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INFORMATION PAPER

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STEERING GROUP MEETING

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Agenda Item 3: Forecasting and Economic Analysis Support Group (FESG)

REVIEW OF STUDIES ON THE FINANCIAL IMPACT OF INCLUDING INTERNATIONAL AVIATION IN EXISTING TRADING SCHEMES

(Presented by the FESG Market-Based Measures Task Group)

SUMMARY

This report presents the results and key findings of economic studies analyzed by the FESG Market-Based Measures Task Group (MBMTG) on the financial impact of including international aviation in existing trading schemes, as requested in Task F.05.1) of the CAEP/8 work programme.

1. INTRODUCTION

1.1 The Market-Based Measures Task Group (MBMTG)[1] was convened to take forward work on Task F.05 of the FESG CAEP/8 work programme. The two parts to this task are:

- Part A: Conduct an economic analysis of the financial impact of including international aviation in existing trading schemes. [Task F.05.1)]
- Part B: Undertake a literature review of cost-benefit analysis of existing trading systems with a special emphasis on how it has been applied to other sectors in order draw some pertinent lessons learned for the aviation sector. [Task F.05.2)]

1.2 These tasks were subsequently extended (at the request of the CAEP Steering Group) to consider the impacts on developing countries and to include lessons about cross-border applications (in Part B). Separate reports have been made for both tasks.

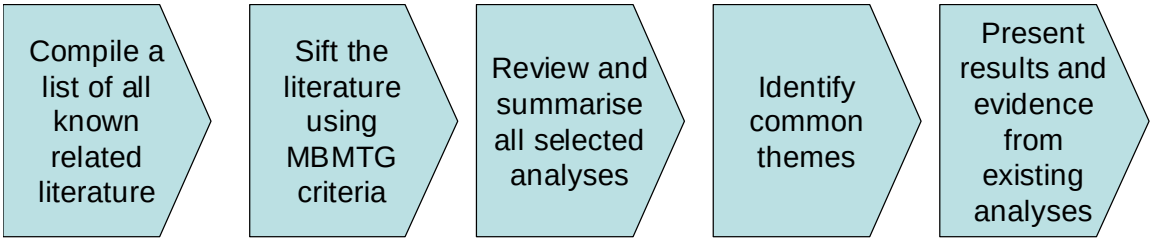
1.3 This paper reports the work for Task F.05.1).

[1] The list of MBMTG members can be found in Appendix A.

2. APPROACH: OVERVIEW

2.1 A significant volume of literature already exists on the financial implications of aviation joining an emissions trading scheme. Recognising this, and that commissioning new work would be resource intensive and risks duplication, the approach taken by the MBMTG has been to review existing analysis and not to take forward new work.

2.2 The process used was as follows:



2.3 The MBMTG has compiled a wide range of literature[2], including work undertaken for national Governments, trade associations, academic bodies, CAEP, etc. This literature consisted of work done by FESG in previous CAEP cycles, and various analyses carried out within the context of the inclusion of aviation in the European Emission Trading Scheme. This provided the MBMTG with a broad range of studies to draw on.

2.4 The compiled literature was sifted to ensure it was directly relevant to the task and contained sufficient information to be of value. The sifting process was carried out using criteria generated by the MBMTG specifically for this task.[3] Having identified all relevant analyses compiled by the group, MBMTG members then reviewed and summarised each of them.

2.5 The summaries were all presented in a template format[4] to ensure the same information was collated and to ease the process of contrasting and comparing the findings, assumptions, conclusions, etc.

2.6 The template also allowed common themes to be identified, i.e. those issues pertinent to aviation and emissions trading that were addressed in the analyses. The themes were:

i. Competition: the extent to which airlines are affected differently by the inclusion in the emissions trading scheme (ETS) and how that might influence the fares they can charge and/or quality of service provided.

ii. Cost pass through: the extent to which the increased cost induced by the ETS is charged to customers in response to market conditions.

iii. Windfall profits: in the circumstance that airlines get part of their allowances for free, "windfall profits" can be generated if the value of the free allocated allowances is charged to their customers.

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[2] The list of studies reviewed is appended at the end of the report as Appendix B.

[3] The criteria used were i) whether the study covered the subject area of this task; ii) whether the study included an economic analysis of the financial impacts of including international aviation in existing trading schemes; and, iii) whether the study included sufficient information on its analysis to add value to the task.

[4] The summaries (in a template format) of all the studies reviewed are presented in Appendix C.

iv. Benchmarking: the approach used to allocate free allowances, based on relative levels of airline activity.

v. Auctioning: an approach for distributing allowances before trading; airlines bid for allowances and they are sold to those who are the successful bidders.

vi. Impact on developing countries: the extent to which airlines from developing countries are affected.

vii. Effect on market price of carbon: the potential impact on carbon prices resulting from the inclusion of aviation in an existing ETS.

2.7 The following sections present the results and key findings of the analyses summarised under each of the seven themes identified.[5]

3. RESULTS AND FINDINGS OF THE ANALYSES BY THEME

3.1 The studies reviewed by the MBMTG varied in terms of their analytical content, evidence base, objective and focus. They presented at least some analysis – some of which was only qualitative – of the implications of aviation joining an emissions trading scheme.

3.2 Competition and Cost pass through

3.2.1 Competition and cost pass through are in many ways related issues. This is because, generally, as competition intensifies in a market (e.g. where there are many airlines competing with one another for business in a particular market) the extent to which profits are achievable is affected, and the lower the scope is for any increase in costs to be 'absorbed' by the airline. Hence, higher cost pass through would be expected, at least in the long term.[6]

3.2.2 The studies reviewed by the MBMTG offered a wide spread of views in terms of impacts on competition and the likely extent of cost pass through. In order to make some sense out of the sometimes conflicting conclusions, careful consideration should be given to the exact situation considered in the studies and the point in time at which these studies were undertaken (or published) because further insight on this subject is emerging over time. In addition, the time frame considered by the studies is also important because those that are looking at short term impacts tend to offer different views to those which are long term only.

3.2.3 The situations emerging from the studies are:

i. **Coverage of the emissions trading scheme is only partial, leaving airlines from some countries with no emission reduction obligations.** In this case, airlines operating in Annex 1 countries[7] are assumed to have emissions targets and are obliged to fulfil them within an emission trading scheme (ETS), whereas airlines from non-Annex 1 countries have no targets. Under these conditions the airlines from non-Annex 1 countries gain a benefit while Annex 1 countries are left with losses. This result is driven by the fact that

[5] The Seattle Steering Group meeting endorsed the MBMTG's intent to reflect the views contained in the studies without attempting to give value judgment, although limitations were to be addressed. Ref. [CAEP-SG/20082-SD/1] "Summary of Discussions and Decisions of the First Meeting of the Steering Group. Monday, 22 September 2008". Second Steering Group of the CAEP/8 cycle held in Seattle (United States) on September 22-26, 2008. Section 4, paragraph 4.13, p.7.

[6] There may be constraints on the ability to pass through costs in the short term.

[7] As defined by the Kyoto Protocol.

emissions constraints imposed by the ETS imply costs (i.e. the requirement to buy emissions allowances) that are not faced by those who fall outside the scheme. If these costs are passed through to passenger fares, within common markets those airlines not covered by the ETS are therefore relatively better off and may be able to attract business from other airlines by charging relatively lower fares or, alternatively, achieve higher yields.

ii. **All airlines are subject to the same ETS conditions.** This would be the case under a worldwide-applied trading system for aviation or, for example, implementing a trading scheme for only Intra-European traffic. Under these conditions all airlines are affected in exactly the same way and consequently there is no distortion of competition and all airlines ***can*** (and probably will) pass their costs on to the customers.

iii. **The ETS is regional, hence the impact on individual airlines may vary**. This is a more complicated situation in which, although airlines that fly into and out of the ETS region are treated equally, the coverage of their full operations is not equal and, therefore, they can be affected differently. In this situation the studies reviewed give different views on what might happen in terms of competition and cost pass through. This latter situation is further explored below.

3.2.4 The report "Giving wings to emission trading" from CE Delft (2005) gives a qualitative reasoning why all costs will be passed on to customers and consequently there would be no distortion of competition. The report draws on economic theory and sets out that given the airline industry is competitive, and profit margins are low, any cost increases would have to be passed through to customers otherwise the industry would not be sustainable. This position is adopted by the European Commission (2006) in its impacts assessment on the inclusion of aviation in the European Union Emission Trading System.

3.2.5 In contrast however, the report of Ernst & Young (2007) on the EU ETS concludes that not all costs can be passed through (35% at maximum) and states that this will lead to a decrease in profits for the European airlines. This is because of both the impact on demand if costs are passed through, and the fact that some airports are capacity constrained which limits the airlines' responsiveness to cost changes.

3.2.6 These two opposing views are the subject of debate.

3.2.7 In its study on the extent to which airlines are likely to pass the costs of emissions allowances through to ticket prices, Vivid Economics (2007) concludes that all costs (and in some specific circumstances, even more than 100%) would be passed on. As with the CE Delft (2005 and 2007) work, this study relies on economic theory to draw this conclusion, coupled with evidence from other industries, and notes that this must be true in the long term 'equilibrium' position.

3.2.8 In another study on the impacts of emissions trading on profits, Vivid Economics (2008) concludes, again using a theoretical approach, that a certain percentage of free allocation should remain to maintain airline profitability. Frontier Economics (2006) illustrates that not all costs will be passed through and that the effect on Low Cost Carriers (LCC) will be larger than for Full Service Airlines (FSA).

3.2.9 Several of the studies in this area are theoretical given the absence of hard evidence from aviation (as it has not yet joined the ETS). More practical approaches are followed in the studies conducted by MVA Consultancy (2006), and by CE Delft and MVA Consultancy (2007).

3.2.10 In its analysis of the consequences (for the Dutch aviation sector) of including aviation in the EU ETS, MVA Consultancy (2007) concludes that there are opportunities for non-EU airlines to cross-subsidize their tickets on routes to and from the EU, while cross-subsidizing on the intra-EU routes is highly unlikely.[8] This study was later amended by CE Delft and MVA Consultancy (2007). In this latter study, the authors conclude that for most airlines cross-subsidizing would not result in higher profits. However the study found it is not possible to rule out completely the possibility that some non-EU carriers could engage in cross-subsidization of their routes to and from the EU.

3.2.11 The study also concluded that the hub effects work in the favour of non-EU carriers. Hub effects relate to the possibility that where passengers have the choice of hub airports at which to change from one flight to another as part of a long haul journey, ETS-related costs are likely to be lower on trips which avoid hub airports that are located in the ETS region. In CE Delft (2008) this aspect is further elaborated and the impact of the hub effect is estimated. On routes where non-EU airlines have the possibility of transferring their traffic to non-EU hubs, EU airlines may not pass on to customers all the costs they incur as a result of the trading system, and therefore have a competitive disadvantage.

3.3 **Windfall profits**

3.3.1 The literature reviewed generally took one of two approaches to determine the unexpected revenue (i.e. windfall profits) airlines may realise if allowances are allocated to them for free in an emission trading system:

- Assume that the "opportunity" or incremental cost of all allowances would be passed on to customers.
- Incorporate some approximation of the market factors such as airline pricing behaviour, demand elasticity, etc.

3.3.2 In line with the first approach, several studies, including MVA Consultancy (2006) and Vivid Economics (2007), concluded, as explained above, that the costs associated with the ETS would be passed through to passengers. Where allowances are allocated for free at the beginning of a trading period, the implication of passing these costs to passengers is that airlines would gain windfall profits.

3.3.3 The Vivid Economics (2008) study concluded that the range of allowances that should be allocated for free in order to maintain airline profits at pre-emissions trading levels is of the order of 20-40% emissions. The CE Delft (2007) study notes that if the opportunity costs of freely allocated allowances are passed through, this may actually increase the airlines operating margin.

3.3.4 In relation to operating margins of EU carriers, CE Delft (2007) concludes that trading schemes would reduce their operating results by 2.4% in 2012 and some 2.5% in 2020. This study assumes that the negative profitability impact of fixed costs with declining demand would be limited since aviation is a growth industry and carriers could adjust their plans well in time.

3.3.5 CE Delft (2007) concluded that if part of the allowances are allocated free of charge, there will either be windfall profits and a demand effect (as fares increase), or no windfall profits and no demand effect. Only in the case of auctioning, can windfall profits be avoided while still inducing a demand effect.

3.3.6 In contrast to these conclusions, several other studies adopted the second approach in their analysis.

[8] "Cross subsidize" means to use the revenue generated in one market to cover costs in another market.

3.3.7 Ernst & Young (2007) analyzed airline pricing behaviour and found that ticket prices are set at a level to maximize profits, given market conditions on every route. Since airline operators will always be buyers of allowances, Ernst &Young concluded that windfall profits will not arise in the aviation sector. They also found that any additional costs borne by the airlines will necessarily lead to a decrease in profits.

3.3.8 Frontier Economics (2006) also questioned the possibility of windfall profits by the airline industry, focusing on passenger pricing in the reality of the European market environment. Assuming that incumbent and new operators alike are not discriminated against in the allocation of free allowances, the cost basis of both groups would be reduced, encouraging market entry and reducing ticket prices.

3.3.9 The CE Delft (2008) study also concluded that there is a very low probability that windfall profits will occur. Common elements in these studies are the questioning of the likelihood of airlines realising windfall profits and the suggestion that an increase in airlines' operating costs would be expected to lead to a reduction of their profit margins. This would happen either directly through higher costs not being passed on, or indirectly through costs being passed on which would lead to reduced revenue (higher ticket prices offset by depressed demand).

3.4 **Auctioning**

3.4.1 The issue of auctioning is very much related to the issues of cost pass through and windfall profits. This is important because auctioning concerns the way in which allowances are allocated to airlines at the beginning of a trading period – they are either given for free (through grandfathering or benchmarking) or auctioned. In addition, as the aviation sector grows but the allocated allowances remain set at the level of 2005 emissions,[9] the gap in allowances will need to be filled by purchases on the carbon market.

3.4.2 Several studies have addressed this issue and have sought to explore the implications for airlines and air travel demand under scenarios where auctioning levels differ. Auctioning impacts on airlines because of the financial implications of having to purchase allowances for compliance with the ETS.

3.4.3 The general view taken by most studies, such as MVA Consultancy (2006), which looked at the impact on the Dutch aviation sector, and CE Delft (2007), which considered the impact of the allocation of allowances on airlines' profits, is that where allowance prices are higher, the impact on ticket prices and therefore demand will be higher (where those costs are passed through) or the impact on airlines' profits will be more adverse (where the airlines do not pass the costs through).

3.4.4 CE Delft (2007) concluded that losses would be made by airlines unless they pass through the cost of allowances bought through auction; if price increases reduce demand then this may lead to excess capacity as investments will already have been made. If only 50-75% of costs are passed through to ticket prices then profit margins are estimated to fall from an average 3.1% to 1.3-2.7%. However, if auctioning levels were to rise over time then this would allow airlines to take this into account in their investment decisions.

3.4.5 Vivid Economics (2008) looked at the estimated level of free allocation in the long term for the industry as a whole (and by implication the level of auctioning) that would be required to maintain airline profit levels at their pre-ETS levels. It found that between 20-40% of emissions allowances (percentage of pre-emissions trading levels) should be allocated for free (and therefore 60-80% auctioning) to maintain aggregate profit levels at their pre-ETS levels, for a wide range of market characteristics. Any additional

[9] Under the EU ETS, the proposed caps on greenhouse gases emissions in 2020 are compared to 2005 emissions levels (baseline).

free allocation above these levels would increase airlines' profits above their pre-ETS levels by an amount equal to the value of that allocation.

3.4.6 The study also found that in markets where there are no more than two airlines supplying a particular route, the range of free allocation required to maintain profits is estimated at between 40-70% of emissions (and therefore 30-60% auctioning) because the airlines' profits on these routes are assumed to be higher to begin with due to lower competition and market power.

3.4.7 Auctioning of aviation allowances will not create any additional overall reduction of CO_2 emissions in the EU as emissions are set by the cap and not by the allocation method.

3.4.8 6.8 Permits purchased through auction or on the carbon market will be similarly priced so their effect on airlines will depend on how much of the costs can be passed through to passengers. Auctioning could create a reduction in demand (if costs are passed through) and therefore lead to potentially small reductions in other aviation emissions (e.g. NO_X, etc.).

3.4.9 If allowances are allocated free of charge on the basis of a revenue tonne-kilometre (RTK) benchmark, the incentive to reduce emissions by demand measures might somewhat be reduced in comparison to when allowances are auctioned (CE Delft 2007). However the costs of auctioning are small in comparison to the costs of other alternatives open to the airlines to reduce their CO_2 emissions, so not too much effect can be expected. In the following section on benchmarking this issue will be addressed further.

3.4.10 FESG (2004b) – Part II suggested in its analysis of different trading schemes that auctioning raises funds that could be used for other purposes, such as those that facilitate further emissions reductions within the aviation sector.

3.5 **Benchmarking**

3.5.1 Benchmarking is a method used for allocating allowances to airlines at the beginning of a trading period. It involves monitoring the activity levels of the airlines involved and allocating allowances for free in relation to their activity relative to a benchmark year.

3.5.2 Very few of the studies reviewed by the MBMTG addressed the issue of benchmarking directly. However, the extent to which this theme is covered broadly falls into two categories:

i. Where free allocation using benchmarking is repeated

ii. How different benchmarking approaches affect different types of airlines

3.5.3 In the first category, the study for WWF[10] by CE Delft (2007) found that if benchmarking (free allocation) is repeated, i.e. allowances are allocated several times and not just once per trading period, then this might give rise to opportunity benefits. Opportunity benefits are described as those benefits in the next trading period which result from increasing activity, as measured by revenue tonne-kilometres (RTKs), in the previous period and hence increasing the airlines' free allocation.

3.5.4 The fact that allowance allocations are repeated means that it is in the airlines' interests to increase activity (RTKs) now and therefore secure a higher allocation of free allowances for the next period – the opportunity benefit. This is assumed to counteract the 'opportunity costs' that exist from the

[10] WWF – World Wide Fund for Nature.

airlines having to hold onto its free allowances, rather than selling them for a profit on the carbon market (though it would have to reduce emissions to do so).

3.5.5 The study concluded that opportunity costs and opportunity benefits would largely cancel out and therefore it is not expected that these costs would be passed on in ticket prices. Thus no windfall profits would arise.

3.5.6 Scheelhaase, Grimme and Schaefer (2008) also note the risk that the behaviour of airlines may change to increase their activity (RTKs) in certain years in order to secure a higher allocation under a benchmarking regime.

3.5.7 CE Delft (2007) concluded that if airlines received allowances free of charge under one-off benchmarking, airlines would pass these costs through to passengers. The implication is that there would be windfall profits. However if the benchmark is done regularly it becomes highly unlikely that windfall profits occur.

3.5.8 In the second category, CE Delft and MVA Consultancy (2007) considered the issue of competition between EU and non-EU carriers, and found that EU carriers do not operate more fuel efficient aircraft than non-EU carriers on long-haul routes from/to the EU. Therefore, although benchmarking is not specifically addressed in this analysis, the implication is that if benchmarks were based on efficiency, there would be no competitive advantage to either EU or non-EU carriers.

3.5.9 The most comprehensive study looking at the impact on different types of airlines is the study carried out by CE Delft and MMU (2007).

3.5.10 This study assesses the relative distributional implications for different sorts of airline operators if different benchmarks are used such as output based (RTKs), inputs (payload, maximum take-off weight, etc.) and technology/age (more allowances are allocated to newer fleets).

3.5.11 It found that low cost carriers would be more sensitive to the choice of benchmark than network airlines – they would be expected to fare better under age benchmarks, but less well against output based (RTKs) given their fuel intensity over short flights. Non-EU carriers from the United States would fare well under input and output benchmarks given they operate long haul with efficient fleets. Freighter aircraft would fare less well generally because they have older fleets and operate mainly short haul trips. Overall, output based benchmarks are concluded to be more consistent with environmental efficiency and have least distributional impacts across airline types.

3.5.12 Scheelhaus and Grimme (2007) also briefly considered the issue of benchmarking and found that because low cost carriers have high load factors and fuel efficient aircraft, a benchmarking approach could give them more allowances than they actually need with a 95% cap and a 15% auctioning level. In such a case, they could sell surplus allowances and make a profit.

3.5.13 It would appear that this could only occur if the activity of such carriers was reduced to a level below their activity in the baseline year.

3.6 **Developing countries**

3.6.1 At CAEP/6, FESG presented an analysis of the effects of CO_2-related charges on developing countries (FESG 2004a). This is the only study the MBMTG found within the scope of this task that specifically addresses impacts on developing countries. Though past CAEP analyses have established general differences between charging and trading systems, the paper is relevant regarding the different

impacts on airlines from Annex 1 versus non-Annex 1 countries depending upon the relative coverage of such airlines in the system.

3.6.2 The analysis showed that the more routes covered by the system with competition between airlines from both developed and developing countries, (1) the greater the impact on airlines from developing countries, and (2) the greater the competitive distortion effects if the system only applies to airlines from Annex 1 countries.

3.6.3 The analysis demonstrated the importance of the definition of Annex 1 countries' emissions used in the assessment (e.g., emissions resulting from flights to and from Annex 1 countries, from flights departing from Annex 1 countries, or only from the flights of airlines based in Annex 1 countries), with the impact on airlines from non-Annex 1 countries being smaller as the application of the system is narrowed.

3.6.4 With the system applied only to airlines from Annex 1 countries, those from non-Annex 1 countries competing on covered routes benefit from the resulting increase in fares on such routes without having to face the increase in costs.

3.7 **Effect on market price of carbon**

3.7.1 ICF Consulting (2006) finds that the inclusion of aviation in the EU ETS will have no incremental impact on the price of allowances.

3.7.2 However, the study made a number of assumptions that are not consistent with the anticipated implementation of Directive 2008/101/EC.

4. SUMMARY

4.1 The literature review carried out by the MBMTG for Part A of Task F.05 has shown that there are a broad range of views, supported by a different degree of evidence, on each of the key themes of competition, cost pass through, windfall profits, auctioning, benchmarking and developing countries.

4.2 In summary, the MBMTG has found that:

4.3 The impacts on competition and cost pass through are highly dependent on the nature of the ETS introduced. The studies have addressed three different situations:

- Coverage of the ETS is only partial, leaving airlines from some countries with no emission reduction obligations. In this case the airlines not covered by the system (e.g., those from developing countries) gain an advantage on routes in common markets.

- All airlines are subject to the same ETS conditions. In this case there is no competitive distortion and airlines can (and probably will) pass their costs on to consumers.

- The ETS is regional, hence the impact on individual airlines may vary.

4.4 Regarding the third case, the studies differ in their views of cost pass through; some have relied on economic theory and others have tried to consider specific characteristics of the airline industry. Cost pass through levels are likely to differ according to the particular markets being considered and the time frame of analysis, i.e. long term effects or short term.

4.5 The studies also vary widely in their conclusions on windfall profits. This is related to the issue of cost pass through, on which there are differing views.

4.6 Auctioning is an important issue in terms of compliance costs because the higher the level of auctioning, the fewer allowances would be allocated for free. Where auctioning levels are higher, a greater impact on airlines' costs would be expected and hence potentially greater impacts on demand. Though revenues would be generated that could be used to further the benefits of the scheme if directed to that purpose. Auctioning has no further reducing effect on CO_2-emissions. Those are set by the emission cap; however, there might be some effects on other aviation emissions like NO_X, due to the reduction in demand induced by the extra costs.

4.7 Benchmarking as a way to allocate emissions allowances for free may have implications for airline activity and would be likely to affect airlines differently depending on their levels of activity, efficiency and costs of purchasing allowances.

4.8 There is no conclusive finding on the effect on the price of allowances resulting from the addition of the aviation sector to an existing ETS.

- END -

APPENDIX A
MEMBERS OF THE FESG MARKET-BASED MEASURES TASK GROUP

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Nancy Young	Air Transport Association

Former members

Bengt-Olov Nas	Scandinavian Airline System ***[retired in February 2008]***
Fred Swanevelt	American Airlines
João Vieira	Transport and Environment

APPENDIX B
LIST OF STUDIES REVIEWED

[1] CE Delft (2005). "Giving Wings to Emissions Trading. Inclusion of aviation under the European emission trading system (ETS): design and impacts." Report for the European Commission, DG Environment. July.

Authors: R.C.N. (Ron) Wit, B.H. (Bart) Boon and A. (André) van Velzen (CE Delft), M. (Martin) Cames and O. (Odette) Deuber (Oeko-Institut, Berlin), D.S. (David) Lee (Manchester Metropolitan University)

[2] CE Delft (2007). "Allocation of allowances for aviation in the EU ETS. The impact on the profitability of the aviation sector under high levels of auctioning". Final report for the WWF UK. June.

Authors: Bart Boon, Marc Davidson, Jasper Faber, André van Velzen

[3] CE Delft (2008). "Competitiveness issues for Dutch industry from EU ETS". Final report for the Dutch Ministry of Transport. October.

Authors: Marc Davidson, Jasper Faber, Sander de Bruyn

[4] CE Delft and MMU (2007)." The Impacts of the Use of Different Benchmarking Methodologies on the Initial Allocation of Emission Trading Scheme Permits to Airlines". Final Report to United Kingdom Department for Transport (DfT) Aviation Environmental Division and the Environment Agency. July.

Authors: Faber, J., Vreede, G. van de & Lee, D. S

[5] CE Delft and MVA Consultancy (2007). "Implications of EU Emission Trading Scheme for Competition Between EU and Non-EU Airlines". Joint Report by CE Delft and MVA Consultancy. Draft final report for the Dutch Directorate General for Transport and Civil Aviation (DGTL). In Association with SEO Amsterdam. November.

[6] Ernst & Young (2007). "Analysis of the EC Proposal to Include International Aviation Activities in the EU ETS". Report commissioned by the European Airlines Associations.

[7] European Commission (2006). "Impact Assessment of the Inclusion of Aviation Activities in the Scheme for Greenhouse Gas Emission Allowance Trading within the Community". December. {COM(2006) 818 final} {SEC(2006) 1685}

[8] FESG (2001). "Report on Economic Analysis of Potential Market-Based Options for Reduction of CO_2 Emissions from Aviation". [CAEP/5-IP/9]. Information paper submitted at the fifth meeting of the CAEP, held in Montreal (Canada) on January 8-17, 2001.

[9] FESG (2004a). "Report on Effects of CO_2-Related Charges on Developing Countries". [CAEP/6-WP/48]. Working paper submitted at the sixth meeting of the CAEP, held in Montreal (Canada) on February 2-12, 2004.

[10] FESG (2004b)."Analysis of Voluntary Agreements and Open Emission Trading Systems for the Limitations of CO_2 emissions from Aviation with the AERO Modelling System". [FESG/6-9 WP6]

[10a] Part I – Analysis of voluntary agreements for the limitation of CO_2 emissions from aviation with the AERO modelling system.

[10b] Part II – Analysis of open emission trading systems for the limitation of CO_2 emissions from aviation with the AERO modelling system

Authors: Hans Pulles (Dutch Civil Aviation Authority), André van Velzen (Vital Link Policy analysis), Gerrit Baarse (BB&C), Richard Hancox and Duncan Edmondson (MVA Limited).

[11] Frontier Economics (2006). "Economic Considerations of Extending the EU ETS to Include Aviation". Report prepared for the European Low Fares Airline Association (ELFAA). March.

[12] ICF Consulting (2006). "Including Aviation into the EU ETS: Impact on EU allowance prices. Report prepared United Kingdom Defra and Dft[11].

[13] MVA Consultancy (2006). "Consequences for the Dutch Aviation Sector of Inclusion in the European Emission Trading Scheme". Final report for the Dutch Directorate General of Civil Aviation and Freight (DGTL). In association with SEO Economic Research Amsterdam. September

[14] Scheelhaase, D. and W.G. Grimme (2007). "Emissions trading for international aviation – an estimation of the economic impact on selected European airlines", *Journal of Air Transport Management* **13**, pp. 253–263.

[15] Scheelhaase, D., Grimme, W.G. and M. Schafer (2008). "The inclusion of aviation into the EU emission trading scheme - impacts on competition between European and non-European network airlines", Forthcoming in *Journal of Air Transport Management*.

[16] Vivid Economics (2007). "A Study to Estimate Ticket Price Changes for Aviation in the EU ETS". Report for Defra and DfT. November.

[17] Vivid Economics (2008). "A Study to Estimate the Impacts of Emissions Trading on Profits in Aviation. Report for Defra and DfT. July.

[11] DEFRA – Department for Environment, Food and Rural Affairs. DfT – Department for Transport. United Kingdom.

APPENDIX C
SUMMARIES OF STUDIES REVIEWED
(IN TEMPLATE FORM)

Study Reviewed: [1] **CE Delft (2005).**
Giving wings to emissions trading – inclusion of aviation under the European emissions trading scheme (ETS): design and impacts

Document information				
Title	**Author**	**Date**	**Sponsor**	**Objective of the paper**
Giving wings to emissions trading – inclusion of aviation under the European emissions trading scheme (ETS): design and impacts	CE Delft (Wit, Boon, van Velzen, Cames, Deuber & Lee)	July 2005	European Commission, DG Environment	To develop concepts for amending the European Directive that formed the European Emissions Trading Scheme (ETS) (Directive 2003/87/EC) "to address the full climate change impact of aviation through emissions trading." Goal under this also included (1) how to address non-CO2 effects of aviation within the ETS "without undermining the scheme's integrity;" (2) designing viable policy options for geographic scope, allocation and surrendering of allowances, and monitoring, reporting and verification of data; and (3) assessing the "qualitative impact of policy options developed for including aviation in the EU ETS." [Note: Economic analysis appears primarily in Chapter 6 and Annex E, with some pieces of the analysis discussed in Chapter 5 and in Annex F]

Issues covered				
Cost pass-through	**Competition**	**Windfall profits**	**Benchmarking**	**Auctioning**
Yes, partial (assume policy-induced cost increases to airlines as passed on fully to consumers; two scenarios assessed for pass-through of "opportunity costs" of grandfathered permits: either (1) not passed on at all or (2) passed on in entirety)	Yes	Yes (assume "opportunity costs" of grandfathered permits are either not passed on at all or are passed on in entirety)	Yes	Yes

Approach adopted (including scope of scheme considered)

After a review of the design features of adding aviation into the European ETS, the study identifies three design options that are then subjected to more detailed environmental and economic analysis. The study focuses primarily on the "potential economic distortions and distributional impacts" of the three proposed options for including aviation into the European ETS. (See Chapter 6). The primary features of the three options covered are as follows:

	Option 1	Option 2	Option 3
Coverage of climate impacts	CO2 and multiplier for non-CO2 impacts	CO2 only and flanking instruments	CO2 only and flanking instruments
Geographic scope	Intra-EU	100% departing flights	EU airspace
Carriers covered	EU and non-EU carriers	EU and non-EU carriers	EU and non-EU carriers
Allowance distribution mechanism	Above historic baseline, purchase from other sectors (free allowances up to 2008 baseline)	Benchmarked allocation (free allowances up to 2008 baseline)	Auctioning
Monitoring method	Actual trip fuel reported by airline	Actual trip fuel reported by airline	EUROCONTROL data (ex ante and surveillance)

The study projects impacts on operating costs and ticket prices for three flight stages (an exemplary short-, medium- and long-haul flight) under the three policy options versus a "business as usual scenario" using spreadsheet models (see Section 5.3.5). For the two policy options where permits are given for free to carriers up to a

Study Reviewed: [1] **CE Delft (2005).**
Giving wings to emissions trading – inclusion of aviation under the European emissions trading scheme (ETS): design and impacts

Approach adopted (including scope of scheme considered) – ***continued***

baseline (Options 1 and 2), the cost and ticket price analysis is calculated under two scenarios, one assuming that the value of free allowances (referred to as "opportunity costs") is passed on in full to consumers (i.e., resulting in what is termed as a "windfall") and the other assuming that the value of free allowances is not passed on as costs to the consumers. The study also projects impacts on demand and supply-side responses by the aviation sector using the AERO-MS model. The study then compares effects on transport volume on the EU market (defined as "all intra EU routes and routes to and from the EU") to determine the extent to which competitive distortion would result as between EU and non-EU carriers. The study also assesses potential economic distortions between airports and between tourist areas as a result of the three policy options. This analysis relies in part on the ticket price analysis, but also on qualitative assessment (e.g, observations like "because of airlines' dependence on traffic rights and slots and, furthermore, on the catchment area of an airport, airlines do not readily change their home base")).

Time frame considered

2008-2012 (but costs are calculated and reported only for 2012)

Key assumptions

- ETS permit (allowance) market price €10 or €30
- No cross-subsidization
- All three policy options cover EU and non-EU carriers on covered routes
- Cost impacts on an example short- (Amsterdam to Paris, CDG), medium- (Munchen to Palma de Mallorca) and long-haul (London Gatwick to Newark) flight
- Under Options 1 and 2 free permits are provided up to 2008 baseline; Option 3 100% auctioning
- Cost pass-through: assume costs of any permits that much be purchased are passed on fully to consumers
- "Windfall" assumption: two scenarios assessed for pass-through of "opportunity costs" of grandfathered permits: either (1) not passed on at all or (2) passed on in entirety (i.e., if the value of free permits are passed on to the consumer as price increases, the study says that will result in a "windfall" to airlines)
- Average emissions growth rate of 4 percent per year
- Oil price (relevant to AERO-MS model runs): assumed $50 US per barrel
- Price elasticities of demand by route group (relevant to AERO-MS model runs)

Route Group	Pax, First/Business	Pax Economy	Cargo
EU – North Am	-0.3	-0.8	-0.7
EU – Central Am	-0.2	-0.8	-0.7
EU – South Am (N)	-0.2	-0.7	-0.7
EU – South Am (S)	-0.2	-0.7	-0.7
EU – EU	-0.2	-0.7	-0.7
EU – Non-Aligned Europe	-0.2	-0.7	-0.7
EU – Middle East	-0.3	-1.1	-0.7
EU – Eastern Af	-0.2	-0.7	-0.7
EU – Western Af	-0.2	-0.7	-0.7
EU – Southern Af	-0.2	-0.7	-0.7
EU – Far East (N)	-0.2	-1.0	-0.7
EU – Far East (S)	-0.2	-1.0	-0.7
EU – Southwest Pacific	-0.2	-1.0	-0.7
EU – Former Eastern Bloc	-0.2	-0.9	-0.7

Study Reviewed: [1] **CE Delft (2005).**
Giving wings to emissions trading – inclusion of aviation under the European emissions trading scheme (ETS): design and impacts

Data relied on
• Spreadsheet model for cost calculation (calculations described in Annex E) AERO-MS model run (basic description of model, but limited detail, in Annex F, refers to Pulles 2002 for details of model)
Financial cost drivers and airline pricing behaviour
Airlines seek to pass on in fare increases the whole of the additional costs arising from the ETS
Key findings and conclusions
Operating costs and ticket prices: The study reports projected operating cost and ticket price impacts. The authors conclude as follows: "The impact on ticket prices is relatively small, for several reasons. In the first place, under Options 1 and 2 the only financial costs borne by aircraft operators are those associated with emissions growth. These costs are expected to be spread out over all tickets for flights falling under the scheme, however. Increases under Option 3 are generally greater because of the auctioning of allowances. As Option 3 in based on EU airspace, however, only a small portion of long-haul flights is subject to the scheme." (Executive Summary, Section 4). Windfall profits: The study did not seek to assess the degree to which airlines would pass on the value of free allowances ("opportunity costs") to consumers. Rather, (as noted above) it assessed airline costs (and resulting impacts) under two windfall/opportunity cost scenarios, one of no pass-through and another of 100% pass through. Based on this, the study concludes that "if these opportunity costs were passed on *in toto*, the ticket price increases under Options 1 and 2 [the Options under which free permits are given to carriers] would be about 7 times greater." However, the study authors state that "it should be borne in mind that passing on opportunity costs to customers would raise ticket prices, but it would also generate so-called windfall profits for aircraft operators by the same amount per ticket, i.e., inclusion of opportunity costs will not increase total costs of aircraft operators, since such an increase in ticket prices would not reflect a rise in actual operating costs for aircraft operators." (Executive Summary, Section 4). Potential for competitive distortion between EU and non-EU carriers: The study concludes that "none of the policy options considered in this study will damage the competitive position of EU airlines relative to non-EU airlines significantly," primarily because all three policy options were defined as covering all carriers flying the covered routes (see Section 6.3). Potential economic distortions between airports and between tourist areas as a result of the three policy options: The study concludes that there would be negligible distortion under the three policy options, in significant part based on the ticket price analysis. The study authors conclude that the policy options would not change ticket prices to such a degree that the airlines would shift to other airports either on the edge of or outside the EU (though the study does not analyze at what cost airlines would or would not shift operations).
Limitations
• Because the design elements of each of the three policy Options assessed differ as between Options, it is difficult to compare the Options or to isolate the effects of any given design element. • There is very little detail provided on the cost calculations and AERO-MS model runs. • Competitive distortion analysis relies mainly on economic theory and general observations about airline behavior – the study does not undertake comparative operating cost analysis to assess the point at which airline choices in airports could be affected.
Consideration of impacts on developing countries
No

Study Reviewed: [2] **CE Delft (2007).**
Allocation of allowances for aviation in the EU ETS - The impact on the profitability of the aviation sector under high levels of auctioning

Document information				
Title	**Author**	**Date**	**Sponsor**	**Objective of the paper**
Allocation of allowances for aviation in the EU ETS - The impact on the profitability of the aviation sector under high levels of auctioning	CE Delft Boon / Davidson / Faber / van Velzen	June, 2007	WWF UK	WWF UK asked CE Delft to study the initial allocation of allowances to aircraft operators, and specifically: • The interaction between allocation method and the likelihood that costs of allowances are passed through. • How the allocation method may affect emission reductions within the aviation sector. • The impact of high levels of auctioning on the profitability of the aviation sector.

Issues covered				
Cost pass-through	**Competition**	**Windfall profits**	**Benchmarking**	**Auctioning**
Yes	Yes	Yes	Yes	Yes

Approach adopted (including scope of scheme considered)

- Theoretical discussion, citing other studies

Time frame considered

2012 - 2020

Key assumptions

The pricing power of airlines is assumed to be similar to the pricing power of regulated monopolies such as utilities
Airline pricing is assumed to be related to the marginal cost of operating the flight (MR=MC)
Airlines absorbed $1.5B in losses at 2003 and, therefore, no further increase in costs and losses can be tolerated. (Apparently, the first billion and a half of losses were to everyone's satisfaction?)

Data relied on

AERO model output

Financial cost drivers and airline pricing behaviour

- Citing OXERA (2003): Airline pricing does not reflect marginal cost. Rather, the product price is set at the level which clears the demand at the given supply which may be different from (and even below) the marginal cost of production, even at congested airports. The Competition Commission (2002) observed the lack of profitability for airlines based at Heathrow.

Key findings and conclusions

- Auctioning was assumed to lead to the highest increase in ticket prices, followed by grandfathering and one-off benchmarking. Repeat benchmarking was not expected to lead to increases in ticket prices
- Repeat benchmarking may drive airlines to increase activity so as to not loose ground at the next benchmarking
- Impact of auctioning:
  - If airlines can not pass through the expenditure on allowances, losses will be incurred and operating margins will be reduced
  - Environmental policy that reduced demand may cause excess capacity, and a loss to airlines, due to the fixed costs associated with investments that can not be reduced in the short term
  - Airlines that are unable to pass on cost increases, such as increases in the price of kerosene, will go bankrupt without long [Note UA/DL/NW/US #1/US #2/AZ/OA, etc]
  - The ability to only pass on 75% or 50% of costs will reduce EU carrier operating margins from a projected 3.1% (business as usual) to 2.1% or 1.3%, respectively

Study Reviewed: [2] **CE Delft (2007).**
Allocation of allowances for aviation in the EU ETS - The impact on the profitability of the aviation sector under high levels of auctioning

Key findings and conclusions – ***continued***
- Given the lead time between ordering new technology (tech insertion, new aircraft), raising the level of auctioning over time may enable airlines to take account of the influence of emissions trading on their investment decisions
Limitations
• Faulty relationship drawn between utility and airline pricing • Failure to recognize that air travel has become a commoditized product, with pricing driven by matching the lowest fare published in the market • Failure to recognize the unique fixed cost/variable costs relationship of airline operations, the pressure to sell a product that perishes at departure and the overall pressure this places on all fare levels • Failure to place airline operating margins in context, which would show these to be very anemic • Failure to recognize that significant capital costs are related to upgrading younger aircraft and replacing older aircraft to comply with new environmental standards. Companies that drag along near break-even can not make these investments • Failure to recognize that emissions will be reduced as allowances are retired, regardless of allocation method
Consideration of impacts on developing countries
Not covered

Study Reviewed: [3] **CE Delft (2008).**
Competitiveness issues for Dutch aviation from EU ETS

Document information				
Title	**Author**	**Date**	**Sponsor**	**Objective of the paper**
Competitiveness issues for Dutch aviation from EU ETS	CE-Delft	October 2008	Dutch Ministry of Transport (DGLM)	To explore the extent to which airlines are likely to pass the costs of emissions allowances through to ticket prices i.e. the level of cost pass through. Analyse the possibilities of windfall profits and determine the environmental benefits of auctioning.

Issues covered				
Cost pass-through	**Competition**	**Windfall profits**	**Benchmarking**	**Auctioning**
Yes	Yes	Yes	No	Yes

Approach adopted (including scope of scheme considered)

The report builds upon the approach used in two previous reports on these subjects (see MVA: Implications of EU Emission Trading Scheme for Competition Between EU and Non-EU Airlines, November 2007 and MVA: Consequences for the Dutch Aviation Sector of inclusion in the European Emission Trading Scheme, June 2006)

Time frame considered

Short term; 2012 till 2020

Key assumptions

- The trading system investigated is based upon the agreement reached in July 2008, although some results are still based upon 10% auctioning.

Data relied on

- Eurocontrol and AERO

Financial cost drivers and airline pricing behaviour

One of the main drivers why EU-airlines cannot pass through all cost of the ETS is driven by the hub-effect in non EU countries.

Key findings and conclusions

- European airlines will ***not*** be able to pass on all costs of the inclusion of aviation in the European Emission Trading system.
- This effect might impact the Dutch aviation more the aviation of other member states.
- Windfall profits are unlikely to occur.
- As the cap is fixed and aviation will be a net buyer of permits the level of auctioning will have no effect on the CO2-emissions of aviation.
- As a result of the high fuel prices and the cost increases of the EU-ETS for the European airlines carbon leakage may occur.

Limitations

- ---

Consideration of impacts on developing countries

The report is not addressing the effects on developing countries.

Study Reviewed: [4] **CE Delft and MMU (2007).**
The impacts of the use of different benchmarking methodologies on the initial allocation of emission trading scheme permits to airlines

Document information				
Title	**Author**	**Date**	**Sponsor**	**Objective of the paper**
The impacts of the use of different benchmarking methodologies on the initial allocation of emission trading scheme permits to airlines	CE Delft and Manchester Metropolitan University	July 2007	UK Department for Transport and the UK Environment Agency	To explore the possible implications of different allocation methodologies for emissions allowances to participating airlines with regard to economic efficiency, environmental effectiveness and the distributional impacts on the airlines.

Issues covered				
Cost pass-through	**Competition**	**Windfall profits**	**Benchmarking**	**Auctioning**
No	No	No	Yes	No

Approach adopted (including scope of scheme considered)

The paper explores the impact of different allocation benchmark methodologies using different illustrative airline types, relative to one another. It does not assess the impacts on specific airlines. Six generic airline types are defined: large network carrier; medium sized network carrier; low cost carrier; non-EU network carrier; regional airlines and freight only airlines. These generic airline types were broken down by fleet composition for the large network carrier, the low cost carrier and the non-EU network carrier. Three different types of benchmarks are explored: output based (e.g. revenue tonne-kms); input based (e.g. capacity offered such as available tonne kms); and fleet age. The allocation of allowances awarded to each airline is assessed in relative terms i.e. relative to the average for aviation as a whole.

Time frame considered

No specific timeframe is considered. Data from 2006 are used and the analysis considers the relative allocations from the static point of view and then the dynamic (i.e. if some airline types grow at a different rate relative to others)

Key assumptions

- The current European Commission's proposal for the design of the scheme is assumed i.e. to consider all departing and arriving flights
- The cap is set at the BAU level of emissions for illustration and ease of reporting results; not because this is what is to be expected
- For the RTK benchmark, passengers are assumed to weigh 100kg, 125kg or 150kg as sensitivity tests
- For the input benchmark, those selected are maximum payload kms; maximum take off weight kms; maximum seating capacity kms; available seat kms
- For the age related benchmarks, actual historical emissions are multiplied by an age factor of 1% per annum or 2.5% per annum i.e. more allowances are allocated for newer fleets
- Mission distances flown are 250km, 550km, 1500km, 2900km, 5500km and 9500km
- Load factors are for network carriers 68% for short/medium haul and 80% for long haul; low cost airlines have 70-80%; regional have 68% and freight 68%

Data relied on

- UK Civil Aviation Data for 2006 for flight related data
- The PIANO model has been used to estimate the carbon dioxide emissions
- Data for the addition to Great Circle Distances due to stacking and circling have been explored from Eurocontrol, for use in sensitivity tests
- Loads factors are from airlines and AEA

Financial cost drivers and airline pricing behaviour

Not applicable

Study Reviewed: [4] **CE Delft and MMU (2007).**
The impacts of the use of different benchmarking methodologies on the initial allocation of emission trading scheme permits to airlines

Key findings and conclusions
The results recognize that benchmarks cannot be designed in a way that is neutral to all business models of airlines, so benchmarking will inevitably create winners and losers. Impacts by airline type (summarized in a Table on page 12 of the report): ▪ Low cost carriers are more sensitive to the choice of benchmark than network carriers. Age benchmarks are favourable to these carriers due to their younger fleets. Despite the high load factors, they have slightly more CO_2 emissions per RTK than network carriers because they do not operate long haul routes which are more efficient per passenger km due to larger aircraft and a smaller share of the total emissions from the landing and take off cycle ▪ Network carriers are less affected by the choice of benchmark than other airline types ▪ Non-EU network carriers from the US fare well under both input and output benchmarks because they have only long haul flights and efficient fleets ▪ Regional carriers face a relative shortfall under all benchmarks due to the high number of short haul flights ▪ Freighter carriers are mostly under allocated in relative terms due to the relatively old and relatively inefficient fleets assumed and most freight from the UK is short haul (on freighters). This is using UK data so if EU data had been used, there may be more long haul Impacts by benchmark type ▪ The RTK assuming passengers weigh 150kg and the fleet age benchmark with an age factor of 1% had the smallest distributional impacts ▪ Output based benchmarks reward operators' actions to improve load factors and fleet optimisation; input based benchmarks reward fleet optimisation but penalise improvements in load factors ▪ Distributive impacts are smaller when greater passenger weights are assumed under RTK ▪ Fast growing airlines would favour a more frequent calculation of the benchmark ▪ **Overall, the output based benchmark is more consistent with encouraging environmental efficiency than other benchmarks. RTK metrics had relatively small distributional impacts with the exception of UK-type freighter aircraft and UK-type regional carriers**
Limitations
▪ Data is used for the UK only so the results may not be fully applicable to the EU as a whole ▪ 2006 data is used so using earlier or later years may affect the results
Consideration of impacts on developing countries
None explicitly presented though results could be applied in the generic sense depending on the nature of the airline carriers from those regions.

Study Reviewed: [5] **CE Delft and MVA Consultancy (2007).**
Implications of EU Emission Trading Scheme for Competition Between EU and Non-EU Airlines

Follow on to the study "Consequences for the Dutch Aviation Sector of the Inclusion in the European Emission Trading Scheme"

Document information				
Title	**Author**	**Date**	**Sponsor**	**Objective of the paper**
Implications of EU Emission Trading Scheme for Competition Between EU and Non-EU Airlines	(Joint report) CE Delft and MVA Consultancy (in association with SEO Amsterdam)[12]	November 2007	Directorate General of Civil Aviation and Freight – DGTL (the Netherlands)	To examine whether, in the event of the EU ETS being applied to civil aviation flights departing from and arriving at EU airports, there might be appreciable opportunity for non-EU carriers to strengthen their competitive position vis-à-vis EU airlines[13]

Issues covered				
Cost pass-through	**Competition**	**Windfall profits**	**Benchmarking**	**Auctioning**
Yes	Yes	Yes	Yes	No

Approach adopted (including scope of scheme considered)

This study was commissioned in view to the conflicting outcomes of two studies conducted respectively by CE Delft (2005) and MVA Consultancy (in association with SEO Amsterdam) (2006). The two consultancies sought to develop a common view in this study.

The modelling done in this study follows on from a previous study by MVA and SEO entitled "*Consequences for the Dutch Aviation Sector of the Inclusion in the European Emission Trading Scheme*", DGTL, September 2006, where several ETS scenarios were analysed.

- The same methodology (and basic underlying assumptions) has been used to analyse the impacts of including international flights into the EU ETS
- Three (3) additional scenarios were defined (compared to the previous study) where the ETS is applied to all flights arriving and departing from the EU.

The analysis focused on

- The impact on total demand for aviation for three (3) types of routing between origin-destination pairs:
  1) Direct flights
  2) Transfer flight via a EU hub airport
  3) Transfer flight at a non-EU hub airport
- The impact on the Dutch Aviation sector (especially on Schiphol and KLM). A comparative analysis of the impacts of the ETS has been done for
  - ✧ Schiphol airport and three competing hubs: Paris Charles de Gaulle (France), London Heathrow (United Kingdom) and Frankfurt (Germany).
  - ✧ KLM and competing "home" airlines at these airports: Air France at Paris Charles de Gaulle, British Airways at London Heathrow and Lufthansa at Frankfurt. The effects on airlines were estimated from the impact on their respective alliances at the "home" hub of the carriers' concerned[14].
- The impact of the benchmarked initial allocation

[12] SEO Amsterdam – Economic research centre affiliated with the University of Amsterdam.
[13] And implicitly, assess the impact of the extension of the ETS to international flights on the Dutch aviation sector (especially on Schiphol airport and KLM).
[14] It is assumed that a large proportion of the traffic of each alliance at its EU hub (or hubs) will be carried by the airline based there.

Study Reviewed: [5] **CE Delft and MVA Consultancy (2007).**
Implications of EU Emission Trading Scheme for Competition Between EU and Non-EU Airlines

Approach adopted (including scope of scheme considered) – ***continued***

- The differential impact due to hub location
  - ✧ A predictive model of the choice by passengers of alternative routings for their journeys was used
  - ✧ The quantification of the hub location effects was undertaken on the basis of routings available from Amsterdam to twelve (12) major representative cities[15] (six in North America[16], six in the Asia/Pacific region[17])
  - ✧ Flights were assigned to major alliances (i.e. SkyTeam, Star or OneWorld). Airlines not belonging to any alliance were assumed to be an independent network.
- The potential for cross-subsidisation[18]
- Possible long-term impacts

Time frame considered

Modelled the year 2006.

Key assumptions

All the modelling assumptions used to perform the analysis were not explicitly discussed in the report. Those related to the additional scenario runs with the NetCost model are presumably the same as in the previous MVA/SEO study.

Base case: no ETS costs are applicable.

Scenarios specification – Inclusion of international flights in the EU ETS

The (3) scenarios have been specified:

1. Permit price at €30 per tonne of CO_2, with no initial allocation of permits to the aviation sector[19]
2. Permit price at €100 per tonne of CO_2, with no initial allocation of permits to the aviation sector
3. Permit price at €100 per tonne of CO_2, with a 90% initial allocation of permits to the aviation sector

Cross-subsidisation

Airlines operate as profit-maximising companies.

Quantification of hub-location effects

- All the components of the generalised cost (i.e. fare, travel time, frequency, need to transfer) for any particular routing remain constant, apart from the fare which is allowed to change in response to the pass-through of ETS costs to consumers
- Routings for which the increase in the fare is the least will attract a higher proportion of the total flow of passengers. That is passengers try to mitigate the ETS-costs by either not travelling (overall reduction in demand) or by seeking alternative routes where the ETS-costs are lower.

[15] The selection of the cities has been based upon their connection to/from Schiphol airport and the nature of the competition between non-EU carriers and KLM.
[16] New York, Washington, Chicago, Los Angeles, Toronto and Vancouver.
[17] Singapore, Bangkok, Tokyo Narita, Hong Kong, Taipei and Shanghai.
[18] The study focused on the cross-subsidisation specifically caused by the inclusion of aviation in the EU ETS, that is the "additional" cross-subsidisation, defined as allocating the cost of the ETS to flights outside the scope of the ETS.
[19] This implies that all emissions have to be covered by paid-for permits purchased by auction.

Study Reviewed: [5] **CE Delft and MVA Consultancy (2007).**
Implications of EU Emission Trading Scheme for Competition Between EU and Non-EU Airlines

Data relied on
The paper does not explicitly address the sources of data used. The data relied upon is presumably the same as the one used to do the previous study[20]. ▪ 2005 scheduled timetable data available from the OAG (Official Airline Guide) – Week of September 19 to 26. ▪ Data from AERO-MS FESG scenario for 2010 (for the calculation of CO_2 emissions, fare elasticities) ▪ FESG CAEP/6 traffic and fleet forecast ▪ A Eurostat paper detailing Air Transport in Europe in 2004[21] (for the calibration of the gravity model)
Financial cost drivers and airline pricing behaviour
All airlines operate as profit maximising companies All airlines seek to pass on in fare increases the whole of the additional costs (expenditures) arising from the ETS
Key findings and conclusions
If international flights are to be included in the EU ETS, the incentives will tend to be to minimize the distances within OD journeys to which ETS applies. ▪ Direct flights with either EU or non-EU carriers will be more attractive[22] ▪ Indirect routings with non-EU carriers will still be more attractive for many OD pairs ▪ The least attractive option being indirect movements with EU-carriers. ▪ On non-EU OD flows that could route through EU hubs, the incentives will be to avoid hubbing in the EU and EU carriers will loose in traffic. Non-EU carriers will gain some of the diverted traffic both on direct flights and indirect routings via non-EU hubs. Demand As ETS-induced costs are passed on through fares, traffic decreases on all routings. The effect is larger for indirect flights via EU hubs than for direct flights. The impact is smaller for indirect flights via non-EU hubs. Schiphol (in comparison with three (3) competing EU hubs[23]) ▪ The impact on the four (4) airports is slightly higher than the EU average. ▪ Traffic transferring at London Heathrow is more largely affected[24] KLM[25] (in comparison with three (3) competing alliance home airlines[26]) ▪ The overall impact on traffic is similar for the four carriers. ▪ All four carriers are impacted more strongly in transfer than in originating markets, under all ETS scenarios. British Airways is more significantly impacted while the impact on KLM is proportionately similar to that of Air France and Lufthansa.

[20] "*Consequences for the Dutch Aviation Sector of the Inclusion in the European Emission Trading Scheme*", DGTL, September 2006
[21] Eurostat, *Statistics in Focus*, Transport 2/2006, "Air transport in Europe in 2004".
[22] As ETS costs on routes via European hubs are slightly more expensive than via the direct routes. The additional ETS costs arise from the detour (extra distance, addition landing/take-off cycle) that has to be made.
[23] Paris Charles de Gaulle (France), London Heathrow (United Kingdom) and Frankfurt (Germany).
[24] A function of its geographical location on the edge of Europe and its wider catchment area across Europe.
[25] The impact on the "home" airline was approximated by the impact on its alliance at the hub.
[26] Air France at Paris Charles de Gaulle (France), British Airways at London Heathrow (United Kingdom) and Lufthansa at Frankfurt (Germany).

Study Reviewed: [5] **CE Delft and MVA Consultancy (2007).**
Implications of EU Emission Trading Scheme for Competition Between EU and Non-EU Airlines

Key findings and conclusions – ***continued***
Benchmark allocation ▪ EU-based carriers do not operate more fuel-efficient aircraft than those of competing non-EU carriers in major long-haul markets on routes from/to the EU. ▪ Carriers that operate more fuel-efficient aircraft on a route will have their efficiency-related competitive position strengthened by the ETS[27]. Cross-subsidisation[28] ▪ It is unlikely that the inclusion of aviation in the EU ETS will open up possibilities in the non-ETS markets where additional profits can be made that can be used to cover the ETS costs. ▪ There is very little, if any, scope for predatory pricing at is would bring no economic benefits even in the long term to airlines engaging in such practices. However it not possible to rule this out completely. Hub location ▪ Hub location can benefit non-EU carriers, as for passengers transferring at EU hubs, both flights used will be subject to the ETS, while only one flight used by those transferring at non-EU hubs will be subject to the ETS. ▪ EU carriers could be competitively disadvantaged in some markets. The differential impact (lost of transfer traffic) will depend on the EU hub location compared to non-EU hubs (that is on the opportunity passengers will have to avoid transferring at EU hubs). Long term impacts The competitive disadvantage of EU carriers may be aggravated through time as they have less opportunity for redeploying aircraft with different fuel efficiencies (than their non-EU competitors[29]). The significance of this point will strongly depend on the price of allowances. Overall conclusion Any effects on the competitive positions of airlines are expected to be small, unless the price of allowances increases very substantially.
Limitations
▪ The study does not permit to assess the impact for individual carriers other than “home airline” at a given hub[30]. ▪ The study considers scheduled passenger demand only[31].
Consideration of impacts on developing countries
No

[27] Since the ETS cost of a flight will be proportional to fuel consumption.
[28] Defined as allocating the ETS costs to routes outside the scope of the EU ETS.
[29] Non-EU carriers could re-deploy their less fuel efficient aircraft to routes not affected by the ETS.
[30] As in the OAG it is difficult to distinguish constituent airlines due to the repetition of code-shared flights.
[31] The study findings suggest that explicit consideration of other operations (e.g. non-scheduled or cargo) would not affect the results significantly.

Study Reviewed: [6] **Ernst & Young (2007).**
Analysis of the EC Proposal to Include Aviation Activities in the EY ETS

Document information				
Title	**Author**	**Date**	**Sponsor**	**Objective of the paper**
Analysis of the EC Proposal to Include Aviation Activities in the EY ETS	Ernst & Young	June 1, 2007	European airline associations	Review of certain assumptions used by the EC in its Impact Assessment and independent examination of potential impacts of the proposal based on revised assumptions

Issues covered				
Cost pass-through	**Competition**	**Windfall profits**	**Benchmarking**	**Auctioning**
Yes	Yes	Yes	No	Yes

Approach adopted (including scope of scheme considered)

Theoretical approach focused on EC Impact Assessment of proposal to include aviation in EU ETS

Time frame considered

2011-2025

Key assumptions

- Ability of airlines to pass costs through to customers varies according to business model, exposure to competition and position in a given market
- Elasticity of demand is established is on the basis of defined market segments--
  - Network short-haul: Business= -0.8 / Leisure= -1.5
  - Network long-haul: Business= -0.8 / Leisure= -1.0
  - Low fare (all routes): Business= -1.5 / Leisure= -1.5
  - Cargo (all routes): Express= -0.8 / Standard= -1.6
- In congested airports a cost increase will not have a consequence on number of passengers and price (ie zero cost pass through)

Data relied on

- Various studies and reports

Financial cost drivers and airline pricing behaviour

Airline prices are already set at a level to maximize profits so any additional costs will necessarily lead to a decrease in profits

Key findings and conclusions

- ETS costs could not be entirely passed through to customers (on average, pass-through will not exceed 1/3 of allowance costs)
- Network Airlines – we have assumed that network airlines would be able to pass on around 35% of their allowance costs to consumers in 2011/2012 but that this ability will decline over time to around 27% by 2022;
- Low Fares Airlines – we have assumed that low fares airlines will seek to pass through around 60% of their allowance costs to passengers. This proportion remains constant over time;
- Cargo Operators – we have assumed that cargo operators will behave in a similar fashion to network airlines in relation to their passenger operations, reflecting the important role played by network airlines in this market. Therefore, we have assumed that cargo operators would be able to pass on around 35% of their allowance costs to consumers in 2011/2012 but that this ability will decline over time to around 27% by 2022.
- Demand will be reduced as a result of increased ticket prices arising from partial cost pass-through
- Windfall profits will not arise in the aviation sector since operators will always be buyers of allowances.

Study Reviewed: [6] **Ernst & Young (2007).**
Analysis of the EC Proposal to Include Aviation Activities in the EY ETS

Key findings and conclusions – ***continued***
• Due to low profit margin, impacts to airline profitability resulting from increased costs and decreased revenues will be significant • Impact on consumers – less choice of air services, number of frequencies and range of routes and reduced development of regional airports. There will be a loss in consumer surplus that will increase over time. • Impact on the EU Economy – the reduction of air services will negatively affect the economic development. Some regions are affected more being more dependants on air services. The aviation sector will support fewer direct and indirect jobs and that represent a loss of gross value added.
Limitations
Results are driven by the particular assumptions used
Consideration of impacts on developing countries
Not considered.

Study Reviewed: [7] **European Commission (2006).**
Impact Assessment of the Inclusion of Aviation activities in the scheme for greenhouse gas emission allowance trading within the Community {(COM (2006) 818 final} {Sec (2006) 1685}

Document information				
Title	**Author**	**Date**	**Sponsor**	**Objective of the paper**
Impact Assessment of the Inclusion of Aviation activities in the scheme for greenhouse gas emission allowance trading within the Community {(COM (2006) 818 final} {Sec (2006) 1685}	The European Commission	20 December 2006	The European Commission	To assess the effects of the different options to include aviation in the European Emission trading system.

Issues covered				
Cost pass-through	**Competition**	**Windfall profits**	**Benchmarking**	**Auctioning**
Yes	Yes	Yes	Yes	Yes

Approach adopted (including scope of scheme considered)

The report focuses on the consequences of the proposal for the environment and the consequences for the aviation sector. It uses three formal models: AERO, PRIMES[32] and TREMOVE[33]. The model PRIMES simulates a market equilibrium solution for energy supply in the EU-25 states and was used to quantify the impacts on the energy market. TREMOVE is a transport and emission simulation model and was used to study the effects on the whole transport sector.

The economic effects are analysed for three different geographical coverage's: Intra EU-flights, all flights departing from EU-airports, and all flights departing from and arriving at EU-airports. The environmental impacts are said to be analysed in the following categories: impacts from changes in air transport volumes, impacts from changes in transport technologies, impacts from other modes of transport substituting for air transport and impacts on public health. These effects, however, receive minimal attention in the report. More attention has been given to the economic consequences for the sector.

Geographical structure: The AERO analysis covers the world; the other models are only EU related.

Time frame considered

Modelled the year 2015 and 2020.

Key assumptions

Scenarios specification

In the global AERO analysis, it is assumed that covered aircraft operators fully pass on the costs of the scheme to their consumers.This assumption is based upon the conclusion reached in the previous report by CE Delft on behalf of the EC, "Giving Wings to Emissions Trading," that there are no effects on competition resulting from such cost pass through. On the basis of economic theory, the report assumes that windfall profits will be generated in the absence of auctioning.

[32] PRIMES see http://wwe3mlab.ntua.gr.
[33] TREMOVE see http://www.tremove.org.

Study Reviewed: [7] **European Commission (2006).**
Impact Assessment of the Inclusion of Aviation activities in the scheme for greenhouse gas emission allowance trading within the Community {(COM (2006) 818 final} {Sec (2006) 1685}

Key assumptions – *continued*
The report addresses the different impacts of the inclusion of aviation in the ETS, as follows: - Impacts on airports—switching to other airports is highly unlikely; a small fraction of the traffic would bypass EU-airports; - Impacts on consumers—some decrease in the demand (the cost increases will mainly affect the wealthier part of the population); - Impacts on other modes of transport—air transport decreases; train travel increases, while total transport decreases a little; - Impacts on the ETS allowance prices—impact on the prices seem limited; - Impacts on tourism--seems small; - Impact on remote and isolated regions—only those countries in outermost regions may have to spend more than €1 million to neutralize the possible effects on operating these routes); - Macro-economic impacts—considered to be small; - Administrative costs—considered to be small; Also different design options were evaluated: - Differences in geographical scope—There will be no distortion of competition between the airlines in all alternatives; effects of geographical scope on airports seems neutral; as long as aviation has access to Kyoto credits, there would not be a big effect on the market price of the allowances in the European Market. - Different ways of addressing non-CO2-emissions that affect the climate—when a multiplier of 2 is used, the cost for aviation will also roughly double. - Different options for allocating allowances: o Auctioning—As noted above, it is assumed that windfall profits will occur in the absence of auctioning. The creation of opportunities for new entrants is the basis for the decision to auction a certain percentage of the allowances; o Benchmarking—The remainder of allowances would be grandfathered on the basis of a benchmark driven by RTK's
Data relied on
Data from AERO-MS FESG scenario for 2015, 2020 (for the calculation of CO_2 emissions, fare elasticities); FESG CAEP/6 traffic and fleet forecast
Financial cost drivers and airline pricing behaviour
Airlines pass on in fare increases all of the additional costs arising from the ETS.

Study Reviewed: [7] **European Commission (2006).**
Impact Assessment of the Inclusion of Aviation activities in the scheme for greenhouse gas emission allowance trading within the Community {(COM (2006) 818 final} {Sec (2006) 1685}

Key findings and conclusions
▪ See above. ▪ The report comes to the following policy findings: o Airlines would be the accountable entity; o The system should be open; o Aviation allowances will be fully tradable but can not be used by operators from non-aviation sectors; o Treat domestic aviation in the same way; o Inclusion of all departing and all arriving flights will have the biggest environmental benefits, therefore this option is chosen; o A specific framework for subsidies should be established for the outermost regions o For administrative reasons the smallest aircrafts (less than 5700 kg) can be excluded; this would have only a very limited effect on the CO2-reduction; o Auctioning would have only a minimal effect on the sector as it is expected that all airline will pass on their marginal costs; o Benchmarking of the remainder will be done on the basis of RTK's o The effects on the ticket price and therefore on demand will be rather small; o Effects on competition between airlines are not expected. This is not influenced by the choice of geographical scope.
Limitations
▪ The report makes a crucial assumption that there will be no effect on competition between airlines and, therefore, EU-airlines will not be penalised more then their non-EU competitors. This essential conclusion is based only upon a qualitative argumentation.
Consideration of impacts on developing countries
There will be some effects, but the majority of the compliance costs will be born by the Annex-1 countries.

Study Reviewed: [8] **FESG (2001).**
Report on Economic Analysis of Potential Market-Based Options for Reduction of CO_2 Emissions from Aviation [CAEP/5-IP/9]

Document information				
Title	**Author**	**Date**	**Sponsor**	**Objective of the paper**
Report on economic analysis of potential market-based options for reduction of CO_2 emissions from aviation [CAEP/5-IP/9]	FESG	January 2001		Present the analysis done by FESG in CAEP/5 to evaluate the economic and environmental impacts of potential market-based options to reduce CO_2 emissions from aviation (i.e. approach used, results, work in progress and future work[34]).

Issues covered				
Cost pass-through	**Competition**	**Windfall profits**	**Benchmarking**	**Auctioning**
Yes	No	Yes	No	Yes

Approach adopted (including scope of scheme considered)

The objective of the FESG analysis was to provide an economic and environmental evaluation of the potential role of market-based options in the reduction of CO_2 emissions from aviation.

The policy options considered in the analysis were defined and designed by CAEP WG5[35]. These options did not pertain to any specific existing scheme.

- Three (3) targets of emission-reduction were defined:
  - T1 – reduce 2010 emissions to 95% of 1990 emission levels (the Kyoto target)
  - T2 – reduction of 50% of emission growth between 1990 and 2010
  - T3 – reduction of 25% of emission growth between 1990 and 2010

  for global (both international and domestic) and international aviation
- Three (3) types of instruments were considered: 1) Levies[36]
  2) Emission trading
  3) Voluntary measures (mechanisms)

The FESG analysis was done in two phases:

1. A Screening analysis was initially done to evaluate globally the effectiveness of the (50) main mitigation options (defined by WG5) and to identify the most promising and feasible ones.
2. A Detailed analysis was done of the most promising options[37], with more regional differentiation.

[34] The work in progress and future work of FESG in CAEP/5 are not summarized in this template.
[35] WG5 – Market Based Options Working Group established within CAEP with the goal to "identify and evaluate the potential role of market based options, including emissions charges, fuel taxes, carbon offsets and emissions trading regimes".
[36] For the evaluation of options, no distinction was made between a charge and a tax, although ICAO makes a distinction between a charge and a tax. "Charges" are regarded as levies to defray the costs of providing facilities and services for civil aviation, whereas "taxes" are levies to raise general national and local government revenues that are applied for non-aviation purposes.
[37] That is options that had the potential to achieve the greatest possible reductions in emissions for the lowest possible cost.

Study Reviewed: [8] **FESG (2001).**
Report on Economic Analysis of Potential Market-Based Options for Reduction of CO_2 Emissions from Aviation [CAEP/5-IP/9]

Approach adopted (including scope of scheme considered) – *continued*
Options were evaluated according to four (4) criteria: 1) Environmental effectiveness[38]; 2) Economic impact; 3) Economic efficiency[39]; 4) Equity and distortions to competition[40] **Modelling approach** The AERO-MS[41] and SCSM[42] were used in conjunction to assess the economic and environmental impacts of the policy options. ▪ Regional differentiation (used in the detailed analysis) 1. Global traffic 2. International traffic 3. Traffic departing from Annex B countries[43] 4. Carriers from Annex B countries 5. International traffic departing from Annex B countries Sensitivity analyses were performed around four (4) critical assumptions (with low and high scenarios) 1. Assumption of the 1% improvement per annum in fuel burn for newly bought aircraft 2. Assumption of the accelerated technology development 3. Price elasticities Assumption on the ability of airlines to pass on cost increases on to the consumers.
Time frame considered
Base year: 1992 (screening analysis) [44]; 1998 (detailed analysis) – *although targets were based on estimates of the 1990 emissions* Target/scenario years: 2010 (main analysis) and 2020[45].

[38] That is the extent to which emissions reductions are directly attributable to a particular option.
[39] Ratio of economic impact to environmental benefit, that is the cost of CO_2 reduction in terms of the amount of CO_2 reduced.
[40] Market distortions considered include destination switching by passengers, impacts on airlines competitiveness and financial health, and tankering of fuel.
[41] AERO-MS – Aviation emissions and Evaluation of Reduction Options Modelling System. AERO-MS is a policy-testing tool developed by the Dutch Civil Aviation Authority to assess the environmental and economic impacts of possible emission-related measures related to air transport system (i.e. aircraft engine emissions), under different future developments. It serves to evaluate options for the reduction of emissions at a global or a regional level and offers the possibility of comparing the costs of reduction options to the environmental results achieved. The reduction options analysed with AERO include operational, technical and economic measures. The AERO-MS is an internationally accepted tool capable of analysing a wide range of measures (including economic, regulatory, technical and operational measures) within a variety of autonomous (economic and technological) developments in the aviation sector.
[42] SCSM – Stratus Consulting Spreadsheet Model. At the time the analysis was done, the SCSM was still under development. The SCSM was designed to augment the capabilities of the AERO-MS model in the evaluation of potential CO_2 reduction on measures. It takes the supply side cost increases and estimates demand side responses on a global scale. Using a global air travel demand elasticity of -0.07, the model estimates the global response in flights and revenue passenger-kilometres, passenger and cargo demand, fuel use, CO_2 emissions, and the effect on consumer surplus.
[43] Definition of parties under the Kyoto protocol.
[44] AERO-MS is using 1992 as the start for its calculations
[45] Although compliance with the target occurs in 2010, measures for achieving it are maintained through 2020.

Study Reviewed: [8] **FESG (2001).**
Report on Economic Analysis of Potential Market-Based Options for Reduction of CO_2 Emissions from Aviation [CAEP/5-IP/9]

Key assumptions[46]

In the AERO-MS

- The growth of aviation is not limited by the capacity of airport and air traffic control systems.
- Total annual fuel consumption is growing at a rate of 2.8%
- Fuel burn is improving by 1% per year for newly bought aircraft.
- There are two classes of aircraft ages: older and current aircraft. Aircraft older than 12 years (before a reference year) are classified as "old" aircraft.
- The real fuel price is constant over time.
- Optimum air traffic operations are assumed (use of great circle routes (inclusive of a detour factor), absence of wind, weather, air traffic delays)

Screening analysis

Baseline future development scenario. From 1992 to 2010

- Total air transport demand increases by 166%
- Total fuel use (emissions) increases by 73%.

Options presented in the report were developed for:

- Global fuel tax of US$ 0.20, 0.50; 0.60, 1.00; 1.50 and US$ 2.00 per kg of fuel with revenues transferred to general treasury
- Route tax equivalent to a fuel tax of US$ 0.20, 0.60 1.00 and 2.00 per kg of fuel
- Revenue neutral charge whereby route charge of current aircraft are decreased by 33% and those of older aircraft increased by 200% (with or without demand change)
- Fuel tax of US$ 0.55, 0.60, 1.90 and US$ 2.00 per kg of fuel with a response from manufacturers
- Global fuel tax of about US$ 0.50 or about US$ 1.80 /kg combined with scrapping of aircraft older than 20 years (with or without a manufacturer 's response)
- Open emission trading with permit prices of 5, 15 and $25 per tonne of CO_2, with permits auctioned or, grand-fathered with windfall revenues either invested in the aviation sector, used to buy permits or to offset capital debt
- Closed emission trading with permits auctioned at market prices
- Analysis where the aviation could use an emission sink
- Voluntary measures
- A hybrid system of voluntary measures and emission trading

Detailed analysis

Some assumptions used for the screening analysis were modified. The main ones were:

- Change in demand projection. (FESG forecast used)
- Lower/different fare elasticities
- Revised aircraft retirement schedule (with longer aircraft useful lives)
- Targets based on 1990 (compared to year 1992 in the screening analysis)
- Different targets (in terms of reduction of fuel use required) were defined according to their regional application (15 = 5 regions x 3 targets)

Options presented in the report were developed for:

- Global fuel tax of US$ 0.23, US$ 0.50 and US$ 1.80 per kg of fuel with revenues transferred to general treasury

[46] All the options studied and the assumptions used in the modelling are described in details in Appendix 1 and 2 of the report.

Study Reviewed: [8] **FESG (2001).**
Report on Economic Analysis of Potential Market-Based Options for Reduction of CO_2 Emissions from Aviation [CAEP/5-IP/9]

Key assumptions – *continued*
▪ Regional environmental levies of US$ 0.50 per kg of fuel ▪ Revenue neutral charge whereby route charge of current aircraft are decreased by 46% and those of older aircraft increased by 200% (with or without demand change) ▪ Permit prices of 5, 15, 25, 45 and 100 per tonne of CO_2 with auctioning or grand-fathering (with windfall and one without windfall profits) ▪ Aircraft early retirement schedule (scrapping) of: 15, 20, 25 and 30 years ▪ Combinations of fuel taxation and scrapping ▪ Combinations of voluntary measures and open emission trading
Data relied on
For the screening analysis: the EU-fuel taxation study undertaken using AERO was used[47] For the detailed analysis: the FESG fleet forecast and economic assumptions were applied Consensus view of the FESG on fare elasticities[48] Fuel data from the IEA (International Energy Agency)
Financial cost drivers and airline pricing behaviour
▪ Airlines pass on all cost increases to consumers (demand effect).
Key findings and conclusions
Screening analysis[49] – Main conclusions Environmental Levies (charges and taxes) ▪ A substantial level of taxation would need to be applied in order to achieve targets with environmental levies only. ▪ The greater part (80-85%) of the emissions reduction was be achieved by reduction of demand (not from airline responses). This was the only reason these targets could be reached. There were simply not enough reduction possibilities within the sector available to reach the stringent targets. Airlines operating results are reduced in all cases, most severely with the more stringent target. ▪ The overall effects of an emission related en route charge are almost identical to those of a fuel tax (based on the same level of taxation). The same holds for the closed emission trading systems. ▪ It would not be possible to reach the targets (of emission reduction) considered with a revenue neutral charge. Emission Trading ▪ Open trading is under the most stringent target (95% of 1990 emission levels) the only viable option (under the assumed permit prices). For less stringent targets other options like the revenue neutral charge and the re-channelling of revenues from charge become more or less equal economical attractive. ▪ In an ***open trading system***, targets will not be directly met from the aviation industry ✧ Most of the reductions are made outside the sector. The great part of the emission reduction in the aviation sector is achieved by reductions of demand. In case windfall profits are assumed an additional reduction within the sector can be achieved. ✧ The grandfather rights system where airlines can reduce their capital debt (with the “windfall” revenues) is significantly more efficient than the other measures. In that case, a very large part of the reduction (60%) is achieved through transport technology effects.

[47] The FESG forecast was not finalised at the time the screening analysis was done.
[48] The elasticities used in the detailed analysis were lower than those used in the screening analysis.
[49] The targets used in the screening analysis where based on year 1992 (instead of 1990).

Study Reviewed: [8] **FESG (2001).**
Report on Economic Analysis of Potential Market-Based Options for Reduction of CO_2 Emissions from Aviation [CAEP/5-IP/9]

Key findings and conclusions – *continued*

- In a ***closed trading system*** (aviation only), targets are difficult to achieve without significant cost increases[50].
  - ✧ This option gives results very similar to those of environmental levies, as permit pries coincide with the required fuel levies (tax) to achieve the targets.
  - ✧ The results of a closed trading system ***with sinks*** are in between the results of a closed and an open trading scheme. Where they are located between the two depends on the size of the sinks available for aviation.
- The potential effects of re-channelling revenues from authorities and airlines to stimulate fleet renewal are limited.

Voluntary Agreements

- Voluntary agreement options are very costly and would induce significant demand effects. The incentives for airlines to adopt such measures are questionable.
- Preliminary tests suggest that is would not be possible to achieve the 50% reduction target through this type of options (unless Air Traffic Control Systems improvements are included[51]).

Overall conclusions

- The impacts of a fuel tax are similar to those of an emission related en route tax and a closed emission trading system. These options are therefore considered as equivalent.
- Although a revenue neutral tax could be an economically efficient option, its impacts were insufficiently large to reach the targets considered.
- Emission trading in an open system would be an economically efficient option (under all established targets). The economic impact will depend on the level of permit prices. A substantial amount of money will be transferred from the aviation sector to other sectors of the economy to realise the reductions needed.
- In an emission trading scheme, the smallest impact on demand and airline costs occurs when permits are grand fathered and no windfall profits are generated and just the cost of purchasing permits is passed on through higher fares.

Detailed analysis – Main conclusions

Based on the results of the screening analysis, the list of possible options to be evaluated in more details was narrowed down to five (5) categories of options:

1. Fuel tax[52]
2. Open emission trading
3. Fuel surcharge (with re-channelling of the proceeds back into the aviation sector)
4. An hybrid system of a voluntary agreement and an open emission trading system
5. A revenue neutral en route charge (with less stringency targets)

Conclusions are similar to those of the screening analysis. The effects of technology improvements are larger with the revised aircraft retirement schedule and the demand effect less pronounced with the lower fare elasticities.

Overall conclusions

- An open emission trading system is the only realistic option capable of meeting targets similar to those under the Kyoto protocol under the permit price assumptions taken from the literature. The effects on aviation would be substantial under all other options
- For less stringent targets, a system of charges (where proceeds are re-channelled to the aviation sector for emmis- sions abatement measures) could be viable. However, considerable implementation problems could be foreseen.

[50] A closed emission trading system leads to results similar to a fuel tax.
[51] The possibilities of improving the Air Traffic Control Systems and the costs of these improvements are highly uncertain.
[52] As a representation of an en route charge, closed trading and voluntary agreements.

Study Reviewed: [8] **FESG (2001).**
Report on Economic Analysis of Potential Market-Based Options for Reduction of CO_2 Emissions from Aviation [CAEP/5-IP/9]

Key findings and conclusions – ***continued***
▪ Re-channelling the proceeds of taxation back into the aviation sector would prove to be complicated and there would not be enough technology improvements available to invest in to reach the targets. ▪ A hybrid combination of a voluntary measure and open trading does not bring additional economic benefits. ▪ The case where only to additional cost needed to buy permits for the emissions above the target are passed on to consumers (windfall) has a very limited effect on demand and the costs for the aviation sector. ▪ Fuel taxation options give a substantial reduction in the number of aircraft to be produced due to the substantial reduction in demand. --- **Sensitivity analysis** – Main conclusions ▪ If a yearly technology improvement is higher than assumed in the central case, lower charging levels need to be applied; less permits have to be acquired to achieve the targets. ▪ With a more elastic demand curve, bigger demand effects are observed, lower charging levels are required; less permits need to be acquired. ▪ The effects of more aggressive assumptions for manufacturers' response are small in 2010, more important in 2020. Lower charging/taxation levels are needed to achieve the targets ▪ If cost increases are not fully passed on to consumers, the demand effect will be smaller and airlines operating results will be decreased
Limitations
▪ Estimation of external costs attributable to climate change impacts is subject to uncertainty and has not been addressed in the analysis. ▪ No thorough analysis of the distortions of competition between airlines ▪ Very limited analysis of the regional effects ▪ No analysis of modal shift (e.g. for cargo or passenger). Was part of the analysis but no results were shown, as its effect was small.
Consideration of impacts on developing countries
No

Study Reviewed: [9] **FESG (2004a).**
Effects of CO_2-related Charges on Developing Countries [CAEP/6-WP/48]

Document information				
Title	**Author**	**Date**	**Sponsor**	**Objective of the paper**
Effects of CO_2-related charges on developing countries [CAEP/6-WP/48]	FESG	January 2004		Present the results of the analysis carried out by FESG in CAEP/5 and CAEP/6 of the impact of the introduction of CO_2-related charges on developing countries[53]

Issues covered				
Cost pass-through	**Competition**	**Windfall profits**	**Benchmarking**	**Auctioning**
Yes	Yes	Yes	No	

Approach adopted (including scope of scheme considered)

The paper presents an overview of the results of analyses done by FESG in CAEP/5 and CAEP/6 on the effects of charges on developing countries. As it is a compilation of results retrieved from previous (3) reports, very few details are provided on the approach used.

The AERO-MS was used to analyse the impact CO_2-related charges (levies) applied only to Annex 1 countries would have on Non-Annex 1 countries. Although a wide range of possible options were analysed, they did not pertain to any specific existing scheme.

- All the analyses were performed at flight stage level.
- Six (6) categories of route groups were considered:

1. From Annex 1 to Annex 1
2. From Annex 1 to Non-Annex 1
3. From Non-Annex 1 to Annex 1
4. From Non-Annex 1 to Non-Annex 1
5. Within Annex 1 (national)
6. Within Non-Annex 1 (national)

Taking into consideration the respective market shares of Annex 1 and non-Annex 1 countries' air carriers on these route groups.

- Four (4) descriptions were used to delimit the emissions from Annex 1 countries to be covered:

1. Emissions from flights to and from Annex 1 countries
2. Emissions from flights departing from Annex 1 countries
3. Emissions from flights within and between Annex 1 countries
4. Emissions from carriers based in Annex 1 countries

[53] The results presented in the working paper were retrieved from three analyses performed by the FESG: 1) the analysis of market-based options for the reduction of CO_2 emissions from aviation with AERO modelling system (November 2000); 2) the assessment of impacts of market-based options for developing states with the AERO-MS (August 2001); and 3) the analysis of voluntary agreements for the limitation of aviation emissions (June 2003).

Study Reviewed: [9] **FESG (2004a).**
Effects of CO_2-related Charges on Developing Countries [CAEP/6-WP/48]

Approach adopted (including scope of scheme considered) – *continued*
▪ Various factors were considered in the analysis, including: 1. The age of equipment owned by air carriers 2. The split of international aviation emissions between air carriers 3. The extent to which Annex 1 countries compete against Non-Annex 1 countries on specific routes 4. The definition of flight routes/emissions covered by the flight 5. The use made of the revenues of the charge Geographic scope: the impacts of measures applied globally and regionally were analysed.
Time frame considered
Base year: 1992 (in CAEP/5), 1998 in CAEP/6 Target/scenario year: 2010
Key assumptions
▪ In the AERO-MS, aircraft older than 12 years (before a reference year) are classified as “old” aircraft. Older aircraft are associated to older technology and higher emission levels than newer aircraft technology. ▪ UNFCCC[54] definitions of Annex 1 and Non-Annex 1 countries were used. ▪ Airlines cannot survive in the long run if they do not pass cost increases to consumers (demand effect). ▪ Airlines adjust their purchase behaviour in the long run (technology effect) ▪ Airlines can only pass on part of the measure-induced cost increases to their consumers[55]. **For measures applied only to Annex 1 carriers** ▪ On any flight stage, all carriers operating that flight stage charge the same fare in all circumstances.
Data relied on
FESG baseline scenario used for the CAEP/5 analysis: FESG2010
Financial cost drivers and airline pricing behaviour
▪ Airlines pass on cost increases to consumers.

[54] UNFCCC – United Nations Framework Convention on Climate Change.
[55] The fare increase resulting from the charge depends on the market share of Annex 1 country air carriers on a given flight stage. The larger is the market share of Annex 1 countries’ air carriers, the larger is the proportion of the fare increase they can pass on to consumers.

Study Reviewed: [9] **FESG (2004a).**
Effects of CO_2-related Charges on Developing Countries [CAEP/6-WP/48]

Key findings and conclusions
▪ The results and conclusions of the analysis are highly dependent of the definition used for the concept of "developing countries" and the scope of application of the charge[56] (as it delimits the number and the extent to which air carriers are faced with cost increases). ▪ The analysis of the fleet in operation in Annex 1 and Non-Annex 1 countries and its use by route group did not substantiate the assumption that Non-Annex 1 countries' air carriers operate an older fleet[57]. ▪ A charge applied only on emissions on routes within an Annex 1 country or between two Annex 1 countries has no direct impact on Non-Annex 1 countries. ▪ The more routes with competition between Annex 1 and Non-Annex 1 countries' air carriers are covered by a charge 1. The greater is the impact on Non-Annex 1 countries' air carriers 2. The greater are the competitive distortion effects of a charge applied only to Annex 1 countries' air carriers. The introduction of a charge or emission trading (applied only to Annex 1 countries' air carriers) increases the operating costs of the air carriers. As they pass on these cost increases to consumers through fare increases, the demand for their services falls and they are faced with a decrease in their operating results. Non-Annex 1 countries can gain to some extent from the application of the charge or emission trading as while they are not subject to the cost increase, they can raise their fares to match those of Annex 1 countries' carriers and generate a benefit. ▪ Market distortion effects resulting from a charge applied only to Annex 1 countries' air carriers can be reduced by returning proceeds from the charge to affected air carriers[58]. ▪ The narrower is the application of the charge, the smaller is the impact on the demand of Non-Annex 1 air carriers. ▪ The narrower is the definition of Annex 1 countries' emissions 1. The smaller is the amount of fuel/CO_2 emission captured under a possible emission-reduction target 2. The smaller is the number of air carriers involved 3. The larger are the competitive distortions for the carriers affected by the target
Limitations
▪ The definition of "older" and "newer" aircraft in the AERO modelling system is built-in and cannot be easily changed. A wide variety of aircraft ages are possible in each of the two aircraft categories. ▪ Using the definitions of the UNFCCC for Non-Annex 1 does not allow to assess well the impact for the poorer part of Non-Annex 1 countries. ▪ In the analyses done in CAEP/5, it was not possible to distinguish emissions within and between Annex 1 countries, and to split international emissions between Annex 1 and non-Annex 1 countries. Improvements were subsequently made to AERO-MS in CAEP/6 to enable the introduction of this distinction. ▪ The results of the analyses conducted in CAEP/5 cannot be compared to those of the analysis done in CAEP/6 as different targets were used and other variants of the options considered in CAEP/5 were designed.
Consideration of impacts on developing countries
Yes. Impact of charges (applied to Annex 1 countries' air carriers) as an emission-reduction measure.

[56] That is the definition of emissions (i.e. flights and air carriers affected by the charge) used to assess the impacts.
[57] Although this conclusion stands for Non-Annex 1 countries grouped together, it may not hold when countries are taken individually (in particular for the poorer part of the Non-Annex 1 countries). Note: Non-annex 1 countries like Singapore, Malaysia, Thailand and a like have modern fleets. These countries skew the distribution.
[58] Returns from the charge could be re-channelled to air carriers affected by the charge to stimulate fleet renewal.

Study Reviewed: [10a] **FESG (2004b).**
Analysis of Voluntary Agreements and Open Emission Trading Systems for the Limitations of CO2 emissions from Aviation with the AERO Modelling System – FESG – CAEP/6

Part I – Analysis of voluntary agreements for the limitation of CO_2 emissions with the AERO modelling system

Document information				
Title	**Author**	**Date**	**Sponsor**	**Objective of the paper**
Part I – Analysis of voluntary agreements for the limitation of CO_2 emissions from aviation with the AERO modelling system	Hans Pulles, André van Velzen, Gerrit Baarse, Richard Hancox, Duncan Edmondson[59]	February 2004		Present the results of the additional analysis carried out in CAEP/6 with AERO-MS with respect to voluntary agreements[60] in order to reduce CO_2 emissions from aviation

Issues covered[61]				
Cost pass-through	**Competition**	**Windfall profits**	**Benchmarking**	**Auctioning**
Yes	Yes	No	No	No

Approach adopted (including scope of scheme considered)

This analysis is a follow-up to the analysis done by FESG in CAEP/5 on Market-Based Options (MBO).
The objective of the analysis was to evaluate whether potential voluntary agreements[62] (as defined by WG5[63,64]) could be more cost-effective to achieve a reduction of CO_2 emissions than alternative actions or programmes in the form of charges[65].
A broad variety of options (voluntary measures) to limit or reduce emissions have been considered in the analysis. These options were split in two (2) blocks:

1. Voluntary measures applied globally
2. Voluntary measures applied only to carriers from Annex 1 countries

These options did not pertain to any specific existing scheme.
Two (2) emission reduction targets were adopted (specified in terms of an additional reduction of emissions per RTK over the 12-year period: 1998 -2010). Improvements were to be achieved relative to the scenario case (FESG2010)

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[59] Hans Pulles (Dutch Civil Aviation Authority), André van Velzen (Vital Link Policy analysis), Gerrit Baarse (BB&C), Richard Hancox and Duncan Edmondson (MVA Limited).

[60] Context: For CAEP/5 an analysis of market-based options (such as environmental levies, voluntary agreements and emission trading) for the reduction or limitation of the emissions of greenhouse gases by international aviation was carried out. On the basis of discussions at CAEP, taking into account the analysis of the results produced for CAEP/5, it was decided to carry out additional analyses for CAEP/6. The additional analyses comprised: the study of implications for the developing States of the measures already analysed in CAEP/5 and additional analysis (requested by WG5) for voluntary agreements and open emission trading.

[61] Impacts considered include changes in 1) fuel use per CO_2 emissions; 2) aircraft operating costs, revenues and airlines' results; 3) passenger and cargo demands, fares, freight rates and associated changes in consumer surplus; 4) fleet size, fleet composition and new aircraft purchases; 5) other measures of fleet operation efficiency (load factors, per unit of operating costs and revenues).

[62] Voluntary agreements can be defined as possible arrangements between private and public partners in the air transport sector, which would achieve a reduction in fuel burn (CO_2 emissions). A prerequisite of a voluntary agreement is that it is *acceptable* to all parties involved.

[63] WG5 – Market Based Options Working Group established within CAEP with the goal to "identify and evaluate the potential role of market based options, including emissions charges, fuel taxes, carbon offsets and emissions trading regimes".

[64] WG5 developed a template on voluntary agreements that included a Guidance Document describing the key elements of voluntary agreements and a checklist for use in the development of such agreements. The analysis done with AERO-MS for CAEP/6 built on these key elements.

[65] Although voluntary agreements involve costs in meeting the target pursued, successful agreements will minimise these costs in comparison to other possible approaches (such as regulatory actions). For the analysis, alternative actions or programmes have been interpreted as charges.

Study Reviewed: [10a] **FESG (2004b).**
Analysis of Voluntary Agreements and Open Emission Trading Systems for the Limitations of CO2 emissions from Aviation with the AERO Modelling System – FESG – CAEP/6

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Approach adopted (including scope of scheme considered) – *continued*

Target A – additional improvement of CO_2 emissions per RTK of 1% per year
Target B – additional improvement of CO_2 emissions per RTK of 0.5% per year[66]

The global voluntary measures considered were classified in five (5) categories[67]:

1. Fleet renewal[68]: airlines only
2. Fleet renewal: airlines and manufacturers
3. Improvements of existing fleet[69]: airlines only
4. Change in aircraft operations[70]: airlines and airports (ATC)
5. Change in flight management[71]: airlines only.

To the extent possible, the analysis included the perspectives of all parties playing an important role in the actual implementation of the measures (i.e. airlines as well as airports, air traffic control (ATC) bodies and manufacturers)

Modelling approach

- The AERO-MS[72] and SCSM[73] were used in conjunction[74] to analyse the range of possible voluntary agreement options considered. A number of possible technological options **[TO]** were also analysed.

[66] Target A [B] implies an improvement of 12% [6%] in emissions per RTK in 2010 relative to the baseline scenario case FESG2010. The target-related improvements of emissions per RTK to be achieved by voluntary measures comes on top of the autonomous improvement of emissions per RTK (i.e. the improvement independent of any measure taken) over the period 1998-2010 which is part of the baseline development.

[67] All possible measures included in these 5 categories were investigated at the global level, while only a selected number of them were analysed in the case of measures applied (regionally) to carriers from Annex 1 countries only.

[68] Fleet renewal. Improvements to the characteristics of the operated fleet by adjusting aircraft purchase behaviour (e.g. early retirement of old aircraft, purchase of latest technology aircraft, fly the most fuel efficient aircraft type for the sector).

[69] Improvement of existing fleet. Technical improvement to enhance the fuel performance of the aircraft already in use (e.g. minimise the empty weight of the aircraft, maintain clean and efficient airframe and engines, installation of winglets **[TO]**, engine retrofit and/or upgrades **[TO]**, re-engining aircraft **[TO]**, use of polished aircraft **[TO]**, perform more regular maintenance to correct aerodynamic deterioration **[TO]**).

[70] Change in aircraft operations. Improvements in the technical operations of aircraft in performing actual flights (e.g. reductions of detour time/distance, cruise speed, aircraft weight, amount of tankering; more efficient ground operations, limits to maximum flight altitudes).

[71] Change in flight management. Flight scheduling in order to use the most efficient aircraft and optimise pay loads (e.g. fly the most fuel efficient aircraft type for the sector, maximise the aircraft load factor, minimise the number of non-revenue flights).

[72] AERO-MS – Aviation emissions and Evaluation of Reduction Options Modelling System. AERO-MS is a policy-testing tool developed by the Dutch Civil Aviation Authority to assess the environmental and economic consequences of responses to emission-related measures within the context of relevant future developments in the air transport sector. It serves to evaluate options for the reduction of emissions at a global or a regional level and offers the possibility of comparing the costs of reduction options to the environmental results achieved. The reduction options analysed with AERO include operational, technical and economic measures.

[73] SCSM – Stratus Consulting Spreadsheet Model. The SCSM was designed to augment the capabilities of the AERO-MS model in the evaluation of potential CO_2 reduction of measures. It takes the supply side cost increases and estimates demand side responses on a global scale. Using a global air travel demand elasticity of -0.07, the model estimates the global response in flights and revenue passenger-kilometres, passenger and cargo demand, fuel use, CO_2 emissions, and the effect on consumer surplus.

[74] The comparative results of the two models were slightly different due to modelling differences (e.g. the fuel savings and the demand effects were higher in AERO than in the SCSM). However, as the results of SCSM matched quite well with those of AERO-MS and to the extent that differences in results occur, they were fully explainable, the results of SCSM were judged usable for the analysis and comparison with other measures.

Study Reviewed: [10a] **FESG (2004b).**
Analysis of Voluntary Agreements and Open Emission Trading Systems for the Limitations of CO2 emissions from Aviation with the AERO Modelling System – FESG – CAEP/6

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Approach adopted (including scope of scheme considered) – *continued*
▪ When the costs of the measures were unknown (e.g. measures related to "change in aircraft operations"), simplified estimates were developed based on a "what if" approach (indicating the effects on fuel use for a number of assumed reductions). Competition: the analysis focused on the possible distortion of competition between Annex 1 and non-Annex 1 carriers in the case of voluntary measures applied to Annex 1 carriers only. Although the analysis mainly focused on voluntary measures, an assessment of the impacts of a number of global charges on the new defined targets (A and B) was also done at the request of WG5. The charges considered were fuel taxes, re-channelling options and revenue neutral charges. The analysis also included an assessment of the impact of combining a number of voluntary measures.
Time frame considered
Timeframe: 1998-2010 (12 years) Base year: 1998 Target/scenario year: 2010[75]
Key assumptions
All the modelling assumptions used to perform the analysis were not explicitly discussed in the report, as these assumptions were the same as the ones used in the MBO analysis performed in CAEP/5.[76] **FESG2010 Scenario: (Business-as-usual case) Over the period 1998-2010** ▪ The autonomous improvement of emissions (fuel use) per RTK resulting from the scenario assumptions is 24.9% ✧ The average aircraft size increases by 9.1% over the period ✧ The average load factor is assumed to go up by 5.7% from .63 in 1998 to .67 in 2010 ✧ Fuel efficiency of newly certified aircraft improves by 1% per year (technology improvement), for an improvement of fuel use per aircraft-kilometres for the entire fleet of 13.5%[77] ▪ A detour factor[78] of the order of 1.10 is used (implying a 10% additional flying time/distance) ▪ There is no tankering **Voluntary measures** A number of options were developed for each category of voluntary measures considered. The factors and assumptions used to develop these options include: 1. Fleet renewal: airlines only ▪ Voluntary operating bans (2): retirement of aircraft older than 25 and 30 years ▪ Assumption: the aircraft scrap value is zero ▪ Airlines operating costs and annual interest charge (on outstanding loans) are fully met by consumers

[75] Although no quantified emission reduction targets were defined for year 2020, a selected number of runs were made to show how the effects of alternative voluntary measures develop over time.

[76] Ref. Analysis of Market Based Options for the reduction of CO_2 emissions from aviation with the AERO modelling system. Produced for the FESG. CAEP/5. Pulles, J.W. (Dutch Civil Aviation Authority), van Velzen, A. (Resource Analysis), Baarse, G. (BB&C), Hancox, R. and others (MVA Limited), November 2000.

[77] The fuel efficiency improvement of newly certified aircraft was of 1% per year from 1992 to 1998, and of 2% per year for the period prior to 1992.

[78] The detour factor reflects both the increase in the distance due to the vagaries of the air traffic management system and extra time due to airborne delays.

Study Reviewed: [10a] **FESG (2004b).**
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Key assumptions – *continued*

- Percentage of recovery of the flexibility cost[79] through fare increases: 25%, 50%, 75% and 100%

2. Fleet renewal: airlines and manufacturers[80]
   - Accelerated fuel technology improvement (FTI): 0.5% and 1% additional FTI per year from 2005 onwards (with or without change in aircraft choice)[81]
   - Assumptions on additional costs:
     Low cost [High cost]: 1% [2%] increase in price of new aircraft for every 1% of additional FTI

3. Improvements of existing fleet: airlines only (supply side related measures)
   Options analysed in this category of voluntary measures were based on the results of the SCSM[82]. The SCSM analysed a package of measures[83] to improve (the fuel use characteristics of) the existing fleet (purchased between 1992 and 2000) in the period 2000-2010.
   - (3) Packages of measures were considered: a maximum package and two reduced versions of the maximum package achieving 50% and 75% of the maximum fuel reduction, respectively[84].

4. Change in aircraft operations: airlines and airports (ATC)
   Five (5) measures aiming at improving the operating efficiency were analysed:
   1) Reduction of airborne delays/flying of more efficient routes (i.e. detour time/distance)
      - The measures analysed considered the possibility that investments in the global air traffic management (ATM) system would reduce the detour factor[85] by 25%, 50% and 75%[86]
      - Assumed investments in the ATM were made to retain delays to the 1998 levels
      - The estimated costs for a 25% reduction were assumed to range between 27.5 and 51.3 billion US$ (using route charge increases of between 100% and 200%).
      - Airlines do not pass on cost savings to consumers (there is no demand effect)

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79 The AERO-MS breaks down the costs of voluntarily retiring aircraft in three components: 1) the loss of the value of the scrapped aircraft (i.e. annual interest charge); 2) the change in airlines' direct operating costs; 3) a flexibility cost. This latter cost component is defined as the additional costs incurred by airlines in having to adopt a fleet mix different from that of the scenario case. It represents the change in whatever prevents airlines from minimising "tangible costs". Such costs of "lost of flexibility" might include those associated with commonality of aircraft type such as the ability to transfer crew between aircraft or reducing the size of the stock of spares. Flexibility costs are intangible costs and are by far the largest cost component.

80 Measure analysed by applying a fuel technology stringency measure and passing through additional costs (i.e. increases in aircraft prices) to consumers.

81 As the price of aircraft increases, the airlines' response to shift to using older aircraft was not considered as a logical behaviour considering the fact that accelerated fleet renewal is part of a voluntary agreement between airlines and manufacturers.

82 SCSM – Stratus Consulting Spreadsheet Model. The procedure developed (for the conjunctive use of SCSM and AERO-MS) reproduced in AERO-MS the analysis results of the SCSM related to measures that could not be directly handled by AERO-MS (that is the **[TO]** measures and the reduction of engine and airframe maintenance intervals). The SCSM results are based on a cumulative cost curve ranking measures in order of decreasing cost benefit ratio.

83 Including e.g. reduction of air resistance (polishing instead of painting aircraft, reducing aerodynamic deterioration), application of winglets, reduction of engine and airframe maintenance intervals, engines retrofit and upgrade, re-engining.

84 No detail is provided on the composition of theses packages.

85 The detour factor used in the FESG2010 scenario was of the order of 1.10 (implying a 10% additional flying time/distance).

86 That is, result in 7.5%, 5.0% and 2.5 % additional flying time, respectively.

Study Reviewed: [10a] **FESG (2004b).**
Analysis of Voluntary Agreements and Open Emission Trading Systems for the Limitations of CO2 emissions from Aviation with the AERO Modelling System – FESG – CAEP/6

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Key assumptions – *continued*

2) Reduction of aircraft cruise speed
- Estimated that a 10% reduction in cruise speed would result in a 4.1 % increase in total airline operating costs (modelled through an in route charge)
- Modelled the estimated cost impact of reductions in aircraft speed of 5%, 10%, 15% and 20%

3) Reduction of maximum aircraft flight level
- The effect of five (5) different flight level limits on fuel use and emissions were analysed:
  Max. flight level of: 27,000 and 30,000 feet (both at the global level and only internal to IATA regions) and 33,000 feet

4) Reduction of aircraft weight
- The impacts of this measure could not be modelled in AERO-MS and only limited analysis was done.
- To estimate the reduction in fuel use, an approximation of the impacts of reducing the fixed weight of the aircraft (i.e. airframe, engine and internal fittings) was made using the following assumptions:
  - ✧ Increasing passenger aircraft load factors by 2% leads to an increase of 0.14% in fuel use
  - ✧ The weight of passengers contributes approximately to 20% of the total average aircraft weight
  - ✧ The fixed weight of aircraft accounts approximately for 65% of the total weight

5) Reduction of tankering
- Only the effect of tankering due to fuel price differentials was estimated. It was not possible to model in AERO-MS other motives why airlines tanker fuel.

5. Change in flight management: airlines only.
Two (2) measures were investigated: 1) banning aircraft beyond a certain age from Annex 1 regions[87]
2) Improvement in load factors

Global Charges

1. Fuel taxes
- Fuel taxation levels ranged from 0.02$ to 0.50$/kg

2. Re-channelling options
- Targeted funds raised through fuel taxation are re-channelled within the sector for investments in accelerated fleet renewal
- The net additional costs of all options stimulating fleet renewal[88] are borne by consumers[89]
- Six (6) options for internal redistribution of targeted funds have been considered:
  1) Reducing finance charges for all aircraft
  2) Reducing finance charges for relatively new (current) aircraft only
  3) Reducing purchase prices for latest technology aircraft
  4) Paying for premature retirement of old aircraft (with 50% or 100% scrapping cost recovery)

[87] Impacts of this measure had not been evaluated at the time the results were presented as the AERO-MS team was still investigating how to model it in AERO-MS.
[88] That is, a reduction of the finance charges of the fleet, a reduction of purchase prices of the most recent technology aircraft, a premature retirement (scrapping) of old aircraft or a combination of all these possibilities.
[89] The underlying principle being that the combination of fund targeting and fund redistribution should be neutral with respect to the financial consequences (operating result) of airlines to stimulate fleet renewal.

Study Reviewed: [10a] **FESG (2004b).**
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Key assumptions – *continued*
5) Paying for premature retirement of old aircraft by reducing finance charges for current aircraft 6) Paying for premature retirement of old aircraft by reducing purchase prices for latest technology aircraft ▪ The amount of targeted funds available is based on actual fuel use by applying a range of fuel taxations of 0.02, 0.05 and 0.10 $/kg. These amounts are applied to reducing airline operating cost to stimulate fleet renewal. 3. Revenue neutral charges[90] ▪ Maximum (extreme) situations were modelled (using AERO-MS) for a revenue neutral en route charge and a revenue neutral airport charge for older aircraft. En route/airport charge increases of 100% and 200% were considered. **Measures applied to Annex 1 carriers only** ▪ On any flight stage, all carriers operating that flight stage charge the same fare in all circumstances ▪ The larger the market share of the Annex 1 carriers on a flight stage, the larger the proportion of the measure-induced cost increases which can be passed on to the consumers, the larger the fare increase. ▪ The voluntary measures considered included: 1) Fleet renewal: airlines only ✧ Voluntary operating bans (2): retirement of aircraft older than 25 and 30 years ✧ Percentage of recovery of the flexibility cost through fare increases: 50% and 100% 2) Fuel taxation: of 0.05$/kg combined with re-channelling options **Combination of voluntary measures** Feasible combinations of two or more of the four (4) following measures were considered: M1 – voluntary operating ban of 25+ years and 100% recovery of the flexibility cost M2 – accelerated FTI of 1% per year from 2005 onwards at relatively low cost M3 – maximum improvement package to existing fleet (AERO features) M4 – reduction of detour time/distance of 25%, 150% en route charge increase
Data relied on
▪ FESG baseline scenario used for the CAEP/5 analysis: FESG2010
Financial cost drivers and airline pricing behaviour
▪ Airlines pass on all cost increases to consumers (to maintain their profitability) ▪ On any flight stage, all carriers operating that flight stage charge the same fare in all circumstances
Key findings and conclusions
Global voluntary measures **Fleet renewal: airlines only** ▪ When airlines can fully recover their costs through fare increases, there is a significant reduction in CO_2 emissions largely due to a reduction of demand. Airlines suffer a small reduction in their operating results.

[90] The notion is to impose higher chargers on less fuel efficient aircraft that are offset by lower charges on more fuel efficient aircraft.

Study Reviewed: [10a] **FESG (2004b).**
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Key findings and conclusions
▪ The effects are less marked for a ban of aircraft older than 30 years. **Fleet renewal: airlines and manufacturers** (technology improvement measures) ▪ The effects of accelerated technology improvement on fuel use are negligible in the short and medium term (2010) (as the improvements are assumed to take effect only in 2005). They are more substantial in the longer run (2020). The costs of these measures are however unknown. ▪ The effects would be substantially increased if airlines accept and pass on the higher cost of improved technology to consumers (without adjusting their choices in the use of older versus current aircraft). **Improvement in existing fleet: airlines only** ▪ Improvements to the existing fleet could provide a useful contribution to the fuel reduction to be achieved by voluntary measures. **Change in aircraft operations: airlines and airports** ▪ The reduction of detour time/distance is the only measure among all those considered that led to sensible results[91]. ▪ Reduction of cruise speed ✧ The cruise speeds used in the FESG2010 scenario were almost optimal as regards to fuel consumption and CO_2 emissions. ✧ As airlines seek to retain their profitability by passing the cost increase on to consumers, there is a reduction in demand. It is almost solely the demand reduction that leads to the reduction in fuel use and CO_2 emissions **Change in flight management: airlines only** ▪ Only a qualitative assessment of the measures was done. **Global charges** Global charges where generated funds are redistributed into the airline industry to stimulate fleet renewal are more cost-efficient than straight fuel taxation. Revenue neutral charges are also more cost-efficient than straight fuel taxation. **Measures applied to Annex 1 carriers only** ▪ There is a negative effect on the operating results of carriers from Annex 1 countries and a positive effect on non-Annex 1 carriers (as they are not subject to the measures, they do not face cost increases and can raise their fares) ▪ There is a distortion of competition to some extent for all measures considered. The distortion effects are lower for some re-channelling options where generated funds are used for fleet renewal **Overall conclusions** ▪ Target B (a 6% improvement in CO_2 emissions per RTK over the period 1998-2010) can only be met with a voluntary operating ban of older aircraft. ▪ Target A (a 12% improvement in CO_2 emissions per RTK over the period 1998-2010) is not met for any of the individual global measures. It can only be achieved where measures are combined.
Limitations
▪ Theoretical scenarios. ▪ The version of AERO-MS available at the time of the analysis had some modelling limitations, e.g. ✧ It did not allow for effects to be assessed at the country level or country pairs). The standard presentation of AERO model results was based on IATA regions and region pairs.

[91] The other measures investigated in this category had only very limited or adverse effects on fuel use, or could not be simulated with the version of AERO-MS available at the time.

Study Reviewed: [10a] **FESG (2004b).**
Analysis of Voluntary Agreements and Open Emission Trading Systems for the Limitations of CO2 emissions from Aviation with the AERO Modelling System – FESG – CAEP/6

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Limitations – *continued*

- ✧ It was not possible to model explicitly the implications of the changes in costs due to changes in fuel consumption or reduced aircraft and crew productivity.
- ✧ Airlines could not be studied individually (competitive position)

Consideration of impacts on developing countries

Appendix F of the report provides an overview of the analysis carried out to assess the impacts of market-based options for developing countries (vs. developed countries). The analysis was done using the same assumptions as in the CAEP/5 analysis [Ref. Summary of CAEP/5-IP/09]

two (2) types of measures were assessed:
- Global and regional environmental levies (i.e. fuel taxation)
- Global and regional open emission trading regimes

with application to developed countries only

- Regional differentiation (used in the analysis)
  1. Global traffic
  2. International traffic
  3. Traffic to/from Annex B countries (all flights and international flights only)
  4. Traffic departing from Annex B countries
- The effects were assessed in terms of impacts on home carriers of developing vs. developed countries. In the case of revenue from taxation/charges effects on "governments" were assessed.
- Twenty countries were considered in the analysis: 10 developing countries[92] and 10 developed countries[93]
- Revenue tonnes-kilometres (air traffic volumes) were allocated to countries on the basis of country of departure.

Assumption in the AERO-MS

The policy induced cost increases are added to the fare of a return trip.

Options presented in the appendix were developed for:

- Global and regional fuel taxes of US$ 0.23 and US$ 0.50 per kg of fuel
- Auctioned and grandfathered permits
- Permit prices of 45$ and 75$
- With "windfall" profits used to reduce permit price

Key findings and conclusions (measures applied to developing countries)

Fuel taxation

- Annex B carriers are more affected compared to those of non-Annex B countries. The effects are relatively small for these latter carriers as they operate for a larger part non-taxed flights. Annex B carriers incur larger cost increases and have greater incentive for fuel reduction.
- The effects of a taxation for international traffic only is comparable for all carriers

Open emission trading regimes

- Annex B carriers are more affected (compared to those of non-Annex B countries) as their based flights become more costly to operate

[92] Developing – Thailand, Singapore, India, United Arab Emirates, Indonesia, Brazil, Malaysia, Mexico, Philippines and Pakistan.

[93] Developed – United States, United Kingdom, Germany, France, Canada, Spain, Netherlands, Italy, Greece and Belgium. It was not possible to include some major countries (such as Japan and China) in the analysis as the schematisation of regions in the model version of AERO-MS available at the time then did not allow to assess the effects of measures on these countries individually (e.g. Japan and China were part of the same region in AERO-MS, while Japan is a developed country and China is not).

Study Reviewed: [10b] **FESG (2004b).**
Analysis of Voluntary Agreements and Open Emission Trading Systems for the Limitations of CO_2 emissions from Aviation with the AERO Modelling System – FESG – CAEP/6

Part II – Analysis of open emission trading systems for the limitation of CO_2 emissions from aviation with the AERO modelling system

Document information				
Title	**Author**	**Date**	**Sponsor**	**Objective of the paper**
Part II – Analysis of open emission trading systems[94] for the limitation of CO_2 emissions from aviation with the AERO modelling system[95]	Hans Pulles, André van Velzen, Gerrit Baarse, Richard Hancox, Duncan Edmondson[96]	February 2004		Present the results of the impact analysis conducted in CAEP/6 with AERO-MS on open emission trading systems aimed at limiting aviation emissions

Issues covered				
Cost pass-through	**Competition**	**Windfall profits**	**Benchmarking**	**Auctioning**
Yes	Yes	Yes	No	Yes

Approach adopted (including scope of scheme considered)

The impact analysis built on the analysis of emission trading systems carried out for CAEP/5.

The impact analysis was divided in two (2) steps:

1. A building block analysis, focusing on the analysis of (alternative assumptions for individual) key elements of open emission trading systems affecting the economic and environmental impacts
2. An analysis of the five (5) emission trading system options[97] initially considered in Phase 2 of the Design Study[98]. These options did not pertain to any specific existing scheme

Four (4) open emission trading systems (ETS) were considered[99]:

Option 1 – Aviation trading system with ICAO guidance [FS1 and FS2]

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94 As part of the analysis of open emission trading systems for CAEP/6, upon request from WG5, an impact assessment was made of the different emission trading systems identified in the ICAO-financed study on the "Design of a Greenhouse Gas Emission Trading System for International Aviation" (the Design Study). WG5 – Market Based Options Working Group established within CAEP with the goal to "identify and evaluate the potential role of market based options, including emissions charges, fuel taxes, carbon offsets and emissions trading regimes".

95 AERO-MS – Aviation emissions and Evaluation of Reduction Options Modelling System. AERO-MS is a policy-testing tool developed by the Dutch Civil Aviation Authority to assess the environmental and economic consequences of responses to emission-related measures within the context of relevant future developments in the air transport sector. It serves to evaluate options for the reduction of emissions at a global or a regional level and offers the possibility of comparing the costs of reduction options to the environmental results achieved. The reduction options analysed with AERO include operational, technical and economic measures. The AERO-MS is an internationally accepted tool capable of analysing a wide range of measures (including economic, regulatory, technical and operational measures) within a variety of autonomous (economic and technological) developments in the aviation sector.

96 Hans Pulles (Dutch Civil Aviation Authority), André van Velzen (Vital Link Policy analysis), Gerrit Baarse (BB&C), Richard Hancox and Duncan Edmondson (MVA Limited)

97 The five (5) principal options initially identified by WG5 were: FS1 – ICAO allowance system with airlines. FS2 – Aviation trading system with ICAO guidance. FS3 – ICAO based cap system for airlines. FS4 – ICAO binding dual target system with airlines. FS5 – Voluntary emission trading scheme. As options FS1 and FS2 were found to be identical in terms of specification (i.e. key elements to be considered) for the impact study and option FS1 had not been considered in the final report of the Design Study, only four (4) of the original options (i.e. FS2 to FS5) were considered in the impact study conducted by FESG.

98 "Design of a Greenhouse Gas Emission Trading System for International Aviation". Final Report. Study for the International Civil Aviation Organisation (ICAO) by ICF Consulting in association with CE Delft, Jones Day Gouldens and Dr. Hugh Somerville, November 2003.

99 No description of the options was provided in the report. For a more detailed discussion, including a detailed description of similarities and differences regarding the implementation of these options, the reader is referred to the "Design Study."

Study Reviewed: [10b] **FESG (2004b).**
Analysis of Voluntary Agreements and Open Emission Trading Systems for the Limitations of CO_2 emissions from Aviation with the AERO Modelling System – FESG – CAEP/6

Part II – Analysis of open emission trading systems for the limitation of CO_2 emissions from aviation with the AERO modelling system

Approach adopted (including scope of scheme considered) – *continued*
Option 2 – ICAO based cap system for airlines [FS3] Option 3 – ICAO binding dual target system with airlines [FS4] Option 4 – Voluntary emission trading scheme [FS5] Five (5) emission reduction targets were considered Target A – additional improvement of CO_2 emissions per RTK[100] of 1% per year Target B – additional improvement of CO_2 emissions per RTK of 0.5% per year[101] Target 1 – reduction of 50% of CO_2 emission growth between 1990 and 2010[102] Target 2 – reduce 2010 CO_2 emissions to 95% of 1990 emission levels Target 3 – reduction of 25% of CO_2 emission growth The analysis focused on the impacts[103] on the aviation industry and the various actors involved in aviation (airlines, manufacturers and consumers) Modelling approach AERO-MS was used to conduct the building block analysis to show to what extent economic and environmental impacts differed when alternative assumptions were made for each key element of the open emission trading systems. An explorative analysis was done to assess the potential for credits (i.e. reduction in emissions) to be generated by a non-binding baseline and credit system. This analysis was based on the results of Part I of the analysis conducted by FESG[104] in CAEP/6 (and that were derived using AERO-MS and the Stratus Consulting Spreadsheet Model in conjunction)
Time frame considered
Time frame: 2010 Base year: 1998
Key assumptions
All the modelling assumptions used to perform the analysis were not explicitly discussed in the report, as these assumptions were the same as the ones used in the Market Based Options analysis performed in CAEP/5[105] and/or in the first part of the analysis conducted by FESG in CAEP/6[106] **FESG2010 Scenario** (Business-as-usual case) developed for CAEP/5 over the period 1998-2010

[100] RTK – Revenue tonne-kilometres.
[101] Targets A and B are expressed in terms of an additional reduction of emissions per RTK over the 12-year period: 1998 -2010. Improvements were to be achieved relative to the scenario case FESG2010 quantities of CO_2 emissions for the global aviation industry. Target A [B] implies an improvement of 12% [6%] in emissions per RTK in 2010 relative to the baseline scenario case FESG2010.
[102] Targets 1, 2 and 3 are expressed as an absolute reduction of CO_2 emissions and are previous targets considered in CAEP/5.
[103] The impacts considered included: changes in 1) fuel use per CO_2 emissions; 2) aircraft operating costs, revenues and airlines' results; 3) passenger and cargo demands, fares, freight rates and associated changes in consumer surplus; 4) fleet size, fleet composition and new aircraft purchases; 5) other measures of fleet operation efficiency (load factors, per unit of operating costs and revenues).
[104] Ref. Summary template of Part I – Analysis of voluntary agreements for the limitation of CO_2 emissions with the AERO modelling system.
[105] Ref. Analysis of Market Based Options for the reduction of CO_2 emissions from aviation with the AERO modelling system. Produced for the FESG. CAEP/5. Pulles, J.W. (Dutch Civil Aviation Authority), van Velzen, A. (Resource Analysis), Baarse, G. (BB&C), Hancox, R. and others (MVA Limited), November 2000.
[106] See footnote 12.

Study Reviewed: [10b] **FESG (2004b).**
Analysis of Voluntary Agreements and Open Emission Trading Systems for the Limitations of CO_2 emissions from Aviation with the AERO Modelling System – FESG – CAEP/6

Part II – Analysis of open emission trading systems for the limitation of CO_2 emissions from aviation with the AERO modelling system

Key assumptions – ***continued***
Key elements of open emission trading systems (7) (considered in the building block analysis) 1. Overall structure of the system Three (3) options were considered: ▪ A cap and trade system[107] ▪ A binding two-way baseline and credit system[108] ▪ A non-binding baseline and credit system[109] 2. Emission reduction targets that have to be met ▪ For the cap and trade systems (ETS options 1 and 2), Targets 1, 2 and 3 were applied ▪ For the baseline and credit systems (ETS options 3 and 4), Targets A and B were applied 3. Assumed prices of emission permits/credits (3): US$ 5, US$ 20 and US$ 50 per tonne of CO_2 4. Geographical coverage of the system Thirty-eight (38) combinations were considered, covering four (4) aspects of an open emission trading system: ▪ International routes included[110,111] ▪ Inclusion or not of national routes (international routes only vs. international and national (domestic) routes) ▪ Carriers participating in the system (all carriers vs. carriers from Annex 1 countries only) ▪ Countries considered as Annex 1 countries[112] (3 definitions were used) 5. Distribution mechanism for the initial allocation of permits Three (3) options were considered: ▪ 100% auctioning of permits ▪ 100% grandfathering of permits (no auctioning)

[107] In a **Cap and Trade System** there is an absolute cap on the total amount of emissions for the aviation industry. Emission permits up to the absolute cap can be distributed to airlines by grandfathering or auctioning. If an airline's actual emissions are higher than its cap, additional emission allowances have to be bought from other airlines or from outside the aviation sector.

[108] In a **Binding two-way baseline and credit system** airlines do not need any allowances for the emissions as long as their emissions are within the baseline set. There is therefore no need for grandfathering or auctioning in this case. Where airlines exceed their baseline emission target, credits from other airlines or from outside the aviation sector have to be bought. If an airline's emissions are lower than its baseline, credits can be generated and sold to other airlines or to trading entities outside the aviation sector. In the case of dual target binding two-way baseline and credit system, the baseline at which credits need to be bought is less than the target level at which credits can be sold.

[109] In a **Non-binding baseline and credit system** airlines can voluntarily choose to generate credits by reducing emissions below a baseline, but are not required to limit emissions to a baseline. If an airline is allowed to sell credits at a given credit price, there would be an incentive to generate such positive credits, provided that this could be done at a lower unit cost than the prevailing credit price. If this could be achieved, airlines with emissions above the baseline would not have an incentive to buy credits from airlines with positive credits (nor from any other actor) since the system would not be binding. Therefore, the positive credits generated by airlines could only be purchased by actors outside the aviation sector. There would have to be at least some sectors outside the aviation sector that are subject to binding arrangements, otherwise the credit price would be zero.

[110] International routes to be included: All international routes, international routes from and to Annex 1 countries, international routes from Annex 1 countries or international routes between Annex 1 countries.

[111] Annex 1 route groups: 1) From Annex 1 to Annex 1; 2) From Annex 1 to Non-Annex ; 3) From Non-Annex 1 to Annex 1; 4) From Non-Annex 1 to Non-Annex 1; 5) Within Annex 1 (National); 6) Within Non-Annex 1 (National).

[112] Definitions of Annex 1 countries: 1) Annex 1 main definition: all countries listed as Annex 1 countries by the UNFCCC (United Nations Framework Convention for Climate Change) are considered as Annex 1 country (whether or not they have ratified the Kyoto protocol). 2) Annex 1 plus definition: a number of countries with a relatively strong aviation industry are also considered as Annex 1 countries (e.g. Malaysia, Singapore, Hong Kong, China, Korea, Thailand, United Arab Emirates and Brazil). 3) Annex 1 minus definition: countries that have not ratified (and will not ratify) the Kyoto protocol are not considered as Annex 1 countries (e.g. United States and Australia).

Study Reviewed: [10b] **FESG (2004b).**
Analysis of Voluntary Agreements and Open Emission Trading Systems for the Limitations of CO_2 emissions from Aviation with the AERO Modelling System – FESG – CAEP/6

Part II – Analysis of open emission trading systems for the limitation of CO_2 emissions from aviation with the AERO modelling system

Key assumptions – *continued*

- 10% auctioning and 90% grandfathering of permits (partial auctioning)

6. Use of auctioned revenues Four (4) alternative options were considered
   - No use of auctioned revenues
   - Use of auctioned revenues for the improvement of Air Traffic control (ATC)
   - Use of auctioned revenues for (aircraft) scrapping
   - Use of auctioned revenues to reduce finance charges for current aircraft
7. Treatment of revenues from grandfathered permits[113] Four (4) alternative assumptions were tested:
   - The windfall is kept by airlines by ensuring that airline consumers pay the true cost of emission permits
   - The windfall funds are used to reduce permit prices
   - The windfall cannot be kept by airlines as market conditions dictate that airlines will not be able to raise fares to cover the tradable value of the grandfathered permits
   - The windfall is used by airlines to offset finance charges of aircraft

Building block analysis

As the combination of all possible alternatives of key elements of open emission trading systems would have led to a very large number of options, four (4) blocks of analysis were defined to keep the number of cases tested workable.

Block 1 – Sub-options for structure of emission trading system, targets and prices [Key elements 1, 2 and 3]
Block 2 – Sub-options for geographical coverage [Key element 4]
Block 3 – Sub-options for use of auction revenues [Key elements 5 and 6]
Block 4 – Sub-options for treatment of windfall revenues [Key elements 5 and 7]

In the building block analysis only the key elements tested in each of the blocks were varied. Default assumptions about the key elements in the other blocks were made based on the following reference case (that was included in each analysis block)

1. Structure of emission trading system	Cap and Trade
2. Emission reduction target	Target 2 (95% of 1990 emissions)
3. Permit price	US$ 50 per tonne of CO_2
4. Geographical coverage	Only international traffic to/from Annex 1; All carriers; Annex 1 main definition
5. Distribution mechanism	Grandfathering
6. Use of auctioned revenues	Not applicable[114]
7. Treatment of revenues grandfathered permits	Reduce permit prices

[113] Grandfathering implies that permits are allocated free of charge to existing emitters. As permits allocated to airlines have a market value, the free allocation of permits can be regarded as "windfall" revenues.
[114] When testing blocks 1, 2 and 3, the default assumption made for Block 4 was 100% grandfathering and use of windfall funds to reduce permit prices

Study Reviewed: [10b] **FESG (2004b).**
Analysis of Voluntary Agreements and Open Emission Trading Systems for the Limitations of CO_2 emissions from Aviation with the AERO Modelling System – FESG – CAEP/6

Part II – Analysis of open emission trading systems for the limitation of CO_2 emissions from aviation with the AERO modelling system

Key assumptions – *continued*
Block 1 (Sub-options for structure of emission trading system, targets and prices) An **explorative analysis** was conducted to determine the potential for non-binding baseline and credit systems to generate credits. A number of measures from previous analyses were selected with the potential of reducing CO_2 emissions at a relatively low cost: 1) Improvement in existing fleet[115]; 2) Premature retirement of aircraft. The analysis was undertaken at the level of IATA (196) region pairs, both at the global level (all routes, all carriers) and for international routes only, with a credit price of US$ 50 per tonne of CO_2 and with a set of targets (expressed in terms of % reduction of CO_2/RTK) ranging from 1% to 12% Block 3 (Sub-options for use of auction revenues) ▪ For the last two alternative options (i.e. potential use of auction revenues)[116], two (2) situations were considered: auction revenues become available: 1) to global aviation as a whole, 2) to Annex 1 main international routes only ▪ Cost of ATC: Low [High] cost estimate: 4% [8%] increase of route charges giving a 1% reduction in detour[117] ▪ Cost of premature retirement = the annual cost of the loss in fleet value and all increases in operational cost, including all costs labelled as "flexibility cost" ▪ All runs were carried out in AERO-MS by specifying an equivalent fuel taxation to express the cost of the permits. Block 4. (Sub-options for treatment of windfall revenues) The analysis assumed that given the 4 potential options, all carriers would behave the same way. **Analysis of emission trading system options** The effects of the four ETS options of the Design study were computed for two cases: when 1) all carriers participate, 2) only Annex 1 carriers participate
Data relied on
▪ FESG baseline scenario used for the CAEP/5 analysis: FESG2010
Financial cost drivers and airline pricing behaviour
▪ Airlines pass on the cost increases (i.e. costs of permits) to consumers (to maintain their profitability) ▪ On any flight stage all carriers operating that flight stage charge the same fare in all circumstances[118]
Key findings and conclusions
Building block analysis – Main conclusions Block 1. Sub-options for structure of emission trading system, targets and prices

[115] Improvement to existing fleet: reduction of air resistance (polishing instead of painting, reducing aerodynamic deterioration), application of winglets, reduction in engine and airframe maintenance intervals; engine retrofit and upgrade; re-engining.
[116] Premature retirement (scrappage) of older aircraft and reduce financial charges for relatively new (current) aircraft
[117] In the AERO model, detour is expressed as a factor larger than 1, expressing the total distance/time flown that is in excess of the shortest route (based on great circle).
[118] Where Annex 1 carriers are faced with measure-induced cost increases and non-Annex 1 carriers are not, one single fare will still apply for a flight stage, with the fare depending on the market share of the Annex 1 carriers. The higher the market share, the larger the proportion of the measure-induced cost increases that can be passed on to the consumers, the larger the fare increase.

Study Reviewed: [10b] **FESG (2004b).**
Analysis of Voluntary Agreements and Open Emission Trading Systems for the Limitations of CO_2 emissions from Aviation with the AERO Modelling System – FESG – CAEP/6

Part II – Analysis of open emission trading systems for the limitation of CO_2 emissions from aviation with the AERO modelling system

Key findings and conclusions – *continued*

Cap and Trade systems and Binding Baseline and Credit systems

- The effects on demand (RTK) for the aviation industry are limited[119]. With a permit price of 20$ the maximum effect on RTKs is less than 1%For all the cases considered, less than 10% of the CO_2 emission reduction is achieved within the aviation sector[120]
- The number of permits to be bought is largely dependent on the target specified. In a cap and trade system, the less strict is the target, the more permits are grandfathered and the higher are the windfall revenues[121]. In the binding baseline and credit systems considered, the aviation industry is a net buyer of credits[122].

Non-Binding Baseline and Credit systems

- There is very low potential for this type of open ETS to generate credits for targets beyond 6%.

Block 2. Sub-options for geographical coverage [Key element 4][123]

- The effects on demand (RTK) for the aviation industry are limited. In the case where all aviation traffic is covered in the ETS, the effect on the RTK is about 2%.
- For all the cases considered, less than 10% of the CO_2 emission reduction (6% < x < 8%) is achieved within the aviation sector.

Where measures are applied to Annex 1 carriers only, there is a potential distortion of competition between Annex 1 carriers and non-Annex 1 carriers (that are not faced with the measures)[124]

Block 3. Sub-options for use of auction revenues [Key elements 5 and 6]

- The use of auction revenues for further technology improvement could contribute to the further reduction of CO_2 emissions but the effects are limited if only a small proportion of the permits are auctioned
- The use of auction revenues for the scrapping of older aircraft clearly has the largest effect in terms of reduction of CO_2 emissions
- A global application of auction revenues would be more effective than a regional application

Block 4. Sub-options for treatment of windfall revenues [Key elements 5 and 7]

- While most economically beneficial for the aviation industry, it is anticipated that an ETS with a grandfathering of emissions permits will be structured to prevent airlines from making windfall profits
- Under a grandfathering system, should airlines consider the permit requirements and increases in operating costs for individual aircraft then there are likely to be greater environmental benefits and overall fewer permits will need to be purchased from outside the aviation sector
- The rules of the initial allocation of permits to individual carriers under a grandfathering system could result in significant distortions to existing competition

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[119] Because it is assumed that for Cap and Trade systems (ETS options 1 and 2) permits are grandfathered and windfall funds are used by airlines to reduce permit prices. This implies that the fare increases passed on to consumers are only based on the costs of permits that are purchased above the grandfathered allowances.

[120] The majority of the CO_2 emission reduction is achieved by the buying of permits or credits from other sectors than aviation.

[121] As it is assumed that windfall revenues are used to reduce permit prices, they do not affect the airlines' operating results.

[122] In the case of Binding Baseline and Credit systems, there is no initial distribution of credits. Credits can be generated and sold when airlines emit less CO_2 per RTK than the target. Credits need to be bought when airlines emit more than the target.

[123] The extent of the geographical coverage and types of carriers affected were only investigated in the context of a Cap and Trade system, however the report states that the general conclusions reached would also apply to the baseline and credit system.

[124] The distortion of competition depends on the assumption made about the cost and fare increases on the flight stages where only a proportion of the carriers are faced with the measure-induced cost increases. If measures are applied to Annex 1 carriers only, these carriers will only be able to pass on part of the measure-induced cost increase to their consumers (and the cost increase is larger than the fare increase) while non-Annex 1 carriers will be able to raise their fares without having to face the cost increase.

Study Reviewed: [10b] **FESG (2004b).**
Analysis of Voluntary Agreements and Open Emission Trading Systems for the Limitations of CO_2 emissions from Aviation with the AERO Modelling System – FESG – CAEP/6

Part II – Analysis of open emission trading systems for the limitation of CO_2 emissions from aviation with the AERO modelling system

Key findings and conclusions – *continued*

Note
In a Cap and Trade system the economic consequences are less certain. With a grandfathered initial allocation of permits there is uncertainty over the potential range of behaviours of airlines in treating the costs of all their permit requirements relative to the proportion grandfathered (i.e. windfall profits), unless the ETS is designed to avoid the potential for windfall profits to airlines. In the case of auctioning, the economic effects for airlines depend on the possible use of the auctioned revenues.
Key conclusions
- The extent of the geographical coverage of the ETS is important in determining the overall economic and environmental impacts and there are potentially significant distortions of competition if not all carriers on the same route are affected by emission trading
- The strictness of the target and the permit/credit prices have a more significant impact than the type of ETS(as for comparable targets and prices, different systems will produce similar impacts on the aviation industry)
- If permit auctioning is used for a large part of the initial allocation of permits there could be substantial funds available to be used within the aviation industry to further reduce emissions[125]

Specific ETS options
- Option 1 (Cap and Trade System)[126] applied to all carriers would produce the largest reduction in CO_2 emissions in meeting the most severe target (95% of 1990 emissions) and highest permit price. The reduction (achieved within the aviation sector) would be primarily achieved by the demand effect due to increase costs supplemented by the removal of the oldest aircraft of the fleet (through scrapping paid for by auction revenues). However, for all the ETS options considered, less than 10% of the CO_2 emission reduction is achieved within the aviation sector. The majority of the CO_2 emission reduction is achieved by the buying of permits or credits from other sectors than aviation.
- Option 2 (Cap and Trade System)[127] applied to all carriers would produce the largest reduction in global RTKs emissions in meeting the most severe target (95% of 1990 emissions) and highest permit price. The impact on RTKs is larger than under Option 1 as there are more routes affected by the Annex 1 definition
- For Options 1 and 2 there are potentially significant distortions to carrier profitability if only Annex 1 carriers participate in emission trading
- As the target to be achieved under Option 3 (Binding Baseline and Credit System)[128] is less severe than for the two first options (and consequently the aviation industry), the reduction achieved in RTK and emissions are limited

[125] If auctioned revenues are used for further technology improvements, CO_2 emissions within the aviation industry could be reduced further and the number of permits bought from sectors outside the aviation sector would also reduce.
[126] Option 1 specification: Cap and Trade System; reduction of 50% of CO_2 emission growth between 1990 and 2010;permit price of US$ 50 per tonne of CO_2; International routes from and to Annex 1 countries; No domestic routes; all carriers vs. Annex 1 carriers, Annex 1 countries minus definition; windfall profits used to reduce permit prices; 10% of permit allocated through auctioning, 90% through grandfathering; auction revenues used for scrapping old aircraft.
[127] Option 2 specification: Cap and Trade System; reduction of 50% of CO_2 emission growth between 1990 and 2010;permit price of US$ 50 per tonne of CO_2; International routes from and to Annex 1 countries; No domestic routes; all carriers vs. Annex 1 carriers, Annex 1 countries plus definition; windfall profits used to reduce permit prices; 100% grandfathering; use of auction revenues – not applicable.
[128] Option 3 specification: Binding Baseline and Credit; reduction of 50% of CO_2 emission growth between 1990 and 2010;permit price of US$ 50 per tonne of CO_2; International routes from and to Annex 1 countries; No domestic routes; all carriers vs. Annex 1 carriers, Annex 1 countries plus definition; treatment of windfall profits, permit allocation mechanism and use of auction revenues – not applicable.

Study Reviewed: [10b] **FESG (2004b).**
Analysis of Voluntary Agreements and Open Emission Trading Systems for the Limitations of CO_2 emissions from Aviation with the AERO Modelling System – FESG – CAEP/6

Part II – Analysis of open emission trading systems for the limitation of CO_2 emissions from aviation with the AERO modelling system

Key findings and conclusions – *continued*
▫ Option 4 (Non-Binding Baseline and Credit System)[129] would not result in any emission reductions from the aviation industry
Limitations
▪ Theoretical scenarios ▪ Some aspects are not covered (e.g. the possible use of windfall revenues by Annex 1 carriers to compensate for the negative change in their operating results because of the distortion effects)
Consideration of impacts on developing countries
Yes. In the analysis of Block 2 – Sub-options for geographical coverage Emission trading scheme for Annex 1 carriers only ▪ The effect on demand (RTKs) is less for non-Annex 1 carriers than for Annex 1 carriers as a larger proportion of the operations of non-Annex 1 carriers take place on routes that are not included in the ETS. Therefore, they see a smaller proportion of fare increases. ▪ There is a positive effect on the total operating results of carriers from non-Annex 1 countries (and a negative one on the operating results of carriers from Annex 1 countries), as there is a distortion of competition to some extent. The distortion effects are larger where more routes are included in the emission trading system. ▪ For the cases where only Annex 1 carriers participate in the ETS, there is an effect on the CO_2 emissions of non-Annex 1 carriers due to the reduction of demand that follows from the increase in fares of non-Annex 1 carriers.

[129] Option 4 specification: Non-binding Baseline and Credit (voluntary ETS); reduction of 50% of CO_2 emission growth between 1990 and 2010;permit price of US$ 50 per tonne of CO_2; International routes from and to Annex 1 countries; No domestic routes; all carriers vs. Annex 1 carriers, Annex 1 countries main definition; treatment of windfall profits, permit allocation mechanism and use of auction revenues – not applicable.

Study Reviewed: [11] **Frontier Economics (2006).**
Economic Consideration of extending the EU ETS to include Aviation

Document information				
Title	**Author**	**Date**	**Sponsor**	**Objective of the paper**
Economic Consideration of extending the EU ETS to include Aviation	Frontier Economics Limited	March 2006	European Low Fares Airline Association (ELFAA)	Assess the economic issues relating to including aviation in the EU ETS

Issues covered				
Cost pass-through	**Competition**	**Windfall profits**	**Benchmarking**	**Auctioning**
Yes	Yes	Yes	No	No

Approach adopted (including scope of scheme considered)

- Theoretical discussion, citing other studies
- Suggested framework for an inclusion of aviation in EU ETS

Time frame considered

June 2006: to feed into EUETC Commission legislative proposal

Key assumptions

- No grandfathering of existing airline emissions
- Use RTK (weight-based, revenue tonne kilometres) as relevant emissions measurement
- No fuel burn multiplier for other sources (HAPs, etc)

Data relied on

Literature review
Cost-benefit framework to assess impact on aviation of EU ETS, as compared to other sectors
Net benefits calculation of the aviation sector as compared to other sectors

Financial cost drivers and airline pricing behaviour

- The impact of EU ETS on aviation will likely be disproportional to other services/industries measured in EU ETS due to price sensitivity, likely reducing aviation demand
- Unit of cost calculation: Fuel Burn

Key findings and conclusions

- Need a full cost-benefit analysis to make an objective judgement of the net benefits of aviation relative to the emissions that it generates; and whether environmental policy (read EU ETS) should target aviation
- The contribution of aviation to total CO2 emissions is material but small
- The impact of EU ETS on Low Fare Airlines will be great than that on Full Service Airlines (FSAs)
- Aviation CO2 emission is self-incentivized by high jet fuel prices and their relative impact on profitability (and so involvement in EU ETS won't make a significant impact/change in aviation CO2 emissions)
- Restricting the EU ETS to inter-European flights is less 'effective' than a broader focus; covering only 20% of EU aviation emissions and less than 1% of total EU emissions.
- Carbon Scheme should be the responsibility of airlines, and possibly airport operators, and should include ATM providers
- Geographic coverage should be all IFR flights touching EU (international and national)

Study Reviewed: [11] **Frontier Economics (2006).**
Economic Consideration of extending the EU ETS to include Aviation

Limitations
• Little original research, no transparent methodology of same • Obvious bias against involvement of aviation, and emphasis on impact to Low Fare Carriers • Overall focus on NOT including aviation in EU ETS and minimizing impact and cost if included • If you must focus on aviation focus on retiring older aircraft, and role of ATM • Little discussion/detail of how RTK will be measured esp. for passenger airlines, or of the structure of reporting.
Consideration of impacts on developing countries
Growth in 25 new European Member States: need aviation growth to develop economies Not developing countries

Study Reviewed: [12] **ICF Consulting (2006).**
Including Aviation into the EU ETS: Impact on EU allowance prices

Document information				
Title	**Author**	**Date**	**Sponsor**	**Objective of the paper**
Including Aviation into the EU ETS: Impact on EU allowance prices	ICF Consulting	01 February 2006	UK DEFRA and DfT[130]	To provide a quantitative assessment of the impact that including aviation will have on the price of EU allowances.

Issues covered				
Cost pass-through	**Competition**	**Windfall profits**	**Benchmarking**	**Auctioning**
No	No	No	No	No

Approach adopted (including scope of scheme considered)

This study is an extension of the analysis of carbon market and price effects done in 2005 by CE Delft for the European Commission[131]

- The results are based on a ICF model InCaP[132]. The model is designed to determine the price of tradable carbon instruments for time periods out to 2027;
- Based on a set of assumptions InCaP generates an equilibrium price assuming a linkage with other trading systems through the Kyoto mechanisms. Thus InCaP is designed to solve for a global price with the basic assumption of well functioning markets[133].
- InCAP calculates the net global demand by calculating the aggregated gap between projected business-as-usual emissions and the emission cap for each individual country participating in trading market and;
- Compares that with the supply curve based on the marginal abatement cost curve, which accounts AAUs[134] due to abatement activities, CERs[135] from CDM[136] activities and Track I ERUs[137] based on JI projects.
- The study considers the options evaluated by CE-Delft in their study; Giving wings to emission trading
- The model tries to estimate the total worldwide emission market.
- Nine different EU allowance price forecasts were generated.

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[130] United Kingdom. Defra - Department for Environment, Food and Rural Affairs. DfT – Department for Transport.

[131] Ref. CE Delft (2005). "Giving Wings to Emission Trading. Inclusion of aviation under the European emission trading system (ETS): design and impacts". Report for the European Commission, DG Environment. July. The study assessed alternative approaches to incorporating aviation in emissions trading during the 2008-2012 commitment period (Phase II of the EU ETS).

[132] InCAP – International Carbon Pricing Tool. Model of the global carbon market that generates estimates of the average annual price of tradable carbon instrument (allowances and emission reduction credits) over the short, medium and long term.

[133] That is in well functioning markets, average annual prices of carbon instruments will tend to equalize across trading systems as emissions trading expands into additional regions.

[134] AAU – Assigned amount units. A tradable unit of 1 tonne of CO_2 equivalent.

[135] CER – Certified Emissions Reductions. Basic unit of the Clean Development Mechanism (CDM). One CER represents the successful emissions reduction equivalent to one tonne of CO_2 equivalent.

[136] The Clean Development Mechanism (CDM), defined in Article 12 of the Protocol, allows a country with an emission-reduction or emission-limitation commitment under the Kyoto Protocol (Annex B Party) to implement an emission-reduction project in developing countries. Such projects can earn saleable certified emission reduction (CER) credits, each equivalent to one tonne of CO2, which can be counted towards meeting Kyoto targets.

[137] ERU – Emission reduction unit. A unit of emission reductions achieved through a joint implementation (JI) project. Equivalent to one metric tonne of CO_2 equivalent. Joint Implementation – Industrialised countries can contribute to their greenhouse gas emission reductions targets by investing in emissions reduction projects in other industrialised (Annex-I) countries and receiving credits called Emission Reduction Units (ERUs). This is advantageous if mitigation costs are lower than those for national action. Joint Implementation (JI) is defined in Article 6 of the Kyoto Protocol. Track 1 – ERUs from JI projects may be generated via the Track 1 simplified procedure, where the host country is able to verify the ERUs and issue ERUs appropriately. Track 1 requires host countries to have clear processes in place for approving JI projects, monitoring project performance and verifying ERUs generated, compared to the baseline. Host countries must also have a national system to track their greenhouse gas inventory and Assigned Amount Units (AAUs).

Study Reviewed: [12] **ICF Consulting (2006).**
Including Aviation into the EU ETS: Impact on EU allowance prices

Time frame considered
Base year: 2008 The study considers the period 2008-2012. (Phase II of the EU ETS) It assumes that aviation will be included in the Phase II trading period from 2008-2012
Key assumptions
The assumptions used in the analysis were not all explicitly outlined in the report (as the analysis was based on scenarios defined in the CE Delft report) ▪ Forecast emissions for each country/regions that might participated in the ETS under three different economic growth scenarios[138]; ▪ EU allowance prices: 5, 11 and 21 € per tonne of CO_2 equivalent (low, medium and high scenarios) ▪ Emissions and emission targets for the six sectors currently included in the EU ETS[139], including aviation; ▪ Three policy options (defined by CE Delft) were considered (breadth of the aviation activity covered) ✧ Intra-EU flights ✧ Departing from EU ✧ EU airspace ▪ Emission reduction costs forecasts under three fuel price scenarios (i.e. for natural gas and liquefied natural gas)[140]; ▪ Carbon credits available through Clean Development Mechanism (CDM) and ▪ Track I ERUs that could enter the market due to investments in emission reduction projects in countries with economies in transition. ▪ When estimating the permits on the market the study takes various options regarding the fixed installations into account, such as the closure of nuclear power plants in Germany. ▪ Assumed that all Annex 1 Parties that have ratified the Kyoto Protocol meet their agreed targets and apply the policy measures they have pledged to undertake
Data relied on
Not clear from the report. The aviation sector carbon emissions data was ascertained from the CE Delft report.
Financial cost drivers and airline pricing behaviour
The model is based on marginal costs price principles and a market equilibrium between reductions offered and permits requested.
Key findings and conclusions
The study concludes that the inclusion of aviation in the European Emission Trading scheme will have no incremental effect on the price of the permits.

[138] Including assumptions on gas prices, German nuclear plant closure, abatement activity by the sectors currently covered by the EU ETS, the amount of Track 1 ERU entering the trading system and the amount of CERs available for purchase in the carbon market.
[139] That are pulp and paper, glass, ceramics, power, cement, and iron and steel.
[140] As it is expected that the dominant portion of the abatement will come from the power sector, primarily taking the form of fuel switching between coal and natural gas.

Study Reviewed: [12] **ICF Consulting (2006).**
Including Aviation into the EU ETS: Impact on EU allowance prices

Limitations
The study could not foresee that aviation would be only included from 2012 onwards. Furthermore it assumes that 2008 will be the base year. Both premises will affect the conclusions that the inclusion of aviation in the EU ETS will have no impact on the prices of the permits, as the report already states. First of all the amounts of permits that will be needed from the system will be substantially higher than estimated by the report. The report estimates permits needed by aviation in the order of 20 Mt, while in 2012 substantially larger amounts will be needed (+/-60 Mt)[141]. Secondly due to the much stricter targets set for the fixed installations in the period 2013-2020 the amounts of permits that become available for trading will be substantially diminished. It is assumed that the EU ETS is linked with other Kyoto Mechanisms and also that there will be a global emission trading market, in which there will be an abundance of CDM credits and a possible linkage between the EU ETS and other emissions trading schemes that may be established (by Canada, Japan, Australia and US), which is not possible at the moment. Reductions made within these markets cannot be used in the EU ETS. Consequently aviation will demand a larger fraction from a smaller market, so it is highly uncertain if this conclusion can be maintained. All in all this makes the conclusions of this report that the inclusion of aviation in the EU ETS will have no effect on the allowance price at least questionable.
Consideration of impacts on developing countries
Not considered in the report.

[141] Based on the assumption that according to the Directive all arriving and all departing traffic from EU-airports are included in the EU ETS and that the cap is based on 95% of the average of aviations emissions in period 2004-2006.

Study Reviewed: [13] **MVA Consultancy (2006).**
Consequences for the Dutch Aviation Sector of Inclusion in the European Emission Trading Scheme

Document information				
Title	**Author**	**Date**	**Sponsor**	**Objective of the paper**
Consequences for the Dutch Aviation Sector of Inclusion in the European Emission Trading Scheme[142]	MVA Consultancy (in association with SEO Economic Research[143])	September 2006	Directorate General of Civil Aviation and Freight – DGTL (the Netherlands)	To investigate the influences of different ETS design criteria on the Dutch aviation sector (including Schiphol's position as a Mainport) Understand how the ETS will impact the Dutch aviation sector differently than other European and non-European countries[144].

Issues covered				
Cost pass-through	**Competition**	**Windfall profits**	**Benchmarking**	**Auctioning**
Yes	Yes	Yes	Yes	Yes

Approach adopted (including scope of scheme considered)

The study focuses on forecasting the effect of ETS-derived additional costs on passengers' routing[145]. The detailed "NetCost" model developed by AAE[146] and a gravity model[147] were used to this end.

The NetCost model builds a representation of all relevant global aviation supply by origin and destination[148]. The model determines and classifies possible route alternatives based on a combination of journey time, frequency and fare, and allocates demand accordingly. Once a possible base case has been created it is possible to assess the impact of fare increase induced by the introduction of the ETS on the overall air service levels and travel alternatives for a given ETS scenario.

- Twenty-four (24) scenarios were defined to estimates these effects.

The analysis considered

- The two (2) possible scopes of aircraft emissions (for which EUA[149] would be required)
  1) Intra EU flights only
  2) All flights departing EU airports.
- Three (3) types of routing between origin-destination pairs:
  1) Direct flights
  2) Transfer flight via a EU hub airport
  3) Transfer flight at a non-EU hub airport

[142] Follow-on to a study undertaken by CE Delft and others: " Giving wings to emissions trading – inclusion of aviation under the European emission trading system (ETS): design and impacts" Report for the European Commission, DG Environment, as the CE Delft study did not address the impact of the ETS on the economic and competitive position of air carriers.
[143] SEO Economic Research – Research centre affiliated with the University of Amsterdam (The Netherlands).
[144] In particular to examine the perception that because KLM and Schiphol traffic both have a disproportionately high share or transfer traffic they will be more adversely affected than their European rivals.
[145] Rather than forecasting the demand on origin-destination pairs or the overall reduction in emissions.
[146] AAE – Amsterdam Aviation Economics, a division of SEO Economic Research.
[147] The gravity model is used to estimate demand by all origin-destination pairs involving travel via the EU.
[148] Based on scheduled timetable data available from the OAG.
[149] EUA – European Union ETS Allowance.

Study Reviewed: [13] **MVA Consultancy (2006).**
Consequences for the Dutch Aviation Sector of Inclusion in the European Emission Trading Scheme

Approach adopted (including scope of scheme considered) - ***continued***
The methodology addressed the routing issue as follows: 1. Estimate the impact of ETS on individual route costs and hence fare using a relationship based on fuel use 2. Use the NetCost model to allocate origin-destination demand by route, in both a base case and a with-ETS case 3. Use a gravity model to estimate demand by all origin-destination pairs involving travel via the EU 4. Use an elatisticity-based method to assess the impact of the generalised cost[150] changes on overall demand 5. Combine the above to estimate the impact on demand and revenue of routings via the EU. Geographical structure: The analysis was undertaken at the level of 131 geographical zones covering the world[151]. All origin-destination pairs involving European zones or that could involve an interchange in the EU were included[152]. Airlines ▪ A subset of 147 top airlines serving the major airports in the 131 geographical zones was used[153]. ▪ Flights were assigned to major alliances (i.e. SkyTeam, Star or OneWorld). Airlines not belonging to any alliance are assumed to be an independent network. A comparative analysis of the impacts of the ETS has been done for ▪ Schiphol airport and three competing airports: Paris Charles de Gaulle (France), London Heathrow (United Kingdom) and Frankfurt (Germany). ▪ KLM and competing "home" airlines at these airports: Air France at Paris Charles de Gaulle, British Airways at London Heathrow and Lufthansa at Frankfurt. The effects on airlines are estimated from the impact on their respective alliances at the "home" hub of the carriers' concerned.
Time frame considered
Modelled the year 2005.
Key assumptions
Scenarios specification The (24) scenarios have been specified according to four (4) variables: (to cover the range of outcomes of alternative assumptions) 1. ETS permit market price ⇨ Four (4) alternative assumptions[154]: €10, €30, €100 and €200 per tonne of CO_2 2. Initial allocation of permits to the aviation sector ⇨ Two (2) alternative assumptions: 1) Initial allocation covering 95% of existing emissions 2) No initial allocation (all emissions have to be covered by paid-for permits purchased by auction)[155] 3. Treatment of opportunity cost of allocated permits (only relevant where there is an initial allocation of permits) ⇨ Two (2) alternative assumptions: 1) Recover the opportunity cost by passing on the market value of permits in fares (even when permits are drawn from an initial allocation rather than purchased)

[150] That is based on the "perceived" cost of the routes to the passenger, estimated from a combination of journey time, frequency, need to interchange and fare.
[151] These zones consist of a single airport for the most significant airports, a city where the city has more than one significant airport or a cluster of airports for smaller airports and regions away from the EU.
[152] Origin-destination pairs that had no impact of the results (e.g. Intra North America) were excluded.
[153] These top airlines represented 24% of all airlines in operation in the geographical zones and accounted for 95% of the available seat-kilometres.
[154] The lower two values coincide with the permit prices assumed in the CE Delft study, the third one would be consistent with a high phase 2 permit price and the upward pressures of the cap not being raised, the last one has been taken as a possible consequence of aviation effectively doubling the size of the market in trading permits, with no additional cap.
[155] This denies carriers to possibility of opportunity cost "windfall profits".

Study Reviewed: [13] **MVA Consultancy (2006).**
Consequences for the Dutch Aviation Sector of Inclusion in the European Emission Trading Scheme

Key assumptions – *continued*
2) Recover none of the opportunity cost by passing on only the cost of the additional permits required (over and above the initial allocation) 4. Flights subject to ETS ⇨ Two (2) alternative "scopes": 1) Intra- EU flights only 2) All flights departing from EU airports[156] The scenarios presume that the cost impact of the ETS varies by route, aircraft type and market served (but not additionally by carrier), leading to two possible interpretations: 1) Carriers allocate the ETS cost impacts only to the routes where they are included; 2) Carriers spread their ETS cost impacts across their operations more generally (thereby "cross-subsiding" the routes on which the costs are actually incurred) If aviation is to be included in the ETS ▪ Carriers are the relevant EU ETS allowance (EUA) trading parties for the aviation sector[157]. ▪ ETS would apply non-discriminatorily between EU and non-EU carriers ▪ Carriers' liability for surrendering permits is restricted to one tonne of CO_2 [158] ▪ Year 2005 was modelled assuming that the overall structure of the European aviation timetable remains similar to the current structure (in 2006). In particular that the hub and spoke structure of the network carriers remains. ▪ No improvement is made in the air service between the modelled year 2005 and the point at which aviation might be included in the ETS (say 2010)
Data relied on
▪ 2005 scheduled timetable data available from the OAG (Official Airline Guide) – Week of September 19 to 26. ▪ Data from AERO-MS FESG scenario for 2010 (for the calculation of CO_2 emissions, fare elasticities) ▪ FESG CAEP/6 traffic and fleet forecast ▪ A Eurostat paper detailing Air Transport in Europe in 2004[159] (for the calibration of the gravity model)
Financial cost drivers and airline pricing behaviour
Airlines seek to pass on in fare increases the whole of the additional costs arising from the ETS
Key findings and conclusions
▪ The impacts are more significant with higher permit prices. ▪ The longer the European leg involved is, the higher are the ETS-costs induced. Traffic transferring at EU hubs is likely to be impacted more strongly than originating flows, as there are incentives to divert traffic to direct flights or transfers at non-EU hubs. ▪ The impact of ETS on EU carriers is considerably greater than on non-EU carriers. Non-EU carriers could potentially benefit from an Intra-EU scope of the ETS. Intra-EU flights subject to the ETS ▪ Main impacts are on Intra-EU OD flows and transfer traffic at EU hubs to non-EU destinations. For both groups, one flight stage is affected by the ETS, leading to a decrease in traffic. ▪ Almost all the Intra-EU OD traffic reduction is lost completely. The loss is almost wholly borne by EU carriers.

[156] ETS costs of flights departing EU airports to non-EU airports are being divided equally between that leg and return leg from non-EU to EU airports.
[157] That is carriers bear the cost of acquiring permits, or take the reward for selling any that are surplus to the aviation sector needs.
[158] As for non-aviation sectors in the ETS. The ETS is therefore assumed no to address the non-CO_2 radiative-forcing potential of the aviation sector.
[159] Eurostat, *Statistics in Focus*, Transport 2/2006, "Air transport in Europe in 2004".

Study Reviewed: [13] **MVA Consultancy (2006).**
Consequences for the Dutch Aviation Sector of Inclusion in the European Emission Trading Scheme

Key findings and conclusions – ***continued***
▪ The reduction in transfer traffic at EU hubs is mostly a diversion of traffic to direct flights or transfers at non-EU hubs. Departing EU flights subject to the ETS ▪ No further effect on Intra-EU OD flows. Noticeably greater impact on transfer traffic at EU hubs as both flight stages of a journey are affected by the ETS. Greater incentive to divert traffic to direct flights and transfer at non-EU hubs. ▪ The reduction in traffic at EU hubs will be borne mainly by EU carriers. Non-EU carriers will benefit from the diversion of traffic (to direct flights and transfers at non-EU hubs) ▪ Under both definitions of the ETS, there is only a decrease in traffic for a minority of non-EU carriers Schiphol (in comparison with three (3) competing EU hubs[160]) ▪ The impact on the four (4) airports is slightly higher than the EU-wide average. ▪ There is a reduction in traffic under both definitions of the ETS. ▪ Traffic transferring at London Heathrow is more largely affected (as the average intra-EU leg is longer) KLM[161] (in comparison with three (3) competing alliance home European airlines[162]) ▪ The overall impact on traffic is similar for the four carriers. ▪ All four carriers are impacted more strongly in transfer than in originating markets, under the Departing EU case. British Airways is more significantly impacted while the impact on KLM is proportionately similar to that of Air France and Lufthansa. Cross-subsidisation ▪ Under the Intra-EU definition of the ETS, there is not much potential for cross-subsidisation. If it was possible, European network carriers[163] would have a competitive advantage over airlines without much non-EU traffic (e.g. low cost carriers). However this competitive advantage would be negated however by the potential lost of market shares to the benefit of non-EU competitors. ▪ With the Departing EU definition, the potential opportunity for cross-subsidisation shift to non-EU carriers also serving EU airports.
Limitations
▪ The study does not permit to assess the impact for individual carriers other than “home airline” at a given hub[164]. ▪ The study considers scheduled passenger demand only[165].
Consideration of impacts on developing countries
No

[160] Paris Charles de Gaulle (France), London Heathrow (United Kingdom) and Frankfurt (Germany).
[161] The impact on the “home” airline was approximated by the impact on its alliance at the hub.
[162] Air France at Paris Charles de Gaulle (France), British Airways at London Heathrow (United Kingdom) and Lufthansa at Frankfurt (Germany).
[163] Network carriers would have the possibility to spread the ETS costs to their operations to and from points outside Europe.
[164] As in the OAG it is difficult to distinguish constituent airlines due to the repetition of code-shared flights.
[165] The study findings suggest that explicit consideration of other operations (e.g. non-scheduled or cargo) would not affect the results significantly.

Study Reviewed: [14] **Scheelhaase, D. and W.G. Grimme (2007).**
Emissions Trading for International Aviation – an estimation of the economic impact on selected European Airlines

Document information				
Title	**Author**	**Date**	**Sponsor**	**Objective of the paper**
Emissions Trading for International Aviation – an estimation of the economic impact on selected European Airlines	Janina Scheelhaus Wolfgang Grimme	September 2007	German Aerospace Centre (DLR)	Outlines possibilities for including aviation in existing emissions trading schemes; provides overview of political discussion; estimates impacts on operating costs and transport demand for low cost, full service, holiday and regional airlines in Europe; and draws conclusions on impacts on intra-European and worldwide airline competition.

Issues covered				
Cost pass-through	**Competition**	**Windfall profits**	**Benchmarking**	**Auctioning**
Yes	Yes	No	Yes	No

Approach adopted (including scope of scheme considered)

Political review concludes it is advantageous to integrate international aviation in existing emissions trading schemes, so simple model is developed to estimate current and future carbon dioxide emissions; the cost of acquiring allowances; and the demand side effects of different airlines to pass through costs. Data on Ryanair, Lufthansa, Condor and Air Dolomiti are compared.

Time frame considered

2008-2012

Key assumptions

- Analysis only includes passenger transport; belly cargo effects excluded due lack of belly cargo load factor data and emissions/aircraft type.
- 3 impact options assessed; the favourable and unfavourable options allocate allowances through grandfathering; option two allocates allowances by benchmarking.
- Emissions estimated using bottom-up approach from publicly available airline sources plus OAG; plus assumptions on ASK/RPK growth and average ticket prices per segment from airline reports.
- Efficiency increase estimates based on IATA and German Institute for Applied Ecology.
- Passenger fare demand elasticities based on several published studies

Data relied on

- Published airline information on overall fuel consumption
- Airline load factor data
- OAG timetables
- LH fuel consumption data by aircraft type and load factors by traffic area.
- Various emission studies to determine model assumptions
- Various studies on fare demand elasticities
- Growth rates based on airline reports and Eurocontrol data
- ATP based on airline reports

Financial cost drivers and airline pricing behaviour

Lufthansa can shift emission costs onto business class passengers
Network carriers have more scope to pass on cost increases to passengers than LCCs, holiday carriers and regional airlines.
LCCs and holidays airlines can only pass on costs involving selective price increase for short notice purchases

Study Reviewed: [14] **Scheelhaase, D. and W.G. Grimme (2007).**
Emissions Trading for International Aviation – an estimation of the economic impact on selected European Airlines

Key findings and conclusions
Overall, the financial impacts for individual airlines are relatively moderate Cost increases for LH lower than 1% of traffic revenues. For Ryanair, about 3% of traffic revenues. These cost increases small compared to recent fuel price increases; e.g. jet fuel cost increase for LH 2004/2005 was €800m. ETS would add about €101m in 2012. Integration of European aviation into the EU ETS politically viable in medium term Impact on EU airlines operating to the Gulf would entail significant competitive disadvantages EU carrier traffic from N America to India for example, via an EU hub, could be diverted to a Gulf hub given fare increases of €50. Economic effects depend on design option for integrating into ETS. Operating costs impacted 0-€91m for Ryanair; €1.5m-€101m for LH;0-€36m for Condor and 0-€2.5m for Air Dolomiti Per passenger costs; 0-€2.50 for FR;€0.04-€1.74 for LH;€2.97 for Condor and €1.00 for Air Dolomiti If ETS limited to only intra-EU flights, FR impacted 97% of airline's emissions, while LH only 28%. If all EU airports included, FR affected 100%; LH 92% (due non-EU fifth freedom sectors) and Condor 92% (due non-EU tech stops.) By assigning all emission costs to business passengers, LH could cut demand losses from 1,51% to 0.44% in 2012. By passing on costs to last minute passengers, Ryanair could cut demand losses from 5.56% to 1.2% in 2012. Impact of demand from full pass-through is higher for LCCs than network carriers Due to high LCC load factors, high density seating and fuel efficient aircraft, emission allowances from benchmarking would exceed requirements allowing Ryanair to sell €25m of emissions allowance surpluses in 2012.
Limitations
Emission models limited by lack of route specific fuel consumption data
Consideration of impacts on developing countries
Competitive advantage for Gulf based carriers operating into EU

Study Reviewed: [15] **Scheelhaase, D., Grimme, W.G. and M. Schafer (2008).**
The inclusion of aviation into the EU emission trading scheme – impacts on competition between European and non-European network airlines

Document information				
Title	**Author**	**Date**	**Sponsor**	**Objective of the paper**
The inclusion of aviation into the EU emission trading scheme – impacts on competition between European and non-European network airlines	Janina Scheelhaase Wolfgang Grimme Martin Schaefer	2008	German Aerospace Centre (DLR)	Provide overview of political developments at EU and ICAO. Set out modelling results concerning competitive impacts on operating costs, ticket prices and cargo rates for European and non-European airlines.

Issues covered				
Cost pass-through	**Competition**	**Windfall profits**	**Benchmarking**	**Auctioning**
Yes	Yes	Yes	Yes	Yes

Approach adopted (including scope of scheme considered)

Model-based approached comparing impact of EU ETS on Lufthansa and Continental operations in 2012. Benchmark (2004-2006) fuel burn and emissions were calculated using Eurocontrol's BADA aircraft data & OAG schedules run through DLR's VARMission software to determine fuel emissions by flight and ultimately the 2012 initial free allocation of allowances.

Time frame considered

2004-2006 for calculating the emissions baseline; 2010 to calculate ton-kilometres; and expected emissions for 2012 and impacts that year.

Key assumptions

- Lufthansa chosen as representative European network carrier heavily dependant on feeder flights
- Continental chosen as important competitor with decentralised intercontinental services to Europe
- OAG scheduled data used to calculate emissions benchmark in conjunction with DLR developed analysis tool "VarMission".
- Emissions liabilities for other carriers operating codeshares is not included.
- 2012 schedules were forecast from Jan and July published yearly schedules and annualised.
- Estimates made of share of longhaul flights in total EU ETS emissions to calculate emissions by type; the benchmark, and & LH/CO's free allowance allocation
- Correction factors applied to great circle routes to account for route inefficiencies. Cruise altitudes assigned.
- Fuel burn was modelled not actual. Continental's 787 fuel burn estimated at A330-200 minus 20%
- Two scenarios modelled for calculating 2012 emissions; a zero traffic and emission growth scenario based on 2006 traffic. And a moderate traffic and emission scenario.
- 50% of CO's new aircraft after 2009 assigned to Europe

Data relied on

- OAG schedules; Eurocontrol aircraft fuel performance data and emissions by flight mission; airline published load factors and ton kilometres

Financial cost drivers and airline pricing behaviour

ETS could incentivise European carriers towards more direct longhaul flights than hubbing.
Carriers might look to upguage and reduce frequencies.
Full passthrough assumed of opportunity cost of freely allocated allowances as well as cost of market-acquired allowances.
This less so for oligopolistic markets. For airports with constrained capacity and no alternatives, zero passthrough likely.

Study Reviewed: [15] **Scheelhaase, D., Grimme, W.G. and M. Schafer (2008).**
The inclusion of aviation into the EU emission trading scheme – impacts on competition between European and non-European network airlines

Key findings and conclusions
• Airlines with higher cargo share will receive higher amount of allowances for free • LH receives 9.9-105 megatons of free allowances while CO receives 2.7-2.8 tons. • CO would enjoy significant competitive advantage over LH as it would receive a higher % of free allowances than LH because by hubbing over Newark its transatlantic flights to Europe subject to the ETS are shorter in length than LH'. • LH's relatively environmentally inefficient short feeder flights in Europe are subject to ETS but CO's in the USA are not. • Same competitive disadvantage applies to other European network carriers compared to other non-EU longhaul carriers. • Airlines may boost 2010 ton kms to achieve a higher number of 2012 free allowances which can be carried forward. • Only moderate ticket price increases likely; €10-€13 one-way, longhaul. • Likely demand reduction with full pass-through; 2% (carbon priced at €20 per tonne.
Limitations
The calculation of the 2004-2006 benchmark for allocating free allowances in 2012 is based on modelled fuel burn, OAG scheduled data and estimated 787 fuel burn, rather than actual Actual 2012 demand and therefore emission requirements is based on forecasts of beyond 2006 traffic growth and available OAG schedules
Consideration of impacts on developing countries
None

Study Reviewed: [16] **Vivid Economics (2007)**
A Study to Estimate Ticket Price Changes for Aviation in the EU ETS

Document information				
Title	**Author**	**Date**	**Sponsor**	**Objective of the paper**
A Study to Estimate Ticket price Changes for Aviation in the EU ETS	Vivid Economics	November 2007	UK Government: Defra and DfT	To explore the extent to which airlines are likely to pass the costs of emissions allowances through to ticket prices i.e. the level of cost pass through

Issues covered				
Cost pass-through	**Competition**	**Windfall profits**	**Benchmarking**	**Auctioning**
Yes	No	Yes	No	No

Approach adopted (including scope of scheme considered)

A theoretical approach is used which relies on an economic model of firm behaviour. The model is simplistic so is not able to represent the true complexities of the aviation industry in terms of price setting behaviour, competition or specific markets. It is however able to employ several aviation specific parameters (market shares, market concentration and demand elasticities) to demonstrate the likely price effects on some illustrative routes. The analysis indicates the order of magnitude of impact expected under different circumstances.

Time frame considered

This is a theoretical approach used so is not time dependent.

Key assumptions

The economic model assumes a 'Cournot' framework where firms are setting price and quantity to reach 'equilibrium'. Key assumptions are:

- No emissions abatement in aviation so all emissions must be covered by buying allowances
- There is no competition from firms outside the EU ETS i.e. the work is not able to reflect the competition from those airlines able to route indirectly via non-EU airports
- The change in the ticket price is not a large proportion of the total ticket price so there is very little feedback on demand
- Capacity constraints at airports or airspace are not accounted for
- Demand can follow one of two forms: ‘constant elasticity’ where only a few passengers are willing to pay a high prices and increasing numbers will pay lower amounts; or ‘linear demand’ where there is a uniform distribution of willingness to pay among customers such that the proportional response of passengers to price changes does not change
- Leisure passengers have different responses to price than business passengers, and freight responses are different again
- No specific time frame is considered because it is a simplistic model representing the medium/long term equilibrium position

Data relied on

- UK Civil Aviation Authority data for the number of airlines operating on different routes
- Demand elasticities from UK Department for Transport literature review: range selected captures the range relevant for EU markets

Financial cost drivers and airline pricing behaviour

Airlines are assumed to maximise profits, maximise sales or maximise market share. Given the reliance on the economic model, the study only considers the medium/long term equilibrium decisions of the firms when setting prices. The study assumes that firms will respond the same in terms of price setting whether allowances are allocated for free or if they have to buy them from the market/auction, i.e. free allowances are perceived as a cost that would be reflected in prices. Prices are described as being driven by the nature of competition and the responsiveness of demand to ticket prices.

Study Reviewed: [16] **Vivid Economics (2007)**
A Study to Estimate Ticket Price Changes for Aviation in the EU ETS

Key findings and conclusions
▪ The extent of cost pass through is dependent on the nature of competition and how passengers respond to changes in ticket prices. Where demand is described with a 'constant elasticity' (such as business passengers) cost-pass through is expected to be higher and may be greater than 100% but only under particular circumstances such as where there is little competition. Where demand is 'linear' in nature (which is more representative of leisure passengers), cost-pass through would be less than 100%. ▪ In general, around 100% cost pass through would be expected ▪ Significant variation in the rate of pass through would be expected according to the nature of competition, the nature of passenger demand and the particular market being served ▪ High levels of cost pass through mean that high levels of free allocation of allowances would generate windfall profits ▪ Periodic updating of allowance allocation would diminish the level of cost pass through
Limitations
▪ As the modelling approach can present only a long term ‘final equilibrium’ outcome, it is not able to represent how airline behaviour may differ in the short term compared to the long term ▪ The model is not able to show how airline pricing behaviour may differ if there are capacity constraints at airports ▪ The model is not able to reflect the detailed complexities of airline pricing behaviour – any model by definition must simplify reality ▪ Given the approach is relatively aggregate, a detailed view of the specific aspects of the market e.g. those areas that are contestable, and how this may change over time is not possible to capture market are not captured due to the static nature of the model
Consideration of impacts on developing countries
The theoretical nature of this work means no specific countries are possible to identify.

Study Reviewed: [17] **Vivid Economics (2008)**
A Study to Estimate the Impacts of Emissions Trading on Profits in Aviation

Document information				
Title	**Author**	**Date**	**Sponsor**	**Objective of the paper**
A study to estimate the impacts of emissions trading on profits in aviation	Vivid Economics	January 2008	UK Government Defra and DfT	To explore the level of free allocation of allowances that would cause the EU ETS to have a neutral effect on airlines' profits

Issues covered				
Cost pass-through	**Competition**	**Windfall profits**	**Benchmarking**	**Auctioning**
Yes	Yes	No	No	Yes

Approach adopted (including scope of scheme considered)

A theoretical approach is used which relies on an economic model of firm behaviour. The model is simplistic so is not able to represent the true complexities of the aviation industry in terms of price setting behaviour, competition or specific markets. It builds upon previous work by the author, using the same model to analyze airlines' cost pass-through capability, to estimate the level of free allocation (as opposed to auctioning or buying allowances from the market) that would cause the EU ETS to have a neutral effect on airline's profits i.e. maintain them at their pre-ETS level (see summary for companion report, "A study to estimate ticket price changes for aviation in the EU ETS"). The approach further relies on market data such as market shares, Herfindahl Index of concentration by route and demand elasticity ranges. The results are illustrative and are designed to help build an understanding of the possible impact on profits under different assumptions.

Time frame considered

This is a theoretical approach used so is not time dependent.

Key assumptions

The economic model assumes a 'Cournot' framework where firms are setting price and quantity to reach 'equilibrium.' Key assumptions are:

- Demand can follow one of two forms: 'constant elasticity' where only a few passengers are willing to pay a high prices and increasing numbers will pay lower amounts; or 'linear demand' where there is a uniform distribution of willingness to pay among customers such that the proportional response of passengers to price changes does not change
- In the Cournot framework, profits are most quickly eroded relative to pre-ETS levels in markets where a few airlines supply the large majority of the market
- In the Cournot framework of economic theory, smaller airlines have higher marginal costs than larger airlines

Data relied on

- UK Civil Aviation Authority data for the number of airlines operating on different routes
- Literature review of demand elasticities

Financial cost drivers and airline pricing behaviour

The study draws upon conclusions reached in a previous companion report by the author that the rate of cost pass-through associated with constant elasticity may be greater than 100%, but the rate of cost pass-through associated with linear demand is less than 100%.

Study Reviewed: [17] **Vivid Economics (2008)**
A Study to Estimate the Impacts of Emissions Trading on Profits in Aviation

Key findings and conclusions
▪ Without free allocation, airlines' profits are likely to fall even though prices rise due to a decline in demand ▪ Airlines operating in the same market will experience different impacts on profits (in the Cournot framework, the impact on profits relative to their pre-ETS levels is greatest in markets with fewer competing airlines) ▪ Where constant elasticity (most likely to be representative of business passengers) is assumed, the relative costs arising from emissions trading shift market share from larger to smaller airlines, thereby increasing the average cost of production and depressing the aggregate level of airline profits ▪ Where linear demand (most likely to be representative of leisure passengers i.e. the majority of the market) is assumed, the costs from emissions trading shift market share from smaller to larger airlines; while aggregate profits also decrease in this case, the industry-wide impact is offset to some degree due to a resulting increase in the number of smaller airlines and the higher market share of larger airlines and the average cost of production decreases ▪ The range of free allocation required in order to maintain total sector profits at the pre-emissions trading level is estimated at between 20 – 40% of emissions (pre-emissions trading levels) for a wide range of market characteristics. Any additional allocation above these levels would increase airlines' profits above their pre-ETS levels by the value of that allocation. Likewise, any shortfall would reduce profits by the value of the shortfall in allowances. ▪ In markets where there are no more than two airlines supplying a particular route, the range of free allocation required to maintain profits is estimated at between 40 – 70% of emissions
Limitations
▪ Not able to reflect the true complexities of airline pricing behaviour ▪ There is little or no evidence on the precise nature of demand for airline services
Consideration of impacts on developing countries
The theoretical nature of this work means no specific countries are possible to identify.