

# **Appendix 3**

## **International Shipping and Aviation**

## **International Shipping and Aviation: Emission Estimates for England, Scotland, Wales and Northern Ireland, 1990-2009**

### **A3.1 Background**

There is growing interest in the methods that could be used to allocate emissions from international shipping and aviation sources to the constituent countries of the UK. This is particularly important for Scotland, as it has chosen to include emissions from these sources within the emission reduction targets that have been established under the recent Climate Change (Scotland) Act 2009. At a UK level, emissions from shipping and aviation are estimated but are not included in national totals. The emissions are reported as memo items.

Therefore, AEA have analysed the available data to provide the estimates outlined below, which have been derived by estimating the DA share of the UK-level GHG emission estimates from international shipping and international aviation.

Emissions from these two transport sources include the GHGs:

- carbon dioxide (CO<sub>2</sub>)
- methane (CH<sub>4</sub>)
- nitrous oxide (N<sub>2</sub>O)

In accordance with international inventory protocol, the emissions from international shipping and aviation are not included in national totals, but rather are reported as separate memo items to the national inventories. Hence we have maintained this approach here, with separate reporting of these memo items to the inventories for England, Scotland, Wales and Northern Ireland.

The emission estimates presented below for international shipping are regarded as preliminary, as there is limited data availability for regional marine shipping fuel use. It should also be noted that there is research ongoing in the shipping sector, to derive improved emission estimates for the national and international shipping GHG emissions at UK level, following a recent study into shipping movements around the UK (Entec, 2008). It is anticipated that this study will lead to a revision of the UK emissions from both national and international shipping sources within the 1990-2009 UK GHG inventory. Once this work is complete, the analysis of data for England, Scotland, Wales and Northern Ireland will need to be re-examined.

The estimates of emissions from international aviation, presented below, are associated with low uncertainty. The emission estimates are based on a database of UK flight movements and detailed calculations of emissions from different phases of flights (take off, cruise, landing cycles).

### **A3.2 Emission Estimation Methodology**

#### ***A3.2.1 International Shipping: Allocation of UK emissions across England, Scotland, Wales and Northern Ireland***

International shipping fuel data are estimated within the UK GHGI, based on fuel use estimates derived from a recent Entec study on UK shipping movements, and the total gas oil and fuel oil use by shipping reported within the annual DECC publication, The Digest of United Kingdom Energy Statistics (DUKES). DUKES contains annual data for gas oil and fuel oil use in national navigation (domestic shipping) and marine bunkers (international shipping). The Entec study of shipping movements has revised the national-international shipping fuel use allocation whilst retaining the overall energy balance, and the UK GHGI uses these more accurate fuel use allocations for shipping.

No detailed dataset of international shipping movements is currently available, and hence emissions are assigned based on the assumption that the total mass of port traffic per DA is a representative proxy to estimate shipping fuel sales and use in the ports and waters around the DAs. Note that the sum of the DA shipping emission allocations are constrained by the UK fuel use data for the sector; this method of estimation is therefore consistent with the principles of international inventory guidance, whereby emissions are allocated to the country (here, the UK) at point of fuel sale.

**A3.2.2 *International Aviation: Allocation of UK emissions across England, Scotland, Wales and Northern Ireland***

Emission estimates for both domestic and international aviation are constrained at UK level by the fuel use data reported within the annual publication of DUKES. Annual aviation fuel sales in the UK therefore define the overall aviation emissions, in accordance with UNFCCC, UNECE and IPCC inventory guidance.

Data for total aviation fuel use from UK airports are provided within the annual DUKES publication. No equivalent DA-specific fuel use data have been found. The split of domestic and international aviation fuel use at UK level is based on analysis of a CAA database of flight details, which comprises both domestic and international flights. To provide a split of the UK international aviation emissions across England, Scotland, Wales and Northern Ireland, this detailed database of all flights (including details of airport of origin, destination, fuel type, plane type and engine type) has been used. There is no agreed international protocol that defines how a sub-country split should be made (the DA GHG inventories are not currently required for any mandatory international reporting mechanisms) and the protocol adopted in the DA data disaggregation method assumes that all emissions from a flight originating in a DA is allocated to that DA. (e.g. for a flight from Glasgow to Paris, all emissions from that flight, e.g. take-off, cruise and landing cycles, are assigned to Scotland).

**Note on Aviation Emission Estimates and the impact of Hub Airports**

The aviation emission estimates at DA level are, as indicated above, based on a detailed database of flight information. Emissions have been assigned to the DAs based on the protocol that the total emissions (take-off, cruise and landing cycles) from flights originating in a DA are assigned to that DA. This methodology has been chosen as it is consistent with international guidance for GHG inventories, i.e. it follows the principle that the emissions are allocated to the country of origin of the aviation fuel sales. In the absence of aviation fuel sales data by DA, the DA aviation fuel sales are estimated assuming that fuel sales for a given flight are at the origin airport. In these circumstances, the impact of hub airports may play a significant role in influencing the emission totals presented here. It is notable, for example, that whilst Scotland has a high percentage of domestic flight emissions (around 29% in 2008), only 3.2% of international flight emissions are allocated to Scotland. England, meanwhile, accounts for nearly 96% of international aviation emissions in 2008. This reflects the dominance of the London airports as international aviation route hubs.

**Examples**

For a passenger taking a flight that originates in Glasgow, on to Dubai and then onwards to Australia, only the emissions from the Glasgow to Dubai leg will be used in the DA allocation method (noting that emissions in total are aligned with aviation fuel sales in the UK), and the emissions will be assigned to Scotland.

For a passenger taking flights from Glasgow to London and then on to Paris, the Glasgow to London leg would be classed as a domestic flight and the London to Paris leg would be international. In these circumstances, Scotland is assigned emissions from the domestic leg, whilst England is assigned emissions from the international leg.

**A3.3 Results**

The estimates of emissions from international shipping and aviation are presented in the tables below. The emissions are presented as kt CO<sub>2</sub>e. There are emissions of CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O from both shipping and aviation but CO<sub>2</sub> dominates the emissions from both sources on a GWP basis.

Please note these estimates are indicative only, and the methods for estimating emissions will be kept under review. The estimates of emissions from international aviation are associated with low uncertainty. The estimates from shipping are associated with a much higher uncertainty, and research continues to derive improved emission estimates for the national and international shipping GHG emissions at UK and DA level.

**Table A3.3.1 International Shipping Emissions: England, Scotland, Wales and Northern Ireland**

GAS	DA	UNITS	EMISSION YEARS													
			1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Carbon dioxide	England	ktCO2	5664	5330	6891	4963	4492	4720	3720	4509	5039	5432	7195	6860	7767	7135
	Scotland	ktCO2	2089	1966	2338	1805	1614	1594	1254	1347	1469	1508	1825	1752	1936	1792
	Wales	ktCO2	942	886	1053	785	716	705	534	641	799	821	1018	973	1119	1125
	N Ireland	ktCO2	335	315	376	295	265	273	219	268	311	333	440	410	472	435
Methane	England	ktCO2	1.9	1.8	2.3	1.6	1.5	1.6	1.2	1.5	1.7	1.8	2.4	2.2	2.5	2.3
	Scotland	ktCO2	0.7	0.6	0.8	0.6	0.5	0.5	0.4	0.4	0.5	0.5	0.6	0.6	0.6	0.6
	Wales	ktCO2	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4
	N Ireland	ktCO2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1
Nitrous oxide	England	ktCO2	44.1	41.6	53.5	38.5	34.9	36.6	28.9	35.0	39.0	42.0	55.7	53.0	59.9	55.1
	Scotland	ktCO2	16.3	15.3	18.2	14.0	12.5	12.4	9.7	10.4	11.4	11.7	14.1	13.5	14.9	13.8
	Wales	ktCO2	7.3	6.9	8.2	6.1	5.6	5.5	4.1	5.0	6.2	6.4	7.9	7.5	8.6	8.7
	N Ireland	ktCO2	2.6	2.5	2.9	2.3	2.1	2.1	1.7	2.1	2.4	2.6	3.4	3.2	3.6	3.4
All GHGs	England	ktCO2	5,710	5,373	6,946	5,003	4,528	4,758	3,750	4,546	5,079	5,475	7,253	6,915	7,829	7,193
	Scotland	ktCO2	2,106	1,982	2,357	1,820	1,627	1,607	1,264	1,358	1,481	1,520	1,839	1,767	1,951	1,806
	Wales	ktCO2	949	893	1,061	791	722	710	538	646	805	828	1,026	981	1,128	1,134
	N Ireland	ktCO2	338	318	379	298	267	275	221	270	314	336	443	414	476	439
	UK	ktCO2	9,104	8,566	10,744	7,912	7,144	7,350	5,774	6,819	7,679	8,159	10,562	10,076	11,384	10,572

**Table A3.3.2 International Shipping Fuel Use Estimates: England, Scotland, Wales and Northern Ireland**

	DA	UNITS	EMISSION YEARS													
			1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Fuel Use	England	Mt	1.78	1.68	2.16	1.55	1.41	1.48	1.16	1.41	1.57	1.69	2.25	2.14	2.42	2.22
	Scotland	Mt	0.66	0.62	0.73	0.56	0.51	0.50	0.39	0.42	0.46	0.47	0.57	0.55	0.60	0.56
	Wales	Mt	0.30	0.28	0.33	0.25	0.22	0.22	0.17	0.20	0.25	0.26	0.32	0.30	0.35	0.35
	N Ireland	Mt	0.11	0.10	0.12	0.09	0.08	0.09	0.07	0.08	0.10	0.10	0.14	0.13	0.15	0.14
	uk		2.84	2.67	3.34	2.46	2.22	2.28	1.79	2.11	2.38	2.53	3.27	3.11	3.51	3.26

**Table A3.3.3 International Aviation Emissions: England, Scotland, Wales and Northern Ireland**

GAS	DA	UNITS	EMISSION YEARS													
			1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Carbon dioxide	England	ktCO2	14,984	19,332	24,264	26,344	29,074	28,310	27,840	28,440	31,130	33,642	33,962	33,757	32,659	31,337
	Scotland	ktCO2	417	513	621	715	755	769	749	813	955	1,113	1,184	1,226	1,076	1,018
	Wales	ktCO2	54	86	94	98	123	119	107	124	122	122	143	127	114	93
	N Ireland	ktCO2	56	84	110	118	125	119	92	103	120	159	176	206	232	168
	UK	ktCO2	15,511	20,015	25,090	27,275	30,077	29,316	28,787	29,479	32,327	35,036	35,466	35,315	34,081	32,616
Methane	England	ktCO2e	5.84	3.88	3.83	3.35	2.81	2.20	2.04	1.99	1.87	1.96	1.94	1.84	1.74	1.68
	Scotland	ktCO2e	0.28	0.22	0.22	0.20	0.20	0.20	0.19	0.18	0.17	0.18	0.19	0.19	0.18	0.16
	Wales	ktCO2e	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	N Ireland	ktCO2e	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	UK	ktCO2e	6.15	4.13	4.08	3.58	3.03	2.42	2.25	2.18	2.06	2.16	2.15	2.05	1.94	1.86
Nitrous Oxide	England	ktCO2e	147.5	190.3	238.8	259.3	286.2	278.6	274.0	279.9	306.4	331.1	334.3	332.2	321.4	308.4
	Scotland	ktCO2e	4.1	5.0	6.1	7.0	7.4	7.6	7.4	8.0	9.4	11.0	11.7	12.1	10.6	10.0
	Wales	ktCO2e	0.5	0.8	0.9	1.0	1.2	1.2	1.1	1.2	1.2	1.2	1.4	1.2	1.1	0.9
	N Ireland	ktCO2e	0.5	0.8	1.1	1.2	1.2	1.2	0.9	1.0	1.2	1.6	1.7	2.0	2.3	1.7
	UK	ktCO2e	152.7	197.0	246.9	268.4	296.0	288.5	283.3	290.1	318.2	344.8	349.1	347.6	335.4	321.0
All GHGs	England	ktCO2e	15,137	19,526	24,507	26,607	29,363	28,591	28,116	28,722	31,439	33,975	34,298	34,091	32,982	31,647
	Scotland	ktCO2e	422	518	628	722	763	777	756	821	965	1,124	1,196	1,238	1,087	1,028
	Wales	ktCO2e	55	87	95	99	124	120	108	125	123	123	145	128	116	94
	N Ireland	ktCO2e	56	85	111	119	126	120	93	104	121	161	178	208	234	170
	UK	ktCO2e	15,670	20,216	25,341	27,547	30,376	29,607	29,073	29,772	32,647	35,383	35,817	35,665	34,419	32,939

**Table A3.3.4 International Aviation Fuel Use Estimates: England, Scotland, Wales and Northern Ireland**

	DA	UNITS	EMISSION YEARS													
			1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Fuel Use	England	Mt	4.76	6.14	7.70	8.36	9.23	8.99	8.84	9.03	9.88	10.68	10.78	10.72	10.37	9.95
	Scotland	Mt	0.13	0.16	0.20	0.23	0.24	0.24	0.24	0.26	0.30	0.35	0.38	0.39	0.34	0.32
	Wales	Mt	0.02	0.03	0.03	0.03	0.04	0.04	0.03	0.04	0.04	0.04	0.05	0.04	0.04	0.03
	N Ireland	Mt	0.02	0.03	0.03	0.04	0.04	0.04	0.03	0.03	0.04	0.05	0.06	0.07	0.07	0.05
	UK	Mt	4.92	6.35	7.97	8.66	9.55	9.31	9.14	9.36	10.26	11.12	11.26	11.21	10.82	10.36