# **Appendix 6:** calculation approach and GHG emission estimates from international aviation and international shipping sources

**International Shipping and Aviation: Emission Estimates for England, Scotland, Wales and Northern Ireland, 1990-2010**

**Background**

This appendix outlines the calculation approach and GHG emission estimates from international aviation and international shipping sources that may be allocated to each of the constituent countries across the time-series. 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 emissions from these sources are included within the emission reduction targets that have been established under the 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 ($CO_2$)
- methane ($CH_4$)
- nitrous oxide ($N_2O$)

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 indicative, as there is limited data availability for regional marine shipping fuel use. 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), and include estimates of flights from the DAs to the Crown Dependencies, Overseas Territories and Gibraltar.

**Emission Estimation Methodology**

***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; the UK GHGI uses these more accurate domestic and international shipping fuel use allocations, deviating from the DUKES data.

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.

***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 27% in 2010), only 3.1% of international flight emissions are allocated to Scotland. England, meanwhile, accounts for around 96% of international aviation emissions in 2010. 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.

**Results**

The estimates of emissions from international shipping and aviation are presented in the tables below. The emissions are presented as kt $CO_2$e. There are emissions of $CO_2$, $CH_4$ and $N_2O$ from both shipping and aviation but $CO_2$ dominates the emissions from both sources on a GWP basis.

**Table A6.1 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 | 2010 |
| All GHGs | England | ktCO2 | 5,529 | 5,175 | 6,741 | 4,803 | 4,327 | 4,556 | 3,544 | 4,335 | 4,866 | 5,255 | 7,025 | 6,686 | 7,548 | 6,904 | 5,903 |
| | Scotland | ktCO2 | 2,039 | 1,909 | 2,287 | 1,747 | 1,555 | 1,539 | 1,195 | 1,294 | 1,418 | 1,459 | 1,782 | 1,708 | 1,881 | 1,734 | 1,458 |
| | Wales | ktCO2 | 919 | 860 | 1,030 | 760 | 690 | 680 | 509 | 616 | 771 | 794 | 994 | 948 | 1,088 | 1,088 | 1,044 |
| | N Ireland | ktCO2 | 327 | 306 | 368 | 286 | 255 | 263 | 209 | 257 | 300 | 322 | 429 | 400 | 459 | 421 | 394 |
| | UK | ktCO2 | 8,814 | 8,250 | 10,427 | 7,596 | 6,826 | 7,038 | 5,457 | 6,503 | 7,356 | 7,830 | 10,230 | 9,742 | 10,975 | 10,147 | 8,799 |

**Table A6.2 International Shipping Fuel Use Estimates: England, Scotland, Wales and Northern Ireland**

| Fuel Use | DA | UNITS | EMISSION YEARS | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1990 | 1995 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
| Gas oil and fuel oil | England | Mt | 1.72 | 1.61 | 2.10 | 1.49 | 1.34 | 1.41 | 1.10 | 1.34 | 1.51 | 1.63 | 2.17 | 2.07 | 2.33 | 2.13 | 1.82 |
| | Scotland | Mt | 0.64 | 0.60 | 0.71 | 0.54 | 0.48 | 0.48 | 0.37 | 0.40 | 0.44 | 0.45 | 0.55 | 0.53 | 0.58 | 0.54 | 0.45 |
| | Wales | Mt | 0.29 | 0.27 | 0.32 | 0.24 | 0.21 | 0.21 | 0.16 | 0.19 | 0.24 | 0.25 | 0.31 | 0.29 | 0.34 | 0.34 | 0.32 |
| | N Ireland | Mt | 0.10 | 0.10 | 0.11 | 0.09 | 0.08 | 0.08 | 0.06 | 0.08 | 0.09 | 0.10 | 0.13 | 0.12 | 0.14 | 0.13 | 0.12 |
| | UK | Mt | 2.75 | 2.57 | 3.24 | 2.36 | 2.12 | 2.19 | 1.69 | 2.02 | 2.28 | 2.42 | 3.17 | 3.01 | 3.39 | 3.13 | 2.72 |

**Table A6.3 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 | 2010 |
| All GHGs | England | ktCO2e | 15,293 | 19,678 | 24,680 | 26,753 | 29,530 | 28,754 | 28,290 | 28,901 | 31,643 | 34,161 | 34,479 | 34,268 | 33,448 | 32,053 | 30,673 |
| | Scotland | ktCO2e | 426 | 522 | 632 | 726 | 767 | 781 | 761 | 826 | 971 | 1,130 | 1,202 | 1,244 | 1,102 | 1,041 | 975 |
| | Wales | ktCO2e | 56 | 88 | 96 | 99 | 125 | 121 | 108 | 126 | 124 | 124 | 145 | 128 | 117 | 95 | 90 |
| | N Ireland | ktCO2e | 57 | 86 | 112 | 120 | 127 | 120 | 94 | 105 | 121 | 161 | 179 | 209 | 237 | 172 | 165 |
| | UK | ktCO2e | 15,831 | 20,373 | 25,520 | 27,698 | 30,549 | 29,776 | 29,253 | 29,958 | 32,859 | 35,576 | 36,005 | 35,849 | 34,905 | 33,361 | 31,904 |

**Table A6.4 International Aviation Fuel Use Estimates: England, Scotland, Wales and Northern Ireland**

| Fuel Use | DA | UNITS | EMISSION YEARS | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1990 | 1995 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
| Aviation | England | Mt | 4.75 | 6.14 | 7.71 | 8.37 | 9.23 | 8.99 | 8.84 | 9.03 | 9.88 | 10.67 | 10.77 | 10.71 | 10.45 | 10.01 | 9.58 |
| spirit and | 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 | 0.33 | 0.30 |
| aviation | 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 | 0.03 |
| turbine | 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 | 0.05 |
| fuel | UK | Mt | 4.92 | 6.36 | 7.97 | 8.66 | 9.55 | 9.31 | 9.14 | 9.36 | 10.26 | 11.12 | 11.25 | 11.20 | 10.90 | 10.42 | 9.96 |