Investor Insights

Fasten your seat belt

Airlines and cap-and-trade

Key findings

- Civil aviation is one of the fastest growing sources of greenhouse gas emissions, showing long-term compound annual growth rates of emissions of 3-4%. A key policy objective will be to ensure airline emissions return to 2005 levels by 2050.
- Airlines join the European Union Emissions Trading System (EU ETS) on 1 January 2012 and are likely to be net buyers of carbon allowances in the EU ETS – potentially increasing the net 'short' of allowances in the EU ETS by 50-100% and purchasing €23-35bn of allowances over 2012-2020, assuming a carbon price of €25/tCO_2.
- A cost of carbon for airlines in the EU ETS will act as a 'turbo boost' on the already volatile jet fuel price, raising the cost by ~15% at €25/tCO_2. This impact could increase up to 2-4 fold if non-CO_2 impacts are included.
- The ultimate impact of a cap-and-trade scheme on an individual airline's performance is critically determined by four criteria:
  - the prevailing cost of carbon
  - the number of carbon allowances allocated for free to airlines
  - the rate of 'price pass-through' of the cost of carbon by airlines to their customers
  - any resulting change in demand by customers due to the increased ticket price and the airlines' ability to manage its cost structure in response.
- Although airlines initially are allocated ~80% of their allowances for free, the overall impact of the EU ETS on European airlines' total profit pool is uncertain. More price-elastic and competitive routes such as short haul leisure may be the most exposed whilst less price-elastic and competitive routes such as long haul business are less exposed and could even gain in profitability in the short term.
- The EU ETS has the potential to reward more fuel-efficient players with the ability to increase their relative profitability by 20-40% compared to average players if the cost of carbon is between €25-50/tCO_2.
- Given airlines' profit sensitivity to the impact of cap and trade, industry analysts and investors will need to make clear their assumptions concerning the impact of these cap-and-trade drivers on profitability and growth.
- Unless the airline industry can achieve a significant breakthrough in energy efficiency or low carbon biofuels, additional policies to reduce emissions may follow, including further taxation to boost R&D spend and measures to limit new runway capacity.

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Preface

Background to the Carbon Trust and its Investor Engagement Programme

The Carbon Trust is an independent company set up in 2001 with the support of the UK Government. Its mission is to accelerate the transition to a low carbon economy. The Carbon Trust carries out a wide range of activities, including working directly with business to reduce carbon emissions, explaining the strategic implications of climate change and investing in new technologies and businesses that will help to tackle climate change.

The Carbon Trust has engaged with investors since commencing its thought leadership work. Investors play a crucial role in holding companies to account on their strategies and providing the investment capital for the new technology and infrastructure that will reduce carbon emissions. We regard investors as one of the four pillars of the transition to a low carbon economy, together with business, government and consumers.

In 2008, we published a report titled *Climate change – a business revolution?* which set out the value creation opportunity and value-at-risk for typical players in six mainstream investment sectors: Oil & Gas, Automotive, Aluminium, Consumer electronics, Building insulation and Beer. This demonstrated that climate change is a significant investment theme which has the potential to materially influence valuations for companies across these sectors.

Aims of this report

This report aims to give mainstream institutional investors and their advisors a briefing on the potential consequences of climate change regulation on the financial performance of the airline industry. It focuses in particular on the sensitivity of airline industry profits on entry to a cap-and-trade scheme, and uses example scenarios that could apply when aircraft operators (including large airlines) enter the EU ETS.

Through this briefing, we hope to stimulate institutional investors and their advisors to carry out their own analysis of the implications of climate change regulation on airlines – in particular the EU ETS – but also other emerging schemes in other regions. We also hope to stimulate investors to engage with airlines to hold their management to account on the development of far-sighted strategies to reduce their overall emissions and to engage with policy makers to ensure an efficient policy framework which both succeeds in combating climate change and preserves and creates shareholder value.

1 Airlines in cap-and-trade – the EU ETS

- Global airline emissions have grown rapidly over the last 10 years, rising at between 3-4% per annum, driven by strong growth in overall demand of approximately 5% per annum and efficiency gains of 1-2% per annum.
- Aircraft operators (including airlines) will join the EU ETS cap-and-trade scheme on 1 January 2012. This is the first significant scheme aimed at managing emissions reduction for the airline industry as a whole and it may prove a model for other regulators.
- Total airline allowances to be issued in the scheme over the period 2013-2020 will be limited to 95% of the estimated airline industry's average emissions in the years 2004-2006.
- Over the period 2012-20, 82% of the total allowances will be allocated to existing airlines for free, 15% will be sold to aircraft operators via auction and 3% will be placed into a special reserve for new entrants.

Global airline emissions have grown strongly

Over the last 10 years, aviation demand has increased at roughly 5% per annum, substantially above the global economic growth rate[1]. Even given annual energy efficiency savings of 1-2%[2], this has left aviation emissions rising at between 3% and 4% per annum[3].

So while aviation emissions have risen less rapidly than aviation demand, both figures have remained positive, although 2008 breaks the long-term trend with a reduction in aviation demand (and emissions) – with total global revenue passenger kilometres down approximately 10% and freight tonne kilometres down approximately 20% compared to a year earlier[4]. However, growth is expected to return to the sector over the longer term.

Over the long term, for aviation emissions to stabilise – let alone to fall – while aviation demand grows strongly, much more substantial annual falls in carbon intensity (CO_2 per passenger km) are required.

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[1] Committee on Climate Change (2008), Building a Low Carbon Economy – the UK's Contribution to Tackling Climate Change, p. 308.

[2] IATA Environment Review 2004 states annual efficiency improvements of 1.9%.

[3] World Resources Institute, Navigating the Numbers (2005) report 2.7% emissions growth (1990-2002) for global aviation over the period 1990-2002.

[4] IATA Financial Forecast September 2009 – www.iata.org/whatwedo/economics

Aviation and the environment

Burning one tonne of kerosene (jet fuel) emits 3.15 tonnes of CO_2[5]. This fact of chemistry, coupled with the strong rise in demand for flight, means that aviation emissions have risen rapidly.

Global emissions from aviation are expected to grow over three-fold in the period to 2050, making it amongst the fastest growing sectors for emissions, under a business-as-usual scenario[6].

In 2005, global aviation CO_2 emissions accounted for about 0.7 giga tonnes of CO_2, 1.6% of global greenhouse emissions[7]. The UK's Committee on Climate Change (CCC) sees global aviation emissions rising to 2.4 giga tonnes in 2050 under 'business as usual', even assuming annual fleet efficiency improvements of 1.5% per annum[8]. This could represent between 2.5% and 10.0% of global GHG emissions in 2050, depending on the amount of global emissions reduction achieved[9].

The situation may be more pressing for aviation because the environmental impact of aviation's non-CO_2 emissions, such as NOx, is significant, although the precise global warming impact is less certain than for CO_2 emissions. CE Delft, a consultancy commissioned by the European Commission, states that: "Apart from emitting CO_2, aircraft contribute to climate change through the emission of nitrogen oxides (NOx), which are particularly effective in forming the greenhouse gas ozone when emitted at cruise altitudes. Aircraft also trigger formation of condensation trails, or contrails, and are suspected of enhancing formation of cirrus clouds, both of which add to the overall global warming effect. In 1999 the Intergovernmental Panel on Climate Change (IPCC), examining the total climate impact of aviation, estimated these effects to be about 2 to 4 times greater than those of CO_2 alone, even without considering the potential impact of cirrus cloud enhancement[10]."

And while aviation emissions are a looming problem in a global context, in regions of the world that have committed to emissions reduction targets and that already have high aviation emissions, the problem is more immediate. Given the EU's commitment to reduce its greenhouse gas emissions by between 20% and 30% by 2020 versus 1990 levels, Europe is perhaps the region of the world where rising aviation emissions represent the most pressing policy challenge.

Airlines in the EU ETS

Aircraft operators were not included as a sector governed by the Kyoto Protocol, largely because the majority of airline pollution is emitted in international airspace, and assigning a national source of emissions was considered difficult. Airlines were also excluded from phase 1 of the EU ETS.

However, on 8 July 2008, the European Parliament formally adopted measures to integrate international and domestic aviation into the European Emission Trading System (EU ETS). Whilst many parts of the world impose taxes on aviation, the EU ETS will be the first significant scheme to manage emissions reduction for the aviation industry as a whole and may be a model for other regulators.

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[5] Defra GHG Conversion Factors (Sept 2009) www.defra.gov.uk/environment/business/reporting/conversion-factors.htm

[6] Stern (2007), The Economics of Climate Change, p.172.

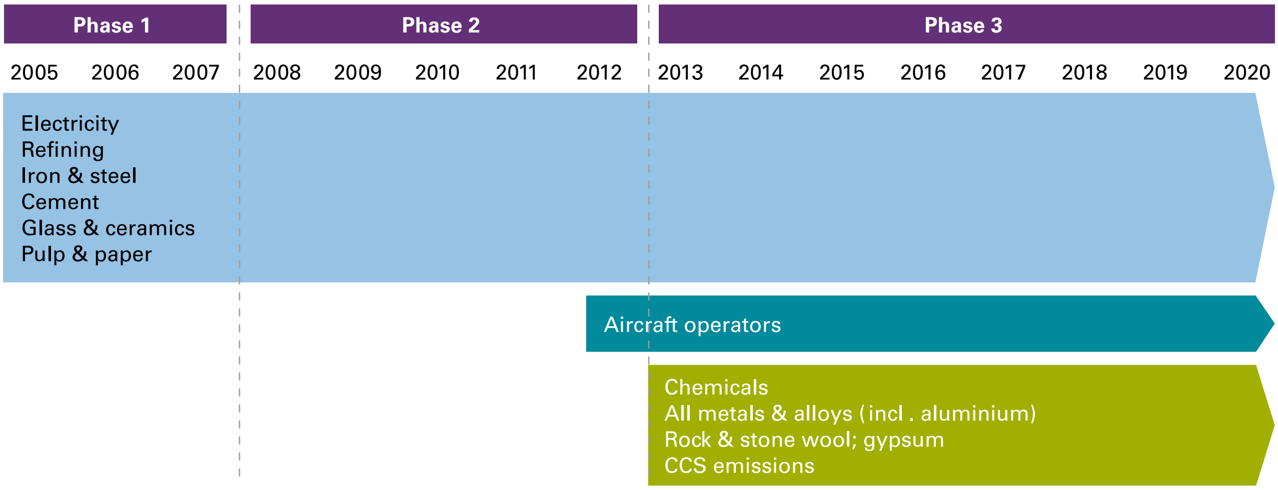
[7] World Resources Institute (2005), Navigating the Numbers, World Resources Institute, Washington DC.

[8] Committee on Climate Change (2008), Building a Low Carbon Economy – the UK's Contribution to Tackling Climate Change, p.308.

[9] World Business Council for Sustainable Development (2004), Mobility 2030; Meeting the Challenges to Sustainability, Geneva, WBCSD.

[10] CE Delft (2005), Giving Wings to Emission Trading: Inclusion of Aviation under the European Emission Trading System (ETS): Design and Impacts, July, Report for the European Commission, DG Environment, No. ENV.C.2/ETU/2004/0074, p.1.

Chart 1 *Industrial sectors and date of their inclusion in the EU ETS*



Source: EU Commission

Phase 1 of the EU ETS began on 1 January 2005 and ran for three years until 31 December 2007. Phase 2 of the EU ETS runs from 1 January 2008 to 31 December 2012. Phase 3 begins on 1 January 2013 and runs to 31 December 2020.

As *Chart 1* indicates, European electricity generators were included in the EU ETS from the beginning of Phase 1, as were several industrial sectors: refining, iron & steel, cement, glass & ceramics, and pulp & paper. Aircraft operators join the EU ETS in 2012. Chemicals, all metals & alloys (including aluminium), rock & stone wool, gypsum and CCS emissions join in 2013.

But what does it mean for an industry to be included in the EU ETS? Essentially, all industry participants must make sure that they have sufficient allowances to cover their emissions. Firms are either granted allowances for free, or buy them at auction or in the open market. Firms must surrender sufficient allowances to cover their emissions each year, or be fined (as well as still surrendering sufficient allowances).

All flights departing from or arriving at EU airports will be caught by the Directive, regardless of the airline's place of incorporation. This includes airlines flying into Europe from other regions. And note that all of the emissions for the whole distance of a New York to London flight would be included within the EU ETS regime: as soon as an airline turned on its engines in JFK airport in New York, these emissions would be included within the EU ETS regime.

A plane that flew from Hong Kong to Dubai and on to London would only have the emissions from the Dubai to London leg included in the EU ETS. A plane flying direct from Hong Kong to London would have all of its emissions included in the EU ETS.

Note, however, that the EU Directive[11] introducing aircraft operators into the EU ETS includes a provision which would allow emissions that took place outside Europe, in another country, to be excluded from the EU ETS, if that country introduces equivalent legislation to reduce emissions (whether by a carbon cap-and-trade scheme or another measure) subject to a subsequent recommendation by the European Commission. This anticipates the potential for double counting of airline emissions.

An operator that fails to surrender the requisite number of allowances will be subject to a €100 fine for each tonne of CO_2 emitted for which it does not have an allowance. The operator must still surrender an allowance to make good its shortfall, in addition to paying the fine.

The basic functioning of a cap-and-trade system ensures that companies faced with a shortage of allowances will either reduce their emissions or buy allowances. Economic theory suggests this should trigger the most economically efficient carbon reduction across the players included in the scheme.

Even though airlines are joining the EU ETS in 2012, many argue that the industry should be included in a global scheme which potentially could be outlined at the United Nations Conference of the Parties meeting taking place in Copenhagen in December 2009 (COP-15), or subsequently. To cover aircraft operators globally the most likely approaches are either a global airline cap-and-trade scheme or a series of regional cap-and-trade schemes, potentially linked together. Chapter 6 of this report discusses some of the features of a potential global deal for aviation.

Allocation of allowances

The European Commission has capped the number of allowances available to aircraft operators in 2012 at 97% of the airline industry's average emissions in the years 2004-2006. For 2013-2020, the cap will be 95% of the average emissions in 2004-2006[12].

For the years 2012-2020, 82% of the total allowances will be allocated initially to airlines for free, 15% will be sold to aircraft operators via auction and 3% will be placed into a special reserve for free allocation to qualifying airlines.

Allowances in the special reserve will be available to new airlines, and to existing airlines that grow at over 18% per year. But if new entrant reserve allowances are not taken up, they will be auctioned.

The European Commission is currently gathering information which will help it to allocate allowances to individual airlines.

First, the European Commission is gathering data on the average annual aggregate emissions of aircraft operators for the period 2004-2006. The Commission is gathering this data from Eurocontrol, the European body responsible for air traffic navigation as well as seeking the input of airlines. Once the Commission has identified this figure, the Commission will cap European aircraft operator emissions at 97% of this figure for 2012, and at 95% for 2013 to 2020.

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[11] Directive 2008/101/EC of the European Parliament and of the Council of 19 November 2008 amending Directive 2003/87/EC, so as to include aircraft operators in the scheme for greenhouse gas emission allowance trading within the Community http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:008:0003:0021:EN:PDF

[12] See: http://ec.europe.eu/environment/climat/aviation_eu.htm

***Chart 2** Estimated aircraft operator allowance cap for 2012-2020*

	EUAA annual allowances (million tonnes of CO_2)			
Year(s)	**Allocated freely**	**New entrant reserve**	**Auctioned to airlines**	**Total allowance cap**
2012	175.0	6.4	32.0	213.4
2013-2020	171.4	6.3	31.4	209.0

Source: EU Commission, Carbon Trust calculations

Second, the Commission will then allocate a proportion of the permitted carbon emissions available under the cap among aircraft operators (i.e. airlines). To divide up the allowances, the Commission has asked airlines to submit their total 'tonne kilometres' achieved on EU ETS covered routes for 2010. The total tonne kilometres of a flight is the product of an individual flight's payload and the total distance travelled (in kilometres), subject to precise parameters to determine weight and distance travelled[13].

Airlines will be allocated allowances in proportion to their 2010 tonne kilometres, as a percentage of overall European 2010 tonne kilometres. This basis is used rather than the total amount of kerosene used or carbon emitted, in order to avoid rewarding less efficient airlines with relatively more allowances.

The EU has not yet stated its view of the average EU aircraft operator emissions for the period 2004-2006. However, the Tyndall Centre for Climate Research[14] states that EU aircraft operator CO_2 emissions in 2005 were 225 million tonnes, while Ernst and Young[15] estimates that average annual emissions for 2004-2006 were 218.3 million. Based on these studies, a central figure of 220 million tonnes is assumed. Based on this assumption, the allocation of allowances for 2012-2020 are set out in *Chart 2.*

Airline allowance purchasing

If, as is expected, the aircraft operator cap – the number of allowances either given or auctioned to airlines – is insufficient to cover aircraft operator emissions, airlines will need to move into the 'wider' carbon market, and buy one of a number of permitted classes of allowance: EUAs, CERs or ERUs.

European Union Allowances (EUAs) are carbon allowances that can be surrendered by all participants in the EU ETS, while European Union Aviation Allowances (EUAAs) can only be surrendered by aircraft operators. Certified Emission Reductions units (CERs)[16] are units created under the Kyoto Protocol in developing economy countries (non-Annex 1 countries to the Kyoto Protocol) through emission reductions registered under the Clean Development Mechanism (CDM). Emission Reduction Units (ERUs)[17] are units created under the Kyoto Protocol in developed/transition economy countries (Annex 1 countries to the Kyoto Protocol) through emission reductions under the Joint Implementation programme (these are most often in Russia, Ukraine and other Eastern European countries).

However, under the current design of the EU ETS, airlines' access to CERs and ERUs, which typically trade at a discount to EUAs, will be restricted. In 2012, airlines will be able to submit 15% of their allowances for compliance in the form of CERs and ERUs. From 2013 and beyond (i.e. in Phase 3), airlines will only be able to use CERs and ERUs to the extent that they have unused CER and ERU capacity left over from 2012. Once airlines' capacity for CERs and ERUs is used up, they will only be able to submit EUAAs and EUAs for compliance purposes.

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[13] See Directive 2008/101/EC of 19 November 2008.

[14] Anderson. K, A. Bows and A. Footitt (2007), Aviation in a Low-Carbon EU: A Research Report by the Tyndall Centre, University of Manchester, Tyndall Centre for Climate Change Research, a report for Friends of the Earth, September.

[15] Ernst and Young and York Aviation (2007), Analysis of the EC Proposal to Include Aviation Activities in the Emissions Trading Scheme, 1 June, p.23.

[16] CERs are 'certified' in that the emission reduction project from which they are derived has been certified by the Executive Board of the United Nations Framework Convention on Climate Change, based in Bonn, Germany.

[17] ERUs are emission reduction permits achieved within Annex 1 countries under the Kyoto Protocol, under Joint Implementation.

Non-CO_2 emission damage

Prior to introducing legislation on aircraft operators and the EU ETS, the Commission of the European Union considered trying to capture aircraft operators' non-CO_2 emissions under the EU ETS. Methods were considered for capturing the environmental impact of non-CO_2 greenhouse gas emissions, but ultimately not included because of the complexity and uncertainty of the environmental impact of non-CO_2 emissions. The non-CO_2 effects, together with complex further effects which vary with altitude and the nature of the flight plan, mean that the impacts are not well understood or easy to define, so it is difficult to ascertain a fixed additional effect. This creates significant challenges to incorporating these effects into a trading system like EU ETS.

Aircraft operators are eventually likely to have to internalise the cost of their non-CO_2 emissions, as science outlining the environmental impacts becomes better understood. This is a significant risk hanging over aircraft operators, given that scientists suggest the non-CO_2 damage could be as large as 2-4 times the level of the CO_2 damage.

A number of carbon markets already factor in the CO_2 equivalent impact of non-CO_2 pollutants. The Kyoto Protocol supports non-CO_2 greenhouse gas emission reduction. Whilst Phases 1 and 2 of the EU ETS only included CO_2, Phase 3 will include perfluorocarbons, pollution created in the production of aluminium and not in some sectors. In time it is likely that the non-CO_2 impacts of aircraft operators will be incorporated into any regime to tackle aircraft operator emissions, including the EU ETS and the European Commission is already considering this.

2 Airline emissions abatement options

- Energy efficiency savings and aviation biofuels offer the main abatement options for aviation.
- Adding a cost of carbon to the price of kerosene, at recent prevailing carbon prices (~€14/tCO_2), does not provide significant additional incentive for energy efficiency beyond 'business as usual' in the short term.
- Aviation biofuels could provide a vital breakthrough to low carbon flying, but the aviation industry may be under investing in biofuels at present.

Abatement options available to airlines

The EU ETS gives airlines the opportunity **either** to buy allowances **or** to try to reduce their emissions. In this Chapter the different abatement options open to airlines are discussed.

Airline CO_2 emissions are a function of energy efficiency of travel (measured in tonnes of oil equivalent (toe) of fuel used per km), the carbon intensity of the fuel (measured in tonnes CO_2 emitted per toe fuel used) and distance of flight (measured in kms).

$$CO_2 \text{ emissions} = \text{toe/km} \times CO_2\text{/toe} \times \text{kms travelled}$$

So to cut emissions airline operators can either:

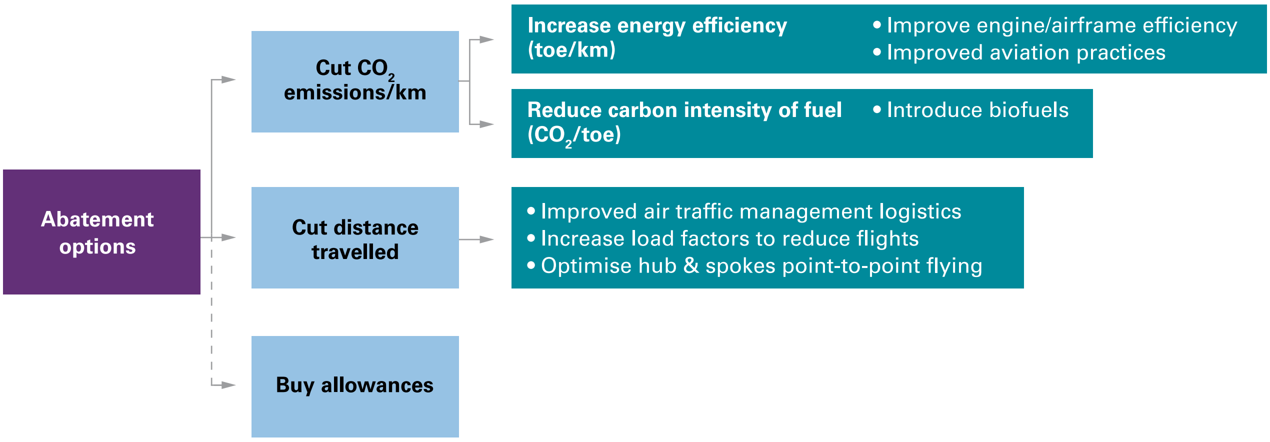
1. increase energy efficiency of travel (reducing the amount of fuel burned per kilometre)
2. reduce carbon intensity of fuel (switching from kerosene to aviation biofuels, or a blend between the two)
3. reduce kms travelled.

However, once airlines join the EU ETS, they have the option, **instead of cutting emissions,** to:

4. buy carbon allowances.

Once inside the EU ETS, airlines will, for the first time, be incentivised to reduce the carbon intensity of their fuel. And they will enjoy an additional reason to increase their energy efficiency, on top of the incentive they already have to reduce their large kerosene (jet fuel) bills.

***Chart 3** Options for aircraft operators in a carbon-capped world*



Increase energy efficiency

Improved engine/airframe efficiency

The main way to reduce the amount of fuel burned per passenger km is to invest in renewing the fleet of aircraft. Each new generation of aircraft and engine tends to be more energy efficient than the former. However, replacing the fleet only cuts global CO_2 emissions if the replaced planes ultimately cause another plane in the global fleet to be scrapped earlier. If an airline only sells its old planes to another carrier, then whether emissions fall or not depends on whether or not this reduces the usage of other planes in the global fleet.

Some technological developments offer potentially large gains in energy efficiency. Open rotor engines could lead to a step change reduction in emissions, though present versions of the open rotor engine tend to be noisy. Blended wing technology aims to give the aircraft greater upward thrust, by designing more of the body of the plane in the shape and format of the adjoining wing and can be more fuel-efficient. Advanced structure design and use of carbon fibres can further improve fuel efficiency.

ACARE, the Advisory Council for Aeronautical Research in Europe, has set the goal that a model of plane produced in 2020 should be 40-45% more efficient, in terms of CO_2 emissions per passenger kilometre, than the same plane developed in 2000[18] (with 5-10% efficiency gains achieved by air traffic management). Achieving a ~40% fall in only 20 years would mean achieving energy efficiency gains of 2.5% per annum. However, despite ACARE's ambitious target, stated targets for energy efficiency gains by individual airlines tend to average more like 1-2% per annum, which are more in line with the 'business as usual' gains achieved over the past 20 years.

Improved aviation practices

Improved aviation practices can also improve airline's energy efficiency. There are two key categories: better airline practices and better airport operations.

Better airline practices would include improved flight planning, speed control, weight reduction and better matching of the plane provided to the task in hand.

Better airport operations would include improved towing services to reduce aircraft taxiing under their own power and potentially designing terminal buildings and taxi ways to cut down on the amount of ground taxiing. Whilst aircraft need to idle before take-off thrust and cool down after landing, there is room to reduce fuel used in taxiing.

Whilst many of these measures are attractive, it is likely there are a number of barriers to achieving efficiency gains in these areas, due to the increased need for co-ordination between airlines and airport operators to overcome the problem of the split incentive that airport operators must act to reduces airline costs. In addition, planes would need to be redesigned to enable long towing, especially when fully laden.

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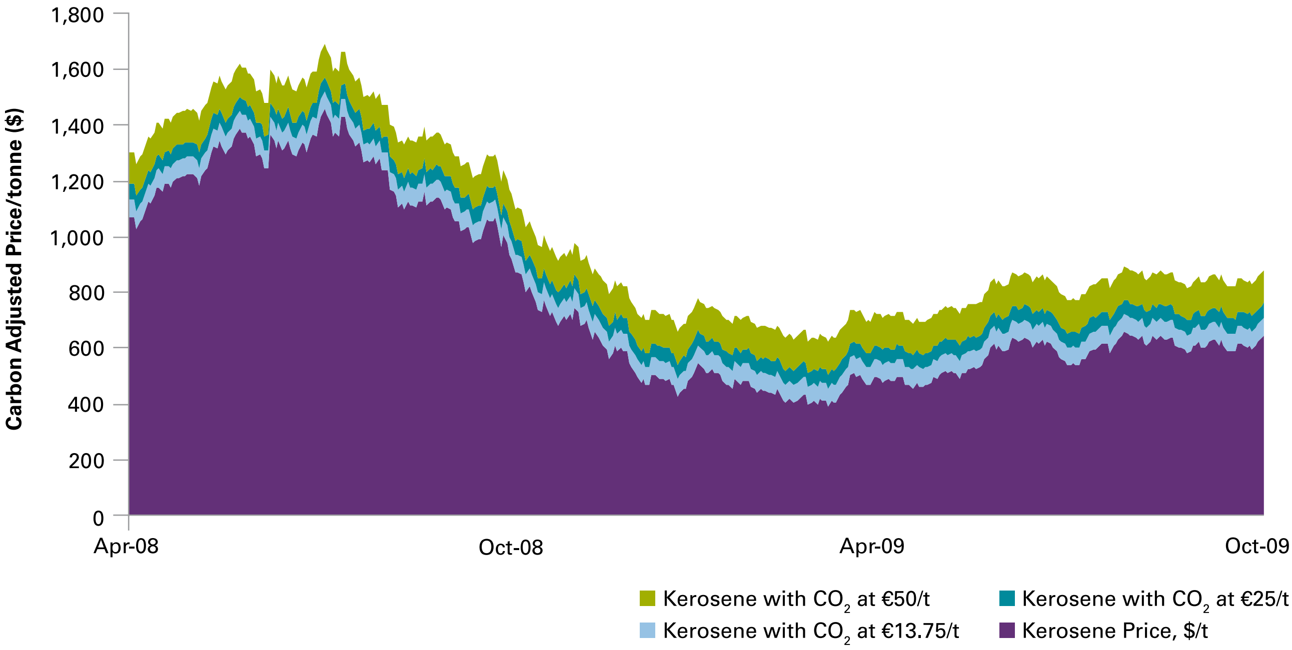
[18] ACARE 2008 Addendum to the Strategic Research Agenda.

Chart 4 *Carbon adjusted prices of kerosene*



Source: Cargos CIF NWE and the Carbon Trust analysis

Will joining the EU ETS greatly increase energy efficiency?

One concern about relying on energy efficiency gains to reduce aircraft operator emissions within the EU ETS, is that airlines already are heavily incentivised to reduce their energy use due to the high proportion – often 30-40% – of an airline's cost base that kerosene represents. Adding the recent low cost of carbon in 2009 to kerosene prices does not provide much additional incentive for energy efficiency.

For example, the price of kerosene on 7 October 2009 was ~$615/tonne of kerosene. Adding the kerosene price to take into account its carbon emissions[19], at a prevailing carbon price of $20.35/t$CO_2$,[20] the 'carbon adjusted' price of kerosene would be ~$680/tonne of kerosene, only approximately 10% higher.

The price of kerosene more than halved in the 12 months from June 2008 to June 2009 from ~$1,300/tonne to ~$600/tonne. For a cost of carbon to make up a $700/tonne[21] fall in the kerosene price, the price would need to rise to ~$220/t$CO_2$, or €150/t$CO_2$, up from a price of €13.75/tCO_2 as of 7 October 2009.

Chart 4 displays kerosene prices with CO_2 prices 'internalised': a carbon adjusted kerosene price is calculated, based on a spot CO_2 price of €13.75/tCO_2; two further CO_2 adjusted kerosene prices are calculated, assuming €25/tCO_2, and €50/tCO_2 prices.

The chart suggests that adding a cost of carbon will be less effective than the high kerosene prices airlines faced in 2008. It appears likely that it will make little difference in the short term, although it should create an important signal that in future the effective cost of kerosene will be higher and therefore greater efforts to improve energy efficiency will be rewarded.

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[19] Burning one tonne of kerosene emits 3.15 tonnes of carbon dioxide.

[20] Assuming a prevailing carbon price of €13.75/tCO_2 and a €:$ exchange rate of 1:1.48.

[21] 1 tonne = 7.88 barrels.

Chart 5 *Sample airlines that have undertaken biofuel blend test flights*

Airline	Aircraft	Partners	Date	Biomass	Blend
Virgin Atlantic	B747-400	Boeing GE Aviation	23-Feb-08	Coconut Babassu	20% One engine
Air New Zealand	B747-400	Boeing Rolls-Royce	30-Dec-08	Jatropha	50% One engine
Continental Airlines	B737-800	Boeing GE Aviation CFM Honeywell UOP	07-Jan-09	Algae Jatropha	50% One engine
Japan Airlines	B747-300	Boeing Pratt and Whitney Honeywell UOP	30-Jan-09	Camelina Jatropha Algae	50% One engine

Source: Air Transport Action Group, May 2009

Reduce carbon intensity of fuels – biofuels

Carbon pricing incentivises airlines to use fuels with lower carbon content than kerosene.

Great technical progress has been made on aviation biofuels recently. The aviation industry is hopeful that one or more biofuels might be certified as viable before 2011. The Air Transport Action Group stated, "The target is to certify aviation biofuels by 2013, although there is now a possibility that a 50:50 blend of biofuels mixed with jet A-1 fuel could be certified before 2011[22]".

An early problem with biofuel has been its ability to perform at low temperatures. Mixing biofuel into kerosene may compromise kerosene's ability to perform at cold temperatures, such as those experienced at altitude[23]. But studies now suggest that certain biofuels could be added to kerosene in up to a 50:50 blend or even higher and it appears the problem is being tackled.

A number of airlines have run test flights using biofuels, three using a 50:50 blend (see *Chart 5* for some examples). While the technology is still in the feasibility stage, the technical challenges seem to be surmountable.

If the technical issues are surmountable, then the key remaining issues are:

1. Can biofuels that meet the challenging technical specifications for aviation be provided in very large quantities, without causing widespread environmental problems or food prices to rise?

2. Will aviation biofuels be economic compared to kerosene?

There is some evidence that there is sufficient non-food biomass to cover all current jet fuel consumption. Global demand for jet fuel is forecast to be 6.9 million barrels per day by 2010[24]. The available biomass from agricultural residues, non-food energy crops, and municipal waste has been estimated to be sufficient to generate in excess of 100 million barrels of kerosene per day[25].

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[22] Air Transport Action Group (2009), Beginner's Guide to Aviation Biofuels, May p. 14.

[23] Saynor, Saynor B., Bauen A. and M. Leach (2003), The Potential for Renewable Energy Sources in Aviation, report commissioned for the DTI, Imperial College for Energy Policy and Technology.

[24] Griffin, J, Editor, World Oil Outlook, OPEC, Vienna, 2007.

[25] IATA 2008 Report on Alternative Fuels.

However, it is not yet clear whether these quantities of biomass will be available in forms from which they can be cost-effectively converted into aviation-grade fuel. In particular, it will be challenging to do this for feedstocks with high lignin content, which includes many woody and waste biomass sources, which may be better used as biomass to create heat or power. Aviation will be competing with ground transport for biofuels. In addition, it has yet to be established whether biofuel production on these scales, even with the use of more benign feedstocks, can avoid significant indirect land use and agronomic changes that could significantly undermine the climate change abatement. For example, if agricultural residues are diverted from natural fertiliser to biofuel production, this may lead to an increase in the use of petrochemical fertilisers. These fertilisers are often carbon intensive to produce and lead to significant nitrous oxide emissions.

Further, the land available for cultivation of dedicated energy crops may be significantly reduced if climate change impacts (higher temperatures, greater frequency of extreme weather events, drought) start to manifest, although these factors are hard to predict. Whatever land is available for agricultural and pastoral cultivation must also in the future be able to serve a likely population of nine billion by 2050, and so may not be available for energy crops.

There is a great deal of interest in algae biofuels for aviation, and this is due to this technology's potential to resolve the issues listed above, in particular: (i) ease of conversion to aviation fuel; (ii) indirect land use change impacts; and (iii) competition with resources required for food production. Algae can produce very high proportions (up to 30% of their own weight) of triglyceride oils which are relatively easy to convert to aviation biofuel. Algae cultivation does not require fertile land and algae farms could in principle be set up on waste land with little or no indirect land use change impacts. Finally, sea water or brackish water—salty water that cannot be used for food crop cultivation—can be used for algae farming and this, combined with the different land use requirements, means that algae could in principle be cultivated in very large quantities without affecting food supplies.

However, it appears unlikely that algae and other aviation biofuels can be produced at a lower cost than fossil aviation fuels, given the cost of transformation of biomass to fuels compared to the relatively cheap cost of extraction. However, at times of very high fossil fuel prices, biofuels may be cost competitive – for example, biofuels may be cost competitive over the medium term (e.g. 2020) at greater than $150-200 per barrel. Some form of price signal (a subsidy for biofuels or additional tax for kerosene) or mandate to use a certain proportion of biofuels (equivalent to the Road Transport Fuel Obligation in the UK, mandating a rising mix of biofuels in automotive gasoline) is therefore likely to be necessary to ensure the aviation biofuels market develops.

A key problem for the development of aviation biofuels is that neither airlines nor aero-engine manufacturers are directly overseeing development. Airlines rely on aero-engine and aircraft manufacturers to develop more efficient planes over time. The aero-engine and aircraft manufacturers rely on the biofuels industry to develop aviation biofuels that can function in aircraft engines. Given this dynamic, it is likely that there is significant underinvestment in aviation biofuels by the aviation industry as a whole.

Cut distance travelled

The final option to cut aircraft operator emissions is to fly shorter distances. Stopping short of reducing overall levels of consumption (which is discussed in Chapter 6), there are a number of ways in which planes can be organised to fly shorter distances whilst delivering passengers to the same destination.

Improved Air Traffic Management (ATM) logistics

A rationalised, modern air traffic control system can cut travel distances. Flight trajectories can be optimised, with significant savings possible by optimising take-off and landing trajectories to use fuel most efficiently. More efficient air traffic management could also anticipate air traffic congestion and help to minimise aircraft 'stacking' which can occur when planes are delayed before landing. More direct flight paths can also improve fuel efficiency by reducing the total journey travelled, regardless of stacking.

The UK's National Air Traffic Services recently announced a goal of cutting air traffic management related CO_2 emissions by 10% per flight by 2020, versus a 2006 baseline by improved air traffic management[26]. The European Commission and EUROCONTROL are co-sponsoring a programme of rationalisation of European air traffic management through project SESAR – the Single European Sky ATM Research.

Increase load factors to reduce flights

The load factor of a flight is the percentage of seats on a plane that are full. This is measured as RPK (revenue passenger kilometres) divided by ASKs (available seat kilometres). Increasing the load factor reduces the amount of fuel consumed per passenger.

Increasing the load factor does not itself reduce the emissions from a particular flight – indeed it raises emissions somewhat due to increased weight. If higher load factors are achieved merely by offering very cheap seats to passengers that would not otherwise travel, this can stimulate higher long-term demand. However, if an airline that increases its load factor is able to operate fewer flights per week, or force competing airlines to cut flights from their schedule, it might achieve emissions reduction compared to the alternative. An airline in a buoyant market that allows its load factors to rise before laying on new flights, may achieve emissions reduction, versus an airline that introduced new flights earlier.

In sum it appears an airline can reduce emissions growth if it achieves rising load factors. However, as it is already in the airlines' interests to try to maximise load factors, tackling climate change is unlikely to provide much additional incentive for improvement beyond that already provided by current economics.

Optimise hub and spoke flying versus point-to-point flying

There is a complex and unresolved debate about whether point to point (spoke to spoke) flying has a smaller environmental impact than hub to spoke flying.

Because aircraft burn a substantial proportion of their fuel during take-off, a direct (point to point) flight from Manchester to Madrid would use less fuel than flying from Manchester to London (spoke to hub) followed by London to Madrid (hub to spoke). In addition, point-to-point flights generally involve a shorter overall flight path than hub and spoke flights.

However, the trade-off is not clear-cut because a hub and spoke model can drive higher load factors, which, as mentioned above, can lead to more efficiencies. As airlines are already significantly incentivised to optimise this trade-off, again it is unlikely that a cost of carbon will significantly improve this dynamic.

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[26] NATS Environment Plan 2009, www.nats.co.uk/uploads/NATSEnvironmentPlan(1).pdf

3 European Airline Emissions to 2020

- Due to limited short-term greenhouse gas emissions reductions opportunities, airlines are likely to be net buyers of carbon allowances in the EU ETS.
- Airlines may potentially buy an additional ~80-160m tonnes CO_2 in the wider EU ETS, increasing the net 'short' of allowances in the EU ETS by 50-100%.
- Over the period 2012-2020, if the cost of carbon allowances averaged €25/tCO_2, airlines operating in Europe could spend between €23 and €35 billion purchasing allowances.

Airline emissions to 2020

A key question is, what will EU airline CO_2 emissions be in 2012, when airline joins the EU ETS? The Tyndall Centre estimates between 284 million and 355 million tonnes. Ernst and Young estimated 280 million. In this report, a conservative estimate of 250 million is used in 2012, because of the current recession. 250 million in 2012 still represents a 2.6% compound annual growth rate from 2005.

What about beyond 2012? Ernst and Young in 2008 saw European emissions rising to 373 million tonnes of CO_2 in 2020, from 280 million in 2012, a compound annual growth rate of 3.65%.

For the purposes of this report, a lower end estimate of emissions based on further evidence of the decline in demand over 2009 assumes a 2.5% per annum rise in emissions in the period 2012-2016 (made up of 3.5%/year passenger growth and -1.0%/year fall in CO_2 per passenger kms, representing ongoing energy efficiency gains). A 1.5% per annum rise in CO_2 emissions is assumed for 2016-2020 (made up of 3.0%/year passenger growth and a -1.5%/year fall in CO_2 per passenger kms), representing some slowing in growth due to the EU ETS itself.

Fitting these assumptions to the 250 million figure for 2012, gives the following: EU airline emissions rise to 293 million in 2020; and the airline sector is short 84 million tonnes of CO_2 in that year.

Chart 7 shows the European airline emissions over the period to 2020. The top line shows where airline emissions under the EU ETS would be using the assumptions above. The middle line shows that cap on airline emissions under the EU ETS. The lower line shows the allowances that will be allocated for free to airlines in the EU ETS.

The space in the middle segment shows that number of airline allowances that are being made available for surrender to airlines via auction. Airlines would need to buy additional allowances represented by the space at the top of the figure. This would see airlines buying EUAs, or if they are available to airlines, CERs and ERUs.

Chart 6 Actual and estimated European carbon emissions, cap, and short, 1990-2020

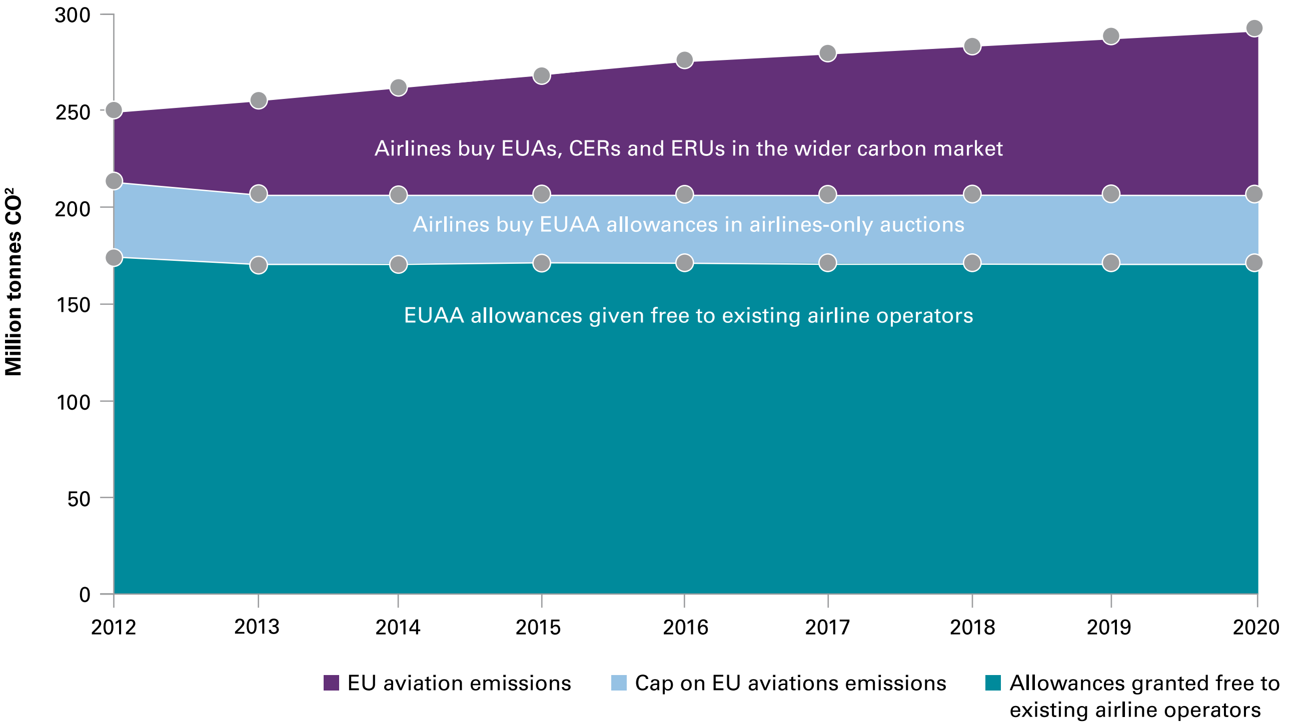
Ernst & Young estimates		1990	2000	2005e	2012e	2013e	2014e	2015e	2016e	2017e	2018e	2019e	2020e	Total 2012-'20
A	Emissions	123	200	218	280	290	300	311	323	334	347	359	373	2,917
B	EUAAs – allocated free				174	170	170	170	170	170	170	170	170	1,534
C	EUAAs – auctioned				38	37	37	37	37	37	37	37	37	337
D=B+C	Cap				**212**	**207**	**207**	**207**	**207**	**207**	**207**	**207**	**207**	
E=A-D	Short – buys EUAs, CERs, ERUs				68	83	93	104	116	127	140	152	166	1,046
F=C+E	**Total allowances purchased**				**106**	**120**	**130**	**141**	**153**	**164**	**177**	**189**	**203**	**1,383**

Lower end estimates		1990	2000	2005e	2012e	2013e	2014e	2015e	2016e	2017e	2018e	2019e	2020e	Total 2012-'20
A	Emissions	123	200	220	250	256	263	269	276	280	284	289	293	2,460
B	EUAAs – allocated free				175	171	171	171	171	171	171	171	171	1,546
C	EUAAs – auctioned				38	38	38	38	38	38	38	38	38	339
D=B+C	Cap				**213**	**209**	**209**	**209**	**209**	**209**	**209**	**209**	**209**	
E=A-D	Short – buys EUAs, CERs, ERUs				37	47	54	60	67	71	75	80	84	575
F=C+E	**Total allowances purchased**				**75**	**85**	**91**	**98**	**105**	**109**	**113**	**117**	**122**	**914**

Assumptions:
i) 250 million tCO_2 emissions 2012
ii) 2.5%/annum emissions growth, 2012-2016
iii)1.5%/annum emissions growth, 2017-2020

Source: Ernst & Young: Inclusion of Aviation in the EU ETS: Cases for Carbon Leakage (October 31st 2008) the Carbon Trust analysis

Chart 7 *Estimated airline operator cap, free allowances and possible future emissions, 2012-2020*



Source: The Carbon Trust

Deutsche Bank[27] calculates business-as-usual emissions in the EU ETS in 2020 (excluding airlines) of 2,023 million tonnes, and a cap on emissions of 1,854 million tonnes, giving a short of 169 million tonnes for European industry in the EU ETS (excluding airlines). So the calculated estimate of the airline short, at 84-166 million tonnes of CO_2, represents 50-100% of the whole of the EU industry's (excluding airlines) short in 2020.

Based on the assumptions of 250 million tonnes of emissions in 2012, 2.5% per annum emissions growth between 2012 and 2016 and 1.5% per annum growth between 2017 and 2020, airlines have to buy 914 million allowances in the period 2012-2020, made up of 339 million EUAAs bought within the aircraft operator cap, and 575 million EUAs, CERs or ERUs bought in the wider carbon markets. Based on Ernst and Young's assumptions, airlines would buy 1,383 million allowances between 2012 and 2020, made up of 337 million EUAAs, and 1,046 million EUAs, CERs or ERUs bought in the wider carbon market. This amounts to a total of ~€23-35 billion over the period 2012-2020 on purchasing allowances.

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[27] Deutsche Bank (2009) How Long is a Piece of String; Another Look at the 2008 Data?, 26 May, p.15.

4 How cap-and-trade schemes could impact airline performance

- A cost of carbon for airlines in the EU ETS will act as a 'turbo boost' on the already volatile kerosene fuel price, raising the cost by ~15% at €25-50/tCO_2. This impact could increase 2-4 fold if non-CO_2 impacts are intended.
- The ultimate impact of a cap-and-trade scheme on an individual airline's performance is critically determined by four criteria: **1)** the prevailing cost of carbon, **2)** the number of carbon allowances allocated for free to airlines, **3)** the rate of successful 'price pass-through' of the cost of carbon by airlines to their customers, **4)** any resulting change in demand by customers due to the increased ticket price and the airline's ability to manage its cost structure in response.
- The overall impact of the EU ETS on European airlines' total profit pool is uncertain, although more price-elastic and competitive routes such as short haul leisure may be the most exposed whilst less price-elastic and competitive routes such as long haul business may gain in profitability in the short term.
- The EU ETS will reward more fuel-efficient players with the ability to increase their relative profitability by 20-40% compared to average players if the cost of carbon is between €25-50/tCO_2. More nimble players which can cut costs in the face of reduced demand could also gain significantly compared with less nimble competitors.

Modelling an archetypal airline

To test the impact of carbon pricing on airlines, this report models the financials of an 'archetypal' airline. The archetypal airline is similar to a typical large European airline and has the following profile in 2009:

- Earns revenues of $6,500 million
- Flies 100 billion passenger km
- Burns 3.47 million tonnes of kerosene
- Emits an average of 10.96 million tonnes of CO_2 per annum over 2004-6
- Emits 109.6 grams of CO_2 per passenger km.

The airline joins the EU ETS in 2012. The airline receives 8.72 million allowances for free in 2012, and 8.54 million allowances per annum from 2013-2020.

The annual increase in passenger kilometres is a key driver: the model assumes that revenues rise at the annual growth rate of passenger kms, minus 0.75%, to reflect the continual competitive pressure on the price of underlying passenger tickets seen in the airline sector. All other costs rise at the annual growth rate of passenger kms, minus 1.00%. This reflects increasing efficiencies of operations and value delivered to customers.

The kerosene price is modelled at $750/tonne, with passenger km growing at 2% per annum and energy efficiency at 1% per annum and a euro-dollar exchange rate of €1.00 to $1.48.

The key variables that are addressed are:

1. price of carbon
2. percentage of carbon allowances allocated for free to the airline
3. any carbon 'multiplier' that may be used (if non-CO_2 effects are included)
4. percentage of carbon costs passed through to the customer by the airline
5. price-elasticity of passenger demand and the ability of the airline to adjust its costs in response.

Potential responses by the airlines to reduce their emissions (in terms of additional energy efficiency and the introduction of biofuels) are considered in a later part of this Chapter.

Throughout this analysis, the calculations assume the airline buys allowances at the prevailing price of EUAAs or EUAs and ignores the fact it might be able to buy some CERs and ERUs, which usually trade at a discount to EUAAs and EUAs. This is reasonable as the current design of the EU ETS gives airlines only limited access to CERs and ERUs.

i) 'Business as usual' EBIT of $336 million with no carbon price

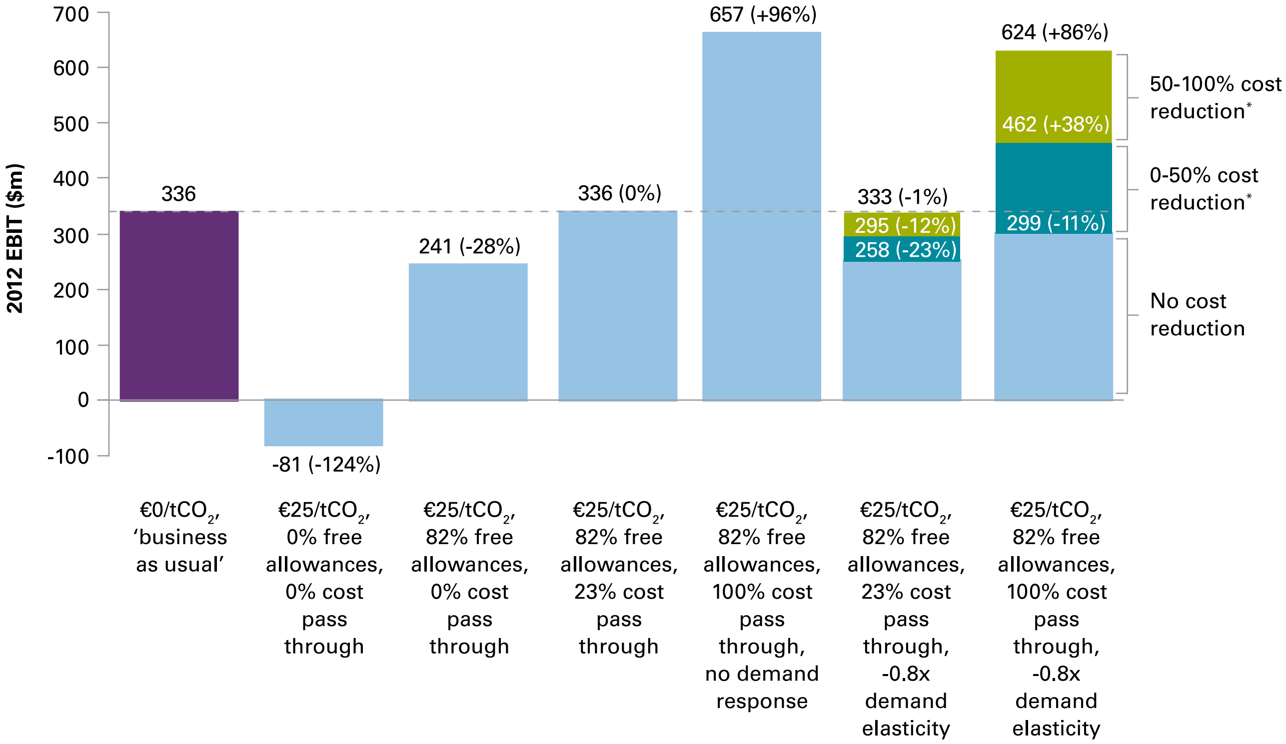
Initially, before adjusting for any of the above variables and assuming no carbon price (a carbon price of €0/tonne) and no (0%) cost pass through, the archetype achieves in 2012, the first year that aircraft operators joins the EU ETS, EBIT of $336 million. (This result is shown as the first bar in *Chart 8* and *Chart 9*).

ii) EBIT hit as carbon price rises

First the analysis focuses on the EBIT impact of rising carbon prices, assuming the airline is given no allowances for free and has to buy 100% of its allowances. As the price of carbon rises, so the firm's EBIT in 2012 falls. Assuming 0% cost pass through and a 1x carbon multiplier, the airline's 2012 EBIT falls to -$81 million (-124%) as carbon rises to €25/tonne (from €0/tonne) and to -$497 million (-248%) as carbon rises to €50/tonne (see the second bars in *Chart 8* and *Chart 9* respectively).

If a 2x carbon multiplier is introduced for CO_2 emissions, the impact on EBIT would be even more pronounced: EBIT falls to -$497 million (-248%) with carbon at €25/tonne and to -$1,330 million (-496%) with carbon at €50/tonne. This 2x carbon multiplier scenario is included because there is some risk to airlines that a carbon multiplier (or an equivalent additional requirement to surrender allowances) of between 2-4 times will be applied to the CO_2 emissions of airlines, to cover the substantial damage from kerosene's non-CO_2 emissions.

Chart 8 *Archetype airline 2012 EBIT in $ millions, with €25/tCO$_2$*



Note: Percentage in brackets represents change versus 'business as usual'

* The reduction in cost as a percentage of revenue reduction is defined as the reduction in cost base as a proportion of the reduction in revenue that takes place (due to a demand response to increased ticket price). Theoretically, this varies from 0% (entirely fixed cost base) to 100% (entirely variable cost base) and will depend on factors such as the flexibility of the cost base and the extent to which the airline correctly anticipates any reduction in demand due to a cost increase.

Source: The Carbon Trust

iii) Free allocation of 82% of allowances diminishes EBIT hit

The impact of carbon pricing in the EU ETS as currently designed limits the cost impact on airlines by allocating 82% of their total allowance cap for free, so that airlines will only have to buy at auction the remaining 18% of the sector's cap, together with any additional allowances required beyond the cap.

Under this scenario, a €25/tonne carbon price sees EBIT fall to $241 million (-28%), versus $336 million without a carbon price. A €50/tonne carbon price, when the company receives 82% of its allowances free, sees EBIT fall to $146 million (-56%) (see the third bar in *Chart 8* and *Chart 9* respectively).

iv) EBIT rises on cost pass through, as carbon price rises

The model next calculates the position following the successful pass-through to customers of a proportion of the costs of carbon. This could be achieved, for example, by airlines introducing a carbon allowance surcharge, set in line with the carbon price, which is levied on all customers or simply an addition to the inclusive ticket price.

With 82% free allocation of allowances, assuming no demand reduction, an airline will break even when it passes through 23% of the full cost of carbon (see fourth bar in *Chart 8* and *Chart 9*). This break even point is relatively low because airlines are being given such a high percentage of their allowances, 82%, for free[28].

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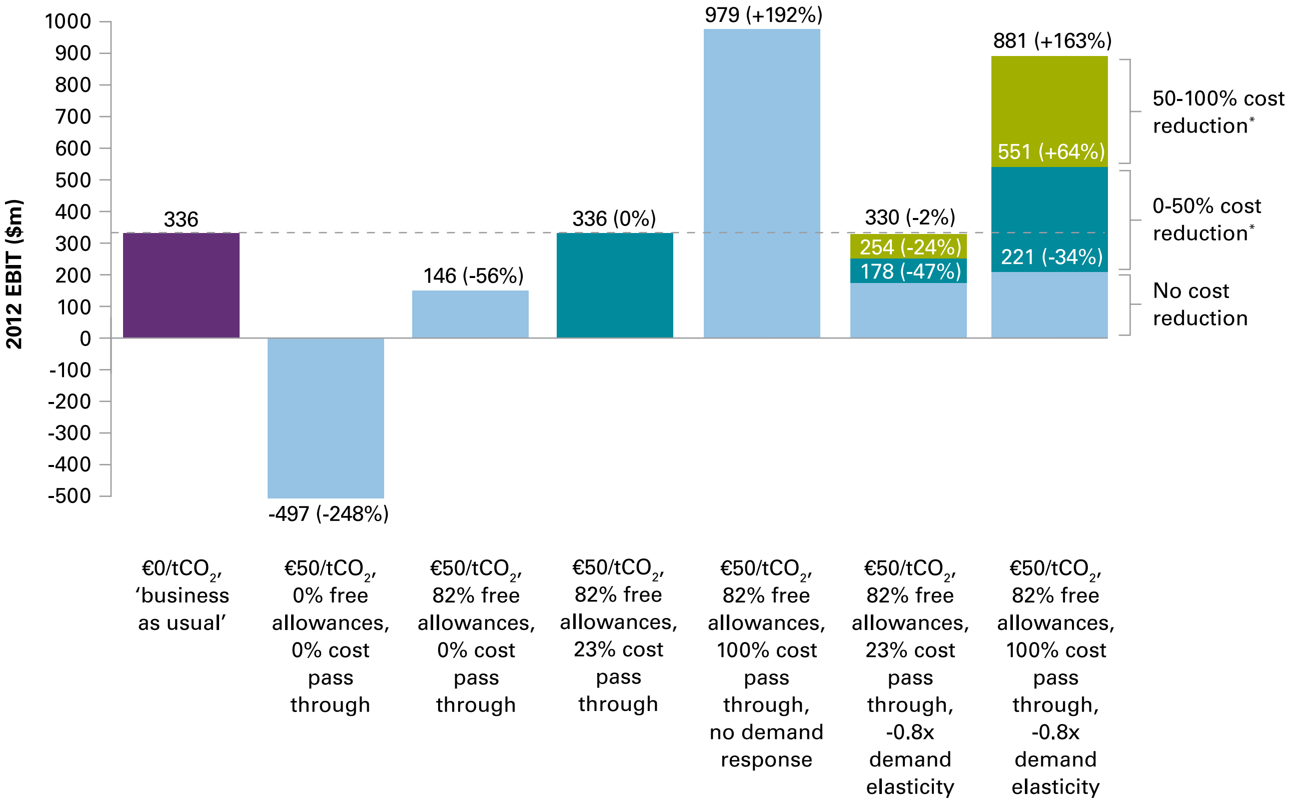
[28] The percentage is greater than 18% in part because airlines are given 82% of their cap for free, but their cap in 2012 is only 97% (not 100%) of their 2004-2006 emissions (which is typically lower than projected 2012 emissions due to growth).

***Chart 9** Archetype airline 2012 EBIT in $ millions, with €50/tCO$_2$*



Note: Percentage in bracket represents change versus 'business as usual'

* The reduction in cost as a percentage of revenue reduction is defined as the reduction in cost base as a proportion of the reduction in revenue that takes place (due to a demand response to increased ticket price). Theoretically, this varies from 0% (entirely fixed cost base) to 100% (entirely variable cost base) and will depend on factors such as the flexibility of the cost base and the extent to which the airline correctly anticipates any reduction in demand due to a cost increase.

Another scenario is that the archetype passes through all the value of the carbon allowances used by the airline, including both those that it buys and those that it is allocated for free. This is a possible outcome as there is precedence for this occurring in other industries. For example, the European power sector enjoyed significant profit taking from receiving the majority of its carbon allowances for free in phases I and II of the EU ETS. The UK Committee on Climate Change, for example, notes that the UK power industry is estimated to have achieved profits of up to £1.6 billion per annum as a result of successfully passing through to customers a significant proportion of the total costs of carbon whilst also being allocated the majority of its allowances for free in phases 1 and 2 of the EU ETS[29].

Typically, an industry player is incentivised to pass through all or a majority of the value of the carbon allowances used (including free allocations of allowances) if the player bears a marginal cost of carbon for each product or service delivered and if other competitors (in particular the price-setting player in the market) would bear a similar cost at the margin of its production.

Airlines may fulfil these conditions as each additional flight at the margin would require additional fuel and, therefore, additional carbon allowances to offset emissions above and beyond those allocated for free. Given this logic, airlines could be expected to pass through to customers the full cost of carbon per passenger for each flight. However, there is an alternative view that due to the intense competition arising in the airline industry, no airline would be able to pass through costs so that it made a higher marginal return. Anecdotal evidence supports this view when fuel costs rise significantly[30].

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[29] Committee on Climate Change, 'CCC advice on a framework for reducing global aviation emissions', 9 September 2009.

[30] For conflicting reports on this issue, see Vivid Economics (Nov 2007), Impact of emissions trading on profits in aviation and Frontier Economics (Mar 2006), Impact of emission trading on profits in aviation and Frontier Economics: review of Vivid Economics reports 2008.

For the archetypal airline, assuming a carbon price of €25/tonne with the airlines receiving 82% of its EUAAs for free, and undertaking 100% cost pass through, 2012 EBIT rises to $657 million (+96%) if there is no demand response. As the carbon price rises to €50/tonne, EBIT rises $979 million (+192%) (see the fifth bar in *Chart 8* and *Chart 9* respectively).

v) But demand may fall as costs are passed through

The successful pass through of the cost of carbon allowances to customers will increase each ticket price and is likely to have at least some impact on demand.

To demonstrate the impact on ticket price on a long-haul ticket, a typical one way flight from Charles de Gaulle Airport in Paris to JFK in New York covers 6,096km and might have a carbon intensity of travel of 94.1 grams of CO_2 per passenger kilometre[31].

Each passenger would be responsible for approximately 0.6 tonnes of CO_2 emissions:

6,096km x 94.1 grams CO_2/km = 0.574 tonnes CO_2

So if the price of carbon was €25/tonne, it would add ~€15 to the price of a ticket. Assuming a one way tourist ticket from Paris Charles De Gaulle to New York JFK costs ~€200, the carbon price adds 7.5% to the ticket price. For a business class ticket at €2,000, the price increase is less than 1%.

Similar results could occur from short haul. A typical one way flight from London Heathrow to Paris Charles de Gaulle is 386km and might have a carbon intensity of travel of 165.8 CO_2/km. This gives a total of 64kg of CO_2 emissions per passenger. For a low-cost tourist ticket price of only €50, then at €25/tonne CO_2, the cost is €1.6, which is a 3.2% cost increase. If this were a business class ticket of approximately €200, then the price increase would be 0.8%. In the archetype model the overall increase in average revenue for the airline if it successfully passed through to customers all of the value of its carbon allowances to customers at a price of €25/tCO_2 is 6.3%.

Price-elasticity of demand ('Elasticity') is defined by the equation:

Demand change (%) = Elasticity x Price Change (%)

Price-elasticity of demand is difficult to identify and varies significantly by route and class. Broadly, business flights are considered less elastic than leisure and long haul is less elastic than short haul. It tends to be lower across an industry as a whole than for any single player as individual players compete with each other, whereas the industry as a whole may have little, if any, direct competition.

One management consultancy states that the price-elasticity of long haul demand is approximately -0.7[32]. Another report states the overall price-elasticity for UK air travel is -0.5[33]. This same report suggests foreign leisure travel has an elasticity of -0.2, but domestic leisure has an elasticity of -1.0. Other ad hoc data points suggest a range of -0.3 to -0.5 for long haul business travel, compared to -0.8 to -1.2 for long haul leisure and between -1 and -2 for short haul leisure. However, these apply to individual players and will be higher than those applicable for the industry as a whole for the reason given in the previous paragraph. The model assumes a central scenario of -0.8 demand elasticity.

The model takes the percentage increase in revenues resulting from the pass through of carbon prices as the proxy for price increase. Assuming a carbon price of €25/tonne CO_2 and 82% allowances allocated for free, cost pass through at 23% (the break even point before the impact of demand elasticity is considered) but an average price-elasticity of demand of -0.8 gives 2012 EBIT of $258 million (-23%). Similarly, assuming a carbon price of €50/tonne, but a price-elasticity of demand -0.8 gives 2012 EBIT of $178 million (-47%) (see bar six in *Chart 8* and *Chart 9* respectively).

If the airline were to pass through 100% of costs, assuming a carbon price of €25/tonne CO_2 and 82% allowances allocated for free, gives a 2012 EBIT of $299 million (-11%) when demand elasticity is -0.8. Similarly, assuming a carbon price of €50/tonne gives 2012 EBIT of $221 million (-34%) (see bar seven in *Chart 8* and *Chart 9* respectively).

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[31] http://developpement-durable.airfrance.com/FR/en/local/calculateurCO_2/calculateurCO_2Passager.htm?

[32] Boston Consulting Group (2006), Understanding the demand for air travel: how to compete more effectively; meeting the new challenges of the airline industry, June.

[33] UK Air Passenger Demand and CO_2 forecasts, January 2009, Department for Transport (UK).

However, these results do not allow for the ability of the airline to reduce costs as demand reduces. If the cost base can be reduced as demand reduces (or – potentially more relevant – as demand growth slows), EBIT can be further improved. Whilst airlines clearly have significant fixed costs in the short term, over the medium term, the ability to predict demand and manage fleet size and routes to ensure high load factors is a key competitive advantage. Anecdotal evidence suggests that airlines can cut their cost base by up to 10% relatively easily by eliminating less profitable routes and flights, recouping at least 50% of costs as a proportion of revenue reduction. In *Chart 8* and *Chart 9*, the dark blue area of the sixth and seventh bars shows the range of EBIT if costs can be managed down in line with a reduction in demand over the range 100% to 0%. If an airline could reduce costs at the rate of 50% of the reduction of demand, then this can significantly boost EBIT to above 'business-as-usual'.

Airline break-even points on cost pass-through

The results above demonstrate that a typical airline's profitability is very sensitive to the effects of the cost of carbon in the EU ETS. The archetype model indicates some levels of price-elasticity that may assist in anticipating whether individual airlines in the EU ETS might break-even on the cost of carbon, or are exposed or potentially make a profit.

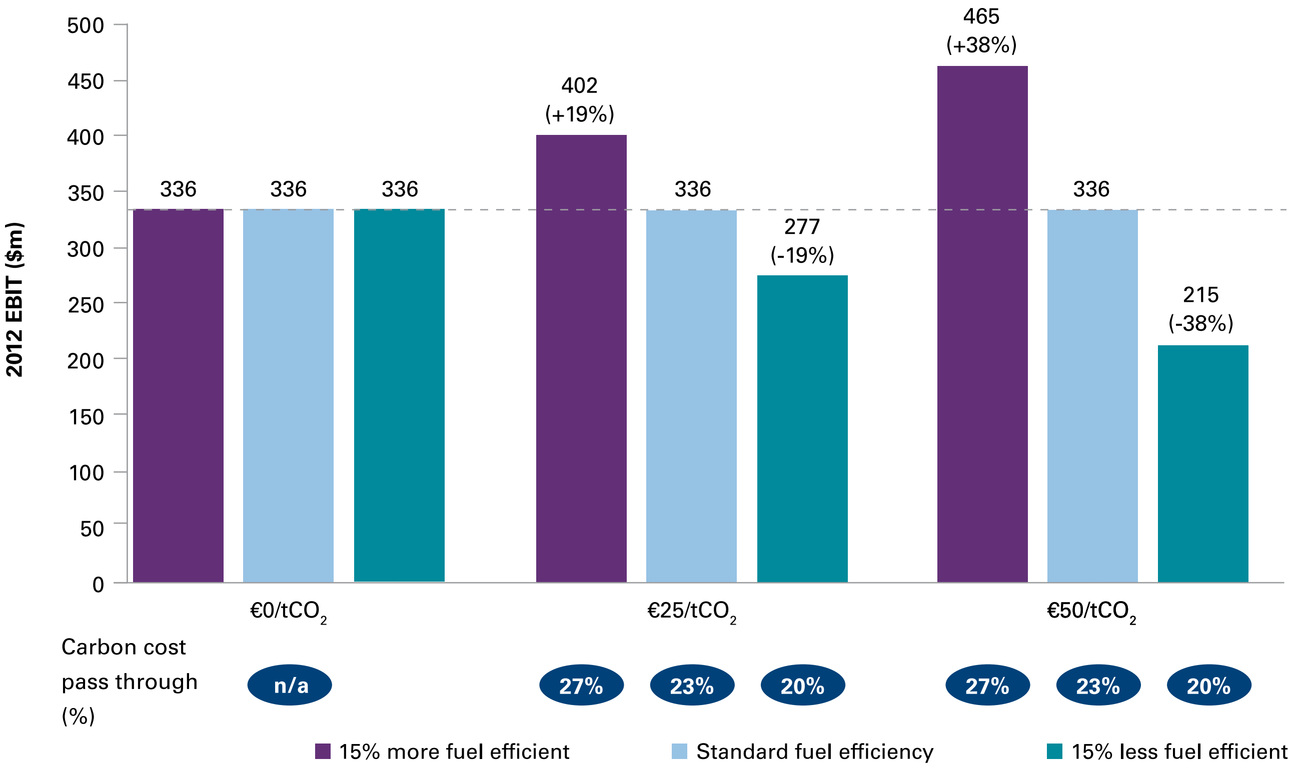
The archetype model identifies that if airline price-elasticity is less negative than -0.72 (e.g. -0.65), then assuming a carbon price of €25/tonne, 82% allowances allocated for free and 100% cost pass through, then even after the effects of reduced demand and assuming no commensurate reduction in cost base, an airline could profit. However, if price-elasticity of demand is more negative than -0.72, an airline would need to be able to reduce its cost base in order to avoid making a loss (and potentially to profit) from passing through 100% of the cost of carbon. For example, if an airline could reduce costs at ~50% of the rate at which revenues reduce on a drop in demand, then using the same assumptions on carbon price and free allocations of allowances, the model suggests that airlines would increase profitability above 'business-as-usual' (i.e. a zero carbon world) if price-elasticity of demand is less negative than approximately -1.31 (e.g. -1.1). If airlines can reduce costs at only 25% of the rate at which revenues reduce, then using the same assumptions, the break-even price-elasticity of demand is approximately -0.93.

Reducing the carbon intensity of fuel

Airlines may be able to reduce their exposure to the cost of carbon by reducing the carbon intensity of fuel. To identify the profit sensitivity to reducing carbon intensity of fuel, the model assumes that in 2012 the archetype airline sources a fuel mix that is 90% kerosene, 10% biofuel and that the biofuel is declared 'zero' carbon resulting in a blend that emits 10% less carbon on combustion. Before taking account of any increased cost burden for the airline of buying biofuels, compared to fossil fuel based kerosene, then this should improve the profitability of the airline. Assuming a carbon price of €25/tonne, the total value of carbon (including free allocations within the EU ETS) is ~125% of the archetype's business as usual EBIT, or $417 million. Therefore a reduction in carbon intensity of fuel by 10% would be worth ~12.5% of EBIT, or $42 million. Similarly, with a carbon price of €50/tonne the total value of carbon is ~250% of the archetype's business-as-usual EBIT, or $833 million and a reduction in carbon intensity of fuel of 10% would be worth 25% of EBIT, or $83 million.

However, as explained in Chapter 2, it is unlikely that biofuels will be cost competitive with fossil fuel based kerosene, unless there is a relatively high oil price, combined with further breakthroughs in the production of aviation grade biofuels. It is anticipated that such a breakthrough would require additional biofuel R&D on the basis on an anticipated future oil price of ~$150-200. At a cost of carbon of €25-50/tCO$_2$ and a kerosene price of $750 per tonne, the cost of carbon only adds 15-30% to the kerosene price. As aviation biofuels are likely to be more than 15-30% more expensive, at least in the short term, it is unlikely that biofuels will prove a means of improving profitability for airlines over the near term.

***Chart 10** Changes in the 2012 EBIT for three archetypal airlines with different efficiencies assuming central archetype passes through enough cost to maintain EBIT, and other airlines match prices*



Source: Carbon Trust Analysis

Competitive advantages for more efficient airlines

Some airlines can be much more fuel-efficient than others, based on a combination of more efficient aircraft, higher load factors and more efficient routes. A typical range might be from 95-130g CO_2/passenger km, the best having up to a 30% advantage over the worst. Whilst there is likely to be a trade-off between the average annual cost of fleet (e.g. depreciation) and fleet efficiency, introducing a cost of carbon further increases the competitive advantage of efficient airlines – particularly where this reflects a difference in load factor.

More efficient airlines would have a choice either to pass on a lower overall cost of carbon per passenger km to their customers, and potentially take market share from their competitors (due to lower prices), or to pass on a market prevailing cost of carbon to their customers, yet bear a lower burden of carbon and therefore increase profitability.

For the archetype airline referred to in this report, the total cost of carbon as a proportion of revenue at €25/tCO_2 is ~6%. A 30% efficiency advantage could lead to ticket prices ~2% lower than its competitor, if the benefits of lower carbon intensity are passed on which should lead, all other things being equal, to higher market share. Alternatively, a player with a carbon efficiency advantage could achieve an EBIT advantage over its less efficient competitors if a higher market cost of carbon is successfully passed through to customers, whilst the carbon burden to the airline is lower (albeit that all airlines will suffer some reduction in demand in this scenario). Within the EU ETS, allowances are allocated regardless of efficiency, (based on a revenue tonne km benchmark) and therefore more efficient airlines will achieve this advantage over less efficient airlines.

We have previously shown that our archetype airline with standard fuel efficiency will break even on its cost of carbon when it passes through 23% of the total carbon cost ignoring demand reactions (see *Chart 8* and *Chart 9*). If we assume that all other airlines in the industry pass on a proportion of their cost of carbon to their customers to match the new price point set by the archetype, we see that more efficient airlines are relatively advantaged, while less efficient airlines are disadvantaged (see *Chart 10*). Assuming a carbon cost of €25/tonne, an airline with a 15% efficiency advantage will have a lower overall cost of carbon, and therefore be able to match the new price point set by the archetype while passing through a greater percentage of their carbon cost (27%, versus 23% for the archetype). This gives an EBIT of $402 million, 19% higher than the archetype in this simplified case. Similarly, an airline that is 15% less efficient will have a higher overall total cost of carbon and be able to pass on a smaller proportion if they wish to match the new price set by the archetype in this simplified case. When the carbon price is €50/tonne, we see that a 15% fuel efficiency advantage leads to an EBIT uplift of +38%, and similarly a 15% disadvantage to a downward impact on EBIT of -38% in this simplified case.

Potential for 'carbon leakage'

In addition to the potential impacts on profitability due to the immediate impact of a cost of carbon, there is also a risk of increased competition between the EU and non-EU carriers, which could result in 'carbon leakage' – the migration of business and carbon to less regulated parts of the world. Flights that either connect at a non-EU airport or fly direct between two non-EU destinations could compete more effectively against those flights that connect at an EU airport. For example, a direct flight from New York to Delhi would not bear a cost of carbon under the EU ETS and would have an increased advantage over a similar flight that connected in Frankfurt, which would bear the full cost of carbon on both legs under the EU ETS. Similarly, if the same flight connected in Dubai, it would avoid the cost of carbon. Additional analysis beyond the scope of this paper would be required to estimate the extent of this potential leakage effect for airline financial performance and would depend on the proportion of flights potentially affected and the potential leakage rate, based on relative cost increases and elasticities of demand.

Conclusion

In conclusion, the final impact of the EU ETS on airlines will depend critically on four criteria:

- the prevailing cost of carbon
- the number of carbon allowances allocated for free to airlines remaining at 82% of the total cap
- the rate of 'price pass-through' of the cost of carbon by airlines to their customer
- any resulting change in demand by customers due to the increased ticket price and an airlines' ability to manage its cost structure in response.

The addition of a cost of carbon adds an additional volatility, or 'turbo boost' to the price of kerosene which will increase further the case for fuel efficiency for airlines.

Although airlines initially are allocated ~80% of their allowances for free, the overall impact of the EU ETS on European airlines' total profit pool is uncertain. For certain routes, for example short haul leisure, high levels of price-elasticity of demand and competition will mean that airlines will struggle to pass through the additional cost of carbon and players will be exposed to the additional cost, with the level of additional pass-through of cost being set by the most efficient player in the market, and less efficient players experiencing a reduction in margins.

On less price-elastic and competitive routes such as long haul business, some airlines may be able to pass through higher proportions of the total cost of carbon and should be less exposed, and could even gain in profitability in the short term, due to the free allocations of allowances that airlines receive.

Whilst the effect on the overall European airline profit pool is uncertain, it is likely that those airlines that are more efficient will do relatively well out of the EU ETS and will be able to achieve profits between 20-40% higher than the average based on improved energy efficiency performance. Those that are less efficient could see profits fall by 20-40% below the average, based on a cost of carbon of €25-€50.

5 Additional potential policy measures to reduce airline emissions

- Further policy measures, beyond joining a cap-and-trade scheme, may be necessary to cut airlines' emission growth over the medium to long term. The current design of the EU ETS is unlikely to be the airlines' regulatory 'end-game'.
- Additional policy measures to further cut emissions growth in airlines over the medium to long term could potentially include:
  - airlines to pay for damage due to non-CO_2 emissions
  - increased tax to help fund technology innovation
  - airports or regulators to impose minimum environmental standards on aircraft
  - supply or demand management measures including modal shift incentives (e.g. high-speed rail), and additional taxes or limiting growth of runway capacity.

This Chapter considers policy measures (beyond cap-and-trade schemes such as the EU ETS) that policy makers might consider to accelerate energy efficiency or low carbon fuels, or measures that policy makers might introduce to reduce growth in air travel.

The UK Government has already set out a policy objective that UK aircraft operator GHG emissions in 2050 should be no larger than in 2005. The Committee on Climate Change expects that all developed countries will ultimately set the same goal[34].

Indeed the International Air Transport Association (IATA) recently went further than this, stating as an 'aspirational goal' that aircraft operator emissions in 2050 should be 50% below their 2005 level, although this also requires the purchase of offsets[35]. Getting aircraft operator emissions to hit either of these targets is likely to require further policy measures.

Airlines to pay for damage from non-CO_2 emissions

Policy makers may in future cause airlines to internalise the cost of their non CO_2 greenhouse gas emissions. Although the science is complex, there is some agreement that the impact of airlines' non-CO_2 emission is significant.

European Union policy makers have scoped out the potential for a 'carbon multiplier'[36] which includes the global warming impact of emissions above and beyond CO_2. This could significantly increase the cost of emissions to airlines. This is supported by the UK's Committee on Climate Change which has called for 'early introduction' of measures to reduce NOx emissions.

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[34] Committee on Climate Change, 'Advice on a Framework for Reducing Global Aviation Emissions', 9 September 2009.

[35] International Air Transport Association, Press Release, 'Airlines present climate change proposals to heads of governments', 22 September 2009; see also, International Civil Aviation Organisation, Working Paper, 'High-level meeting on international aviation and climate change', Montreal, 7-9 October 2009.

[36] CE Delft, 'Giving Wings to Emission Trading: Inclusion of Aviation under the European Emission Trading System (ETS): Design and Impacts', July 2007, Report for the European Commission, DG Environment, No. ENV.C.2/ETU/2004/0074r, p.4.; see also, Fahey, David W., 'The use of non-CO_2 multipliers for the climate impact of aviation: the scientific basis', Workshop on Aviation and Carbon Markets, ICAO Headquarters, Montreal, Canada, 18-19 June 2008.

Increased taxation on airlines to help fund industry R&D and other measures to tackle climate change

As noted in Chapter 5, the airline industry's long-term growth prospects critically depend upon some combination of a breakthrough in biofuels and step change in aircraft efficiency via more radical aircraft design, in order to achieve total industry emissions to 2050 that are no greater than 2005 levels.

Some commentators[37] suggest that the industry currently is not sufficiently incentivised to fund the required level of R&D in either biofuels or aircraft design. In the case of biofuels, this is partly caused by a lack of clear incentive for aeroengine manufacturers and a lack of expertise for airlines. In the case of aircraft design, the benefits of long-term breakthroughs may not always accrue to the manufacturers that contribute most to the research, as the intellectual property of these inventions can often 'leak' to other players. In each case, at least some government-funded support is likely to be necessary.

Further, international aviation, as well as maritime shipping, has often been raised as a potential source of international funding for a global fund to tackle climate change. Such a fund could be used to help fund developing nations' climate change mitigation (emissions reduction) programmes or their need to invest in infrastructure adaptation to cope with the inevitable 2°C rise in temperatures that is anticipated to take place, even with a strong effort to tackle climate change.

The most likely source of any such increased revenue is from the sale of carbon allowances in an emission trading scheme. This likely puts at threat the current proposed level of 82% free allocations in the EU ETS. This appears even more likely given that the free allocations could see some parts of the sector profiting, as suggested by some commentators (see analysis in Chapter 5). The UK Committee on Climate Change has highlighted to the UK Government the need to move to full auctioning, rather than free allocation of any credits to the European airline industry and the potential to use revenues to fund both biofuels and aircraft design R&D, as well as global adaptation.

Airports or regulators to impose minimum environmental standards on aircraft

In the future, it is possible that airports will be allowed to prohibit certain aircraft on the grounds that they are too polluting. A prohibition might be possible in the future, if ICAO (the International Civil Aviation Organisation) becomes more flexible in the way that it interprets the Convention on International Civil Aviation. It is currently interpreted as meaning that airports cannot use environmental pollution as a means to prevent an aircraft from landing at the airport. This policy could be further extended to a global or regional standard on maximum CO_2 emissions for new aircraft.

[37] Committee on Climate Change, 'Advice on a Framework for Reducing Global Aviation Emissions', 9 September 2009.

Consumption (demand or supply) management

If technical solutions cannot be found to reduce the carbon intensity of flying, then ultimately consumption will need to be reduced. This can involve either managing demand or supply of aviation services.

The main ways in which governments might manage demand would be through either 1) pricing or 2) restricting the supply of the necessary infrastructure that supports aviation services, i.e., limiting growth in new runways and terminals, or 3) a cap on the emissions of the industry, with limited recourse to purchase offset allowances.

i) Reduce demand – modal shift incentives

Demand for air travel can be reduced by improving the quality (e.g. speed) and availability of substitute rail services. This could encourage people to switch from travelling by plane to travelling by train. Short haul airline traffic could progressively be shifted onto high-speed rail, if high-speed rail services were provided, and if travel by rail was economic at the point of use.

ii) Reduce demand – taxation

Air traffic taxes already exist and obviously have some effect on demand, although at current levels, this may be limited. Travellers departing the UK by air, since 1 November 1994, have had to pay an Air Passenger Duty. The current duty on short haul flights out of the UK is £10 per passenger and rose to £11 per passenger in November 2009. The Air Passenger Duty currently raises about £2 billion a year.

The introduction of CO_2 pricing will further increase the total price of air travel and will have a further effect on demand. Again, however, this may be quite low given that airlines are likely to be able to purchase credits at the prevailing market cost of CO_2, which is not expected to rise above €50/tonne CO_2 over the next decade. As demonstrated in Chapter 4, this will have some impact on ticket price – perhaps ~5-6% on average. Governments may be tempted, therefore, to raise additional taxes on air travel to help to reduce growing demand.

iii) Reduce supply – reduced infrastructure planning permissions

Rather than reduce demand, which may be politically unpopular, governments could seek to limit the availability of aviation infrastructure through restricting permission to expand runway capacity or take-off and landing slots. This can itself be aligned to other interest groups that may be against the development of additional runways due to environmental concerns such as air pollution and noise. In the UK, the Committee on Climate Change has been asked to review the implications of further runway expansion and appropriate policy levers for the UK Government's 2050 target of an 80% reduction in greenhouse gas emissions. The report, due on 8 December 2009, may comment on the compatibilty with long-term climate change targets of development of runways, given the 'lock-in' effect it would have, potentially requiring the infrastructure to be under utilised over its lifetime to meet climate change objectives.

iv) Reduce supply – limited offsets

A further way to manage aviation's long-term emissions would be to impose a cap on airline emissions, but with a limited ability to offset with credits from other industries or other countries. The UK Committee on Climate Change has noted that even if airline emissions in the UK returned to 2005 levels, this would still require approximately 25% of the total allowable emissions in 2050 and would require a 90% reduction in emissions across the remainder of the economy to deliver the overall 80% cut. Given the difficulty of reducing the remainder of the economy's emissions beyond a 90% reduction, it may be necessary to impose a fixed cap on total aircraft operators' emissions which does not permit additional offsets. Tightening limits on the ability to offset emissions may be the long-term policy tool for the industry.

Toward a global aviation deal

This report primarily addresses aircraft operators joining the EU ETS. Over the next few years aircraft operators' emissions are likely to be regulated much more broadly around the world. Either one global aviation cap-and-trade scheme could be created, or aviation could be incorporated into a number of regional schemes which could themselves be linked over the medium term.

There is a possibility that aviation could be included in a 'global aviation deal' following the United Nations Framework Convention on Climate Change Conference of the Parties meeting in Copenhagen in December 2009 (COP 15). IATA has announced that aviation should be part of a global aviation cap-and-trade regime[38]. International aviation and maritime each have some attractive features for a global solution, given that their emissions are primarily in international air and waters and they offer a potentially lucrative source of revenue to help fund global efforts to tackle climate change[39].

A global scheme could be structured as a straightforward tax on greenhouse gas emissions to raise funds, or as a global cap-and-trade scheme. If structured as a tax, the key question would be the level at which a carbon tax might be set. If structured as a cap-and-trade scheme, key questions would be a) the level of cap set for the scheme; b) the extent of access to emission reduction allowances from other trading regimes, such as EUAs or CERs; c) the amount of any free allocations of allowances.

The type of analysis set out in this paper in the case of airlines entering the EU ETS could be similarly applied to other cap-and-trade schemes, although different parameters would yield different results.

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[38] International Air Transport Association, Press Release, 'Airlines present climate change proposals to heads of governments', 22 September 2009; see also, International Civil Aviation Organisation, Working Paper, 'High-level meeting on international aviation and climate change', Montreal, 7-9 October 2009.

[39] The British Chamber of Shipping on 23 September 2009 recommended that shipping should be included in a global carbon trading regime; The Times, p.42, 24 September 2009.

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