chapter show the % traded and non-traded emissions for 2008-2012 with Figure 7 showing emissions from all sectors and Figure 8 showing emissions from Industry. The methodology used to estimate the split between traded and non-traded emissions by DA is presented in Appendix 4.

End User Inventory

The End User inventory allocates emissions from the Energy Supply sector (electricity, production of refined petroleum fuels, gas and solid fuel) to the users (end users: Residential, Transport, Agriculture, Public and Business sectors) of the energy supplied (see Figure 9 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 associated with greater uncertainty than the By Source estimates and Policy makers must consider this when using the End User inventory data.

In particular, the End User emission estimates for each country are associated with higher uncertainty for 1990 due to the lack of detailed electricity consumption data by country available for that year, whereas the estimates of total emissions from 2003 onwards are subject to lower uncertainty due to the development of the 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.

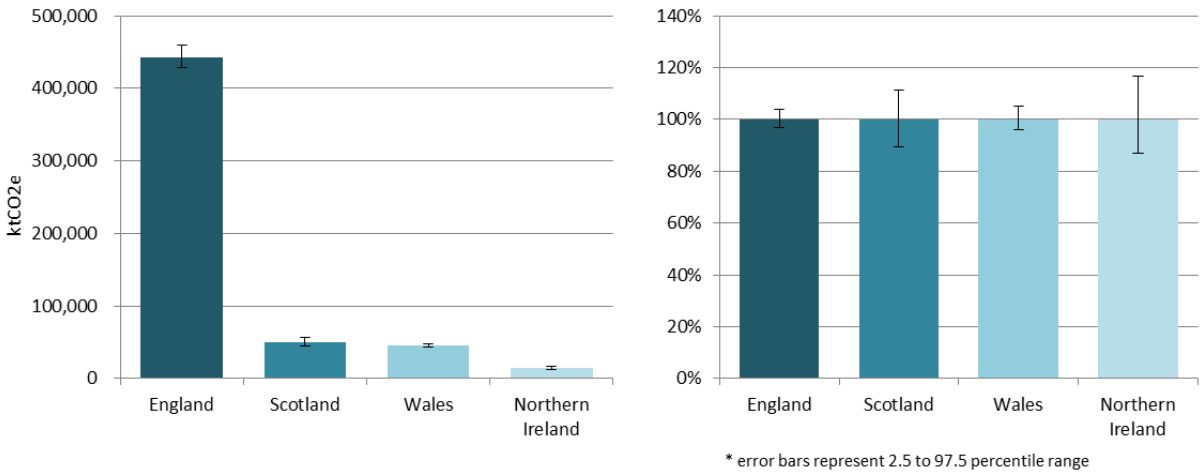
The End User emission estimates at sector level are more uncertain than the country totals, and hence the absolute sector End User emission estimates and reported trends by sector since 1990 should be regarded as indicative. The End User inventories are presented in each DA Chapter using National Communication reporting format. The methodology used for estimating the End User emissions for each DA is presented in Appendix 3.

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 Devolved Administrations for the 2012 estimates are presented in Figure 1.3 below.

Figure 1.3 Total GHG emissions and uncertainties by Devolved Administration (2012)*



UK uncertainties for the GHG estimates in 2012 are (+-6%). Uncertainties are calculated as ± 2×(standard deviation)/mean emissions, which approximates the 95% confidence interval approach shown in Figure 1.3. 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 (+-5%) 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 (+-14%) reflect the fact that there is a much greater contribution to the Scotland total from sources and sinks with significant uncertainties. The uncertainties for carbon dioxide are higher than for the other DAs, a sensitivity analysis has been carried out which indicates that this is largely due to the impact of uncertainties in LULUCF, and combustion of OPG.
- Wales inventory uncertainties of (+-7%) are comparable to those for the UK as a whole. 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 (+-15%) are higher than elsewhere in the UK 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 sectors 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. The main source of uncertainty in carbon dioxide estimates at the DA level is the lack of detailed DA-specific energy balances. The “outlier” in carbon dioxide inventory terms is Scotland, where there is a much greater contribution from more uncertain LULUCF sources and sinks and combustion of Other Petroleum Gas (OPG), 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 2012 are: +-2% England, +-15% Scotland, +-4% Wales and +-10% Northern Ireland.

- Emissions of nitrous oxide are the least certain (+-81% England, +-82% Scotland, +-85% Wales, +-90% 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 3 in each DA chapter. The methodology used to estimate the By Source emissions by DA is presented in Appendix 2, which also includes a summary of sensitivity analysis conducted on the DA uncertainty model. The uncertainty model has been tested by taking out certain sources from the analysis in order to determine the main sources of uncertainty, focussing on the impacts in Scotland and Northern Ireland where the overall uncertainty is notably higher than for other parts of the UK. Whilst further development of the uncertainty model is required in order to derive more detailed sector-specific uncertainty estimates, initial findings from the sensitivity analysis are:

- Excluding agricultural nitrous oxide emissions from the analysis reduces the uncertainty in all DAs, but most notably for Northern Ireland, where overall uncertainty reduces from +-15% to +-9%. In Northern Ireland, this source accounts for 13% of the inventory total, compared to a UK average of only 5%, hence the greater sensitivity in Northern Ireland to the high uncertainty associated with this source.
- Excluding LULUCF sources and sinks from the analysis reduces the inventory uncertainty in Scotland from +-14% to +-11%; excluding LULUCF sources and sinks, and excluding carbon dioxide emissions from other petroleum gas (OPG) use in Scotland reduces the overall uncertainty further, to +-7%. Scotland is affected the most by the removal of LULUCF emissions and removals, since this sector has a greater impact on Scotland's inventory than the other DAs. Uncertainties from OPG use are high because the inventory is not constrained to the DUKES total and therefore there is no final check to ensure all use of this fuel is included.

2 Emission Estimates in England (1990-2012)

2.1 Overview of Total Emissions

By Source Emissions

Overview

The greenhouse gas (GHG) emissions for England for 1990 – 2012 are presented in Table 2.1 and in the graph in Figure 2.1 below. Emissions in 2012 are 441,778 $ktCO_2e$ with 33% of emissions in 2012 from Energy Supply, 14% from Residential, 15% from Business and 22% from Transport sources.

Table 2.1: 1990-2012 England GHG Emission Inventory ($ktCO_2e$)

NC Format	Base Year	1990	1995	2000	2005	2008	2009	2010	2011	2012	% of 2012
Agriculture	45,495	45,495	44,165	41,782	38,384	36,244	35,623	36,184	35,920	35,387	8%
Business	88,830	87,829	84,586	86,188	86,185	79,618	71,273	69,861	66,025	67,902	15%
Energy Supply	211,875	211,875	167,824	148,660	165,520	160,683	142,996	145,942	138,968	147,166	33%
Industrial Process	51,063	49,222	40,772	20,345	15,299	13,849	8,844	9,100	7,649	7,644	2%
LULUCF	2,522	2,522	2,612	1,188	-707	-1,311	-1,352	-1,361	-1,248	-1,049	0%
Public	10,270	10,270	10,059	9,255	8,852	7,934	7,810	8,420	7,819	8,144	2%
Residential	63,520	63,195	65,080	71,982	70,396	66,383	61,956	71,716	55,147	62,445	14%
Transport	101,161	101,161	101,474	105,171	107,761	104,062	100,027	98,796	97,515	97,042	22%
Waste Management	36,929	36,929	37,407	30,398	23,520	22,069	20,713	18,294	17,945	17,096	4%
Total	**611,665**	**608,499**	**553,979**	**514,970**	**515,210**	**489,530**	**447,890**	**456,952**	**425,741**	**441,778**	**100%**

Trends

Figure 2.2 shows the change in emissions from the Base Year and 2011 to the latest year, 2012. Total GHG emissions for England show a steady decrease between the Base Year[12] and 2012 with an overall decrease of 28% over this time. However, emissions between 2011 and 2012 have increased slightly (3.8%). The reasons for this change in the trend are given below for each sector along with the significance of this change.

The 2011 to 2012 increase of emissions is predominantly driven by a shift from natural gas to coal (which has a higher carbon content per unit of energy) in the power generation sector due to the impact of changes in global fuel prices, and an increase in the consumption of natural gas in the Residential sector due to colder average temperatures.

The following list provides an overview of the trend for each NC sector:

- **Energy Supply** sector emissions have decreased by 31% between the Base Year and 2012. There was an increase in overall emissions between 2011 and 2012. This 6% increase (8,198 $ktCO_2e$) was mainly due to a shift from natural gas to coal in power stations due to global fuel prices.
- **Residential** sector emissions have, generally, decreased since the Base Year. Emissions between 2011 and 2012, however, increased by 13% (7,298 $ktCO_2e$) due to an increase in natural gas consumption reported for the sector. This increase in gas use reflects the colder average daily temperatures of 2012 (9.8 degrees C) compared to 2011 (10.7 degrees C).[13].
- **Business** sector emissions have reduced by 24% since the Base Year. Emissions have, however, increased by 3% (1,876.97 $ktCO_2e$) between 2011 and 2012 caused mainly by an increase in the iron and steel sector as the Teesside plant resumed production in 2012.

[12] 1995 for fluorinated greenhouse gases (F-Gases) and 1990 for all other gases

[13] DECC Energy Trends Table 7.1, February 2014.

- **Waste Management** sector emissions have significantly declined by 54% since the Base Year, largely due to the progressive introduction of methane capture and oxidation systems within landfill management. Emissions decreased by 5% (849 $ktCO_2e$) between 2011 and 2012 in line with this decline.
- **Agriculture** sector emissions have reduced by 22% since the Base Year mainly due to a decrease in livestock numbers. There was a small decrease of 1% (533 $ktCO_2e$) in emissions from 2011 to 2012 mainly due a reduction in the production of wheat and the resulting reduction in emissions from crop residues and fertilizer.
- **Transport** sector emissions have decreased by 4% between the Base Year and 2012 due to strong growth in transport demand over the period coupled with improvements in efficiency of transport vehicles. Emissions between 2011 and 2012 decreased by less than 1% (473 $ktCO_2e$).
- **Public** sector emissions have reduced by 21% since the Base Year. This is due to increased energy efficiency measures and the switch to gas-fired heating. However, emissions between 2011 and 2012 increased by 4% (324 $ktCO_2e$) due mainly to an increase in natural gas consumption in 2012 in response to the colder average daily temperatures of 2012 compared to 2011.
- **LULUCF** sector was a source of emissions between the Base Year and 2003 after which the LULUCF sector was a sink. The sink reduced by 16% between 2011 and 2012 (199 $ktCO_2e$).
- **Industrial Process** emissions have decreased significantly since the Base Year (85%). Emissions slightly decreased by 0.1% between 2011 and 2012 (4.8 $ktCO_2e$) due to a significant increase in emissions from iron and steel (due to the reopening of the Teesside Steel works) offset by emission reductions due to plant closures in the aluminium industry and lower cement clinker production from kilns in England.

Emissions Detail

Figure 2.3 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 Management, where methane from landfills, are the most important gases (see Figure 2.4).

The dominant emission sources in 2012 include road transport (20% of total GHG emissions), residential combustion for heating and cooking (13%), electricity production (29%) and industrial combustion for heat and electricity in the Business sector (11%) as shown in Figure 2.5.

Recalculations

Revisions to the estimates since the last inventory report (Salisbury *et al.*, 2013) have resulted in a 1% (4,634 $ktCO_2e$) increase in the 2011 estimates for England. The most significant revisions to the 2011 estimates have been for the following sub-categories:

1. **Business – other manufacturing industry and construction**: (3,279 $ktCO_2e$ decrease) due to recalculations of the activity data for the sector's use of fuel oil, gas oil, natural gas, and coal for the years 2008 – 2011 in the UK energy statistics digest (DUKES), as well as a reallocation of Other Petroleum Gases (OPG) emissions to the chemicals industry to improve the accuracy of the inventory as a large proportion of the OPG burnt in the industry is known to occur within chemical and petrochemical production facilities.
2. **LULUCF – forest land remaining forests land**: (3,442 $ktCO_2e$ decrease) due to a change in the methodology used to estimate emissions from the LULUCF sector. The new CARBINE model represents a comprehensive range of forest tree species relevant to the UK, representing UK growth conditions and management practices, and combining area/age class information for carbon stocks. Compared to previous estimates, this more detailed methodology provides a greater representation of Forest Land and the range of forest management practices observed in the UK.
3. **Waste Management – managed waste disposal on land**: (4,210 $ktCO_2e$ increase) due to a revision in the estimates of methane oxidised within landfill as engines and landfill gas flares in the UK landfill model; the estimate of methane utilisation is now based on research by Defra and the Environment Agency to collate and analyse the available data on the quantities of gas collected and burnt in landfill gas engines and flares, from reports by the operators of landfills permitted under the Integrated Pollution Prevention and Control (IPPC) Directive.
4. **Business – commercial/institutional combustion**: (1,937 $ktCO_2e$ increase) due to the revision in the UK energy statistics digest (DUKES) for gas consumption.

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

Figure 2.1: Total GHG Emissions by NC category for Base Year to 2012, as kt CO2e, England

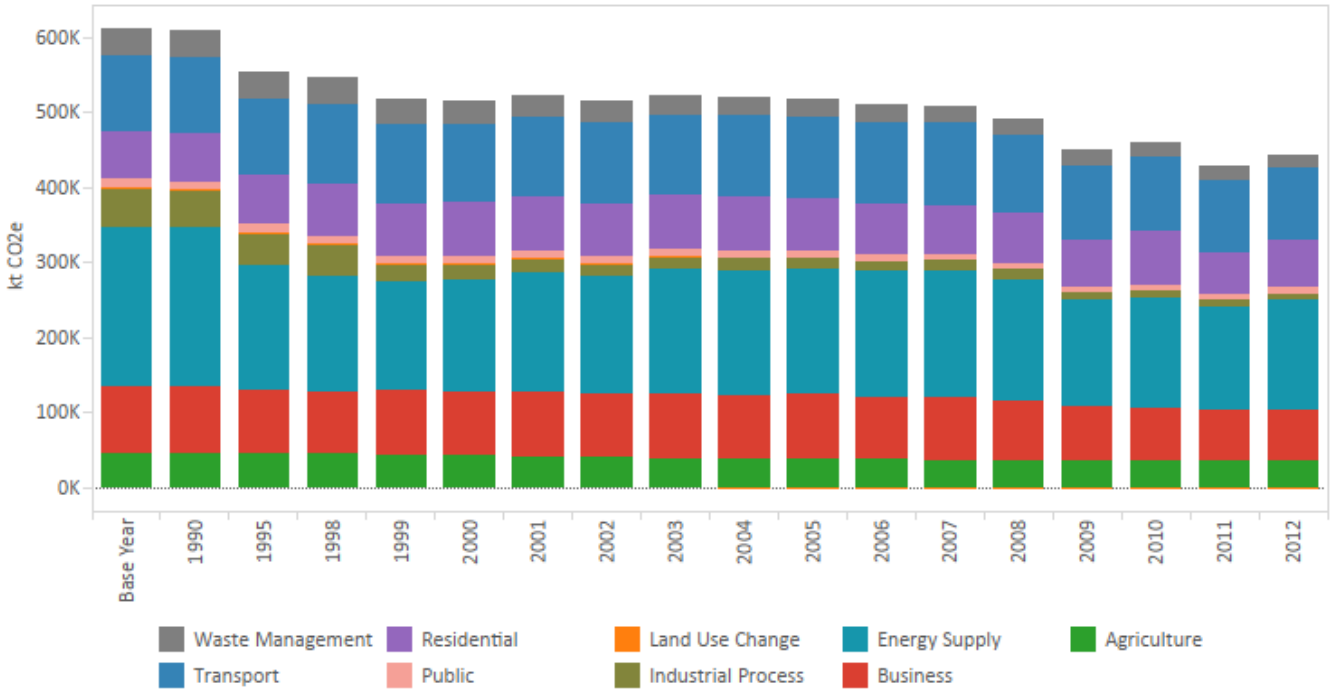
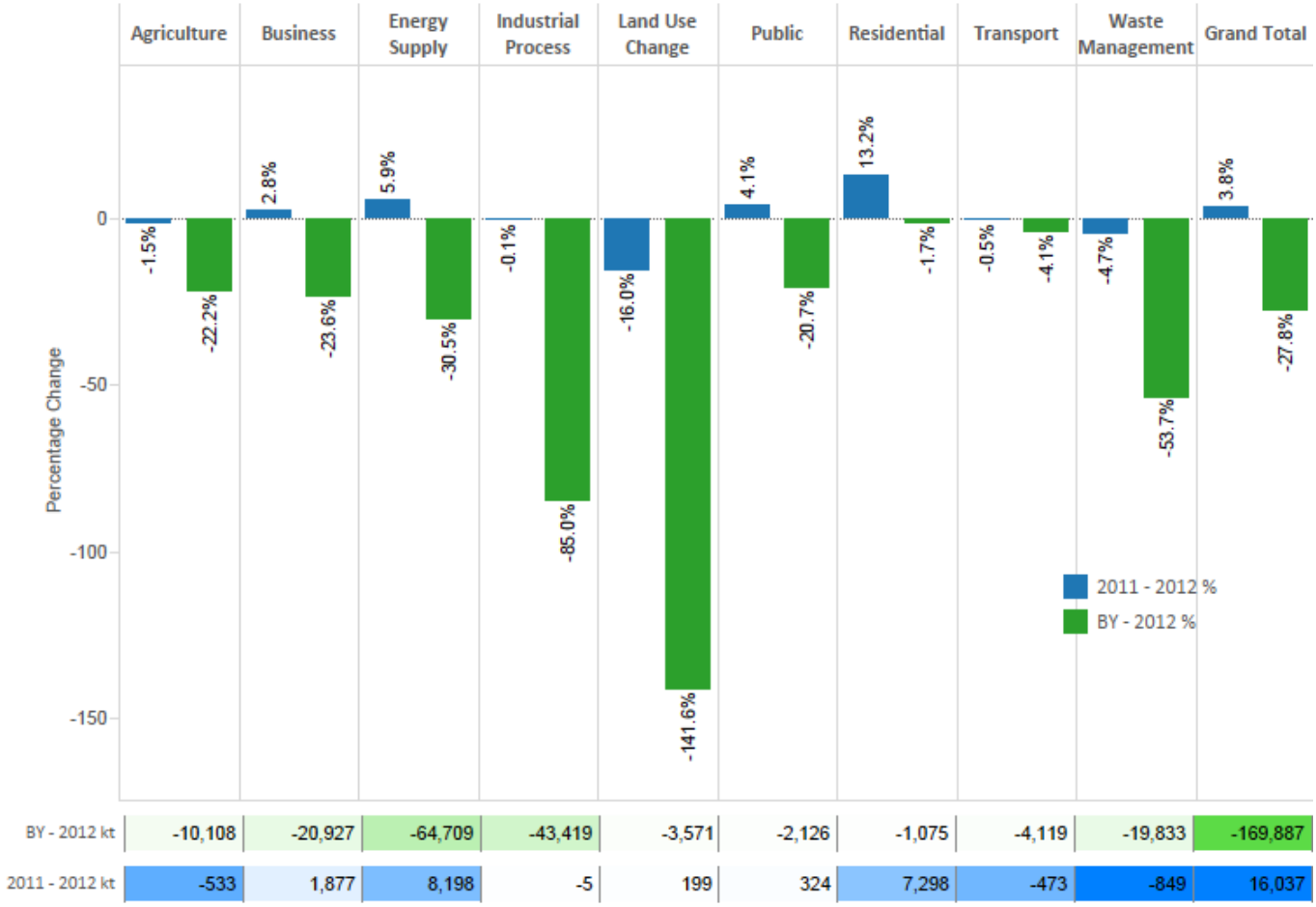


Figure 2.2: Percentage Change and Absolute (kt CO2e) Change in GHG Emissions by NC: Base Year(BY) - 2012 and 2011 - 2012, England

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



	Agriculture	Business	Energy Supply	Industrial Process	Land Use Change	Public	Residential	Transport	Waste Management	Grand Total
BY - 2012 kt	-10,108	-20,927	-64,709	-43,419	-3,571	-2,126	-1,075	-4,119	-19,833	-169,887
2011 - 2012 kt	-533	1,877	8,198	-5	199	324	7,298	-473	-849	16,037

Figure 2.3: Total GHG emissions and uncertainties by pollutant,2012, England

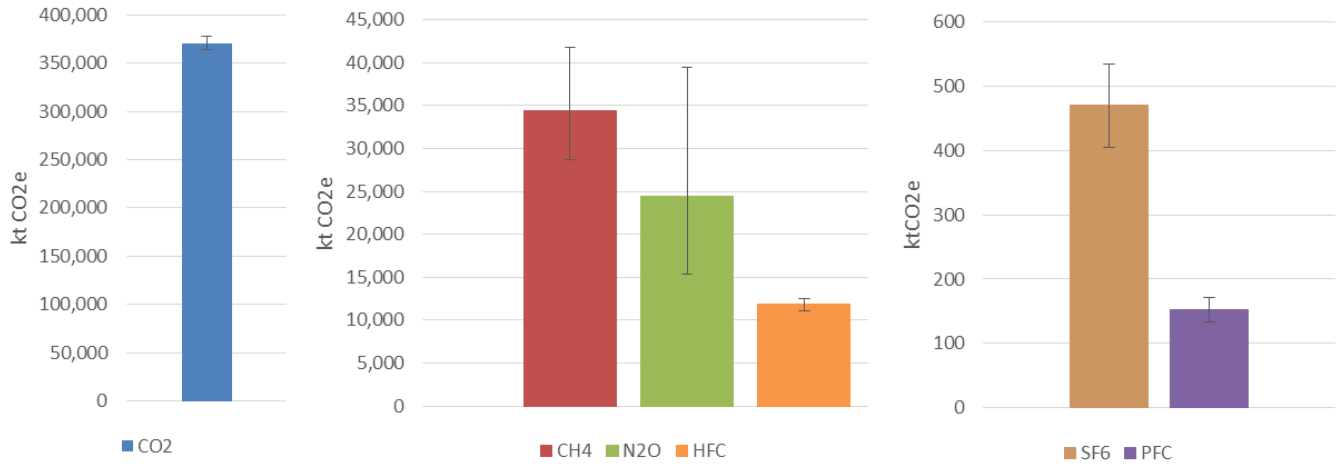


Figure 2.4: Total GHG Emissions by NC and pollutant, 2012, England

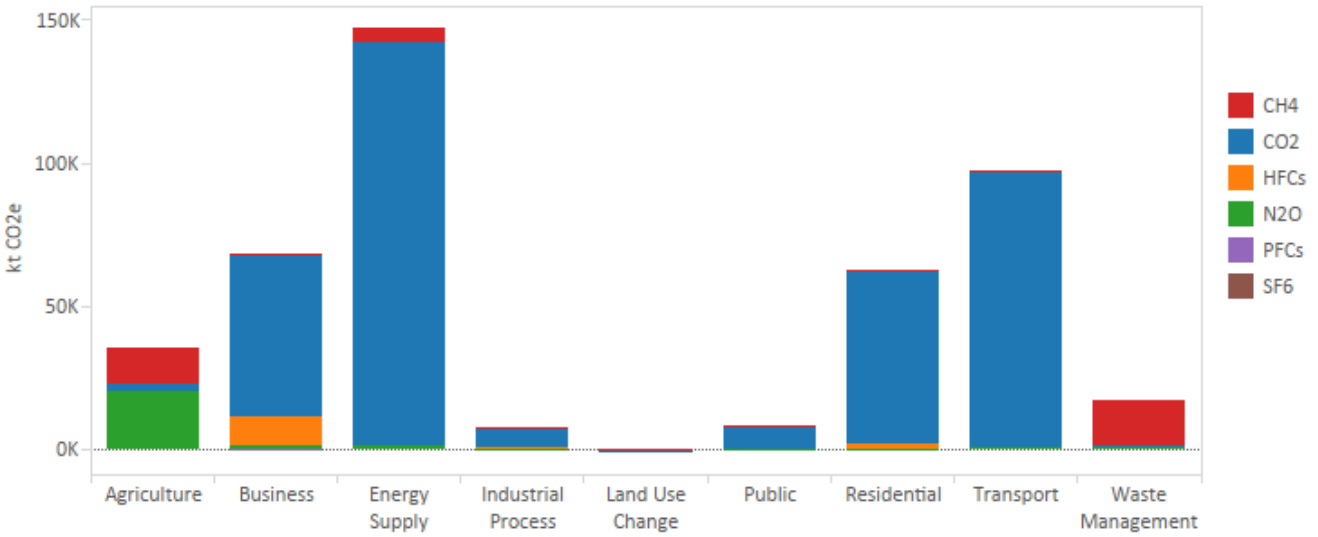
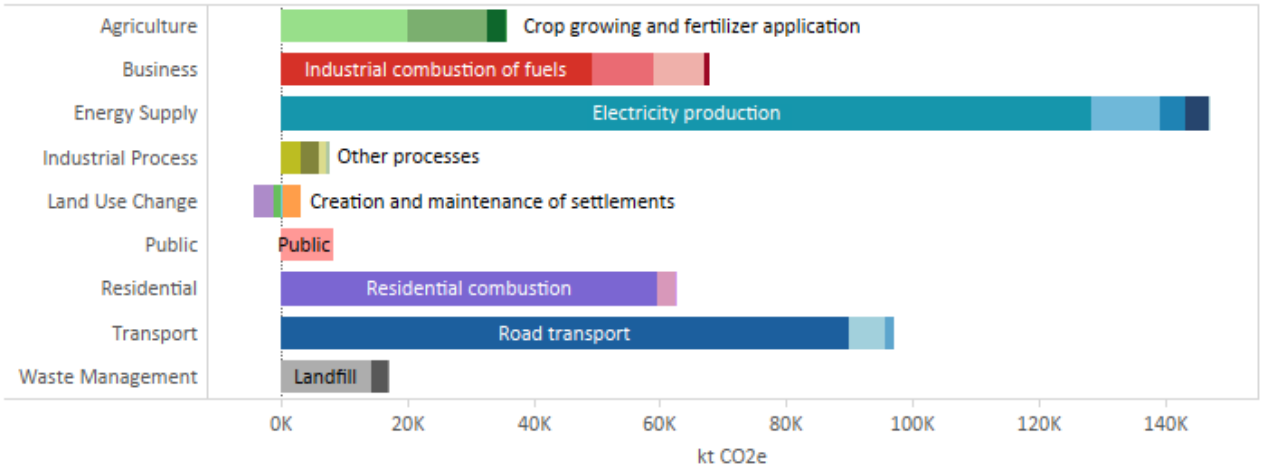


Figure 2.5: Total GHG Emissions labelling the largest sub-category in each NC, 2012, England



Traded and Non-Traded Emissions

Emissions from installations in the EU ETS contribute 38% of total GHG emissions in England in 2012. See Figure 2.6 for the Traded/Non-Traded split for each sector. The main contributors to these traded emissions are the Energy Supply sector (of which 95% total emissions are within the EU ETS, including all power stations) and the Business and Industrial Process sectors, of which 37% across 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, cement and lime kilns, iron and steel works, aluminium and brick manufacture plant.

Emissions from installations included in the European Union Emissions Trading Scheme (EU ETS) were relatively constant between 2009 and 2010 (see Figure 2.7); however this was followed by a 5.4% decrease between 2010 and 2011 as power demand in the economy dropped. There was subsequently a 5.5% increase between 2011 and 2012 returning emissions to previous levels. By comparison emissions from the non-EU ETS sources have reduced by 7.7% between 2010 and 2011 and then increased by 2.7% between 2011 and 2012. These recent trends are due to the changes in the daily average temperatures across these years, and are also reflected in the Traded/Non-Traded emission estimates for Industry (see Figure 2.8).

Figure 2.6: Total Traded and Non-Traded GHG Emissions by NC Category, 2012, England

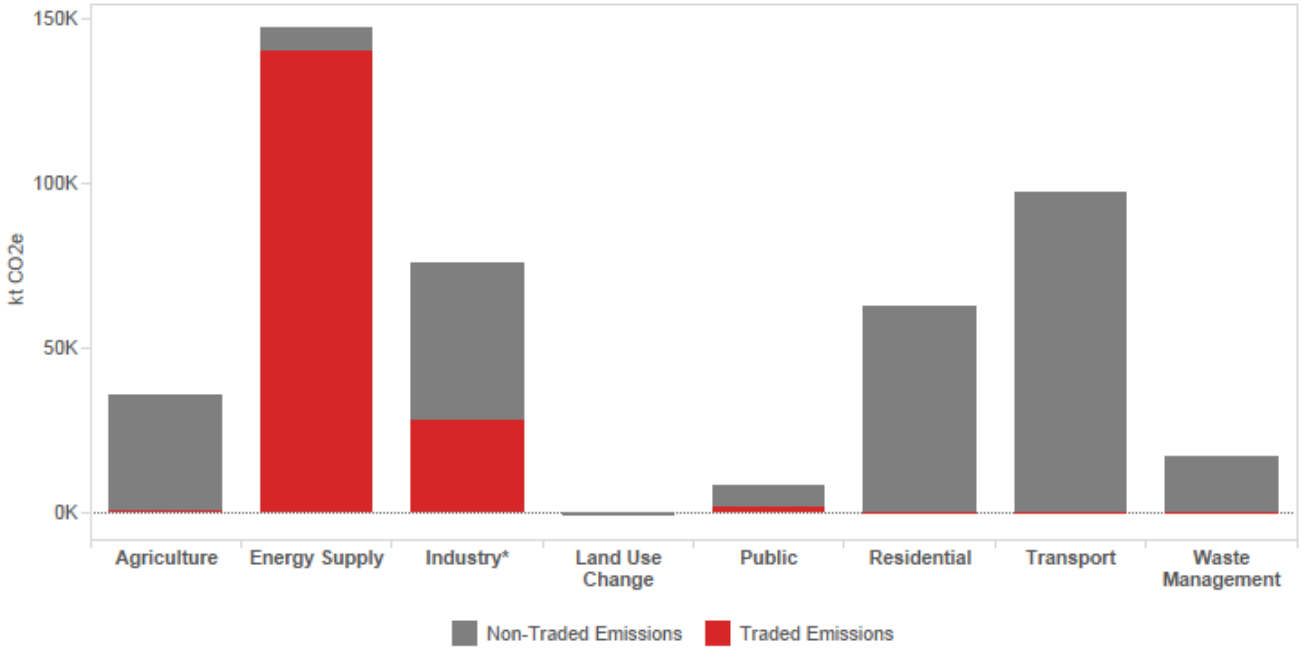


Figure 2.7: Total Traded and Non-Traded GHG Emissions 2008-2012, England

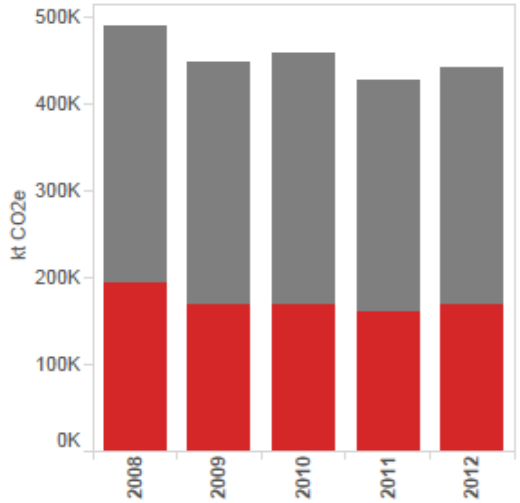
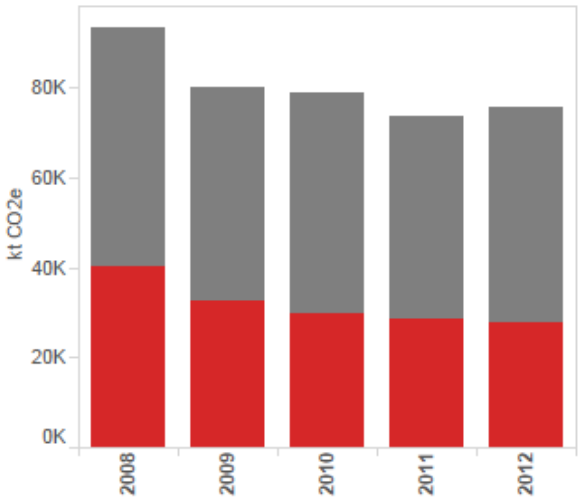


Figure 2.8: Traded and Non-Traded GHG Emissions from Industry 2008-2012, England*



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

Emissions on an End User Basis

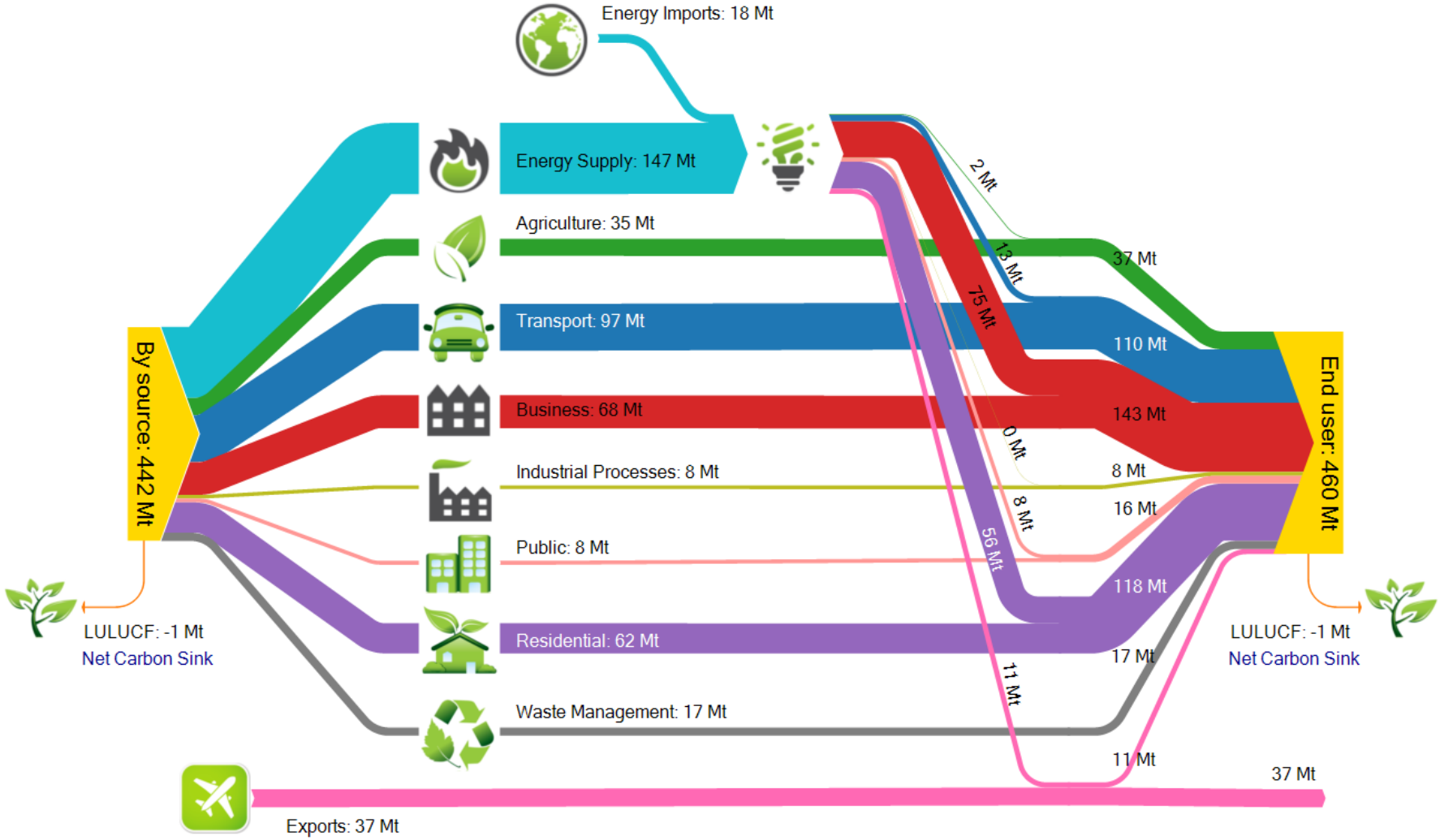
In addition to presenting emissions based on direct emissions from processes or combustion of fuels in England, the emissions from the Energy Supply sector can be attributed to the users of the energy (see Appendix 3 for more details of the End User inventory methodology). Figure 2.9 illustrates the 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 2012 are: 31% from Business, 26% from the Residential sector and 24% from Transport sources. As illustrated in Figure 2.9, England is a net importer of electricity which results in slightly higher (4.1%) emissions in England for End User (459,776 $ktCO_2e$) compared to By Source (441,778 $ktCO_2e$) estimates for 2012.

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 (e.g. gas oil use in mobile machinery).

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

Figure 2.9 Sankey diagram showing By Source and End User[14] GHG emission transfers for England in 2012 (Mt CO_2e)[15]



[14] 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.

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

2.2 Energy Supply Sector

Figure 2.10: Overall Contribution to 2012 GHG emissions, England

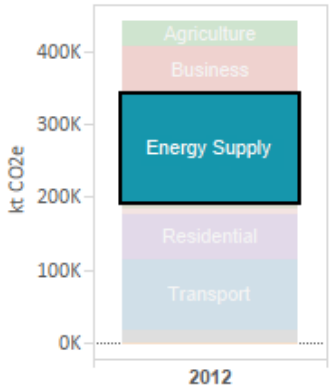


Figure 2.11: GHG Contribution to Energy Supply Emissions, 2012, England

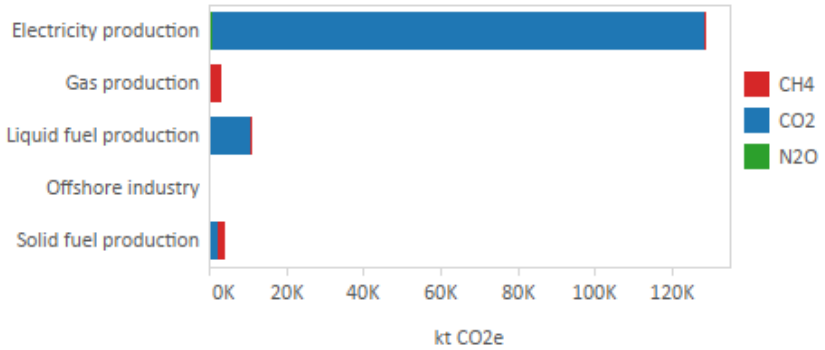


Table 2.2: Change in GHG Emissions from Base Year to 2012 and from 2011 to 2012, England

	2011 - 2012 %	2011 - 2012 kt	BY - 2012 %	BY - 2012 kt
Electricity production	8%	9,531	-26%	-44,863
Gas production	1%	18	-53%	-3,908
Liquid fuel production	-8%	-976	-5%	-593
Offshore industry	-28%	-118	-22%	-84
Solid fuel production	-6%	-258	-79%	-15,261
Energy Supply Total	6%	8,198	-31%	-64,709

Table 2.3: NC Category Contribution to End User Inventory by percentage of Electricity Production Emissions, England

Agriculture	1%
Business	54%
Industrial Process	0%
Public	5%
Residential	38%
Transport	2%
Exports*	1%

Figure 2.12: Total GHG Emissions from Energy Supply, Base Year to 2012, England

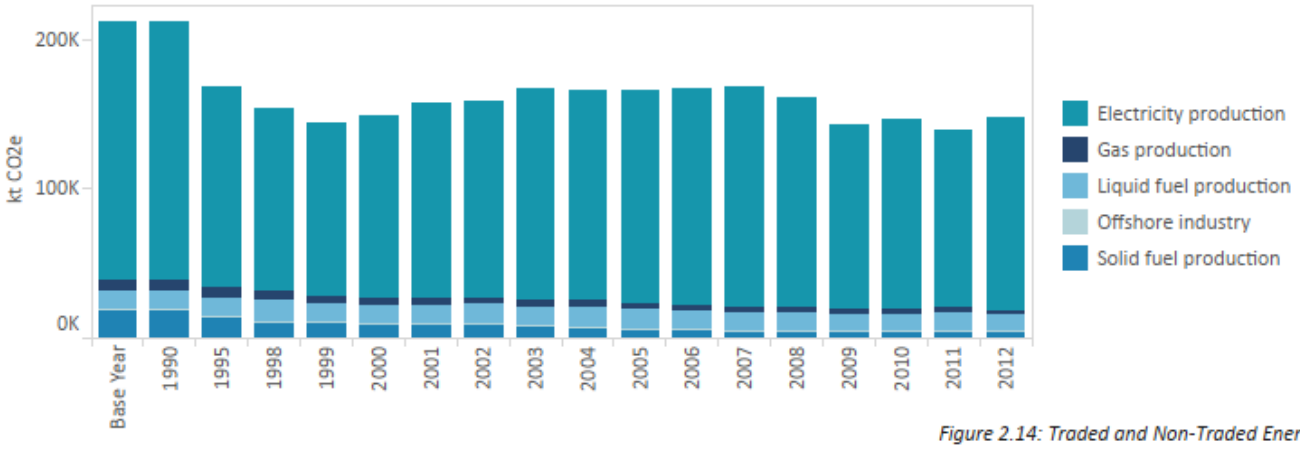


Figure 2.13: Emissions and Electricity Production by Fuel Type from Major Power Producers (1A1a), England

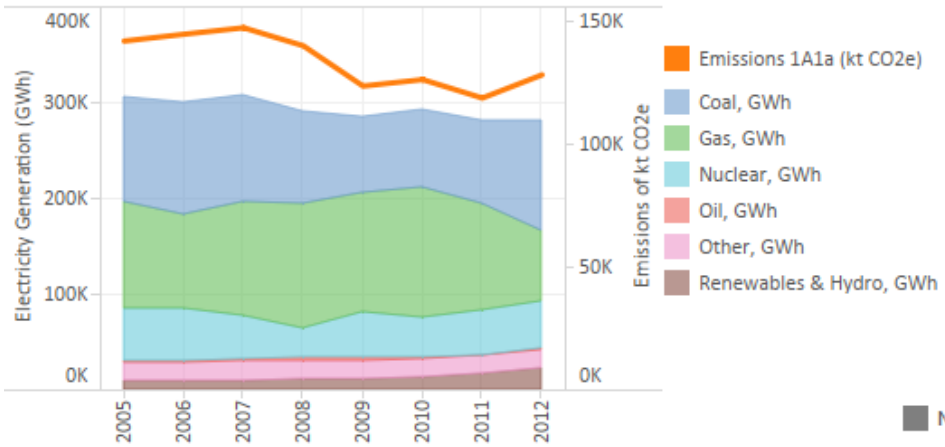
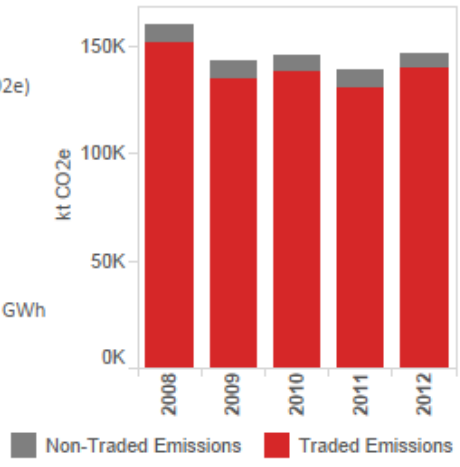


Figure 2.14: Traded and Non-Traded Energy Supply Emissions, 2008-2012, England



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

By Source Emissions

Overview

Figures 2.10 – 2.14 show detailed emissions and trends for the Energy Supply sector. In England, Energy Supply contributes 33% to total 2012 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 87% of Energy Supply emissions in 2012; refinery emissions account for a further 7% of the Energy Supply sector emissions in 2012.

Features of the Trends

Table 2.2 shows the change in emissions between the Base Year and 2012, and between 2011 and 2012 for the sector. Energy Supply sector emissions have reduced steadily from 1990 to 2011 (by 31% between the Base Year and 2012) 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 increased by 6% between 2011 and 2012, due mainly to a shift from natural gas to coal in power stations due to global fuel prices.

Sector Detail

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

Carbon dioxide is the predominant gas accounting for over 96% of emissions from the Energy Supply sector in 2012 as a result of the combustion of fossil fuels.

The mix of generation capacity in England is shown in Figure 2.13. 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 (DECC, 2013a). The By Source inventories presented here allocate emissions to the Devolved Administrations 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.

Traded and Non-Traded Emissions

Emissions in the Energy Supply sector (Figure 2.14) are dominated by Traded (EU ETS) installations with 95% of emissions in Energy Supply from Traded operations; these traded emissions are primarily from power stations, refineries and coke ovens.

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. Table 2.3 indicates the reallocation of emissions related to the production of electricity to the other sectors. The Business and Residential sectors are the most prominent, with 54% and 38%, respectively, of emissions from the production of electricity reallocated to each.

2.3 Transport Sector

Figure 2.15: Overall Contribution to 2012 GHG emissions, England

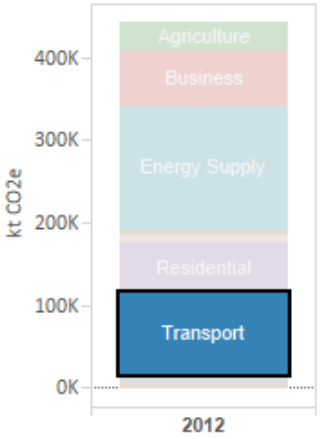


Figure 2.16: Total GHG Emissions from Transport, Base Year to 2012, England

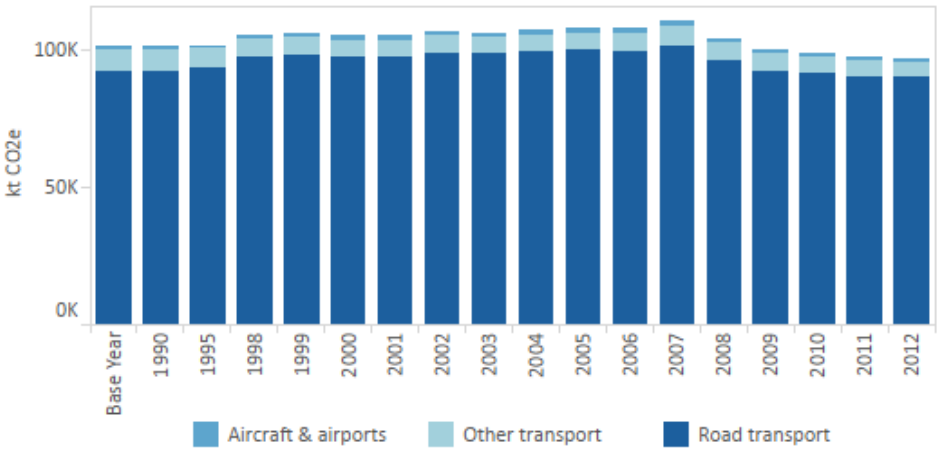


Table 2.4: Change in GHG Emissions from Base Year to 2012 and from 2011 to 2012, England

	Base Year to 2012 as %	Base Year to 2012 kt	2011 to 2012 as %	2011 to 2012 kt
Aircraft & Airports	25%	257	-4%	-52
Road Transport	-3%	-2,397	0%	-253
Other Transport	-25%	-1,979	-3%	-169
Transport Total	-4%	-4,119	0%	-473

Figure 2.17: GHG Contribution for Transport Emissions, 2012, England

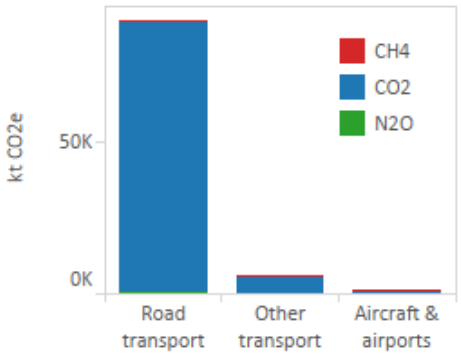


Figure 2.18: Comparison of End User and By Source for Transport, England

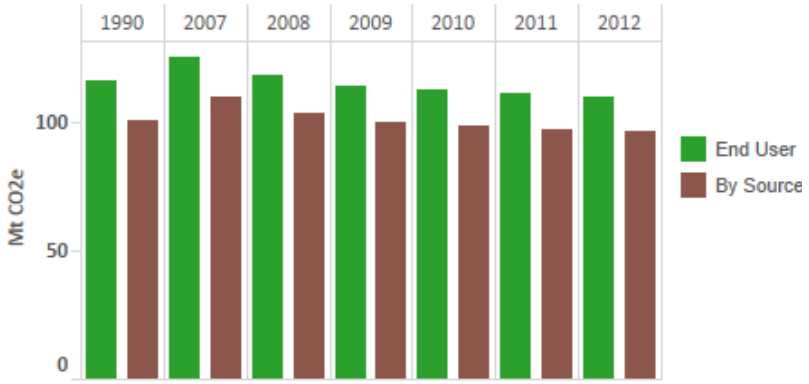


Figure 2.19 Road Transport CO2 Emissions (fuel sales basis), England

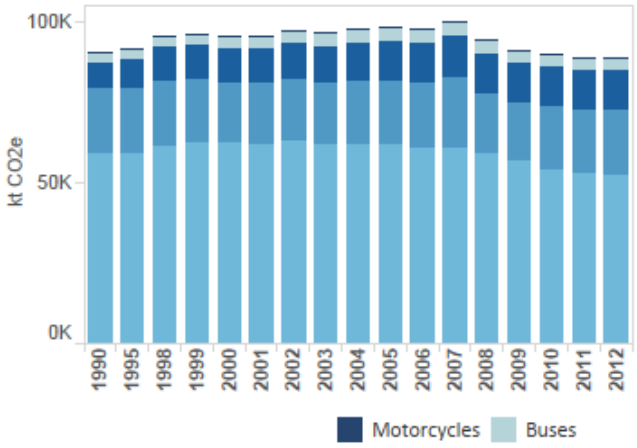
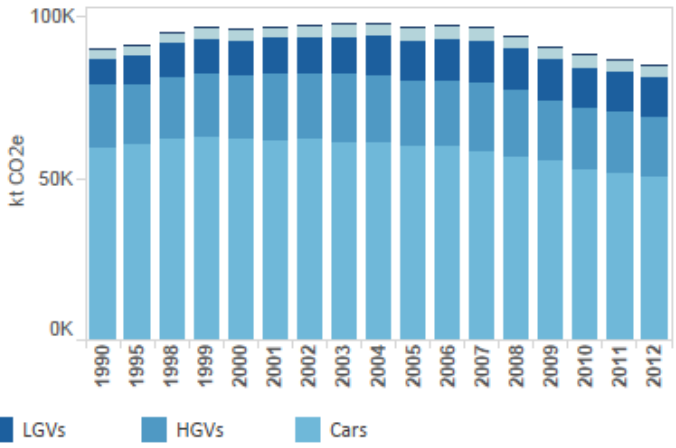


Figure 2.20: Road Transport CO2 Emissions (vkm basis), England



By Source Emissions

Overview

Figures 2.15 – 2.20 show detailed emissions and trends for the Transport sector. Transport emissions account for 22% of England's total GHG emissions in 2012. Transport emissions are dominated by emissions from road transport (93% of all Transport emissions in 2012, with 54% of Transport emissions from cars alone). The Transport sector also includes 1.8% from rail (including stationary sources), 1.8% from national navigation and coastal shipping, 0.9% from domestic aviation and 2.3% from military aviation and shipping. Emissions from international aviation are excluded from these estimates and are reported as memo items to the inventory.

Features of the Trends

Table 2.4 shows the change in emissions between the Base Year and 2012, and between 2011 and 2012 for the sector. Total GHG emissions from the Transport sector in England have decreased by only 4% between the Base Year and 2012 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 peaked in 2007 and have since declined partly due to improvements in average fuel efficiency of vehicles and the switch from petrol to diesel cars and from a reduction in traffic volumes.

Emissions between 2011 and 2012 have decreased by less than 1%. Recent trends for the sector are driven by the changes in emissions from passenger cars. Although emissions from diesel cars have increased, emissions from petrol have significantly decreased, which has led to the overall reduction in emissions between 2011 and 2012.

Sector Detail

There are two approaches used to calculate emissions from Road Transport: fuel sales basis – emissions are constrained to the total fuel sold within the UK as stated in DUKES (DECC, 2013b); vehicle kilometre basis – emissions are estimated using vehicle km data and are not constrained by the total fuel sold, so estimate emissions based on fuel used within the UK. The inventory emission estimates for Road Transport are calculated on a fuel sold basis and are, therefore, consistent with DUKES.

Figures 2.19 and 2.20 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 4.3% lower than the estimates constrained to DUKES for 1990 and 2012 respectively. The differences between the two approaches fluctuate year on year but they remain within a 4.5% 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 2012) 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 2012 are 5.4% lower than in the Base Year, while the constrained approach indicates that carbon dioxide emissions have decreased by 1.9% between the Base Year and 2012.

Emissions on an End User Basis

The End User estimates in recent years are around 13.6% 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 2.18) since 1990 shows a decline of 5.3% to 2012, 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.

2.4 Residential Sector

Figure 2.21: Overall Contribution to 2012 GHG emissions, England

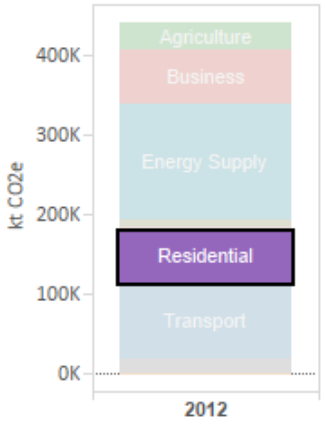


Figure 2.22: Total GHG Emissions from Residential, Base Year to 2012, England

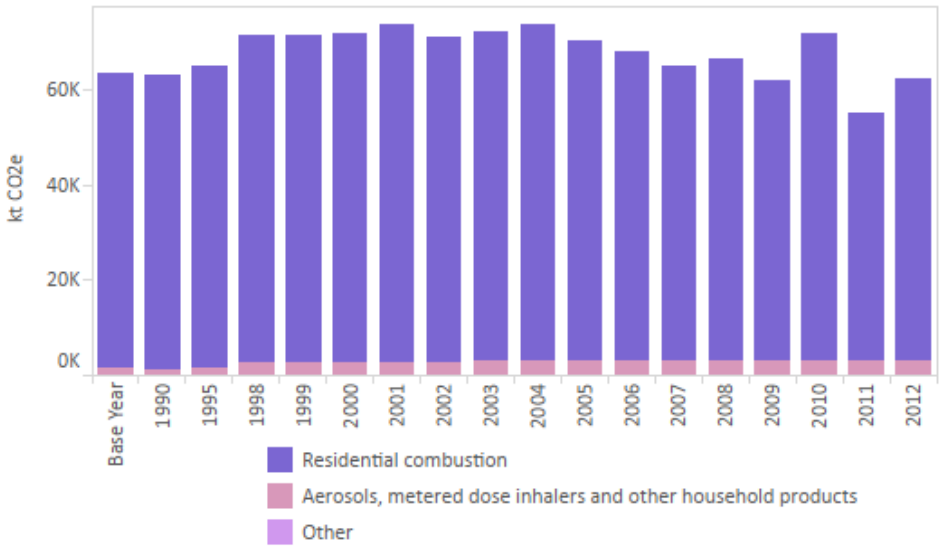


Table 2.5: Change in GHG Emissions from Base Year to 2012 and from 2011 to 2012, England

	Base Year to 2012 as %	Base Year to 2012 kt	2011 to 2012 as %	2011 to 2012 kt
Aerosols, metered dose inhalers and other household products	119%	1,613	1%	30
Other	-43%	0	0%	0
Residential combustion	-4%	-2,687	14%	7,268
Residential Total	-2%	-1,075	13%	7,298

Figure 2.23: GHG Contribution for Residential Emissions, 2012, England

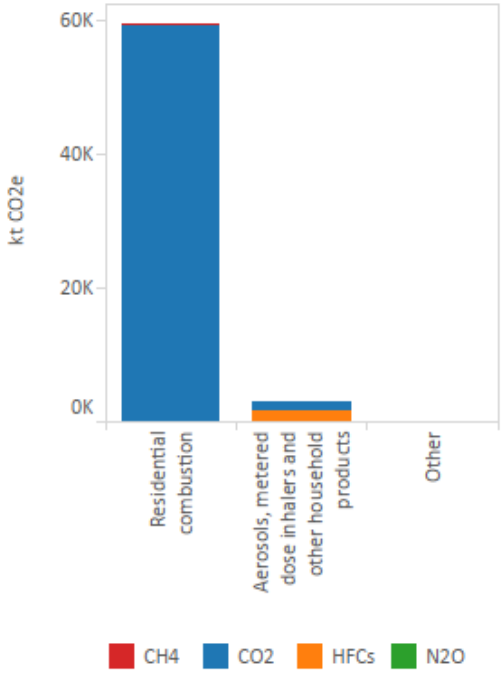
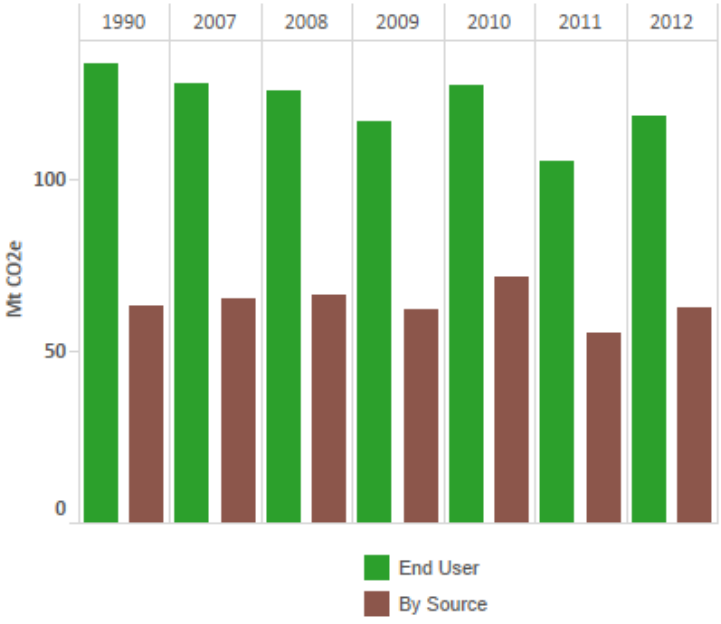


Figure 2.24: Comparison of End User and By Source for Residential, England



By Source Emissions

Overview

Figures 2.21 – 2.24 show detailed emissions and trends for the sector. The Residential sector accounts for 14% of England's total GHG emissions in 2012. The sector comprises emissions from domestic combustion (95% 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 96% of all residential GHG emissions are from the release of carbon dioxide from the direct combustion of fossil fuels (see Figure 2.23).

Features of the Trends

Total GHG emissions from the Residential sector (Table 2.5) in England have decreased by 1.7% between the Base Year and 2012. There was a large increase in natural gas consumption[16] in 2012, resulting in a 13% increase in GHG emissions from the sector between 2011 and 2012. The sector emission trends reflect the average mean temperatures over recent years, with notably higher emissions during the very cold year 2010, followed by a notable decline to 2011 and subsequent increase during the colder year of 2012.

Emissions on an End User Basis

In 2012 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 2.24). This increases the overall significance of this sector in the End User inventory to 26% of the England total, compared to just 14% of the By Source inventory total. The trend in Residential End User emissions since 1990 shows a decline of around 12% to 2012 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.

[16] 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 Sector

Figure 2.25: Overall Contribution to 2012 GHG emissions, England

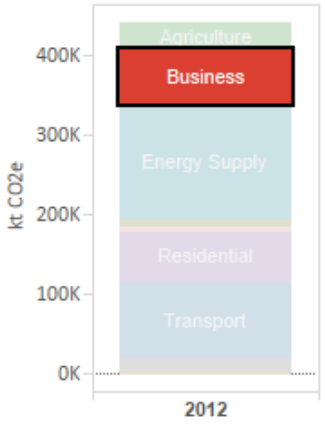


Figure 2.26: Total GHG Emissions from Business, Base Year to 2012, England

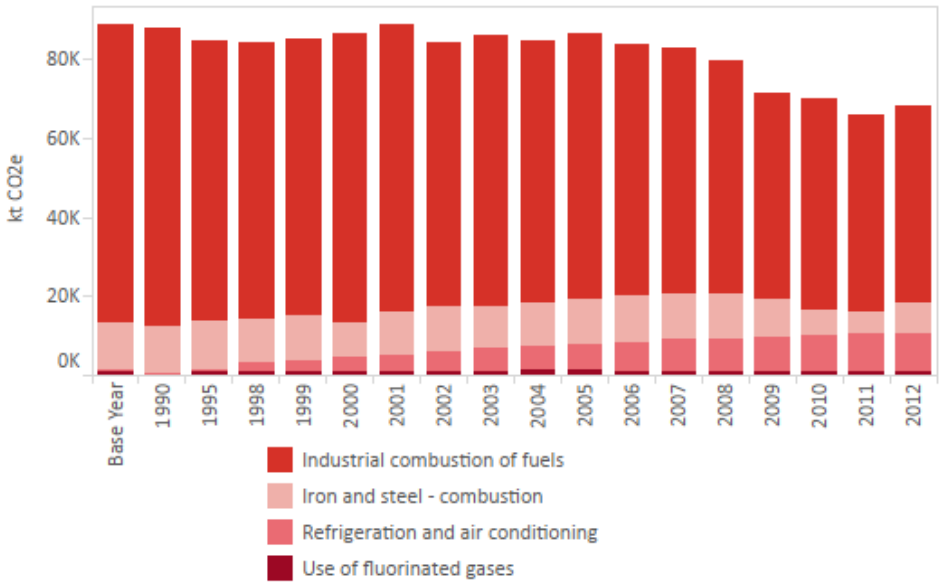


Table 2.6: Change in GHG Emissions from Base Year to 2012 and from 2011 to 2012, England

	Base Year to 2012 as %	Base Year to 2012 kt	2011 to 2012 as %	2011 to 2012 kt
Industrial Combustion of fuels	-35%	-26,238	-1%	-521
Iron and steel - combustion	-31%	-3,604	39%	2,267
Refrigeration and air conditioning	1,376%	8,937	1%	130
Use of fluorinated Gases	-3%	-23	0%	0
Business Total	-24%	-20,927	3%	1,877

Figure 2.27: GHG Contribution for Business Emissions, 2012, England

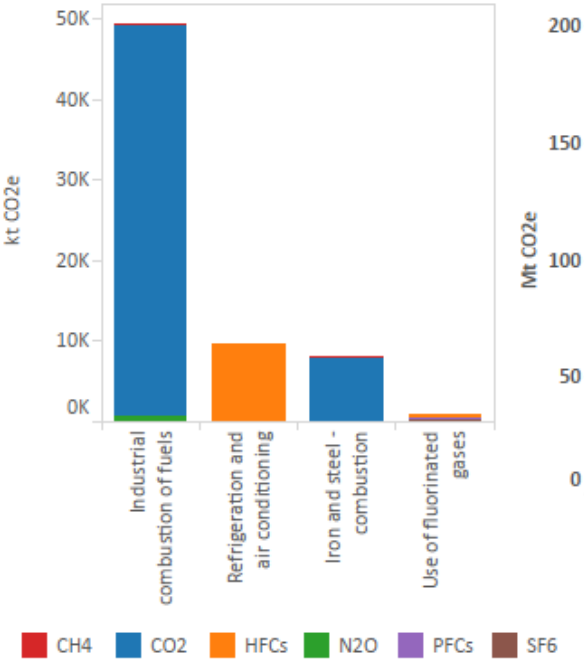
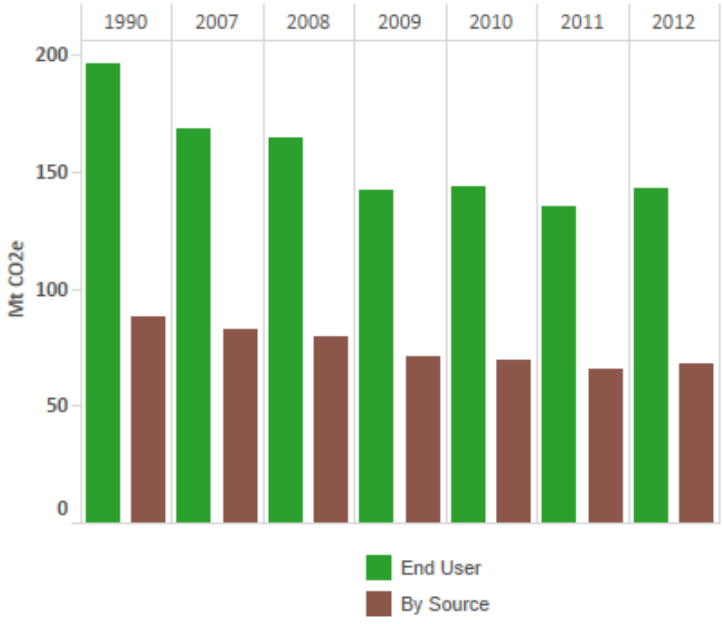


Figure 2.28: Comparison of End User and By Source for Business, England



By Source Emissions

Overview

Figures 2.25 – 2.28 show detailed emissions and trends for the sector. In England, the Business sector contributes 15% to total 2012 GHG emissions in England. The sector in 2012 includes emissions from industrial combustion of fuels (73% of Business emissions) from manufacturing and construction industry, iron and steel fuel combustion (12% of total emissions), refrigeration & air conditioning (14% of Business emissions), arising from losses of HFCs during equipment manufacture, leaks and disposal; as well as HFC emissions from foam production, firefighting solvents and electronics (1.3% of Business GHGs). In 2012, 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.

Features of the Trends

Overall Business sector emissions have reduced steadily since the Base Year, and by 2012 a 24% reduction in GHG emissions has been achieved in the sector in England (see Table 2.6). These reductions have primarily been achieved as a result of declining manufacturing and iron and steel industry emissions and fuel switching from coal to natural gas. Despite this general decline in emissions, emissions of HFC from refrigeration and air conditioning have risen by over 1300% since 1990; these emissions now account for around 15% of total business emissions in 2012 since the introduction of these gases as replacement to CFCs banned by the Montreal Protocol. Emissions from the sector have increased by 3% between 2011 and 2012, caused mainly by an increase in the iron and steel sector as the Teesside plant resumed production in 2012.

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, the Business and Industrial Process emissions are not easy to separate.

The contribution to total aggregate emissions from the traded and non-traded sector across the Business and Industrial Process sectors are presented in Figure 2.8 in the Overview section under the category: “Industry”. Traded emissions accounted for 37% of total Industry emissions in 2012.

Emissions on an End User Basis

In 2012, England’s End User emissions for the Business sector are 211% 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 31% of total emissions for England compared to just 15% 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 Sector

Figure 2.29: Overall Contribution to 2012 GHG emissions, England

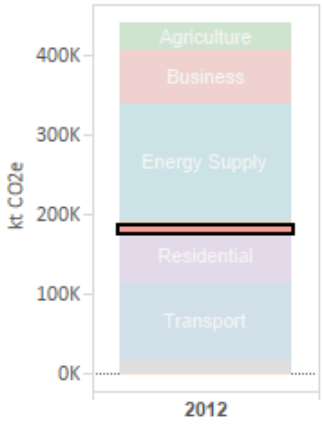


Figure 2.30: Total GHG Emissions from Public, Base Year to 2012, England

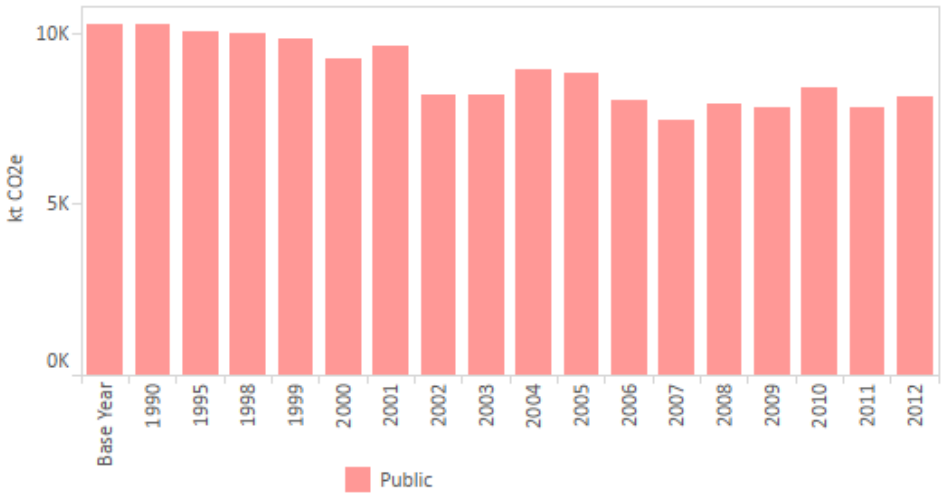


Table 2.7: Change in GHG Emissions from Base Year to 2012 and from 2011 to 2012, England

	Base Year to 2012 as %	Base Year to 2012 kt	2011 to 2012 as %	2011 to 2012 kt
Public	-21%	-2,126	4%	324
Public Total	-21%	-2,126	4%	324

Figure 2.31: GHG Contribution for Public Emissions, 2012, England

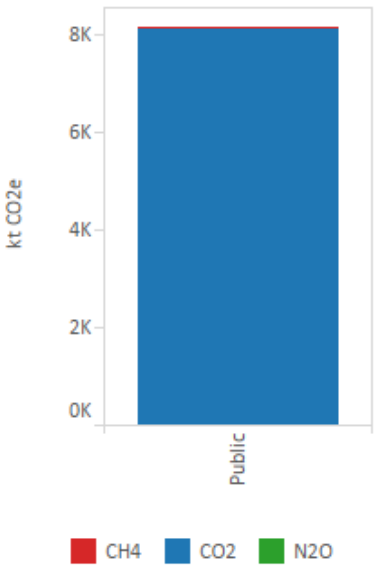
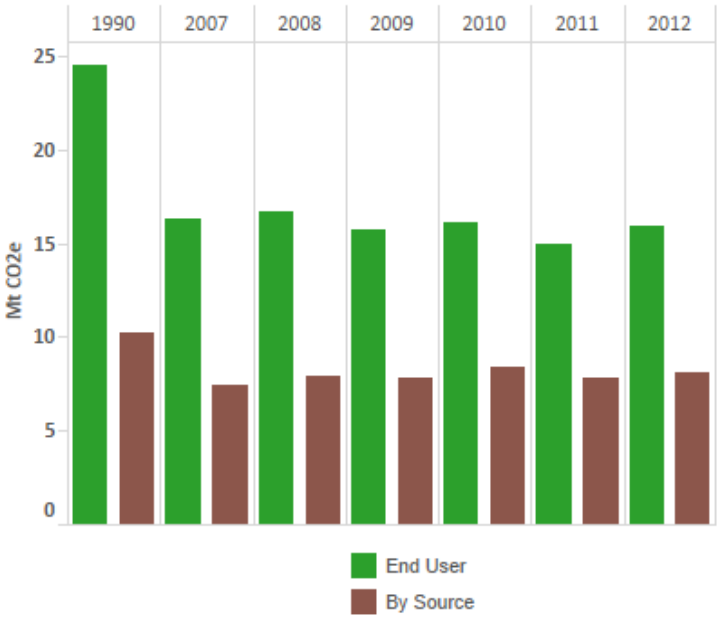


Figure 2.32: Comparison of End User and By Source for Public, England



By Source Emissions

Overview

Figures 2.29 – 2.32 show detailed emissions and trends for the sector. Emissions from Public sector combustion account for 1.8% of GHG emissions in England in 2012. Almost 100% of emissions in this sector are from carbon dioxide from the combustion of fossil fuels (predominantly natural gas).

Features of the Trends

Overall Public sector emissions have reduced steadily between the Base Year and 2012, with an overall reduction of 21% over the period (Table 2.7). 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 increased by 4.1% between 2011 and 2012, due mainly to an increase in natural gas consumption in 2012 in response to the colder average daily temperatures compared to 2011.

Emissions on an End User Basis

In 2012, England End User emissions for the Public sector are 196% 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 to 3.5% in 2012 on an End User basis. The trend in End User emissions since 1990 shows a decline of around 35% to 2012.

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.

2.7 Industrial Process Sector

Figure 2.33: Overall Contribution to 2012 GHG emissions, England

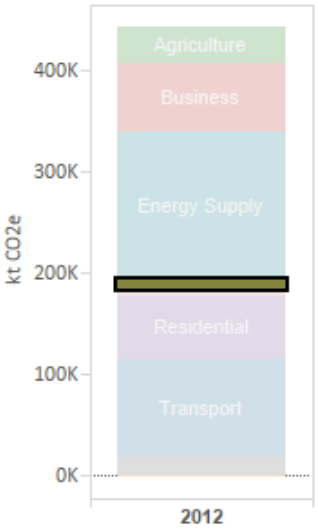
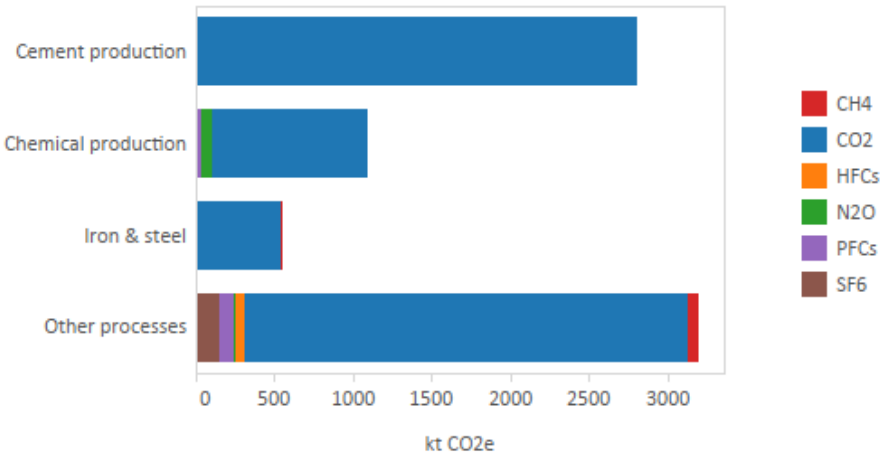


Figure 2.34: Total GHG Emissions from Industrial Process, Base Year to 2012, England

Table 2.8: Change in GHG Emissions from Base Year to 2012 and from 2011 to 2012, England

	Base Year to 2012 as %	Base Year to 2012 kt	2011 to 2012 as %	2011 to 2012 kt
Cement production	-51%	-2,983	-14%	-446
Chemical production	-96%	-24,324	19%	160
Iron & steel	-39%	-946	69%	600
Other processes	-87%	-15,166	-12%	-319
Industrial Process Total	-85%	-43,419	0%	-5

Figure 2.35: GHG Contribution to Industrial Process Emissions, 2012, England



By Source Emissions

Overview

Figures 2.33 – 2.35 show detailed emissions and trends for the sector. The Industrial Process sector contributes 1.7% to total 2012 GHG emissions in England. The Industrial Process sector includes non-combustion sources such as the use of limestone in cement production (37% of total sector emissions); Chemical production (14% of sector emissions) including fertilizers and other bulk chemicals; Iron and Steel processes (7% of sector emissions) excluding the use of electricity and fossil fuels for heating processes; Other processes (42% of sector emissions) including glass & brick making and lime production.

In 2012, 94% of total GHG emissions for the sector were from emissions of carbon dioxide from processes (primarily cement and iron and steel production), with 1% from nitrous oxide emissions from Nitric acid production. Around 4% of total GHGs emissions are from the use/production of F-Gases, predominantly PFCs and 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.

Features of the Trends

Overall, Industrial Process sector emissions in England have reduced by 85% since the Base Year to 2012 (Table 2.8). 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. The reduction seen between 1998 and 1999 is due to the adipic acid production facilities and the HCFC production plant. Emissions slightly decreased between 2011 and 2012 (0.1%) due to a significant increase in emissions from iron and steel (due to the reopening of the Teesside Steel works) offset by plant closures in the aluminium sector and lower production of cement clinker.

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, the Business and Industrial Process emissions are not easy to separate.

The contribution to total aggregate emissions from the traded and non-traded sector across the Business and Industrial Process sectors are presented in Figure 2.8 in the Overview section under the category: “Industry”. Traded emissions accounted for 37% of total Industry emissions in 2012.

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 By Source inventory emissions: in 2012, the End User estimates are only 6.5% 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 Sector

Figure 2.36: Overall Contribution to 2012 GHG emissions, England

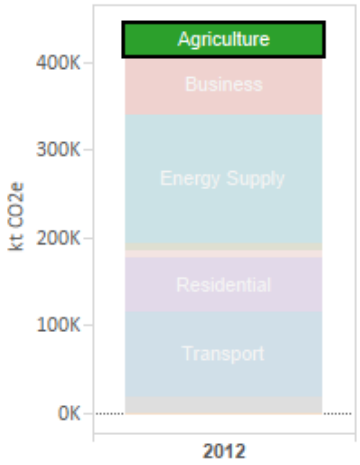


Figure 2.37: Total GHG Emissions from Agriculture, Base Year to 2012, England

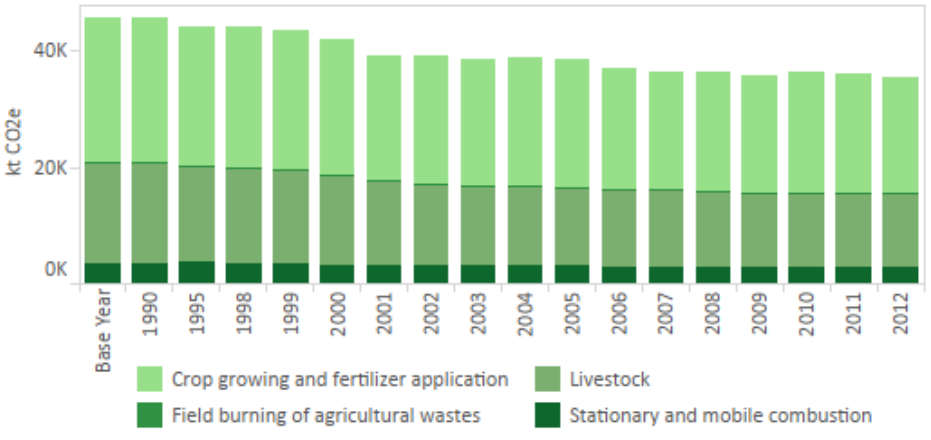


Table 2.9: Change in GHG Emissions from Base Year to 2012 and from 2011 to 2012, England

	Base Year to 2012 as %	Base Year to 2012 kt	2011 to 2012 as %	2011 to 2012 kt
Crop growing and fertilizer application	-19%	-4,667	-2%	-476
Field burning of agricultural wastes	-100%	-317		0
Livestock	-26%	-4,377	0%	-49
Stationary and mobile combustion	-21%	-747	0%	-7
Agriculture Total	-22%	-10,108	-1%	-533

Figure 2.38: Methane emissions from livestock by type, 2012, England

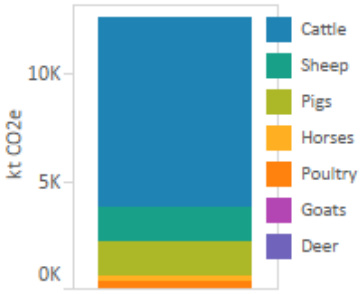


Figure 2.39: GHG Contribution for Agriculture Emissions, 2012, England

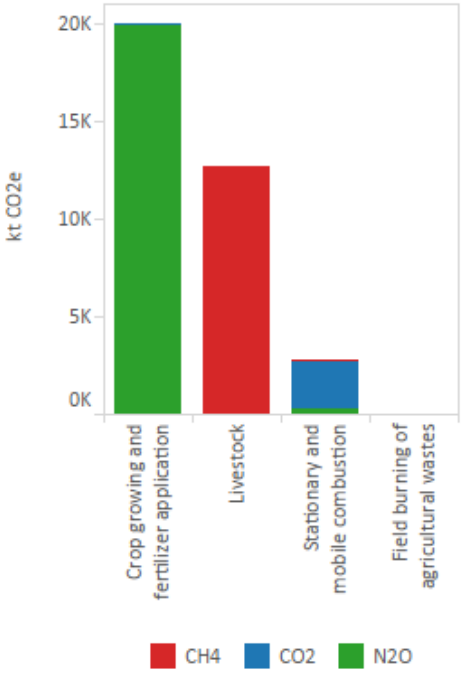


Table 2.10: Emissions of nitrous oxide from agricultural sources in 2012 (kt CO2e), England*

Manure management				1,658
Soils				18,334
	Direct			12,071
		Biological fixation		112
		Crop residues		2,184
		Fertiliser		4,487
		Grazing returns		3,171
		Histosols		585
		Improved grassland		94
		Manure application		1,238
		Sewage sludge		201
	Indirect			6,263
		Deposition		1,004
			Fertiliser	399
			Grazing returns	317
			Manure application	248
			Sewage sludge	40
		Leaching		5,259
			Fertiliser	2,991
			Grazing returns	1,189
			Manure application	929
			Sewage sludge	151
TOTAL				19,993

*Total emissions comprise manure management and soils. Soils include direct and indirect emissions; indirect emissions include leaching and deposition.

By Source Emissions

Overview

Figures 2.36 – 2.39 show detailed emissions and trends for the sector. The Agriculture sector contributed 8% to total 2012 GHG emissions in England. GHG emissions from this sector comprise mainly of nitrous oxide (57%) from fertilizer application to soils including management of manure (related to handling of manure before it is added to the soil) and methane (36%) from livestock including enteric fermentation and management of manure, with a small amount of carbon dioxide (7%) from agricultural combustion and agrochemical use.

Features of the Trends

Overall emissions from the Agriculture sector have reduced by 22% since the Base Year (Table 2.9). Methane emissions from agriculture are largely dependent on the numbers of livestock and have fallen by 27% from 1990 to 2012, mainly due to a decline in cattle and sheep numbers. There was a small decrease (0.4%) in total agricultural methane emissions from 2011 to 2012 primarily due to a decrease in cattle numbers. Field burning has largely ceased in the UK since 1993, hence the significant decrease in emissions since the Base Year.

Nitrous oxide emissions from agriculture have fallen by 19% from 1990 to 2012 resulting from a general decline in livestock numbers and in fertiliser nitrogen use (particularly to grassland). Nitrous oxide emissions decreased by approximately 2% between 2011 and 2012 due to a reduction in the production of wheat and the resulting reduction in emissions from crop residues and fertilizer.

Sector Detail

Livestock emissions include two main sub-categories: emissions from enteric fermentation (a digestive process by which carbohydrates are broken down by microorganisms into simple molecules) and emissions from manure management. Enteric fermentation contributed 67% (8,395 $ktCO_2e$) to the total agricultural methane emissions in England in 2012. Emissions from dairy and beef cattle (enteric and manure management emissions combined) accounted for 70% of the total agricultural methane emissions. Total emissions from sheep make up 13% 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. Most nitrous oxide emissions in England (90%) arise from the agricultural soils category (see Figure 2.39). A relatively small proportion (1,044 $ktCO_2e$) is emitted from the management of animal manure (emissions related to handling of manure before it is added to the soil). Table 2.10 gives a detailed breakdown of nitrous oxide emissions from agriculture for England.

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 2012, 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.

2.9 Land Use, Land Use Change and Forestry Sector

Figure 2.40: Overall Contribution to 2012 GHG emissions, England

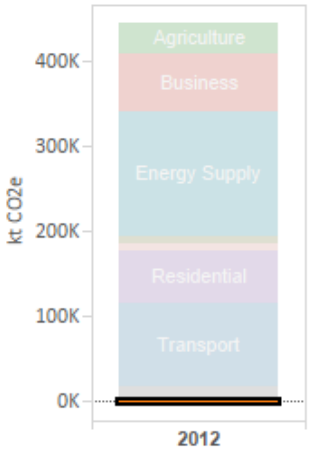


Figure 2.41: GHG Contribution to Land Use Change Emissions, 2012, England

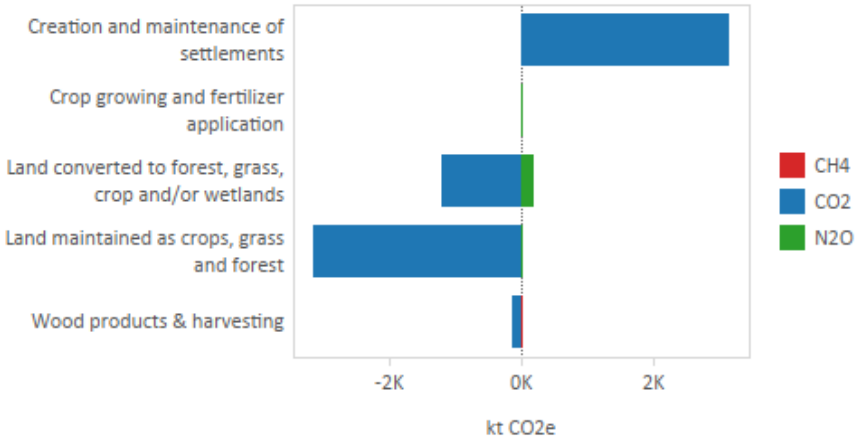
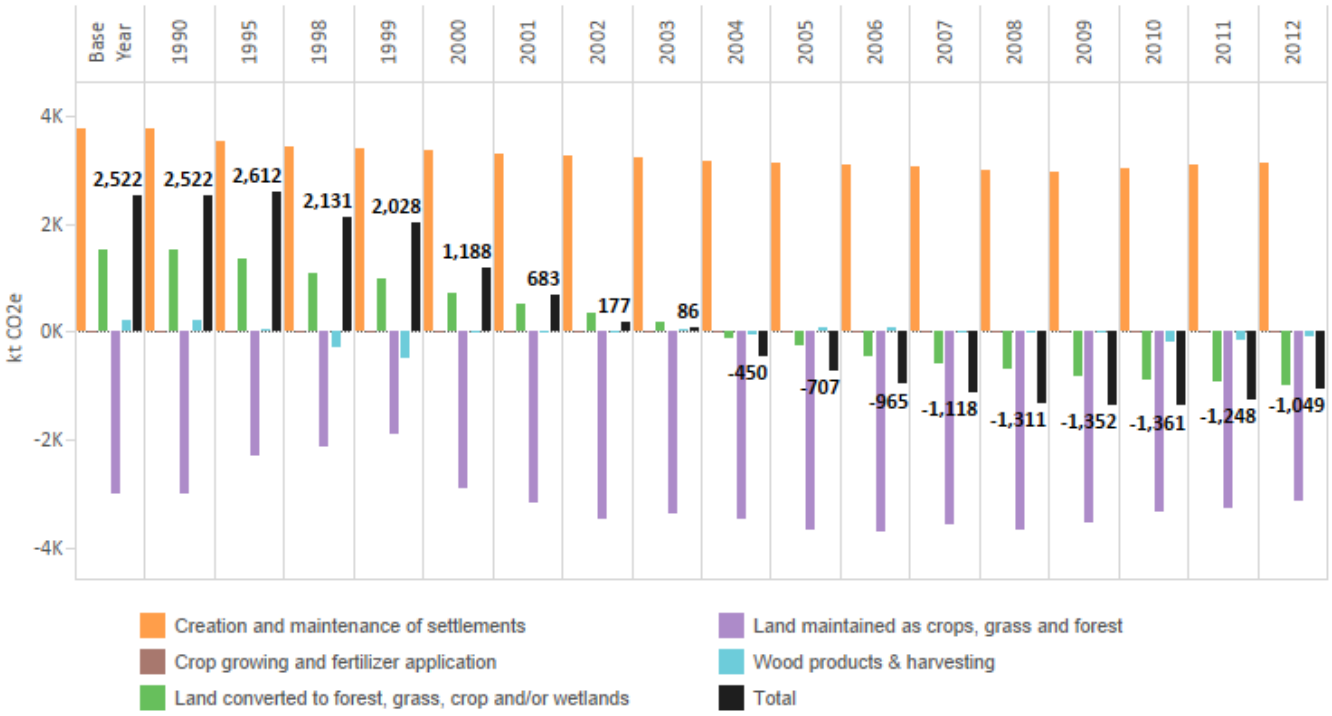


Table 2.11: Change in GHG Emissions from Base Year to 2012 and from 2011 to 2012, England

	Base Year to 2012 as %	Base Year to 2012 kt	2011 to 2012 as %	2011 to 2012 kt
Creation and maintenance of settlements	-17%	-624	2%	55
Crop growing and fertilizer application	16%	2	0%	0
Land converted to forest, grass, crop and/or wetlands	-165%	-2,509	6%	-59
Land maintained as crops, grass and forest	5%	-135	-5%	149
Wood products & harvesting	-146%	-305	-36%	55
Land Use Change Total	-142%	-3,571	-16%	145

Figure 2.42: Total GHG Emissions from LULUCF, Base Year - 2012, England



By Source Emissions

Overview

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 (Miles *et al*., 2014) and more detailed information is also available in the UK Greenhouse Gas Inventory Report, available on the NAEI website.

Figures 2.40 – 2.42 show detailed emissions and trends for the sector. England is a net sink of greenhouse gases from Land Use, Land Use Change and Forestry (LULUCF) activities (removal of 1,049 $ktCO_2e$ in 2012). In the Base Year England was a net source of emissions from LULUCF (2,522 $ktCO_2e$), having since decreased by 142%. 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[17] 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.

Features of the Trends

Table 2.11 show a 16% reduction in net removal of CO_2e from LULUCF between 2011 and 2012 (a decrease in the size of the sink), along with 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 16.5% between 1990 and 2012, and are a result of emissions from biomass removal from built-up and 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 increased, resulting in a switch of the category from a source to sink across the time series.

Net removals from Land Maintained as Crops, Grass and Forest (which includes land converted to forest) have generally increased to 2005 with a decrease between 2005 and 2012 as a result of declining removals in the harvesting of wood products (Wood Products and Harvesting).

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.

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

2.10 Waste Management Sector

Figure 2.43: Overall Contribution to 2012 GHG emissions, England

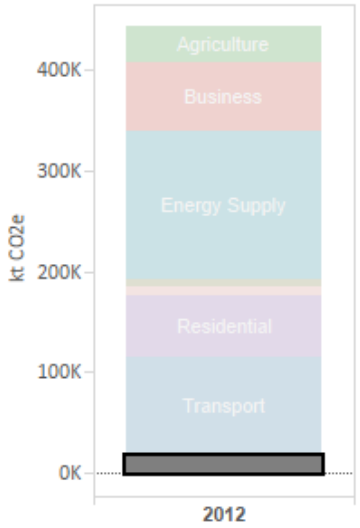


Figure 2.44: Total GHG Emissions from Waste Management, Base Year to 2012, England

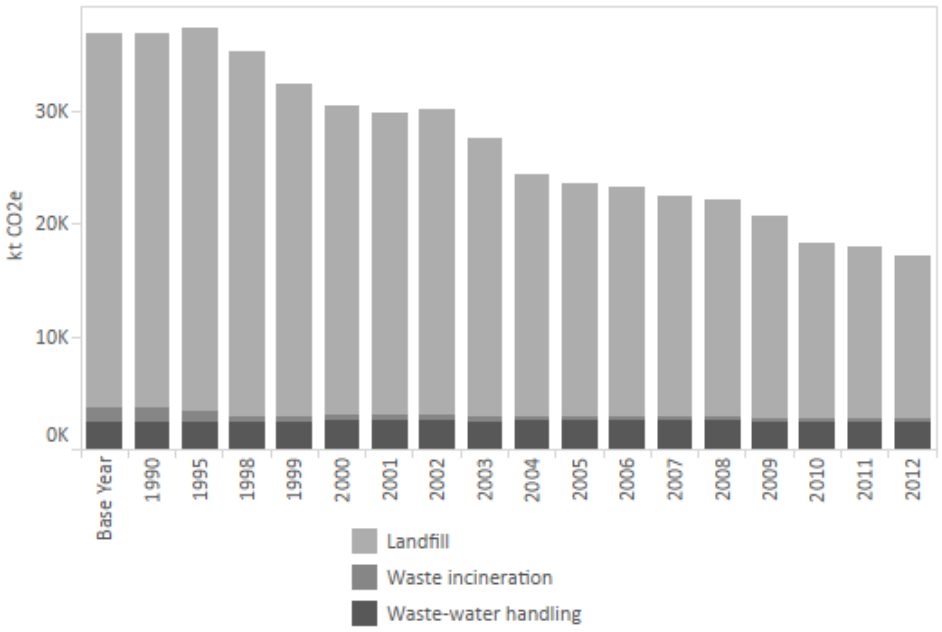
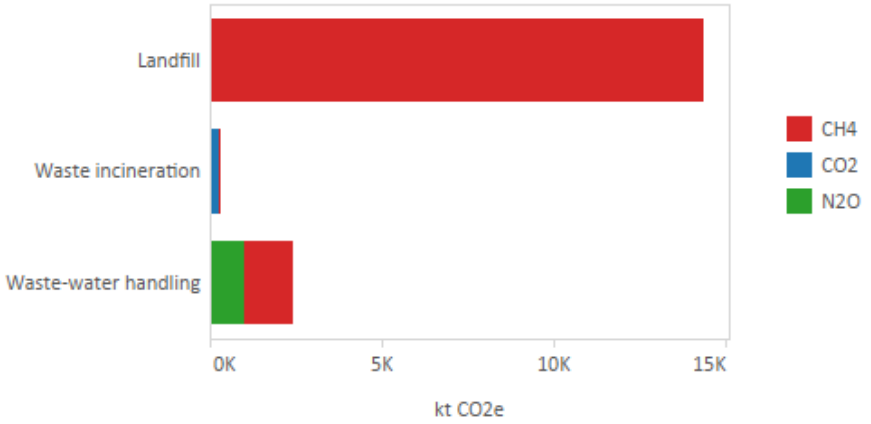


Table 2.12: Change in GHG Emissions from Base Year to 2012 and from 2011 to 2012, England

	Base Year to 2012 as %	Base Year to 2012 kt	2011 to 2012 as %	2011 to 2012 kt
Landfill	-57%	-18,796	-5%	-811
Waste incineration	-80%	-1,086	-6%	-19
Waste-water handling	2%	48	-1%	-20
Waste Management Total	-54%	-19,833	-5%	-849

Figure 2.45: GHG Contribution to Waste Management Emissions, 2012, England



By Source Emissions

Overview

Figures 2.43 – 2.45 show detailed emissions and trends for the sector. The Waste Management sector contributes 3.9% to total GHG emissions in England, and is the largest source sector for methane emissions, representing 46% of total methane emissions in 2012. Emissions from this sector are dominated by methane from landfill (84% of total GHGs from the Waste Management sector), with a smaller contribution of emissions of methane and nitrous oxide from wastewater treatment (14%). Methane emissions from industrial waste-water treatment contribute 7% of total Waste Management emissions in 2012. Emissions from landfill in England constitute approximately 78% of UK landfill emissions.

The majority of total GHG emissions are of methane (93% of total sector GHG emissions in 2012). Nitrous oxide emissions from waste water treatment represent 6% of emissions in the sector, and contribute 4% to the total emissions of nitrous oxide in England in 2012.

Features of the Trends

Table 2.12 shows the change in emissions between the Base Year and 2012, and between 2011 and 2012 for the sector. Emissions of GHGs from the Waste Management sector in England have shown a significant decline of 54% in total for the sector and by 57% from landfill between 1990 and 2012, due largely to the progressive introduction of methane capture and oxidation systems within landfill management. Sector GHG emissions have decreased between 2011 and 2012 by 5%, which is mainly due to UK-wide reductions in methane emission estimates from landfill due to improved management systems.

Emissions on an End User Basis

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

3 Emission Estimates in Scotland (1990-2012)

3.1 Overview of Total Emissions

By Source Emissions

Overview

The greenhouse gas (GHG) emissions for Scotland for 1990 – 2012 are presented in Table 3.1 and in the graph in Figure 3.1 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 2012 (excluding international aviation and shipping) were 50,531 $ktCO_2e$ with 34% of net GHG emissions in 2012 from the Energy Supply sector, 21% from Transport sources, 17% from Agriculture, 16% from Business and 14% from Residential sources. Emissions from the sector Land Use, Land Use Change and Forestry (LULUCF) have been a net sink across the time series, resulting in a net removal (-5,680 $ktCO_2e$ in 2012).

Table 3.1: 1990-2012 Scotland GHG Emission Inventory ($ktCO_2e$)

NC Format	Base Year	1990	1995	2000	2005	2008	2009	2010	2011	2012	% of 2012
Agriculture	10,811	10,811	10,711	10,430	9,658	8,948	8,788	8,792	8,744	8,603	17%
Business	11,756	11,636	8,786	9,319	9,252	8,542	7,678	7,772	8,033	8,082	16%
Energy Supply	22,399	22,399	26,481	26,033	20,512	19,978	18,583	20,730	16,895	17,129	34%
Industrial Process	1,844	1,903	562	584	536	517	397	385	443	445	1%
LULUCF [18]	-824	-824	-910	-2,570	-4,184	-4,824	-4,844	-5,263	-5,491	-5,680	-11%
Public	1,663	1,663	1,761	1,584	1,517	1,360	1,329	1,426	1,310	1,367	3%
Residential	8,188	8,153	8,137	8,245	7,919	7,716	7,251	8,321	6,551	7,277	14%
Transport	10,531	10,531	10,544	10,851	11,396	11,308	10,868	10,694	10,489	10,540	21%
Waste Management	6,696	6,696	6,745	5,235	3,893	3,588	3,383	2,965	2,923	2,769	5%
Sub-total [19]	**73,062**	**72,966**	**72,818**	**69,711**	**60,498**	**57,133**	**53,433**	**55,822**	**49,898**	**50,531**	**100%**
International aviation & shipping	2,528	2,528	2,543	2,321	2,571	3,053	2,883	2,496	2,589	2,365	
Total	**75,589**	**75,493**	**75,361**	**72,032**	**63,069**	**60,186**	**56,316**	**58,318**	**52,487**	**52,895**	

Trends

Figure 3.1 shows the full trend of emissions from the sectors, highlighting that the Energy Supply sector has consistently been the most prominent sector and is the source of much of the reduction in emissions that has been seen since 1990. This can also be seen in Figure 3.2, which also shows the relative change in emissions. These consider the change from 2011 to 2012 as well as the overall trend: 1990-2012.

As indicated in these graphs, emissions in Scotland have shown a slight increase between 2011 and 2012 of 1.3% for all GHGs, with emission reductions between the Base Year[20] and 2012 of 31% for all GHGs. Net emission reductions are the result of many factors from across the economy, including: a decline in manufacturing (e.g. closure of the Ravenscraig Steel works), efficiencies in energy generation and Business heating, an increasing carbon sink in the LULUCF 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.

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

[19] 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.

[20] 1995 for fluorinated greenhouse gases (F-Gases) and 1990 for all other gases

The reasons for the increase in emissions between 2011 and 2012 are given below for each sector along with the significance of this change. It is predominantly driven by a slight shift from natural gas back to coal (which has a higher carbon content per unit of energy) in the energy sector due to global fuel prices, and an increase in the consumption of natural gas in the Residential sector due to colder average temperatures.

The following list provides an overview of the trend for each NC sector:

- **Residential** sector emissions have, generally, decreased since the Base Year. Emissions between 2011 and 2012, however, increased by 11% (726 $ktCO_2e$) due to colder average temperatures in 2012 compared to 2011.
- **Energy Supply** sector emissions have decreased by 24% between the Base Year and 2012. There was an increase in overall emissions between 2011 and 2012. This 1% increase (233 $ktCO_2e$) was mainly due to a shift from natural gas to coal in power stations due to global fuel prices.
- **LULUCF** sector has been a net sink since the Base Year. The sink has increased by 3% between 2011 and 2012 (-195 $ktCO_2e$).
- **Waste Management** sector emissions have significantly declined by 59% since the Base Year, largely due to the progressive introduction of methane capture and oxidation systems within landfill management. Emissions decreased by 5% (154 $ktCO_2e$) between 2011 and 2012 in line with this decline.
- **Agriculture** sector emissions have reduced by 21% since the Base Year mainly due to a decrease in livestock numbers. There was a small decrease of 2% (141 $ktCO_2e$) in emissions from 2011 to 2012 mainly due a reduction in the production of wheat and the resulting reduction in emissions from crop residues and fertilizer.
- **Public** sector emissions have reduced by 18% since the Base Year. This is due to increased energy efficiency measures and the switch to gas-fired heating. However, emissions between 2011 and 2012 increased by 4% (57 $ktCO_2e$) due mainly to an increase in natural gas consumption in 2012 in response to the mild winter of 2011.
- **Transport** sector emissions have increased by only 0.1% between the Base Year and 2012 due to strong growth in transport demand over the period coupled with improvements in efficiency of transport vehicles. Emissions between 2011 and 2012 decreased by less than 1% (50 $ktCO_2e$).
- **Business** sector emissions have reduced by 31% since the Base Year. Emissions have, however, slightly increased by 1% (49 $ktCO_2e$) between 2011 and 2012 caused mainly by an increase in coal consumption in the other industrial combustion category, and a decrease in emissions from natural gas in the chemicals industry.
- **Industrial Process** emissions have decreased significantly since the Base Year (76%). Emissions slightly increased by 0.5% between 2011 and 2012 (2.3 $ktCO_2e$) due to a decrease in emissions from cement production balanced by an increase in emissions from ethylene production.

Emissions Detail

Detailed analysis of Scotland emissions in 2012 is presented in Figures 3.1 – 3.5. The dominant sub-categories in the inventory for 2012 are displayed in Figure 3.5. These include emissions from electricity production (25% of total), road transport (18% of total), Residential combustion for heating and cooking (14% of total), industrial combustion for heat and electricity in the Business sector (14% of total) as well as the removal of emissions from the sub-category Land Maintained as Crops, Grass and Forest (-16% of total).

Figure 3.3 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 Management where methane from landfills is the main GHG emission source (see Figure 3.4).

International Aviation and International Shipping

Emissions from international aviation in the UK have increased significantly since 1990, with emissions from Northern Ireland increasing by 172%, Scotland increasing by 109% and England by 106%. This reflects the growth in aviation and the increase in international routes at airports in Scotland and Northern Ireland in particular. From 2011 to 2012, emissions have decreased in all Devolved Administrations from -2% in Scotland to -17% in Wales.

UK emissions from international shipping have decreased between 1990 and 2012 and emissions from Scotland have decreased by 35% over this time period. The UK shows a drop in emissions between 2011 and 2012 and Scotland emissions have decreased by 13%. These trends are primarily due to a continual decrease in Scotland's port freight movements.

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 (Salisbury *et al.,* 2013). The impact of these revisions to Scotland GHG emission estimates for 2011 is an increase of 1,104 $ktCO_2e$ (2.2%) primarily due to:

1. **Harvested Wood (LULUCF)**: (1,260 $ktCO_2e$ increase in 2011) due to the methodological improvement of the use of the CARBINE carbon accounting model for carbon stock change modelling and the inclusion of emissions from all forests older than 20 years in the Forest remaining Forest Land category – instead of just from post-1921 forests as was reported in previous submissions. The deforestation areas have also been updated.
2. **Commercial and Institutional combustion (Business and Public)**: (878 $ktCO_2e$ increase in 2011) due predominantly to a major revision to the UK natural gas allocation to the public sector within the Digest of UK Energy Statistics (DECC, 2013b) which affects recent years (from 2008 onwards, with very large revisions in 2010, 2011). In addition, improvements to energy mapping analysis, to use new datasets such as Display Energy Certificates to over-write previous energy modelling assumptions on building energy demand, have led to a higher allocation of public sector emissions to Scotland than was previously estimated.
3. **Land Converted to Forest Land (LULUCF)**: (647 $ktCO_2e$ increase in 2011) due to the implementation of the CARBINE model to estimate emissions from LULUCF. This change in methodology has led to significant recalculations across the time series. CARBINE can represent a comprehensive range of forest tree species relevant to the UK, representing UK growth conditions and management practices, and combining area / age class information for carbon stocks. Compared to previous estimates, this more detailed methodology based on application of CARBINE provides greater representation of Forest Land and the range of forest management practices observed in the UK.
4. **Manure Management of Cattle (Agriculture)**: (461 $ktCO_2e$ increase in 2011) due to revisions of the allocation of manure into the various management systems. In particular, the estimated amounts going to daily spread were reduced significantly and the amounts previously allocated to solid storage were reallocated to deep litter leading to an increase from 1% to 39% in the methane conversion factor.
5. **Managed Waste Disposal on Land (Waste Management)**: (746 $ktCO_2e$ increase in 2011) due to revisions to the estimated methane recovery at UK landfills within the inventory model; the methane recovery rate is now based on the analysis of available data on landfill gas collected and burnt in landfill gas engines and flares.

There are also a number of sub-categories that have seen a significant reduction in emission estimates for 2011, which offset part of the impact of the recalculations described above. For more details of revisions to GHG emission estimates, see Appendix 6.

Figure 3.1: Total GHG Emissions by NC category for Base Year to 2012, as kt CO2e, Scotland

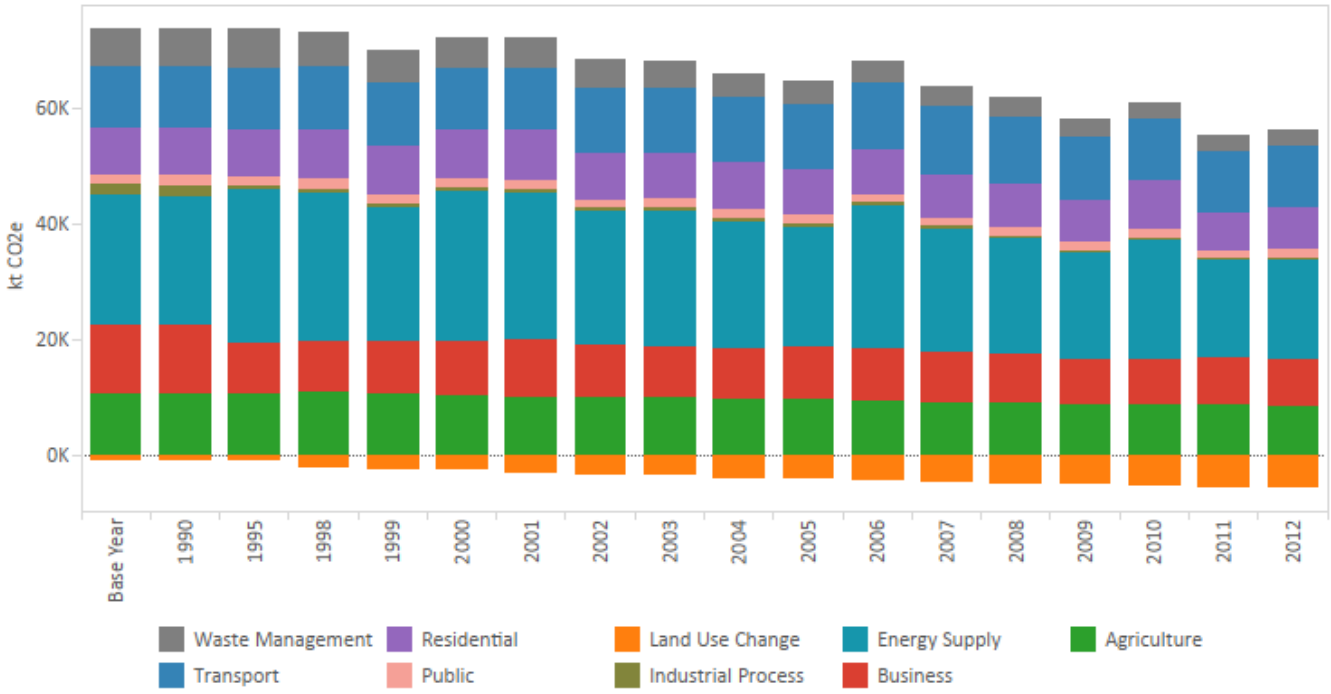


Figure 3.2: Percentage Change and Absolute (kt CO2e) Change in GHG Emissions by NC: Base Year(BY) - 2012 and 2011 - 2012, Scotland

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

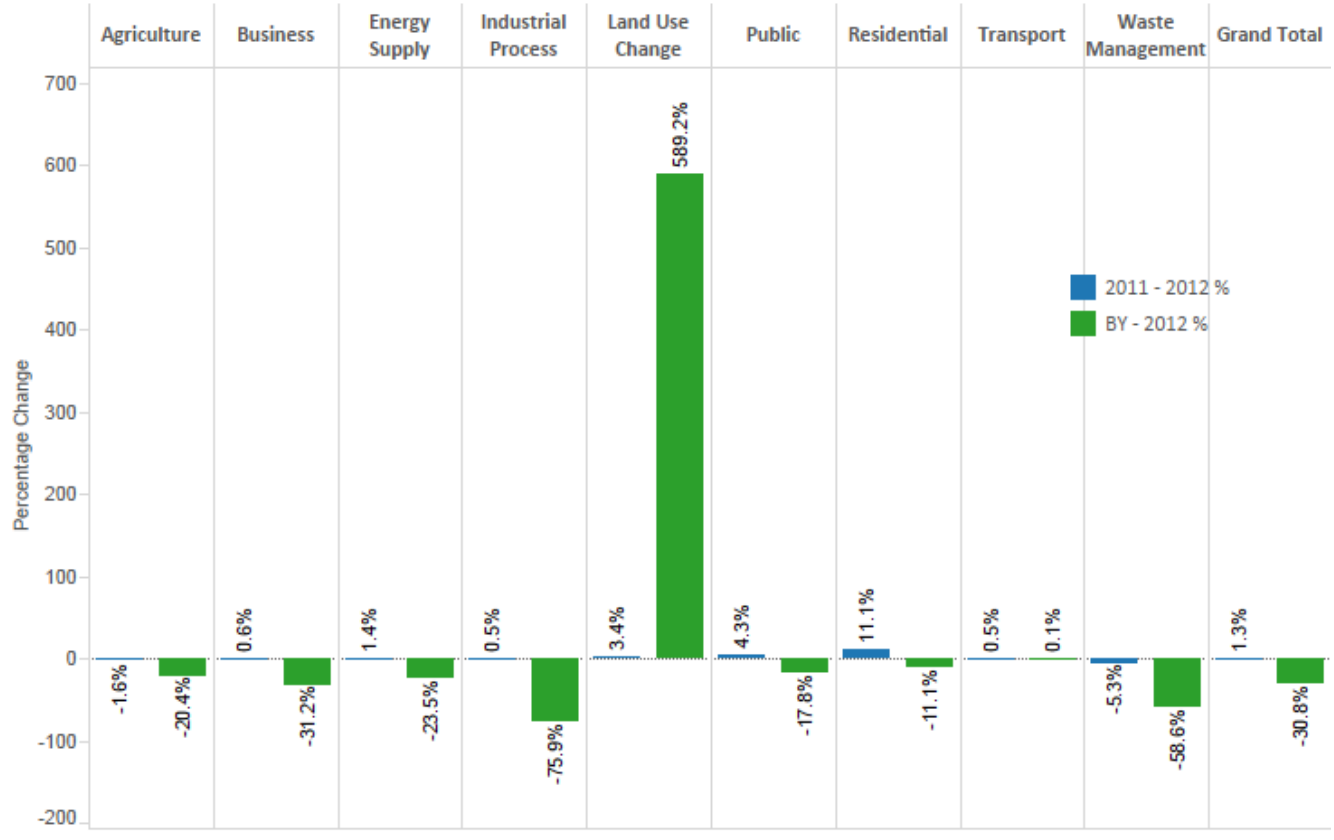


Figure 3.3: Total GHG emissions and uncertainties by pollutant, 2012, Scotland

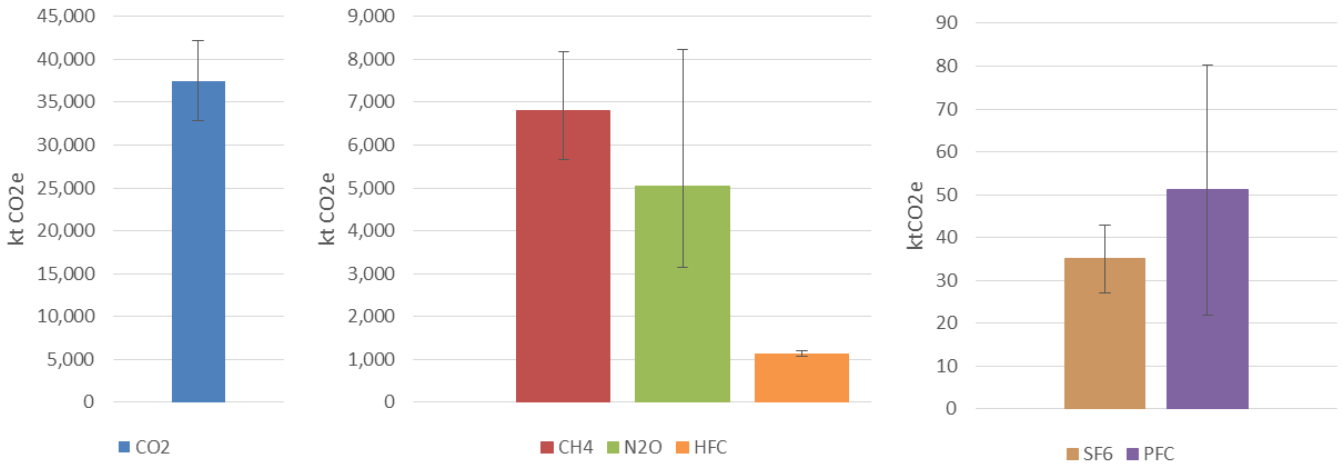


Figure 3.4: Total GHG Emissions by NC and pollutant, 2012, Scotland

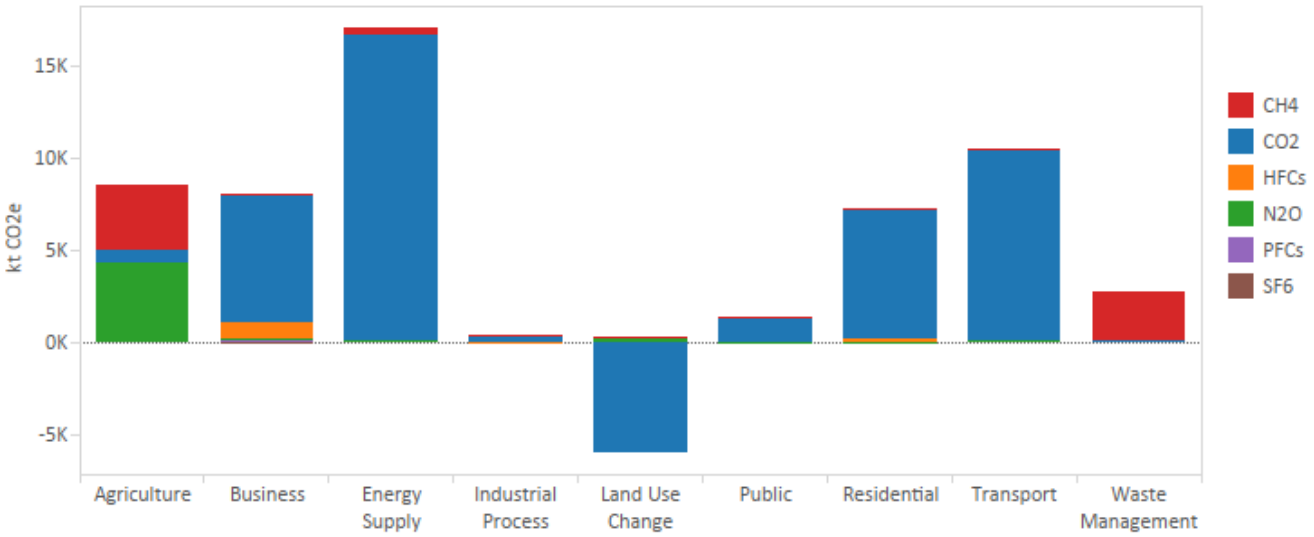
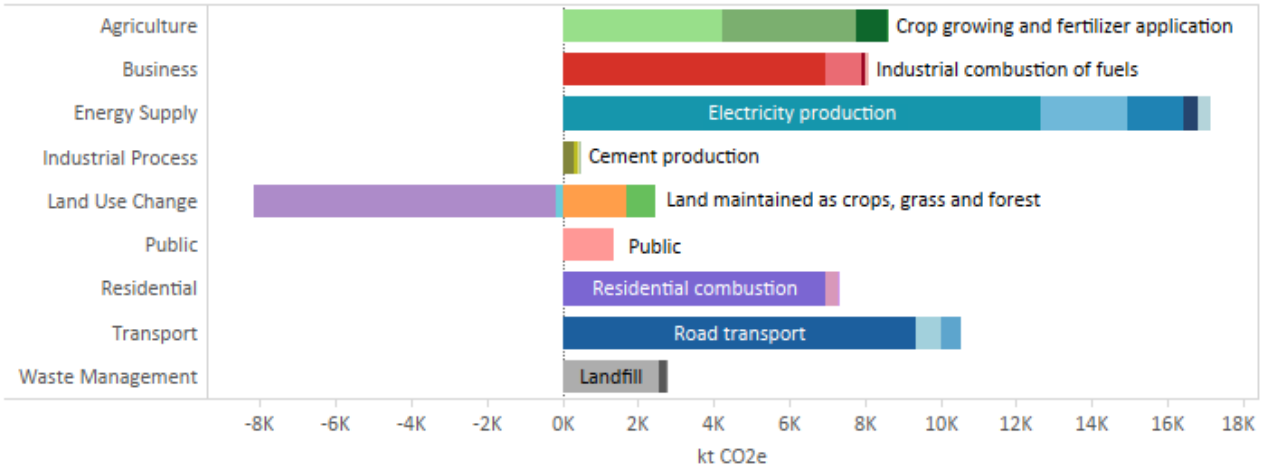


Figure 3.5: Total GHG Emissions labelling the largest sub-category in each NC, 2012, Scotland



Traded and Non-Traded Emissions

Emissions from installations in the European Union Emissions Trading System (EU ETS) (see Figure 3.6) contributed 40% of total net GHG emissions in Scotland in 2012. The main contributors to these traded emissions are the Energy Supply sector of which 96% 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 3.7 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 12% between 2009 and 2010, which was a much higher growth than the UK average of 4% 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%. The trend in the traded sector in 2011-2012 has remained stable, increasing by only 1%.

Figure 3.6: Total Traded and Non-Traded GHG Emissions by NC Category, 2012, Scotland

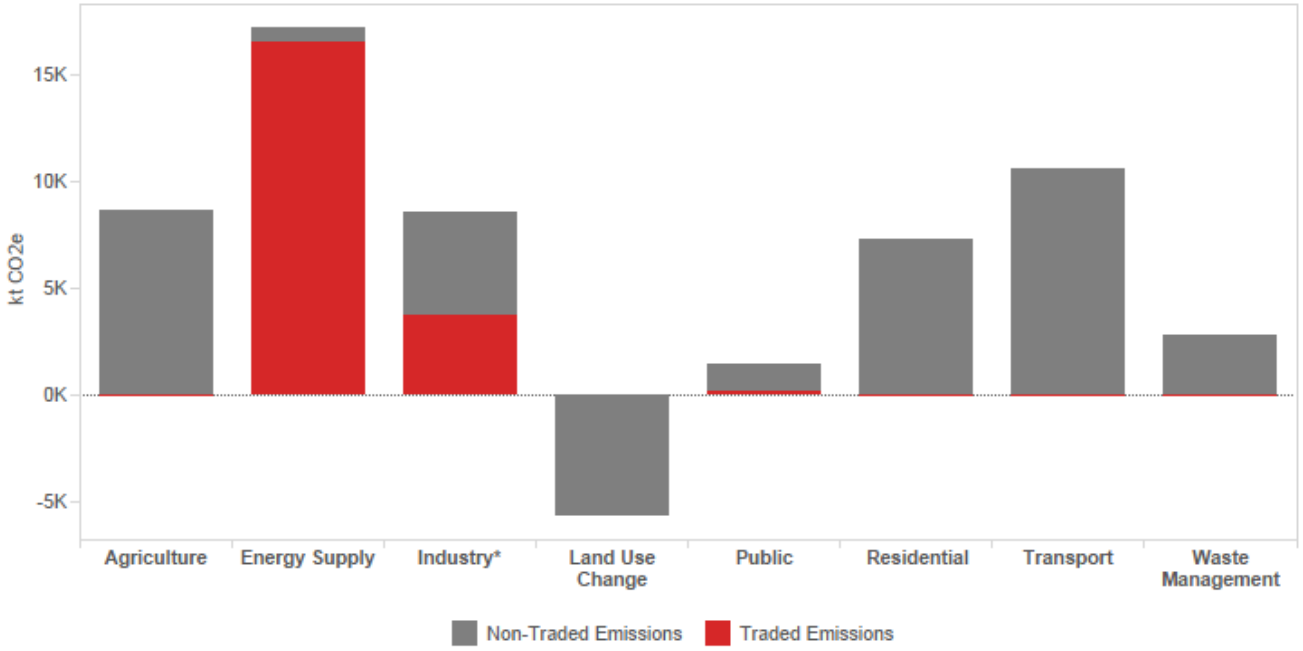


Figure 3.7: Total Traded and Non-Traded GHG Emissions 2008-2012, Scotland

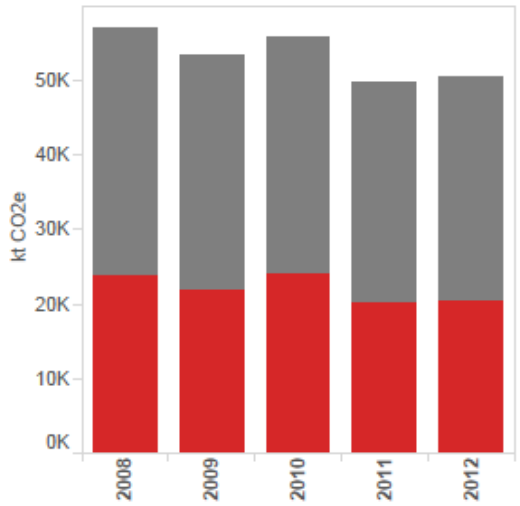
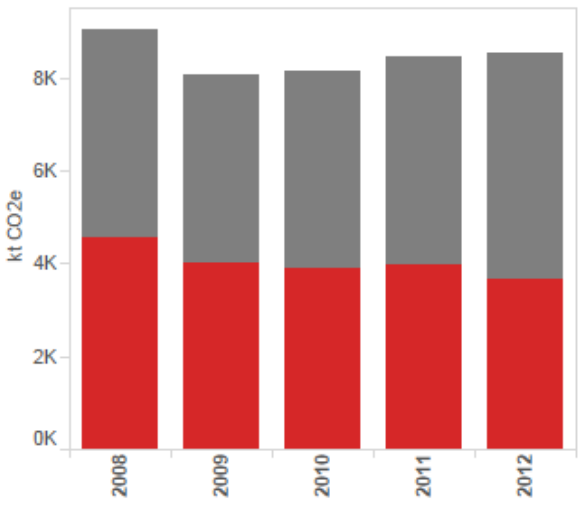


Figure 3.8: Traded and Non-Traded GHG Emissions from Industry 2008-2012, Scotland*



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

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 3.9 illustrates the difference between the By Source and End User inventory emission estimates and how emissions from the Energy Supply sector are attributed to the other sectors.

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 2012 are: 32% from Business, 24% from the Residential sector and 23% from Transport sources. As illustrated in Figure 3.9, Scotland has slightly higher net GHG emissions in Scotland on an End User basis (52,022 $ktCO_2e$), compared to the By Source inventory estimates for 2012 (50,531 $ktCO_2e$). 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 only slightly higher than the By Source estimates at 50,577 $ktCO_2e$.

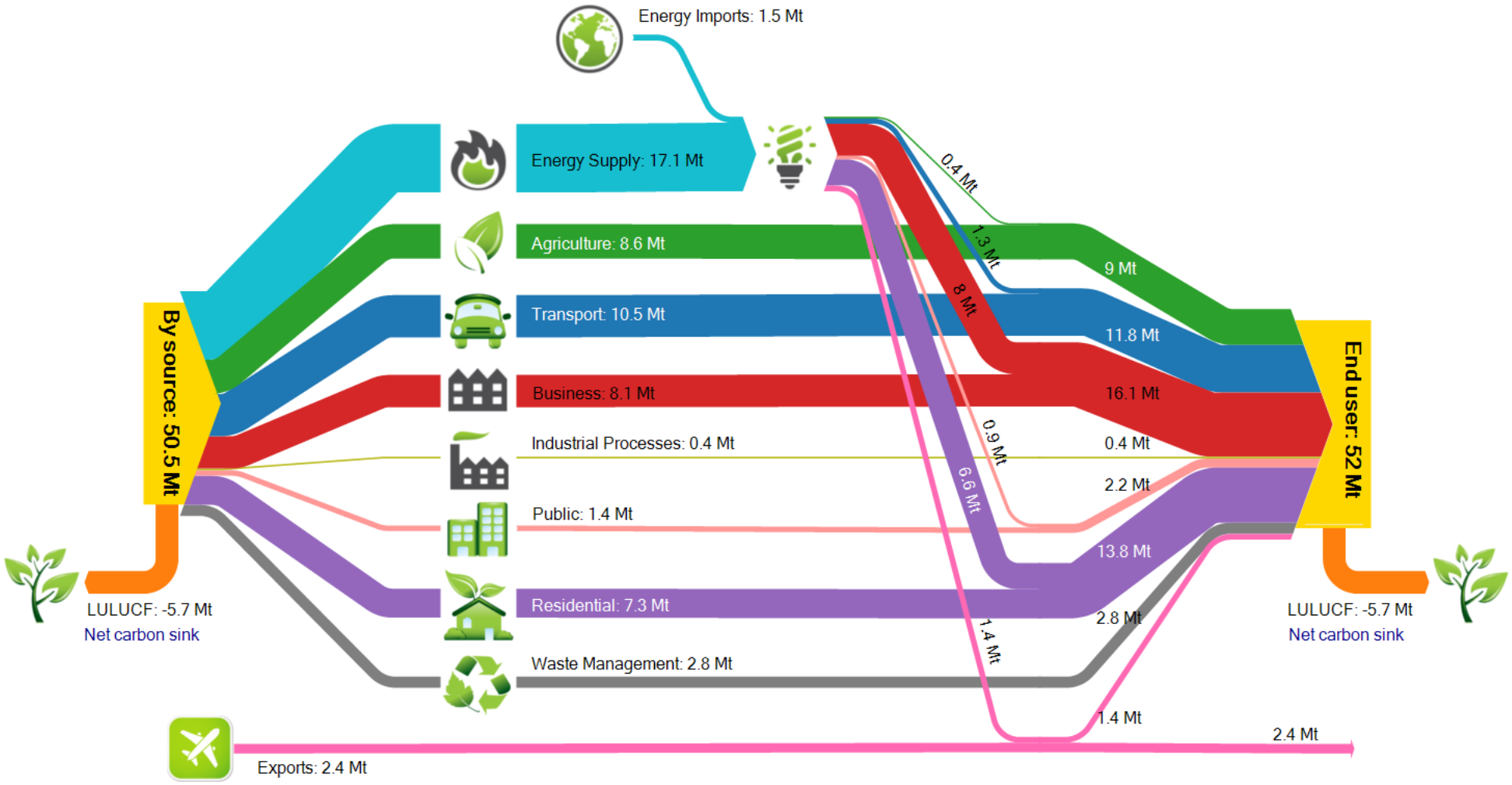
The End User model applies a UK-wide greenhouse gas emission factor to electricity use, and this has an important impact on the data for Scotland, in particular. Scotland is a net exporter of electricity. However, the End User model (see Figure 3.9) implies that Scotland is a net importer of electricity.

This is because the greenhouse gas emissions ($ktCO_2e$) per unit of electricity (GWh) in Scotland are very much lower than the UK average in 2012 due to the higher proportion of renewable and nuclear generation in the Scotland power sector. However, as previously stated, the End User model applies a UK-wide GHG emission factor to electricity use, so does not take into account the lower emission factor for Scotland. This increases the total emissions for Scotland in the End User model. As a result, the total End User emissions are actually higher than the By Source Energy Supply sector emissions. This implies that Scotland is a net importer of electricity, which is not the case.

Scotland is a net exporter of electricity to the rest of the UK in 2012, but 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 2012 are unchanged between the By Source and End User inventories, since there are no emissions from energy use allocated to these sectors.

Figure 3.9 Sankey diagram showing By Source and End User[21] GHG emission transfers for Scotland in 2012 (Mt CO_2e)[22]



[21] 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.

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

3.2 Energy Supply Sector

Figure 3.10: Overall Contribution to 2012 GHG emissions, Scotland

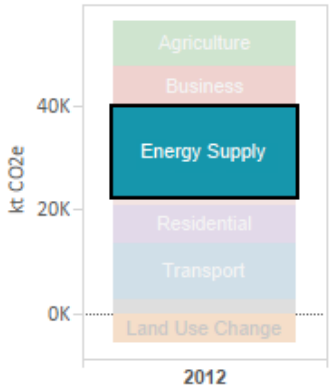


Figure 3.11: GHG Contribution to Energy Supply Emissions, 2012, Scotland

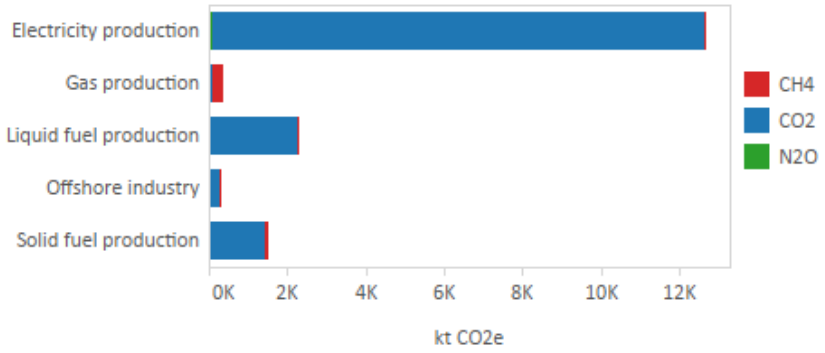


Table 3.2: Change in GHG Emissions from Base Year to 2012 and from 2011 to 2012, Scotland

	2011 - 2012 %	2011 - 2012 kt	BY - 2012 %	BY - 2012 kt
Electricity production	4%	521	-14%	-2,127
Gas production	-6%	-23	-63%	-606
Liquid fuel production	0%	-5	-22%	-655
Offshore industry	-30%	-135	-73%	-855
Solid fuel production	-8%	-124	-40%	-1,027
Energy Supply Total	1%	233	-24%	-5,270

Table 3.3: NC Category Contribution to End User Inventory by percentage of Electricity Production Emissions, Scotland

Agriculture	2%
Business	53%
Industrial Process	0%
Public	5%
Residential	39%
Transport	1%
Exports*	0%

Figure 3.12: Total GHG Emissions from Energy Supply, Base Year to 2012, Scotland

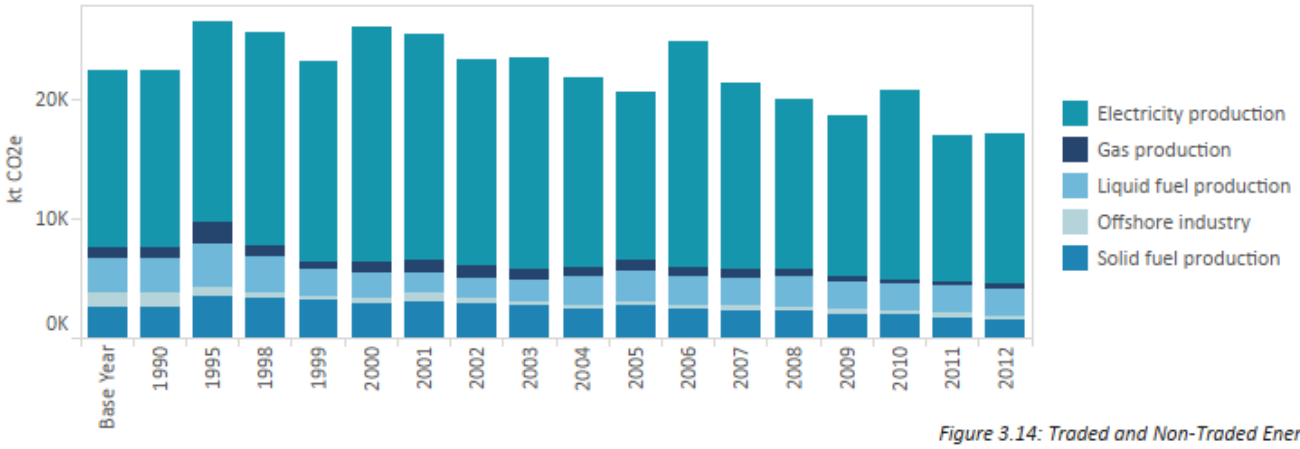


Figure 3.13: Emissions and Electricity Production by Fuel Type from Major Power Producers (1A1a), Scotland

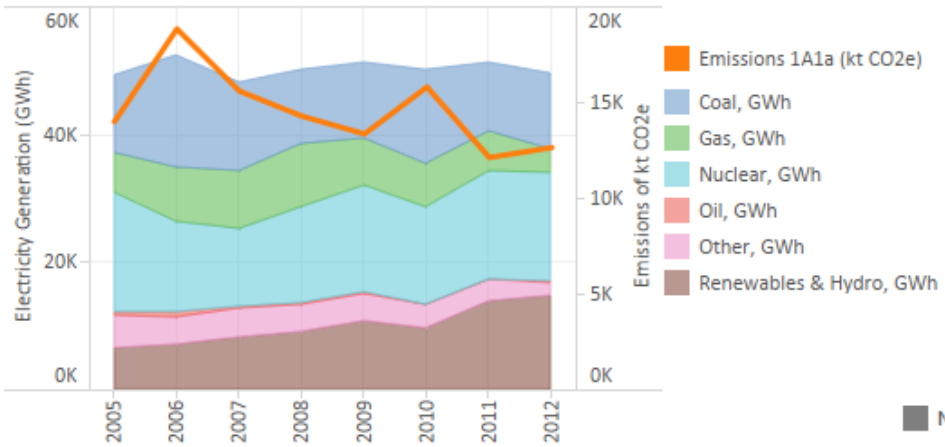
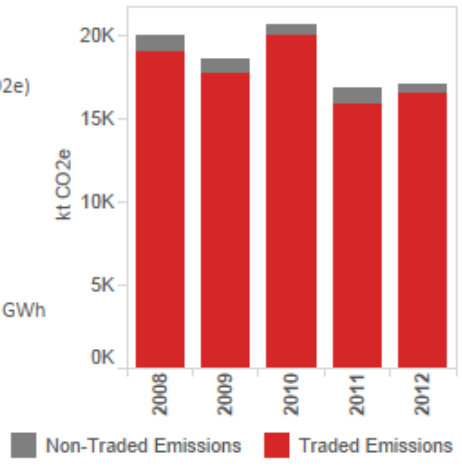


Figure 3.14: Traded and Non-Traded Energy Supply Emissions, 2008-2012, Scotland



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

By Source Emissions

Overview

Figures 3.10 – 3.14 show detailed emissions and trends for the Energy Supply sector. In Scotland, Energy Supply sources contribute 34% to total 2012 GHG emissions. Energy Supply includes emissions from power generation, refineries, coal mines, solid fuel transformation, oil and gas extraction and processing, and other energy industries. The main source of emissions in Scotland within the Energy Supply sector is electricity generation at power stations, which accounts for 74% of Energy Supply emissions in 2012; refinery emissions account for a further 13% of the Energy Supply sector emissions in 2012.

Features of the Trends

Table 3.2 shows the change in emissions between the Base Year and 2012, and between 2011 and 2012 for the sector. Energy Supply sector emissions have reduced by 24% since the Base Year, compared to the UK average of 26% reductions. Emissions have declined across many sectors such as coal mining, upstream oil and gas production, coke manufacture (due to closure of Ravenscraig Steel works) and oil refining. Emissions from power stations in Scotland have reduced by 14% between the Base Year and 2012, whereas the UK average is a 22% 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 increased by 6% between 2011 and 2012. This is primarily due to international fuel prices leading to a shift from natural gas to coal and therefore higher emissions.

Sector Detail

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 2012 from nuclear power (34%) and renewable sources of energy (30%, mainly hydro-electricity and onshore wind). The remaining generation capacity is predominantly from coal-fired stations (24% of Scottish power generation in 2012), whilst Scotland has a notably lower share of electricity production from gas-fired stations, at only 7% of the Scottish electricity generation total in 2012 compared to a UK average of 24%.

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 95% of total GHG emissions from the Energy Supply sector in Scotland in 2012.

Traded and Non-Traded Emissions

Emissions in the Energy Supply sector are dominated by installations within the European Union Emissions Trading Scheme (EU ETS), with 96% of emissions in this sector allocated to the traded sector (EU ETS). These traded emissions are primarily from power stations, refineries and upstream oil and gas terminals. See Figure 3.14 for the trend of Traded/Non-Traded emissions.

Emissions on an End User Basis

The “By Source” inventory allocates emissions to the Devolved Administrations 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 (see Table 3.3). Therefore, in 2012, as Scotland consumed 8% of total electricity in the UK, the Scotland End User inventory includes a total allocation of 8% of emissions associated with electricity production.

However, as noted 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 2012, 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 3.3. On an End User basis, Business and Residential demand for electricity in Scotland in 2012 accounts for 47% and 38% of electricity supply emissions respectively.

3.3 Transport Sector

Figure 3.15: Overall Contribution to 2012 GHG emissions, Scotland

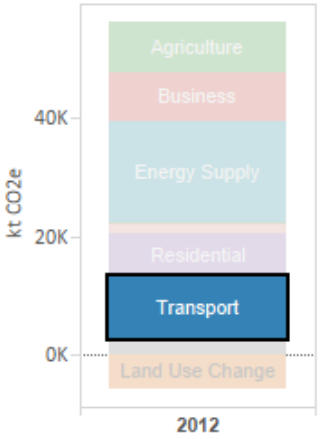


Figure 3.16: Total GHG Emissions from Transport, Base Year to 2012, Scotland

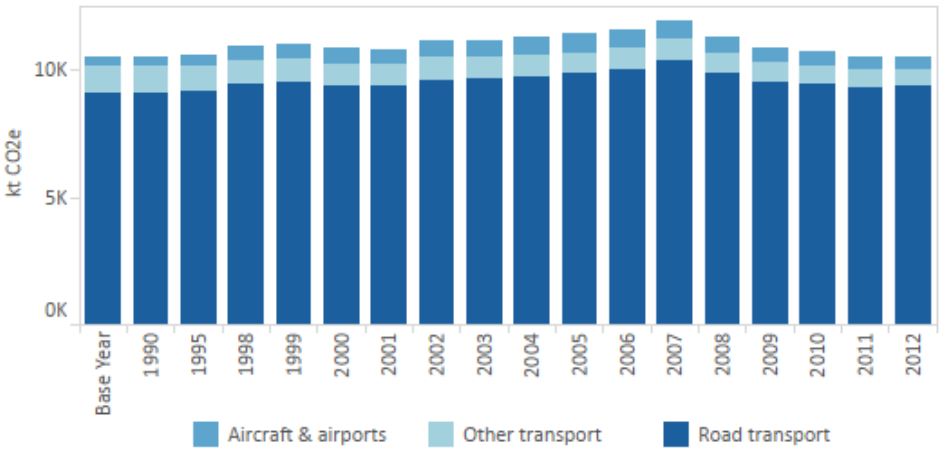


Table 3.4: Change in GHG Emissions from Base Year to 2012 and from 2011 to 2012, Scotland

	Base Year to 2012 as %	Base Year to 2012 kt	2011 to 2012 as %	2011 to 2012 kt
Aircraft & Airports	30.1%	117.0	-1.1%	-5.8
Road Transport	2.9%	264.5	0.8%	76.7
Other Transport	-35.2%	-372.5	-2.9%	-20.8
Transport	0.1%	9.0	0.5%	50.1

Figure 3.17: GHG Contribution for Transport Emissions, 2012, Scotland

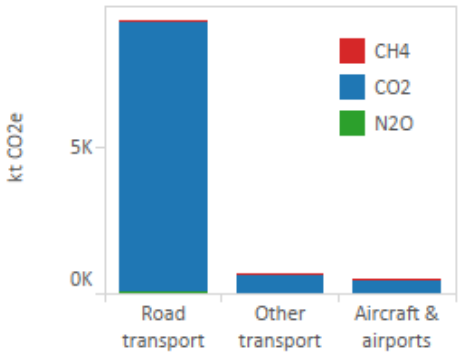


Figure 3.18: Comparison of End User and By Source for Transport, Scotland

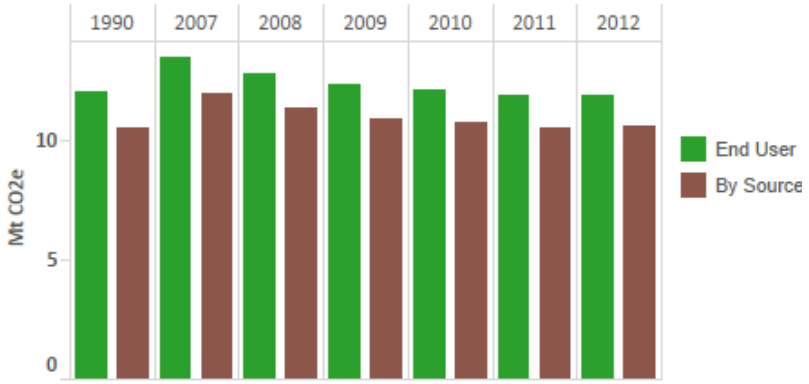


Figure 3.19 Road Transport CO2 Emissions (fuel sales basis), Scotland

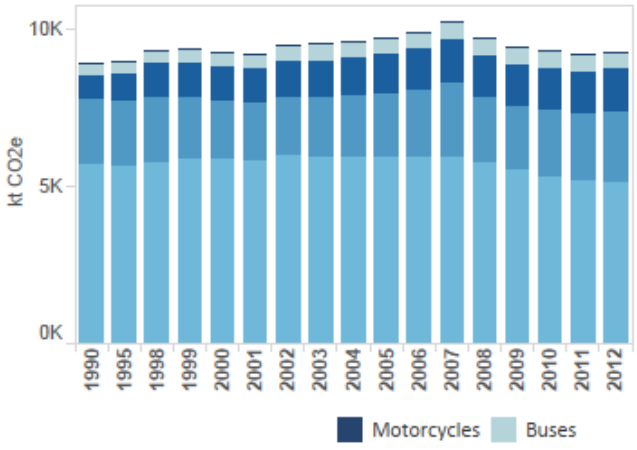
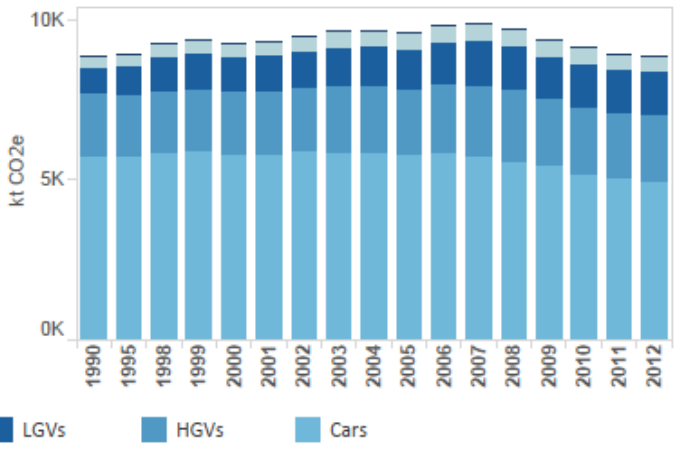


Figure 3.20: Road Transport CO2 Emissions (vkm basis), Scotland



By Source Emissions

Overview

Figures 3.15 – 3.20 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 and the methodology is presented in Appendix 2.

Transport emissions accounted for 21% of Scotland's total GHG emissions in 2012. Transport emissions were dominated by emissions from road transport (89% of all Transport emissions in 2012, with 49% of transport emissions from cars alone). The Transport sector also includes 2% from rail (including stationary sources), 3% from national navigation and coastal shipping, 4% from domestic aviation and 2% from military aviation and shipping.

Features of the Trends

Table 3.4 shows the change in emissions between the Base Year and 2012, and between 2011 and 2012 for the sector. Total GHG emissions from the Transport sector in Scotland have increased minimally (by 0.1%) between the Base Year and 2012 despite improvements in efficiency of transport vehicles, as a result of strong growth in transport demand. Emissions peaked in 2007 and have since declined partly due to improvements in average fuel efficiency of vehicles and the switch from petrol to diesel cars and from a reduction in traffic volumes.

Emissions between 2011 and 2012 have not seen any significant change, with a small increase of 0.5% in total. This sector is driven by the changes in emissions from passenger cars. Although emissions from petrol have decreased, emissions from road diesel (DERV) have significantly increased, which has led to this overall, small increase in emissions.

Sector Detail

There are two approaches used to calculate emissions from Road Transport: fuel sales basis – emissions are constrained to the total fuel sold within the UK as stated in DUKES (DECC, 2013b); vehicle kilometre basis – emissions are estimated using vehicle km data and are not constrained by the total fuel sold, so estimate emissions based on fuel used within the UK. The inventory emission estimates for Road Transport are calculated on a fuel sold basis and are, therefore, consistent with DUKES.

Figures 3.19 and 3.20 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 4.2% lower than the estimates constrained to DUKES for 1990 and 2012, respectively. The differences between the two approaches fluctuate year on year but they remain within 4.2% 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 2012) 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 decreased by 0.01% between the Base Year and 2012, while the constrained approach indicates a 3.6% increase.

Emissions on an End User Basis

Figure 3.18 shows 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. 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% by 2012, 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.

3.4 Residential Sector

Figure 3.21: Overall Contribution to 2012 GHG emissions, Scotland

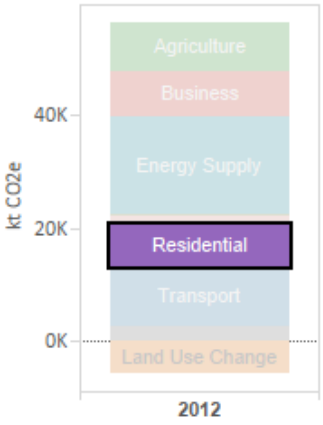


Figure 3.22: Total GHG Emissions from Residential, Base Year to 2012, Scotland

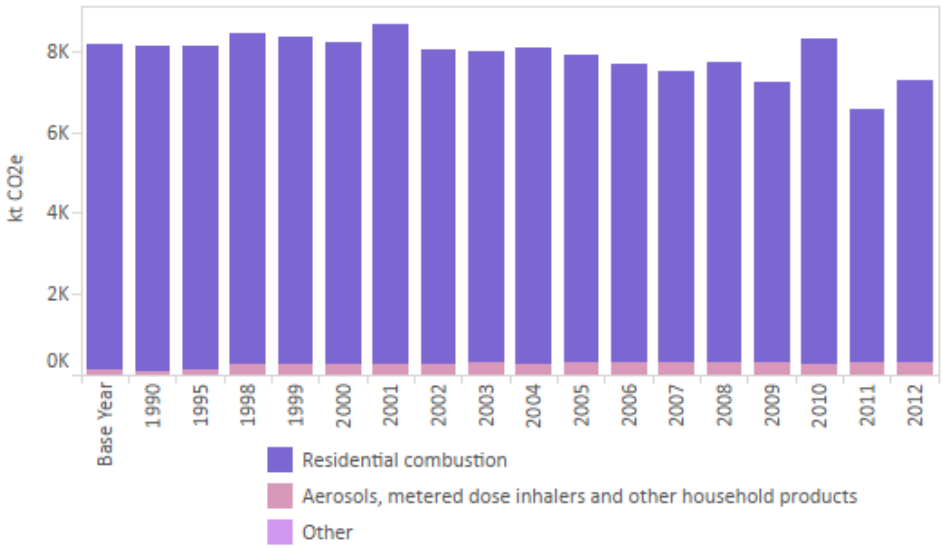


Table 3.5: Change in GHG Emissions from Base Year to 2012 and from 2011 to 2012, Scotland

	Base Year to 2012 as %	Base Year to 2012 kt	2011 to 2012 as %	2011 to 2012 kt
Aerosols, metered dose inhalers and other household products	106%	152	1%	2
Other	-47%	0	0%	0
Residential combustion	-13%	-1,063	12%	724
Residential Total	-11%	-911	11%	726

Figure 3.23: GHG Contribution for Residential Emissions, 2012, Scotland

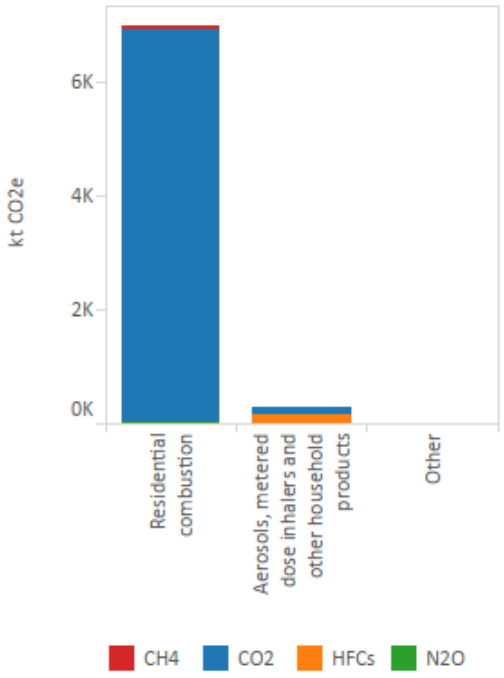
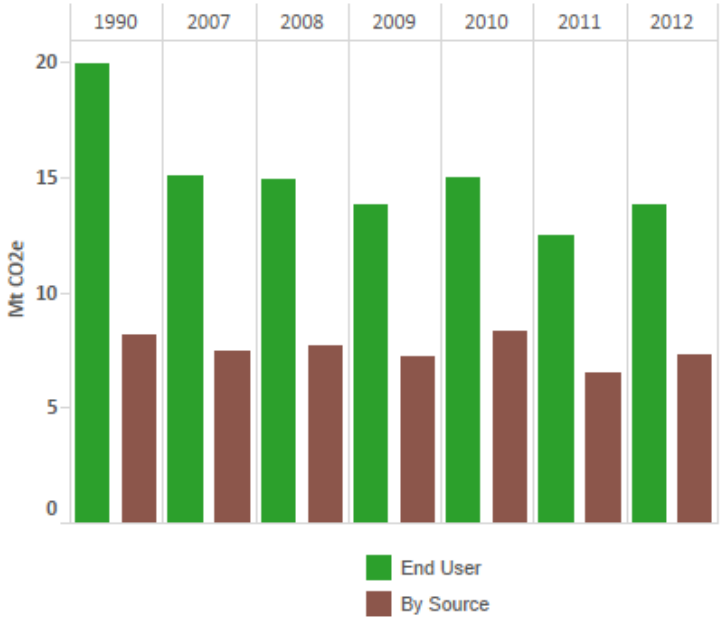


Figure 3.24: Comparison of End User and By Source for Residential, Scotland



By Source Emissions

Overview

Figures 3.21 – 3.24 show detailed emissions and trends for the sector. The Residential sector accounted for 14% of Scotland's total net GHG emissions in 2012. The sector comprises emissions from domestic 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-related) inhalers. Over 97% of all Residential sector GHG emissions are from the release of carbon dioxide from the direct combustion of fossil fuels (see Figure 3.23).

Features of the Trends

Table 3.5 shows the change in emissions between the Base Year and 2012, and between 2011 and 2012 for the sector. Total GHG emissions from the Residential sector in Scotland have decreased by 11% between the Base Year and 2012. 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 fuel heating in many parts of Scotland.

Emissions from this sector then decreased by 21% between 2010 and 2011 due to a warm winter. Emissions have increased by 11% between 2011 and 2012 due to a switch in favour of coal consumption over natural gas in power stations. These trends result in an overall decrease of emissions from 2009 to 2012 of only 0.4%.

Emissions on an End User Basis

Figure 3.24 shows that in 2012 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 27% of the Scotland total, compared to just 14% of the By Source inventory total. The trend in the Residential sector End User emissions since 1990 shows a decline of 31% to 2012. 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.

3.5 Business Sector

Figure 3.25: Overall Contribution to 2012 GHG emissions, Scotland

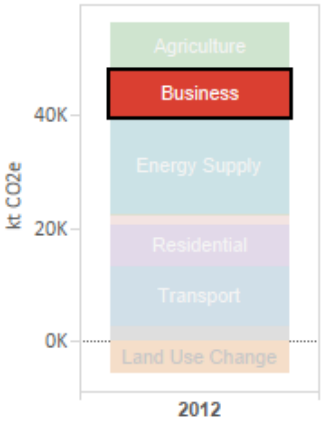


Figure 3.26: Total GHG Emissions from Business, Base Year to 2012, Scotland

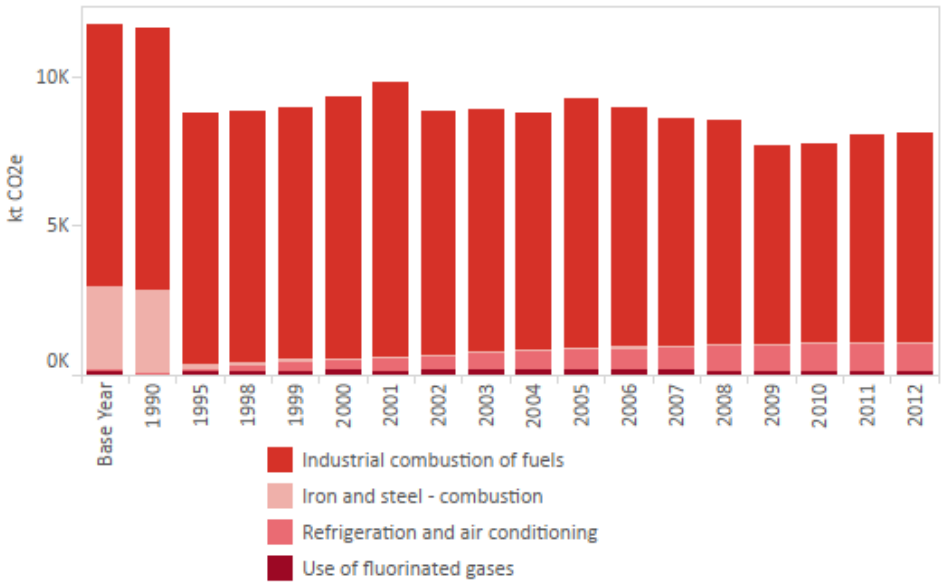


Table 3.6: Change in GHG Emissions from Base Year to 2012 and from 2011 to 2012, Scotland

	Base Year to 2012 as %	Base Year to 2012 kt	2011 to 2012 as %	2011 to 2012 kt
Industrial Combustion of fuels	-20%	-1,790	1%	48
Iron and steel - combustion	-98%	-2,780	-12%	-6
Refrigeration and air conditioning	1,370%	855	1%	6
Use of fluorinated Gases	43%	42	0%	0
Business	-31%	-3,673	1%	49

Figure 3.27: GHG Contribution for Business Emissions, 2012, Scotland

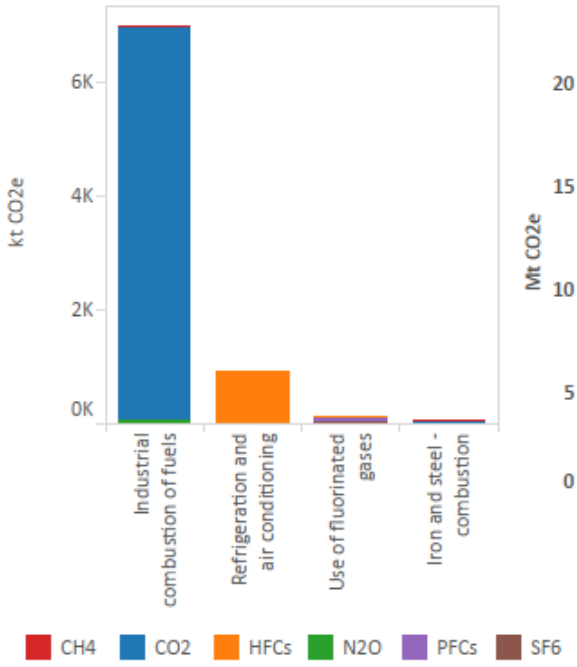
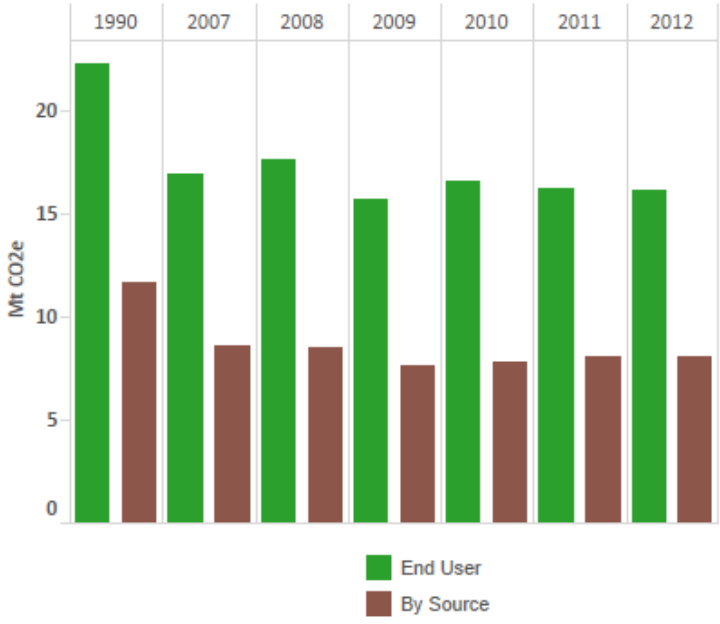


Figure 3.28: Comparison of End User and By Source for Business, Scotland



By Source Emissions

Overview

Figures 3.56 – 3.28 show detailed emissions and trends for the sector. In Scotland, the Business sector contributes 16% to 2012 total net GHG emissions in Scotland. The Business sector in 2012 includes emissions from industrial combustion of fuels (86% of Business emissions) from manufacturing and construction industry; refrigeration & air conditioning (11% of Business emissions), arising from losses of hydrofluorocarbons (HFCs) during equipment manufacture, leaks and disposal; as well as emissions from fluorinated gases 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 2012, 86% of the Scottish Business sector GHG emissions were carbon dioxide, primarily released from the combustion of fossil fuels, with 13% from the use of fluorinated gases, predominantly HFCs.

Features of the Trends

Table 3.6 shows the change in emissions between the Base Year and 2012, and between 2011 and 2012 for the sector. Total Business sector GHG emissions in Scotland have reduced by 31% 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 HFCs from refrigeration and air conditioning have risen by over 1300% since 1995 with the introduction of these gases as replacements to chlorofluorocarbons (CFCs) which were banned by the Montreal Protocol; these emissions now account for 13% of total Business emissions in 2012.

Business emissions increased by 1% between 2011 and 2012 due to an increase in emissions from coal consumption in the other industrial combustion category, and a decrease in emissions from natural gas in the chemicals industry.

Sector Detail

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 13% of the total Business emissions in Scotland. These data are also uncertain due to the lack of DA-specific data on sources of fluorinated gases and the use of proxy data such as economic indices and population to estimate the DA share of UK emissions for these sources.

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, the Business and Industrial Process sector emissions are not easy to separate. The contribution of emissions from traded and non-traded sources across these sectors are presented in the Introduction section (see Figure 3.8), which groups together emissions from the Business sector and the Industrial Process sector as one category: Industry.

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 40-43% of total Business and Industrial Process sector emissions in Scotland during 2008 to 2012, and comprise cement kiln emissions and fuel combustion emissions from large industrial combustion plant and autogenerators.

Emissions on an End User Basis

As shown in Figure 3.28, 2012 Scotland End User emissions for the Business sector are 199% 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 Scotland compared to just 16% of the By Source inventory total.

3.6 Public Sector

Figure 3.29: Overall Contribution to 2012 GHG emissions, Scotland

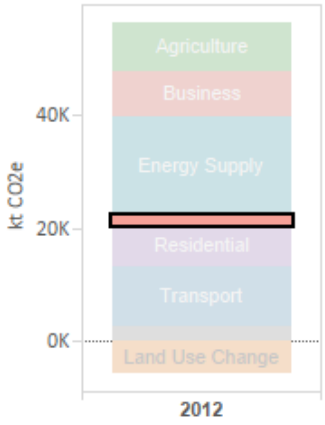


Figure 3.30: Total GHG Emissions from Public, Base Year to 2012, Scotland

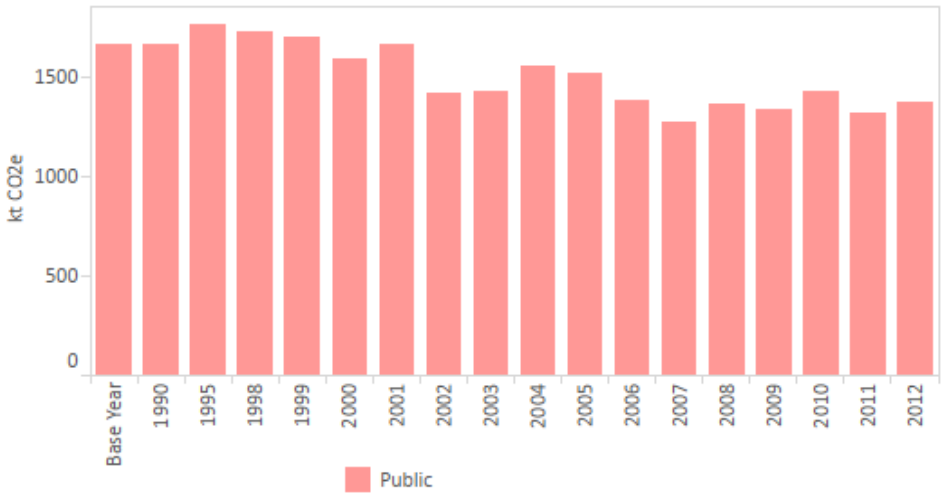


Table 3.7: Change in GHG Emissions from Base Year to 2012 and from 2011 to 2012, Scotland

	Base Year to 2012 as %	Base Year to 2012 kt	2011 to 2012 as %	2011 to 2012 kt
Public	-17.8%	-296.0	4.3%	56.6
Public Total	-17.8%	-296.0	4.3%	56.6

Figure 3.31: GHG Contribution for Public Emissions, 2012, Scotland

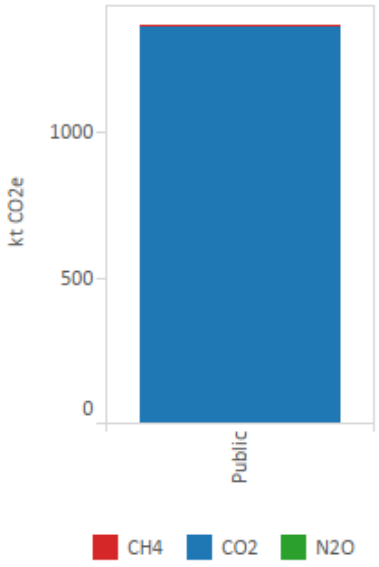
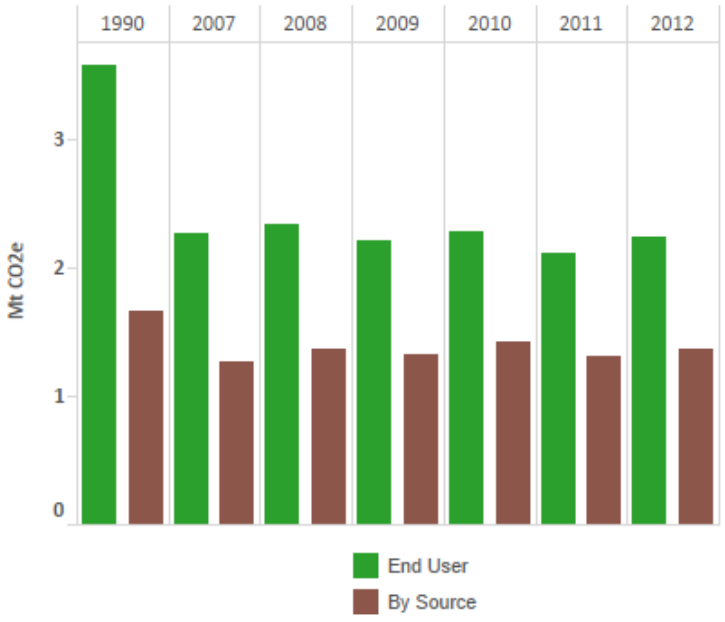


Figure 3.32: Comparison of End User and By Source for Public, Scotland



By Source Emissions

Overview

Figures 3.29 – 3.32 show detailed emissions and trends for the sector. Emissions from Public sector combustion account for 3% of GHG emissions in Scotland in 2012. Over 99% of emissions in this sector are from carbon dioxide from the combustion of fossil fuels (predominantly natural gas).

Features of the Trends

Table 3.7 shows the change in emissions between the Base Year and 2012, and between 2011 and 2012 for the sector. Public sector GHG emissions have reduced by 18% 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 increased by 4% between 2011 and 2012, primarily due to an increase in the consumption of natural gas within the sector in response to colder average temperatures in 2012 compared to 2011.

Emissions on an End User Basis

As illustrated in Figure 3.32, Scotland End User emissions in 2012 for the Public sector were 164% of the By Source emission estimates, reflecting the high consumption of electricity in the sector. This increased the overall significance of this sector in the End User inventory to 4% of the Scotland total, compared to 3% of the By Source inventory total in 2012.

The trend in End User emissions since 1990 shows a decline of around 38% to 2012. 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.

3.7 Industrial Process Sector

Figure 3.33: Overall Contribution to 2012 GHG emissions, Scotland

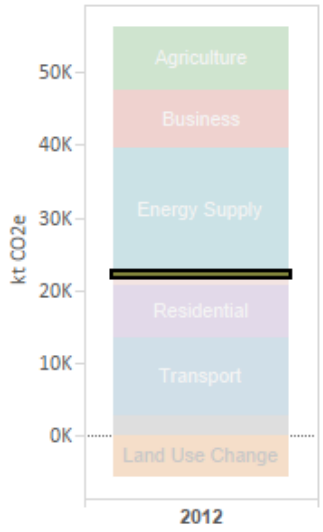
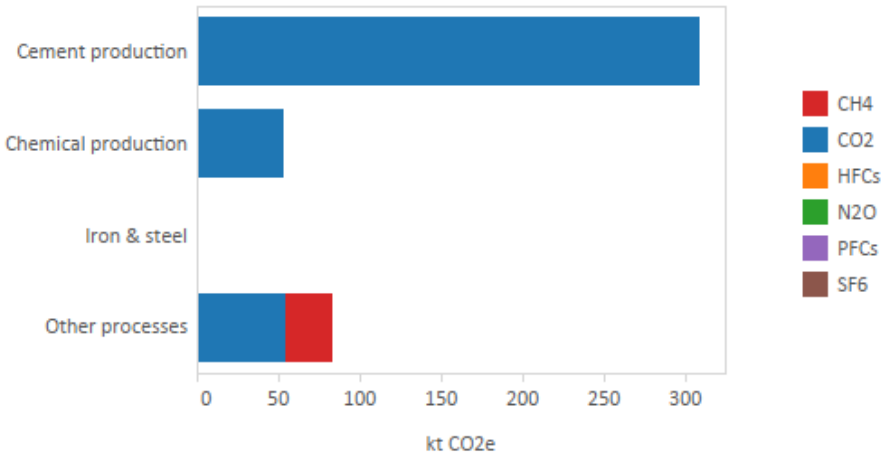


Figure 3.34: Total GHG Emissions from Industrial Process, Base Year to 2012, Scotland

Table 3.8: Change in GHG Emissions from Base Year to 2012 and from 2011 to 2012, Scotland

	Base Year to 2012 as %	Base Year to 2012 kt	2011 to 2012 as %	2011 to 2012 kt
Cement production	-40%	-202	-8%	-27
Chemical production	-100%	-394	%	0
Iron & steel	-100%	-604	-1%	0
Other processes	-59%	-199	28%	30
Industrial Process Total	-76%	-1,399	1%	2

Figure 3.35: GHG Contribution to Industrial Process Emissions, 2012, Scotland



By Source Emissions

Overview

Figures 3.33 – 3.35 show detailed emissions and trends for the sector. In 2012, 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 2012: 69% of total sector emissions come from cement decarbonisation of limestone, with 25% from process sources in the glass industry and 12% from primary aluminium production (decarbonisation of anodes leading to small emissions of perfluorocarbons [PFCs]). Emissions of methane accounted for only 6% of total GHG emissions from the Industrial Process sector, while emissions of carbon dioxide accounted for 93% of total GHG emissions in 2012.

Features of the Trends

Table 3.8 shows the change in emissions between the Base Year and 2012, and between 2011 and 2012 for the sector. Overall Industrial Process sector emissions in Scotland have reduced by 76% between the Base Year and 2012.This large decline in emissions is primarily due to the closure of the nitric acid plant, closure of Ravenscraig iron and steel works both of which occurred between 1990 and 1995, and a reduction in emissions from the chemicals and cement sectors. Emissions have remained relatively level between 2011 and 2012 increasing by only 0.5% due to a decrease in emissions from cement production balanced by an increase in emissions from ethylene production.

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, the Business and Industrial Process sector emissions are not easy to separate. The contribution of emissions from traded and non-traded sources across these sectors are presented in the Introduction section (see Figure 3.8), which groups together emissions from the Industrial Process sector and the Business sector as one category: Industry.

A high proportion of total emissions in the Industrial Process sector are from installations that are included in the EU ETS. Traded emissions have accounted for between 40-43% of total Industrial Process and Business sector emissions in Scotland during 2008 to 2012, and comprise cement kiln emissions and fuel combustion emissions from large industrial combustion plant and autogenerators.

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 2012, the End User estimates are less than 0.1% higher than those in the By Source 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 Sector

Figure 3.36: Overall Contribution to 2012 GHG emissions, Scotland

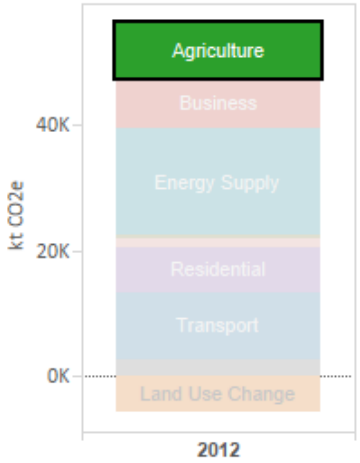


Figure 3.37: Total GHG Emissions from Agriculture, Base Year to 2012, Scotland

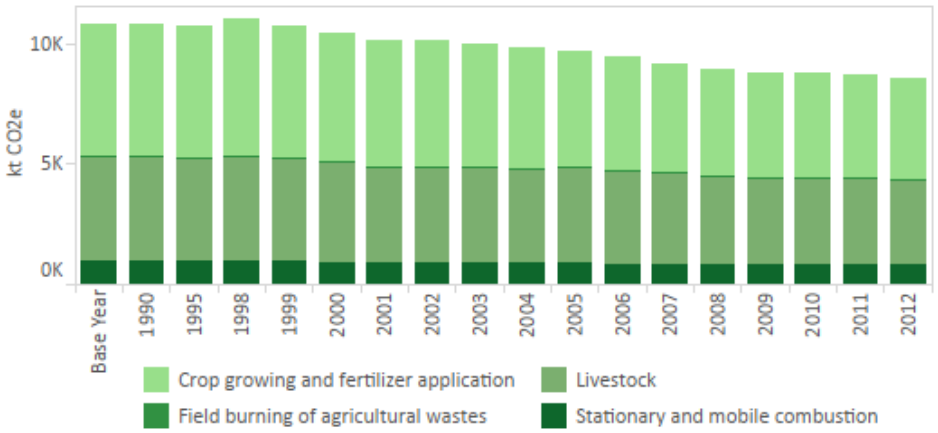


Table 3.9: Change in GHG Emissions from Base Year to 2012 and from 2011 to 2012, Scotland

	Base Year to 2012 as %	Base Year to 2012 kt	2011 to 2012 as %	2011 to 2012 kt
Crop growing and fertilizer application	-23%	-1,278	-2%	-98
Field burning of agricultural wastes	-100%	-24		0
Livestock	-17%	-732	-1%	-44
Stationary and mobile combustion	-18%	-174	0%	0
Agriculture Total	-20%	-2,208	-2%	-141

Figure 3.38: Methane emissions from livestock by type, 2012, Scotland

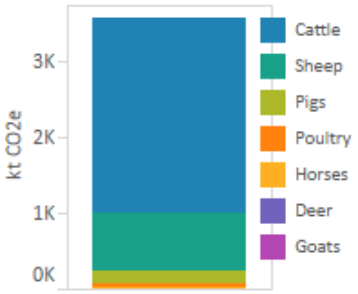


Figure 3.39: GHG Contribution for Agriculture Emissions, 2012, Scotland

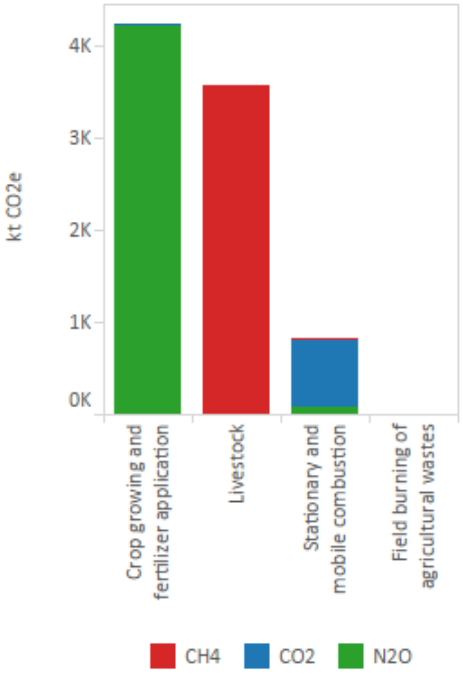


Table 3.10: Emissions of nitrous oxide from agricultural sources in 2012 (kt CO2e), Scotland*

Manure management				395
Soils				3,841
	Direct			2,453
		Biological fixation		6
		Crop residues		265
		Fertiliser		841
		Grazing returns		1,033
		Histosols		0
		Improved grassland		32
		Manure application		267
		Sewage sludge		10
	Indirect			1,388
		Deposition		233
			Fertiliser	75
			Grazing returns	103
			Manure application	53
			Sewage sludge	2
		Leaching		1,155
			Fertiliser	561
			Grazing returns	387
			Manure application	200
			Sewage sludge	7
TOTAL				4,236

*Total emissions comprise manure management and soils. Soils include direct and indirect emissions; indirect emissions include leaching and deposition.

By Source Emissions

Overview

Figures 3.36 – 3.39 show detailed emissions and trends for the sector. 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 3.37). Agriculture accounted for 17% of total greenhouse gas emissions in Scotland in 2012, and is the most significant source sector for methane and nitrous oxide, accounting for 52% and 86% of total Scotland emissions of these two gases, respectively.

Features of the Trends

Table 3.9 shows the change in emissions between the Base Year and 2012, and between 2011 and 2012 for the sector. Emissions from the Agriculture sector decreased by 21% between the Base Year and 2012, with pollutant contributions of -17% for methane and -23% for nitrous oxide. The trends result from a general decline in livestock numbers (particularly cattle and sheep) and in nitrogen fertiliser use. There was only a small decrease of 2% in agricultural emissions between 2011 and 2012 mainly due a reduction in the production of wheat and the resulting reduction in emissions from crop residues and fertilizer. Field burning has largely ceased in the UK since 1993, hence the significant decrease in emissions since the Base Year.

Sector Detail

Livestock emissions include two main sub-categories: emissions from enteric fermentation (a digestive process by which carbohydrates are broken down by microorganisms into simple molecules) and emissions from manure management. Enteric fermentation contributed 75% (2,664 $ktCO_2e$) to total agricultural methane in Scotland in 2012. Total cattle emissions (dairy and beef enteric and manure management) accounted for 72% of the total agricultural methane emissions, whilst emissions from sheep accounted for a further 22% of the total.

Nitrous oxide emissions are largely driven by fertiliser nitrogen use, manure applications and grazing returns to soils. Agriculture is the most important source of nitrous oxide in Scotland and 89% (3,841 $ktCO_2e$) of the total nitrous oxide emissions in the Agriculture sector arose from agricultural soils. This source accounted for 76% of total nitrous oxide emissions in Scotland in 2012. A further breakdown of these emissions is shown in Table 3.10.

The graphs and tables also include emissions from field burning of agricultural waste. This activity resulted in a small emission in 1990, but the practice has now ceased in the UK and is therefore no longer a source.

Emissions on an End User Basis

As the majority of emissions in the Agriculture sector are not due to energy consumption, therefore, emissions on an End User basis are very similar to the emissions By Source. In 2012, 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 (e.g. for heating, lighting and machinery), compared to the higher-emitting sources of nitrous oxide and methane from soils and livestock sources.

3.9 Land Use, Land Use Change and Forestry Sector

Figure 3.40: Overall Contribution to 2012 GHG emissions, Scotland

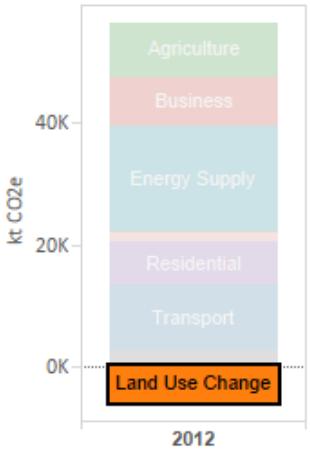


Figure 3.41: GHG Contribution to Land Use Change Emissions, 2012, Scotland

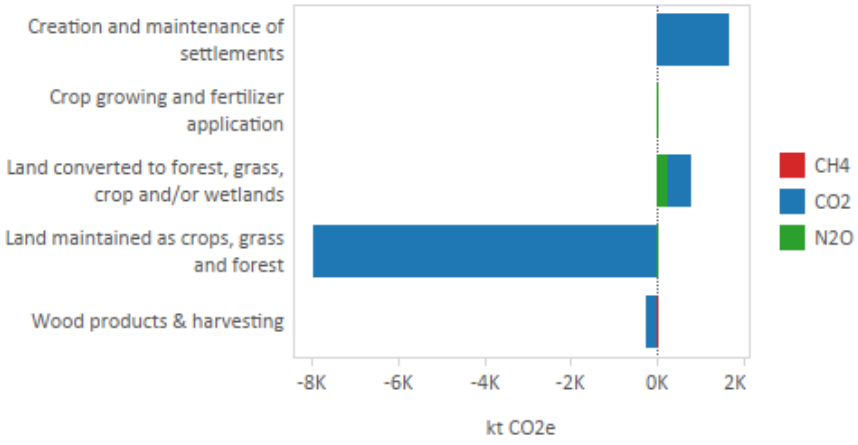
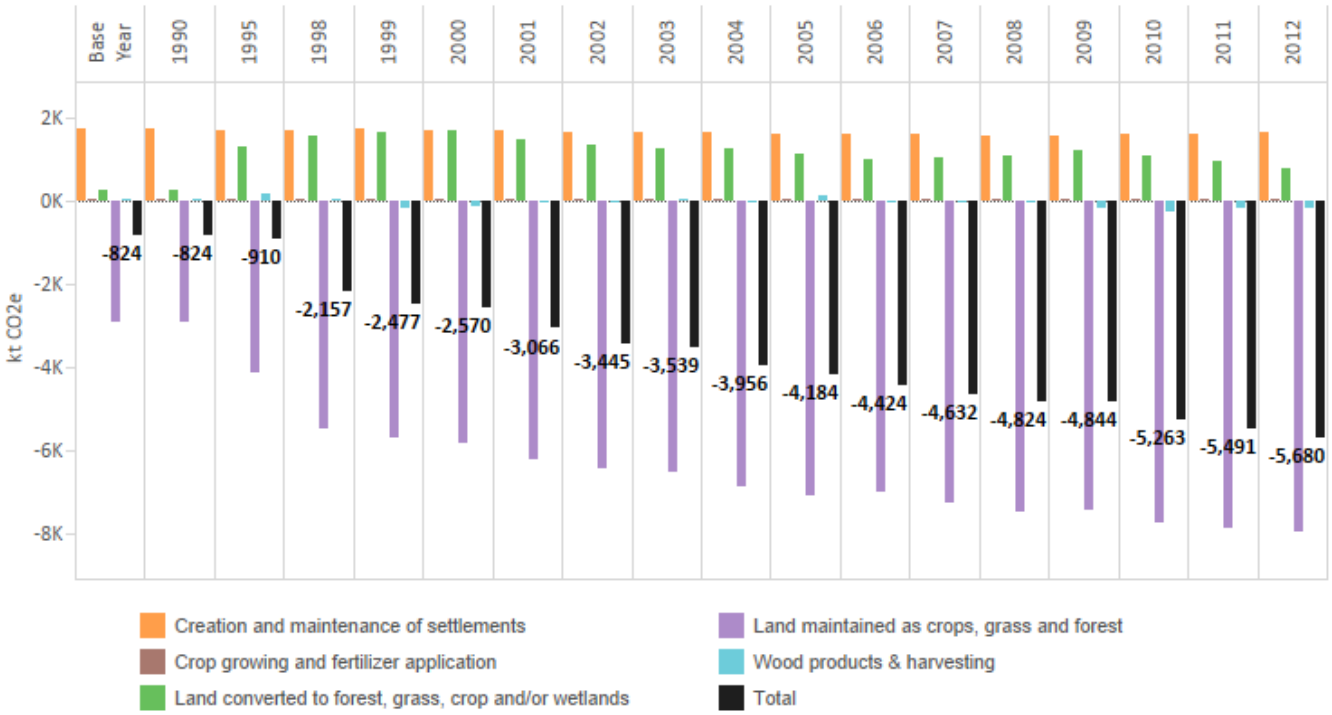


Table 3.11: Change in GHG Emissions from Base Year to 2012 and from 2011 to 2012, Scotland

	Base Year to 2012 as %	Base Year to 2012 kt	2011 to 2012 as %	2011 to 2012 kt
Creation and maintenance of settlements	-4%	-77	2%	29
Crop growing and fertilizer application	18%	4	1%	0
Land converted to forest, grass, crop and/or wetlands	186%	507	-16%	-153
Land maintained as crops, grass and forest	173%	-5,037	1%	-72
Wood products & harvesting	-408%	-253	-3%	6
Land Use Change Total	589%	-4,856	3%	-195

Figure 3.42: Total GHG Emissions from LULUCF, Base Year - 2012, Scotland



By Source Emissions

Overview

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 (Miles *et al*., 2014) and more detailed information is also available in the UK Greenhouse Gas Inventory Report, available on the NAEI website.

Figures 3.40 – 3.42 show detailed emissions and trends for the Land Use, Land Use Change and Forestry (LULUCF) sector. In 2012, Scotland was a large net sink of greenhouse gases from LULUCF activities removing 5,680 $ktCO_2e$ in 2012. The LULUCF emissions and sinks arise from human activities that change the way land is used or affect the amount of biomass in existing biomass stocks. The most significant category is Land Maintained as Crops, Grass and Forest, which accounted for the removal of 7,950 $ktCO_2e$. This removal was offset, to some extent, by emissions from land conversions and the creation and maintenance of settlements, which together emitted 2,433 $ktCO_2e$ in 2012.

Features of the Trends

The LULUCF sector has been a net sink of greenhouse gases since 1990. The size of this sink (CO_2e removal) has grown by 589% between 1990 and 2012 from -824 to -5,680 $ktCO_2e$. 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 forest land 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 of extensive conifer plantations established in the mid-20th century that are now reaching felling age, with reduced removals from forest but with increased carbon stocks in harvested wood products in recent years.

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 Sector

Figure 3.43: Overall Contribution to 2012 GHG emissions, Scotland

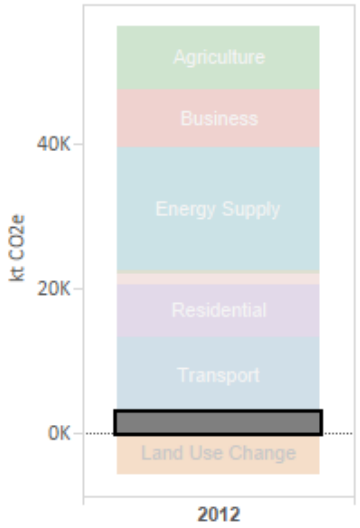


Figure 3.44: Total GHG Emissions from Waste Management, Base Year to 2012, Scotland

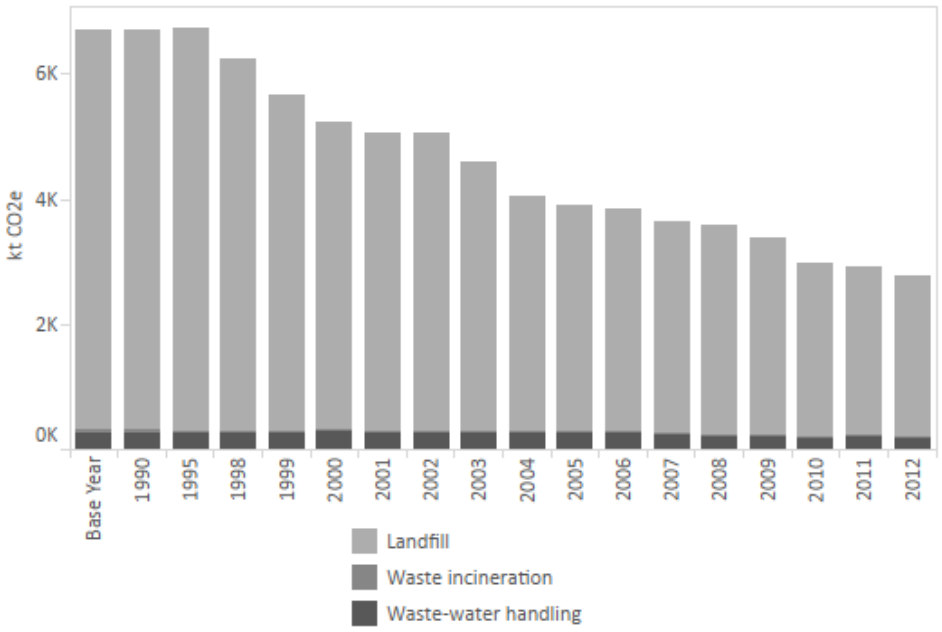
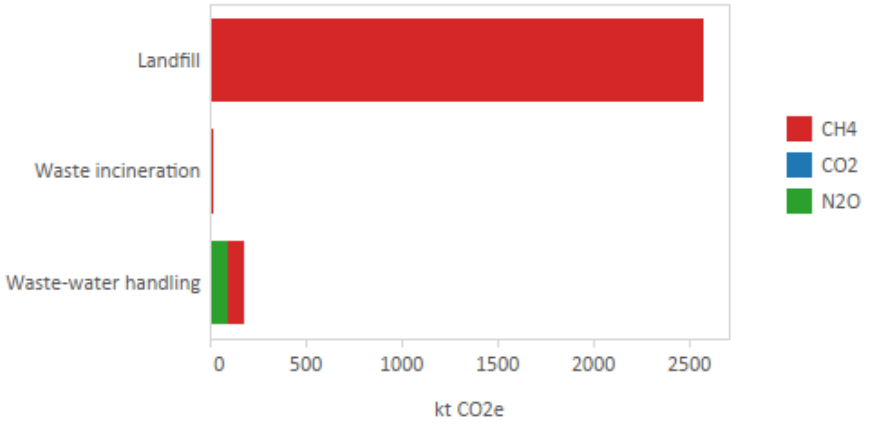


Table 3.12: Change in GHG Emissions from Base Year to 2012 and from 2011 to 2012, Scotland

	Base Year to 2012 as %	Base Year to 2012 kt	2011 to 2012 as %	2011 to 2012 kt
Landfill	-60%	-3,797	-4%	-121
Waste incineration	-80%	-41	-10%	-1
Waste-water handling	-33%	-89	-15%	-32
Waste Management	-59%	-3,927	-5%	-154

Figure 3.45: GHG Contribution to Waste Management Emissions, 2012, Scotland



By Source Emissions

Overview

Figures 3.43 – 3.45 show detailed emissions and trends for the sector. The Waste Management sector contributed 5% to total GHG emissions in Scotland in 2012, and was the second largest source sector for methane emissions, representing 39% of total methane emissions in 2012. Emissions from this sector in 2012 were dominated by methane from landfill (93% of total GHGs from the Waste Management sector), with a smaller contribution of emissions of methane and nitrous oxide from wastewater treatment (7%).

Nitrous oxide emissions from waste water treatment represent 4% of emissions in the sector in 2012, and contribute 2% to the total emissions of nitrous oxide in Scotland.

Features of the Trends

Table 3.12 shows the change in emissions between the Base Year and 2012, and between 2011 and 2012 for the sector. Emissions from the Waste Management sector in Scotland have reduced by 59% since the Base Year, driven by reductions of emissions from landfill of 60% between the Base Year and 2012; these reductions have been achieved by the progressive introduction of methane capture and oxidation systems within landfill management. Waste Management sector emissions have reduced by 5% between 2011 and 2012. This was due to a continued decline in methane emission estimates from landfill from improved management systems.

Emissions on an End User Basis

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

4 Emission Estimates in Wales (1990-2012)

4.1 Overview of Total Emissions

By Source Emissions

Overview

The greenhouse gas (GHG) emissions for Wales for 1990 – 2012 are presented in Table 4.1 and in the graph in Figure 4.1 below. Emissions in 2012 are 45,826 $ktCO_2e$ with 42% of emissions in 2012 from Energy Supply, 17% from Business, 13% from Transport, 13% from Agriculture and 9% from Residential sources.

Table 4.1: 1990-2012 Wales GHG Emission Inventory ($ktCO_2e$)

NC Format	Base Year	1990	1995	2000	2005	2008	2009	2010	2011	2012	% of 2012
Agriculture	7,746	7,746	7,774	7,489	7,044	6,014	5,947	6,124	6,129	6,142	13%
Business	13,621	13,572	14,562	16,860	10,141	9,804	8,104	9,707	9,100	7,976	17%
Energy Supply	17,477	17,477	12,767	16,180	17,197	19,324	16,277	16,558	15,719	19,066	42%
Industrial Process	2,749	2,912	3,087	3,283	2,804	2,454	1,500	2,166	2,017	1,554	3%
LULUCF	70	70	-111	-447	-597	-561	-591	-483	-632	-491	-1%
Public	748	748	674	515	508	431	423	449	411	440	1%
Residential	4,983	4,964	5,120	5,277	4,822	4,660	4,365	4,951	3,848	4,233	9%
Transport	6,061	6,061	6,053	6,134	6,417	6,318	6,056	5,950	5,844	5,770	13%
Waste Management	2,370	2,370	2,423	2,051	1,558	1,477	1,395	1,234	1,196	1,137	2%
Total	**55,827**	**55,921**	**52,349**	**57,342**	**49,896**	**49,921**	**43,477**	**46,657**	**43,633**	**45,826**	**100%**

Trends

Figure 4.2 shows the change in emissions from the Base Year and 2011 to the latest year 2012. Total GHG emissions from Wales have reduced between the Base Year[23] and 2012 by 18%, whilst carbon dioxide emissions have fallen by 14%. 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 only reduced slightly (-5%) 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 increased between 2011 and 2012 by 5%. The reasons for this change in the trend are given below for each sector along with the significance of this change. **The 2011 to 2012 increase of emissions is predominantly driven by a slight shift from natural gas back to coal (which has a higher carbon content per unit of energy) in the energy sector due to global fuel prices, and a decrease in emissions from iron and steel production in Wales during 2012, as the No.4 Blast Furnace re-build began in July 2012.**

The following list provides an overview of the trend for each NC sector:

- **Energy Supply** sector emissions have increased by 9% between the Base Year and 2012 due to increases in emissions from power stations despite reductions in the production of coke in the iron and steel industry over the period. Emissions from power stations have increased by 21% (3,346 $ktCO_2e$) due to a significant increase in the consumption of coal between 2011 and 2012, whilst total energy generation has fallen between the Base Year and 2012. This shift in fuel use is due to global fuel prices.
- **Business** sector emissions have reduced by 41% since the Base Year. These reductions have primarily been achieved as a result of declining manufacturing and iron and steel industry emissions. Emissions have decreased by 12% (1,125 $ktCO_2e$) between 2011 and 2012 caused mainly by a decrease in the iron and steel sector as the No.4 Blast Furnace re-build began in July 2012 reducing production.
- **Industrial Process** emissions have decreased significantly since the Base Year (43%). have shown significant fluctuations during this timeframe reflecting manufacturing output and abatement installations. This is due to several factors including a decline in

[23] 1995 for fluorinated greenhouse gases (F-Gases) and 1990 for all other gases

manufacturing, cement, aluminium production, bulk chemical and iron and steel industries. Emissions decreased significantly by 23% between 2011 and 2012 (463 $ktCO_2e$) due to a significant decrease in emissions from iron and steel (due to the No.4 Blast Furnace re-build began in July 2012).

- **Residential** sector emissions have decreased by 15% since the Base Year partly due to a change in the fuel mx from coal towards natural gas. Emissions between 2011 and 2012, however, increased by 10% (385 $ktCO_2e$) due to the return to average temperatures in 2012. This led to an increase in natural gas consumption compared to the warmer winter experienced in 2011.
- **LULUCF** sector was a source of emissions from the Base Year prior to 1995, and has since been a sink. The sink reduced by 22% between 2011 and 2012 (82 $ktCO_2e$).
- **Transport** sector emissions have only decreased by 5% between the Base Year and 2012 due to strong growth in transport demand over the period coupled with improvements in efficiency of transport vehicles. Emissions between 2011 and 2012 decreased by 1% (75 $ktCO_2e$). This sector is driven by the changes in emissions from passenger cars. Although emissions from road diesel (DERV) have increased between 2011 and 2012, emissions from petrol have significantly decreased, which has led to an overall reduction in emissions in the transport sector.
- **Waste Management** sector emissions have significantly declined by 52% since the Base Year, largely due to the progressive introduction of methane capture and oxidation systems within landfill management. Emissions continued to decrease between 2011 and 2012, decreasing by 5% (58 $ktCO_2e$).
- **Public** sector emissions have reduced by 41% since the Base Year. This is due to increased energy efficiency measures and the switch to gas-fired heating. However, emissions between 2011 and 2012 increased by 7% (30 $ktCO_2e$) due mainly to an increase in natural gas consumption in 2012 compared to the warmer average temperatures experienced in 2011.
- **Agriculture** sector emissions have reduced by 21% since the Base Year mainly due to a decrease in livestock numbers. There was a small increase of less than 1% (12 $ktCO_2e$) in emissions from 2011 to 2012 mainly due to a 1% reduction in cattle numbers balanced by an increase of 3% in sheep numbers.

Emissions Detail

Detailed analysis of Wales GHG emissions in 2012 is presented in Figures 4.3 – 4.9. The largest sources of emission in 2012 include electricity production (32% of total emissions), road transport (12% of total emissions), iron and steel combustion in the Business sector (9% of total emissions) and residential combustion for heating and cooking (9% of total emissions).

Figure 4.3 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 the Agriculture sector where methane from livestock and nitrous oxide from soils are the most important gases, and the Waste Management sector where methane from landfills is the most important gas (see Figure 4.4).

Recalculations

Revisions to the estimates since the last inventory report (Salisbury *et al.,* 2013) have resulted in a -0.5% (-211 $ktCO_2e$) reduction in the 2011 estimates for Wales. The most significant revisions to the 2011 estimates have been for the following sectors:

1. **LULUCF**: (-773 $ktCO_2e$ decrease). The inventory now uses the CARBINE model to estimate emissions from LULUCF. This change in methodology has led to significant recalculations across the time series. CARBINE can represent a comprehensive range of forest tree species relevant to the UK, representing UK growth conditions and management practices, and combining area / age class information for carbon stocks. Compared to previous estimates, this more detailed methodology based on application of CARBINE provides greater representation of Forest Land and the range of forest management practices observed in the UK.
2. **Manure Management (Agriculture)**: (427 $ktCO_2e$ increase). In response to reviewer questions, the UK revised its allocation of manure into the various management systems. In particular the amounts going to daily spread were reduced significantly and the amounts previously allocated to solid storage were reallocated to deep litter leading to an increase from 1% to 39% in the methane conversion factor.
3. **Combustion within Iron and Steel industry (Energy Supply)**: (-282 $ktCO_2e$ decrease) due to revisions of the combustion of coke, coke oven gas and blast furnace gas as part of improvements made to the carbon balance model.

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

Figure 4.1: Total GHG Emissions by NC category for Base Year to 2012, as kt CO2e, Wales

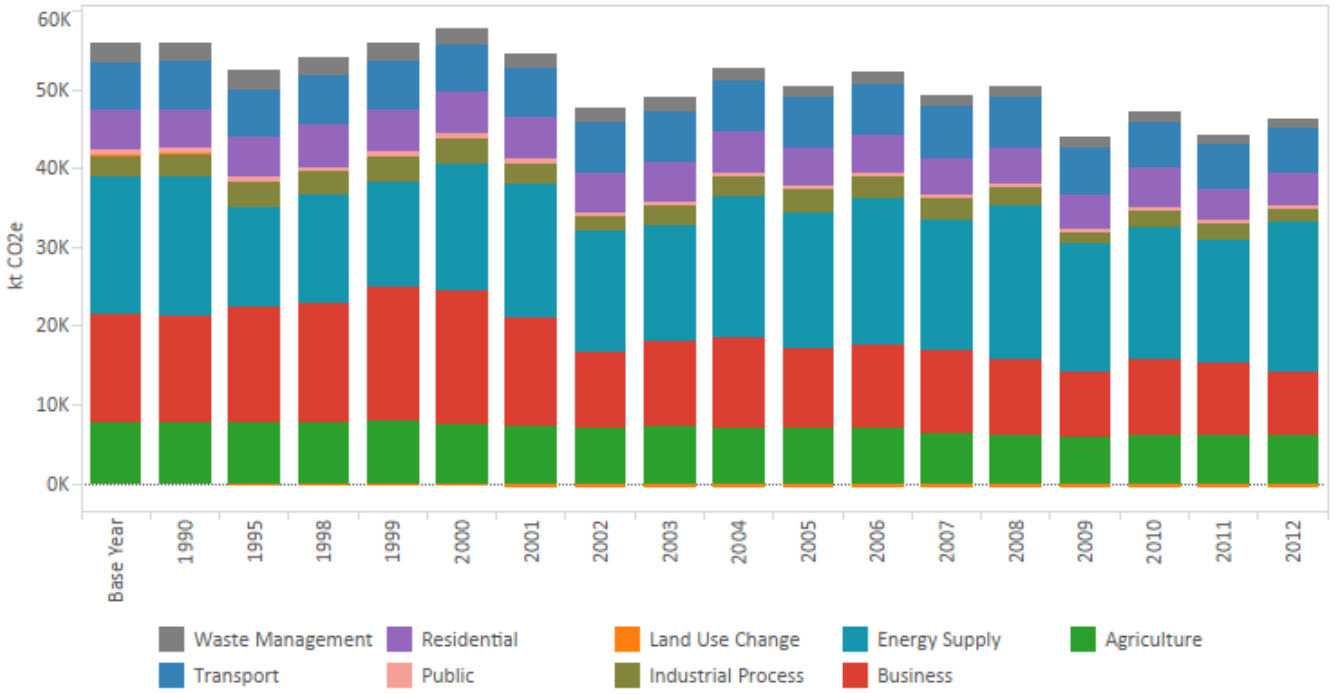
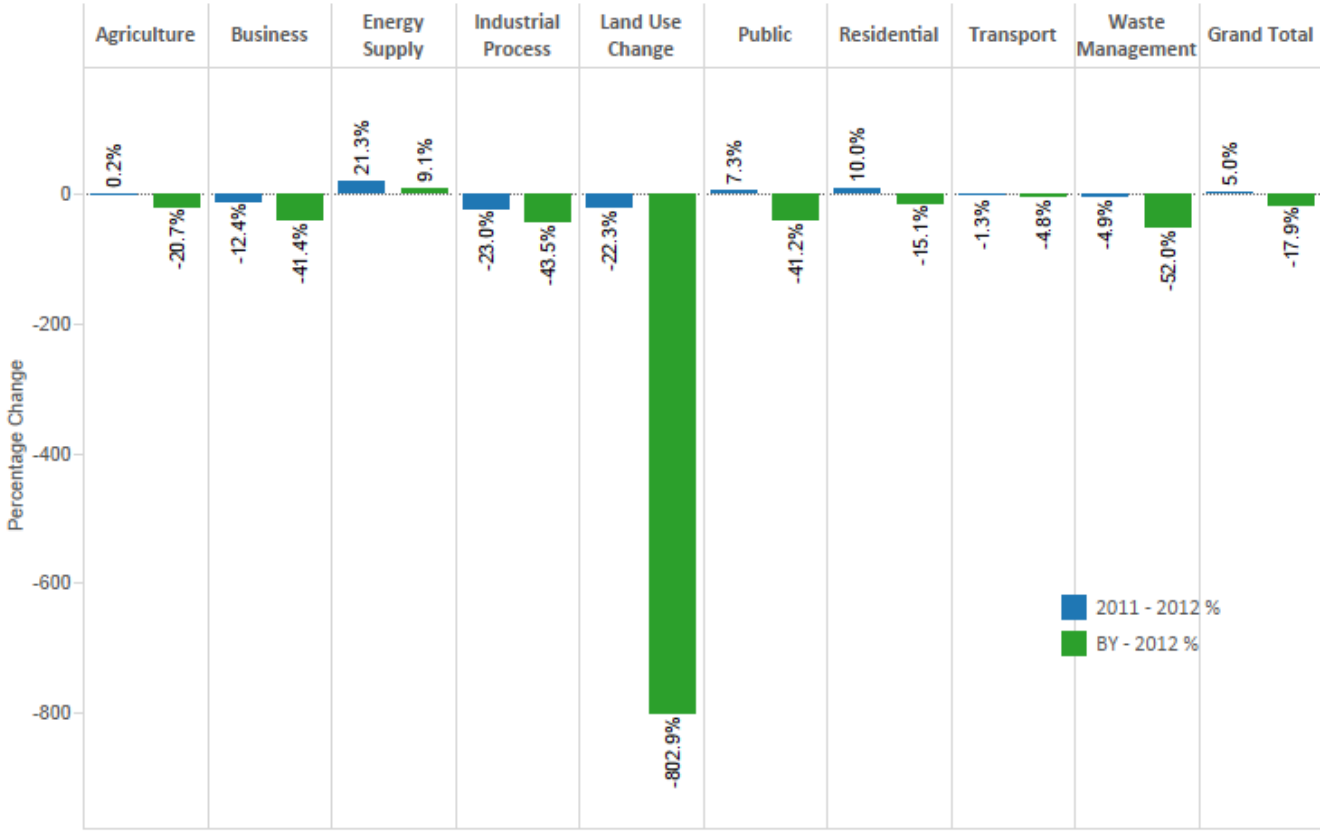


Figure 4.2: Percentage Change and Absolute (kt CO2e) Change in GHG Emissions by NC: Base Year(BY) - 2012 and 2011 - 2012, Wales

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



	Agriculture	Business	Energy Supply	Industrial Process	Land Use Change	Public	Residential	Transport	Waste Management	Grand Total
BY - 2012 kt	-1,604	-5,646	1,588	-1,196	-561	-308	-750	-291	-1,232	-10,001
2011 - 2012 kt	12	-1,125	3,346	-463	141	30	385	-75	-58	2,193

Figure 4.3: Total GHG emissions and uncertainties by pollutant, 2012, Wales

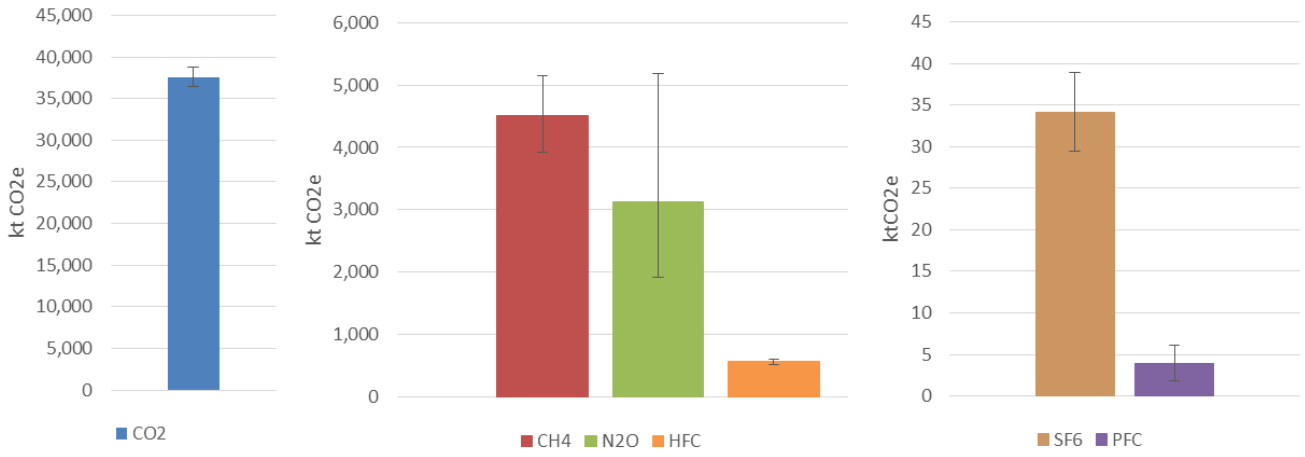


Figure 4.4: Total GHG Emissions by NC and pollutant, 2012, Wales

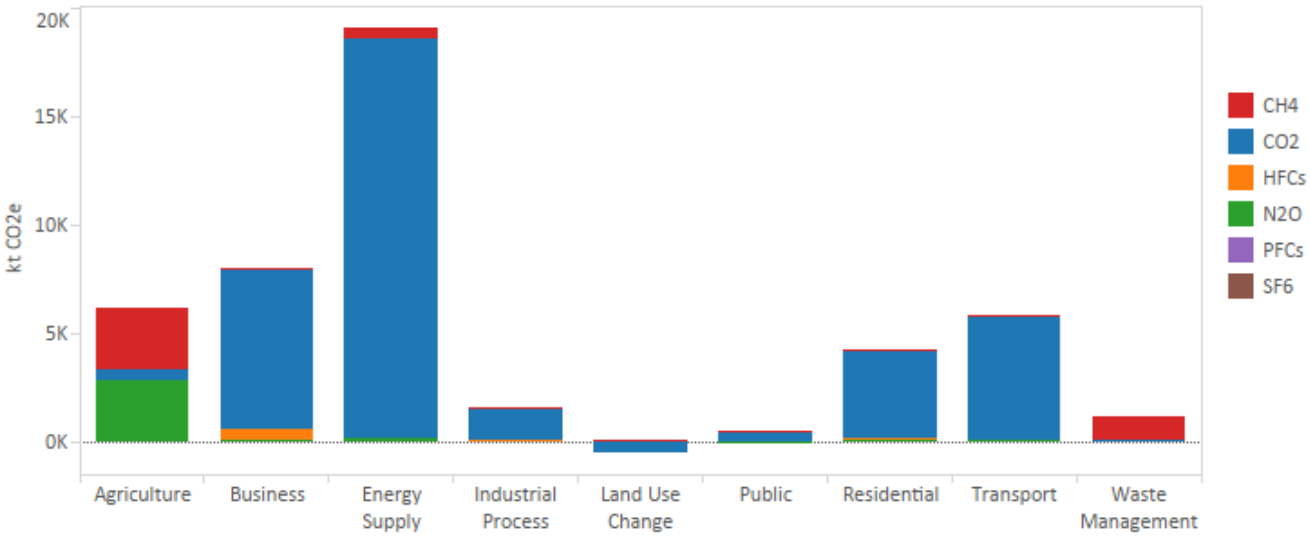
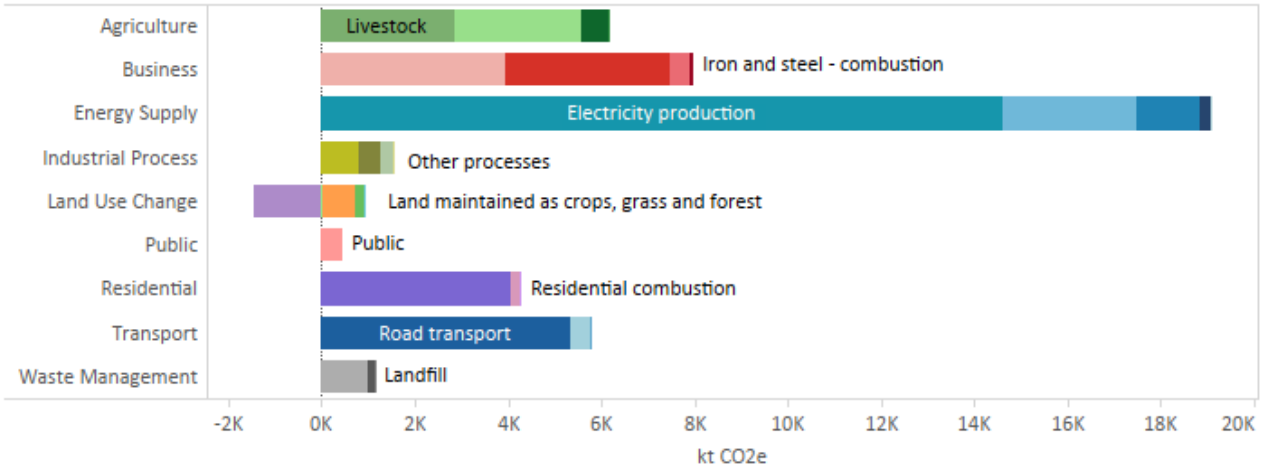


Figure 4.5: Total GHG Emissions labelling the largest sub-category in each NC, 2012, Wales



Traded and Non-Traded Emissions

Total GHG emissions from installations that operate within the European Union Emissions Trading Scheme (EU ETS) (see Figure 4.7) decreased by 6% decrease between 2010 and 2011, before increasing by 9% between 2011 and 2012. Emissions from installations in the EU ETS (see Figure 4.7) account for 54% of total GHG emissions in Wales in 2012. The main contributors to these traded emissions are the Energy Supply sector (of which 98% total emissions are within the EU ETS, including all power stations) and the Business and Industrial Process sector (see Figure 4.6) of which, 64% of total sector emissions are in the EU ETS.

Figure 4.6: Total Traded and Non-Traded GHG Emissions by NC Category, 2012, Wales

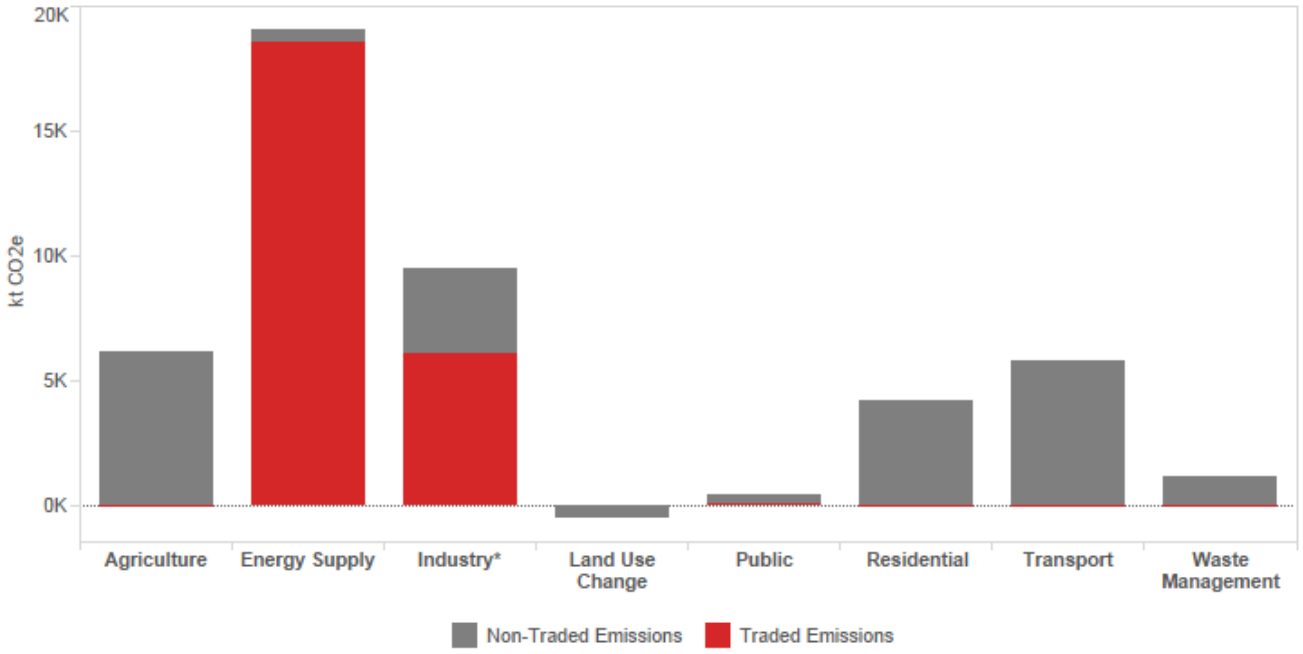


Figure 4.7: Total Traded and Non-Traded GHG Emissions 2008-2012, Wales

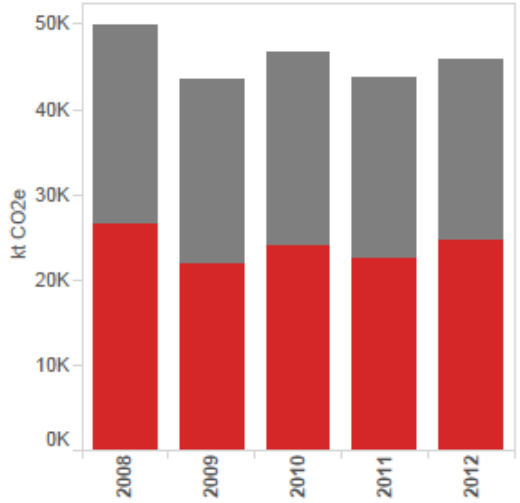
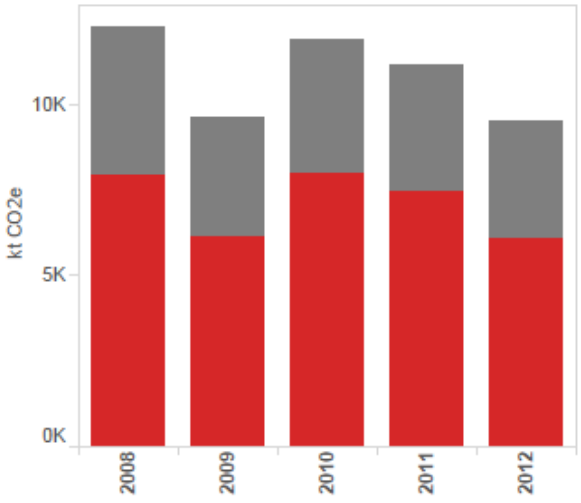


Figure 4.8: Traded and Non-Traded GHG Emissions from Industry 2008-2012, Wales*



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

Emissions on an End User Basis

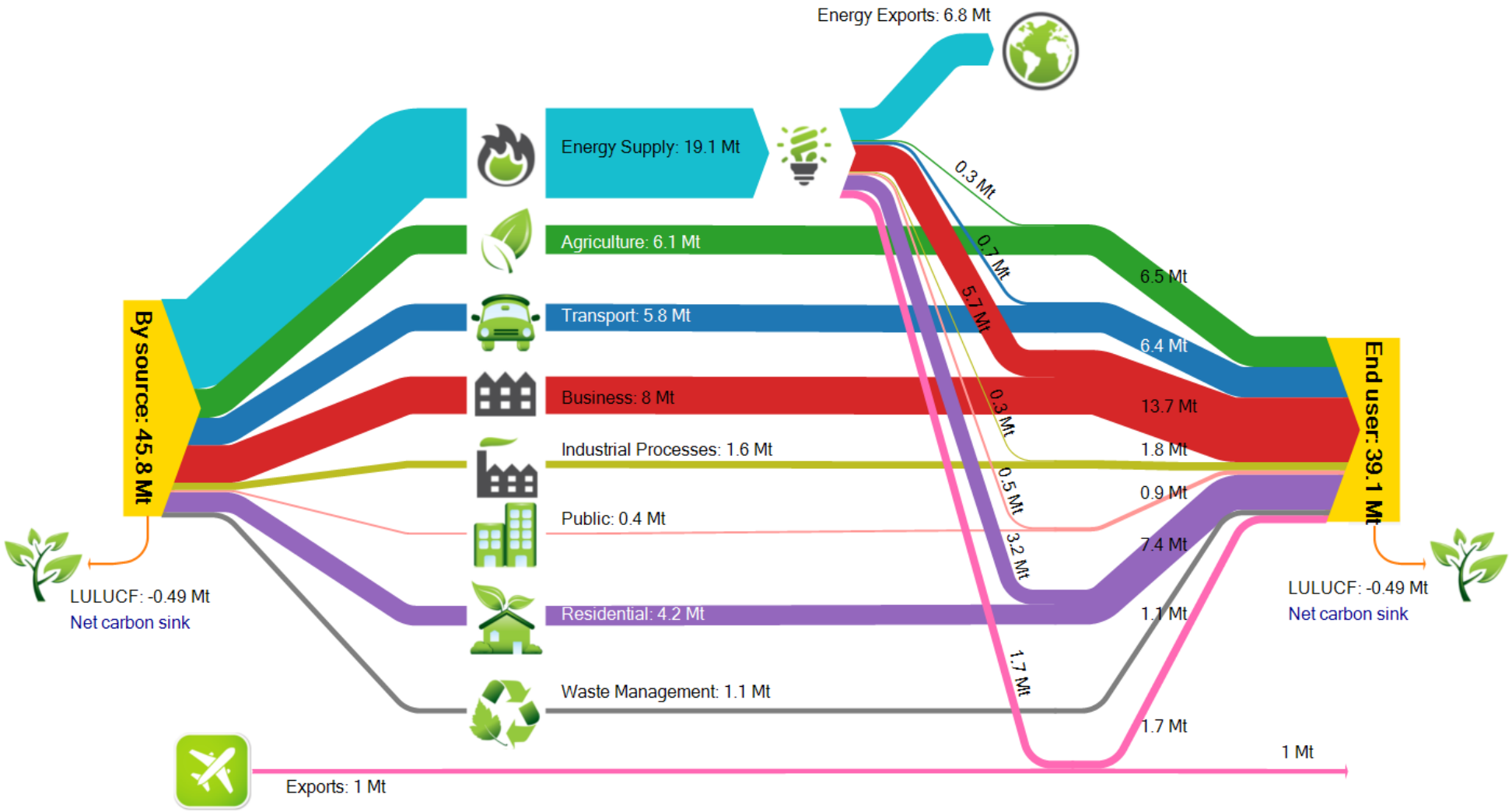
In addition to presenting emissions based on direct emissions from processes or combustion of fuels in Wales, the emissions from the Energy Supply sector can be attributed to the users of the energy (see Appendix 3 for more details of the End User inventory methodology).

Figure 4.9 illustrates the difference between the By Source and End User inventory emission estimates and how emissions from the Energy Supply sector 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 2012 are: 35% from Business, 19% from the Residential sector and 16% from Transport sources. As illustrated in Figure 4.9 Wales is a net exporter of electricity which resulted in lower (-15%) emissions in Wales on an end user basis (39,051 $ktCO_2e$) compared to the by source (45,826 $ktCO_2e$) 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 sector a small additional End User emission allocation is evident to reflect the fuel use in stationary and mobile combustion units within the sector.

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

Figure 4.9 Sankey diagram showing By Source and End User[24] GHG emission transfers for Wales in 2012 (Mt CO_2e)[25]



[24] 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.

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

4.2 Energy Supply Sector

Figure 4.10: Overall Contribution to 2012 GHG emissions, Wales

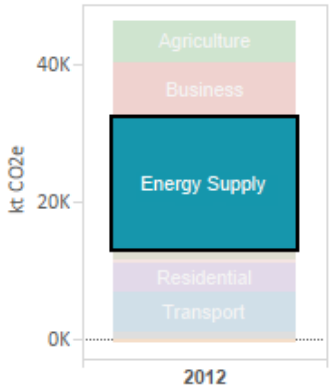


Figure 4.11: GHG Contribution to Energy Supply Emissions, 2012, Wales

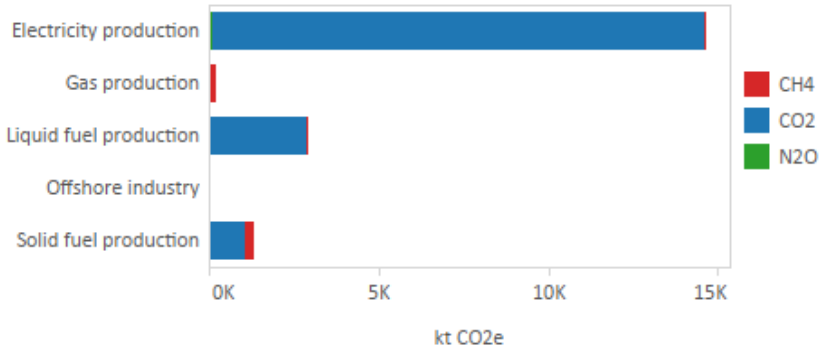


Table 4.2: Change in GHG Emissions from Base Year to 2012 and from 2011 to 2012, Wales

	2011 - 2012 %	2011 - 2012 kt	BY - 2012 %	BY - 2012 kt
Electricity production	40%	4,186	30%	3,359
Gas production	1%	3	-35%	-125
Liquid fuel production	-20%	-708	-17%	-608
Offshore industry	-93%	-1		0
Solid fuel production	-9%	-134	-44%	-1,038
Energy Supply Total	21%	3,346	9%	1,588

Table 4.3: NC Category Contribution to End User Inventory by percentage of Electricity Production Emissions, Wales

Agriculture	3%
Business	60%
Industrial Process	0%
Public	5%
Residential	32%
Transport	0%
Exports*	0%

Figure 4.12: Total GHG Emissions from Energy Supply, Base Year to 2012, Wales

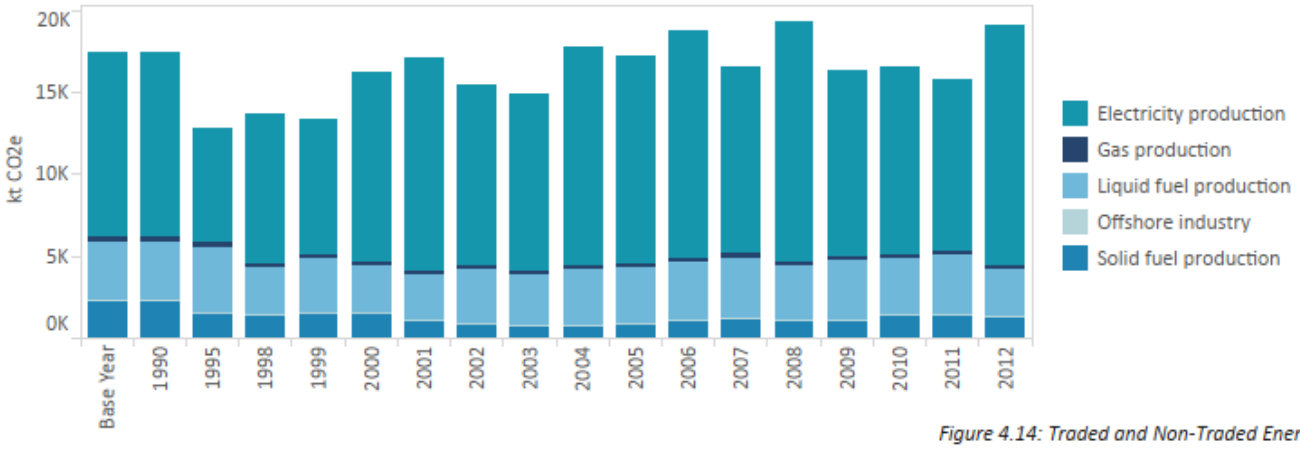


Figure 4.13: Emissions and Electricity Production by Fuel Type from Major Power Producers (1A1a), Wales

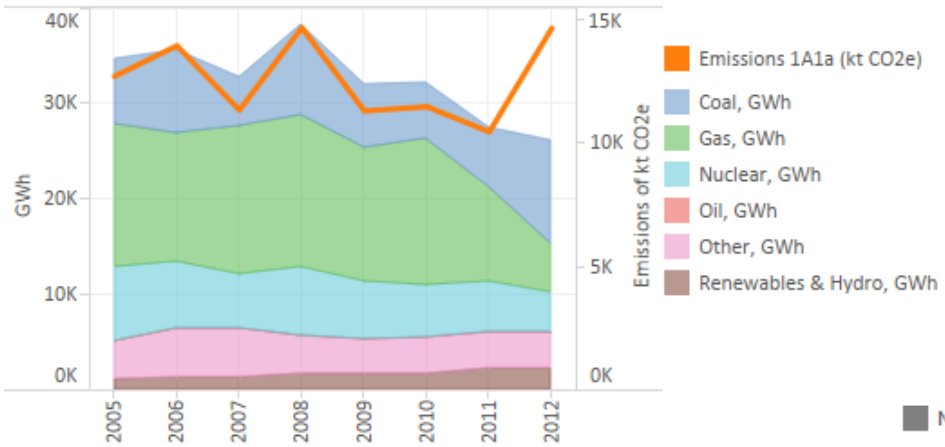
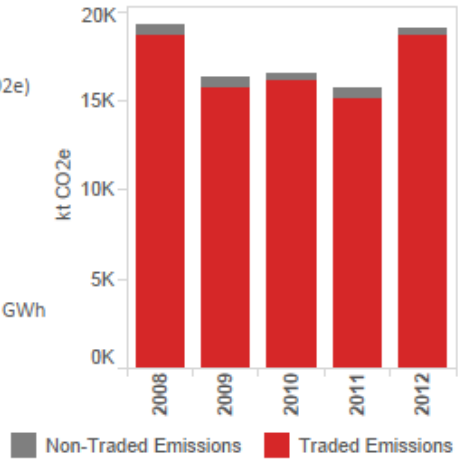


Figure 4.14: Traded and Non-Traded Energy Supply Emissions, 2008-2012, Wales



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

By Source Emissions

Overview

In Wales, Energy Supply sources contributed 42% to total 2012 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 77% of Energy Supply emissions in 2012 and refinery emissions which accounted for a further 15%.

Features of the Trends

Energy Supply sector emissions have increased by 9% between the Base Year and 2012 due to increases in emissions from power stations seen in 2012. As shown in Figure 4.12, the trend is dominated by emissions from electricity production. Figure 4.13 provides the fuel split for electricity production from 2005 to 2012.This clearly shows the significant increase of 21% (3,346 $ktCO_2e$) from 2011 to 2012 is due to the shift in fuel use from natural gas to coal, which was driven by global fuel prices. Emissions were generally following the same downward trend as overall generation until this significant change in the fuel mix in 2012.

Sector Detail

The mix of generation capacity in Wales is shown in Figure 4.13. Natural gas combustion accounts for 20% of total generation, with coal power stations generating 41% compared to the UK-average of 39% of electricity generation. Nuclear generation and renewable sources produce 24% of electricity. In addition, Wales is a net exporter of electricity (see Figure 4.9).

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 2012, released through the combustion of fossil fuels.

Traded and Non-Traded Emissions

Emissions in the Energy Supply sector are dominated by installations that operate within the EU ETS, with 98% of emissions in Energy Supply from traded (EU ETS) operations in 2012; these traded emissions are primarily from power stations, refineries and coke ovens.

Emissions on an End User Basis

End user emissions from electricity are presented in Table 4.3. 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 2012 the Business sector was estimated to use 60% of electricity whilst the Residential sector accounts for 32% of electricity demand, and hence these sectors have the largest additional emissions allocation on an End User basis.

4.3 Transport Sector

Figure 4.15: Overall Contribution to 2012 GHG emissions, Wales

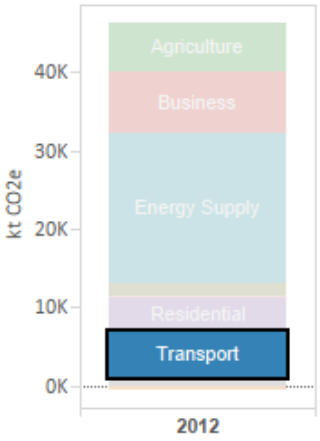


Figure 4.16: Total GHG Emissions from Transport, Base Year to 2012, Wales

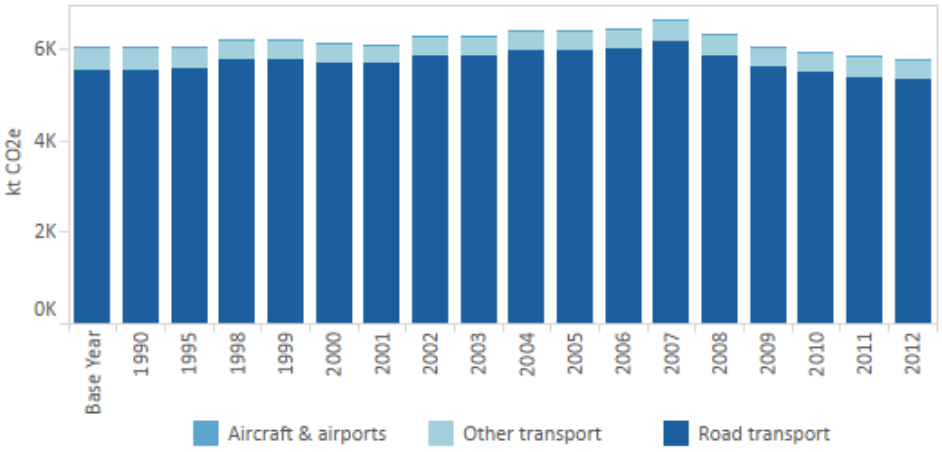


Table 4.4: Change in GHG Emissions from Base Year to 2012 and from 2011 to 2012, Wales

	Base Year to 2012 as %	Base Year to 2012 kt	2011 to 2012 as %	2011 to 2012 kt
Aircraft & Airports	85.7%	6.9	-14.3%	-2.5
Road Transport	-3.4%	-186.4	-0.6%	-33.6
Other Transport	-21.9%	-111.9	-8.9%	-38.7
Transport	-4.8%	-291.4	-1.3%	-74.8

Figure 4.17: GHG Contribution for Transport Emissions, 2012, Wales

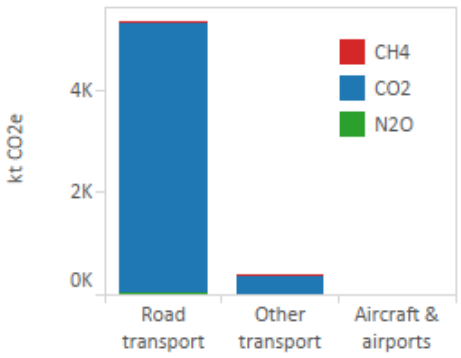


Figure 4.18: Comparison of End User and By Source for Transport, Wales

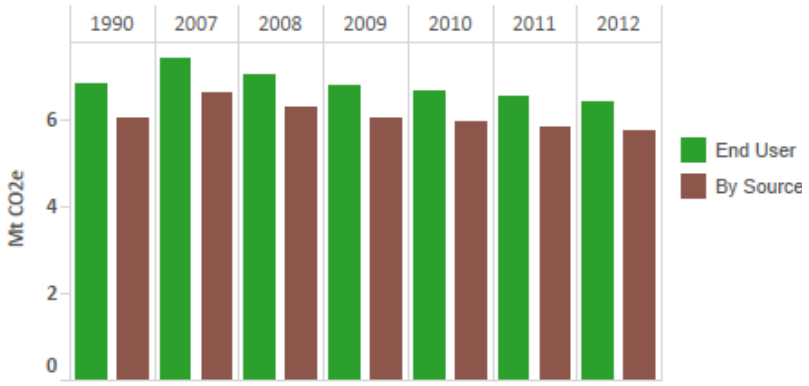


Figure 4.19 Road Transport CO2 Emissions (fuel sales basis), Wales

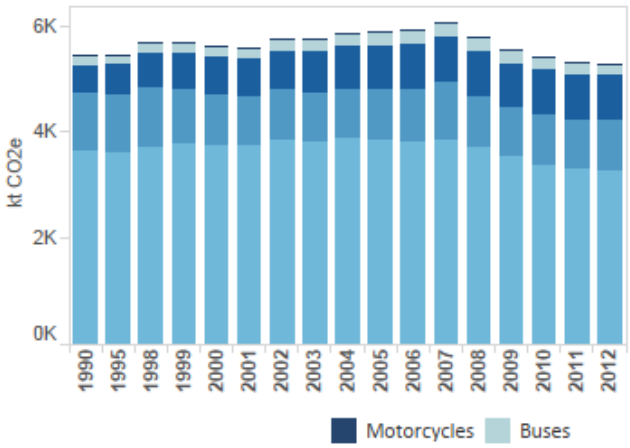
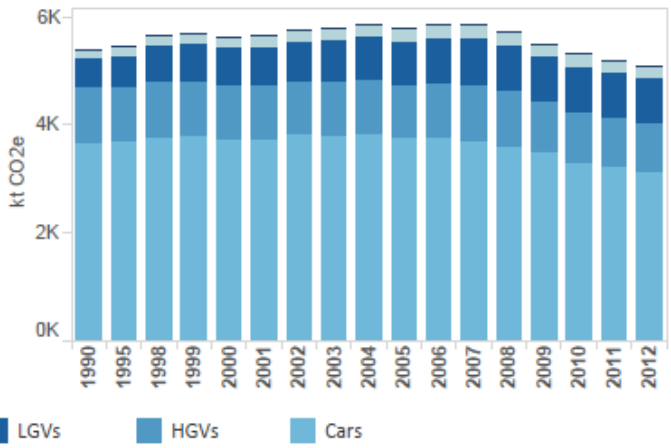


Figure 4.20: Road Transport CO2 Emissions (vkm basis), Wales



By Source Emissions

Overview

Transport emissions account for 13% of Wales' total GHG emissions in 2012. Transport emissions are dominated by emissions from road transport (93% of all transport emissions in 2012, with 57% of transport emissions from cars alone) (see Figures 4.16, 4.19 and 4.20). The Transport sector also includes: 2% from rail (including stationary sources), 3% from national navigation and coastal shipping, 1.5% from military aviation and shipping and 0.2% from domestic aviation. Emissions from international aviation are excluded from these estimates.

Features of the Trends

Total emissions from the Transport sector in Wales have decreased by only 5% between the Base Year and 2012 despite improvements in efficiency of transport vehicles, as a result of strong growth in transport demand since 1990 and increased affordability of cars over the period. Emissions peaked in 2007 and have since declined partly due to improvements in average fuel efficiency of vehicles and the switch from petrol to diesel cars and from a reduction in traffic volumes in this latter part of the time series.

Emissions between 2011 and 2012 have reduced by 1.3% (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 2011 and 2012 by 2%, emissions from petrol have decreased by 5%, which has led to an overall reduction in emissions in the transport sector.

Sector Detail

There are two approaches used to calculate emissions from Road Transport: fuel sales basis – emissions are constrained to the total fuel sold within the UK as stated in DUKES (DECC, 2013b); vehicle kilometre basis – emissions are estimated using vehicle km data and are not constrained by the total fuel sold, so estimate emissions based on fuel used within the UK. The inventory emission estimates for Road Transport are calculated on a fuel sold basis and are, therefore, consistent with DUKES.

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 3.9% lower than the estimates constrained to DUKES for 1990 and 2012, respectively.

The differences between the two approaches fluctuate year on year but they remain within 3.9% 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 2012) 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 2012 are 6.0% lower than in the Base Year, while the constrained approach indicates that carbon dioxide emissions have decreased by 2.9% between the Base Year and 2012.

Emissions on an End User Basis

The End User inventory estimates in recent years are 11% higher than the By Source estimates, reflecting the additional emissions from upstream oil extraction and the oil refining sector (see Figure 4.18).

The trend in End User emissions since 1990 shows a decline of 6% to 2012, which is a slightly larger reduction than reported in the By Source inventory (5%), reflecting the improved energy efficiency of upstream production and refining of crude oil to produce the fuels used in the transport sector.

4.4 Residential Sector

Figure 4.21: Overall Contribution to 2012 GHG emissions, Wales

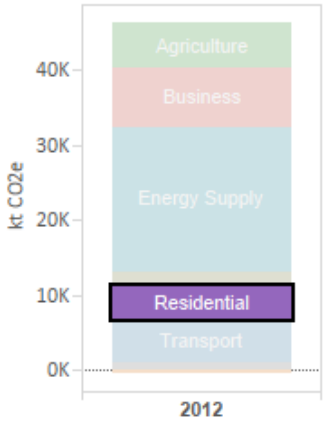


Figure 4.22: Total GHG Emissions from Residential, Base Year to 2012, Wales

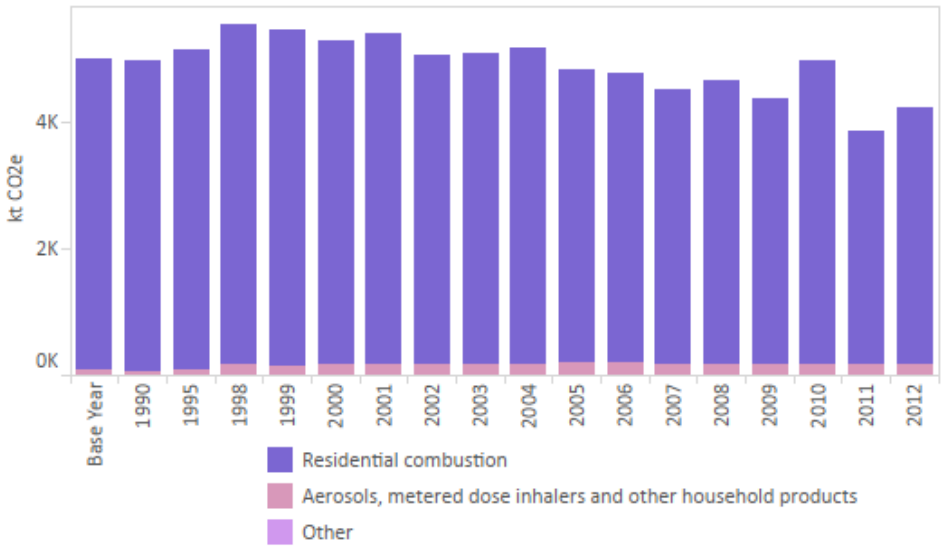


Table 4.5: Change in GHG Emissions from Base Year to 2012 and from 2011 to 2012, Wales

	Base Year to 2012 as %	Base Year to 2012 kt	2011 to 2012 as %	2011 to 2012 kt
Aerosols, metered dose inhalers and other household products	120%	97	1%	1
Other	-46%	0	0%	0
Residential combustion	-17%	-848	10%	383
Residential Total	-15%	-750	10%	385

Figure 4.23: GHG Contribution for Residential Emissions, 2012, Wales

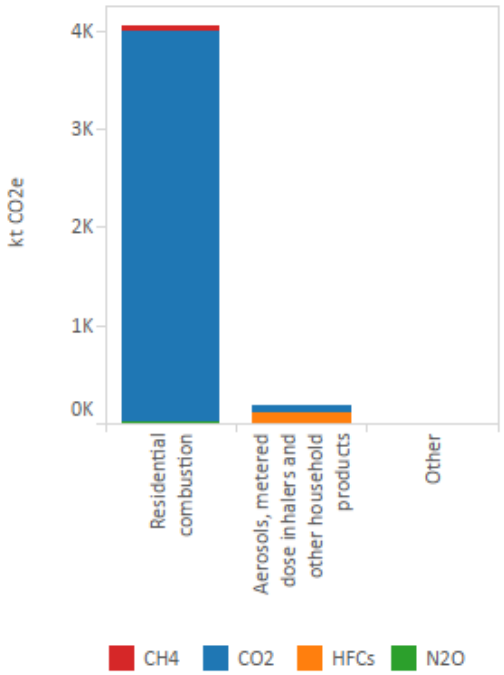
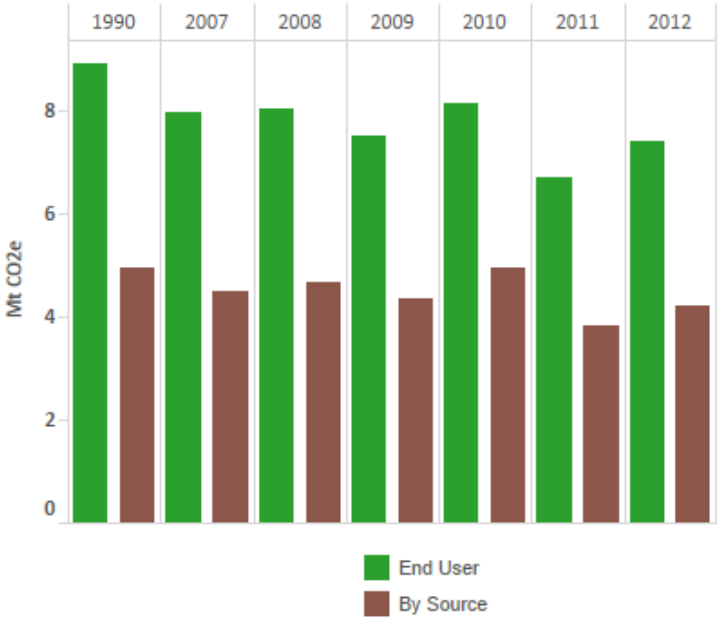


Figure 4.24: Comparison of End User and By Source for Residential, Wales



Overview of Emissions

Overview

Figures 4.21 – 4.24 show detailed emissions and trends for the sector. The Residential sector accounts for 9% of Wales' total emissions in 2012. The sector is dominated by emissions from residential combustion of fuels for heating and cooking, which account for 96% of emissions in this sector. The remaining 4% of emissions were from house and garden machinery, and HFC emissions from aerosols and metered-dose inhalers (MDIs), which would include some inhalers used for asthma.

Features of the Trends

Total GHG emissions from the Residential sector in Wales have decreased by 15% between the Base Year and 2012 (see Table 4.5) partly due to a change in the fuel mx from coal towards natural gas. Despite this, emissions significantly increased by 10% between 2011 and 2012, primarily due to increased consumption of natural gas within the sector[26]. The year-on-year trend can change significantly based upon a number of factors, for example emissions significantly decreased by 22% between 2010 and 2011, primarily due to the cold winter in 2010.

Emissions on an End User Basis

In 2012, Wales End User emissions for the Residential sector are 175% of the By Source emission estimates, reflecting the high consumption of electricity in the sector (Figure 4.24). This increases the overall significance of this sector in the End User inventory to 19% of the Wales total, compared to just 9% of the By Source inventory total. The trend in Residential End User emissions since 1990 shows a decline of around 17% to 2012 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 (see Figure 4.13 in the Energy Supply section for fuel trends since 2005).

[26] Note that the emission estimates in the residential 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 Sector

Figure 4.25: Overall Contribution to 2012 GHG emissions, Wales

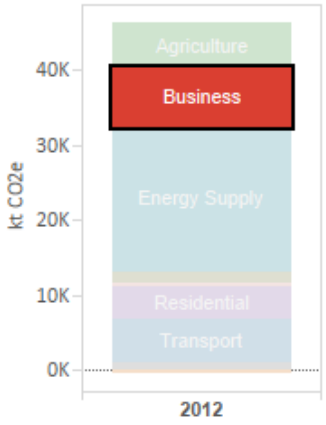


Figure 4.26: Total GHG Emissions from Business, Base Year to 2012, Wales

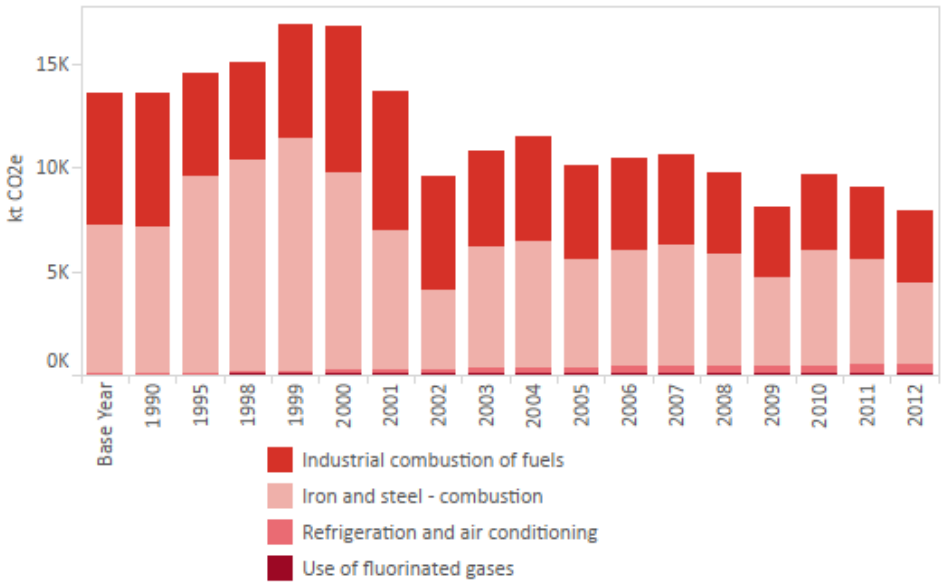


Table 4.6: Change in GHG Emissions from Base Year to 2012 and from 2011 to 2012, Wales

	Base Year to 2012 as %	Base Year to 2012 kt	2011 to 2012 as %	2011 to 2012 kt
Industrial Combustion of fuels	-45%	-2,852	1%	42
Iron and steel - combustion	-45%	-3,188	-23%	-1,173
Refrigeration and air conditioning	1,279%	400	2%	7
Use of fluorinated Gases	-10%	-6	-1%	0
Business	-41%	-5,646	-12%	-1,125

Figure 4.27: GHG Contribution for Business Emissions, 2012, Wales

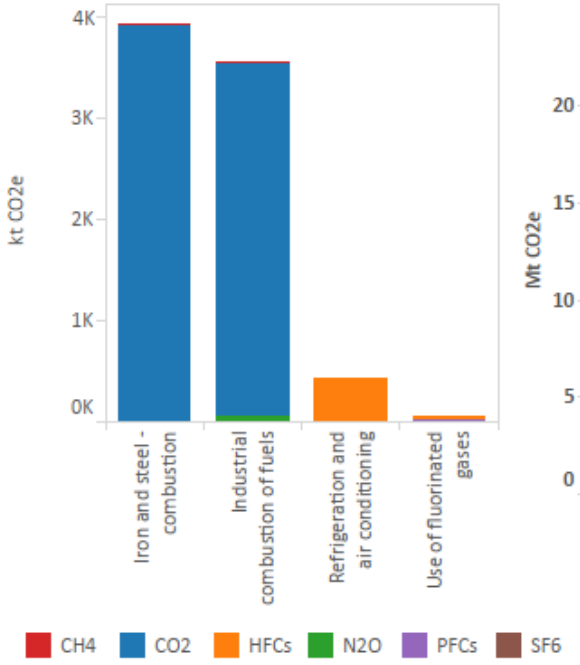
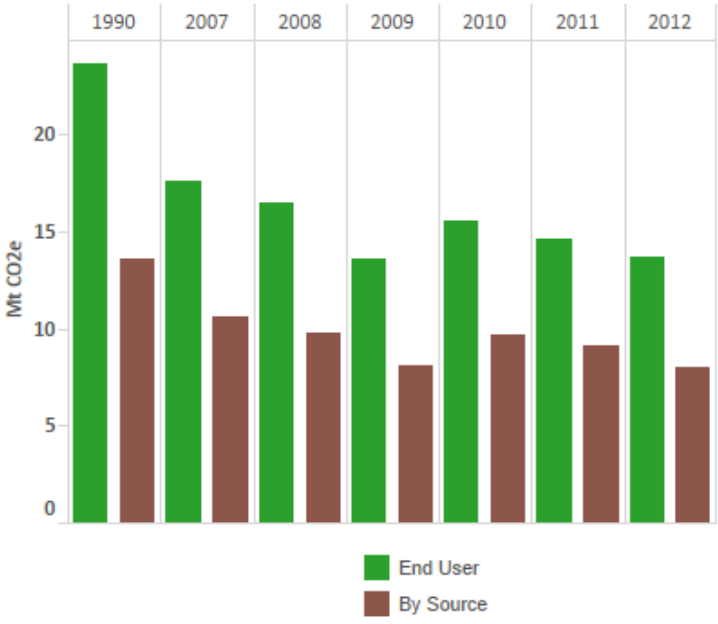


Figure 4.28: Comparison of End User and By Source for Business, Wales



By Source Emissions

Overview

Figures 4.25-4.28 show detailed emissions and trends for the sector. The Business sector contributes 17% to total 2012 GHG emissions in Wales. The Business sector in 2012 includes emissions from industrial combustion of fuels (45% of total emissions); iron and steel fuel combustion (49% of total emissions); refrigeration & air conditioning (5% of total emissions), arising from losses of HFCs during equipment manufacture, leaks and disposal, and HFC emissions from foam production, fire-fighting solvents and electronics (0.7% of total emissions).

In 2012, 93% of emissions were carbon dioxide released from the combustion of fossil fuels in the Business sector with 6% 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).

Features of the Trends

Total GHG emissions from the Business sector have declined by 41% since the Base Year (see Table 4.6). 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 6% of total Business emissions in 2012 since the introduction of these gases as replacement to CFCs banned by the Montreal Protocol.

Emissions have decreased by 12% between 2011 and 2012. The trend is driven largely by a continued decrease in the Iron and Steel sector in Wales and the No.4 Blast Furnace re-build, which began in July 2012, leading to a reduction in production for 2012. A similar trend can be seen in the Iron and Steel sub-category of the Industrial Processes sector, which includes emissions from all non-combustion activities within the production of iron and steel. All combustion-related emissions are reported under the Business sector.

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, the Business and Industrial Process emissions are not easy to separate.

The contribution to total aggregate emissions from the traded and non-traded sector across the Business and Industrial Process sectors are presented in Figure 4.8 in the Overview section under the category: “Industry”. Traded emissions accounted for 64% of total Industry emissions in 2012.

Emissions on an End User Basis

In 2012, Wales’ End User emissions for the Business sector were 172% higher than the by source emission estimates, reflecting the high consumption of electricity for heating, lighting and operating equipment in the sector (see Figure 4.28). On an End User basis, therefore, Business sector represents 35% of total emissions for Wales compared to just 17% of the By Source inventory total.

4.6 Public Sector

Figure 4.29: Overall Contribution to 2012 GHG emissions, Wales

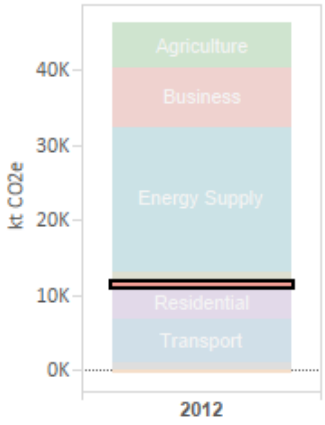


Figure 4.30: Total GHG Emissions from Public, Base Year to 2012, Wales

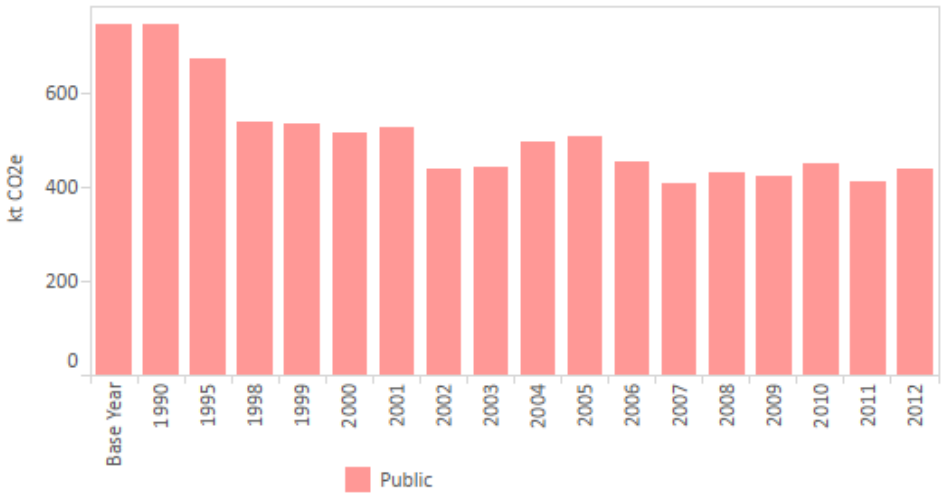


Table 4.7: Change in GHG Emissions from Base Year to 2012 and from 2011 to 2012, Wales

	Base Year to 2012 as %	Base Year to 2012 kt	2011 to 2012 as %	2011 to 2012 kt
Public	-41.2%	-308.0	7.3%	29.8
Public Total	-41.2%	-308.0	7.3%	29.8

Figure 4.31: GHG Contribution for Public Emissions, 2012, Wales

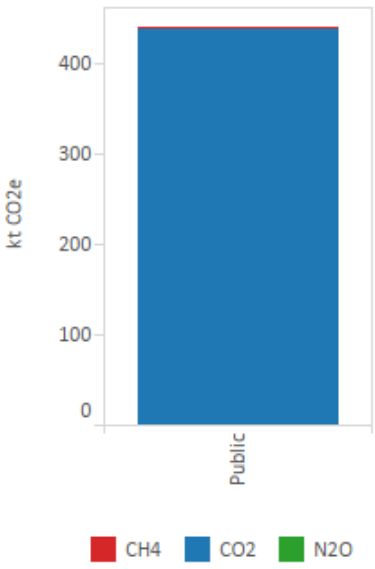
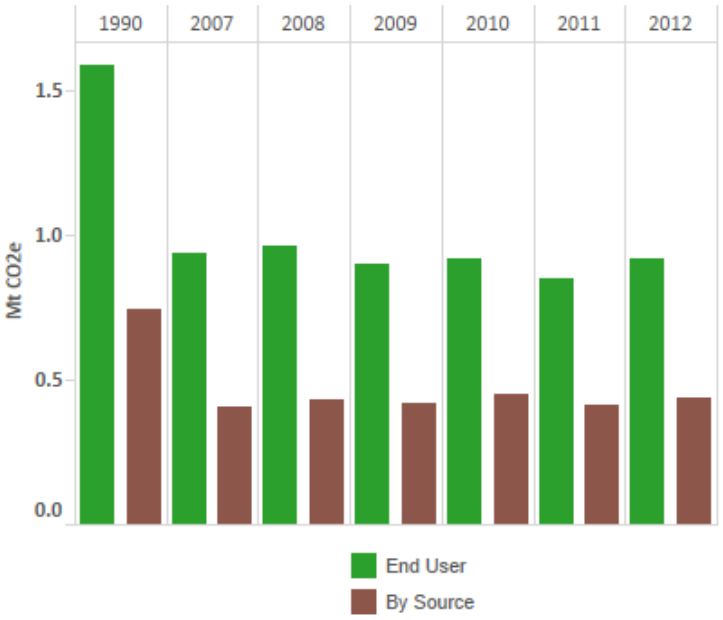


Figure 4.32: Comparison of End User and By Source for Public, Wales



By Source Emissions

Overview

Emissions from Public sector combustion account for 1% of GHG emissions in Wales in 2012. Carbon dioxide emissions from the combustion of fossil fuels accounts for over 99% of emissions in 2012. These emissions are primarily from the combustion of natural gas to heat buildings.

Features of the Trends

Public sector emissions have reduced by 41% since the Base Year (see Table 4.7); 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.

Public sector emissions increased by 7% between 2011 and 2012 primarily due to increased consumption of natural gas in the sector as colder average temperatures were experienced in 2012 compared to 2011. 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.

Emissions on an End User Basis

In 2012, Wales' End User emissions for the Public sector were 209% higher than the By Source emission estimates, reflecting the high consumption of electricity in the sector. This increased the sector's share of total national emissions from 1.0% in the By Source inventory to 2.4% in the End User inventory for 2012 (see Figure 4.32). The trend in End User emissions since 1990 shows a decline of 42% to 2012, which could, in part, be due to a shift in the fuel mix away from coal and oil towards natural gas. Trends in the End User inventory are highly uncertain and should be regarded as indicative.

4.7 Industrial Process Sector

Figure 4.33: Overall Contribution to 2012 GHG emissions, Wales

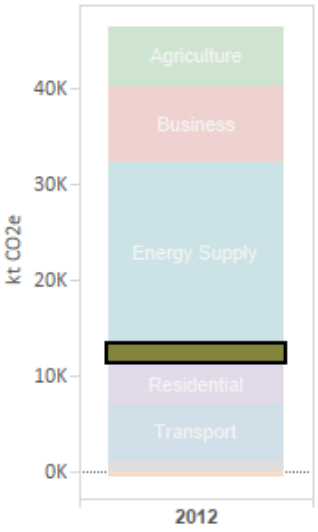
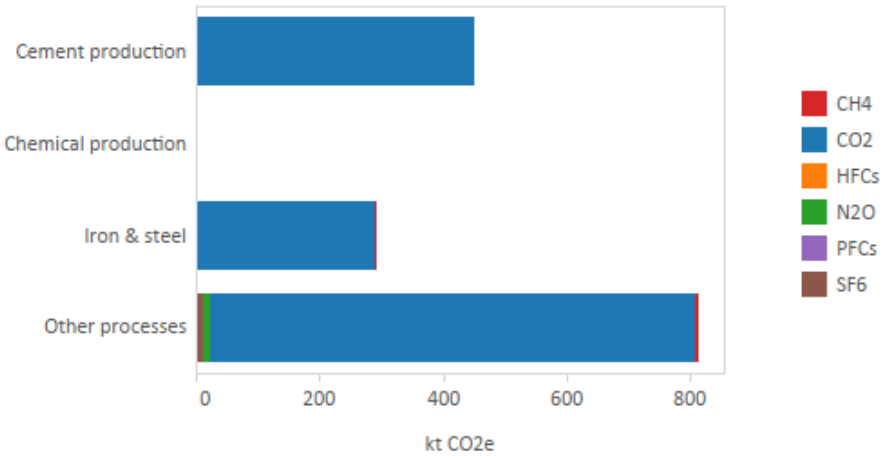


Figure 4.34: Total GHG Emissions from Industrial Process, Base Year to 2012, Wales

Table 4.8: Change in GHG Emissions from Base Year to 2012 and from 2011 to 2012, Wales

	Base Year to 2012 as %	Base Year to 2012 kt	2011 to 2012 as %	2011 to 2012 kt
Cement production	-22%	-125	24%	86
Chemical production	%	0		0
Iron & steel	-43%	-616	-40%	-530
Other processes	-61%	-454	-6%	-19
Industrial Process Total	-43%	-1,196	-23%	-463

Figure 4.35: GHG Contribution to Industrial Process Emissions, 2012, Wales



By Source Emissions

Overview

In Wales in 2012, the Industrial Process sector contributed 3% to total GHG emissions. The Industrial Process sector includes non-combustion sources such as the use of limestone in cement production (29% of total sector GHG emissions); iron and steel processes (19% of total emissions) excluding the use of electricity and fossil fuels for heating processes; and other processes (52% of total emissions) including fertilizers & other bulk chemical feedstocks, glass & brick making and lime production (see Figure 4.34).

In 2012, 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 1.2% of total GHG emissions in this sector.

Features of the Trends

Overall, Industrial Process emissions in Wales have reduced by 43% between the Base Year and 2012 (see Table 4.8) but have shown significant fluctuations during this timeframe reflecting manufacturing output and abatement installations. The overall decline in emissions is due to several factors including a decline in iron and steel industries (contributing approximately 60% to the total declining trend) aluminium production (contributing approximately 30% of to the total declining trend) and cement production (contributing approximately 10% to the total declining trend).

Total GHG emissions have decreased significantly by 23% between 2011 and 2012. The trend is driven largely by a continued decrease in the Iron and Steel sector in Wales and the No.4 Blast Furnace re-build, which began in July 2012. A similar trend can be seen in the "Iron and Steel – combustion" sub-category of the Business sector, which includes emissions from all combustion activities within the production of iron and steel. All emissions from non-combustion activities are reported under the Industrial Processes sector.

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, the Business and Industrial Process emissions are not easy to separate.

The contribution to total aggregate emissions from the traded and non-traded sector across the Business and Industrial Process sectors are presented in Figure 4.8 in the Overview section under the category: "Industry". Traded emissions accounted for 64% of total Industry emissions in 2012.

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 2012, the End User estimates are only 16% 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 Sector

Figure 4.36: Overall Contribution to 2012 GHG emissions, Wales

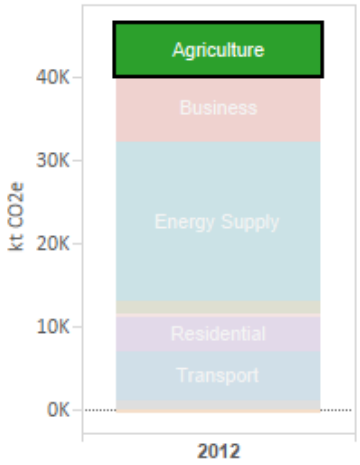


Figure 4.37: Total GHG Emissions from Agriculture, Base Year to 2012, Wales

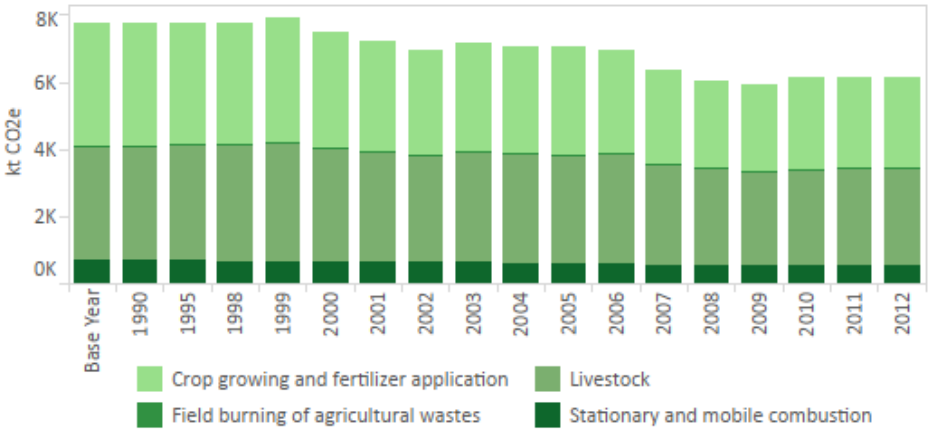


Table 4.9: Change in GHG Emissions from Base Year to 2012 and from 2011 to 2012, Wales

	Base Year to 2012 as %	Base Year to 2012 kt	2011 to 2012 as %	2011 to 2012 kt
Crop growing and fertilizer application	-25%	-918	0%	8
Field burning of agricultural wastes	-100%	-3		0
Livestock	-16%	-562	0%	5
Stationary and mobile combustion	-18%	-122	0%	0
Agriculture Total	-21%	-1,605	0%	12

Figure 4.38: Methane emissions from livestock by type, 2012, Wales

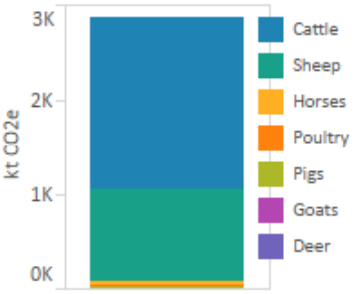


Figure 4.39: GHG Contribution for Agriculture Emissions, 2012, Wales

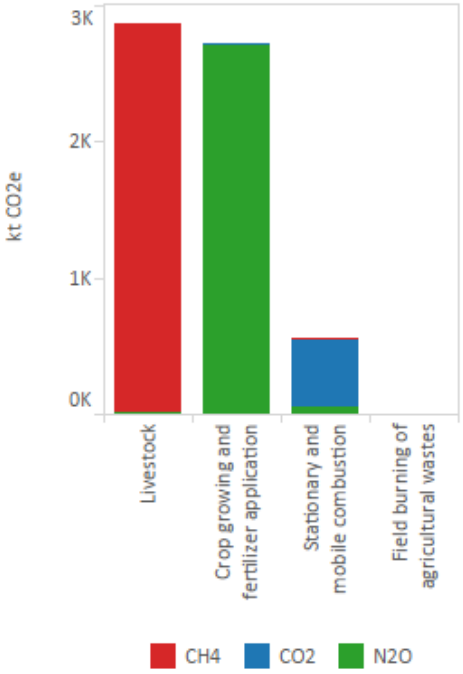


Table 4.10: Emissions of nitrous oxide from agricultural sources in 2012 (kt CO2e), Wales*

Manure management				232
Soils				2,491
	Direct			1,565
		Biological fixation		0
		Crop residues		31
		Fertiliser		404
		Grazing returns		898
		Histosols		0
		Improved grassland		29
		Manure application		190
		Sewage sludge		14
	Indirect			925
		Deposition		166
			Fertiliser	36
			Grazing returns	90
			Manure application	38
			Sewage sludge	3
		Leaching		759
			Fertiliser	269
			Grazing returns	337
			Manure application	143
			Sewage sludge	10
TOTAL				2,723

*Total emissions comprise manure management and soils. Soils include direct and indirect emissions; indirect emissions include leaching and deposition.

By Source Emissions

Overview

GHG emissions from the Agriculture sector 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 (such as tractors and generators) in the sector (see Figure 4.39). The Agriculture sector accounts for 13% of total greenhouse gas emissions in Wales in 2012, and is the most significant source sector for methane and nitrous oxide, accounting for 64% and 89% of total Welsh emissions of these two gases, respectively.

Features of the Trends

Emissions from the Agriculture sector have decreased by -21% between the Base Year and 2012, with pollutant contributions of -16% for methane and -25% for nitrous oxide. The trends result from a general decline in livestock numbers and in fertiliser nitrogen use (particularly to grassland). There was no significant trend between Agriculture sector emissions in Wales between 2011 and 2012 (0.2% increase). There has been a decrease in emissions from cattle, however, a more significant increase in emissions from sheep. Both trends are due to livestock numbers with cattle numbers decreasing by 1% and numbers of sheep increasing by 3%. Field burning has largely ceased in the UK since 1993, hence the significant decrease in emissions since the Base Year.

Sector Detail

Livestock emissions include two main sub-categories: emissions from enteric fermentation (a digestive process by which carbohydrates are broken down by microorganisms into simple molecules) and emissions from manure management. Enteric fermentation contributed 80% (2,294 ktCO_2e) to total agricultural methane in Wales in 2012. Total methane emissions from beef and dairy cattle (enteric and manure management sources combined) accounted for 63% of the all Welsh agricultural methane emissions. Total emissions from sheep were 34% of the total methane from Agriculture in 2012.

Nitrous oxide emissions are largely driven by fertiliser nitrogen use, manure applications and grazing returns to soils. Agriculture is the most important source of nitrous oxide in Wales and 90% (2,491 ktCO_2e) of the total nitrous oxide emissions in the Agriculture sector arose from agricultural soils. This source accounted for 79% of total nitrous oxide emissions in Wales in 2012. A further breakdown of these emissions is shown in Table 4.10.

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 2012, 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.

4.9 Land Use, Land Use Change and Forestry Sector

Figure 4.40: Overall Contribution to 2012 GHG emissions, Wales

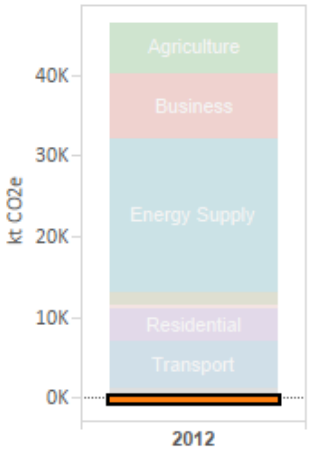


Figure 4.41: GHG Contribution to Land Use Change Emissions, 2012, Wales

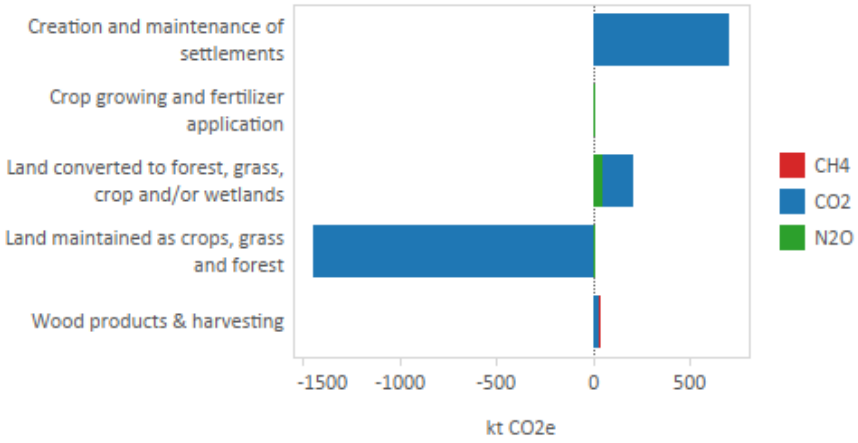


Table 4.11: Change in GHG Emissions from Base Year to 2012 and from 2011 to 2012, Wales

	Base Year to 2012 as %	Base Year to 2012 kt	2011 to 2012 as %	2011 to 2012 kt
Creation and maintenance of settlements	-9.0%	-68.7	-0.2%	-1.6
Crop growing and fertilizer application	2.9%	0.1	0.2%	0.0
Land converted to forest, grass, crop and/or wetlands	-27.8%	-81.1	-2.0%	-4.3
Land maintained as crops, grass and forest	41.2%	-419.6	-5.8%	88.1
Wood products & harvesting	30.6%	8.3	-251.5%	58.8
Land Use Change Total	-802.9%	-561.0	-22.3%	82.2

Figure 4.42: Total GHG Emissions from LULUCF, Base Year - 2012, Wales

By Source Emissions

Overview

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 (Miles *et al*., 2014) and more detailed information is also available in the UK Greenhouse Gas Inventory Report, available on the NAEI website.

Figures 4.40 – 4.42 and Table 4.11 show detailed emissions and trends for the Land Use, Land Use Change and Forestry (LULUCF) sector. Wales was a net source of GHG emissions in 1990, but since has been a net sink of GHG emissions and the size of this sink (CO_2e removal) has grown by over 300% between 1995 and 2012 from -111 ktCO_2e to -491 ktCO_2e. This is predominantly due to a reduction in the sink from land maintained as crops, grass and forest.

Features of the Trends

Table 2.11 show a 22% reduction in net removal of CO_2e from LULUCF between 2011 and 2012 (a decrease in the size of the sink), along with the trends in emissions and removals from important activities in the LULUCF sector. The net emissions in Wales are dominated by emissions from Creation and maintenance of settlements, which have reduced by 9% between 1990 and 2012, and are a result of emissions from biomass removal from built-up and transport areas, gardens and mineral workings.

Net removals from Land Maintained as Crops, Grass and Forest (which includes land converted to forest) have generally increased to 2005 with a decrease between 2005 and 2012 as a result of declining removals in the harvesting of wood products (Wood Products and Harvesting).

The increase in the sink for Land Maintained as Crops, Grass and Forest contributed to 75% of the total change in emissions between 1990 and 2012.

Emissions on an End User Basis

As emissions and removals from LULUCF do not relate to Energy Supply the End User emissions are the same as emissions By Source.

4.10 Waste Management Sector

Figure 4.43: Overall Contribution to 2012 GHG emissions, Wales

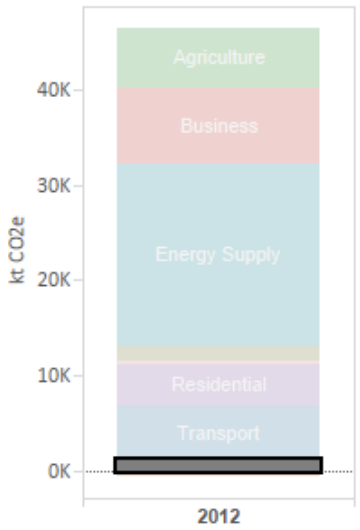


Figure 4.44: Total GHG Emissions from Waste Management, Base Year to 2012, Wales

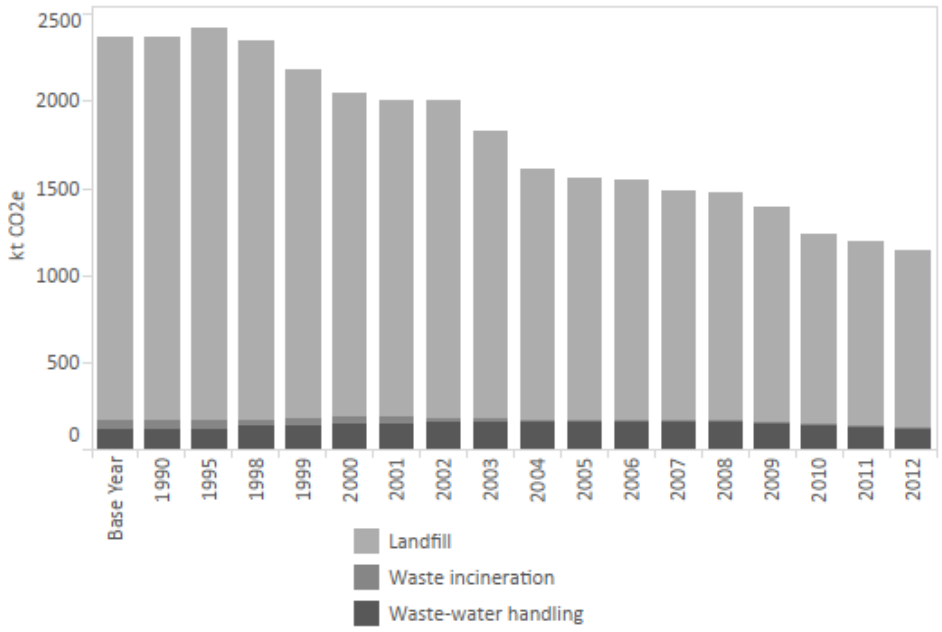
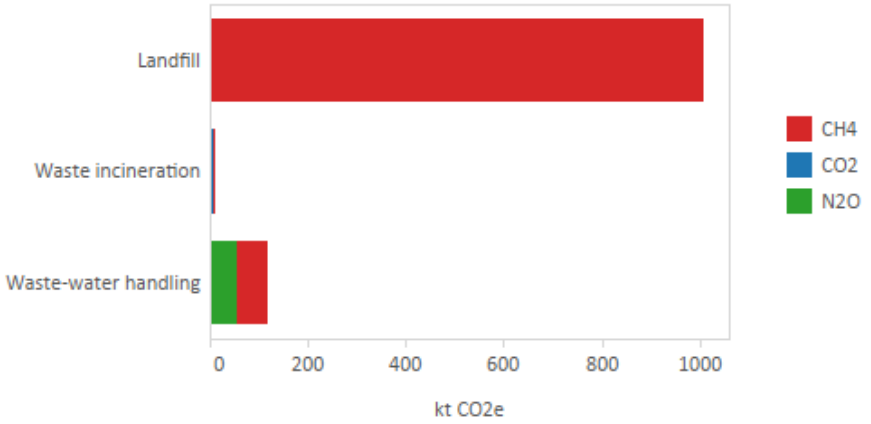


Table 4.12: Change in GHG Emissions from Base Year to 2012 and from 2011 to 2012, Wales

	Base Year to 2012 as %	Base Year to 2012 kt	2011 to 2012 as %	2011 to 2012 kt
Landfill	-54%	-1,191	-5%	-51
Waste incineration	-85%	-46	-9%	-1
Waste-water handling	4%	4	-5%	-6
Waste Management	-52%	-1,232	-5%	-58

Figure 4.45: GHG Contribution to Waste Management Emissions, 2012, Wales



By Source Emissions

Overview

In 2012, the Waste Management sector contributed 2.5% to total GHG emissions in Wales. It was the second largest source for methane emissions, representing 24% of total methane emissions. Emissions from this sector are dominated by methane from landfill (89% of emissions) with a smaller contribution of methane and nitrous oxide emissions from wastewater treatment (11% of emissions) and a minimal remaining contribution from waste incineration (see Figure 4.45).

Nitrous oxide emissions from wastewater treatment represented 5% of emissions in the sector, and contributed 2% to the total emissions of nitrous oxide in Wales.

Features of the Trends

Total GHG emissions from the Waste Management sector in Wales have shown a significant decline of 52% in total for the sector and by 54% for landfill between the Base Year and 2012, as shown in Table 4.12, 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 2011 and 2012, which has been the primary driver for the overall decrease of 5% in emissions from the Waste Management sector due to improved management systems. There were also further, small reductions in the methane emission estimates from industrial and municipal waste water treatment.

Emissions on an End User Basis

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

5 Emission Estimates in Northern Ireland (1990-2012)

5.1 Overview of Total Emissions

By Source Emissions

Overview

The greenhouse gas (GHG) emissions for Northern Ireland for 1990 – 2012 are presented in Table 5.1 and in the graph in Figure 5.1 below. Emissions in 2012 are 20,974 $ktCO_2e$ with 30% from Agriculture, 20% from Transport, 18% from Energy Supply, 15% from Residential sources and 11% from the Business sector.

Table 5.1: 1990-2012 Northern Ireland GHG Emission Inventory ($ktCO_2e$)

NC Format	Base Year	1990	1995	2000	2005	2008	2009	2010	2011	2012	% of 2012
Agriculture	6,864	6,864	7,272	6,974	6,746	6,226	6,195	6,275	6,309	6,322	30%
Business	2,808	2,781	2,577	2,362	2,499	2,357	2,303	2,639	2,407	2,396	11%
Energy Supply	5,315	5,315	6,541	6,341	5,349	4,840	3,681	3,944	3,738	3,826	18%
Industrial Process	761	761	779	682	418	400	178	170	162	162	1%
LULUCF	126	126	-73	-243	-182	-173	-159	-154	-125	230	1%
Public	462	462	288	147	173	200	200	197	204	198	1%
Residential	4,176	4,165	3,611	3,811	3,505	3,433	3,389	3,808	3,116	3,164	15%
Transport	3,328	3,328	3,559	4,003	4,419	4,402	4,283	4,207	4,114	4,102	20%
Waste Management	1,133	1,133	1,180	981	761	733	688	616	599	577	3%
Total [27]	**24,971**	**24,934**	**25,735**	**25,059**	**23,688**	**22,418**	**20,760**	**21,703**	**20,524**	**20,974**	**100%**

Trends

Figure 5.2 shows the change in emissions from the Base Year and 2011 to the latest year, 2012. Total GHG emissions for Northern Ireland show an increase of 2% between 2011 and 2012, and a decrease between the Base Year[28] and 2012 of 16%. **The 2011 to 2012 trend is predominantly driven by the forest fires that occurred in 2012 and the shift from natural gas to coal in the Energy Supply sector.**

The following list provides an overview of the trend for each NC sector:

- **LULUCF** sector was a source of emissions in the Base Year. From 1995, this sector was a sink. In 2012, there was a large wildfire that resulted in a large increase in emissions for that one year. This sector was previously a sink (-125 $ktCO_2e$) in 2011 and is now a source (230 $ktCO_2e$) in 2012.
- **Energy Supply** sector emissions have decreased by 28% between the Base Year and 2012. There was a small increase in overall emissions between 2011 and 2012. This 2% increase (88 $ktCO_2e$) was mainly due to a shift from natural gas to coal in power stations due to global fuel prices.
- **Residential** sector emissions have, generally, decreased since the Base Year. Emissions between 2011 and 2012, however, increased by 2% (47 $ktCO_2e$) due to the return to average temperatures in 2012. This led to an increase in fuel consumption compared to the warm year experienced in 2011.
- **Waste Management** sector emissions have significantly declined by 49% since the Base Year, largely due to the progressive introduction of methane capture and oxidation systems within landfill management. Emissions decreased by 4% (22 $ktCO_2e$) between 2011 and 2012 in line with this decline.

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

[28] 1995 for fluorinated greenhouse gases (F-Gases) and 1990 for all other gases

- **Agriculture** sector emissions have reduced by 8% since the Base Year mainly due to an overall decrease in livestock numbers. There was a small decrease of less than 1% (13 $ktCO_2e$) in emissions from 2011 to 2012 mainly due to an increase in emissions from cattle due to increased livestock numbers over this period, which then also lead to an increase in emissions from grazing.
- **Transport** sector emissions have increased by 23% between the Base Year and 2012 due to strong growth in transport demand over the period. Emissions between 2011 and 2012 decreased by less than 1% (12 $ktCO_2e$).
- **Business** sector emissions have reduced by 15% since the Base Year. Emissions have slightly decreased by less than 1% (11 $ktCO_2e$) between 2011 and 2012 caused by a decrease in emissions from the food and drink, and chemicals industries balanced by an increase in emissions from other industrial combustion sources.
- **Public** sector emissions have reduced by 57% since the Base Year. This is due to increased energy efficiency measures and the switch to gas-fired heating. Emissions between 2011 and 2012 decreased by 3% (6 $ktCO_2e$) due mainly to a decrease in the use of fuel oil.
- **Industrial Process** emissions have decreased significantly since the Base Year (79%). Emissions slightly decreased by 0.3% between 2011 and 2012 (0.6 $ktCO_2e$).

Emissions Detail

Detailed analysis of Northern Ireland emissions in 2012 is presented in Figures 5.4-5.9. The largest sources of emissions in 2012 include road transport (18% of total GHGs), electricity production (18% of total GHGs), residential combustion for heating and cooking (15% of total GHGs), livestock emissions (15% of total GHGs) and crop growing and fertilizer application (13% of total GHGs).

Figure 5.3 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 the Agriculture sector, where methane from livestock and nitrous oxide from soils, and for Waste Management, where methane from landfills are the most important gases (see Figure 5.5).

Recalculations

Revisions to the estimates since the last inventory report (Salisbury *et al.,* 2013) have resulted in a 3.4% (697 $ktCO_2e$) increase in the 2011 estimates for Northern Ireland. The most significant revisions to the 2011 estimates have been for the following sectors:

1. **Manure Management (Agriculture)**: (735 $ktCO_2e$ increase). In response to reviewer questions, the UK revised its allocation of manure into the various management systems. In particular the amounts going to daily spread were reduced significantly and the amounts previously allocated to solid storage were reallocated to deep litter leading to an increase from 1% to 39% in the methane conversion factor.
2. **LULUCF**: (-305 $ktCO_2e$ decrease). The inventory now uses the CARBINE model to estimate emissions from LULUCF. This change in methodology has led to significant recalculations across the time series. CARBINE can represent a comprehensive range of forest tree species relevant to the UK, representing UK growth conditions and management practices, and combining area / age class information for carbon stocks. Compared to previous estimates, this more detailed methodology based on application of CARBINE provides greater representation of Forest Land and the range of forest management practices observed in the UK.
3. **Managed Waste Disposal on Land**: (144 $ktCO_2e$ increase) due to flaring data within the inventory now being based on the quantities of gas recorded as being collected and burnt in landfill gas engines and flares. This has led to an increase in estimates for Northern Ireland.

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

Figure 5.1: Total GHG Emissions by NC category for Base Year to 2012, as kt CO2e, Northern Ireland

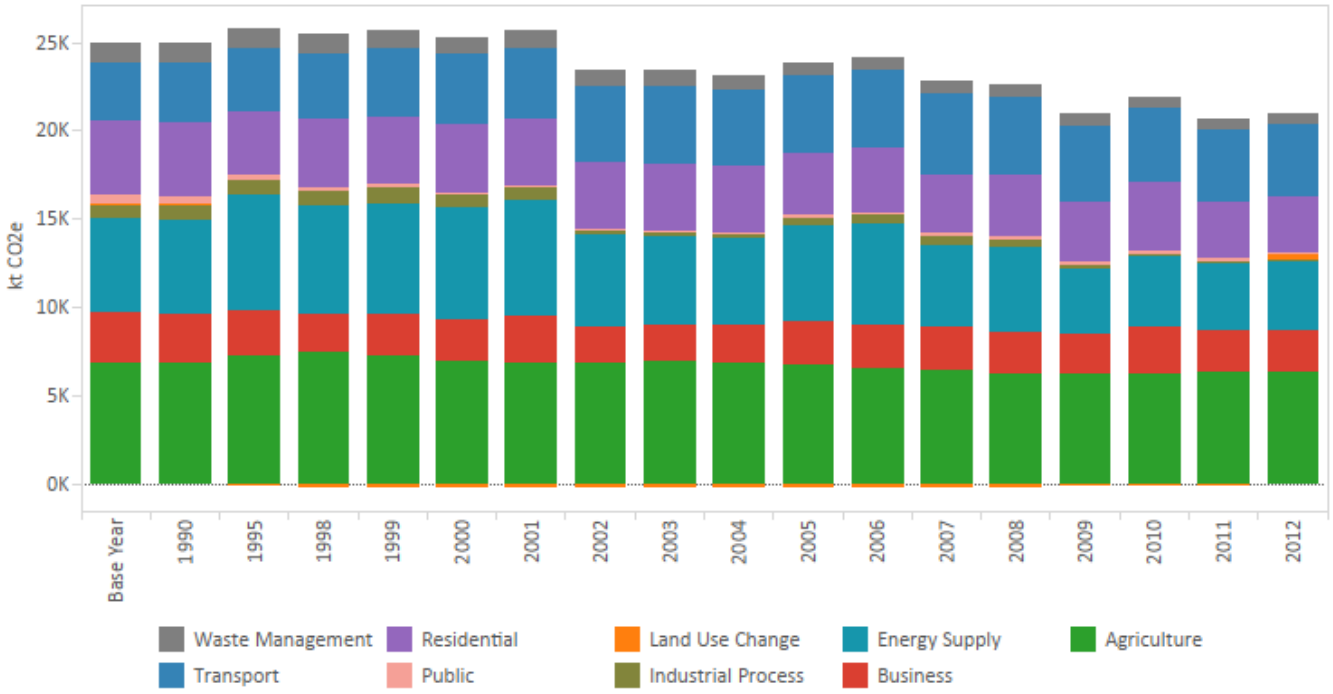
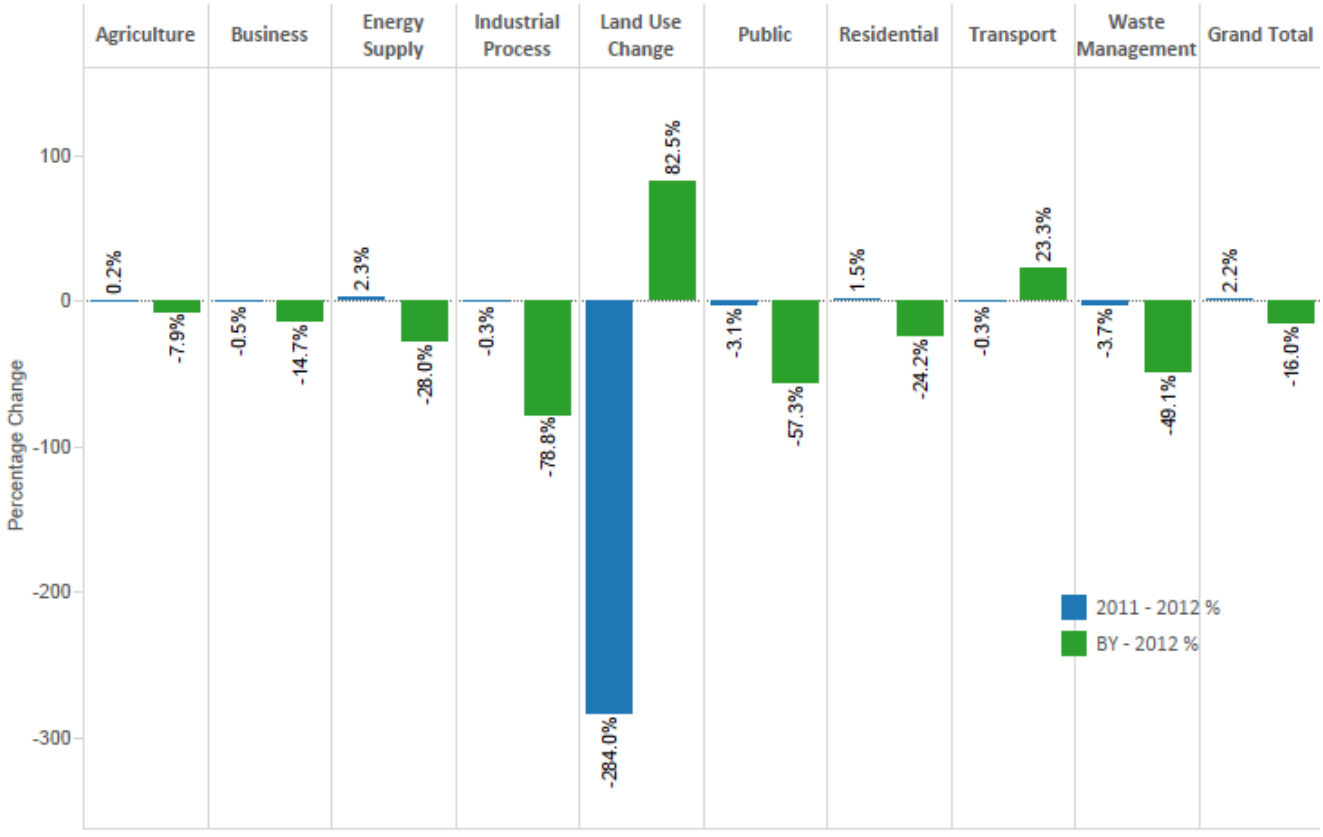


Figure 5.2: Percentage Change and Absolute (kt CO2e) Change in GHG Emissions by NC: Base Year(BY) - 2012 and 2011 - 2012, Northern Ireland

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



	Agriculture	Business	Energy Supply	Industrial Process	Land Use Change	Public	Residential	Transport	Waste Management	Grand Total
BY - 2012 kt	-542	-412	-1,489	-599	104	-265	-1,012	774	-556	-3,997
2011 - 2012 kt	13.1	-11.3	87.8	-0.6	354.4	-6.3	47.4	-12.4	-22.3	449.9

Figure 5.3: Total GHG emissions and uncertainties by pollutant, 2012, Northern Ireland

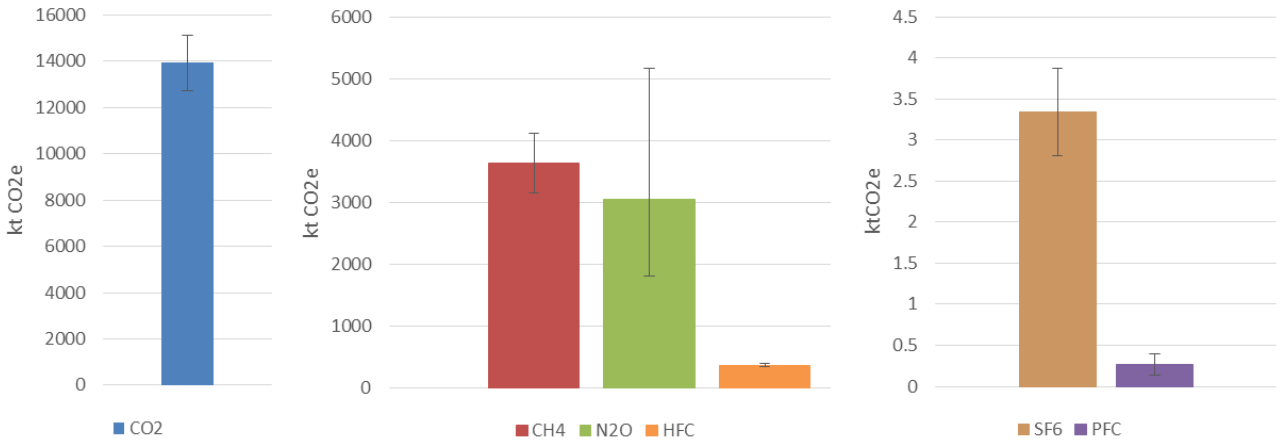


Figure 5.4: Total GHG Emissions by NC and pollutant, 2012, Northern Ireland

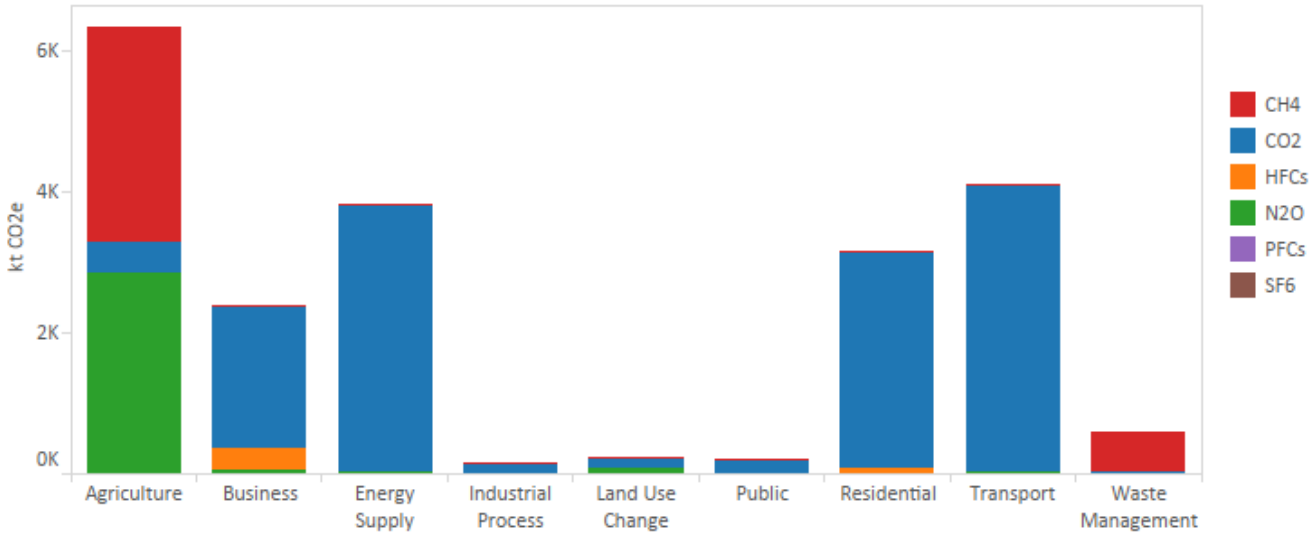
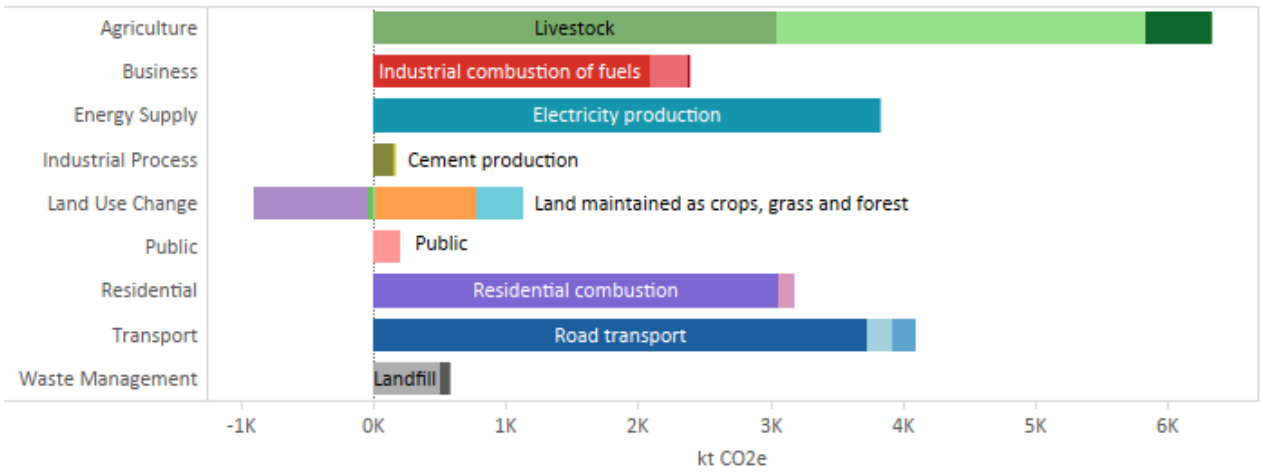


Figure 5.5: Total GHG Emissions labelling the largest sub-category in each NC, 2012, Northern Ireland



Traded and Non-Traded Emissions

Emissions from installations included in the European Union Emissions Trading Scheme (EU ETS) (see Figure 5.7) reduced by 5% between 2010 and 2011, followed by an increase of 3% between 2011 and 2012. Emissions from installations in the EU ETS (see Figure 5.7) accounted for 21% of total GHG emissions in Northern Ireland in 2012; the main contributors to these traded emissions are the Energy Supply sector (of which over 99% of total emissions are within the EU ETS, including all power stations) and the Business and Industrial Process sectors (see Figure 5.8) of which, 24% of total sector emissions are in the EU ETS.

Figure 5.6: Total Traded and Non-Traded GHG Emissions by NC Category, 2012, Northern Ireland

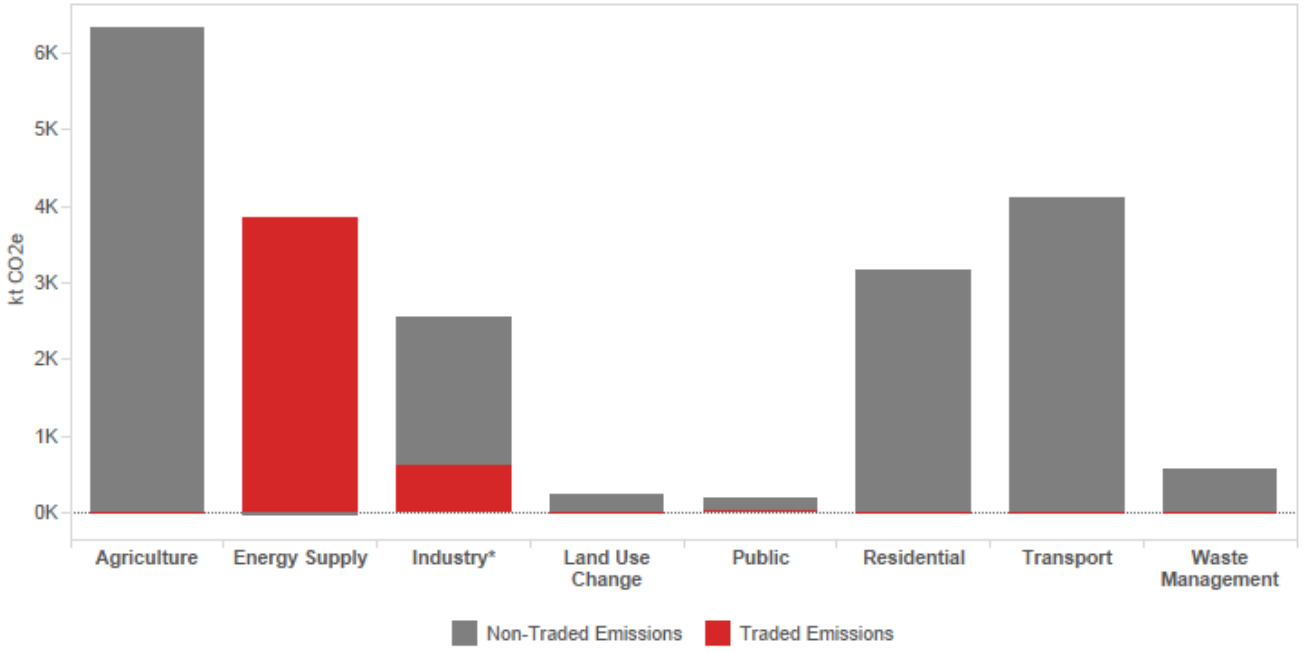


Figure 5.7: Total Traded and Non-Traded GHG Emissions 2008-2012, Northern Ireland

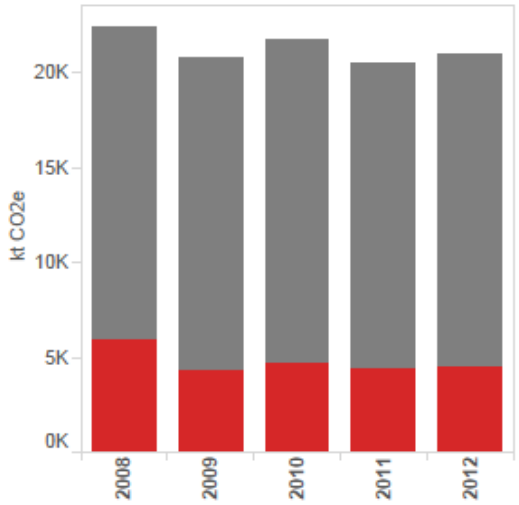
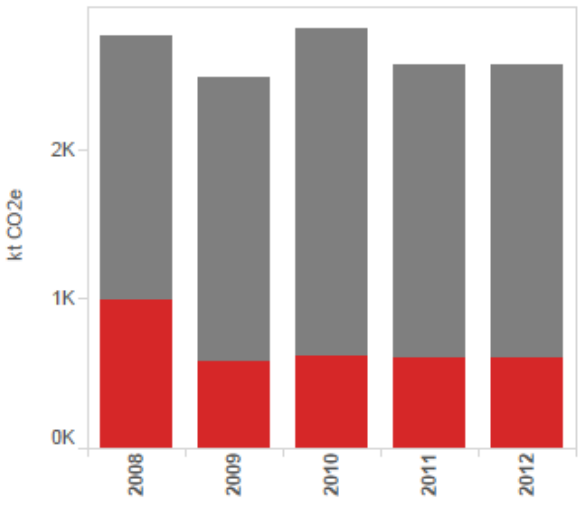


Figure 5.8: Traded and Non-Traded GHG Emissions from Industry 2008-2012, Northern Ireland*



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

Emissions on an End User Basis

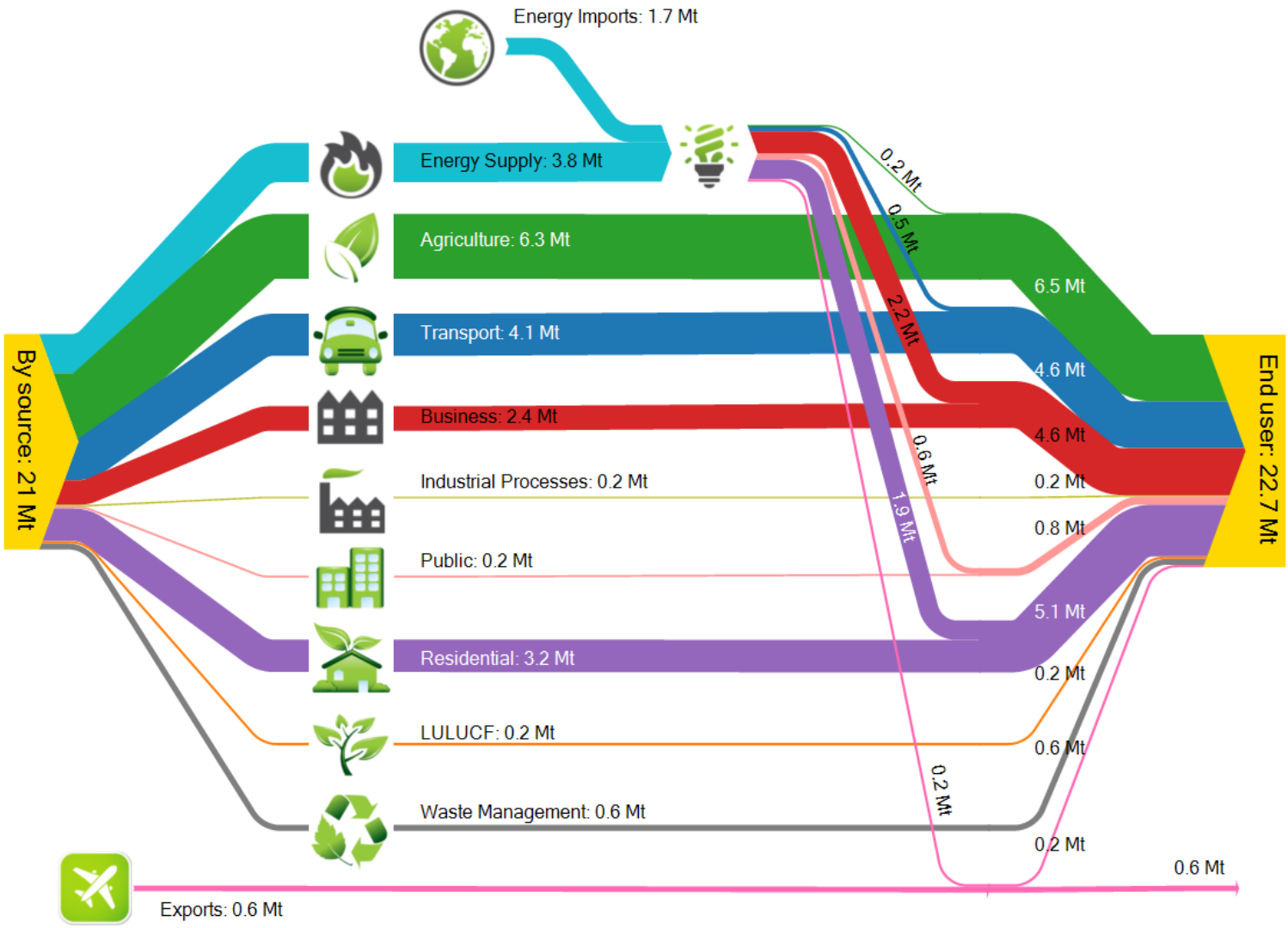
In addition to presenting emissions based on direct emissions from processes or combustion of fuels in Northern Ireland, the emissions from the Energy Supply sector can be attributed to the users of the energy (see Appendix 3 for more details of the End User inventory methodology).

Figure 5.9 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 2012 are: 22% from the Residential sector, 20% from Transport sources and 20% from the Business sector. As illustrated in Figure 5.9, Northern Ireland is a net importer of electricity which results in higher emissions (8% of all GHGs) in Northern Ireland on an End User basis (22,673 $ktCO_2e$) compared to by source (20,974 $ktCO_2e$) inventory estimates for 2012.

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.

Figure 5.9 Sankey diagram showing By Source and End User[29] GHG emission transfers for Northern Ireland in 2012 (Mt CO_2e)[30]



[29] 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.

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

5.2 Energy Supply Sector

Figure 5.10: Overall Contribution to 2012 GHG emissions, Northern Ireland

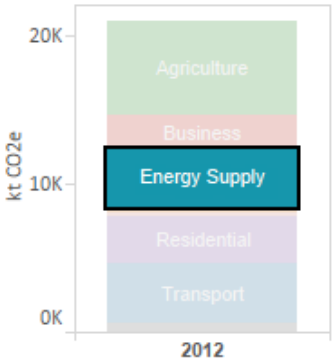


Figure 5.11: GHG Contribution to Energy Supply Emissions, 2012, Northern Ireland

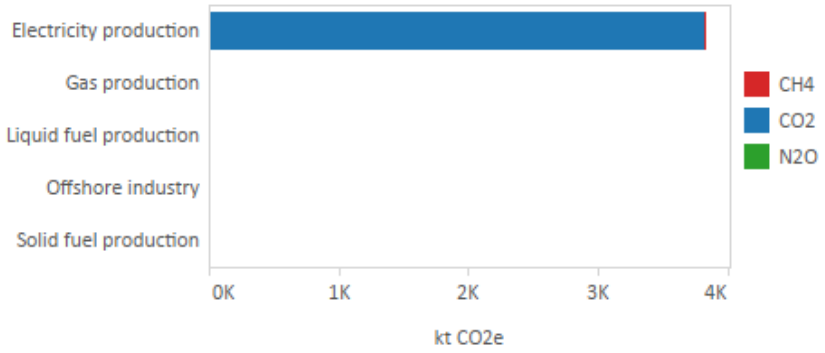


Table 5.2: Change in GHG Emissions from Base Year to 2012 and from 2011 to 2012, Northern Ireland

	2011 - 2012 %	2011 - 2012 kt	BY - 2012 %	BY - 2012 kt
Electricity production	2%	88	-28%	-1,490
Gas production	-4%	0		0
Liquid fuel production		0		0
Offshore industry		0		0
Solid fuel production	409%	0		0
Energy Supply Total	2%	88	-28%	-1,489

Table 5.3: NC Category Contribution to End User Inventory by percentage of Electricity Production Emissions, Northern Ireland

Agriculture	2%
Business	46%
Industrial Process	0%
Public	12%
Residential	35%
Transport	0%
Exports*	4%

Figure 5.12: Total GHG Emissions from Energy Supply, Base Year to 2012, Northern Ireland

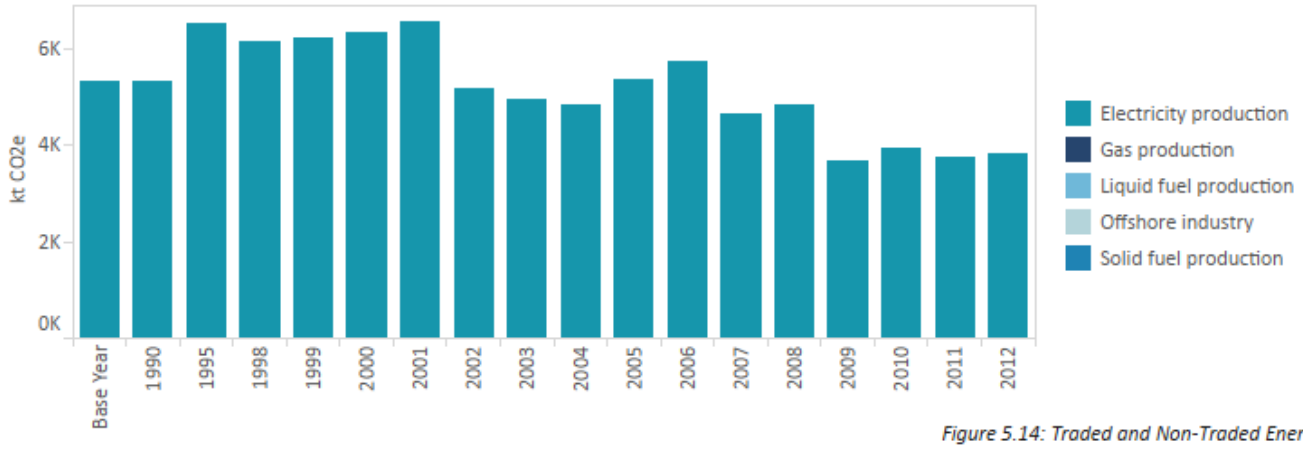


Figure 5.13: Emissions and Electricity Production by Fuel Type from Major Power Producers (1A1a), Northern Ireland

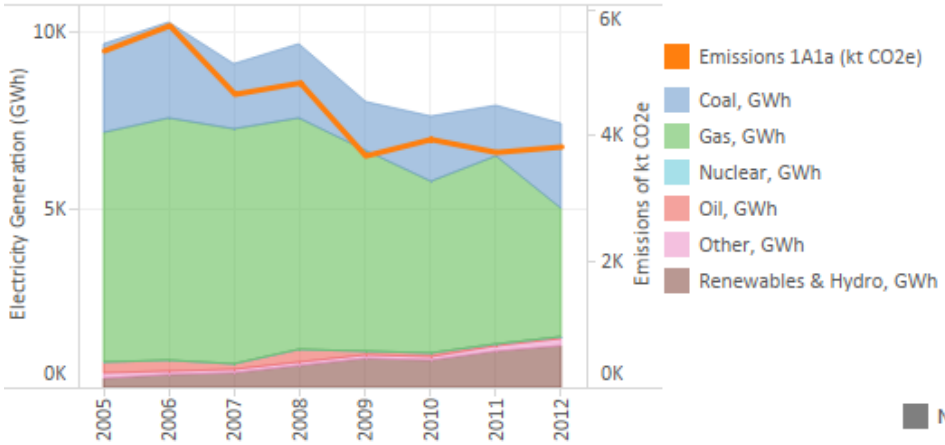
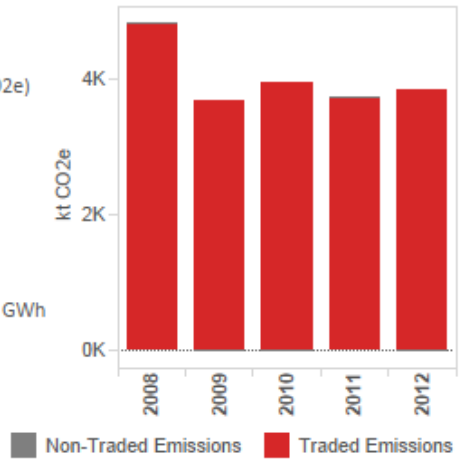


Figure 5.14: Traded and Non-Traded Energy Supply Emissions, 2008-2012, Northern Ireland



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

By Source Emissions

Overview

In Northern Ireland the Energy Supply sector contributes 18% to total 2012 GHG emissions (see Figure 5.10). 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.

Features of the Trends

Energy Supply sector emissions have reduced since 1990 (by 28% between the Base Year and 2012), but have seen a small increase between 2011 and 2012 (by 2%), with the trend due to a shift from the consumption of natural gas to coal due to global fuel prices and this fuel switch has led to an overall increase in emissions from this sector.

Sector Detail

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 2012; gas production accounts for approximately 0.01% of emissions (see Figure 5.12). Carbon dioxide is the predominant gas accounting for over 99% of emissions from the Energy Supply sector in 2012 as a result of the combustion of fossil fuels (see Figure 5.11).

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, subsequently, be exported and sold into the Republic of Ireland electricity grid, whilst the country also imports electricity from Scotland via the Moyle interconnector.

Traded and Non-Traded Emissions

All emissions from electricity production in the Energy Supply sector originate from Traded (EU ETS) installations (see Figure 5.14).

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. Table 5.3 indicates the reallocation of emissions related to the production of electricity to the other sectors. The Business and Residential sectors are the most prominent, with 46% and 35%, respectively, of emissions from the production of electricity reallocated to each.

5.3 Transport Sector

Figure 5.15: Overall Contribution to 2012 GHG emissions, Northern Ireland

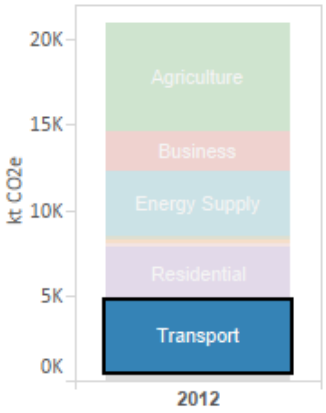


Figure 5.16: Total GHG Emissions from Transport, Base Year to 2012, Northern Ireland

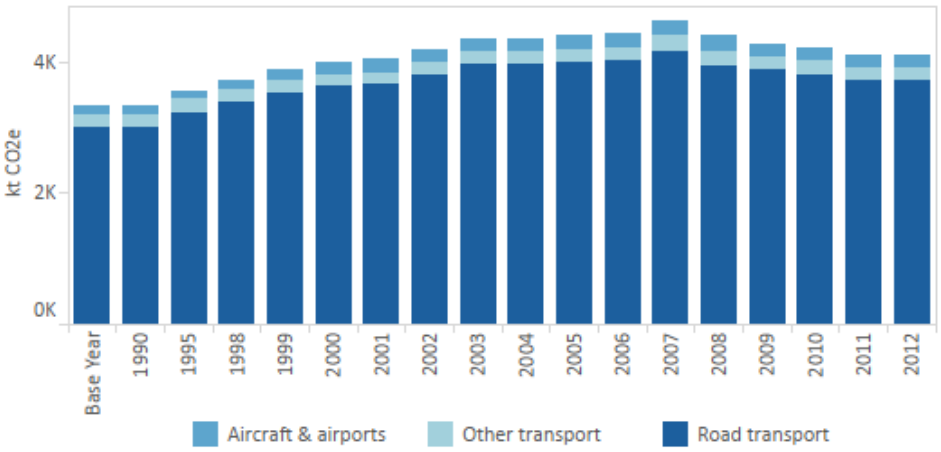


Table 5.4: Change in GHG Emissions from Base Year to 2012 and from 2011 to 2012, Northern Ireland

	Base Year to 2012 as %	Base Year to 2012 kt	2011 to 2012 as %	2011 to 2012 kt
Aircraft & Airports	55.3%	64.8	-2.8%	-5.2
Road Transport	24.6%	734.9	-0.1%	-5.0
Other Transport	-11.7%	-25.7	-1.2%	-2.2
Transport	23.3%	774.0	-0.3%	-12.4

Figure 5.17: GHG Contribution for Transport Emissions, 2012, Northern Ireland

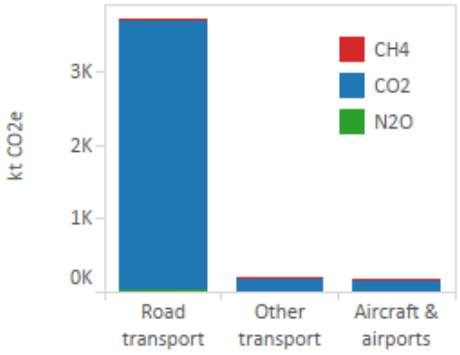


Figure 5.18: Comparison of End User and By Source for Transport, Northern Ireland

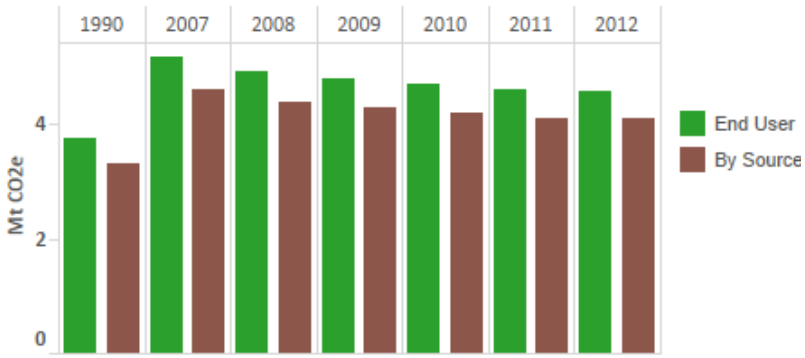


Figure 5.19 Road Transport CO2 Emissions (fuel sales basis), Northern Ireland

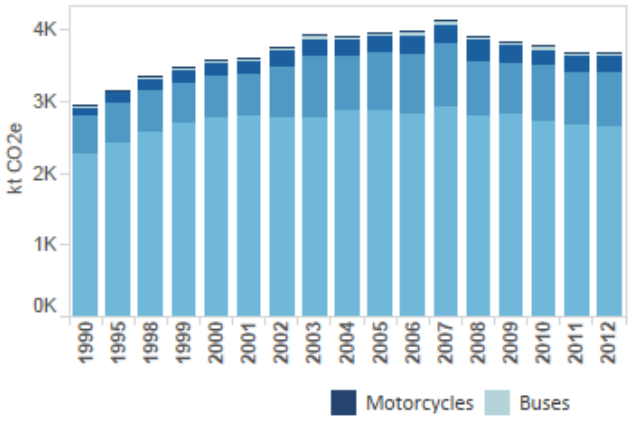
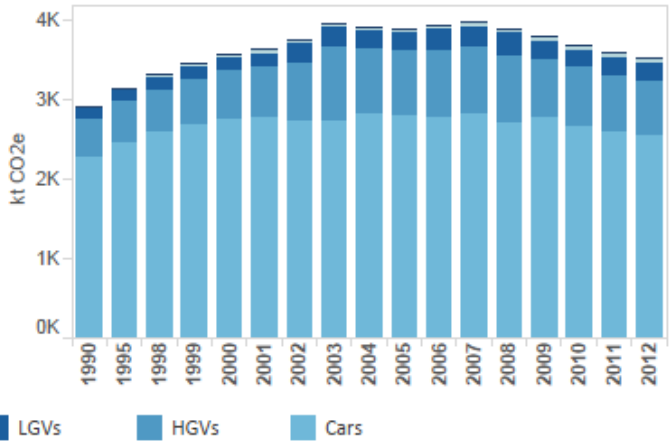


Figure 5.20: Road Transport CO2 Emissions (vkm basis), Northern Ireland



By Source Emissions

Overview

Transport emissions account for 20% of Northern Ireland's total GHG emissions in 2012. Transport emissions are dominated by emissions from road Transport (91% of all Transport emissions in 2012, with 65% of Transport emissions from cars alone (see Figures 5.19 and 5.20).

The Transport sector also includes 0.9% from rail (including stationary sources), 4% from domestic aviation, 2% from national navigation and coastal shipping, and 1% from military aviation and shipping. Emissions from international aviation are excluded from these estimates. Details of these emissions are included in Appendix 6.

Features of the Trends

Total GHG emissions from the Transport sector in Northern Ireland have increased by 23% between the Base Year and 2012 despite improvements in efficiency of vehicles, as a result of strong growth in demand. Emissions peaked in 2007 and have since declined partly due to improvements in average fuel efficiency of vehicles and the switch from petrol to diesel cars and from a reduction in traffic volumes. Emissions between 2011 and 2012 have not seen any significant change – decreasing by less than 0.5% (see Table 5.4).

Sector Detail

There are two approaches used to calculate emissions from Road Transport: fuel sales basis – emissions are constrained to the total fuel sold within the UK as stated in DUKES (DECC, 2013b); vehicle kilometre basis – emissions are estimated using vehicle km data and are not constrained by the total fuel sold, so estimate emissions based on fuel used within the UK. The inventory emission estimates for Road Transport are calculated on a fuel sold basis and are, therefore, consistent with DUKES.

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 4.2% lower than the estimates constrained to DUKES for 1990 and 2012, respectively. The differences between the two approaches fluctuate year on year but they remain within 4.2% 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 2012) 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% between the Base Year and 2012, while the constrained approach indicates a 25% increase.

Emissions on an End User Basis

The End User estimates for 2012 are 11% higher than the by source estimates, reflecting the additional emissions from upstream oil extraction and the oil refining sector (see Figure 5.18).

The trend in End User emissions since 1990 shows an increase of 22% to 2012, 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.

5.4 Residential Sector

Figure 5.21: Overall Contribution to 2012 GHG emissions, Northern Ireland

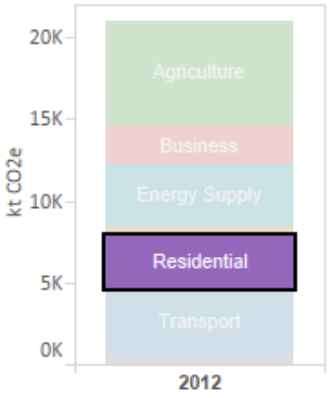


Figure 5.22: Total GHG Emissions from Residential, Base Year to 2012, Northern Ireland

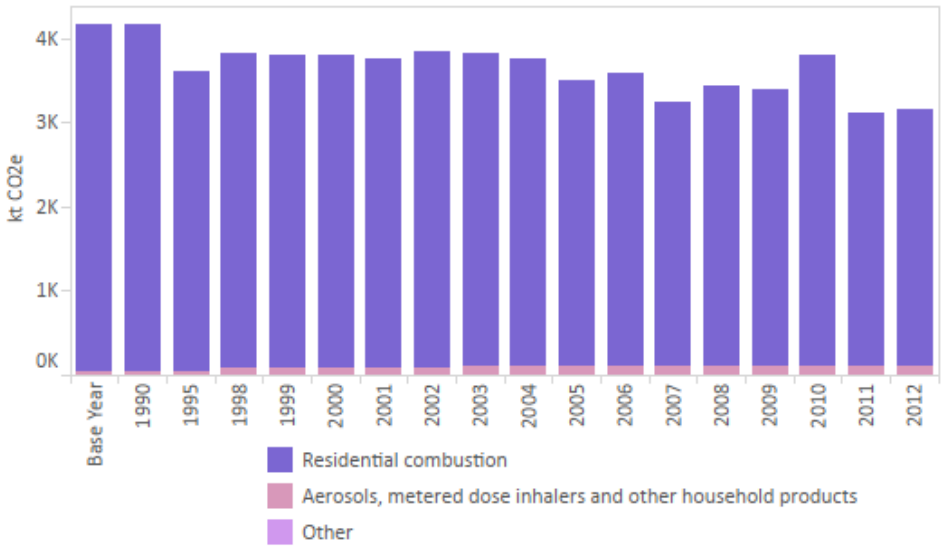


Table 5.5: Change in GHG Emissions from Base Year to 2012 and from 2011 to 2012, Northern Ireland

	Base Year to 2012 as %	Base Year to 2012 kt	2011 to 2012 as %	2011 to 2012 kt
Aerosols, metered dose inhalers and other household products	122%	55	1%	1
Other	-42%	0	0%	0
Residential combustion	-26%	-1,068	2%	47
Residential Total	-24%	-1,012	2%	47

Figure 5.23: GHG Contribution for Residential Emissions, 2012, Northern Ireland

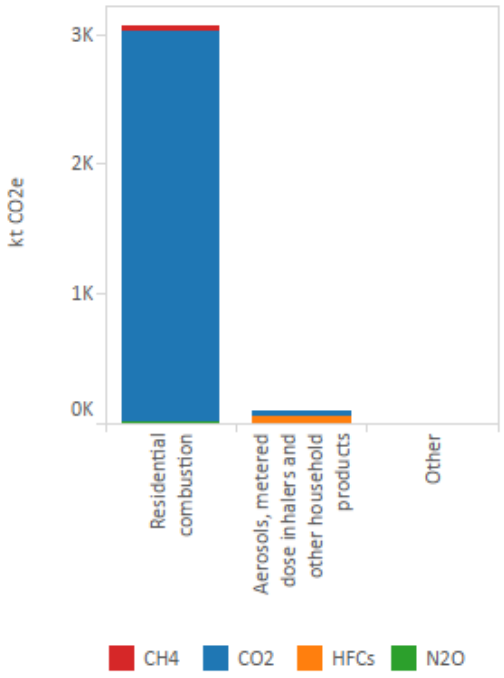
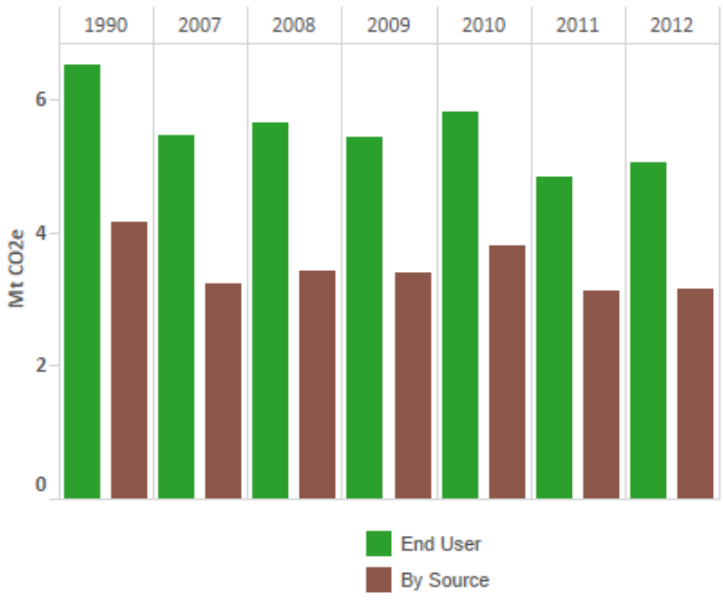


Figure 5.24: Comparison of End User and By Source for Residential, Northern Ireland



By Source Emissions

Overview

The Residential sector accounts for 15% of Northern Ireland's total GHG emissions in 2012. The sector comprises emissions from Residential combustion (97% 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. 97% of all Residential GHG emissions are from the release of carbon dioxide from the direct combustion of fossil fuels (see Figure 5.23).

Features of the Trends

Total GHG emissions from the Residential sector in Northern Ireland have decreased by 24% between the Base Year and 2012. There was a small increase in GHG emissions from the sector of 2% between 2011 and 2012 primarily driven by an increase in the consumption of natural gas in the sector in response to the colder average temperatures seen in 2012 compared to 2011.

Sector Detail

As a proportion of UK residential emissions, Northern Ireland represents a higher share compared to 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. Natural gas has steadily become more widely available in the past 15 years. This factor, along with increased energy efficiency of buildings has led to a decrease of 22% since 1990 (see Table 5.5).

Emissions on an End User Basis

In 2012, Northern Ireland End User emissions for the Residential sector are 160% of the By Source emission estimates (see Figure 5.24), reflecting the high consumption of electricity in the sector. This increases the overall significance of this sector in the End User inventory to 22% of the Northern Ireland total, compared to just 15% of the by source inventory total.

The trend in Residential End User emissions since 1990 shows a decline of around 22% to 2012 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.

5.5 Business Sector

Figure 5.25: Overall Contribution to 2012 GHG emissions, Northern Ireland

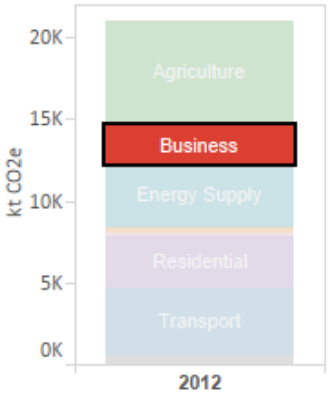


Figure 5.26: Total GHG Emissions from Business, Base Year to 2012, Northern Ireland

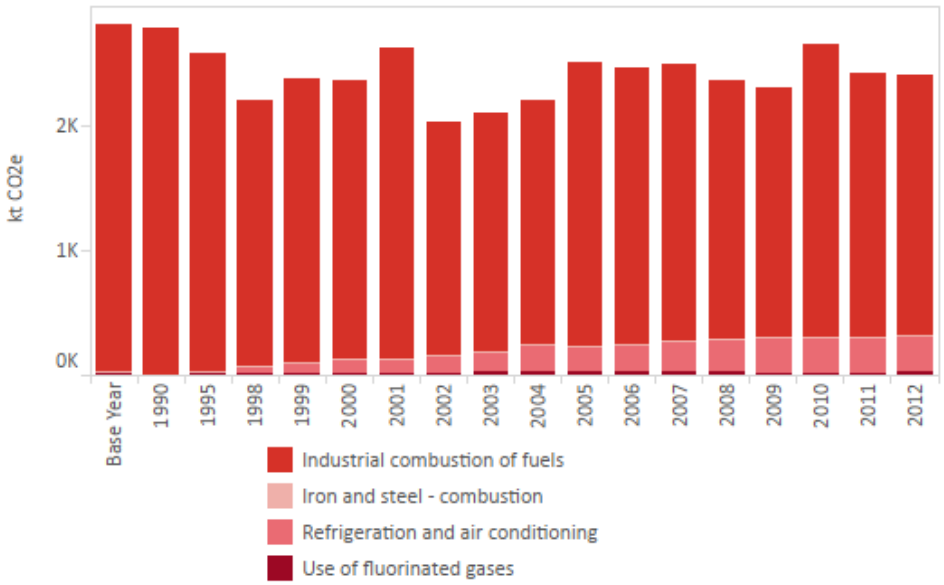


Table 5.6: Change in GHG Emissions from Base Year to 2012 and from 2011 to 2012, Northern Ireland

	Base Year to 2012 as %	Base Year to 2012 kt	2011 to 2012 as %	2011 to 2012 kt
Industrial Combustion of fuels	-25%	-695	-1%	-14
Iron and steel - combustion		0		0
Refrigeration and air conditioning	1,206%	269	1%	3
Use of fluorinated Gases	197%	14	1%	0
Business	-15%	-412	0%	-11

Figure 5.27: GHG Contribution for Business Emissions, 2012, Northern Ireland

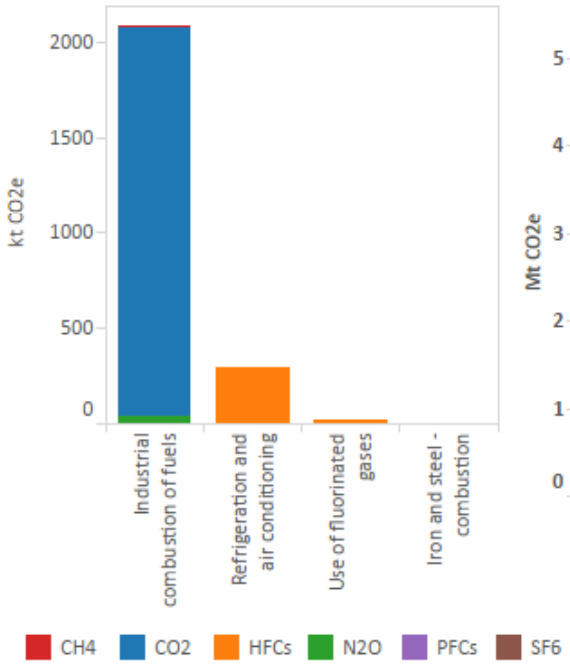
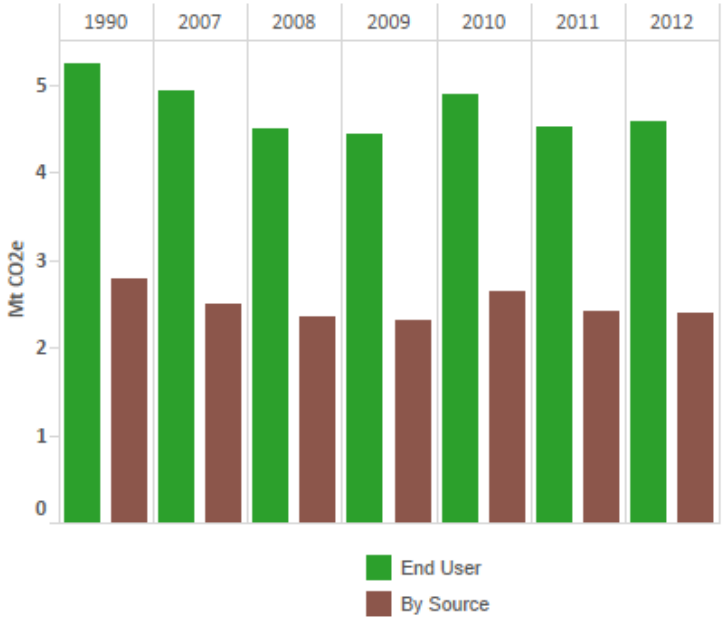


Figure 5.28: Comparison of End User and By Source for Business, Northern Ireland



By Source Emissions

Overview

In Northern Ireland, the Business sector contributes 11% to total 2012 GHG emissions. Combustion emissions from manufacturing industry and construction account for 15% of the total Northern Ireland carbon dioxide emission in 2012. There is no iron and steel production in Northern Ireland, so the category is entirely 'Other Industry'. In 2012, 85% of emissions were carbon dioxide released from the combustion of fossil fuels in the Business sector.

Sulphur hexafluoride (SF_6) constitutes 0.1% 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 80% of HFC emissions in Northern Ireland in 2012 (see Figure 5.27). Emissions from these sectors have risen by approximately 1200% in Northern Ireland since the 1995 base year.

Features of the Trends

Emissions from the Business sector for Northern Ireland have decreased by an estimated 15% over the period 1990-2012. This reflects the impacts of a gradual growth in access to the gas network over the last 15 years in Northern Ireland, enabling fuel-switching from more carbon-intensive oil- and coal-fired boilers to gas.

Business sector GHG emissions have decreased minimally by 0.5% between 2011 and 2012 caused by a decrease in emissions from the food and drink, and chemicals industry balanced by an increase in emissions from other industrial combustion sources.

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, the Business and Industrial Process emissions are not easy to separate.

The contribution to total aggregate emissions from the traded and non-traded sector across the Business and Industrial Process sectors are presented in Figure 5.8 in the Overview section under the category: "Industry". Traded emissions accounted for 24% of total Industry emissions in 2012.

Emissions on an End User Basis

In 2012, Northern Ireland End User emissions for the Business sector are 191% 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 20% of total emissions for Northern Ireland compared to just 11% of the By Source inventory total (see Figure 5.28).

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 12% 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 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 Sector

Figure 5.29: Overall Contribution to 2012 GHG emissions, Northern Ireland

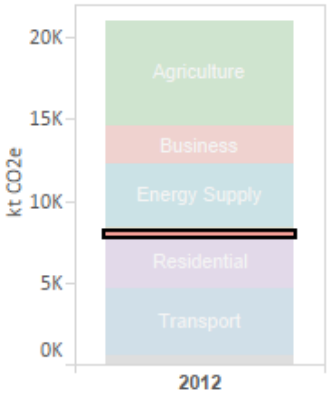


Figure 5.30: Total GHG Emissions from Public, Base Year to 2012, Northern Ireland

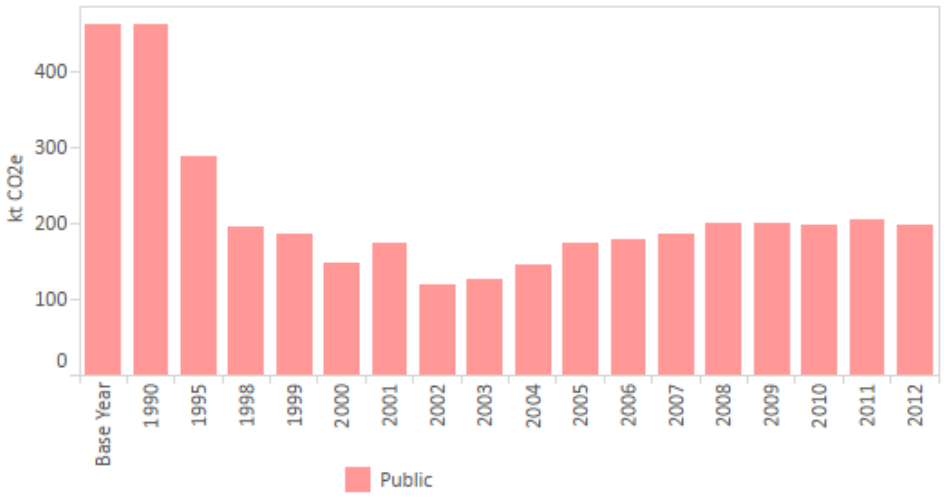


Table 5.7: Change in GHG Emissions from Base Year to 2012 and from 2011 to 2012, Northern Ireland

	Base Year to 2012 as %	Base Year to 2012 kt	2011 to 2012 as %	2011 to 2012 kt
Public	-57.3%	-264.6	-3.1%	-6.3
Public Total	-57.3%	-264.6	-3.1%	-6.3

Figure 5.31: GHG Contribution for Public Emissions, 2012, Northern Ireland

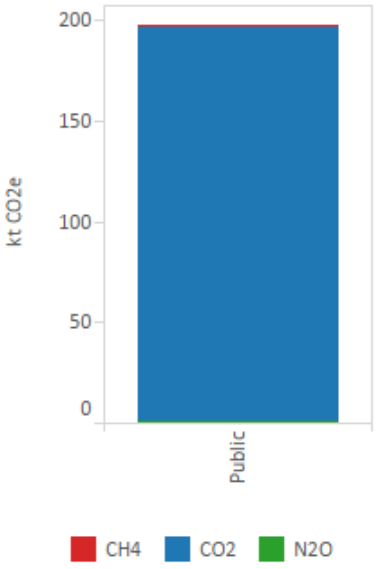
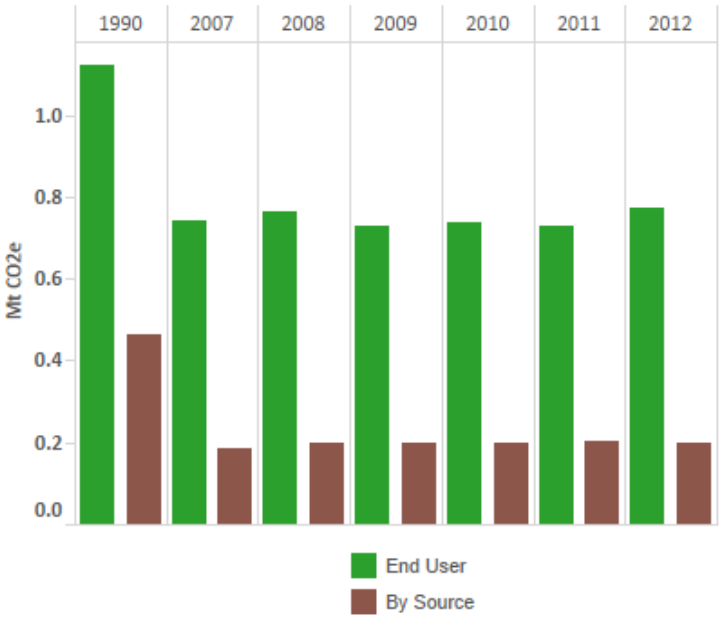


Figure 5.32: Comparison of End User and By Source for Public, Northern Ireland



By Source Emissions

Overview

Emissions from Public sector combustion account for 0.9% of GHG emissions in Northern Ireland in 2012. Over 99% of emissions in this sector are of carbon dioxide from the combustion of fossil fuels. See Figures 5.30 and 5.31.

Features of the Trends

Overall Public sector emissions have generally reduced since the Base Year up to 2002, then steadily increasing from 2002 to 2008 after which emissions have generally plateaued. The most recent trend from 2011 to 2012 of a 3% decrease in emissions is due to reductions in fuel oil consumption within the sector (see Table 5.7 and Figure 5.30). The overall reduction from the Base Year to 2012 is 57%. 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.

Emissions on an End User Basis

In 2012, Northern Ireland End User emissions for the Public sector are 390% 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% in 2012 (see Figure 5.32). The trend in End User emissions since 1990 shows a decline of around 31% to 2012[31].

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.

[31] 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 Sector

Figure 5.33: Overall Contribution to 2012 GHG emissions, Northern Ireland

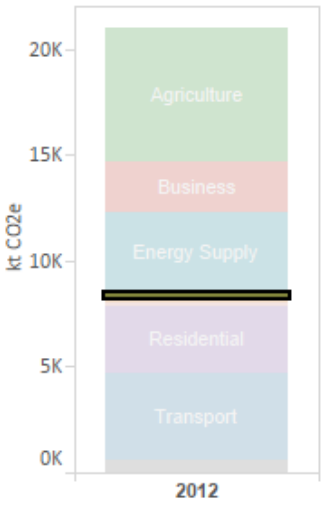


Figure 5.34: Total GHG Emissions from Industrial Process, Base Year to 2012, Northern Ireland

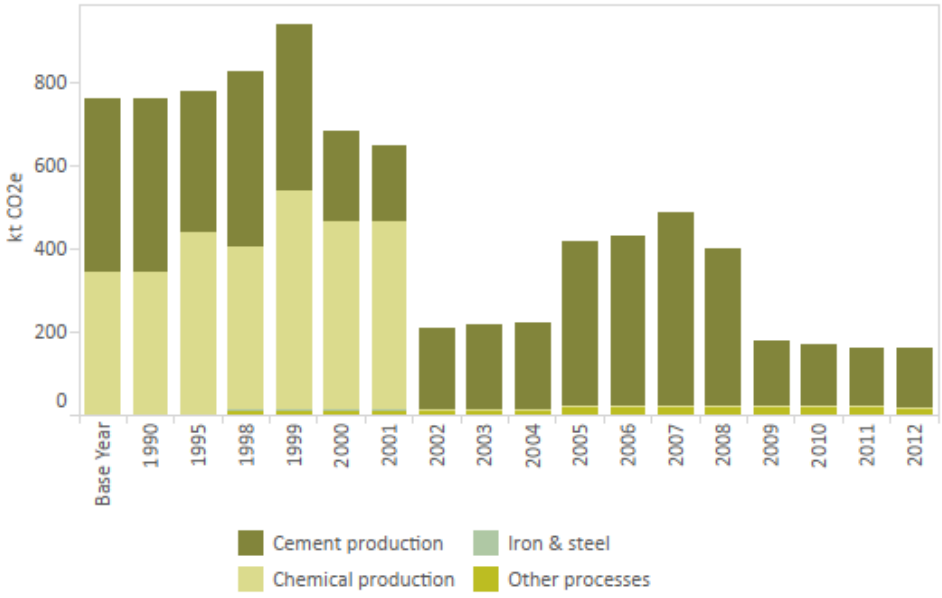
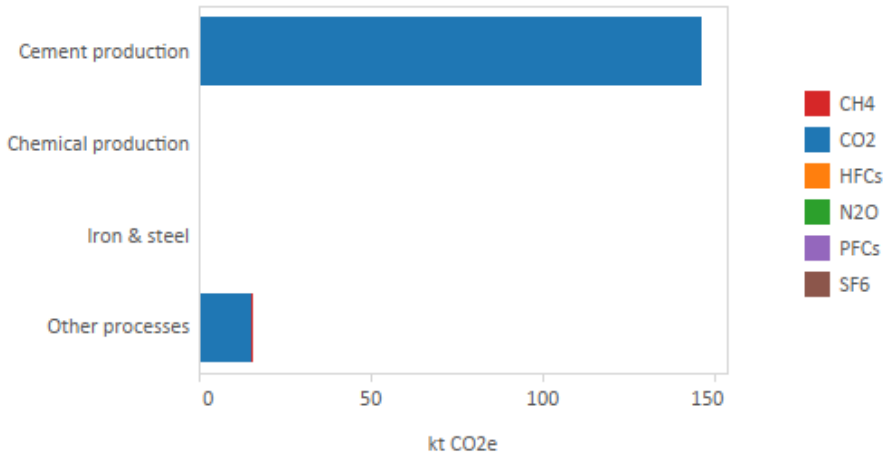


Table 5.8: Change in GHG Emissions from Base Year to 2012 and from 2011 to 2012, Northern Ireland

	Base Year to 2012 as %	Base Year to 2012 kt	2011 to 2012 as %	2011 to 2012 kt
Cement production	-65%	-270	5%	7
Chemical production	-100%	-345		0
Iron & steel		0		0
Other processes	35,414%	15	-33%	-8
Industrial Process Total	-79%	-599	0%	-1

Figure 5.35: GHG Contribution to Industrial Process Emissions, 2012, Northern Ireland



By Source Emissions

Overview

The Industrial Process sector contributes 0.8% to total 2012 GHG emissions in Northern Ireland. The Industrial Process sector includes cement production (91% of sector GHG emissions) and glass production (9% of sector GHG emissions) and all emissions in 2012 from this sector are carbon dioxide emissions (see Figure 5.35).

Features of the Trends

In 2012, Industrial Process sector emissions are 79% lower than in 1990 (see Figure 5.34 and Table 5.8), partly due to the 2008-2009 down-turn in cement production in Northern Ireland, emissions from 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. 2012 GHG emissions from cement production in Northern Ireland are higher than those reported in 2011, whilst GHG emissions from glass production have decreased over the same period. The overall impact to the 2011-2012 trend is a minimal 0.3% reduction in GHG emissions for the sector.

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, the Business and Industrial Process emissions are not easy to separate.

The contribution to total aggregate emissions from the traded and non-traded sector across the Business and Industrial Process sectors are presented in Figure 5.8 in the Overview section under the category: “Industry”. Traded emissions accounted for 24% of total Industry emissions in 2012.

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 Sector

Figure 5.36: Overall Contribution to 2012 GHG emissions, Northern Ireland

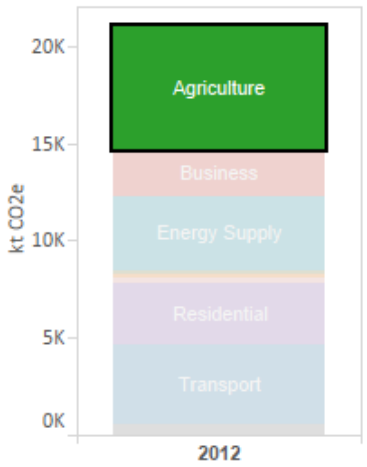


Figure 5.37: Total GHG Emissions from Agriculture, Base Year to 2012, Northern Ireland

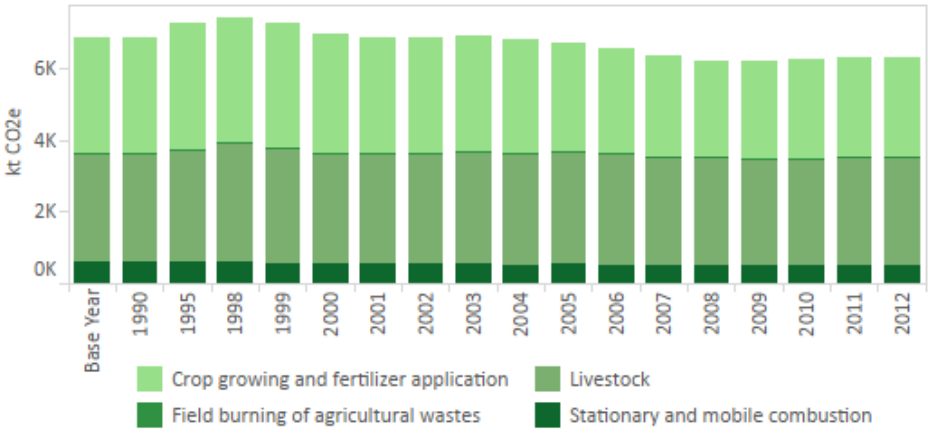


Table 5.9: Change in GHG Emissions from Base Year to 2012 and from 2011 to 2012, Northern Ireland

	Base Year to 2012 as %	Base Year to 2012 kt	2011 to 2012 as %	2011 to 2012 kt
Crop growing and fertilizer application	-13.0%	-417.2	0.6%	17.7
Field burning of agricultural wastes	-100.0%	-1.6		0.0
Livestock	-0.4%	-13.5	1.3%	39.5
Stationary and mobile combustion	-18.5%	-109.7	-8.3%	-44.0
Agriculture Total	-7.9%	-542.0	0.2%	13.1

Figure 5.38: Methane emissions from livestock by type, 2012, Northern Ireland

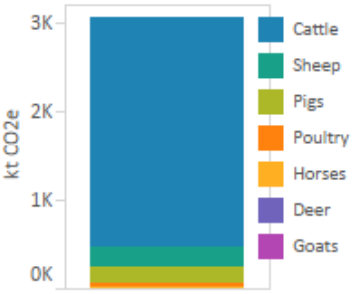


Figure 5.39: GHG Contribution for Agriculture Emissions, 2012, Northern Ireland

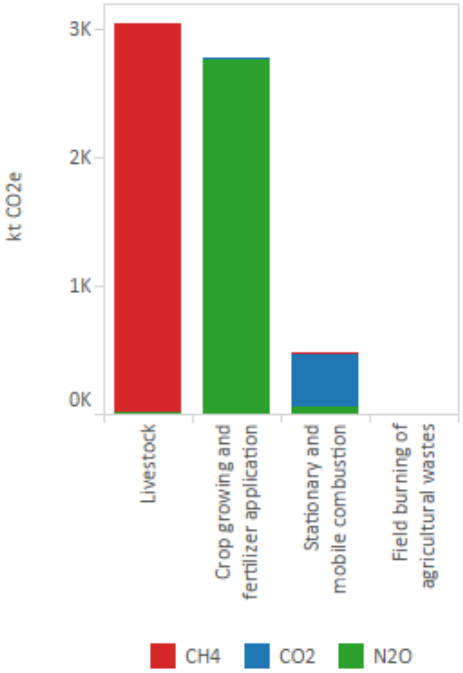


Table 5.10: Emissions of nitrous oxide from agricultural sources in 2012 (kt CO2e), Northern Ireland*

Manure management				374
Soils				2,421
	Direct			1,480
		Biological fixation		0
		Crop residues		20
		Fertiliser		426
		Grazing returns		719
		Histosols		0
		Improved grassland		22
		Manure application		291
		Sewage sludge		1
	Indirect			941
		Deposition		168
			Fertiliser	38
			Grazing returns	72
			Manure application	58
			Sewage sludge	0
		Leaching		773
			Fertiliser	284
			Grazing returns	270
			Manure application	218
			Sewage sludge	1
TOTAL				2,794

* Total emissions comprise manure management and soils. Soils include direct and indirect emissions; indirect emissions include leaching and deposition.

By Source Emissions

Overview

The Agriculture sector contributes 30% to total 2012 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 5.39). Agriculture is the most significant source sector for methane and nitrous oxide, accounting for 84% and 93% of total Northern Ireland emissions of these two gases, respectively.

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.

Features of the Trends

Emissions from Agriculture have decreased by 8% between the Base Year and 2012, with pollutant contributions of -0.5% for methane and -13% for nitrous oxide. The trends result from a general decline in livestock numbers and in fertiliser nitrogen use (particularly to grassland). There was no significant change in Agriculture sector emissions for Northern Ireland between 2011 and 2012 (0.2% increase) mainly due to an increase in emissions from cattle due to the increased livestock numbers, which then also lead to an increase in emissions from grazing. Field burning has largely ceased in the UK since 1993, hence the significant decrease in emissions since the Base Year.

Sector Detail

Livestock emissions include two main sub-categories: emissions from enteric fermentation (a digestive process by which carbohydrates are broken down by microorganisms into simple molecules) and emissions from manure management. Enteric fermentation contributed 69% (2,111 $ktCO_2e$) to total agricultural methane in Northern Ireland in 2012. Total methane emissions from beef and dairy cattle (enteric and manure management sources combined) accounted for 85% of the all Northern Ireland agricultural methane emissions. Emissions from sheep account for 7% of the total methane from Agriculture in 2012.

Nitrous oxide emissions are largely driven by fertiliser nitrogen use, manure applications and grazing returns to soils. Agriculture is the most important source of nitrous oxide in Northern Ireland and 85% (2,421 $ktCO_2e$) of the sector total arose from agricultural soils. This source accounted for 79% of total nitrous oxide emissions in Northern Ireland in 2012. A further breakdown of these emissions is shown in Table 5.10.

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 2012, the End User estimates are only 2% 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.

5.9 Land Use, Land Use Change and Forestry Sector

Figure 5.40: Overall Contribution to 2012 GHG emissions, Northern Ireland

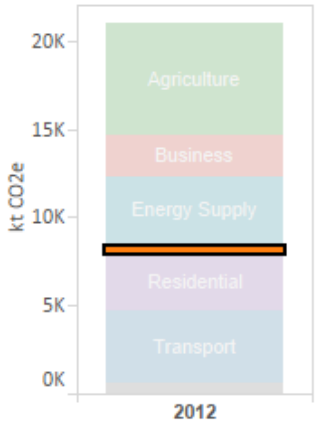


Figure 5.41: GHG Contribution to Land Use Change Emissions, 2012, Northern Ireland

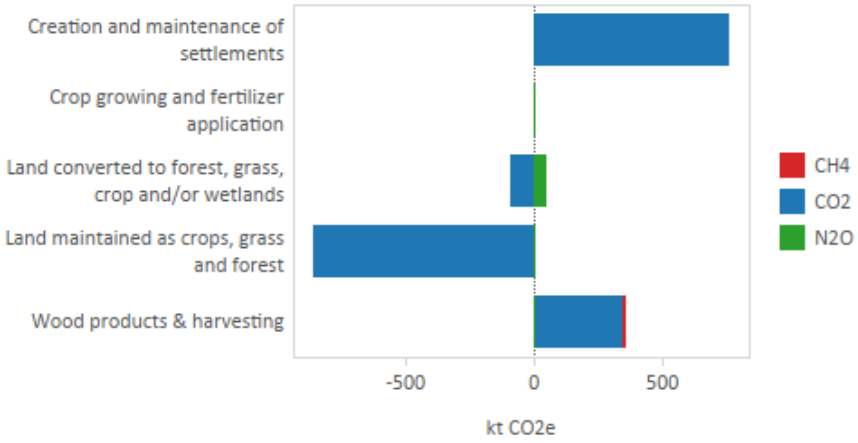
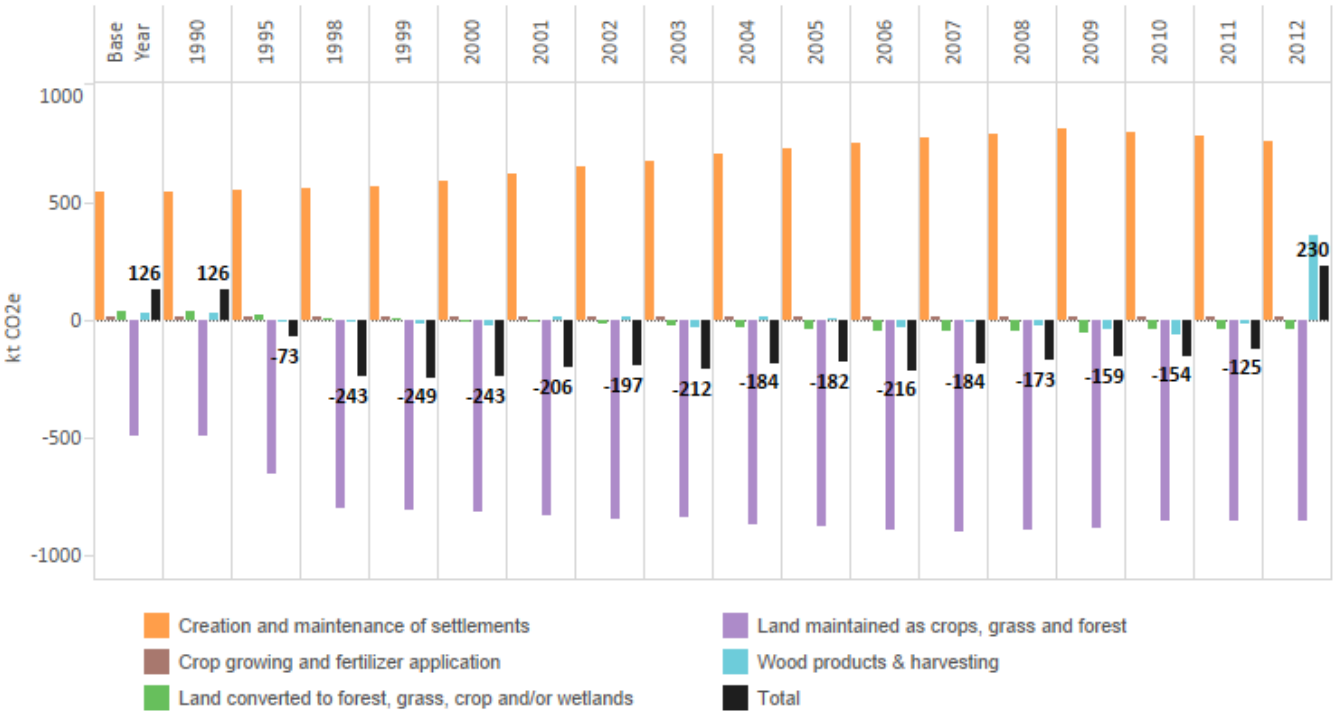


Table 5.11: Change in GHG Emissions from Base Year to 2012 and from 2011 to 2012, Northern Ireland

	Base Year to 2012 as %	Base Year to 2012 kt	2011 to 2012 as %	2011 to 2012 kt
Creation and maintenance of settlements	39%	214	-2%	-17
Crop growing and fertilizer application	20%	2	0%	0
Land converted to forest, grass, crop and/or wetlands	-220%	-76	4%	-2
Land maintained as crops, grass and forest	73%	-363	1%	-6
Wood products & harvesting	1,045%	327	-1,761%	379
Land Use Change Total	83%	104	-284%	-25

Figure 5.42: Total GHG Emissions from LULUCF, Base Year - 2012, Northern Ireland



By Source Emissions

Overview

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 (Miles *et al*., 2014) and more detailed information is also available in the UK Greenhouse Gas Inventory Report, available on the NAEI website (Webb *et al.*, 2014).

Figures 5.40 – 5.42 and Table 5.11 show detailed emissions and trends for the Land Use, Land Use Change and Forestry (LULUCF) sector. In 2012, Northern Ireland was a net emitter of greenhouse gases from LULUCF activities, emitting 230 $ktCO_2e$ in 2012. This represents the first year since 1990 that Northern Ireland has not been a net sink for GHG emissions from the sector, and this is due to a wildfire area of 704ha, 14 times the 1990-2011 forest wildfire average for Northern Ireland and the greatest total forest wildfire area in the UK in 2012.

The LULUCF emissions and sinks arise from human activities that change the way land is used or affect the amount of biomass in existing biomass stocks. The most significant category is Land Maintained as Crops, Grass and Forest, which accounted for the removal of 858 $ktCO_2e$ in 2012. This removal was offset by emissions from the wildfire as identified above, along with emissions from land conversions and the creation and maintenance of settlements, which emitted 760 $ktCO_2e$ in 2012.

Features of the Trends

The LULUCF sector has been a net sink of greenhouse gases since from 1995 to 2011. The size of this sink (CO_2e removal) grew by 71% between 1995 and 2011 from -73 to -125 $ktCO_2e$. This increase in net removals is primarily as a result of less conversion of grassland and forests to cropland over the period. Emissions/removals in 2012 from this sector were significantly influenced by a large wildfire. Taking this into account, the Base Year to 2012 trend is an 83% increase in GHG emissions from the sector.

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.

5.10 Waste Management Sector

Figure 5.43: Overall Contribution to 2012 GHG emissions, Northern Ireland

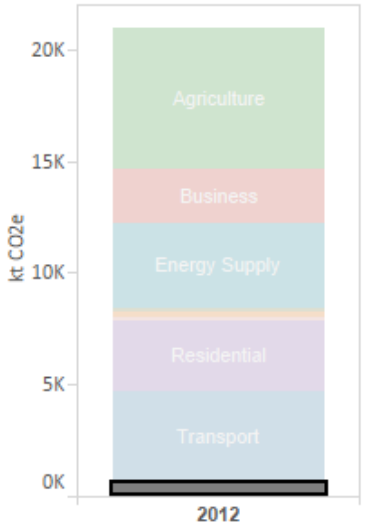


Figure 5.44: Total GHG Emissions from Waste Management, Base Year to 2012, Northern Ireland

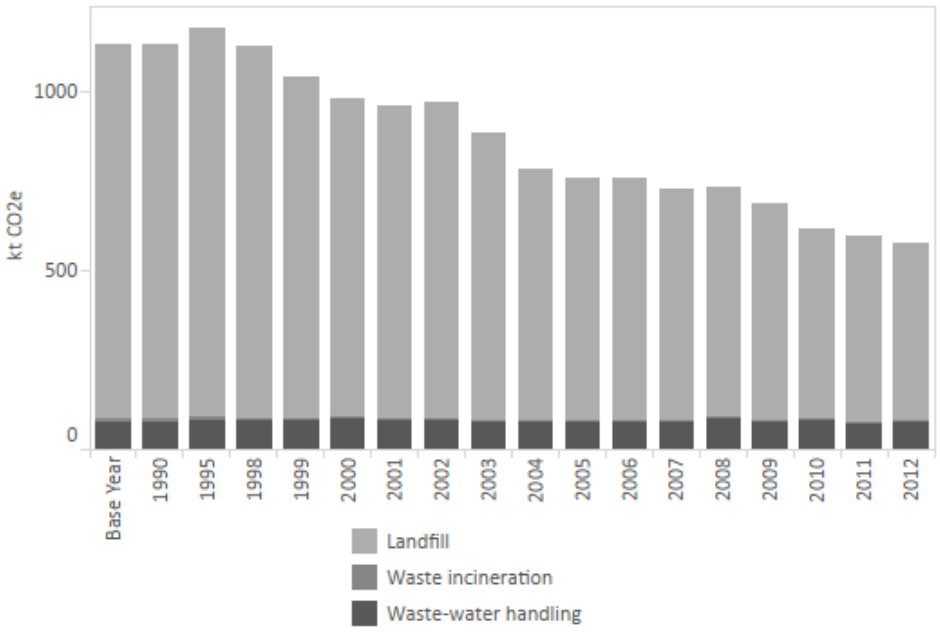
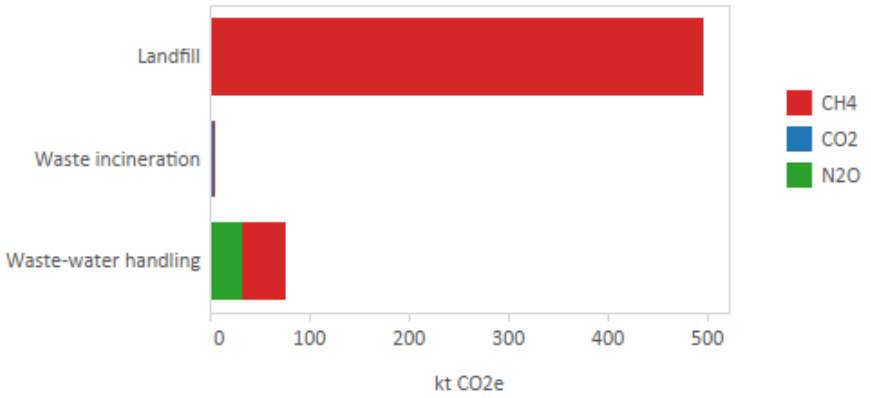


Table 5.12: Change in GHG Emissions from Base Year to 2012 and from 2011 to 2012, Northern Ireland

	Base Year to 2012 as %	Base Year to 2012 kt	2011 to 2012 as %	2011 to 2012 kt
Landfill	-52.6%	-550.4	-4.7%	-24.4
Waste incineration	-58.7%	-5.2	-10.0%	-0.4
Waste-water handling	-0.6%	-0.5	3.3%	2.5
Waste Management	-49.1%	-556.0	-3.7%	-22.3

Figure 5.45: GHG Contribution to Waste Management Emissions, 2012, Northern Ireland



By Source Emissions

Overview

The Waste Management sector contributes 3% to total GHG emissions in Northern Ireland in 2012, and represents 15% of total methane emissions. Emissions from this sector are dominated by methane from landfill (86% of total GHGs from the Waste Management sector – see Figure 5.44), with a smaller contribution of emissions of methane and nitrous oxide from wastewater treatment (13%).

The majority of total GHG emissions are of methane (94% of total sector GHG emissions in 2012). Nitrous oxide emissions from waste water treatment represent 6% of emissions in the sector, and contribute 1% to the total emissions of nitrous oxide in Northern Ireland. See Figure 5.45 for the pollutant contribution within the Waste Management sector.

Features of the Trends

Emissions of GHGs from the Waste Management sector in Northern Ireland have shown a significant decline of 49% in total for the sector and by 53% for landfill between 1990 and 2012, as shown in Table 5.12, due largely to the progressive introduction of methane capture and oxidation systems within landfill management. Between 2011 and 2012 Waste Management sector GHG emissions decreased by 4%, which is mainly due to UK-wide reductions in methane emission estimates from landfill in line with improvements to the management systems.

Emissions on an End User Basis

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

6 References

Please note that the following references are relevant to the text in the main body of the report. A full list of all data sources related to the methodology of the report can be found in the accompanying Appendices file: "DA GHGI 1990-2012 Report_Appendices_Issue1.docx".

(DECC, 2013a) Department of Energy and Climate Change, Energy Trends: December 2013, https://www.gov.uk/government/collections/energy-trends (2013)

(DECC, 2013b) Department of Energy and Climate Change, Digest of United Kingdom energy statistics (DUKES) 2013, https://www.gov.uk/government/collections/digest-of-uk-energy-statistics-dukes (2013)

(DECC, 2014) Department of Energy and Climate Change, Energy Trends: March 2014, https://www.gov.uk/government/collections/energy-trends (2014)

(IPCC, 1996a) IPCC (Intergovernmental Panel on Climate Change), Climate Change 1995, The Science of Climate Change: Summary for Policymakers and Technical Summary of the Working Group I Report, page 22 http://www.ipcc.ch/ipccreports/sar/wg_I/ipcc_sar_wg_I_full_report.pdf (1996)

(Miles *et al.*, 2014) Miles, S., Malcolm, H., Buys, G., Moxley, J. Emissions and Removals of Greenhouse Gases from Land Use, Land Use Change and Forestry (LULUCF) for England, Scotland, Wales and Northern Ireland: 1990-2012, http://naei.defra.gov.uk/reports/reports?report_id=788 (2014)

(Salisbury *et al.*, 2013) Salisbury, E., Claxton, R., Goodwin, J., Thistlethwaite, G., MacCarthy, J., Pang, Y., Thomson, A. & Cardenas, L. Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland: 1990-2011, http://naei.defra.gov.uk/reports/reports?report_id=756 (2013)

(Webb et al., 2014) Webb, N., Broomfield, M., Buys, G., Cardenas, L., Murrells, T., Pang, Y., Passant, N., Thistlethwaite, G., Watterson, J. UK Greenhouse Gas Inventory, 1990 to 2012: Annual Report for submission under the Framework Convention on Climate Change, http://naei.defra.gov.uk/reports/reports?report_id=789 (2014)

7 Appendices

Appendix 1 Uncertainties in the UK and Devolved Administrations Greenhouse Gas Inventory estimates

Appendix 2 Devolved Administrations Greenhouse Gas Inventory compilation methods and data sources

Appendix 3 Methods used for calculating End User Inventory estimates

Appendix 4 Emissions analysis and methods used for Devolved Administrations Traded and Non-Traded Emissions

Appendix 5 Mapping between source name, IPCC category and National Communication Sector

Appendix 6 Recalculations between the previous and this current Devolved Administrations Inventory

Appendix 7 Supporting Data Tables