Fuel and air transport

A report for the European Commission

prepared by

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This report provides supplementary information to the quarterly and annual reports that Cranfield's Department of Air Transport has provided to the European Commission under contract TREN/05/MD/S07.52077.

The main objectives of the report are:

- analyse the effects a change in fuel price has to the industry players
- assess how the ATM related measures can help in fuel savings
- review the potential for introducing alternative fuel resources
- examine the responses aircraft and engine manufactures are providing in the short and long-term
- assess the regulatory framework (EU, national) on aviation fuel related issues

The study focuses on EU airlines, airports and airspace, although the findings are set in the context of the global aviation industry.

Fuel and air transport

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Volatility in fuel costs, culminating in recent price spikes, impelled airlines to adopt two important short-term tactics: one to increase revenues by applying fuel surcharges, the other an attempt to iron out volatility by adopting increasingly complex hedging mechanisms. Longer term strategies aim to improve fuel efficiency, not simply to control costs but also in response to environmental imperatives.

Fuel surcharges on scheduled air fares were introduced by some major carriers in 2004. They have been implemented enthusiastically by most network airlines in Europe, although low-cost carriers have often preferred to recover costs through airfares and the generation of ancillary revenues. The surcharges have increased in scope and scale with increases in the fuel price. They can be modulated by sector length and class of travel. British Airways' system of surcharges has changed from a blanket GBP2.50 per passenger in May 2004 to a current system where a business-class passenger can be charged an extra GBP133 for a long-haul flight. Analysis suggests current surcharges can generate up to 50% of the nominal cost of fuel.

Fuel hedging attempts to manage fuel price risk. The complexity of hedging operations has increased with the sophistication of financial instruments available. Airlines are not restricted to simply assuring fuel will be delivered at a known price in the future, but may use a combination of financial derivatives to protect themselves from locking into fuel prices which may prove disadvantageous. Most European airlines have adopted hedging mechanisms to a greater or lesser degree in recent years. Dollar revenues give some European airlines an element of protection from the concomitant risk of exchange rate movements, but other airlines may employ additional hedging to protect against such movements.

Other short-term to medium-term responses by airlines focus on increasing fuel efficiency through improved operational profiles, while enhancement of aerodynamic performance (e.g. through retrofits of winglets and riblets) can reduce fuel burn. However, results here are limited to relatively small, one-off improvements.

Medium-term and longer-term reactions from airlines and their airframe and engine suppliers centre on increasing the fuel-efficiency of operations and developing renewable sources of fuel, while regulatory initiatives increase the pressure on airlines by placing them within the European Emissions Trading Scheme (ETS).

The greater share of efficiency gains in the past has come from improved engine performance, but gains from available technology have been slowing and it will take radical changes to match past trends in fuel efficiency. Engine manufacturers offer the prospect of technology enhancements creating fuel burn reductions of around 4%, and future developments such as the open rotor could offer up to 20% improvements.

Renewable fuels decouple fuel costs from the price of oil, reduce dependence on petroleum and are more carbon neutral than fossil fuels. Second generation bio-fuels, such as algae, do not compete for land and water resources with food crops and are favoured because of the relatively high oil yields predicted.

The EU ETS will be introduced in 2012, initially capping airlines' CO_2 emissions at 97% of their average annual levels between 2004 and 2006. Airlines producing emissions above this level will be required to acquire permits. Some protection is offered to new entrants and fast growing airlines.

1 Trends in price and efficiency

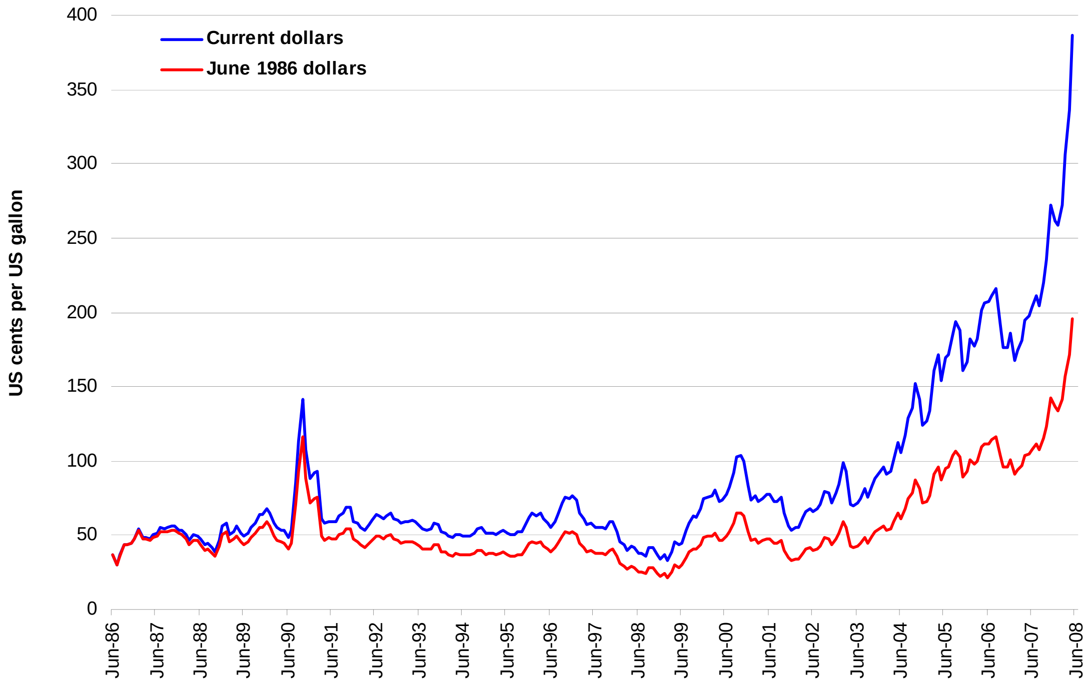
1.1 Past trends in aviation fuel price

The evolution of the spot prices for kerosene from June 1986 till June 2008 is shown Figure 1. The previous inflation adjusted (1986) spike of 115.8 US cents per US gallon in October 1990 was exceeded first only in October 2007. The 1990 spike was mainly attributable to the first Gulf War. The fuel price rose to 114.5 cents per gallon in October 1990, between the time of the Iraqi invasion of Kuwait in August 1990 and the start of the allied attack in January of the following year.

After the terrorist attack on September 11 in 2001, with demand falling, the US jet fuel price dropped by 15% from 82.2 cents per US gallon to 67.8 cents per US gallon in two months. However, it has been gradually increasing after hitting a post 9/11 low of 55.3 US cents in December 2001 and has risen dramatically to 329.2 cents in April 2008: a six times increase in seven years.[1]

This rise has reflected continued world-wide economic growth, and significantly increased demand for oil in emerging markets.

Figure 1: Spot kerosene prices (average Rotterdam and Singapore), 1986 to 2008



Source: US EIA & Department of Labor

The Energy Information Administration forecasts in June 2008 gave a reference case and a high price scenario. Figure 2 shows their reference forecast prices falling from their current high levels to around USD70 per barrel in 2015, then increasing once

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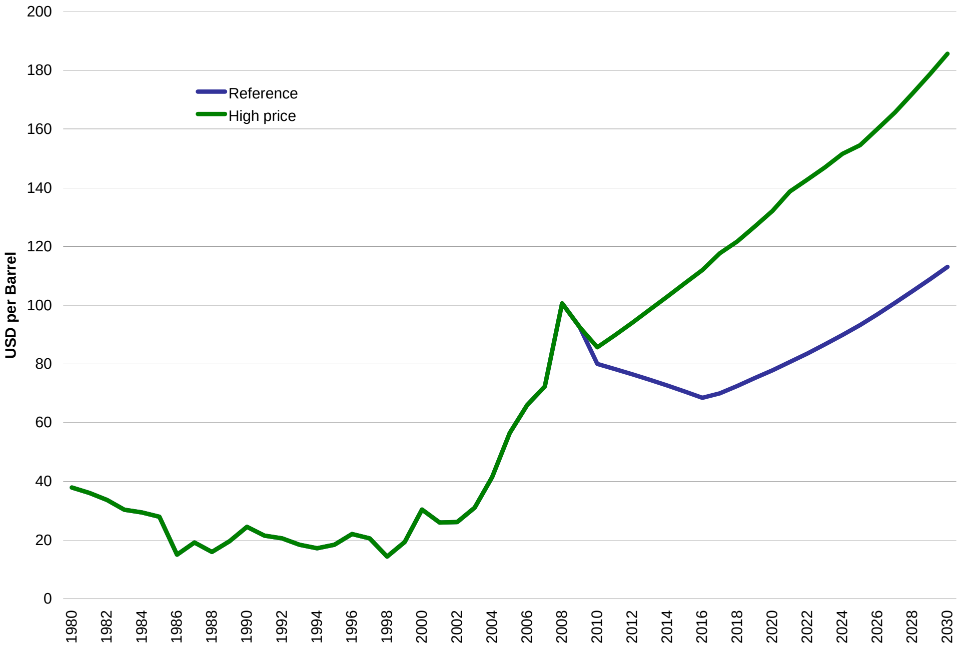
[1] http://tonto.eia.doe.gov/

more to USD113 per barrel by 2030. However, in the high price case, the fuel price will be USD186 per barrel at current prices in 2030, i.e. 65 percent higher than that of the reference case.

Figure 2: World oil price forecasts



Source: Energy Information Administration (2008) International Energy Outlook 2008, June 2008

IATA is using two scenarios for its short-term (12-18 months forward) financial forecasts: the May 2008 futures curve and a consensus forecast. The first suggests a price of USD120 per barrel by January 2010, while the second a fall to just below USD90 by the same month.[2] The AEA are estimating average prices over 2008 to range from USD109 to 120, with Goldman Sachs predicting a range of USD150 to 200 over a horizon between one year and two years from May 2008.[3]

Figure 3 depicts the contrast between the US kerosene jet fuel prices and US gallon consumption levels by US airlines from 1975 to 2007. Until 2003, there seemed to be an interesting relationship between the indices of jet fuel price and the fuel consumption by US airlines: as the fuel price index touched the fuel consumption line, fuel price started to increase again and before fall once more after two or three years. However, since 2003 this loose relationship has broken down as fuel prices have increased up to more than three times.

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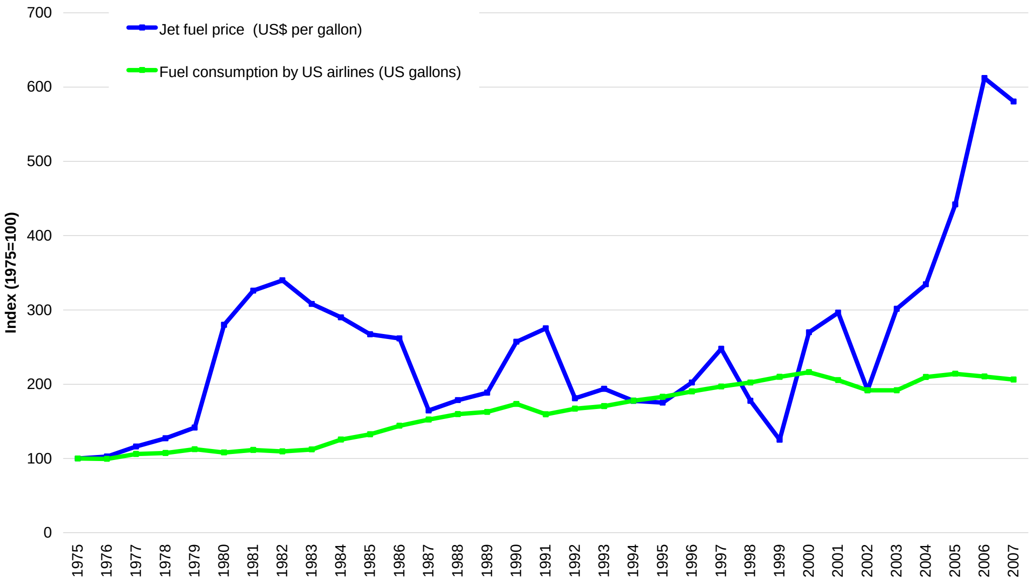
[2] IATA Financial Forecast, June 2008.

[3] AEA, State of the Industry, 29 May 2008

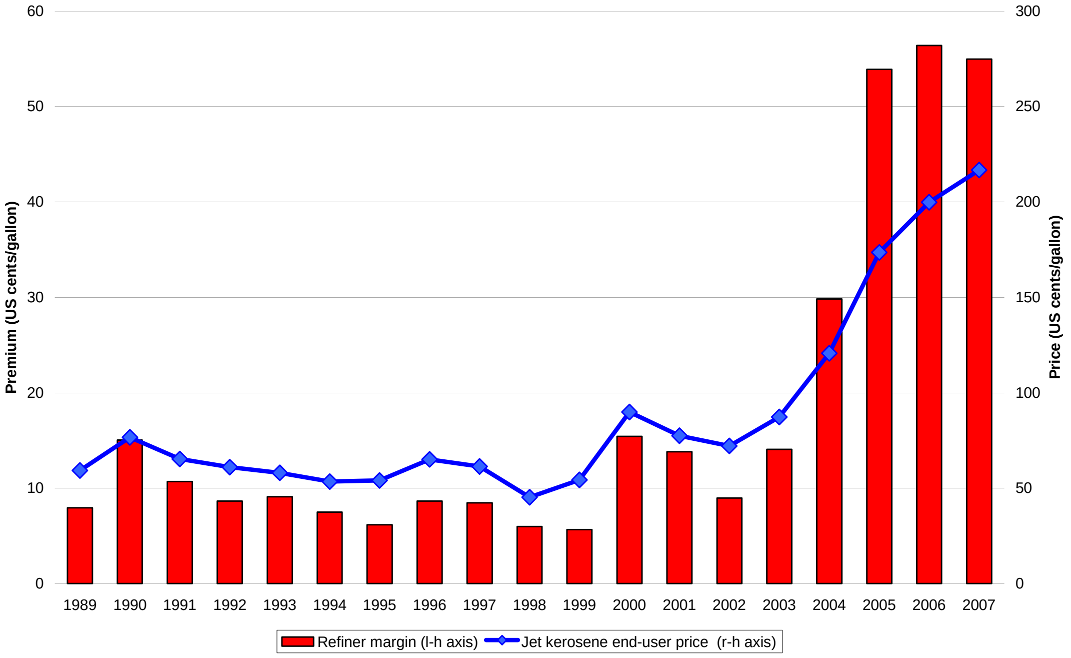
Figure 3: **US kerosene jet fuel price and consumption, 1975 to 2007**



Source: Energy Information Administration (2008) and US Air Transport Association (2008)

This breakdown in the relationship of fuel price to airline fuel demand is also demonstrated in the movement of the crack spread (the difference of kerosene and crude oil prices). Figure 4 shows how the crack spread has widened considerably since 2003.

Figure 4: **US jet kerosene retail versus crude oil prices (crack spread)**



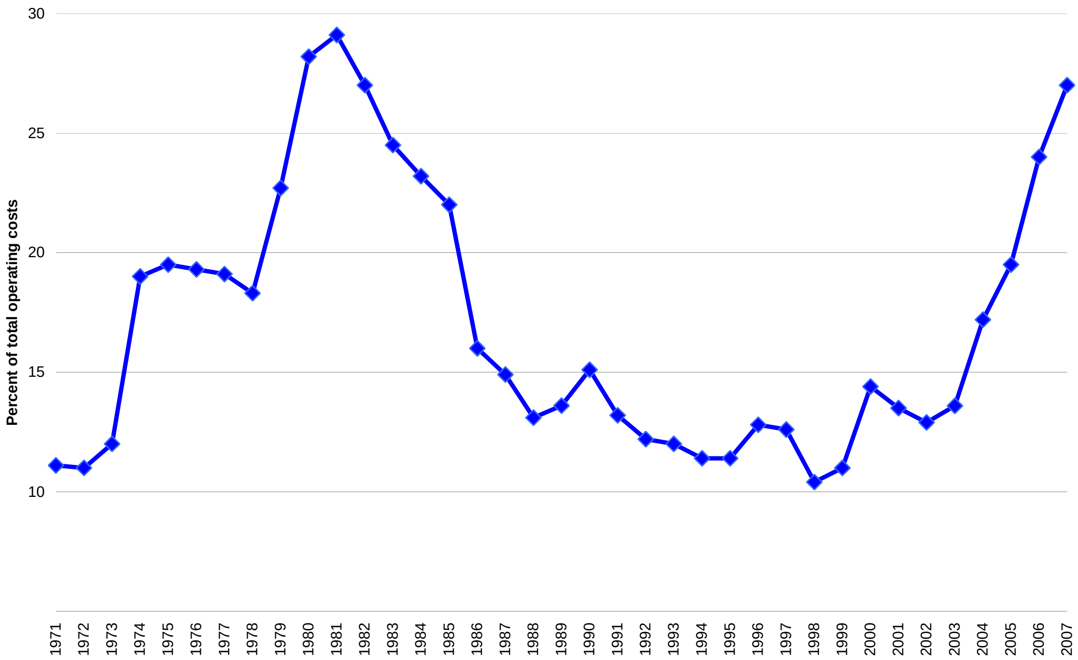
Source: US EIA

Morrell and Swan note that a wider divergence of jet aviation fuel prices from crude prices tends to occur at times of greater volatility in crude prices.[4]

The impact of fuel price volatility on airlines depends on whether they have adopted a fuel-hedging strategy or not. Among European airlines in 2008, KLM/AF and Lufthansa have strong hedging positions with 78% and 85% of fuel hedged respectively. In contrast, easyJet has only 40% of its fuel requirements and Ryanair only 3% of its fuel requirements hedged for the same year (see section 2.2).

The rise of fuel prices has increased its proportional contribution to airline costs. Fuel costs used to represent the second largest part of airlines' operating cost after the personnel costs. The situation has been reversed since the fuel price rose rapidly from 2004, and other costs, especially distribution, have declined or increased only slowly. Fuel represented less than 14% of total operating costs in 2003, but rose to more than 26% in 2007 (Figure 5) with the proportion likely to be even higher in 2008.

Figure 5: World airline fuel cost as percent of total operating costs



Source: ICAO to 2006, IATA estimates 2006-07

1.2 Fuel efficiency trends

The need for airlines to be more fuel efficient will be driven in the coming years both by high fuel prices and environmental taxes or caps. Past trends in fuel efficiency vary considerably depending on the measure and the period chosen. However, there are few forecasters predicting future changes in efficiency of greater than 1-2% a year.

In a 2001 paper entitled 'Historic and future trends in aircraft performance, cost and emissions' Lee and others identified that fuel efficiency per RPK reductions between 1959 and 1998 came from better specific fuel consumption (57%), improved lift to

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[4] 'Airline jet fuel hedging: theory and practice', Peter Morrell & William Swan, *Transport Reviews 26(6)*, November 2006

drag ratio (22%), load factor (17%) and seating capacity (4%).[5] The first two are related to aircraft selection, the latter two to business models and service standards. The selection of larger aircraft could be in response to increasing traffic or through network and other industry structural changes.

The paper mentioned above also reviewed the trend of past aviation fuel efficiency from the IPCC work. Over the past forty years, efficiency has improved by 75% or 3.4% a year. The authors stress that only jet aircraft were included, but if the trend goes back further and the most efficient piston-engined aircraft included, little improvement is discernable over the longer timescale. However, the jet era has brought benefits of speed and comfort that today's market would be unlikely to sacrifice.

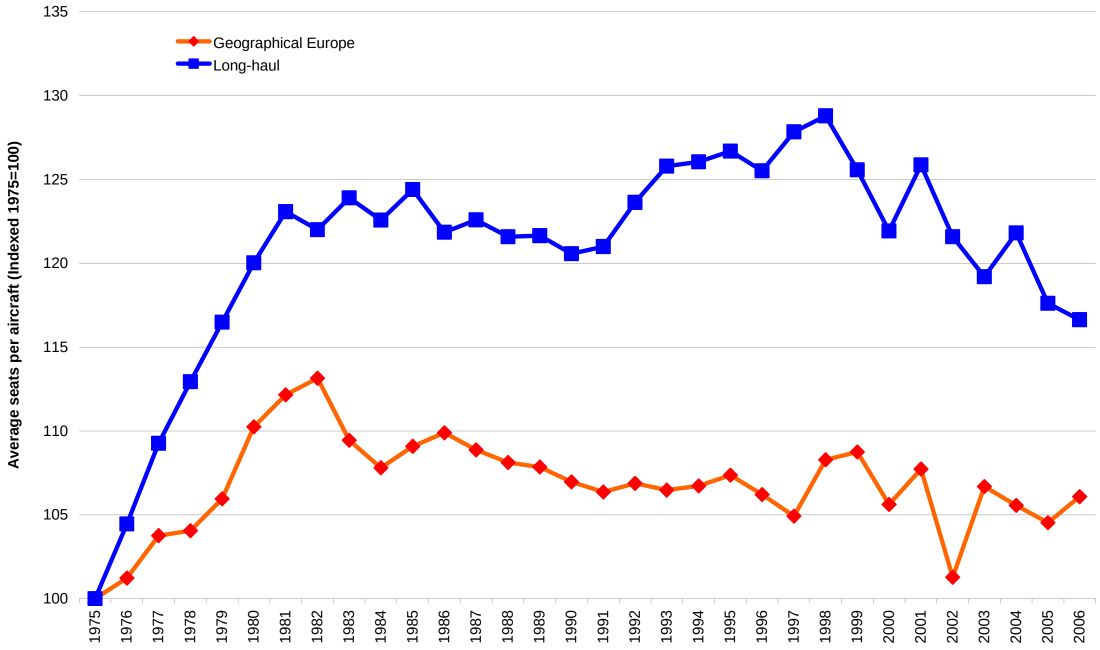
Table 1: Past trends in fuel efficiency

	MJ/Available seat-kms
1960 to 2000	-75%
1960 to 1980	-67%
1980 to 2000	-26%

Source: Lee et al (2001)

From Table 1 it can be seen that much of the gain had already been achieved by 1980, with 5.4% annual improvements (in terms of annual reduction in fuel or energy equivalent per seat-km) over the first twenty years. Over the second twenty years, the improvement was only 1.4%. It should be added that the first two decades coincided with a large increase in average size or capacity of aircraft operated while the more recent period was characterised by a levelling off or even decline in average size.

Figure 6: Evolution of average aircraft size in AEA long-haul and short-haul fleets



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[5] in Annual Review of Energy Environment, 2001, 26:167-200

Figure 6 looks more closely at the way AEA airlines' fleets have changed over the thirty years since 1975. In the first five or six years of that period, long-haul and short-haul fleets increased significantly in terms of average seat capacity per aircraft. However, this initial increase was much greater within long-haul fleets, and the trend upwards in size continued to 1998, while capacity within short-haul fleets fell back sharply after the 1982 peak in size, and the overall trend to smaller aircraft has continued to the present day.

An article in the ICAO Journal (August 1992) reported a 2.5% a year improvement in fuel consumed per ATK between 1983 and 1990, but more recent estimates from IATA (Environmental Review, September 2004) show a somewhat lower average annual reduction of 2.2% between 1994 and 2003. Surprisingly the latter source reported a smaller annual improvement in fuel used per RTK (1.9% pa), even though gains from load factor increases would have been achievable over this period.

Fuel efficiency can be measured in terms of units of traffic (passenger-kms or revenue tonne-kms) or capacity (seat-kms or available tonne-kms). The first is derived from the second by applying a load factor. On international scheduled flights load factors have increased from around 66% in the early 1990s to almost 80% in 2006, but an attainable upper limit of 85-90% will restrict future improvements. Whichever metric is used, forecasters expect a slowing down in improvement.

Table 2 shows how efficient on average the flights of the major EU airlines were for their 2007 financial years. Efficiency is expressed per 100 passenger-km because this is how most airlines report (a better measure for both widebodied and narrow-bodied aircraft would have been revenue tonne-kms). This data covers system-wide flights and their respective average sector distances are shown for comparison. Sector length is just one of the factors that might explain the variation. Others would include age and types of aircraft operated, seat density, passenger load factor, cargo loads and congestion.

For example, British Airways appears relatively inefficient in the sample, but operates from a congested main base, with somewhat older aircraft than some of the other airlines. SAS operates over a shorter average stage and still has quite a few older aircraft. The two low-cost airlines have very new aircraft, high seating densities, high load factors, and also carry no cargo.

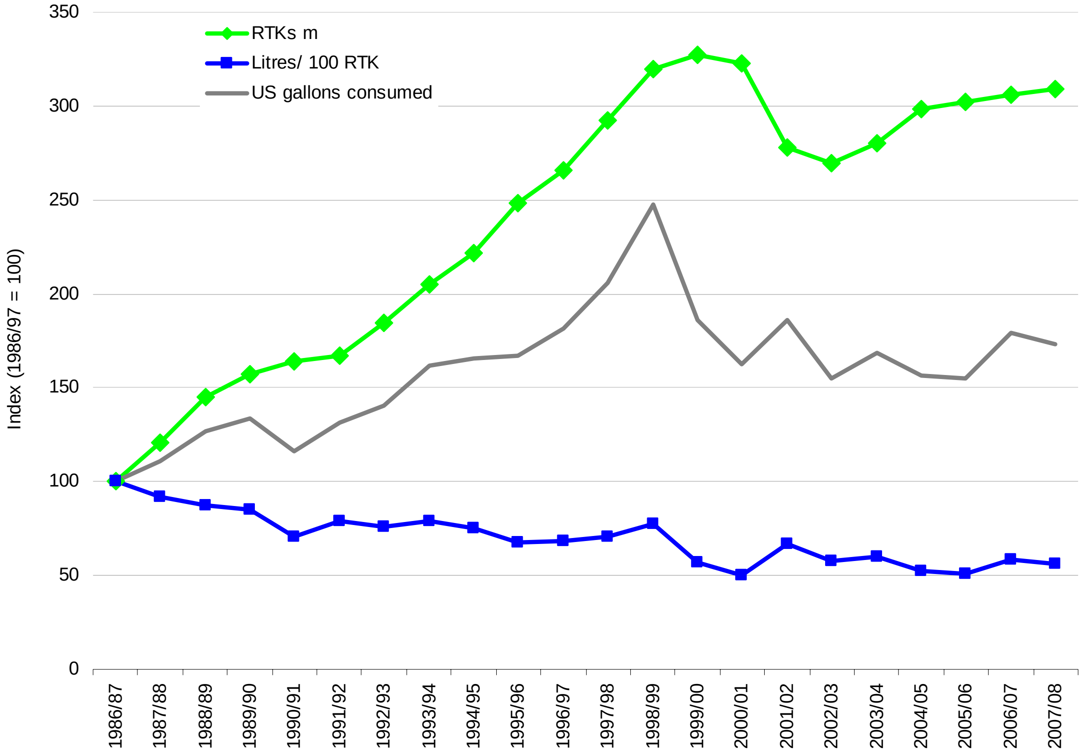
Table 2: Litres per 100 passenger-kms, FY2007

	Fuel efficiency	Sector km
Ryanair	3.21	1,065
easyJet	3.82	1,020
Air France-KLM	3.90	1,661
Iberia	4.02	1,401
Lufthansa	4.32	1,281
British Airways	4.41	2,195
Austrian	4.67	1,058
Finnair	4.89	1,382
SAS	5.20	813

* converted from RTKs using 100kg per passenger

Source: Airline annual and environmental reports

Figure 7: British Airways fuel efficiency and traffic



Source: BA Annual Reports

Figure 7 demonstrates how British Airways managed to increase fuel efficiency in the final decades of last century. However, it is clear that following this initial period, during which much of the fleet was upgraded to more fuel efficient aircraft and the route network began to focus on long-haul services, it has been less easy to increase fuel efficiency. Over the twenty-one year period to 2007/08, British Airways' traffic increased at an average annual rate of 5.5%, while fuel efficiency improved by 2.7% a year. It can also be seen from Figure 7 that following the two periods of recession, fuel efficiency deteriorated, reversing the previous trend. This is likely to have been caused by the grounding or lower utilisation of larger aircraft that are inherently more fuel efficient aircraft.

Many fuel efficiency ratios are reported in terms of passenger traffic or capacity only. This is especially true of US sources, where little lower deck cargo is carried by the passenger airlines; it is also true of the major aircraft manufacturers in spite of their selling widebody aircraft with significant lower deck cargo capacity. Omitting cargo payload distorts the analysis of longer term past trends in aircraft efficiency with the increasing importance of widebodies especially on long-haul sectors.

The future

Aviation Strategy examined various scenarios of air traffic and emissions growth (What happens to traffic growth if emissions are capped, December 2006). With aircraft replaced after twenty-four years, fuel efficiency improvements of 1% a year were examined for a base case, as well as more optimistic scenarios of 2% and 3% a year. These improvements equate to the aircraft introduced for replacement and expansion being of between 24% to 72% greater fuel efficiency than the aircraft they replace.

The bottom end of this range looks the most realistic in the light of American Airlines' accelerated replacement of its three hundred or so MD-82s with 25% more fuel efficient B737-800s (Wall Street Journal, 29 March, 2007, A12). Assertions that 'the A320 and Boeing 737-300, for example, transport twice as many revenue passenger miles per gallon of fuel as the DC-9 and earlier versions of the 737A' are not comparing like with like, the former aircraft being of much larger capacity (see Eurocontrol: 'Forecasting civil aviation fuel burn and emissions in Europe', Interim Report, EEC Note No. 8/2001, May 2001). New aircraft bring efficiency improvements both from the application of new technology to the same sized aircraft and also the potential scale effects of moving to larger aircraft using existing technology. The B737-800s offer only 9% more seats per aircraft, so most of the gains are likely to have come from new technology.

Another airline facing the replacement of relatively fuel inefficient aircraft is SAS: they have 82 MD-80s with an average age of seventeen years. SAS report that these aircraft are reliable and offer a similar level of unit costs to their much newer B737s with fuel price levels of up to 2.5 times the average price in 2006 (SAS Group Annual Report, 2006, p.27). SAS studies showed that replacing these aircraft with the best technology available (i.e. A320/B737) in the next few years giving 15-20% better fuel efficiency would give a much smaller environmental benefit than waiting to 2013 to 2015 when a further increase in fuel efficiency of 15-20% is expected (SAS Group Sustainability Report, 2006). This reasoning is based on the new generation of short/medium haul twin-jets having between 30% to 40% better fuel burn than the MD-80s. Given the expected life of these investments of 20-25 years, this would only give an average fuel efficiency improvement of 1-2% a year.

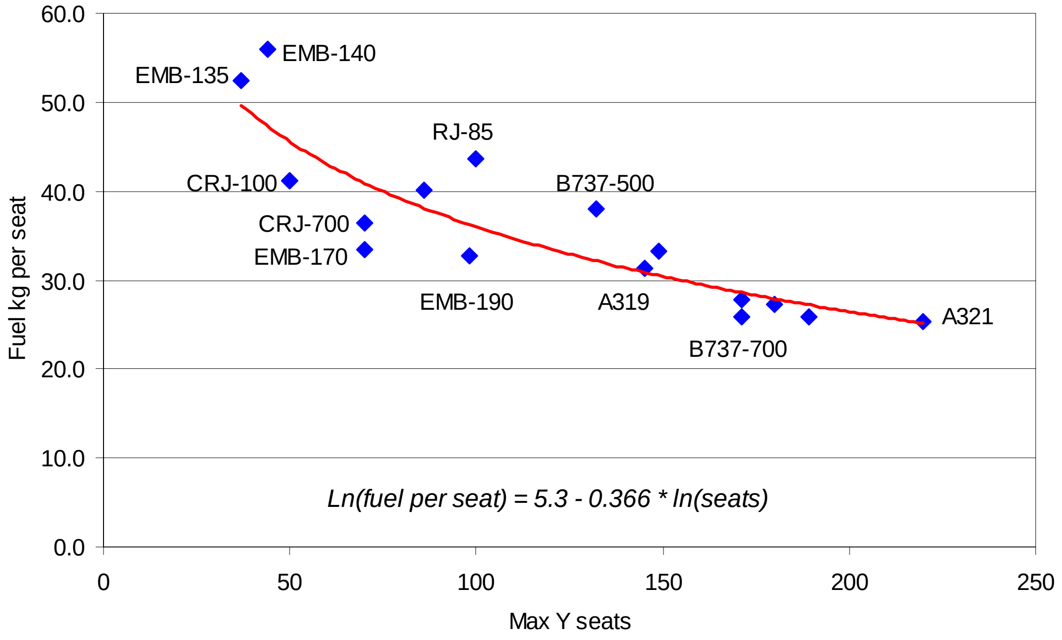
The Department for Transport in the UK summarised other forecasts of rates of fuel efficiency: IPCC in 1999 assumed a 1.3% pa improvement from 2000 to 2010, falling to 1% pa from 2010 to 2015. OXERA in a 2003 EU study assumed 1% a year to 2030 in the absence of any additional economic incentives. Arthur D Little in a 2000 study for the UK Department of the Environment, Transport and the Regions was more optimistic with a 2% pa improvement to 2030, including operational changes (Department for Transport: Aviation and global warming, London, January 2004).

The IPCC forecasts may look pessimistic, but Table 1 above shows the declining trend and suggests that the average rate over the past twenty years might not be achievable in the future. On the other hand, continued high fuel prices combined with a polluter pays mechanism might provide sufficient signals to industry to make a technological step change.

Efficiency in terms of emissions per ATK can be captured by improved operational performance or by applying new technology to aircraft of a similar size. Replacing an older aircraft at the end of its 20-25 years' life in passenger service would give a one off improvement in fuel efficiency of 20-25%, which equates to around 1% gain per year. Reducing aircraft life in service does not add much to this: easyJet proposed the premature retirement of 678 older jets operated by EU airlines on the basis that they were all more than twenty-two years old ('How to green Europe's skies', posted on www.easyjet.com, April 2007). This gave a one-off fuel and emissions reduction of 4-5%, neutralising only one year's traffic growth. A precedent for such measures is the compulsory withdrawal of noisier Chapter 2 aircraft, but the economic penalty incurred by EU airlines might be significantly greater from the easyJet proposal.

Increasing the fuel efficiency trend line above that of the past twenty years might happen if airlines move to larger aircraft once again and reap the benefits of fuel economies of scale. On long-haul sectors this might mean moving to A380 and B747 type aircraft, but these giants tend to compromise fuel benefits to meet noise and airport operating restrictions (e.g. wingspan). However, growing use of composites in the B787 and A350 should give these smaller types very attractive fuel burn.

Figure 8: **Fuel efficiency versus aircraft seat capacity: short/medium haul**



Source: Presentation to ATRS Conference, Berkeley, USA, June 2007, Peter Morrell

On short/medium hauls the hub system gives little opportunity for any trading up without compromising feed frequencies. But the growing share of low-cost airlines with their higher seat densities and somewhat larger aircraft will push up the average. At the shorter haul regional end of the spectrum the replacement of the smallest regional jets by turbo-props of a similar size would make these operations much more fuel efficient, without sacrificing much in sector times. The problem with this speculation is that there are other factors determining network shape, fleet mix and aircraft size.

As Table 3 shows, average fuel efficiency of UK airlines representing the three business models (network, charter and low-cost) varied considerably.

Table 3: **Fleet fuel efficiency for short/medium haul fleet, 2004**

	RPKs/US gallon	% industry	ASKs/US gallon	% industry
British Airways	76.8	91	118.1	91
easyJet	117.5	140	138.3	107
Britannia/Thomsonfly	147.6	176	164.0	127
Industry (IATA)	84.0	100	129.2	100

Source: UK CAA and IATA

The capacity measure (ASKs per gallon) was dependent on average sector lengths and size of aircraft operated (Thomsonfly benefits from this), seating density (easyJet gains here) and type and age of aircraft. The latter is probably the least important factor of the three. The concept of best industry practice in this regard needs to be applied within each model and adjusted for sector length.

1.3 Summary and conclusions

With traffic and capacity expected to grow at between four and five percent a year, it is easy to construct scenarios where aviation's future share of global emissions will be 20% to 50%, taking a long enough time horizon and optimistic assumptions on reductions in other sectors. None of these scenarios assume increases in fuel efficiencies of much over two percent, which means that emissions are likely to increase at over two percent a year for the next twenty to thirty years.

Fuel efficiency projections are usually based in some way on past experience, taking into account the slowing in gains available from new technology. The largest part of the benefits over the past forty years has come from improved engine performance, which cannot be replicated in the future at least without radical changes which will have costly implications in such areas as speed, airport infrastructure and noise.

The current dilemma of two major airlines in replacing their short/medium haul jets illustrates the need to allow for the fact that aircraft will be in the airline's fleet for twenty to twenty-five years. Current replacement aircraft only offer 15-20% better fuel burn, or nearer one percent a year over the lifetime of the aircraft in service.

Other fixes such as early retirement of older, less fuel efficient aircraft and operational improvements make valuable one-off contributions, but are more limited when considered over the longer term.

Some gains might also be achieved by moving to larger aircraft and higher seating densities (and higher load factors if traffic based efficiencies are used). However, most long-term forecasts do not expect much increase in average seats per aircraft worldwide. Apart from the replacement of the smallest regional jets by turbo-props of the same capacity it is difficult to see any major changes in networks without very significant price signals.

2 Airline responses in the shorter term

In reaction to increasing fuel prices, there are two broad types of response airlines might make:

- increase the fuel efficiency of operations by adopting procedural and technical modifications and developments,
- minimise the impact in financial terms by adopting strategies such as fuel hedging to manage the risk of hikes in fuel price, and the imposition of fuel surcharges on passengers.

Although the two responses are not mutually exclusive, the financial approach is geared more towards short-term fluctuations in fuel price. Fuel hedging buys a measure of stability in volatile markets, but would have little or no positive effect in stable markets of high fuel price. Fuel surcharges are effective only up to a certain level, beyond which increasing ticket prices would begin to stifle demand.

Industry bodies and some of the major European airlines have published targets for improvements in aircraft fuel efficiency and/or carbon footprint. Among them:

IATA/Lufthansa	+25% improvement in fuel efficiency between 2006 and 2020
Air France-KLM	+7% in energy efficiency of air operations by 2012 (to 3.7 l/RPK)
British Airways	+25% in CO_2/RPK between 2005 and 2025
SAS	+6-7% improvement in fuel efficiency between 2008 and 2011
Virgin Atlantic	+30% improvement in fuel efficiency between 2007 and 2020
easyJet	+3% improvement in fuel efficiency between 2008 and 2011

2.1 Operational and technical responses

The response by airlines in the longer term will depend on the efficiency and cost of replacement aircraft, as well as structural, other economic and market related factors. Sections 4 and 5 will deal with the longer term. In this section, the focus is more on operational changes that improve fuel efficiency.

IATA listed nine key areas where airlines can improve fuel efficiency in the shorter term (IATA, Environmental Review, 2004):

1. taxi-ing via the most efficient route
2. flying the most fuel efficient aircraft for the sector
3. flying the most efficient routing
4. operating at the most fuel efficient speed
5. operating at the most fuel efficient altitude
6. maximising the aircraft’s load factor
7. minimum fuel to safely complete the flight
8. minimising non-revenue flights
9. maintaining clean and efficient airframes and engines

The Association of European Airlines estimated that the first three measures on IATA’s list could improve efficiency by 18%, but their achievement (and that of items 4 and 5) is largely in the hands of airport and ATC operators. European initiatives in these areas are discussed in the next section.

Commercial considerations will affect items 4 and 6 in the list above, and a reduction in fuel costs may be somewhat offset by increases in other operating costs for many of these areas.

Modifications to aircraft can achieve fuel burn reduction either through improvements in aerodynamic characteristics of the aircraft or through weight reduction. The first involves either fitting winglets or riblets to the wings or upgrading the engine (replacing the engine is unlikely to be a viable option). Retrofitting winglets can give fuel efficiency benefits of between two and six percent for the B737 depending on model and sector lengths operated at a cost approaching USD1m per aircraft including downtime. By early 2008, around 1,500 B737s were flying with winglets saving 150m gallons of fuel a year.[6] Some of these may have been already fitted with winglets when delivered new, but many were retrofitted.

An example of an engine modification is the CFM56 Tech Insertion package. This is available in the form of upgrade kits for the CFM56-7B and -5B engines, and is expected 'to provide operators with lower maintenance costs, improved oxides of nitrogen (NOx) emissions, and better fuel burn' (www.cfm56.com). EasyJet is investing in this for some of its fleet.

Weight reduction reduces fuel burn, and this further reduces the fuel required to carry the weight of the saved fuel. Item 7 above is an example of this, and others include lighter weight seats and galleys and reduced drinking water loads. Iberia reported that it uses a 3% contingency (instead of 5%) in determining fuel reserves, giving them a 200kg per flight saving on its European A320 flights and a 2.5 tonnes saving on a Madrid/Buenos Aires A340 flight.[7] Increased attention is now applied to reducing the weight of in-flight catering, for example replacing glass and even plastic bottles with sachets. Many of these options also involve commercial considerations, whether in terms of seat comfort or loss of in-flight sales revenues.

In 2007 the EU and USA agreed to test 'green approaches' or continuous descent approaches (CDA) on transatlantic routes, with SAS participating in these trials. SAS has been involved such approaches at Stockholm Arlanda and Gothenburg airports, with experience so far indicating an average fuel saving of 150kg per landing (see also section 3.2 below).[8]

British Airways has also taken steps to increase fuel efficiency from operational changes, including:

- refined take-off and landing procedures to make flights more fuel efficient
- fitting new, lightweight seats on some of its short-haul aircraft
- saving 50,000 tonnes of CO_2 over the last two years by flying shorter, more direct international routes including Kazakhstan, China and Brazil

Lufthansa has a similar focus, reporting increased attention to the fuel and fresh water loads on each flight, using lighter seats and galleys, deploying efficiently sized aircraft depending on bookings, flying on optimal routes and at optimal speeds, as well as improving ground processes. It also seeks to optimise the centre of gravity of the aircraft in-flight by pumping fuel between tanks.

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[6] Source: www.aviationpartnersboeing.com.

[7] Presentation by Captain Ricardo Genova of Iberia to the IATA Executive Financial Summit, Paris 11 September 2007.

[8] SAS Sustainability Report, 2007

Air France reports attention to centre of gravity, as well as the shortening of approach paths at Paris-CDG that has been introduced since 2002. Other measures have included:

- the vertical separation minimum has been reduced to 1,000 feet thanks to increased precision in navigation instruments. RVSM has been implemented since 2002 in Europe, and is now being extended to cover other regions of the world. These new standards enable the airline to allocate flight levels that are closer to optimum conditions and to improve the smooth flow of traffic
- taxiing on arrival with one or two engines shut down
- less use of APUs thanks to the available electricity supply at aircraft parking stands.
- individual monitoring of the performance of each aircraft enables Air France to identify fluctuations in fuel consumption in order to take the necessary corrective maintenance.

2.2 Financial responses

Fuel price hedging

Fuel price risk can be managed by airlines in a number of ways:

- Forward contracts
- Futures contracts
- Options, collars, swaps etc

Forward contracts are ‘over the counter’ agreements between two parties whereby one purchases a fixed amount of fuel from the other at a fixed price at some future date. Airline fuel suppliers such as BP Air enter into such agreements, but their tailor-made nature is not a convenient instrument for third parties or speculators. The purchaser also has full counter-party risk.

Futures are better suited to both hedging and trading, since they are usually bought and sold through exchanges that set standard contracts. One party to the contract agrees to deliver to another a standardised quantity of oil at an agreed price (the ‘strike’ price) on an agreed date in the future. These contracts can be easily reversed before due date so that no physical delivery need take place. In fact, according to NYMEX, less than 1% of trades actually result in the delivery of the underlying commodity, in this case crude oil and related products.

The main exchanges offering these contracts are the International Petroleum Exchange (IPE) in London and NYMEX in New York. The former’s future is in Brent crude oil, one contract being for 1,000 barrels. The quality of the oil is assured, and contracts can be fixed for each month up to two years ahead, and then half-yearly to three years out. The liquidity for contracts beyond one year forward declines significantly. A clearing house guarantees the financial performance of contracts with the help of margin requirements.

Options are available in both Brent gas oil and crude at IPE. They are based on the underlying futures and if exercised (there no obligation to do so) will result in a corresponding futures position. Options offer added flexibility over futures, giving holders the possibility to protect themselves against adverse price movements, while at the same time giving them the opportunity to participate in favourable movements. Options (and swaps) can also be taken out with other parties (e.g. approved counter-parties such as banks) in aviation fuel.

Jet fuel is rarely traded on any exchanges and thus must be 'over the counter'. These involve counter-party risk for both sides, and thus financially weak airlines would find it hard to find others willing to take this risk.

More recently airlines have moved toward using combinations of a call and a put option called a collar. The call protects the holder from adverse price increases above its strike price, at a cost of the option premium that must be paid in any event. The holder of this call also writes a put option that limits the advantage it can take of price reductions below its strike price. The total cost of taking the two options is the call option premium paid less the put option premium received. This is popular with airlines since it locks in the price that will be paid for fuel between two known values. A collar limits the speculative risk to a small range of price moves.

Swaps are tailor-made futures contracts whereby an airline exchanges payments at a future date (which can be in jet aviation fuel and could be further into the future than possible through commodity exchanges), based on the fuel or oil price. These could be arranged with a supplier such as Air BP. The airline would buy a swap for a period of, say, one year at a certain strike price for a specified amount of jet fuel per month. The average price for that month is then compared with the strike price, and if it exceeds it the counter-party would pay the airline the difference times the amount of fuel. However, if it were lower, then the airline would pay the difference. They lock in a given price, as with forward contracts.

Table 4: Fuel price hedging by EU airline, FY2008 and FY2009

		2008	2009	2010
Air Berlin	% needs hedged	88%	23%	
	US$/bl price*	84	110	
Air France-KLM	% needs hedged	75%	55%	35%
	US$/bl price	74	80	87
British Airways	% needs hedged	65%	35%	
	US$/bl price	88	100	
Lufthansa	% needs hedged	85%	54%	5%
	US$/bl price	n/a	n/a	n/a
easyJet	% needs hedged	40%	45%	
	US$/bl price*	74	123	
Finnair	% needs hedged	60%	25%	
	US$/bl price	n/a		
Iberia	% needs hedged	47%	0	
	US$/bl price	83		
Ryanair**	% needs hedged	0	80%-90%	
	US$/bl price		124-129	
SAS	% needs hedged	42%		
	US$/bl price	n/a		

*converted from US$ per tonne; ** September-December 2008

Source:ABN-AMRO, 'Feeling for the floor', 9 June 08, updated using airline websites where appropriate.

Table 4 gives an indication of the extent of fuel price hedging by some of the major EU airlines in summer 2008. The years shown are for the financial year which may be calendar year (e.g. Lufthansa), year to end March (Ryanair, BA and AF-KLM) or to end September (easyJet). Where price data is not available it may be because the airline does not wish to release this data, or it could be because the final contract price depends on how the market price evolves, as with collars discussed above. Neither Norwegian nor Sky Europe held any fuel derivative contracts at the end of FY2007.

It should be noted that fuel prices are always quoted in US dollars and contracts with suppliers are also in dollars.[9] This additional dimension of risk is also hedged by many airlines, especially those with limited natural hedges (dollar revenues to offset against dollar expenses such as fuel). This is especially relevant to the recent fall in dollar oil prices the euro impact of which was largely negated by the strengthening dollar. Airline earnings are highly sensitive to assumptions on fuel prices. ABN AMRO estimated that a revision in fuel price assumption from USD110 to USD120 per barrel would reduce European airline earnings before interest and tax for FY2009 by 39%. The impact on low-cost airlines is less than longer-haul network carriers, but their traffic is likely to be more sensitive to price changes.

Fuel surcharges

Many airlines have found the application of surcharges on airfares a useful and flexible way to cushion the impact of increasing fuel costs by recovering some of these costs directly from their passengers. Although a number of low-cost carriers eschew this mechanism to increase revenue, it has been adopted by most network airlines. This means that passengers now incur very significant fuel-related costs in addition to the basic airfare.

Table 5: The evolution of sector fuel charges applied by British Airways

	Short haul		Long haul					
			< 9 hours			**> 9 hours**		
	Economy	Business	Economy	Premium economy	Business & First	Economy	Premium economy	Business & First
May-04	£2.50	£2.50	£2.50	£2.50	£2.50	£2.50	£2.50	£2.50
Aug-04	£2.50	£2.50	£6.00	£6.00	£6.00	£6.00	£6.00	£6.00
Oct-04	£4.00	£4.00	£10.00	£10.00	£10.00	£10.00	£10.00	£10.00
Mar-05	£6.00	£6.00	£16.00	£16.00	£16.00	£16.00	£16.00	£16.00
Jun-05	£8.00	£8.00	£24.00	£24.00	£24.00	£24.00	£24.00	£24.00
Sep-05	£8.00	£8.00	£30.00	£30.00	£30.00	£30.00	£30.00	£30.00
Apr-06	£8.00	£8.00	£35.00	£35.00	£35.00	£35.00	£35.00	£35.00
Jan-07	£8.00	£8.00	£30.00	£30.00	£30.00	£35.00	£35.00	£35.00
May-07	£8.00	£8.00	£33.00	£33.00	£33.00	£38.00	£38.00	£38.00
Jun-07	£8.00	£8.00	£38.00	£38.00	£38.00	£43.00	£43.00	£43.00
Nov-07	£10.00	£10.00	£48.00	£48.00	£48.00	£58.00	£58.00	£58.00
Feb-08	£10.00	£10.00	£53.00	£53.00	£53.00	£64.00	£64.00	£64.00
Jun-08	£16.00	£20.00	£78.00	£88.00	£98.00	£109.00	£121.00	£133.00

Source: Airline websites and news reports

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[9] except the transport and airport supply elements of fuel delivery that are sometimes in local currency.

For example, a passenger making a return trip on British Airways to a long-haul destination such as Bangkok is currently presented with a fuel surcharge of between EUR270 and EUR330, depending on his or her class of travel. Connecting to Bangkok through London from another European airport would bring the fuel surcharge for the journey to between EUR310 and EUR380. Table 5 outlines the way the airline has developed its schedule of fuel surcharges since they were introduced in May 2004.

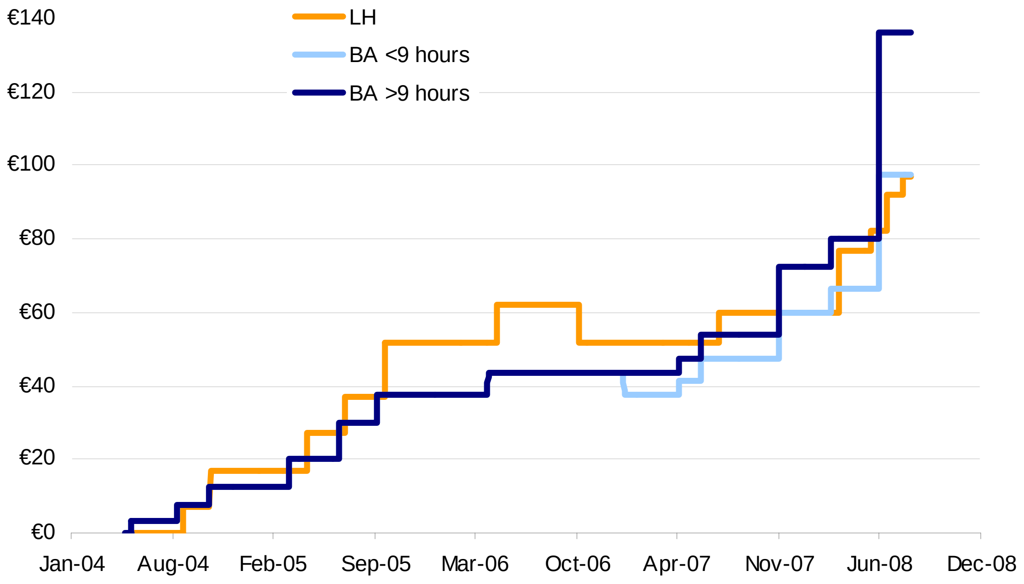
On long-haul services Lufthansa currently passes on to passengers a fee of EUR105 per sector to cover "fuel and insurance". The surcharge within Europe is EUR35. As with British Airways, the surcharge is sector-based, so that intra-European travellers connecting through Lufthansa's Munich or Frankfurt hubs are faced with a surcharge of EUR140 before other unbundled charges are added.

Although fuel surcharges currently represent the largest of the unbundled charges, these additions to the basic fare include not only fuel and security charges but also airport fees and government taxes as well as reservation and ticketing fees. It is an attractive mechanism to airlines for a number of reasons, including:

- the creation of a large fixed element to the price of tickets, allowing the airline to maintain low headline fares
- the means to generate significant contribution to airline costs from passengers travelling on free or reduced-price tickets (e.g. those issued under frequent flyer programmes or under staff travel concessions)
- avoidance of commission payments to travel agents, as these can be calculated on the basic fare, excluding the surcharges.

The only advantage of significance to passengers of unbundled charges is that these are generally returned if the ticket is cancelled, even though the underlying fare is non-refundable.

Figure 9: **Fuel surcharges on Lufthansa and British Airways long-haul flights**



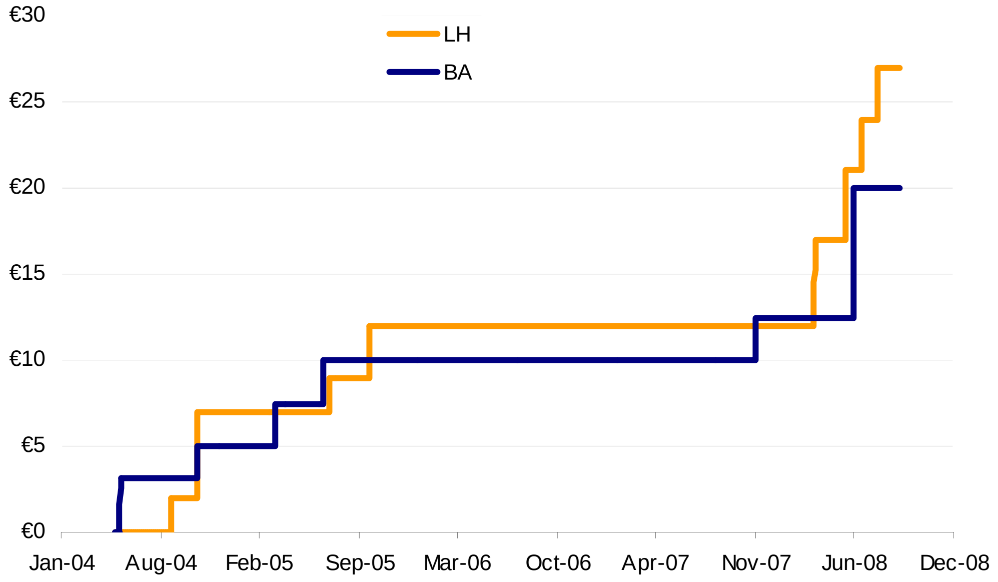
Source: Airline websites and news reports

Figure 9 compares the evolution of fuel surcharges applied by British Airways and Lufthansa to long-haul services. Both airlines began to apply these charges to passengers' tickets in 2004. The initial amounts levied were modest, but have risen steeply to current levels. BA introduced in 2007 an ultra-longhaul charge for flights above nine hours' duration.

Both airlines have increased the surcharge to long-haul economy passengers by an average of around 140% each year since it was introduced.

On intra-European services, Lufthansa's surcharges have grown by an average of some ninety percent a year since they were introduced, compared with British Airway's 60% per year (Figure 10). British Airways have recently refined the surcharge applied to these short-haul flights, increasing it to £20 for passengers booked into business-class cabins, from the £16 economy-class passengers continue to pay.

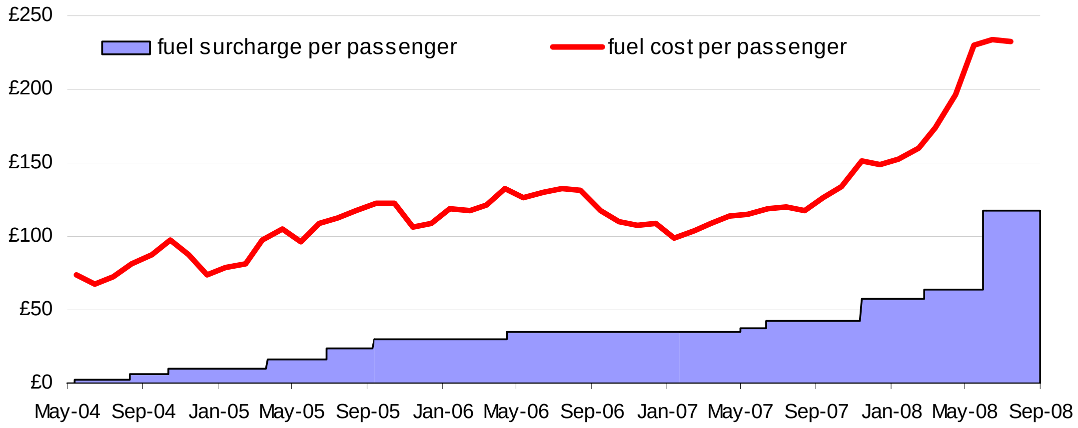
Figure 10: **Fuel surcharges on Lufthansa and British Airways short-haul flights**



Source: Airline websites and news reports

The structure of fuel surcharges has increased in complexity since they were introduced. Airlines generally apply them in bands related to distance flown. British Airways decision to discriminate in the application of charges between classes of travel, noted in the previous paragraph, extends to long-haul services (see Table 5 for details of how surcharges are applied). Higher charges for passengers in premium classes are intended to reflect the allocation of resources in terms of space occupied and additional weight allowances. If the structure of BA's fuel surcharge programme is applied to a typical Boeing B747 operation the cash generated from fuel surcharges can be calculated from the schedule of charges in Table 5.

Figure 11: **Estimates of cost of fuel compared with revenue from fuel surcharge. (B747, ten hour sector, BA surcharge schedule applied)**

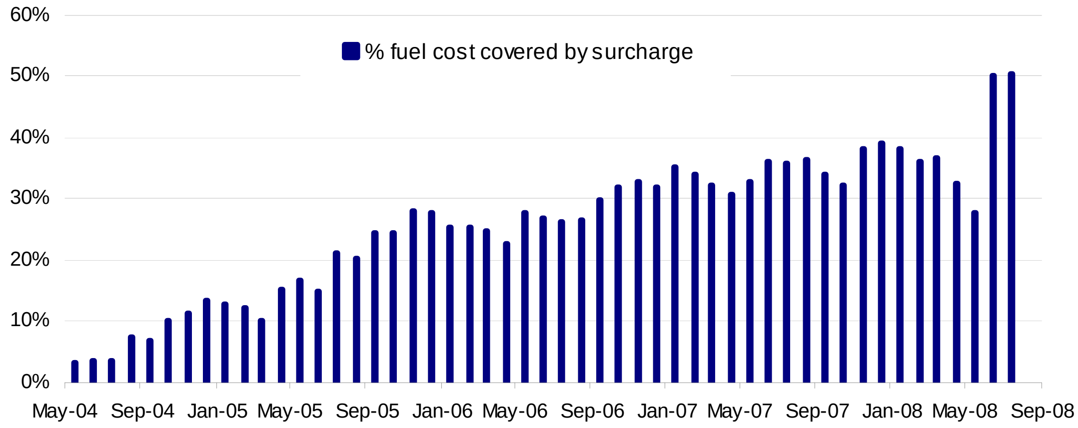


Source: Airline website, EIA and news reports

Aircraft fuel requirements were calculated at 3,360 gallons per block hour, and the costs applied were market rates for kerosene converted from USD to GBP at the appropriate dates' exchange rates. Although surcharges have generally followed movements in the price of fuel, they did not reflect the fall in fuel costs fed by exchange rate movements in 2006.

Figure 12 shows that in May 2004, BA's newly introduced surcharge represented somewhere less than five percent of total fuel costs for our notional long-haul flight, but by the third quarter of 2008 around half the cost of fuelling the flight is covered by the surcharge.

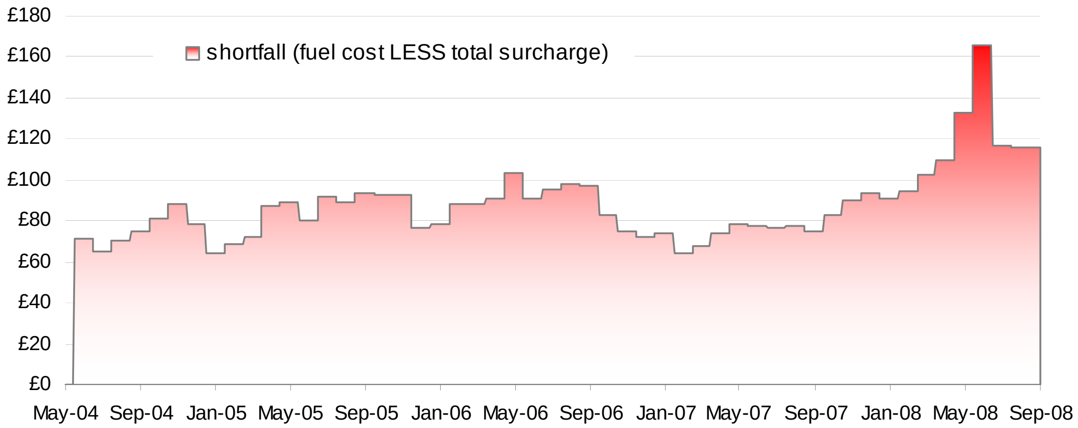
Figure 12: **Percentage of fuel costs covered by surcharge revenue (flight as above)**



Source: Airline website, EIA and news reports

However, the shortfall between the revenue generated by surcharges and the full cost of fuel required in the example presented here had doubled in absolute terms by the third quarter of 2008, from £70 per passenger in May 2004. Figure 13 maps this shortfall for the B747 example. The shortfall represents the difference between surcharge revenue and the full cost of fuel, and does not include any advantage the airline gained from its fuel hedging activities.

Figure 13: **The cost of fuel above revenue generated from fuel surcharges**



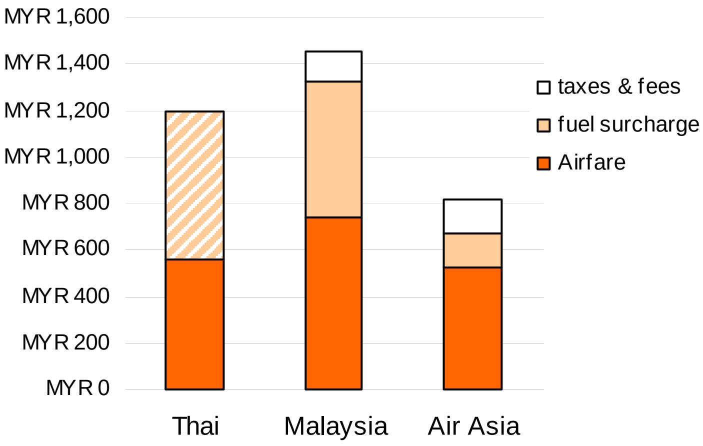
Source: Airline website, EIA and news reports

The application of fuel surcharges by European and non-European airlines

In Europe, the application of fuel surcharges by network carriers is widespread, the sum included in the add-ons to basic airfares. Many airlines apply these add-ons transparently, itemising on websites each additional charge, including the fuel surcharge. Others are less transparent in their exposition of extra charges. Some airlines continue to display fares without any of the additional charges and fees, these appearing only when the passenger has selected his or her flights (e.g. Air Malta). The two major LCC, easyJet and Ryanair, levy no fuel surcharge, although a number of other European LCC do so (e.g. Wizz Air, Air Berlin).

In Asia, airlines, generally apply fuel surcharges. The region's largest LCC, Air Asia, is included among airlines adding the surcharge to their airfares. However, as in Europe, the surcharge imposed and the transparency surrounding it varies among airlines. As an illustration, Figure 14 shows ticket prices for a round trip between Kuala Lumpur and Bangkok in November. Both Malaysia Airlines and Air Asia show clearly their (very different) fuel surcharges, while Thai Airways' approach is less transparent.

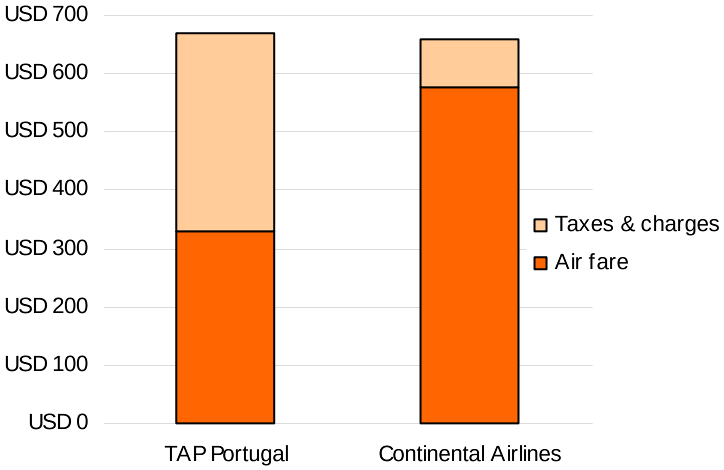
Figure 14: **Roundtrip ticket prices between Kuala Lumpur and Bangkok (Nov 08)**



Source: Airline websites

US airlines, in general, do not follow the fuel surcharge path, but choose to internalise fuel costs. This is reflected in higher basic airfares (before extras are added) than those of European competitors on transatlantic routes, although total ticket cost can often be very similar. For example, looking at return flights between New York's Newark airport and Lisbon in November, Figure 15 shows how the ticket price is broken down by Continental (the US airline operating on the route), and by TAP Portugal, into a basic airfare and additional taxes and charges. The extra charges attached to TAP's airfare include a USD260 fuel surcharge, on top of government and airport taxes and fees. The Continental breakdown of extras covers only these latter taxes and fees, the cost of fuelling its aircraft presumably internalised and reflected in the base airfare.

Figure 15: Roundtrip ticket prices between New York and Lisbon (Nov 08)



Source: Airline websites

2.3 Impact of fuel surcharges on demand

The fuel surcharges discussed above will have a significant impact on demand even after airlines have adjusted the underlying fares downwards. The average economy class fare for a ten hour sector between London and the US could be somewhere between £200 and £300 one-way, and a return fare of double that. Bargain fares will be available at well below this level. British Airways' fuel surcharges for this sector are now £218 for a return economy fare, up from the previous level of £128.

This means that the fuel surcharge alone could add considerably to the return fare paid. A study by the UK CAA found that demand for specific destinations could be fairly elastic with respect to changes in air fares (reporting a broad range of -0.4 to -2.7). But for leisure trips in general they suggested an average of between -0.7 and -0.8.[10] These findings differ from the assumption used for the price elasticity of leisure passengers (-1.5) in SEC(2006)1684 which looked at the likely impact of the aviation ETS for the European Commission.

The UK CAA found that in 2004 the average air fare paid for shorter haul leisure trips was only £150 (around 27% of the total trip cost). They estimated long-haul price

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[10] UK Civil Aviation Authority, 'Demand for outbound leisure travel and its key drivers', CAP, December 2005.

elasticities to be slightly higher but still inelastic. While airlines reported that the UK APD of £40 on long-haul sectors had made little impact on demand, fuel surcharge increases have been far higher.

It is difficult to apply the above elasticities to the increase in overall fares that are due solely to the increase in fuel surcharges. This is because 30-40% of the fuel surcharges are often offset by a reduction in the underlying fare. This will be impossible to determine given the change in fares available over time and the complexities of a network airline revenue management systems.

A similar lack of data prevents any meaningful evaluation of fuel surcharges on short-haul sectors. The two largest low-cost airlines do not specifically levy fuel surcharges but can vary their fares depending on competitor fuel and other surcharge levels. They also have their own add-ons, some of which compensate them for higher fuel consumption and cost (e.g. baggage charges).

There may be some competitive effects of passengers switching airlines with different fuel surcharges serving the same destination. There will also be some destination specific effects, given BA's variation of fuel surcharge by length of flight.

2.4 Other reactions to fuel price increases

Grounding, retirement and replacement of aircraft

The rapid rise in fuel prices has had an appreciable impact on the values of less fuel efficient aircraft. These aircraft are usually the first to be grounded or returned to lessors in a downturn. Increased sales and acquisition of more fuel efficient types tends to widen the value gap between them. For example the older B737-300s have declined in value by around 20% between mid-2007 and mid-2008. The smaller regional jet, EMB-135, has declined in value by 17% and the larger EMB-145 by 8%. This contrasts with an increase in value of much more fuel efficient (albeit slower) turbo-prop ATR-72 by 9%.

Airline bankruptcies

An extreme result of fuel price increases could be airline bankruptcy. In Europe there have been three recent airline failures: EuroManx, Silverjet and XL Airlines. High fuel prices clearly played a role in these, but Silverjet's business strategy was also arguably a major weakness. The two recent Asian bankruptcies, Far Eastern Air Transport (Taiwan) and Oasis (Hong Kong) were also caused more by other factors: competition from the new high speed rail services in the former's case and Oasis suffered from a lack of a clear selling proposition in a very competitive marketplace. In North America, Zoom, ATA Airlines, Frontier, SkyBus, Aloha, Big Sky Airlines, ExpressJet and Air Midwest have recently gone out of business as a result of competitive pressures combined with high fuel costs.

Reaction of cargo airlines

Cargo carriers are certainly not immune from the fuel-related risks outlined above and in previous sections. Indeed, their operating environment makes them more vulnerable to fluctuations in the price of fuel, creating an incentive for the maintenance of fuel-efficient fleets and the adoption of efficient operating practices.

Around half of freight traffic is carried by air on long-haul freighters. Some short-haul freighters are operated by integrators for high priority shipments, but these aircraft tend to be operated on a low frequency basis. Other freight is carried on passenger aircraft which are selected and scheduled for passenger markets, but which provide cargo capacity on routes which could not support freighters.

Long-haul freighters tend to be already very fuel efficient. However, freighter flights also tend to be more fuel intensive than passenger flights because costs such as cabin attendants, catering and passenger related airport charges are not incurred. For example, fuel accounted for 38% of cargo specialist Cargolux's 2005 operating costs compared to only 25% for a passenger airline with a similar average sector length, Virgin Atlantic (also in 2005). High fuel prices tend to force the retirement of uneconomic aircraft, as well as encourage airlines to operate as fuel efficiently as they safely can (e.g. continuous descent approaches, direct routings etc).

Table 6: Jet freighter aircraft, estimated fuel consumption, 2002*

	Total block hours	US gallons used (000)	RTK (m)	RTK/gallon
North America:				
B747-100/200F	180,461	644,338	8,267	12.8
B747-400F	26,667	77,474	1,590	20.5
B757F	111,158	122,528	1,596	13.0
B767F	101,937	161,727	2,300	14.2
MD-11F	163,750	403,674	7,085	17.6
A300F	109,550	175,301	2,104	12.0
A310F	63,242	98,708	908	9.2
DC-10F	179,420	400,585	5,084	12.7
B727-100F	43,230	43,647	207	4.7
B727-200F	159,720	220,901	1,151	5.2
DC-8-70F	56,934	92,748	879	9.5
DC-8-60F	29,234	29,234	369	12.6
Total/average North America	**1,225,303**	**2,470,865**	**31,540**	**12.8**
Europe:				
B747-100/200F	140,947	546,315	8,829	16.2
B747-400F	64,456	206,045	4,449	21.6
MD-11F	68,292	173,929	3,655	21.0
B757F	6,236	5,066	82	16.1
Total/average Europe	279,931	931,355	17,014	18.3
Asia:				
B747-100/200F	164,482	605,709	9,050	14.9
B747-400F	130,441	551,913	9,239	16.7
MD-11F	18,918	48,888	1,074	22.0
Total/average Asia	**313,841**	**1,206,510**	**19,363**	**16.0**
Total/average major regions	**1,819,075**	**4,608,730**	**67,917**	**14.7**

Source: US DOT Form 41, Association of European Airlines, IATA, ICAO.

* Some turbo-props operated especially in North America; for example FedEx operated 247 Cessna 208B single-engined freighters, but only for an average of 1.3 hours per day totalling around 4.7 m gallons (adding only 1% to the world total).

Airlines have been replacing many older DC-10s and B747-100/200s with much more fuel efficient B747-400 and, shortly, B777 and B747-8 freighters. Much has been achieved by the larger air cargo specialists over the past decade or so. For example, Cargolux has moved from a fleet of two B747-400Fs and five B747-200F in 1996 to its 2006 fleet of 14 B747-400Fs. The 33% greater efficiency of the B747-400F compared to the earlier B747 models is shown for European operators in Table 6. This has resulted in an increase in Cargolux's fuel efficiency expressed in terms of ATKs per US gallon consumed across the fleet of around 40%, or just over 3% a year, over the past ten years.

2.5 Summary and conclusions

Airlines have strong incentives to the improve fuel efficiency of their operations. The threat of financial losses and even bankruptcy, forced through a combination of increasing costs and a shifting business environment, has driven some carriers to consider changes to the composition of their fleets. As shorter term expedients, financial and operational solutions have been adopted.

There are a number of operational procedures and technical modifications that enable airlines to improve the fuel efficiency of their existing fleets. While these may be effective, they mostly represent one-off, short-term expedients. Longer term, and possibly more extensive measures await the development of more fuel-efficient aircraft and propulsion units.

Fuel hedging is a tool employed by many airlines. It allows them to escape the short-term risk of hikes in fuel price. It does nothing to improve the fuel efficiency of their operations. If and when fuel prices settle within a new, higher range, the attraction of hedging will be reduced.

Fuel surcharges have generated extra revenue for airlines, partially offsetting their increasing fuel bills. The analysis above, although specific to a specific operation and a single airline's surcharge regime, shows the success of fuel surcharging in buffering the impact of high oil prices. However, the mechanism employed is little more than an alternative means to generate more revenue from passengers without increasing fares. It is a mechanism which brings some advantages to the airline, but increases in the costs of air travel would eventually stifle demand.

3 Air traffic management

3.1 The Single European Sky initiative (SES)

Air traffic management (ATM) in Europe has traditionally been organised at state level and within the confines of flight information regions (FIR). This has meant that ATM provision has been fragmented, with neighbouring states operating different systems and procedures, equipment and training standards. This has adversely affected the overall performance of the European ATM system, against the background of increasing traffic growth and changes in the aviation market such as liberalisation of air services and low cost carriers. The on-going challenge, for air navigation service providers, has been to create sufficient new capacity to absorb the increase in traffic while at the same time improving safety and reducing costs to the airlines. To date, a failure to do so has resulted in significant air traffic delays with consequent additional costs to the airlines (much of which can be attributed to additional fuel consumption) and to the European economy in general.

The fragmented nature of ATM provision in Europe has resulted in flight inefficiencies.[11] Flight efficiency is defined as the difference between actual and optimum unimpeded aircraft trajectories, gate to gate. Deviations from the optimum trajectory generate additional flight time, fuel burn and user costs. Moreover, additional fuel burn has a direct global environmental impact through CO_2 emissions. Flight efficiency can be broken down into four components: horizontal en-routes; vertical; terminal areas; and ground operations.

In terms of horizontal flight efficiencies, it has been calculated by Eurocontrol that, within Europe during 2007, the actual flight distance flown per aircraft was 49km longer than the optimum distance. Of this, 33km was attributable to the en-route sector and the remainder to terminal area operations. In terms of costs and emissions, it has been estimated by Eurocontrol that a reduction of 4km per flight would result in cost savings of about €200-250 million per annum, and an annual reduction in CO_2 emissions of approximately 120,000 tonnes.

Vertical flight efficiency is seen to be a less important issue at the European level; the average additional fuel consumption being estimated by Eurocontrol at 23kg per flight. This is one-tenth of the additional fuel consumption caused by horizontal efficiencies.

Initial estimates of flight efficiency in the terminal area and ground operations phases are that additional fuel burn per flight may vary between 100-250kg and 13 to 40 kg per flight respectively. The total costs related to flight efficiency have been estimated by Eurocontrol as being in the order of €4 billion to €7 billion per annum, of which about one third is related to fuel costs and two thirds related to the cost of time (aircraft utilisation, maintenance and staff costs).

Flight efficiency (which includes delays, fuel consumption and emissions) is just one of a number of reasons why the European Commission has, for many years, made the reform of ATM in Europe one of its priority actions and these are discussed briefly in the following sections.

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[11] Eurocontrol Performance Review Report, PRR 2007

As a start, the Commission launched the Single European Sky (SES)[12] initiative in 1999 as a response to the worsening air traffic delay situation at the time. The SES aims to create a more uniform and better managed European ATM system. The political and legislative framework was created in 2004. Consequently, further implementation measures have been introduced including a common charging scheme for air navigation services (ANS), common requirements for ANS providers, and airspace and interoperability measures.

SESAR

The associated SESAR project (Single European Sky ATM Research)[13] was also launched to provide impetus to the European ATM modernisation programme. The project group includes a consortium of industry partners, other aviation stakeholders and the European Commission. Led by the consortium, and with part funding by the EC and Eurocontrol, an initial two-year Definition Phase commenced in 2006. The main output of the Definition Phase, the ATM master Plan, was delivered in April 2008.

High Level Group

With the support of the European Council, the Commission constituted a High Level Group (HLG) in 2000,[14] bringing together civilian and military representatives of the Community Member States, plus representatives from Norway and Switzerland. The remit of the HLG included delivery of services, safety and obligations; technical and implementation issues; harmonisation of national systems; and the supporting role of Eurocontrol. The HLG was reconvened in 2006 and in July 2007 published 'European Aviation: a Framework for Driving Performance Improvement'.[15] The main recommendations of the HLG included: EU being responsible for improved aviation regulation and performance; greater involvement of industry; accelerate the delivery of the SES; emphasise the role of Eurocontrol; and address issues of airport capacity, safety and environment.

SES II

In late 2007, the EC issued 'First Report on the implementation of the Single Sky Legislation ~ Achievements and the Way Forward'.[16] The Report acknowledged many of the HLG Report recommendations as well as drawing on the 2006 Performance Review Commission Report into SES performance. Although progress had been made, the Commission has recently proposed a second package of SES proposals. The proposals are based on four 'pillars' of action; these being regulating performance, a single safety framework, opening the door to new technologies, and

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[12] For more detailed information, the reader is directed to: Eurocontrol, Performance Review Commission, December 2006, 'Evaluation of the Impact of the Single European Sky Initiative on ATM Performance'

[13] For further information refer to the following:
http://www.sesar-consortium.aero
http://www.eurocontrol.int/sesar
http://ec.europa.en/transport/air_portal/sesame/index_en.htm

[14] Eurocontrol, Performance Review Commission, December 2006, 'Evaluation of the Impact of the Single European Sky Initiative on ATM Performance'

[14] See: http://ec.europa.eu/transport/air_portal/hlg/doc/2007_07_03_hlg_final_report_en.pdf

[16] See: http://eur-lex.europa.eu/LexUriServ/site/en/com/2007/com2007_0845en01.pdf

managing capacity on the ground. The SES II proposals are currently out to consultation and comment by airlines, airports and aviation industry organisations.

3.2 Operational enhancements

As mentioned above, SES II has proposed four ‘pillars’ of action. Two of these refer to opening the door to new technologies, and managing capacity on the ground. It is clear that no immediate quantum leaps are going to be made in terms of providing additional capacity and reducing delays and fuel consumption. However, operational enhancements offer the opportunity to provide incremental improvements to the industry by the introduction new procedures and technologies. The latter have been or are expected to be introduced within the next twenty years.

Arrival and departure management

Arrival management (AMAN)[17] is an integrated system and concept involving a package of airspace design principles, new techniques, procedural development, advanced technology, and highly developed controller support tools. The concept, for use by terminal area controllers, is expected to allow delay to be absorbed by reducing speed and reducing the use of holding stacks. AMAN will allows for the accommodation of less-advanced aircraft, whilst incorporating advanced airborne capabilities, in the transition to a new type of terminal area operations.

Departure management (DMAN)[18] is a concept for use by tower controllers and will reduce the blocking of taxiways, reduce controller workload, improve punctuality and predictability, and exploit the departure capacity of the runway by keeping the number of aircraft waiting for take off at an optimum, typically between two and four. Although not quantified in detail, a reduction in taxi time (for arrivals and departures) would lead to a small overall reduction in engine idling fuel burn and emissions and at some airports, for example Heathrow, the benefits could be significant.

Continuous descent approach (CDA)

CDA[19] is a method by which aircraft approach airports prior to landing, and is designed to reduce fuel burn and noise compared with a conventional approach. It involves maintaining a constant three degree angle during descent, until meeting the ILS slide slope. CDA starts ideally at cruise altitude (typically 37,000 feet), and potentially allows the aircraft to fly its individual optimal vertical profile down to runway threshold with engines at idle, with consequent reduction in the noise footprint. CDA trials are in place at a number of airports including London Heathrow and Stockholm Arlanda. The latter aims to handle between 60-65% of landings in this way by 2012 by focusing on off-peak movements. This initiative is linked to vertical flight efficiency, the principal benefits is that of reducing the noise footprint as well as fuel savings and emissions reduction.

‘*In trials conducted by EUROCONTROL and others, fuel savings of up to 40% during the approach phase have been demonstrated. This equates to between 50 and 150 kgs of fuel depending on the level at which CDA is commenced and the aircraft type. At*

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[17] For more information: http://www.eurocontrol.int/tma2010/public/standard_page/puzzle.html

[18] See also: http://www.eurocontrol.int/airports/public/standard_page/APR2_ACDM.html

[19] See also: http://www.eurocontrol.int/epr/gallery/content/public/docs/2003_win_p14.pdf

June 2007 prices, this is the equivalent of between fifty and one hundred million euros annually.'[20]

Putting this estimate in the context of an A320 flight over 900km would give a saving of 1-3% on a total fuel burn of just under 5 tonnes.

Area navigation

Area navigation (RNAV) is a method of navigation that permits aircraft operation on any desired course within the coverage of station-referenced navigation signals or within the limits of a self contained system capability, or a combination of these. RNAV was developed to provide more lateral freedom and thus more complete use of available airspace. This method of navigation does not require a track directly to or from any specific radio navigation aid, and has three principal applications:

1. a route structure can be organized between any given departure and arrival point to reduce flight distance and traffic separation
2. aircraft can be flown into terminal areas on varied pre-programmed arrival and departure paths to expedite traffic flow; and
3. instrument approaches can be developed and certified at certain airports, without local instrument landing aids at that airport.

Summary

Aviation is required to contribute towards the environmental objectives of the European Union. Implicit in these objectives is an improvement in aircraft fuel efficiency. This will lead to increasing pressure on air traffic management to help deliver the commitments made by the EU.

Meeting the Eurocontrol flight efficiency target of a reduction in the European average route distance flown per flight by two kilometres per annum (Provisional Council, May 2007) would result in cumulative savings between 2007 and 2010 in excess of two millions tonnes of CO_2, and a concomitant reduction in fuel burn.

Eurocontrol is to implement a flight efficiency plan over the next year and beyond with the support of ECAC, CANSO and IATA.[21] This is expected to bring fuel savings of around 470,000 tonnes over one year from:

- enhancing European en-route airspace design through annual improvements of the European ATS route network (24,000t pa)
- improving airspace utilisation and route network availability (180,000t pa)
- efficient TMA design and utilisation (120,000t pa)
- optimising airport operations (145,000t pa)

The total of the above amounts to just under three percent of total fuel and emissions produced by intra-EU flights in 2005.

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[20] Eurocontrol CDA brochure, www.eurocontrol.be/environment, May 2008

[21] Progress report on Air Traffic Management to ECAC 57th Special Meeting of Directors General of Civil Aviation, Yerevan, 22 August to 1 September 2008.

4 Airframe manufacturers

The first fifty or so years of commercial aviation could be said to have been dominated by the need for speed and range. Between the introduction of the Comet in 1952 and the demise of Concorde in 2003, the average speed of jet aircraft and their range had increased dramatically. However at the same time, the fuel consumption of jet aircraft has been a major design consideration and between the Comet 4 of 1958 and the Airbus A380 of 2003 engine fuel consumption had been reduced by over 40% and when translated into a fuel burn per seat this had dropped by over 70%.

The key drivers for fuel burn are airframe related (aerodynamics: lift and drag) and weight and engine related (thrust rating and thermodynamics). The potential improvements in these characteristics will be discussed later. When designing an aircraft the key parameters that are considered are: how much payload (passengers and/or cargo) do we wish to carry, how far, at what speed and how much runway length do we have to take-off and land. The final design will depend on these and it cannot be emphasised enough that either over-specifying or under-specifying these requirements can lead to an unattractive or uneconomic aircraft design.

In the short term the airframe manufacturers are always looking at ways to improve the performance of their current products. To improve fuel burn the following areas are being explored.

4.1 Weight

The lighter the aircraft is, the less thrust is required from the engine and hence the lower the fuel burn is required. The manufacture’s weight empty (MWE) of an aircraft is related to the aircraft’s structure and the equipment which is put on board. In recent years airframe manufacturers have introduced composite and lightweight alloy structures as a means of reducing the weight of their aircraft. Other systems changes such as the elimination of using bleed air on the Boeing 787 all contribute to a lighter aircraft. In combination with the airlines, on board facilities such as seats, galleys and toilets all contribute to the aircraft’s weight. New materials and designs are continually being considered to help reduce weight, while not compromising the aircraft’s safety.

4.2 Short-term aerodynamic improvements

Improving the lift and reducing the drag of an aircraft are key factors in improving the fuel efficiency of an aircraft and aerodynamicists are continually looking at ways of achieving these aims. The aerofoil section of a wing (in essence the cross-section shape) is a key factor in a wing’s lift/drag characteristics. Since the 1980s the supercritical airfoil has been used for most commercial aircraft designs and research is focusing now on how to improve this.

4.3 Winglets

The addition of winglets to the wingtips of aircraft has been shown to improve the aerodynamics of aircraft and hence reduce fuel burn. Boeing, in conjunction with Aviation Partners, offers winglets on its 737NG family for new build and as retrofit for existing aircraft. The maximum benefit from the winglets is achieved on longer routes where reductions in fuel burns of up to six percent are claimed (see section 2).

Airbus's A320 family have smaller wing tip fences, but Airbus is shortly to re-launch flight trials with US partner API. However the decision to retrofit winglets is dependent on the aircraft itself and especially its age. The key question is if winglets will provide sufficient benefit in the aircraft's remaining years of service for the cost of installation to be outweighed by the fuel savings made.

4.4 Riblets

The use of small, v-shaped grooves called riblets on the wetted surface (i.e. the parts of an aircraft exposed to the airflow) of an A320 took place in 1989 and subsequently a Cathay Pacific A340 was tested with riblets. In both cases significant reductions in fuel burn were noted, but concerns were raised over the need for regular cleaning and maintenance to fully benefit from them. With current concerns over fuel burn, riblets are again being seriously considered within the industry.

4.5 Medium to long term improvements

From aerodynamics it can be said that if the drag of a wing is reduced by 50% then the fuel burn would be reduced by 15%. One way of reducing drag is by using a concept known as hybrid laminar flow through a combination of new aerofoil designs (the aerofoil being in essence the cross-sectional shape of the wing) combined with suction of boundary layer air near the forward part of the wing. Airbus and the DLR produced results with their application of hybrid laminar flow technology on transport aircraft. Suction devices at the leading edge aim to again reduce drag.

Aerodynamic research is looking at trailing edge changes to reduce drag. The Boeing 747-8 will see a divergent trailing edge predicted to reduce fuel burn by 2.5%.

The Clean Sky Joint Technology Initiative (JTI) is a European research projects with a budget estimated at EUR1.6 billion, equally shared between the European Commission and industry, over the period 2008 to 2013. It is thus a public-private partnership and is intended to speed up technological breakthrough and shorten the time to market for new solutions tested on full scale demonstrators. It covers fixed wing and rotorcraft, aero engines, operations and aircraft design. It aims to help the European industry meet the 2020 ACARE targets which include a 50% reduction of CO_2 emissions through a reduction of fuel consumption. Membership is from industry, research centres and universities and participation will be from partners selected through tenders for each project.

4.6 Long term developments

For many years the blended wing body (BWB) design has been considered extremely attractive due to its excellent lift/drag ratio and the fact that smaller engines will be required to power a BWB compared to a similar capacity conventional design. The Boeing X-48B designed and built at Cranfield has been tested. Passenger carrying variants of this design may still be some years off, but the compelling performance of the design may ultimately be adopted in the face of mounting fuel costs.

At the other end of the aviation spectrum, the airship has long been proposed as an air freighter for non-time sensitive products. Companies putting designs forward for such craft have come and gone, but there is still a case to be made for such vehicles.

5 Aero-engine manufacturers

It is the gas turbine engine which consumes the fuel on an aircraft and hence improvements in the design of the engine can reduce the fuel burned. Since the advent of the turbofan engine in the late 1950s, improvements in materials and designs have led to many improvements in fuel efficiency and also noise of the engines. For the new wide-body aircraft, the major engine manufacturers have invested heavily in these areas to produce highly efficient engines, such as the GEnx and Trent 800/900/1000.

Manufacturers are not only looking at the new engines, but also at improvements to existing engines, not least CFM who are developing the CFM56 Tech. The CFM56 family has become the world's most prolific jet engine with over 17,550 delivered by early 2008. Using new technology, some developed for the larger aircraft, CFM was able to change some of the design, including introduction of a swept wide chord fan blade, producing more thrust and helping reduce fuel burn. The high pressure compressor was redesigned, enabling CFM to reduce the number of stages needed in the engine from nine to six, while increasing the pressure ratio (the higher the ratio the lower the fuel burn).

CFM's major competitor in this engine size, International Aero Engines, also made improvements to its V2500 engine, including elliptical leading edges, *super polish* finish on the HP compressor blades and cooling improvements in the HP Turbine. The new version known as SelectOne is due to enter service in the autumn of 2008.

Looking to the medium and long term, engine manufacturers are very conscious of the need to improve fuel efficiency and reduce emissions. They are all putting forward new designs, some of which are more radical than others. The need for reduced emissions led to the Advisory Council for Aerospace Research in Europe (ACARE) setting targets for new aircraft technology by 2020, compared to a benchmark of large civil aircraft from 2000:

- reducing CO_2 emissions by 50 per cent per passenger kilometre.
- reducing NOx emissions by 80 per cent.
- reducing perceived aircraft noise by 50 per cent.

The aircraft and engine manufacturers have all committed themselves to these targets and are looking at new solutions to achieve them.

Increasing the bypass ratio of an engine has traditionally been one means of improving the efficiency of the jet engine. However, the need for a large fan requires space and for the new generation of short to medium haul airliners this is not available. Hence the engine manufacturers are looking at other proposals, the key ones being proposed are the advanced turbofans, geared turbofan and the open rotor.

5.1 Advanced turbofans

Less radical solution being considered by the main engine manufacturers are those which look at improving the heat exchange cycle of an engine, for example intercooled turbofan with high pressure ratios is considered to produce fuel burn reductions in the order of four percent.

While Rolls-Royce favours the open rotor as the future powerplant for the new generation of 150-seat aircraft, it is keeping its options open by developing a three-shaft advanced turbofan engine - the RB285. This, they claim, will provide a 15-20% efficiency improvement, similar to that of the geared turbofan.

5.2 Geared turbofan

The geared turbofan (GTF) developed by Pratt & Whitney (now rechristened PurePower) incorporates a gearbox to optimise the speed of the various rotating components within the engine. Efficiencies are gained by running each component at near optimum speed. The fan running more slowly produces less noise and the HP turbine runs faster and hotter reducing fuel burn (and hence CO_2 and NOx).

Estimated fuel burn saving is predicted to be in the region of 12%. The GTF has been adopted by Bombardier for its 110-130 seat C-Series aircraft and by Mitsubishi for its regional jet. It is possible that the GTF could be retrofitted onto current aircraft.

5.3 Open rotor

In the 1980s the unducted fan or propfan, as the designs were then known, were developed by General Electric and P&W/Allison and both produced prototypes. High efficiencies were demonstrated although there were concerns over the noise generated. At the time of the trials fuel price, availability and environmental pressures were not as critical as they are today and the projects were dropped. However, Rolls-Royce (who now own Allison) and GE have recently reviewed the performance data and through the use of new computer modelling and computational fluid dynamics have come up with designs which are as fuel efficient, but produce less noise than previous designs.

With fuel burn savings predicted to be in the region of 25-30% it is not surprising that airframe manufacturers and airlines (including the likes of easyJet with its ecoJet proposal) are keen to see the open rotor progressed.

5.4 Alternative fuels

The issue of alternative fuels has been given a lot of prominence recently with some high profile flight trials carried out by a number of airlines, not least Virgin Atlantic Airways. There are a number of different sources and types of fuels being considered. They can be categorised initially as those from non-renewable and renewable sources.

Non-renewable fuels include coal to liquid and gas to liquid, these are well developed and are possible sources in the near term. But although they have benefits compared to conventional fuel, their non-renewable nature represents a drawback.

Renewable fuels, or biofuels, include those derived from crops and algae. These fuels can be characterised as either first or second generation. First generation biofuels compete for land and water resources with food crops and rain forests, and include those based on soya and corn. Second generation biofuels are more sustainable and include sugar and algae-based fuels. Algae seem to be becoming the favoured source due to its sustainability and also due to the relatively high oil yield predicted. Research continues into this area and the aviation industry is hoping that other industries which could benefit from the fuel will contribute to this research.

5.5 Summary

Increasing fuel price coupled with environmental pressures have given the airframe and engine manufacturers impetus to progress new technologies to produce aircraft which burn less fuel and produce less emissions. The technologies are available but require investment and the support of regulatory bodies to fulfil their potential.

6 Regulatory initiatives

6.1 The EU emissions trading scheme

On 20th December 2006, the Commission adopted a proposal for legislation to include aviation in the EU Emissions Trading Scheme (ETS). This proposal provided for aviation to be brought into the EU ETS in two steps. From the start of 2011, emissions from all domestic and international flights between EU airports will be covered. One year later, at the start of 2012, the scope will be expanded to cover emissions from all international flights - from or to anywhere in the world - which arrive at or depart from an EU airport. The intention is for the EU ETS to serve as a model for other countries considering similar national or regional schemes, and to link these to the EU scheme over time.

The proposal was sent to the European Parliament, whose position in November 2007 was taken into account in the adoption of the common position by the Council of Ministers in April 2008:

- The opinion of the European Economic and Social Committee: 31 May 2007
- The opinion of the Committee of the Regions: 10 Oct 2007
- The opinion of the European Parliament, first reading: 13 Nov 2007
- Adoption of the common position (by unanimity): 18 Apr 2008

The European Parliament voted on 13 November 2007 to support the Commission's original plan to include aviation in the EU Emissions Trading Scheme subject to certain changes. These included the reduction in the number of authorised CO_2 emissions for aviation to 90% of airlines' average annual emissions during 2004-2006, rather than the EC's originally proposed cap of 100%. MEPs also backed more ambitious emission reductions in future depending on the post-2012 target reductions in overall CO_2 emissions Europe sets itself. MEPs also decided that an initial 25% of permits should be auctioned, with revenues earmarked for research, support for alternative transport modes and to help the EU and third countries manage the impact of climate change.

They disagreed, however, with the EC proposal that the scheme initially covers intra-EU flights from 2011, before extending to international flights from 2012, voting that all flights from EU airports should be covered by 2011. The idea to include international flights in the scheme from one unified date was shared by the environment and transport committees, although they disagreed on the date: 2010 with a baseline reference period of 2004-6 or 2012 with a baseline reference period of 2008-10.

Following the receipt of the Parliament’s position, EU ministers reached a political agreement on including aviation in the EU emissions trading scheme on 20 December 2007. The Council position remained close to the Commission's original proposal of 20 December 2006, and most of the changes are technical improvements. However, there are also changes of a more political nature, including:

- the one-year introductory phase for intra-EU flights proposed by the Commission has been dropped, and the scheme will now become operational in a single phase, starting in 2012.

- emissions will be capped at 100 percent of the average level for the years 2004-2006.
- the level of auctioning has been increased to ten percent, and revenue from the auctioned allowances should be used to combat climate change.
- an exemption has been introduced for operators with very low traffic levels on routes to, from or within the EU. Under this mechanism many operators from developing countries with only limited air traffic links with the EU will be exempt. This will not have a significant effect on the emissions covered by the scheme.
- a special reserve of free allowances for new entrants or very fast-growing airlines has been added. While this was not contained in the original Commission proposal, it was found to be acceptable as the reserve is taken from within the overall cap and does not therefore affect the environmental effect of the scheme.
- A new mechanism to ensure consistent and robust enforcement throughout the EU has been introduced. As a last resort, Member States could ask for an operator to be banned from operating in the EU if it persistently has failed to comply with the scheme and other enforcement measures have proven ineffective.

At the end of June 2008, EU ministers formally backed the deal brokered between European Council officials and Parliament negotiators over the terms for aviation's inclusion in the EU emissions trading scheme. The compromise deal was formally approved by the European Parliament at the bill's second reading in July 2008.

Under the agreement intra-EU and flights to and from the EU will be included in the emissions trading scheme from 2012. It also sets the cap on the quantity of allowances allocated to airlines each year at 97% in 2012 and 95% from 2013 (both relative to the 2004 to 2006 baseline average emissions), although this could later be subject to change under a separate emissions trading directive. The agreement also specifies that 15% of allowances should be auctioned.

The European Commission's impact statement (SEC2006) 1684 that accompanied the proposal of 20 December 2006 examined the likely affect of CO_2 allowance prices of €6 and €30 per tonne on passenger and cargo demand, applying the originally proposed baselines and allocation methods for the ETS. With the higher of the two carbon prices, passenger traffic was estimated to be 1.5% lower in 2020 than it would have been without the ETS, or 600 billion passenger-kms versus 609 billion.

'Assuming no multiplier, and with an allowance price of €30 and a coverage of all departing flights, ticket price increases were estimated to vary from €4.6 on a short haul round trip to €19.8 for a long haul flight. As a proportion of the total ticket price, these ticket price increases are modest. Their modesty is also demonstrated by the very limited impact they have on reducing future forecasted demand.' SEC(2006) 1684

The Committee for Environmentally Friendly Aviation (CEFA), a group of European airline trade associations, released the findings of the analysis they commissioned of the EC proposal to include aviation activities in the ETS. The report disagreed with the EC's impact assessment on the degree to which operators would be able to pass on their ETS costs to consumers, concluded that demand would be more affected by the increased fares (assuming the costs were passed on) and did not see any windfall profits from free allowances. The report's cost impacts were stated in terms of the total industry monetary impact rather than on a per passenger or cargo tonne basis, and totalled the costs over the twelve year period (2011-2022).

6.2 Fuel and environmental taxes

Fuel taxation

While fuel taxes may be readily applied in respect of domestic aviation[22], international air services are exempt under Article 24 of the Chicago Convention[23] and in the large majority of bilateral air services agreements. ICAO recommends the reciprocal exemption from all taxes levied on fuel taken on board aircraft in connection with international air services[24]. It also requests that states reduce or eliminate taxes related to the use of international air transport to the fullest practicable extent. States do however have the right to introduce a fuel tax for flights between their respective territories based on mutual agreement.

During the 1990s Sweden had attempted to circumvent the fuel tax exemption for international air services by introducing a tax based on CO_2 emissions instead, but was prevented from doing so by the European Court of Justice (ECJ) in its 1999 judgement in the Braathens case[25] when it ruled such a tax illegal under Council Directive 92/81/EEC of 19 October 1992. The ECJ argued that there is a direct and inseparable link between fuel consumption and the polluting substances on which the tax was levied and that therefore the tax must be regarded as being levied on consumption of the fuel itself for the purposes of Directive 92/81. However, since 2004 this obstacle preventing the taxation of fuel used on domestic flights posed by the Mineral Oil Directive no longer applies due to Council Directive 2003/96, which restructured the Community framework for the taxation of energy products and electricity.

Directive 2003/96 provides for a mandatory exemption from the harmonised excise duty for energy products supplied for use as fuel for the purpose of air transport, other than private pleasure-flying. Provisions enabling Member States to tax aviation fuel for domestic and, subject to bilateral agreement, intra-EU flights are also contained in the Energy Tax Directive.

While a majority of states now support the introduction of market-based measures, such as excise duty on aviation fuel, emission trading, and emission-related charges, to reduce or limit the environmental impact of civil aviation, they only do so if this is accomplished under the framework of ICAO and UNFCCC and if a global solution can be achieved.

While aviation fuel used for domestic flights is generally subject to VAT, there are wide differences across the world in the application of excise duty and in the amounts levied. Table 3 shows the tax levied by six countries on domestic aviation kerosene and gasoline in 2005. As may be seen, in Brazil the duty paid on aviation gasoline is considerably higher than that levied on kerosene.

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[22] For example, the Netherlands has a domestic aviation fuel tax of €0.20 per litre.

[23] Article 24 of the Chicago Convention requires that .. "Fuel, lubricating oils (and other items) on board an aircraft of a Contracting State, on arrival in the territory of another Contracting State and retained on board on leaving the territory of that State, shall be exempt from customs duty, inspection fees or similar national or local duties and charges."

[24] ICAO's Policies on Taxation in the Field of International Air Transport, Doc. 8632, 3rd edition 2000.

[25] Braathens Sverige AB v. Riksskatteverket, Case 346/97 (ECR [1999] I-3419).

Table 7: **Tax rates on domestic aviation fuel**

	Kerosene (USD per US gallon)	% of fuel price	Gasoline (USD per US gallon)	% of fuel price
Australia	0.09	8	0.09	8
Brazil [26]	0.06	5	1.57	40
Canada	0.06	6	0.06	6
Japan	1.10	96	1.10	96
Netherlands	0.92	81	0.92	81
Norway	0.16	14	0.16	14
United States	0.22	21	0.19	18

Source: Indirect Taxes on International Aviation, Michael Keen & Jon Strand, IMF Working Paper WP/06/124, 2006.

Environmental taxation

The ICAO Council is strongly of the view that any environmental levies on air transport should be in the form of charges rather than taxes, with these directly related to the costs of the resulting damage to the environment. In addition, they argue that any funds collected should be used to mitigate the environmental impact of aircraft emissions. Quantification of the environmental impact of aircraft emissions and of the costs of rectifying the resulting damage to the environment poses enormous challenges of course.

Contracting States of ICAO had been urged to refrain from implementing charges aimed at greenhouse gas emissions from aviation prior to its 2007 Assembly meeting. Despite much discussion on the topic within ICAO since the early 1990s, agreement on the implementation of a charging regime at a global level has not proved possible. Nor has it been possible to devise a set of guidelines that would facilitate the introduction of emissions charging by a group of states. It was therefore proposed by Portugal on behalf of the EC at the 2007 ICAO Assembly that Contracting States should be free to take such measures as they deem necessary to fulfil their international obligations to combat climate change. The proposal was rejected however, with the ICAO Assembly only agreeing to establish a group on international aviation and climate change with the task of recommending an “aggressive programme of action” to tackle the issue. The fifteen-member group (GIACC) met for the first time in February 2008 and are tasked with compiling a list of measures by 2009.

Despite the inaction at a global level, a number of states have implemented fiscal measures to combat aircraft emissions. In Europe, the Netherlands, Norway and Sweden have each introduced different forms of environmental charging mechanisms on air transport. Norway was the first European country to address environmental concerns about aircraft emissions when it introduced in 1994 a passenger tax on domestic flights between Oslo and the four largest regional cities (Bergen, Kristiansand, Stavanger, Trondheim). The environmental justification for the tax was that there was an alternative mode of public transport available on these routes, namely the train. In 1998, the passenger tax was replaced by a tax based on the number of seats on each aircraft. This tax covered both international and domestic flights, the rates per seat being NOK130 for the former and NOK65 for the latter. The Government was of the view that the new tax would encourage airlines to increase load factors and so reduce the environmental impact per passenger. The following

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[26] The data for Brazil is for 2003.

year, a tax on aviation fuel for domestic flights of NOK0.24 per litre referred to above was introduced. Although originally intended to cover international flights as well, this had had to be abandoned because it violated the terms of bilateral air services agreements that Norway had established with other countries. On introduction of the fuel tax the seat tax was reduced to NOK106 for international flights and NOK53 for domestic services.

Norway had introduced a general CO_2 taxation system in 1991, but aviation had been made exempt. One of the main proposals of the Norwegian Government in 1998 was that almost all end users of fossil fuels should pay a minimum CO_2 tax of 100 NOK per tonne. With the aviation fuel tax and the seat tax, the CO_2 rates for aviation were about half the rates for most other users of oil products.[27] In 2001, as part of the EEA agreement it became necessary to charge the same tax for domestic and international flights[28], but the following year the passenger tax was removed. Over time, the tax on fuel has been subject to moderate increases and currently the tax on CO_2 emissions from domestic air transport is NOK0.65 [29] per litre, which is expected to generate NOK270 million in revenue annually. Setting the environmental tax at this amount equates to a price per tonne of CO_2 of around NOK234 (around €30 at the current exchange rate). There is also a tax on NOx emissions below 3,000 ft of NOK5.39 per kilogram on domestic flights, which was introduced in 2007 and this is expected to generate around NOK20 million per year.

An environmental tax based solely on distance flown was introduced by the Netherlands in 2008. The tax is fixed at €11.25 per passenger for flights within the EEA (including Turkey) or within a range of 2.500 km. Passengers flying more than 2.500 km pay €45 in tax for the outbound flight. Passengers departing from the Netherlands on journeys of more than 2,500 km and make a transfer at one of Europe's other hub airports, are also levied with a €45 tax. Passengers transferring flights at Schiphol do not pay the tax. Turkey was originally separated into two tax zones, with flights from Eindhoven saving each passenger €34.75 compared to travelling from Schiphol. Turkish carriers diverted to Eindhoven or other countries, until the Netherlands government decided to include all of Turkey in the €11.25 tax zone. The tax has stimulated some Dutch travellers to make use of airports situated in Belgium and Germany to avoid the tax, resulting in more CO_2 emitted by ground transport. The tax is not transparent and the revenues gained are not reinvested in the industry and so it is not compatible with ICAO's cited objectives in respect of emissions charging mechanisms.

Sweden introduced an emissions related charge at its airports in 1998, which was modified in 2004. The emissions element of the take-off charge at Swedish airports is currently SEK50 per kg of NOx. For aircraft over 5.7 tonnes the charge is based on certified emissions values of NOx and HC in the LTO-cycle.

At the European level, ECAC has endorsed recommendation 27-4 agreed in Paris in 2003, which provides a common classification scheme for NOx emissions from aircraft below 8,618 kg MTOW with engines listed in the ICAO Engine Emission Database and the FOI Turboprop Engine Database. For aircraft below this MTOW,

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[27] The Political Economy of the Norwegian Aviation Fuel Tax, ECON Analyse, 2005.

[28] The seat tax had been changed back to a passenger tax as a result of a decision of the Parliament in 1999. The domestic passenger tax increased from 116 NOK to 128 NOK, with international passenger tax falling from 232 NOK to 128 NOK.

[29] The €: NOK exchange rate is currently 1€ = 7.93 NOK.

Sweden and Switzerland have developed a simple matrix that covers engine emissions for this size of equipment.

A number of airports in Europe have introduced aircraft engine emissions charges in order to improve local air quality. Zurich was the first to introduce such a charging mechanism in 1997 in an attempt to reduce NOx emissions that then exceeded the legal standard set in Switzerland by 30%. The emission charge is set is expressed as a percentage of the landing fee. Five levels of engine emissions are included that are determined on a number of criteria, including available technologies, clean air incentives and existing and forecast fleet mix. Aircraft with the lowest level of engine emissions (Class 5) are free, while Class 1 aircraft with the highest level of emissions pay 40% of the landing charge. Landing fees were reduced by 5% on implementation of the scheme in order to make the impact of emission charge overall cost-neutral. Revenue derived from the emissions charges is used to finance environmentally friendly projects aimed at facilitating expansion at the airport. The emissions scheme was extended to include the airports at Geneva in 1998, Bern in 2001, Basel in 2003 and Lugano in 2007.

An emissions charging scheme based on the model used at Swiss airports was introduced at Basel in 2003, while in the UK a scheme based on the ECAC recommendation and the Swedish/Swiss matrix for smaller aircraft was introduced at Heathrow in 2004, Gatwick in 2005 and Manchester in 2007.