

**PART III:
EXTENDING THE
CARBON BUDGET
FRAMEWORK?**

The existing Climate Change Act requires the government to set budgets in terms of CO₂ only, and excluding international aviation and shipping. The Secretary of State has asked the Committee to provide advice on whether these currently excluded sectors and the other greenhouse gases should be included in the legal budget system.

The principle which should apply is clear. What matters from the climate perspective is all greenhouse gases from all sectors. The implication is that all categories of emissions must be accounted for in some way within a greenhouse gas reduction strategy, whether or not they are included in budgets.

The inclusion of the currently excluded sectors and gases in the legally defined budgets, however, raises complex practical questions of emissions measurements and allocation, which we address in the next two chapters.

In **Chapter 8: International aviation and shipping**, we conclude that these sectors should not, for the time being, be included in the UK national budgets, but that it is essential that they are covered by other policy levers and monitored by the Committee. We illustrate that both sectors are likely to see very significant growth in emissions under business as usual, and that while there is emissions reduction potential, the percentage cut will likely be less than in other sectors. To the extent that this is the case, larger percentage reductions will be required elsewhere. We show that international aviation is appropriately included in the EU ETS, but that the national allocation treatment under the EU ETS would create significant practical complexities if international aviation was also included on a different basis in the UK national budgets. In the case of shipping, we illustrate the major complexities involved in any national allocation and the strong arguments for seeking a global sectoral approach.

In **Chapter 9: Non-CO₂ greenhouse gases**, we recommend that the budgets should be set in terms of all GHGs, not just CO₂. We identify that there are greater measurement difficulties in relation to some non-CO₂ gases, than apply to CO₂, but conclude that these are manageable and that the arguments for including non-CO₂ gases within the budgets are compelling. We present initial analysis of abatement potential in waste management and in agriculture, which is an important source of N₂O and methane emissions but where only limited analysis has been done in the past and where policy levers to drive emissions reductions are not yet in place.

The Chapter concludes by illustrating how the budget reduction figures set out in Chapter 3 (for CO₂ alone) need to be changed to incorporate non-CO₂ gases. The Intended budget target for all GHGs in 2020 is 42% below 1990 levels (31% below 2005 levels) and the Interim budget requires a 32% cut from 2020 (21% below 2005 levels).

**CHAPTER 8:
INTERNATIONAL
AVIATION AND SHIPPING**

The Kyoto Protocol committed the UK to achieving reductions in greenhouse gases (GHGs) as measured by the NAEI. The NAEI total for the purposes of the reduction commitments includes emissions from UK domestic aviation and shipping, but does not include an estimated UK share of international aviation and shipping emissions. This reflects the absence of an agreed basis for allocating international passenger and freight traffic to specific countries.

Despite this lack of an international approach, emissions from domestic and international aviation (both within Europe and to and from Europe) will be included within this phase of the European Union Emission Trading Scheme (EU ETS) and therefore subject to a total emissions cap. There are not at present, however, any clear plans for a policy instrument to contain shipping emissions, either at the UK or EU level.

This chapter therefore considers (i) the feasibility of allocating international emissions both to the European and the UK level; (ii) the scope for global abatement in these sectors; and (iii) the implications of allocation systems and appropriate policies for the treatment of the two sectors within the UK budget framework.

Our key conclusions are that:

- Whilst aviation and shipping emissions are today both relatively small as a percent of total global emissions they are likely, if unconstrained, to grow to much larger shares. It is therefore essential either to curtail emissions growth significantly or to set more stringent targets for all other sectors which compensate for the difficulty of achieving cuts in these sectors.
- **On aviation specifically:**
 - If unchecked, global aviation CO₂ emissions could reach 2.4 GtCO₂ in 2050. At this level aviation emissions would, in 2050, account for 15-20% of all CO₂ emissions permitted under our preferred global emissions reduction scenarios set out in Chapter 1: *Setting a 2050 target*. By 2050 UK related international aviation CO₂ emissions (using the bunker fuels methodology) could, under DfT's central scenario, account for around 35% of the UK's GHG emissions cap implied by our preferred global emissions reduction scenario.
 - The global emissions forecast assumes a significant efficiency improvement consistent with preliminary analysis carried out for us by QinetiQ. This analysis suggests that a new production aircraft in 2025 flying in an improved operational environment will be 40-50% more fuel efficient compared to a 2006 new production aircraft flying in a 2006 operational environment. Reducing emissions below forecast would require use of either biofuels or hydrogen. Aviation biokerosene brings the same sustainability and food supply concerns as other biofuels, but if it could be produced sustainably, significant life-cycle emissions reduction could result. The International Energy Agency (IEA) estimate in their BLUE Map scenario that in a world with a substantial carbon price, biomass-to-liquid fuels could account for 30% of aviation fuel by 2050. Hydrogen is another potential fuel source in the longer term, but there are significant implementation barriers. In addition to infrastructure issues and the need for a sustainable source of hydrogen, the climate effect of increased water vapour at high altitude would need to be investigated.

- We conclude that international aviation needs to be covered by an international agreement. In the absence of a global deal the planned inclusion of international and domestic aviation within the EU ETS makes sense and there are few disadvantages to European unilateral action.
 - Given that aviation is included within the EU ETS, it is not essential to have international aviation included within the UK national budgets in order to ensure pressure for emissions reduction.
 - Ideally, international aviation would be included in UK national budgets for completeness. But there are complexities related to methodologies by which emissions might be allocated to the UK. Specifically, we do not think that inclusion on the basis of EU ETS allowances administered by the UK would adequately reflect the UK's international aviation emissions. Inclusion on the basis of bunker fuels is attractive in principle, but could not be effectively monitored against emissions and permits given the way that EU ETS has been designed. We therefore recommend that international aviation is not explicitly included in the UK's carbon budget.
 - If it is not included, the budget which is set for the other sectors will need, when combined with the trend in EU ETS aviation emissions, to be compatible with overall climate objectives. Aviation (both international and domestic) is included in the EU's 20% and 30% GHG emissions reduction targets. Our budget proposals in Chapter 3: *The first three budgets* which are based on this framework, therefore implicitly take into account international aviation emissions.
 - Recognising the importance of including international aviation emissions in the UK's climate mitigation strategy, we propose that the Committee reports annually on UK trends in international aviation emissions (using a range of appropriate methodologies), their climate impact, developments in, and the success of, abatement efforts and appropriate policy levers.
- **On shipping specifically:**
 - Unconstrained growth could result in global CO₂ emissions growing two to three times current levels by 2050 reaching 2.4-3.6 GtCO₂. At this level they would, in 2050, account for 15-30% of all CO₂ emissions permitted under our preferred global emission reduction scenarios set out in Chapter 1. It is therefore essential that international shipping emissions are covered in overall emission targets and policy frameworks.
 - There is a wide range of abatement options that could be applied to ships to reduce energy consumption and hence reduce CO₂. There are significant implementation barriers but some of these could be overcome through the introduction of a global carbon market. Our analysis suggests that global shipping emissions could be reduced by 33% relative to a baseline projection in 2050 at a carbon price of 200 Euro/tCO₂. Even in this scenario, however, global shipping emissions in 2050 could be twice current levels – roughly 2 GtCO₂.
 - There are not at present any firm plans to include international shipping in the EU ETS and applying a European only approach to shipping could be undermined by carbon leakage effects. Shipping is a clear example of a sector where unilateral, national or even regional action is problematic, and where achieving a global sectoral deal is therefore a priority.
 - We do not therefore believe it appropriate at this stage to include international shipping emissions within the UK budget system.

- Likely trends in international shipping emissions should be taken into account in setting budgets (excluding international shipping) so as to ensure that the budgets are compatible with overall climate objectives. At present, however, the EU 20% and 30% GHG targets exclude international shipping, and this is reflected in our carbon budget proposals. The appropriate action here would be for the EU's targets to take into account international shipping emissions when setting targets for other sectors, rather than for the UK to unilaterally adjust its carbon budgets. In the meantime, our recommendation is that the Committee should report annually on trends in the UK's international shipping emissions (using a variety of different measures), their climate impact, developments in, and the success of, abatement efforts and appropriate policy levers.

The chapter covers first aviation (Section A) and then shipping (Section B). For each sector we cover in turn:

1. Trends and projections at the global and UK level
2. Supply side abatement opportunities
3. Appropriate policy levers at national, European and global level
4. International aviation/shipping and the UK national budget

SECTION A: INTERNATIONAL AVIATION

1. INTERNATIONAL AVIATION: TRENDS AND PROJECTIONS

Although total aviation emissions represent a small percentage of total global emissions today, they represent a more significant proportion of developed country emissions. Unconstrained forecasts suggest that global aviation emissions would, in 2050, account for 15-20% of all CO₂ emissions permitted under our preferred emissions reduction scenarios set out in Chapter 1.

- The precise scale of current global CO₂ emissions (international and domestic) from aviation is uncertain, with different sources suggesting a range from 0.5 to 0.7 GtCO₂¹ (roughly half of emissions come from international aviation). This range is equivalent to about 1.9–2.4% of total global emissions of CO₂ (excluding those relating to land-use) (Table 8.1).
- The effect of aviation on the climate is, however, almost certainly somewhat higher than these figures suggest, with further radiative forcing caused by the creation of high clouds and emissions of other non-Kyoto GHGs. The best way of accounting for these additional effects is still a subject of debate for two reasons: first, there is a low level of current scientific understanding regarding some of the processes involved, and second, there is uncertainty about whether traditional metrics for weighting non-CO₂ effects (such as the Global Warming Potential (GWP) metric) are appropriate, as set out in Box 8.1.
- Aviation demand has grown rapidly. Over the last ten years total scheduled demand (domestic and international combined) have increased at roughly 5% per annum, substantially faster than global economic growth (Figure 8.1). Looking forward, rapid growth is likely to continue. Developed country traffic volumes and emissions per capita are today far above developing country levels (Figure 8.2) but air travel in developing countries will increase rapidly as their incomes increase, since estimates of the income elasticity of demand for aviation are very high (Table 8.2).
- There are many projections for global aviation emissions and this makes it hard to establish one 'business as usual' case. Projections vary widely depending on the precise assumptions made about income convergence, traffic growth, fuel efficiency trend and the scope of the study. Other assumptions also relate to the regulatory environment and consumer behaviour. The CONSAVE scenarios (Figure 8.3) show four possible scenarios for the growth of global (domestic and international) aviation emissions. The scenarios range from 'Unlimited Skies' (ULS), which is comparable with an unconstrained demand scenario, but pressure on capacity at airports, to 'Down to Earth' (DtE), which would require strong policy action and regulation. In a world without significant policy action at the global level we are more likely to be on a path resembling the CONSAVE ULS scenario, which would result in 2.4 GtCO₂ from global aviation in 2050 under an assumption that fleet efficiency improves by 1.5% annually. Global CO₂ emissions from aviation at around these levels would, in 2050, account for 15-20% of all CO₂ emissions permitted under our preferred global emissions reduction scenarios set out in Chapter 1.

¹ The lower end of the range comes from models cited by the IPCC which tend to only cover civil emissions and scheduled traffic, whereas the higher end of the range is the IEA's more recent bunker fuel estimate, which includes all traffic including military.

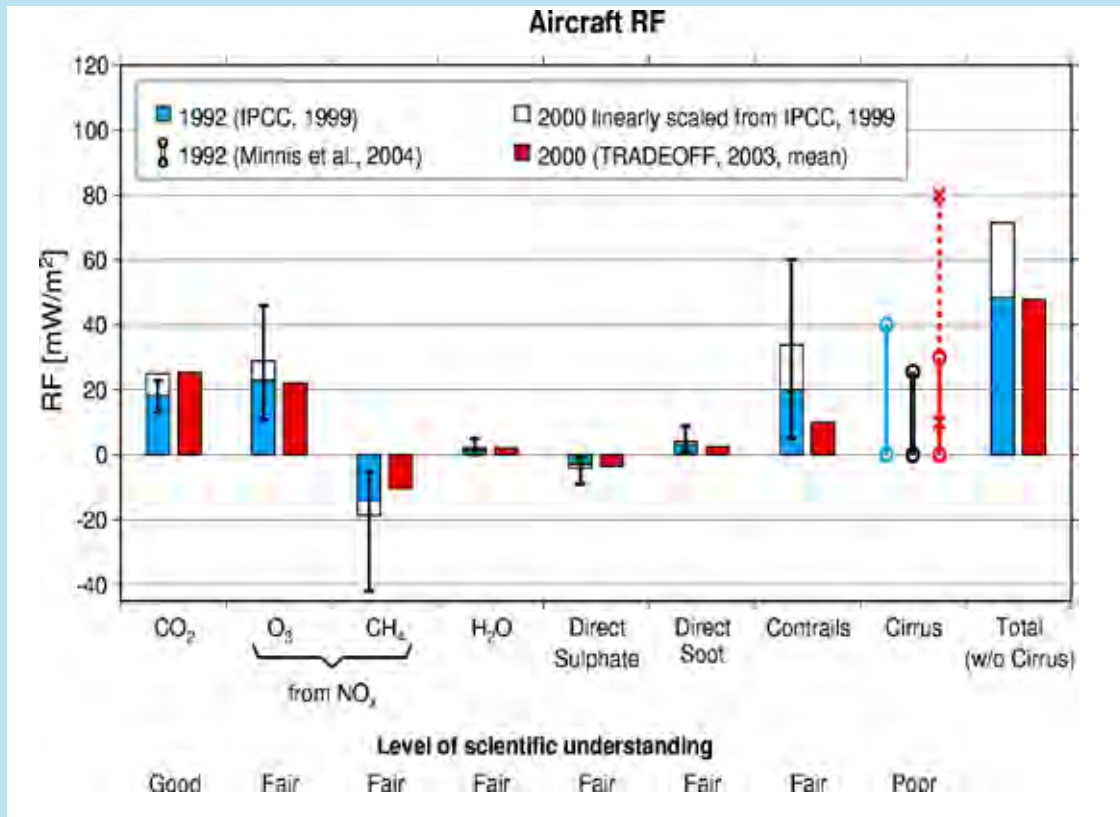
- Turning to the UK level, there is a variety of possible ways of determining the UK share of international aviation emissions. On a 'bunker fuel basis' (which is reported as a memorandum item in the United Nations Framework Convention on Climate Change (UNFCCC) National Register), UK international aviation emissions were around 30 MtCO₂ in 2000 (roughly 8% of the global total). Similar shares result from other allocation methodologies recommended for further consideration by the UNFCCC Subsidiary Body for Scientific and Technological Advice (SBSTA) (Table 8.3). But demand is growing rapidly, both for passenger traffic (Figure 8.4) and freight traffic (Figure 8.5) and so too are emissions. Figure 8.6 illustrates a 66% increase in international aviation CO₂ emissions over ten years using the bunker fuel definition.
- Looking forward, Department for Transport (DfT) central bunker fuel projections suggest that UK related emissions (both domestic and international) by 2030 could reach around 60 million tonnes (Figure 8.7). Beyond 2030 the projections flatten largely because of infrastructure constraints, and CO₂ emissions from aviation in 2050 are approximately 60 MtCO₂. If international aviation emissions remain around the same proportion of emissions as in 2006 then UK international aviation would emit roughly 55 MtCO₂, around 35% of a proposed cap of UK GHG emissions in 2050 (see Chapter 1).

Table 8.1 CO₂ emissions from global aviation

Study/Source	Base Year	Total aviation emissions (MtCO ₂ /yr)	Percentage of global emissions in given year
IEA	2005	730 (416 international)	2.4%
AERO 2K	2002	492	1.9%
FAST	2000	480	1.9%
CONSAVE	2000	531	2.1%
UNFCCC	2005	475 (covers Annex 1 only)	n/a

Note: IEA estimates are taken from 'CO₂ emissions from Fuel Combustion 1971-2005' and are based on bunker fuel use, other models cited by the IPCC (i.e. AERO 2k, FAST and CONSAVE) represent global aviation, whereas UNFCCC estimates derive from reports from Annex 1 countries only. Global emissions are total CO₂ emissions (excluding those related to land-use) and are taken from CDIAC.

Box 8.1 The current radiative effects of aviation



Source: Sausen, R. et al. (2005) Aviation radiative forcing in 2000: an update on IPCC (1999). *Meteorologische Zeitschrift*, 114, 555-561

The overall effect of aviation on climate is currently the subject of active scientific research. As well as emissions of CO₂, aviation fuel burning leads to emissions of water vapour in the form of contrails, sulphate aerosol and soot, which all contribute small but direct radiative effects. Significant radiative forcing (RF) comes from indirect and short-lived processes not covered by the Kyoto Protocol (see above). And major uncertainties in aviation’s forcing are caused by emissions of oxides of nitrogen (NO_x) and cloud formation.

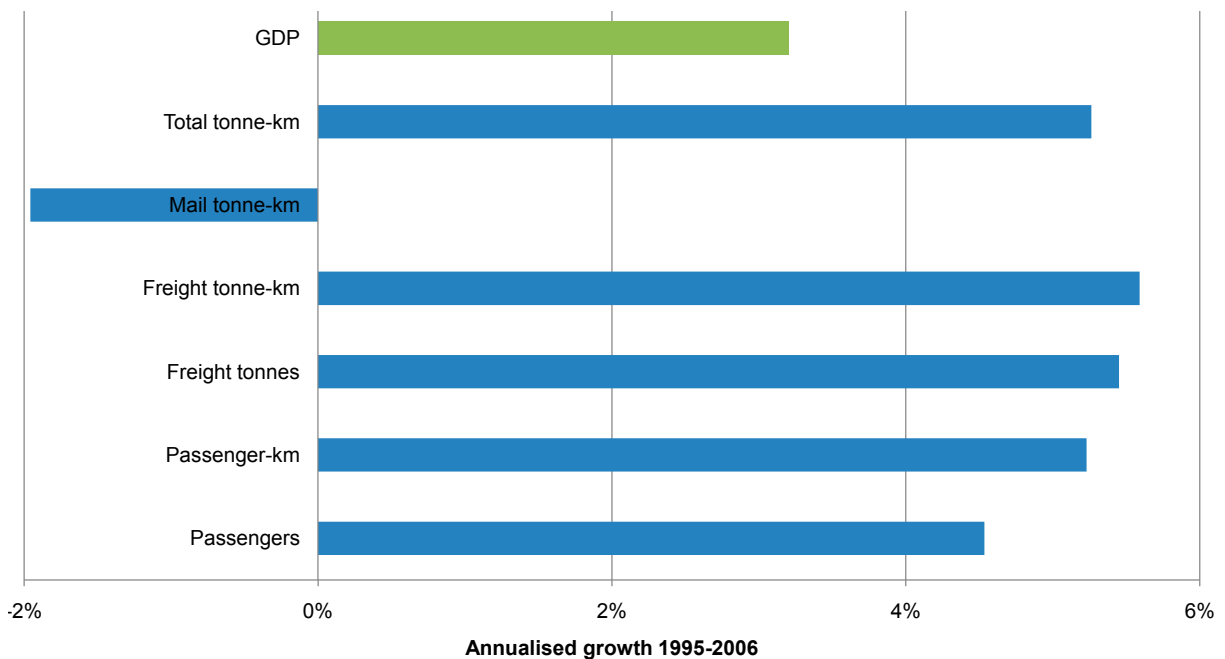
NO_x is known as an indirect GHG because it increases production of ozone (O₃, a short-lived GHG) but also destroys methane (CH₄, a long-lived, Kyoto GHG). These two processes occur over different timescales and different spatial scales, and so the total forcing from NO_x emission can be negative or positive depending on location and air chemistry. Importantly, some methods of reducing CO₂ emissions from aircraft engines lead to an increase in NO_x emissions. Using these methods could therefore be inefficient in reducing radiative forcing from the aviation sector.

Contrail formation is an effect of aviation that can clearly be seen, and it is also thought that aircraft activity may induce more frequent formation of cirrus clouds. Both tend to be very short-lived (on a timescale of minutes to hours), dependent on local weather conditions, and their radiative effect is complex. The level of current scientific understanding of these two processes are thus classed as ‘Fair’ and ‘Poor’ respectively.

The traditional GWP metric for comparing GHGs relies on a one-to-one link between the pulse of a mass of emissions and its time-integrated, globally-averaged radiative forcing. Effects of aviation can involve the sum of two different effects acting over different times and areas (in the case of NO_x), or processes which depend on local conditions and last for uncertain lengths of time (in the case of cloud formation). This makes the use of GWPs as a policy instrument for aviation a controversial issue, although the scientific evidence suggests that non- CO_2 effects of aviation should be accounted for in some way.

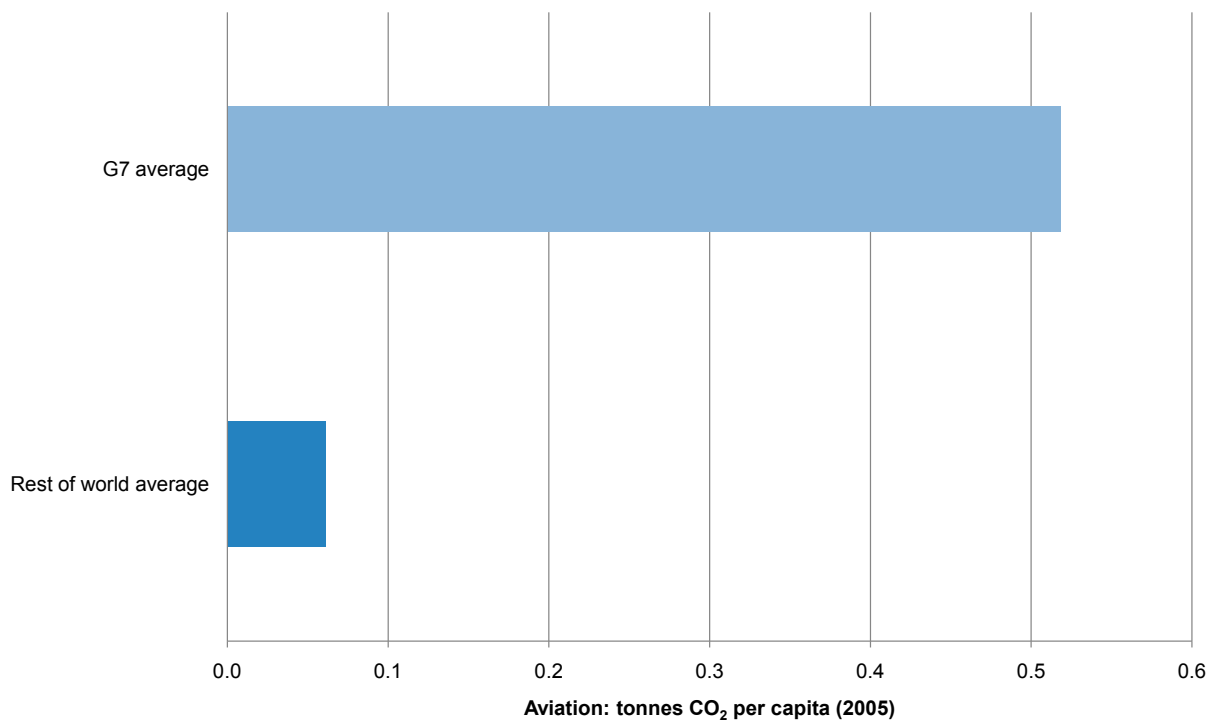
It should be noted that the above figure shows the climate effect of past aviation emissions and therefore, should not be used as a metric to account for the future climate effects of aviation emissions.

Figure 8.1 Annualised growth during 1995-2006 for global aviation revenue traffic (domestic and international) measured using a range of metrics and compared to global GDP growth



Source: ICAO Data. (2008)/UN Statistics Division. (2008)

Figure 8.2 Per capita emissions of CO₂ from aviation (domestic and international) in the year 2005, grouped into G7 nations and the rest of the world



Source: UNFCCC. (2008)

Table 8.2 Estimated income elasticities of passenger demand

Route / Market level	Short-haul	Medium-haul	Long-haul	Very long-haul
US	1.8	1.9	2.0	2.2
Developed economies	1.5	1.6	1.7	2.4
Developing economies	2.0	2.0	2.2	2.7
National level	Short-haul	Medium-haul	Long-haul	Very long-haul
US	1.6	1.7	1.8	2.0
Developed economies	1.3	1.4	1.5	2.2
Developing economies	1.8	1.8	2.0	2.5

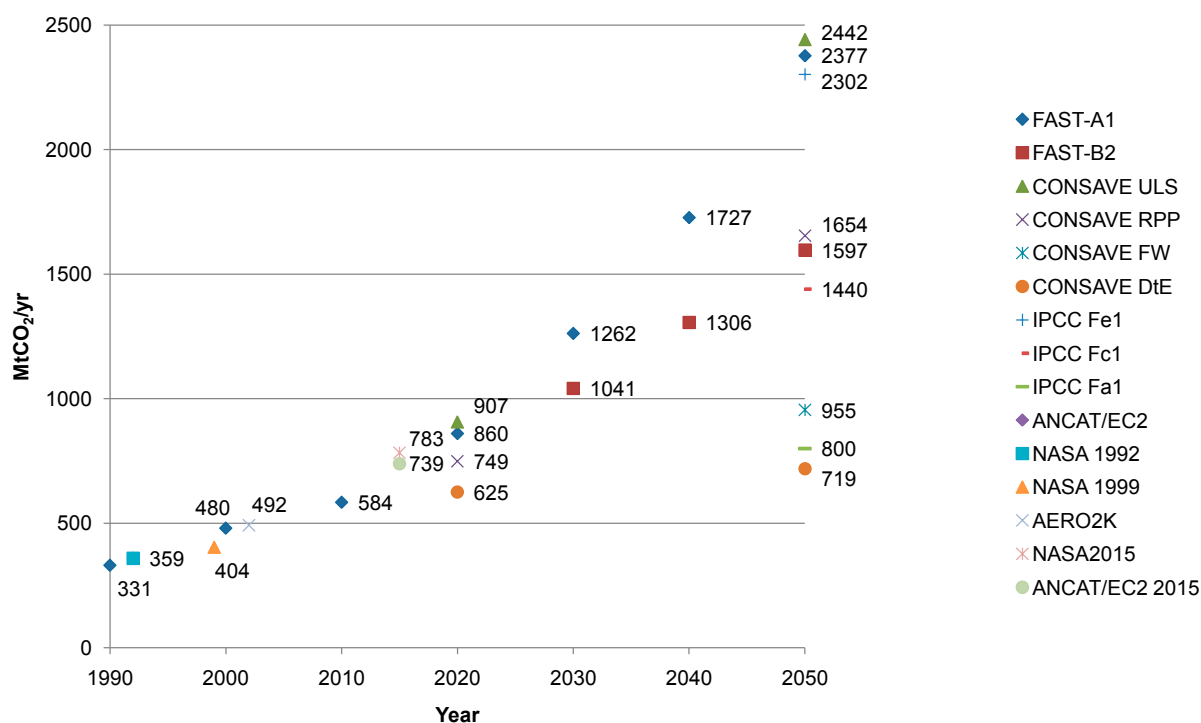
Source: IATA. (2008) *Air Travel Demand*

Table 8.3 Percentage of international aviation emissions that would be allocated to the UK using the SBSTA methodologies

Methodology 'recommended' for further consideration	Owen & Lee	CE Delft	Owen & Lee
	UK 1990	UK 1990	UK 2000
Fuel used for international flights (bunker fuels)	7%	7%	8%
Nationality of the airline	no data	8%	8%
International departures/arrivals (aircraft)	7%	7%	8%
International departures/arrivals (passengers)	7%	7%	8%

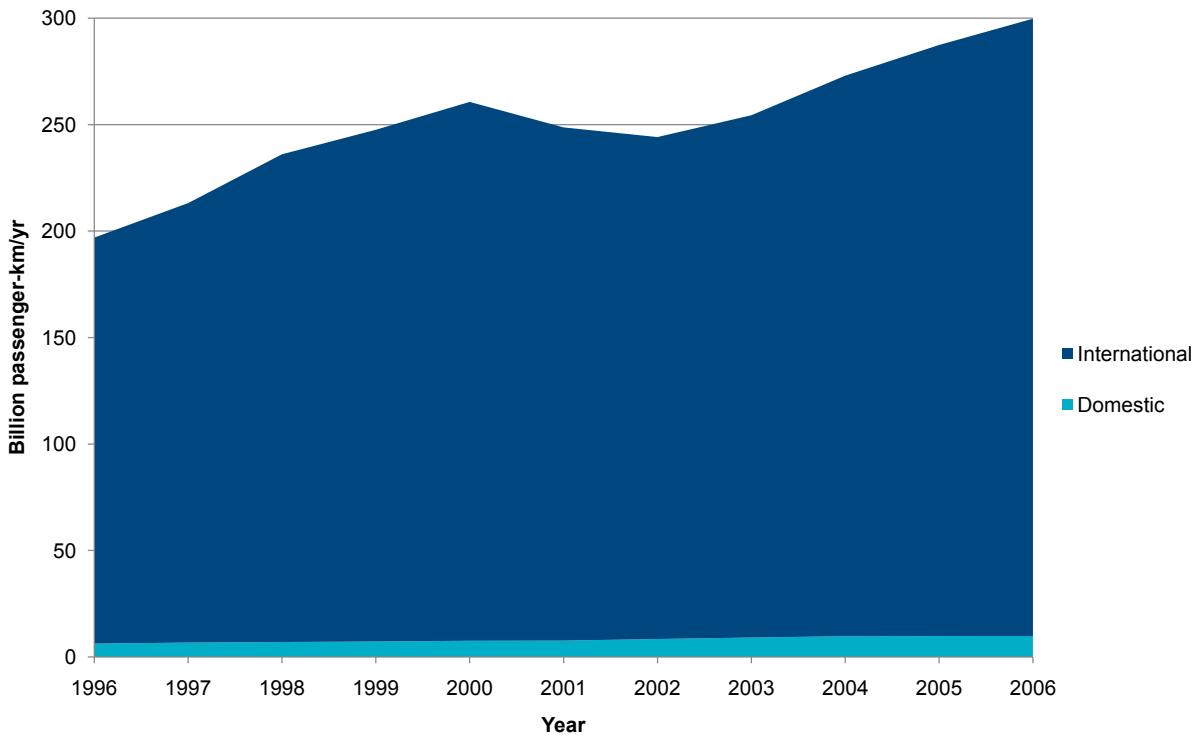
Source: Owen, B. & Lee, D. S. (2005) *Study on the Allocations of Emissions from International Aviation to the UK Inventory*/ CE Delft. (2000) *National allocation of international aviation and marine CO₂ emissions*

Figure 8.3 Comparison of projections of global CO₂ emissions from civil aviation (domestic and international), 1990-2050



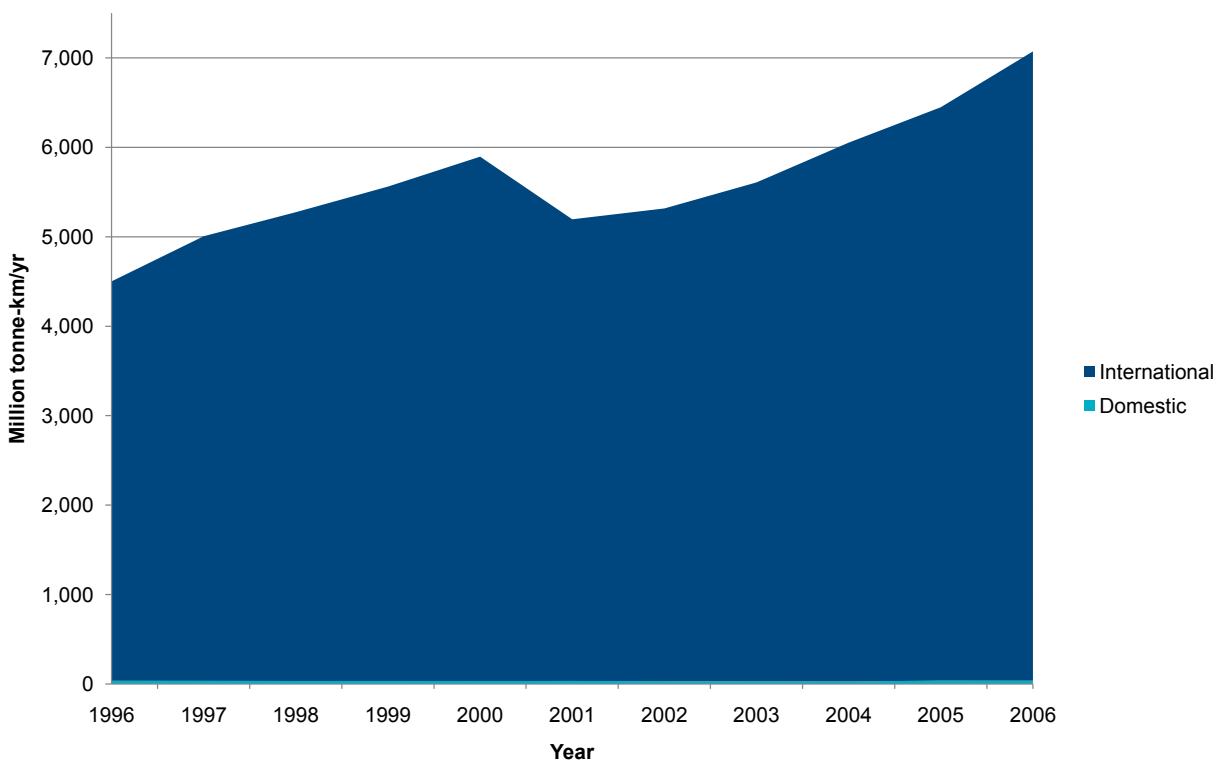
Source: IPCC. (2007) WG3 AR4, Fig. 5.6
 Note: This figure shows how the CONSAVE scenarios (ULS, RPP, FW and DtE) fall within the range of projections cited by the IPCC.

Figure 8.4 UK passenger demand for UK airlines during 1996-2006



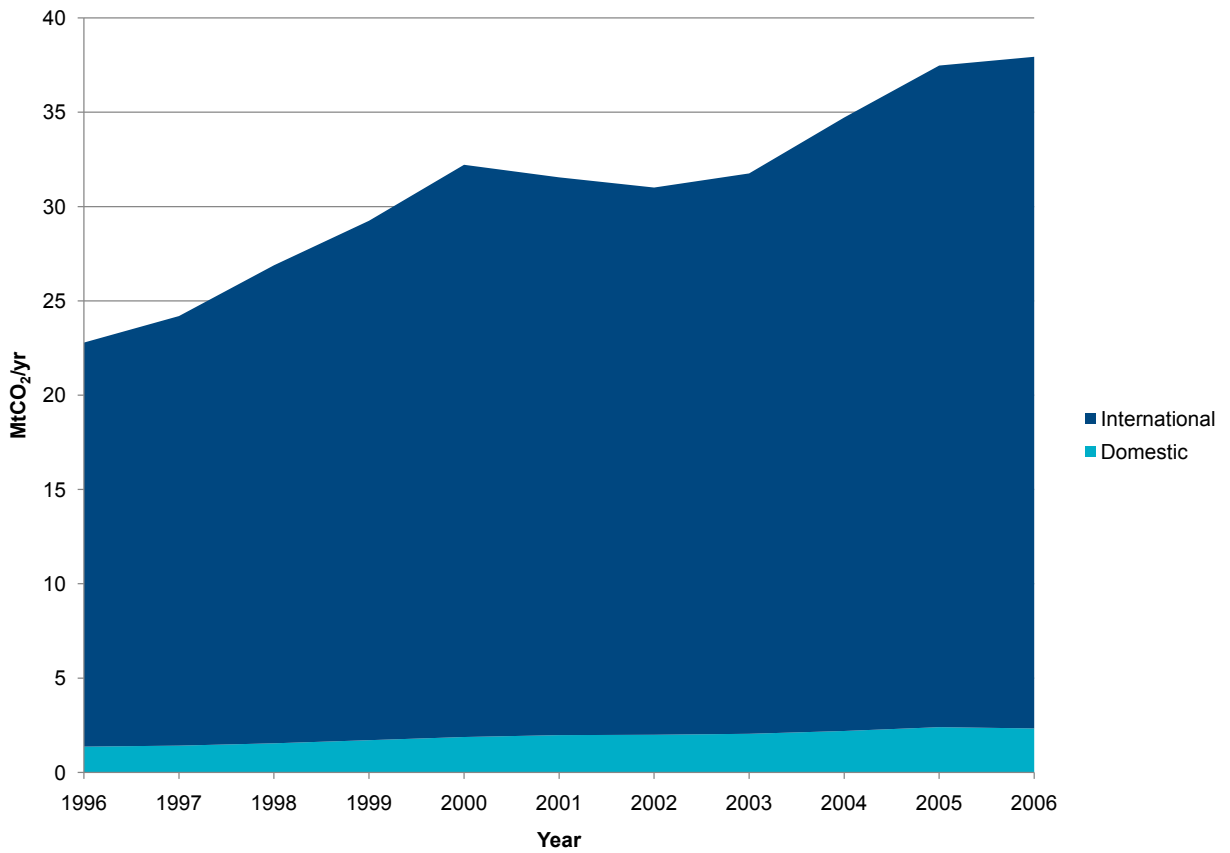
Source: DfT. (2007) *Transport Statistics Great Britain*

Figure 8.5 UK freight demand for UK airlines during 1996-2006



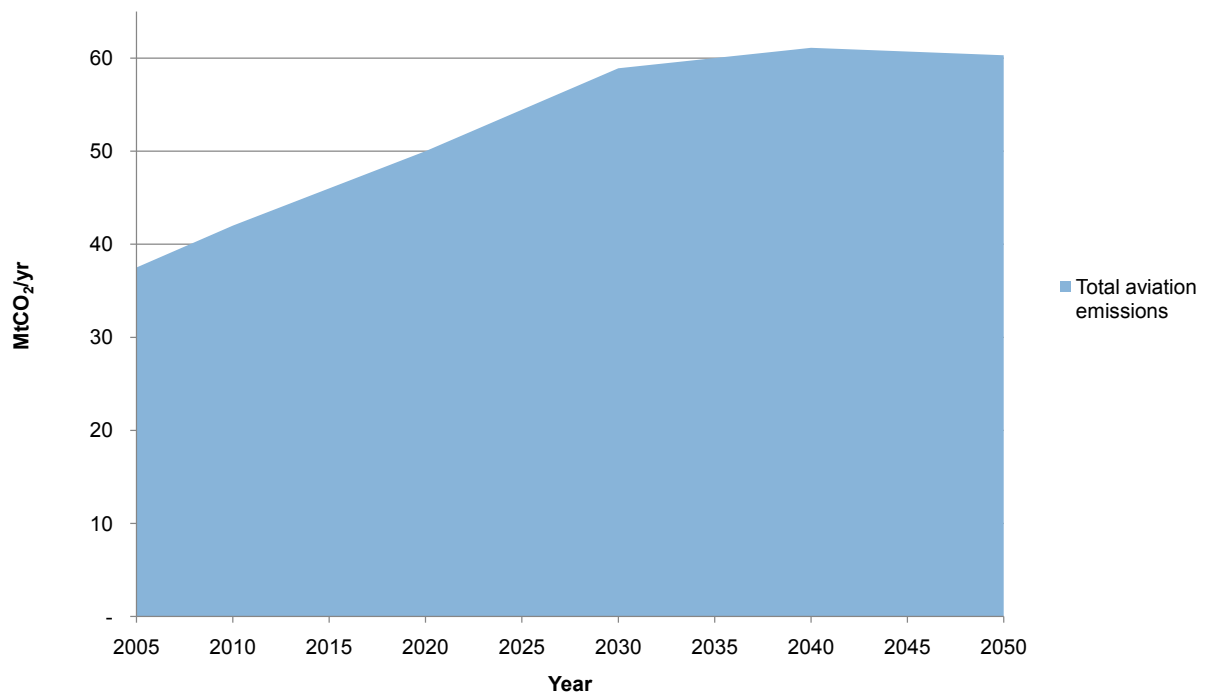
Source: DfT. (2007) *Transport Statistics Great Britain*
 Note: Domestic freight demand is only 0.5% of the UK total in 2006.

Figure 8.6 UK CO₂ emissions from aviation during 1996-2006



Source: Defra statistics. (2008)

Figure 8.7 DfT projections of CO₂ emissions from UK aviation (central scenario)



Source: DfT. (2007) *UK Air Passenger Demand and CO₂ Forecasts*

2. INTERNATIONAL AVIATION: SUPPLY SIDE ABATEMENT OPPORTUNITIES

The Committee commissioned QinetiQ to conduct a preliminary review of present and future possible technological options to reduce emissions. Their analysis takes into account, but is not limited to, the efficiency goals that were voluntarily set under the Advisory Council for Aeronautics Research in Europe (ACARE) targets.

This analysis illustrates that evolutionary technological developments and changes in operational practice have the potential to improve aviation fuel efficiency. These developments are however included in 1.5% per annum efficiency improvements assumed in the global emissions forecast, and do not therefore offer additional potential. They imply that a new production aircraft in 2025 flying in an improved operational environment could be 40-50% more fuel efficient compared to a 2006 new production aircraft flying in a 2006 operational environment.

More radical changes (not included in the emissions forecast) to aviation technologies, e.g. Blended Wing Bodied aircraft, are likely to be more expensive, require changes to infrastructure and may not lead to significant additional emissions reduction. New fuel sources, in particular biofuels, may have a significant role to play in reducing life-cycle emissions in the long term, although their full climate impact would need to be considered.

Improving fuel efficiency: There are significant theoretical opportunities to improve aviation fuel efficiency without changing the fuel source. But the limits to what is economically, and indeed technically, feasible still imply major increases in emissions if demand grows in line with projections.

- **Technological possibility:** QinetiQ's report on technological possibilities for the CCC sets out four categories of change and by 2025:
 - Evolutionary changes in airframe technology could conceivably deliver 20-30% improvement in the efficiency of new aircraft coming into service relative to an average new production aircraft in 2006 (Table 8.4).
 - Evolutionary changes in engine technology could deliver another 15-20% improvement relative to an average new production aircraft in 2006 (Table 8.5). The changes above are not fully additive. Taken together they could yield a 35-45% improvement.
 - Changes in the efficiency of aircraft operations might conceivably deliver a 10-15% improvement (Table 8.6). Technical and operational changes together could result in a new production aircraft in 2025 operating in an improved operating environment being 40-50% more fuel efficient compared to a 2006 new production aircraft flying in a 2006 operational environment.
 - More radical long-term technological options might be applicable in the long term, such as blended wing bodied aircraft or distributed engines, but significant barriers exist in some cases.
- **Industry targets:** These estimates are broadly in line with the ACARE efficiency targets, to have at least one aircraft in service by 2020 which produces 50% less CO₂ per passenger-km compared to a benchmark civil aircraft in 2000.

- **Realistic and cost-effective abatement:** Estimates are complex for the following three reasons:
 - The pace at which average fleet fuel efficiency improves will be driven by investment cycles. These tend to be long – up to 55 years² – and there is limited scope to retrofit new technologies to existing aircraft. Improvements in fleet fuel efficiency will therefore lag improvements to new aircraft as the global fleet could take several decades to turnover.
 - Whilst estimates and targets suggest significant potential to drive efficiency improvement, it is likely that many of these improvements are already factored into projections of aviation emissions.
 - Improved efficiency of individual aircraft, particularly from operations, may lead to rebound effects, whereby reduced delays and stacking encourage more demand.
 - Work on assessing the cost-effectiveness of abatement opportunities is less developed than for the other sectors of the economy considered in chapters 5 to 7: *Decarbonising electricity generation; Energy use in buildings and industry; Reducing domestic transport emissions*.

Nevertheless, the IEA's BLUE Map scenario, which assumes a carbon price of at least US\$200/tCO₂ in 2050, forecasts abatement uptake that would lead to a 42%³ cut in aviation CO₂ emissions relative to baseline. However, this would still result in global aviation emissions exceeding 2 GtCO₂ in 2050.

Alternative fuel sources

The crucial requirement for aircraft flight is a fuel source with a very high energy density by weight and which performs at high operating altitudes. For this reason it is extremely unlikely that aviation can be decarbonised through the use of batteries, which Chapter 7 suggested may play a major role in surface transport. Even the most extremely optimistic projections for battery technology do not anticipate achieving more than a small fraction of the energy density by weight ratio of aviation kerosene. Decarbonisation of the aviation fuel source will therefore entail either biofuels or hydrogen.

- **Biofuels:** Biomass can be converted into hydrocarbons by the Fischer-Tropsch process and upgraded to jet fuel. The fuel could be used without significant modification to the existing fleet. This technology, however, is still at an early stage. The disadvantages are that biomass-to-liquid fuels can lead to direct competition for land with food and the cropland could lead to deforestation or losses in biodiversity. Future developments in biofuel are focused more on the introduction of novel feedstocks such as algae. IATA estimate that later generations of biofuels could potentially reduce aviation emissions by 60-100% on a life-cycle basis.
- **Hydrogen:** Compared to kerosene, hydrogen offers a high energy content per unit mass, around 2.8 times, but liquid hydrogen requires four times the size of fuel tank to carry the same energy. This requires a bulkier and longer aerodynamic shape that will require major aircraft redesign. The main emission from hydrogen combustion is water with some emissions of NO_x. The higher water content of the exhaust will cause contrails and cirrus cloud formation. This points to caution in the use of hydrogen before the climate impacts of hydrogen-powered aircraft are properly understood.

2 10 years for development and certification, 20 years from initial introduction to service to final production and a further 25 years of aircraft family operations until final retirement.

3 In addition to technological improvements this reduction includes significant uptake of biofuels, improvements in routing, load factor as well as modal shift. IEA (2008) *Energy Technology Perspectives*. Paris, IEA.

Overall, a combination of fuel efficiency improvements and new fuel sources could significantly reduce aviation emissions, if appropriate policies and incentives are in place. But the likely growth in demand, the limits to feasible fuel efficiency improvement, and the more limited set of fuel decarbonisation options than are available in surface transport, make it likely that aviation emissions will continue to grow significantly unless demand is constrained, and that by 2050 they will account for a very significant proportion of the appropriate target for total global emissions.

Table 8.4 Summary and combination of evolutionary airframe improvements

Technology	Potential Aircraft CO ₂ improvement	Earliest Availability	Retro-fit?	Key Technical Barriers
Winglets	1-2%	Now	Y	New – none Retrofit benefit is application dependent, leasing
Riblets	1-2%	2015-2020	Y	New – dev and certification Retrofit is application dependent, leasing
Laminar Flow (wings)	10-20%	Now-2020 ^{Note 2}	N	Manufacturing costs, maintenance costs ^{Note 3}
Laminar Flow (Nacelles)	1%	Now	Y	As Laminar flow wings but with less significance.
Lighter Materials (Composites)	10-20% ^{Note 1}	Now	N	Certification, manufacturing, repair, recycling
Active Airframe Health Monitoring	Up to 12%	2015-2025	N	Development test and evaluation costs, certification.
AVG New Production	20-30%	By 2025		
Retrofit	2-5%			

Source: QinetiQ. (2008) *Aviation CO₂ Emissions Abatement Potential from Technology Innovation*

Note 1: Generalised composite figures indicate a 10% reduction in fuselage and wing mass, with potential weight saving in the primary structure overall (including fuselage and wing) of no more than 25% and not more than 15% in the secondary structure, in commercial aircraft. Typically a 25% decrease in a/c weight gives ~10-15% savings in fuel usage, hence 25-40% reduction may result in 10-24% saving in fuel, this is conservatively expressed as 10-20%.

Note 2: Hybrid laminar flow control was previously demonstrated on a B757 aircraft in 1991, technically this could be implemented today.

Note 3: Increased sensitivities to surface imperfections, dirt/bugs/damage etc, lead to increased manufacturing and maintenance costs.

Table 8.5 Summary and combination of evolutionary engine improvements

Technology	Potential Aircraft CO ₂ improvement	Earliest Availability	Retrofit?	Key Barriers
OPR, Materials, Cooling	3-5%	Now-2025	Y	None
Compressor and Turbine Aero	3-5%	Now-2025	Y	None
Cycle (GTF/UHB) ^{Note}	8-10%	2013-2025	N	Dev risk for larger gearboxes
AVG New Production	15-20%	By 2025		
<i>Retrofit by Module Replacement</i>	<i>0.5-1%</i>	<i>Now</i>		
<i>Retrofit by new engine to 10 year old airframe</i>	<i>5-7.5%</i>	<i>Now</i>		

Source: QinetiQ. (2008) *Aviation CO₂ Emissions Abatement Potential from Technology Innovation*

Note: GTF/UHB – Geared turbofan for lower thrust, Ultra high bypass for larger types.

Table 8.6 Summary and combination of operational/ATM improvements

Technology	Potential Aircraft CO ₂ improvement	Earliest Availability	Retro-fit?	Key Barriers
Operations				
Ground towing	Up to 2%	2010s	N	Aircraft design, airport capacity
(Stop) Tankering	0.5%	Now	Y	Turn round time
Cabin dead weight reduction	<1%	Now	Y	Brand image, public expectations
Formation flight	1%	2020s	N	Coordination, risk
Optimum stage length	Up to 7%	2015-2040	N	New fleet , extended journey time, more airports, increased LTO risk and noise
Load factor maximisation	9% Max	Now	Y	Timetabling, frequency
	3-6% feasible			
Point-to-point	Possibly up to 5%	2015-2035	N	Smaller planes, airport size shift, route frequency
Air Traffic Management				
System delays and imperfect trajectories	3-8%	2020	N	System improvements already funded in parallel with capacity increase research
Total Improvement				
	10-15%	2025		
	Up to 25%	2040		Total aircraft and route redesign
<i>Retrofit</i>	4%			

Source: QinetiQ. (2008) *Aviation CO₂ Emissions Abatement Potential from Technology Innovation*

3. INTERNATIONAL AVIATION: APPROPRIATE POLICY LEVERS

Given the strong projected growth of aviation emissions, it is essential that aviation is covered by a policy framework which (i) faces aviation with an appropriate cost of carbon so as to provide an incentive both for supply side abatement and for demand constraint⁴ and (ii) ensures that the total level of emissions (from aviation plus all other sectors) is reduced in line with appropriate scientific targets. There are few impediments to applying this framework at a European level, as now planned under the EU ETS. That framework, and any subsequent binding global agreement to cap emissions, is likely in the long term to drive demand side constraint as well as efficiency improvements.

Aviation within the EU ETS

In October 2008, after some 18 months of negotiations, EU Ministers signed off the deal to include all aviation, international and domestic, in the EU ETS. All flights (both domestic and international) will be included in the EU ETS from 2012. This is an appropriate and essential policy, which will ensure appropriate abatement provided that the total EU ETS cap declines over the long term (i.e. beyond 2020) in line with climate science objectives, whatever the ‘business as usual’ projections for specific sectors. Including aviation in the EU ETS is a major step forward and provides some pressure for abatement and/or demand reduction, but will not encompass non-price policy levers such as decisions over air-traffic control and infrastructure.

- Leakage concerns regarding inclusion of aviation in EU ETS are likely to be far less pronounced than for some of the industries (e.g. iron and steel) we consider in Chapter 11: *Economic costs and fiscal implications*. Aviation is an international industry, but production cannot be shifted to another country: steel consumed in Europe can be manufactured in Europe or China, but a flight from New York to London cannot be produced elsewhere. Whilst there could be some change in hubbing due to the existence of a carbon price for aviation in Europe, which is most likely to affect non-EU to non-EU routes, this is likely to be of a small order of magnitude.
- Aviation will initially be included in an EU ETS system with a specific allocation, some of which will be allocated to airlines and some auctioned. The total allocation for airlines administered by a Member State will be calculated and a percentage (15% in 2012, then 15% 2013-2020 unless changed by the 2020 package negotiation) top-sliced for auction. However, the Committee agrees with the European Commission’s desire for a move towards 100% auctioning of allowances for aviation by 2020. The aviation cap will be based on an average of the emission in the years 2004 to 2006, with 97% of that baseline in the first year 2012 and 95% post, unless the percentage reduction is changed as part of the general review of the ETS. Including aviation effectively adds to the total emissions cap within EU ETS, and results in a percentage rate of reduction in the total which is slightly less than for all covered sectors excluding aviation. The total EU ETS cap, including aviation, has however been set so as to be broadly compatible with the EU’s 20/30% GHG targets (Figure 8.8).
- Looking beyond 2020, and assuming that by then 100% auctioning is in place for all sectors (other than those where legitimate competitiveness concerns exist), there will cease to be a specific aviation sector allocation, and what will matter will be simply the overall EU ETS cap. It is essential that this reduces at an overall rate consistent with climate objectives, creating a discipline which ensures that any shortfalls in reduction rate in difficult to reduce sectors (such as aviation) are offset by more rapid reductions elsewhere.

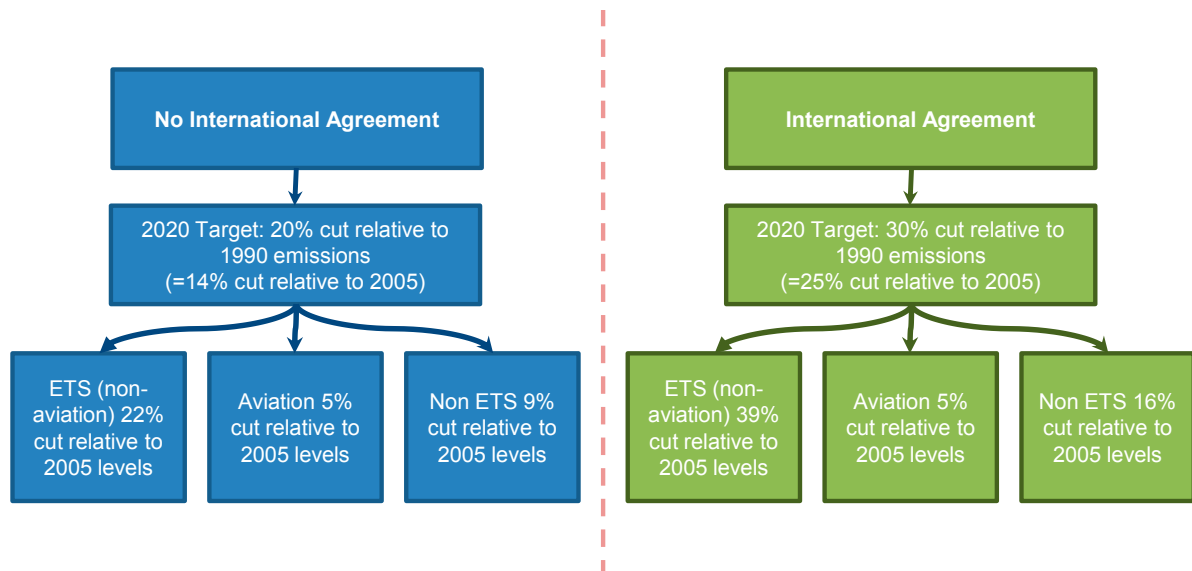
⁴ The extent of demand reduction depends on the carbon price and the extent to which the extra cost is passed through to customers in the form of higher fares. The extent of pass through has been widely debated and we make no judgement about its extent. Suffice it to say that the greater the potential for pass through the less supply side abatement is necessary and vice-versa.

Aviation demand within a European or global system over the long-term

The ideal long-term solution (which will be debated at Copenhagen) would entail caps applying to all countries and sectors, with international trading to allow the achievement of lowest-cost abatement. It is likely that within such a system, aviation emissions would continue to grow as a percentage of total global emissions, given the greater difficulty of achieving abatement in this sector. As the carbon price grew in line with the expectations set out in Chapter 2: *Meeting a 2050 target*, possibly reaching several hundred US\$/tCO₂ by mid century, this would almost certainly result not only in the intensification of supply side abatement but also in demand constraint.

Even with such constraints, however, aviation is likely to grow as a percent of all emissions. This is not in itself undesirable: in a carbon-constrained world fossil fuels should be used in those applications where alternatives are least available. But it does reinforce the importance of ensuring that aviation emissions are included within overall caps which decline in line with climate science requirements.

Figure 8.8 EU 2020 emissions caps, with or without international agreement on emissions reduction



Source: CCC calculations. (2008)

4. INTERNATIONAL AVIATION AND THE UK NATIONAL BUDGET

Including international aviation in budgets is not essential to achieve required objectives

- As Europe’s share of international aviation emissions is included within the EU ETS, with a total cap (aviation plus other sectors) which is consistent with climate objectives, there is no necessity to include international aviation emissions within the UK national budget. Aviation will be subject to a carbon price which encourages supply side abatement and demand constraint: and growth in Europe’s aviation emissions will have to be offset by more rapid reductions in other sectors within Europe.
- And the UK carbon budget can be designed to take account of a reasonable estimate of the UK’s international aviation emissions and their likely growth even if international aviation emissions are formally excluded from the budget. In the calculations of an appropriate UK budget presented in Chapter 3: *The first three budgets* we started with the EU’s 20% and 30% GHG targets. The UK’s share of these targets account for international aviation because the EU targets include international aviation. Our carbon budget proposals in Chapter 3, which are based on the UK’s share of the EU’s targets, are more ambitious than they would otherwise be if aviation were not included in the EU framework.

But inclusion is appropriate unless practical difficulties are severe

Clearly, however, even if it is **not essential** to explicitly include international aviation in the UK budget, it might be desirable for completeness, and to signal the importance of aviation within the overall climate mitigation strategy. But there are practical complexities which argue against inclusion: these relate to the basis on which emissions would be allocated to the UK national budget, and whether these should be the same for the budget as they are within the EU ETS.

- The practical complexities relate entirely to the basis on which to allocate emissions to the UK level (e.g. should flights from UK to Spain be allocated half-and-half to the UK and Spain, or mainly to the UK since the predominant tourist flow is of UK citizens? And do passengers hubbing via Heathrow belong to the UK or to the ultimate destination country?). This difficulty of allocating international aviation emissions was noted early on by the UNFCCC. Following a preliminary assessment, a UNFCCC body (SBSTA) recommended that four allocation methodologies should be considered further (Table 8.3); these would each allocate around 8% of international aviation emissions to the UK. While, therefore, it is possible to debate the precise appropriate methodologies, the implication for figures that might be included within the budget would not be great.
- Within the EU ETS, however, a different methodology for ‘allocating’ to Member States (MS) is proposed. At the EU level emissions are calculated on a departures/arrivals basis and this is similar to one of the recommended methodologies above. The problem occurs, however, when disaggregating administration of operators to the MS level. The disaggregation to the MS level will be required until and unless it becomes acceptable for auction revenues to accrue to the European Union rather than to national governments. This is because there has to be a national government which conducts the auction and receives the auction revenue, and therefore a specification of which government each airline has to buy permits from in respect of which flights. Under current proposals, EU airlines are to be administered by the MS in which they are headquartered, with non-EU airlines to be administered by the MS which accounts for the largest proportion of their emissions. The details are yet to be finalised, but the UK could be responsible for between 50-70 MtCO₂ emissions.

- At the UK level, there are two allocations which are the most plausible: 1) administration under the EU ETS and 2) bunker fuel estimates. There would, however, be disadvantages to either approach:
 - The chosen EU level allocation is not demonstrably fair as a reflection of national responsibility (e.g. an American airline's flight from New York to Rome could be counted against the UK register just because an American airline has most of its EU operations in the UK). As a result, monitored achievement against budgets could be affected by changes in airline practice (for subsequent phases of the EU ETS scheme, administration could change e.g. non-EU airlines shift the bulk of their EU operations from London to Paris) in the absence of any underlying change in emissions. The indicator is potentially volatile making medium-term changes to the indicator difficult to interpret for policy and other purposes.
 - But an alternative, set as bunker fuels, although fairer, would result in a confusing disconnect between the UK's share of European emissions for national budget and for EU ETS purposes. Specifically, it would not be possible to reconcile a methodology based on, say, UK bunker fuel sales with data relating to surrender of EU ETS allowances to UK authorities, given that the latter would include a significant number of allowances relating to non-UK travel (i.e. from America to other countries in Europe) together with allowances relating to some arriving flights. This would undermine the principal benefit of including international aviation within UK budgets – namely greater transparency of international aviation emissions.

Recommendation on the balance of arguments

The arguments above may be summarised as follows:

- International aviation should be included in any national or international strategy to tackle climate change.
- It is included in the EU's 20% and 30% GHG targets, and therefore indirectly included in our budget proposals, which are based on these targets. It will also be capped through inclusion of aviation (both domestic and international) in the EU ETS.
- Ideally, for reasons of transparency international aviation would be explicitly included in the UK's carbon budgets. But in practice, there are complexities related to methodologies for allocating emissions to the UK which preclude inclusion.

Our recommendation is, therefore, that international aviation is accounted for, but not explicitly included in carbon budgets. But it is essential that trends in the UK's international aviation emissions are included in the UK's climate change strategy. We therefore recommend that the Committee reports annually on UK trends in international aviation emissions (using a range of appropriate methodologies), their climate impact, developments in, and the success of, abatement efforts and appropriate policy levers.

SECTION B: INTERNATIONAL SHIPPING

1. INTERNATIONAL SHIPPING: TRENDS AND PROJECTIONS

Estimates of total global shipping emissions are uncertain but a recent International Maritime Organisation (IMO) study⁵ suggests they are around 1 GtCO₂ and exceed those for aviation. Forecast of shipping emissions suggest strong growth, and in 2050 they could account for between 15% and 30% of all CO₂ emissions permitted under our preferred global emission reduction scenarios set out in Chapter 1. Bringing international shipping emissions within the coverage of emissions reduction strategies is therefore essential.

- The latest estimates of global shipping emissions of CO₂ are roughly 1 GtCO₂, with around 80% of emissions coming from international shipping (Table 8.7). Therefore, shipping emissions are equivalent to about 3.3% of total global emissions of CO₂ (excluding those relating to land-use). However, the overall effect of shipping on the climate may differ from the impression given by these figures (Box 8.2).

CO₂ emissions from shipping are on a strongly rising trend due to gross tonnage of the world shipping growing rapidly, and freight tonne-miles also increasing as world trade volume growth significantly outstrips GDP growth (Figure 8.9).

- Looking forward, the latest range of projections of future emissions growth produced by industry experts suggest that emissions in 2050 could be in the 2.4 to 3.6 GtCO₂ range, even after taking into account a significant (one third to a half) efficiency improvement per tonne-km by 2050 (Figure 8.10). They would account for 15-30% of all CO₂ emissions permitted under our preferred global emissions reduction scenarios set out in Chapter 1.
- Allocating global shipping emissions to the national level is difficult and the allocation methodologies listed earlier in the chapter produce a far greater range of emission estimates than for aviation. On a bunker fuel sale basis, the UK was responsible for roughly 9 MtCO₂ in 2000 – of which two thirds is international (Figure 8.11). But on a freight tonne loaded basis, UK emissions could already be 17 MtCO₂, with a possible rise to 28 MtCO₂ by 2020, while the bunker fuel sales estimate could increase to 16 MtCO₂ over a comparable period (Table 8.8). Unlike with aviation, these uncertainties about fair allocation exist even at the European level, where 'sensible' estimates of the EU share of global shipping emissions in 2000 can vary from 120 MtCO₂ to 159 MtCO₂.

Despite the uncertainties, however, it is clear that, if unconstrained, shipping CO₂ emissions are likely to grow to reach significant proportions of UK and European CO₂ emissions implied by our preferred global emissions reduction scenarios set out in Chapter 1. It is therefore essential that they are covered by emission reduction strategies.

⁵ IMO MEPC. (2008) *Updated Study on Greenhouse Gas Emissions from Ships, Phase 1 report*, 58/4/INF.6

Table 8.7 Estimates of global shipping CO₂ emissions

Region	MtCO ₂ (2007)
Global Domestic	176
Global International	843
Global Total	1,019

Source: IMO MEPC. (2008) *Updated Study on Greenhouse Gas Emissions From Ships, Phase 1 report*, 58/4/INF.6

Box 8.2 The current radiative effects of shipping

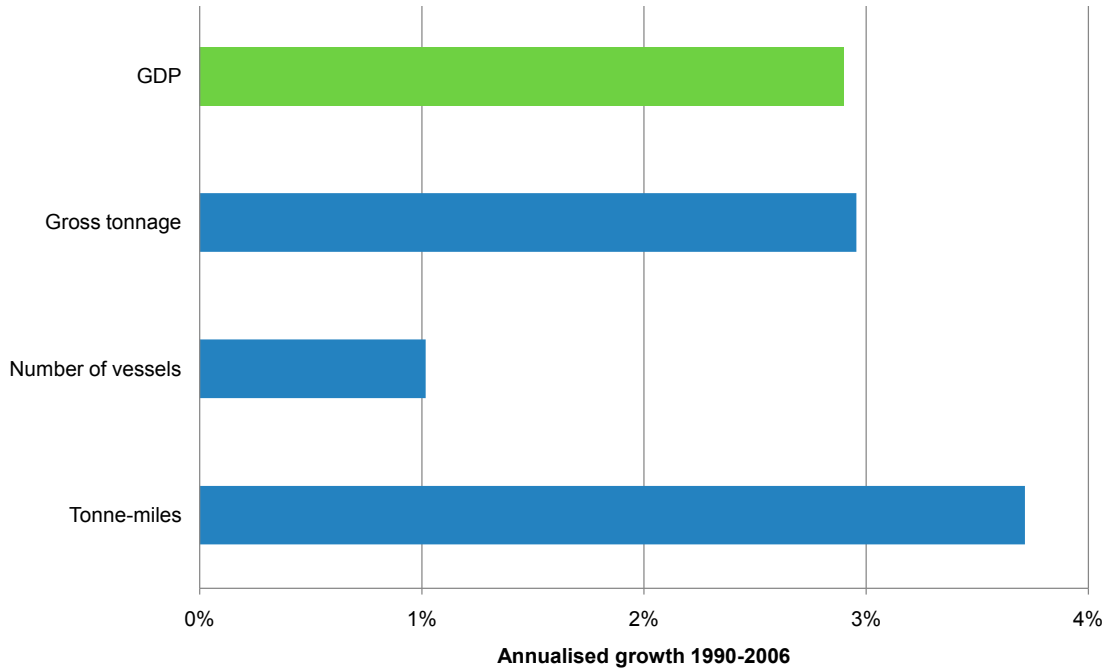
Like aviation, the total contribution of shipping to current radiative forcing of the climate system is made up in large part by emissions of aerosols and non-Kyoto GHGs.

Emissions of CO₂, NO_x, sulphate aerosol and soot are common to both aviation and shipping (see Box 8.1). For shipping however, there is a strong additional indirect effect of aerosol emissions. These small particles can seed the formation of low-level clouds, or alter cloud optical properties to make them reflect more of the sun's radiation, resulting in a significant negative radiative forcing (i.e. cooling). There is still, however, a very low level of scientific understanding about this indirect effect, because the way in which different kinds of aerosols help form cloud droplets is not well known, and the radiative properties of clouds are complex.

It is important to note that an overall negative radiative forcing does not mean the climate effects of shipping are benign. Radiative forcing shows the effect of emissions to date, but does not show that the warming effect of CO₂ will remain for many years longer than the aerosol cooling. The short-lived nature of sulphates also means that emissions do not become well mixed across the globe leading to large variations in regional radiative forcing. Furthermore, policies have been introduced to reduce sulphate emissions because of their impacts on human health and sensitive ecosystems, and this will lead to a steady increase in the overall warming from shipping.

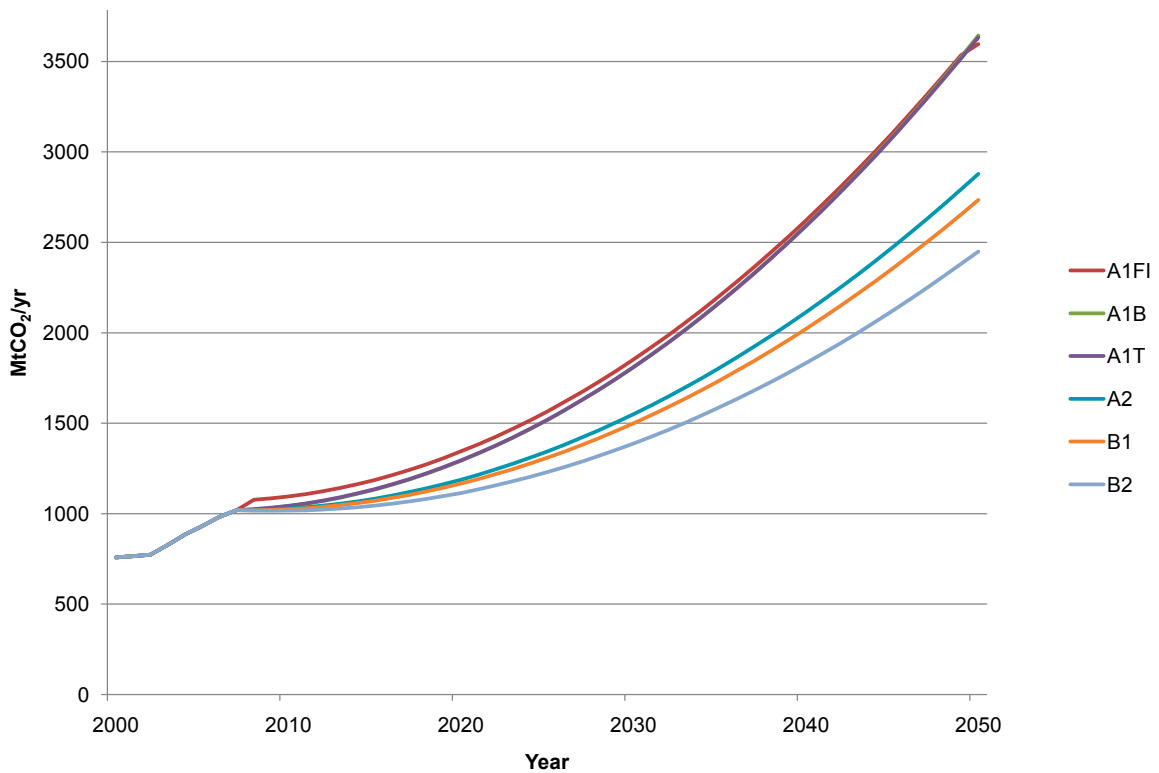
The issues discussed for aviation (see Box 8.1), about how to effectively compare these non-Kyoto radiative effects to the effect of CO₂, are relevant to shipping as well.

Figure 8.9 Annualised growth during 1990-2006 for global merchant shipping fleet, measured using a range of metrics and compared to global GDP growth



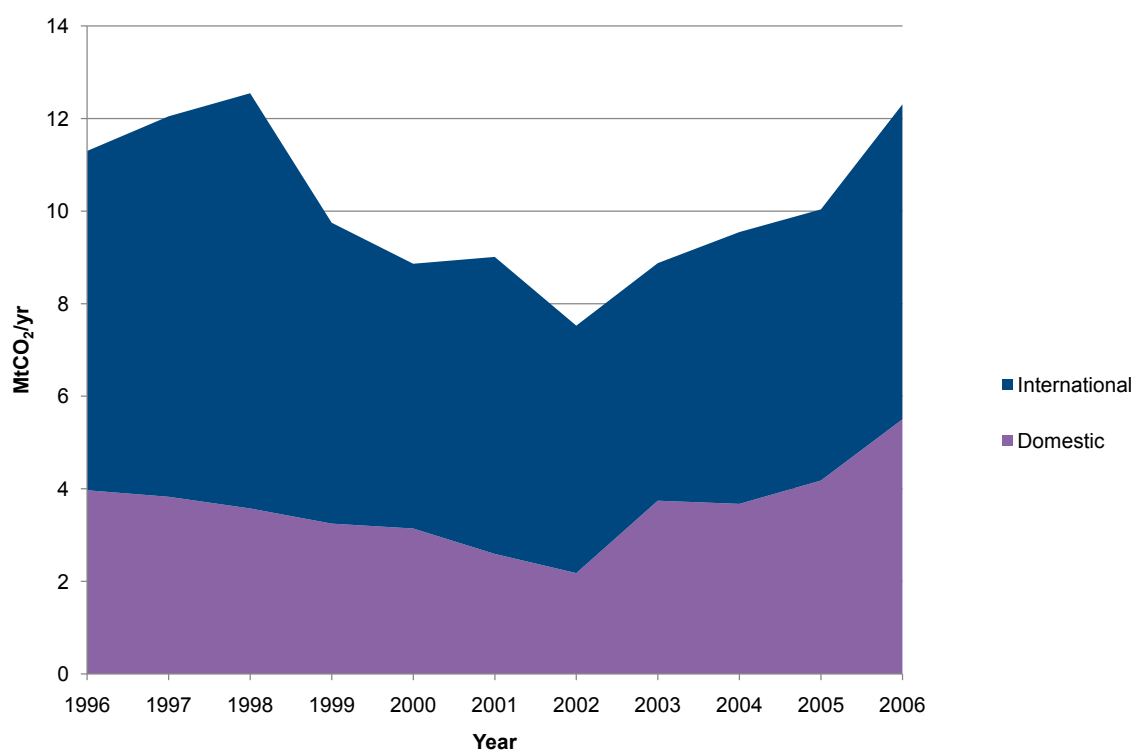
Source: ISL. (2007) *Shipping Statistics Yearbook*/UN Statistics Division. (2008)

Figure 8.10 Projections of global CO₂ emissions (domestic and international) from ships



Source: MARINTEK. (2008) based on data from the *Updated Study on Greenhouse Gas Emissions From Ships, Phase 1 report*, IMO MEPC 58/4/INF.6.

Note: These projections (A1FI etc) are based on the six marker scenarios set out in the IPCC’s Special Report on Emissions Scenarios (SRES) in 2000.

Figure 8.11 UK CO₂ emissions from shipping during 1996-2006

Source: Defra statistics. (2008)

Table 8.8 European and UK allocation of total shipping CO₂ emissions (domestic + international)

Assignment methodology		Coverage	Method	EU27+2, MtCO ₂		UK, MtCO ₂	
				2000	2020	2000	2020
A1	Location of emissions: 12 mile zone	Europe	Vessel activity 500+GT	38.3	63.9	6.0	10.0
A2	Location of emissions: 200 mile zone	Europe	Vessel activity 500+GT	120.6	201.4	13.4	22.2
B	Flag of ship	Global	Vessel activity 500+GT	196.6	328.4	11.8	19.6
C	Bunker fuel sales	Global	Top-down	159.2	266.1	9.7	16.2
D	Reported bunker fuel consumption	Global	Top-down	158.9	265.5	9.5	15.9
E	In proportion to freight tonnes loaded	Europe	Top-down	120.6	201.4	16.6	27.7
F	In proportion to land based national emissions	Europe	Top-down	120.6	201.4	16.1	27.0
G	Country of departure/destination	Global	Vessel activity 500+GT	152.4	254.0	23.8	39.6

Source: Entec. (2005) *Service Contract on Ship Emissions: Assignment, Abatement and Market-based instruments*

2. INTERNATIONAL SHIPPING: SUPPLY SIDE ABATEMENT OPPORTUNITIES

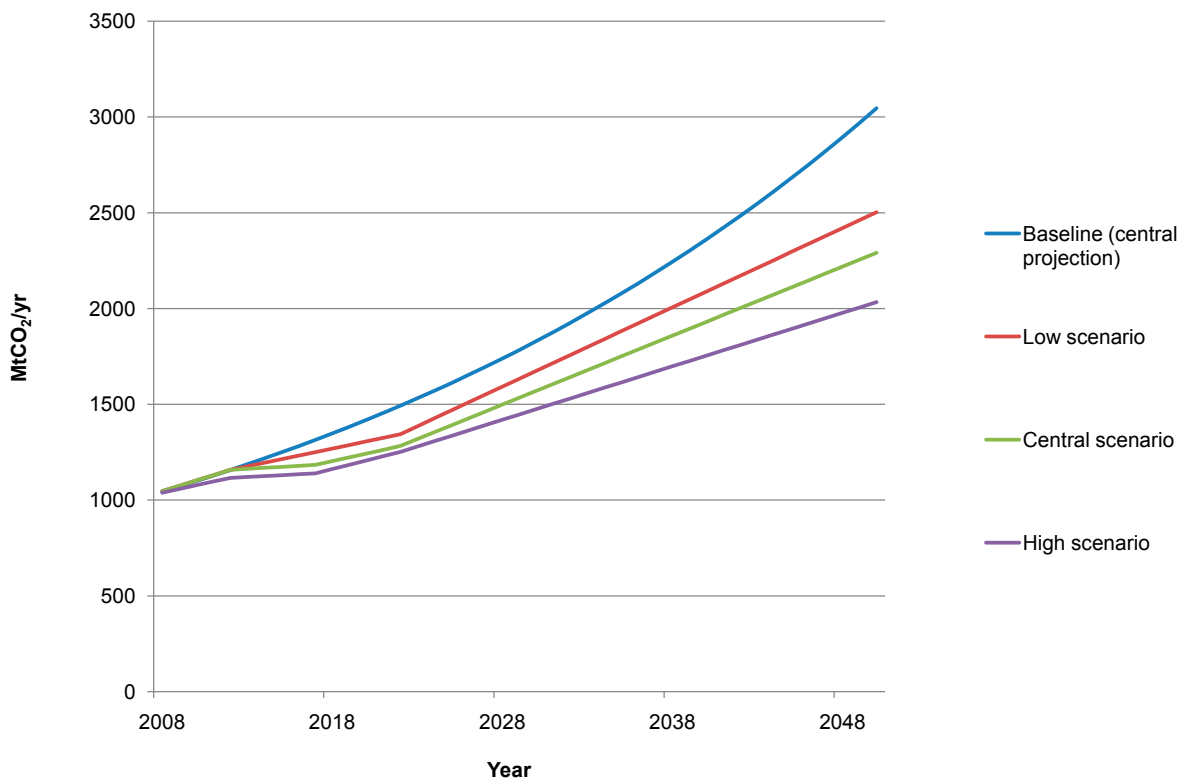
The Committee commissioned a consortium led by AEA⁶ to conduct a review of present and future possible technological options to reduce emissions. Their analysis shows that there is a wide range of abatement options that could be applied to ships to reduce energy consumption and hence reduce CO₂. Implementation barriers vary by region and by ship category. In OECD countries the main barriers include the complex arrangements under which ships are owned/registered/operated, lack of information about abatement measures and their exact effects. Shortages of ship yard capacity and the long life of ships also limit uptake. Some of these barriers could be overcome through the introduction of a global carbon market. The analysis suggests that substantial emissions reduction, compared to a baseline projection, is possible for a range of carbon prices. However, even with a carbon price of 200 Euro/tCO₂ emitted global shipping emissions in 2050 could be twice current levels.

- **Technological possibility:** The AEA consortium's report on technical possibilities sets out three types of change:
 - Design improvements which include: optimisation of hull and propeller designs to reduce resistance and increase propulsive efficiency; optimisation of the superstructure for reduced air and wind resistance and recovering energy from the propeller.
 - Operational improvements which include: a shift to larger ships, or operating ships at slower speeds, optimal hull maintenance and upgrades to propellers and engines and improved on-board operations such as better energy management and voyage optimisation.
 - Alternative fuels and renewable energy: the most promising alternative fuels are liquefied natural gas and wind power although other sources of energy, such as solar energy and biofuels, have some potential to be used on ships. In terms of hydrogen, both AEA and the IEA note challenges with storing, handling and distributing hydrogen. In the IEA's BLUE Map scenario out to 2050, international shipping is assumed to adopt alternative fuels produced from non-food biomass feedstocks rather than hydrogen.
- **Cost-effective abatement:** Estimates suggest that there is potential to reduce CO₂ emissions from existing ships by around 10% through operational measures and by retrofitting various technical measures, while a state-of-the-art ship built in 2008 could emit 27–32% fewer emissions compared to a baseline 2008 typical in-service ship. In the future a 2022 state-of-the-art ship might emit 32–35% fewer emissions than a 2008 typical in-service ship. The small differences between 2022 and 2008 state-of-the-art ships arises because most of the technologies are available now and only incremental improvements to these are expected over the next 15 years. However, by 2050 new ships might be emitting half as much CO₂ as current ships.
- **Limits to realistic potential:** The pace at which average fleet fuel efficiency improves depends on a range of factors. These include production bottlenecks—ship yards are currently operating at full capacity and they are reluctant to introduce design improvements on existing orders. This will lead to a delay in the diffusion of new technologies throughout the fleet. Furthermore ships are long-lived assets – with working lives of around 25 years – so the stock of ships changes very slowly. The implementation of some abatement options may also depend on the willingness of port authorities to change existing port infrastructure. A large number of ships are operated by an agent different from the owner and this may lead to difficulties if the owner invests in abatement technologies but is unable to recoup the costs of these from the ship user.

⁶ The consortium was made up of AEA, Entec, MARINTEK, CE Delft, Manchester Metropolitan University and Deutsches Zentrum für Luft und Raumfahrt.

- Impact on global shipping emissions under different carbon price scenarios:** Some or all of these barriers might be overcome if there were a global carbon price. The Committee asked AEA to apply expert judgement to assess what level of abatement could hypothetically be achieved under three scenarios of a low, central and high-carbon price: 50, 100, and 200 Euro/tCO₂ emitted. They estimate that, by 2050, CO₂ emissions from domestic and international shipping could be 500 MtCO₂ below baseline with a carbon price of 50 Euro. In the high-carbon price scenario abatement rises to approximately 1,000 MtCO₂. It should be noted however that even in this scenario emissions in 2050 are twice current levels (Figure 8.12).

Figure 8.12 Global CO₂ emissions (domestic and international) under different carbon price scenarios



Source: AEA. (2008) *Greenhouse gas emissions from shipping: trends projections and abatement potential*

3. INTERNATIONAL SHIPPING: APPROPRIATE POLICY LEVERS

Given the strong projected growth of shipping emissions it is essential that shipping is covered by a policy framework which (i) faces shipping with an appropriate cost of carbon to provide an incentive both for supply side abatement and for demand constraint and (ii) ensures that the total level of emissions (shipping plus all other sectors) reduces in line with appropriate climate objectives. But unlike aviation, there could be significant difficulties in applying a carbon price based framework on an EU-only basis. The key policy priority should therefore be to achieve a global sectoral agreement that would contain shipping emissions, with an EU-only approach as a second best solution.

- International shipping traffic and bunkering patterns are different from those of international aviation. Flights arriving in Europe from the US do not stop off en-route: ships arriving in Europe from say the Far East may have called at numerous ports en-route, unloading some cargo and taking on new cargo. And while aircraft arriving in or departing from Europe on an intercontinental flight will almost always have to take on more fuel in Europe, ships can pick up bunker fuel outside Europe (e.g. in north Africa) sufficient to cover their journey into and out of Europe. In addition the structure of the shipping industry is more complex and fragmented than the aviation business, with a multiplicity of complex and changing relationships between ship owners, ship charterers, and ship managers.
- As a result, while the inclusion of international aviation in the EU ETS creates neither major administrative complexities nor the danger of significant 'carbon leakage', the inclusion of international shipping could create both. If carbon permits were allocated or auctioned on the basis of some measure of traffic volumes (e.g. freight tonne-km arrivals or departures) major administrative complexity would arise in estimating what proportion of a complex multi-stage journey into or out of Europe belonged to the European system. If, conversely, shipping were brought into the EU ETS on an 'upstream' basis, using the administratively straightforward measurement of bunker fuel sales, there would be dangers of possible total carbon leakage, with shipping companies bunkering to full capacity before the final leg of the journey into Europe.
- Given the importance of including international shipping in some way within the policy framework, these difficulties should not be seen as automatically ruling out any EU unilateral action if a global approach proves impossible. But they illustrate that shipping is one sector where a global sectoral deal would have huge advantages over a European unilateral approach. The IMO has been charged by the UN with developing a proposed global policy framework, and it looks likely that the European Commission will await the IMO's proposals due next year before taking substantive action at the regional level.
- The Committee believes that this is a sensible way to proceed given the inherent difficulties of designing a European unilateral approach. The ideal solution would be to achieve a global sectoral deal which included all of world shipping within a carbon emission cap regime. This is unlikely to be achieved rapidly but it may be possible to make some progress towards this ideal ahead of the wider agreement of comprehensive binding global caps on all economic activities. In the meantime, IMO proposals for benchmarking of technical potential (the Energy Efficiency Design Index) may eventually begin to drive abatement action, although these proposals have not been finalised.

- If an adequate global deal is not possible, the EU will need to consider the best approach for including shipping in the regional framework. It is possible that the most effective measure may be to include shipping in the EU ETS. However, a recent study⁷ suggested two alternative policy options to reduce shipping emissions. The first was differentiation of harbour dues and the second was a requirement of ships calling at EU ports to meet a unitary CO₂ index limit value. Either of these approaches may provide a suitable alternative to inclusion of shipping in the EU ETS.

7 CE Delft. (2006) *Greenhouse Gas Emissions for Shipping and Implementation Guidance for the Marine Fuel Sulphur Directive*

4. INTERNATIONAL SHIPPING AND THE UK NATIONAL BUDGET

The potential problems identified above regarding inclusion of international shipping in EU ETS are magnified when considering potential inclusion in the UK framework. There would be significant administrative complexities, for example, from including international shipping in UK carbon budgets on the basis of traffic volumes. Inclusion on the basis of bunker fuels would be administratively simple, but it is not clear that this reflects the UK’s international shipping activity. For example, UK international port traffic has risen 75% over the period 1980-2006, while international shipping emissions from bunkers have only grown 5% over the same period. This is mainly due to ships bunkering where fuel is cheapest and most convenient on their multi-stage journeys. For this reason, we recommend that international shipping emissions are not included in the UK’s carbon budgets at the current time.

It is, however, essential that international shipping emissions are allowed for in the setting of the UK’s carbon budgets. To the extent that these are not falling, for example, effort in other sectors should be higher to maintain an overall GHG emissions reduction target derived from a climate objective. But, whereas international aviation emissions are included in the EU’s 20% and 30% GHG targets, international shipping emissions are not included. The implication is that international shipping emissions are not accounted for in our carbon budget proposals, which are derived from the EU’s targets. This raises the question of whether the UK’s carbon budgets should be adjusted unilaterally, or whether there should be a multilateral adjustment following inclusion of international shipping in the EU’s GHG targets.

There are three key arguments against a unilateral adjustment of UK carbon budgets:

- It is not clear what methodology for estimating the UK’s international shipping emissions should be used as the basis for such an adjustment.
- If the UK were to make a unilateral adjustment resulting in a tightening of carbon budgets, this could be offset by a relaxation of targets for other EU Member States that may ensue in negotiations over burden sharing of the 20% and 30% GHG targets. In this event, there would be a financial implication for the UK with no environmental benefit.
- More generally, if there were to be a positive environmental impact (i.e. if other Member States were not to relax targets in response to UK unilateral action), this would be small based on UK action alone. In order to leverage inclusion at the UK level, international shipping should be included at the EU level.

We therefore recommend that the UK should argue that the EU’s 20% and 30% GHG targets should allow for a reasonable estimate of the trends in international shipping emissions. As a result of this, emissions reduction targets for other sectors and all Member States including the UK would become tighter, and UK carbon budgets would have to be adjusted to reflect this. International shipping emissions would then be treated in the same way as international aviation: not formally included in the budgets, but allowed for in setting budget targets. And as for international shipping, our recommendation is that the Committee should report annually on trends in the UK’s international shipping emissions (using a variety of different measures), their climate impact, development in, and the success of, abatement efforts and appropriate policy levers.