

ENVIRONMENTAL POLICYMAKING FOR AIR TRANSPORTATION: TOWARD AN EMISSIONS TRADING SYSTEM

**BY
MARTINE DE SERRES**

INSTITUTE OF AIR AND SPACE LAW
MCGILL UNIVERSITY

AUGUST 2007

A thesis submitted to McGill University
in partial fulfillment of the requirements of a Master of Laws.

© Martine De Serres, 2007.



Library and
Archives Canada

Bibliothèque et
Archives Canada

Published Heritage
Branch

Direction du
Patrimoine de l'édition

395 Wellington Street
Ottawa ON K1A 0N4
Canada

395, rue Wellington
Ottawa ON K1A 0N4
Canada

Your file Votre référence
ISBN: 978-0-494-51417-7
Our file Notre référence
ISBN: 978-0-494-51417-7

NOTICE:

The author has granted a non-exclusive license allowing Library and Archives Canada to reproduce, publish, archive, preserve, conserve, communicate to the public by telecommunication or on the Internet, loan, distribute and sell theses worldwide, for commercial or non-commercial purposes, in microform, paper, electronic and/or any other formats.

The author retains copyright ownership and moral rights in this thesis. Neither the thesis nor substantial extracts from it may be printed or otherwise reproduced without the author's permission.

AVIS:

L'auteur a accordé une licence non exclusive permettant à la Bibliothèque et Archives Canada de reproduire, publier, archiver, sauvegarder, conserver, transmettre au public par télécommunication ou par l'Internet, prêter, distribuer et vendre des thèses partout dans le monde, à des fins commerciales ou autres, sur support microforme, papier, électronique et/ou autres formats.

L'auteur conserve la propriété du droit d'auteur et des droits moraux qui protègent cette thèse. Ni la thèse ni des extraits substantiels de celle-ci ne doivent être imprimés ou autrement reproduits sans son autorisation.

In compliance with the Canadian Privacy Act some supporting forms may have been removed from this thesis.

Conformément à la loi canadienne sur la protection de la vie privée, quelques formulaires secondaires ont été enlevés de cette thèse.

While these forms may be included in the document page count, their removal does not represent any loss of content from the thesis.

Bien que ces formulaires aient inclus dans la pagination, il n'y aura aucun contenu manquant.


Canada

ABSTRACT

Aviation is at a turning point. Considerable improvements in aircraft emissions efficiencies are expected through technological improvements, air traffic management, and managerial strategies. But global demand for air travel is increasing at an even faster rate. Mostly for political reasons, aviation has been left behind in international efforts to tackle climate change. However, increasing pressure is on the industry for immediate action, thus making further delays impossible.

This thesis is an attempt to determine the best possible course of action for the industry. To this end, it begins by assessing contemporary understanding of aviation's impact on the environment, and provides an overview of efforts being made toward reducing aircraft emissions. It then examines various policymaking tools available to best address the issue, concluding with an emissions trading system. Finally, design characteristics of such a system are suggested, and used to provide an analysis of the European attempt to include aviation into its own emissions trading system.

RESUME

Le domaine de l'aviation est sur le point de subir d'importants changements. L'avènement de technologies plus efficaces sur le plan énergétique, la révision des méthodes de contrôle du trafic aérien, et la mise en place de nouvelles stratégies de gestion par les compagnies aériennes, contribuent à réduire considérablement les émissions de gaz à effet de serre par l'industrie de l'aviation. Or, la demande des consommateurs pour ce mode de transport s'accroît à une vitesse encore plus fulgurante. Qui plus est, pour des raisons qui sont surtout d'ordre politique, les efforts déployés sur la scène internationale pour combattre les changements climatiques ont laissé le domaine de l'aviation de côté. Mais la pression politique croissante se fait aujourd'hui ressentir dans cette industrie, vers laquelle tous les regards sont maintenant tournés. Une action immédiate est nécessaire, et ne saurait se faire attendre plus longtemps.

La présente thèse a pour but de déterminer la meilleure manière de réglementer les émissions aériennes. Elle débute par une description de l'impact réel de l'aviation sur l'environnement, selon les connaissances actuelles, puis fournit un résumé des efforts déployés à ce jour pour combattre cet impact. Elle poursuit avec une analyse de la panoplie des outils politiques à notre disposition pour réglementer dans le domaine environnemental, et conclut qu'un système d'échange d'émissions serait l'outil le plus adapté aux particularités de l'industrie aérienne. Enfin, elle offre des suggestions quant aux caractéristiques que doit présenter un tel système s'il est appliqué au domaine de l'aviation. Ces suggestions sont prises en compte dans le cadre d'une analyse de la proposition récente de la commission européenne pour l'inclusion de l'aviation dans son système d'échange d'émissions.

ACKNOWLEDGEMENTS

I would like to thank my supervisor, Professor Richard Janda, for providing me with insightful guidance throughout the drafting of this work, and without whose knowledge my understanding of the interplay between the environment and the aviation industry would not have evolved. I would especially like to thank him for his dedication to environmental issues, and for taking the time to sensitize the public to these problems.

I would also like to thank both Professor Paul Stephen Dempsey and Mr. Mark A. Glynn, for their precious input and for having enlightened me, through accurate and interesting remarks, with their understanding of the complex interplay of factors that define the aviation industry.

I would like to express my heartfelt gratitude to Mtre. Patrick Ouellet, for having provided me with invaluable support throughout my legal career. I would like to thank him for his friendship and, though he may always deny having given any, for his wise guidance. I have reached many goals that I would not have without his help.

I am extremely thankful to Michel Dab, primarily for his love and patience, and for always having challenged me to pursue higher knowledge. I would also like to thank him for having taken the time to meticulously review and proof-read this thesis. His enthusiasm and insightful suggestions were greatly appreciated.

I owe most thanks to my parents, for their undying love and support, and for having provided me with the highest possible quality of education. I am grateful to my mother, who has dedicated her

entire life and soul to her children, and who was always there when we needed her most. I owe many thanks to my father, for having fed me with his intellectual curiosity, and for having taught me to strive for greater things. There is no more satisfying sense of achievement than when I read the pride in his eyes. I would also like to thank my brother Jean, for his relentless sense of humor and who, like my mother, has always kept me grounded.

Above all, I would like to dedicate this work to Julien-Maxime Bock-Morin, for having infused me with his love of aviation, and for encouraging me to pursue my work in this field. He has taught me the most important lesson of my life: that one's passions are meant to be pursued.

I- INTRODUCTION	9
II- AVIATION'S RELATIONSHIP WITH THE ENVIRONMENT	13
a. The environmental impact of aviation	13
i. A general assessment	13
ii. Current emissions trends	16
b. Types and effects of aircraft emissions	19
i. Atmospheric distribution of aircraft emissions	19
ii. CO ₂ emissions	21
iii. NO _x , SO _x , water vapor and soot	22
c. Measuring aircraft emissions	25
III- THE INDUSTRY'S RESPONSE TO ENVIRONMENTAL ISSUES	28
a. Air traffic management strategies	28
b. Airline management strategies	30
c. Technological advances	32
i. Alternative fuels	33
ii. Short term technological improvements	35
iii. Future fuel efficiency projections	36
iv. Timeline for introducing new technology	38
d. Conclusion on overall achievements	38
e. A summary of ICAO's position	39
i. Applicable standards on emissions: Annex 16, Vol. II	39
ii. Developing an ETS for aviation	40
iii. Taxes and levies	42
IV-ENVIRONMENTAL POLICYMAKING TOOLS FOR REGULATING AVIATION	45
a. Types of policymaking tools	45
i. Compulsory instruments	45
1) Green taxes	46
2) Emissions Trading Systems	46
3) Environmental Impact Statements	47
4) Best Available Technology	47
ii. Voluntary instruments	48
1) Labeling	49
2) Voluntary agreements	49
b. Choosing an appropriate tool for aviation	49
i. Evaluating the environmental efficiency of a policy	49
ii. Green taxes vs. emissions trading systems	51
1) The dangers of taxation: competition distortion	53
2) The dangers of taxation: tankering	54
3) Avoiding the dangers of taxation through international agreements	55
4) Conclusion	56
c. Proposals of a voluntary system	58

d.	Understanding aviation market specifics	59
i.	Load factor trends	60
ii.	Efficiency provided by alliance agreements	61
iii.	Lowering demand: price elasticity for aviation	64
V-	EMISSIONS TRADING SYSTEMS FOR AVIATION	70
a.	Designing an ETS suited for the aviation industry	70
i.	Methods of allocating allowances	70
ii.	Choosing ETS participants	75
iii.	Scope and coverage	77
iv.	Transactional costs	80
v.	Temporal flexibility: banking and borrowing	81
vi.	Safety valves	82
1)	The general idea	82
2)	Purchasing offsets	83
b.	Design elements of the EU ETS	85
c.	Particularities of an ETS for aviation	89
d.	An overview of the EC's proposal to integrate aviation in its ETS	90
e.	An International ETS and the need for uniformity	94
VI-	SUMMARY AND CONCLUSIONS	97
BIBLIOGRAPHY		99

**THIS THESIS HAS BEEN ENTIRELY PRINTED ON
100% RECYCLED PAPER**



¹ Image from BBC Website. Online: <http://news.bbc.co.uk/2/hi/science/nature/6364663.stm> (Date accessed: 14 August 2007).

I- Introduction

Last October 2006, British economist Sir Nicholas Stern delivered to the British government a 700-page report on the economics of climate change (the “Stern Review”). This report was widely recognized as being accurate and strongly supported by incontestable scientific evidence. As one author puts it, “The Stern Review has been lauded by, amongst others, four Nobel Prize economists and the president of the World Bank as a convincing, accurate and necessary assessment of the reality of climate change, the threat it poses and alacrity with which measures need to be taken to combat it.”²

The main conclusions of the Stern Review are that the world will live through the worst economic crisis and greatest market failure it has ever seen, should nothing be done about the current climate change trends. This crisis could impact GDP by as much as 20%³, with a most probable GDP loss of 11%⁴. However, the worst impact of climate change may be avoided by investing 1% of the GDP into combating it, mainly through a reduction in greenhouse gas emissions (GHG)⁵. In other words, it would be much cheaper to combat climate change today than to do nothing about it at all.

Having recognized the need to lower global greenhouse gas (GHG) emissions, 190 states have become party to the United Nations Framework Convention on Climate Change to date, whose objective, as stated in its article 2, is to achieve “stabilization of greenhouse gas concentrations in

² “Global Warming – The climate change impact of aviation”, (2007) 47 Airline Fleet and Network Management, at p. 10.

³ Stern Review Report, Summary of conclusions, p. 1.

⁴ After the Stern Review: reflexions and responses. Paper A: “A case for action to reduce the risks of climate change”, 12 February 2007, p. 12.

⁵ Stern Review Report, Summary of conclusions, p. 1.

the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.”⁶

In accordance with this objective, 175 states party to the UNFCCC have ratified the Kyoto Protocol, which entered into force on 16 February 2005. The Kyoto Protocol provides for more detailed and specific measures and policies for attaining this objective, and specifically provides that member states shall pursue emissions reduction for aviation through work with ICAO.⁷ To date, ICAO has not created any significant, compulsory legal system for achieving emissions reduction for aviation.

The Kyoto Protocol has taken a most innovative approach to tackling the issue of climate change: it has set a maximum amount of global GHG emissions, a goal to be attained by 2012. The maximum aggregated carbon dioxide equivalent GHG emissions is set to 5% below 1990 levels, worldwide. To achieve this goal, each party has been assigned an emissions target according to their needs and level of development.⁸ Parties may also exchange emissions target.⁹ In effect, the Kyoto Protocol proposes a global emissions trading system (“ETS”).

On 1 January 2005, the European ETS, the first multi-national emissions trading system commenced its activities in Europe, pursuant to Directive 2003/87/EC. On 20 December 2006, possibly following sustained inaction on the part of the International Civil Aviation Organization (ICAO), the European Commission tabled legislation to include aviation in the European ETS. Should this proposal be accepted, all national and international flights within Europe will be

⁶ *United Nations Framework Convention on Climate Change*, 9 May 1992, 1771 U.N.T.S. 107, art. 2 (“UNFCCC”).

⁷ *Kyoto Protocol to the United Nations Framework Convention on Climate Change*, 11 December 1997, U.N. Doc. FCCC/CP/1997/9/Add. 1 (“Kyoto Protocol”), art. 2(1)a) and art. 2(2).

⁸ *Kyoto Protocol*, *ibid.* art. 3(1).

⁹ *Kyoto Protocol*, *supra* note 7, art. 3(10) to 3(12), 6 and 17.

covered by the European ETS by 2011, and all carriers landing in or taking off from an airport in Europe will be covered by 2012.¹⁰

This thesis examines what policies may be used to achieve efficient GHG reductions in the aviation industry, currently the fastest growing contributor to GHG emissions in the world¹¹.

The need to reduce emissions is assessed in the first chapter through a study of the environmental impact of aviation, a review of the various GHG created by aviation and a summary of the scientific impact assessments of these specific gases on the environment.

Private efforts by the aviation industry to reduce emissions will then be assessed in the second chapter, through a study of work being made by airlines, air traffic control organizations, and aircraft manufacturers, as will ongoing efforts by ICAO.

The third chapter will examine various policymaking tools, along with their advantages and disadvantages in regards to aviation. More specifically, the impact of taxation on demand will be assessed and compared with the possible environmental, social and economic benefits of an ETS applied to aviation. Conclusions of this analysis lead to the need for a globally implemented open ETS, allowing aviation to trade with other industries.

Finally, the last chapter will dwell upon issues emerging from the designing of an ETS for aviation, and will examine the various characteristics and mechanisms involved in the current European ETS. With knowledge acquired from the previous chapter, the European proposal to

¹⁰ "Climate change: Commission proposes bringing air transport into EU Emissions Trading Scheme" (20 December 2006) Press Release IP/06/1862. Online: <http://europa.eu/rapid/pressReleasesAction.do?reference=IP/06/1862&format=HTML&aged=1&language=EN&guiLanguage=en#finB1> (Date accessed: 10 August 2007).

¹¹ *Infra*, note 22.

include aviation into its ETS will then be analyzed, as will its possible consequences for the global aviation industry.

II- Aviation's relationship with the environment

a. The environmental impact of aviation

i. A general assessment

This subsection provides an overview of the impact air transportation on climate change, through an assessment of emission levels of various GHG such as carbon dioxide (CO₂) and nitrous oxides (NO_x). Current projections of aviation emissions in the near future are provided, as well as general climate change scenarios currently being predicted by scientists.

According to one estimate, aviation makes a 3.5% contribution to global warming.¹² Other estimates find a 1.6 to 2.2% addition to total anthropogenic CO₂ emissions, a 2-8% contribution to total radiative forcing¹³, and a 7-12% addition to total NO_x emissions.¹⁴ These numbers are climbing.

In terms of CO₂ emissions, other studies are even more drastic. One study suggests that aviation will make a 3-8% contribution to global CO₂ emissions between 1990 and 2050.¹⁵ Others find

¹² 1999 IPCC report estimate as quoted by Martin Cames & Odette Deuber, "Emissions trading in international civil aviation" (2004) Öko-Institut e.V., at p. 9 ("Cames & Deubes").

¹³ Radiative forcing is a measure used to determine the importance of the greenhouse effect of a gas. It is measured in Watts per square meter, and expresses the amount of energy change on the Earth's surface. It is important to understand that this measurement does not take into account atmospheric residence times. A gas with a longer residence time but the same radiative forcing as a gas that is rapidly flushed out of the atmosphere will have a considerably larger impact on overall climate change. Cames & Deubes, *ibid.*, at p. 34.

¹⁴ "Aviation and the Global Atmosphere" (1999) IPCC Special Report. Hans Schlager, ICAO Colloquium on Aviation Emissions with Exhibition, May 15 2007, presentation slide 16; Gregg G. Fleming, "Modeling Aviation Emissions on a Local and Global Scale, May 15 2007, presentation slide 12. Online: <<http://www.icao.int/EnvClq/Clq07/Documentation.htm>> (date accessed: 12 June 2007); Ulrich Schumann, "Effects of Aircraft Emissions on Ozone, Cirrus Clouds, and Global Climate", (2000) 2:3 Air & Space Europe, 29.

¹⁵ 1999 IPCC Report, section 6.3.2.

that CO₂ emissions from aviation will, in the best case scenario, triple between 1995 and 2050, and in the worse case, increase by 600%.¹⁶

Because aviation is the only industry to deposit pollutants directly into the upper troposphere and lower stratosphere, where pollutants are not lost through ground or water absorption but reside in the atmosphere for long periods of time, mixing and reacting with other chemicals, the impact of its GHG on the environment is further increased. The IPCC estimates that aviation GHG are responsible for 2 to 4 times the radiative forcing caused by aircraft carbon dioxide emissions alone.¹⁷ Recent research suggests that these IPCC evaluations of the impact of aviation on the atmosphere were underestimated.¹⁸

From 1960 to 1999, worldwide scheduled passenger air travel grew an average of 9% annually.¹⁹ This impressive growth is due to a variety of reasons, including population growth, GDP growth, the globalization of markets, and the decline of air travel costs, particularly when compared to operational costs of automobiles, which remained fairly constant.²⁰ The UNFCCC estimates that from 1990-2000, air transport in Kyoto Protocol Annex 1 countries has increased by 40%.²¹

Today, the aviation industry is still growing, and is expected to triple, quadruple, or even quintuple by 2050. Today, it is the fastest growing contributor to GHG emissions. Demand for

¹⁶ Xander Olsthoorn, "Carbon dioxide emissions from international aviation: 1950-2050" (2001) 7 *Journal of Air Management* 87.

¹⁷ Solomon Jamin *et al.*, "Aviation emissions and abatement policies in the United States: a city-pair analysis" (2004) Transport Research Part D 295 ("Jamin"), at p. 296. 1999 IPCC report. However, it has been convincingly argued that this may be an overestimate of the contribution of aviation to global radiative forcing: Forster, *supra* note 35. The EC believes this number may be an underestimate, because calculations do not take into account the uncertain effects of cirrus cloud formation: EU proposal, preamble par. 12.

¹⁸ "Impact of International Aviation on Climate Change: Preparation for the 35th Assembly of the International Civil Aviation Organization (ICAO)" (9 July 2004) Council of the European Union ("EU working document for ICAO 35th Assembly").

¹⁹ Jamin, *supra* note 17, at p. 296.

²⁰ Air travel cost has declines by 3.1% annually between 1960 and 2000, and is expected to decline an additional 1.55% annually. Costs are calculated per US\$ per revenue passenger kilometer (RPKM): Jamin, *supra* note 17, at p. 308.

²¹ EU working document for ICAO 35th Assembly, *supra* note 18, at p. 4.

aviation is expected to grow further, on the order of 3.7% to 6.6% annually, according to various studies.²² Aviation fuel consumption is projected to increase by about 4% per year, in spite of expected technological improvements being taken into account.²³

This is not a new trend; demand for air travel has always grown at a faster rate than fuel savings from technological improvements. It is already estimated that in the US, between 1990 and 2005, CO₂ emitted from commercial aircraft grew 14.8%, while accounting for a 69% growth in passenger miles traveled. This disparity is explained by improvements in both aircraft efficiencies and increased load factors.²⁴

In the US, it is estimated that 47% of the increase in air travel growth is attributable to lower air fare costs, while 26% is due to income growth, and only 11% is due to population growth.²⁵ Future drops in airfare costs are expected, although the original rate of decrease is projected to be halved.²⁶

Aviation growth trends vary across the globe, even amongst developed nations. US domestic air travel annual growth has been 5.3% from 1975 to the 1990s, before it declined to around 3.8%. This decline is expected to continue until an average 2.4% annual growth is reached starting from 2015 onward until at least 2030.²⁷ Using this projected 2.4% growth in US domestic air travel and an expected 1.5% reduction in aircraft energy intensity, one study finds that energy intensity from air travel will continue increasing by 0.9% per year, or by 29% within 30 years, causing a considerable increase in aircraft emissions. These projections lead to a 30% jump in CO₂

²² Cames & Deubes, *supra* note 12, at . 103.

²³ Cames & Deubes, *supra* note 12, at p. 100, quoting NASA, ANCAT and DLR projections.

²⁴ "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005" (April 2007), p. 3-8. Online: <http://www.epa.gov/climatechange/emissions/usinventoryreport.html> (date accessed: 21 June 2007).

²⁵ Jamin, *supra* note 17, at p. 309.

²⁶ *Supra* note 13.

²⁷ Jamin, *supra* note 17, at p. 308. Growth rates extracted from table 4, p. 308.

emissions, and a 58% increase in NOx emissions. Even if technology directed at lowering NOx is introduced, a 'best case' 27% increase in NOx emissions is estimated.²⁸

European projections are much worse. Demand for air travel grew at a rate of 7.5% between 2003 and 2004, and 87% from 1990 to 2004, resulting in an average annual growth of 6.2%. Should this growth continue, by 2012, more than a quarter of the EU's Kyoto mandated reductions would be offset by its aviation industry alone.²⁹

Although the total amount of GHG for which the aviation industry is responsible represents only a small fraction of the total, global GHG emissions, aviation's impact on global warming is larger than its emissions contribution. This is due to the fact that aircraft deposit their gases directly into the upper atmosphere, altering the atmospheric concentrations of GHG. In addition, these gases, such as NOx, have significantly higher residence times in the atmosphere when they are emitted in the troposphere rather than closer to the Earth's surface, thereby sustaining their impact on climate change for a longer period of time³⁰.

ii. Current emissions trends

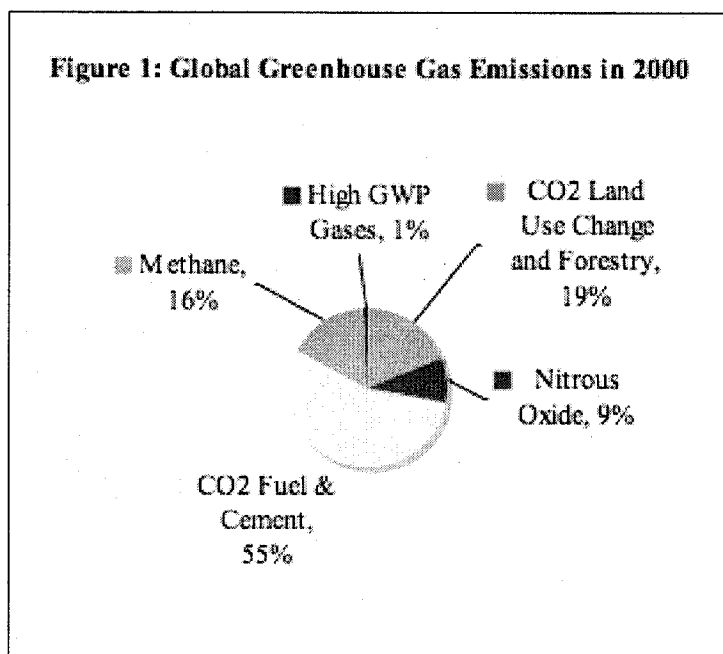
The following graphs best demonstrate worldwide emissions trends, both historical and projected, as well as aviation's share of the burden.

²⁸ Jamin, *supra* note 17, at p. 309-310.

²⁹ "Proposal for a Directive of the European Parliament and of the Council amending Directive 2003/87/EC so as to include aviation activities in the scheme for greenhouse gas emission allowance trading within the Community", (20 December 2006) European Commission, 2006/0304 (COD).

³⁰ Ulrich Schumann, "Effects of Aircraft Emissions on Ozone, Cirrus Clouds, and Global Climate", (2000) 2:3 Air & Space Europe, 29.

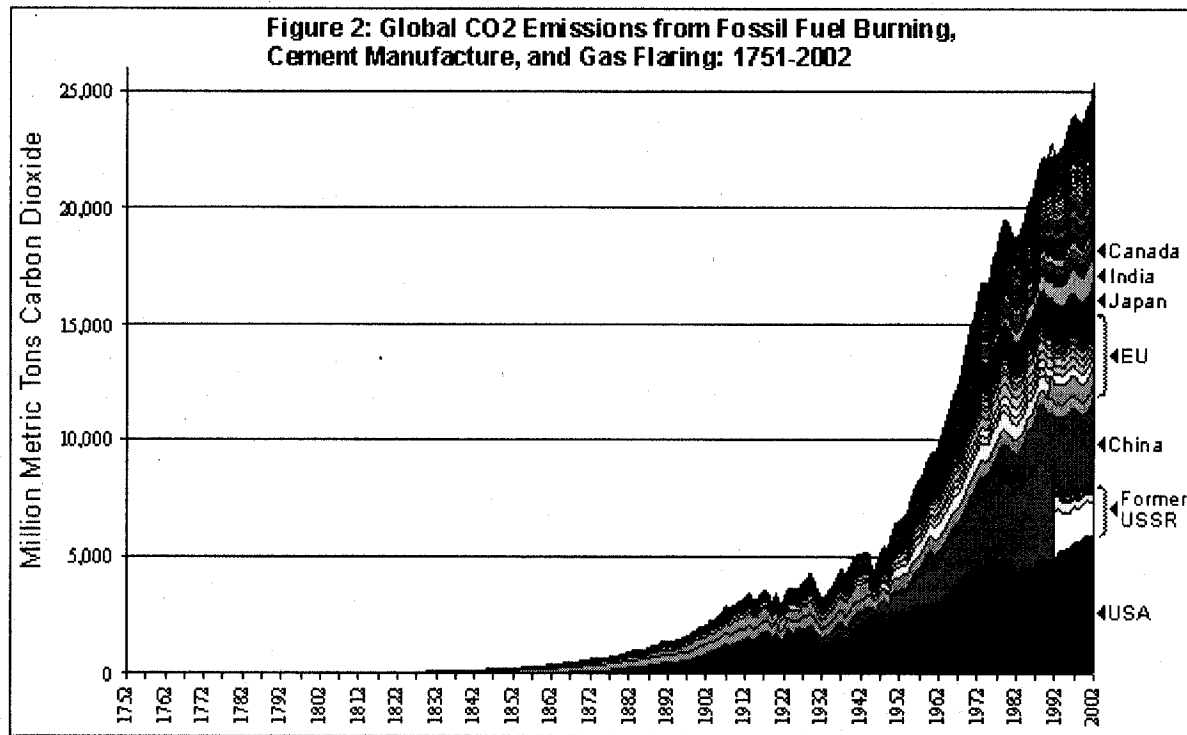
Figure 1³¹ shows the relative global emissions of various GHG throughout all industries worldwide. The importance of regulating CO₂ emissions, at least as a first step toward reducing global GHG emission, is more than apparent. In 2005 in the U.S., 33% of all CO₂ emissions were a result of petroleum products consumed during transportation activities, and 29% of all U.S. GHG resulted from transportation. Personal vehicles accounted for 60% of these CO₂ emissions³². The remaining 40% was emitted both by diesel fuel used in heavy-duty vehicle and jet fuel, excluding all international bunker fuels.



³¹ EPA, Methane to Markets Partnership Fact Sheet Brochure, posted on U.S. Environmental Protection Agency's website; <http://www.epa.gov/climatechange/emissions/globalghg.html>

³² "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005" (April 2007), p. 2-10 and p. 2-28. Online: <http://www.epa.gov/climatechange/emissions/usinventoryreport.html> (date accessed: 25 June 2007).

Figure 2³³ is a well-known graph showing the continuously increasing emissions trend since the industrial era, exponentially.



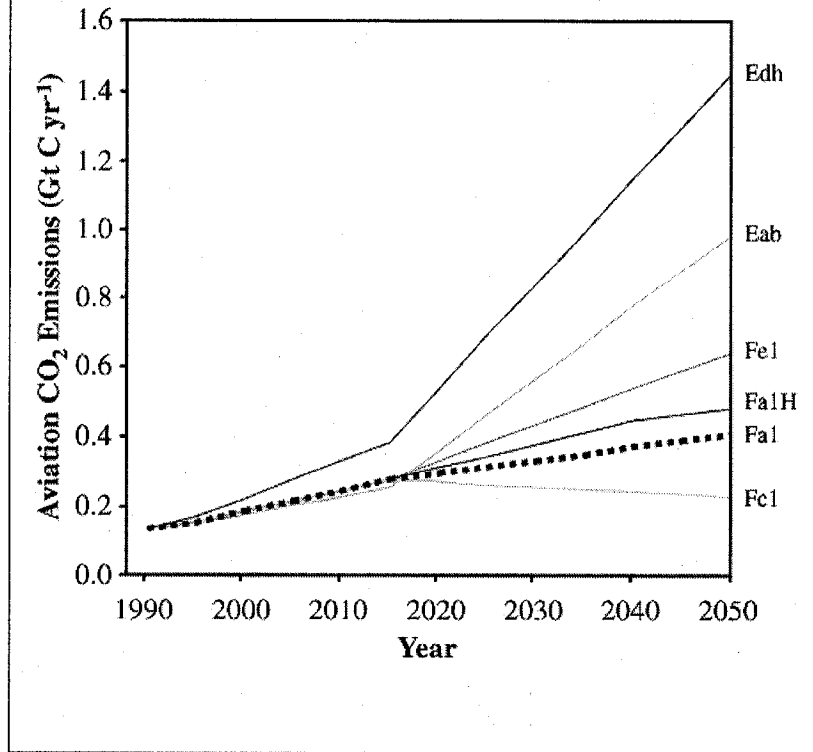
Finally, figure 3 shows projected increases in aircraft CO₂ emissions from various studies.³⁴ Because CO₂ emissions are proportional to fuel consumption and do not depend on other factors such as engine characteristics and flight path, this graph shows a trend that is also representative of fuel consumption trends.³⁵

³³ U.S. Environmental Protection Agency website: <http://www.epa.gov/climatechange/emissions/globalghg.html>

³⁴ 1999 IPCC Report, figure 6.7.

³⁵ "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005" (April 2007), p. 2-10. Online: <http://www.epa.gov/climatechange/emissions/usinventoryreport.html> (date accessed: 25 June 2007). The 30% increase is calculated from table 2-7.

Figure 3: Aviation CO₂ emissions projections from various studies.



b. Types and effects of aircraft emissions

i. Atmospheric distribution of aircraft emissions

Commercial aircraft typically cruise at altitudes of 9 to 13 km, partly in the upper troposphere, partly in the lower stratosphere.³⁶ This altitude range is where aircraft in cruise phases deposit pollutants.

³⁶ 1999 IPCC Report.

Aircraft engines emit principally CO₂ and water vapor, nitrous oxides (NO_x), sulphur oxides (SO_x) and soot, the first two of these gases being the most abundant. The IPCC describes the proportion of GHG from aviation as follows:³⁷

Emissions from aviation come from the combustion of jet fuel (jet kerosene and jet gasoline) and aviation gasoline. Aircraft engine emissions are roughly composed of about 70 percent CO₂, a little less than 30 percent H₂O, and less than 1 percent each of NO_x, CO, SO_x, NMVOC, particulates, and other trace component including hazardous air pollutants. Little or no N₂O emissions occur from modern gas turbines (IPCC, 1999). Methane (CH₄) may be emitted by gas turbines during idle and by older technology engines, but recent data suggest that little or no CH₄ is emitted by modern engines.

Emissions depend on the number and type of aircraft operations; the types and efficiency of the aircraft engines; the fuel used; the length of flight; the power setting; the time spent at each stage of flight; and, to a lesser degree, the altitude at which exhaust gases are emitted.

(...) Generally, about 10 percent of aircraft emissions of all types, except hydrocarbons and CO, are produced during airport ground level operations and during the LTO cycle. The bulk of aircraft emissions (90 percent) occur at higher altitudes. For hydrocarbons and CO, the split is closer to 30 percent local emissions and 70 percent at higher altitudes, (FAA, 2004a).

Other studies show that an average of 60% of all CO₂, NO_x and H₂O aircraft emissions occur at higher altitude, and that by contrast, more than 30% of CO and HC emissions from aircraft occur within a 1 km altitude, where they significantly contribute to local air quality deterioration. This proportion is not expected to change with projected technological improvements.³⁸

The impact of aircraft emissions on the atmosphere and their chemical interaction with other atmospheric gases is extremely complicated. Our goal is not to provide a detailed explanation of

³⁷ 2006 IPCC Guidelines for National Greenhouse Gas Inventories, p. 3.56. An LTO cycle is a landing and take-off cycle.

³⁸ Jamin, *supra* note 17, at p. 310, 1999 IPCC Report, Executive Summary.

these interactions, but rather a simpler overview of their results, for the purposes of examining policymaking tools appropriate for regulating aircraft emissions.³⁹

ii. CO₂ emissions

CO₂ is an important GHG and has a long-term effect, staying in the atmosphere for about 100 years once emitted. Its effect on the atmosphere is independent from the point of emission, so that CO₂ emissions from aviation has no greater effect on climate than the same amount of CO₂ emissions from other industries. In addition, there is a linear relationship between CO₂ and its impact on climate change: doubling the amount of CO₂ in the atmosphere mean doubling its impact on climate change. This simple correlation does not hold for most other GHG.⁴⁰

Unlike NO_x, CO₂ and water vapor emissions are directly related to the amount of fuel consumed, which makes them an easy target for any policymaking tool based on fuel consumption.

As further discussed below, global efforts are underway to regulate CO₂ emissions, as it is the most important GHG, all industries included. It is responsible for 60% of the radiative forcing increase since the pre-industrial era. About 70-90% of the total anthropogenic CO₂ emissions result from fossil fuels. Although most of the combustion process produces CO₂, part of the carbon present in fossil fuels is released in other forms, such as carbon monoxide and methane. These molecules eventually end up reacting with oxidants in the atmosphere and form CO₂. This process may last from a few days to eleven years.⁴¹

³⁹ For details on these interactions and atmospheric effects, refer, *inter alia*, to the 1999 IPCC report.

⁴⁰ Cames & Deubes, *supra* note 12, at p. 28.

⁴¹ Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual, p. 1.8.

iii. NO_x, SO_x, water vapor and soot

Other aircraft emissions have an important global warming effect as well. The overall warming effect caused by aircraft emissions is 2 to 4 times that of the warming caused by aircraft CO₂ emissions alone⁴². This is why regulating aircraft emissions should not be limited solely to CO₂ emissions.

NO_x, SO_x, water vapor and soot have shorter atmospheric residence times than CO₂, but their presence has important effects on the atmosphere.

The residence time of water vapor in the atmosphere is in the range of two weeks, but because it is ejected from aircraft engines at high concentrations, it can contribute to ozone depletion and cause greenhouse effects.⁴³

Aircraft emissions also create condensation trails (contrails)⁴⁴. Contrails are thought to increase global cloudiness, and some scientists believe that increased cloudiness may increase global warming⁴⁵, though the extent of this phenomenon is not yet fully understood⁴⁶. This uncertainty adds a degree of difficulty to the task of attributing responsibility for climate change effect of contrails to emitters.

⁴² Ulrich Schumann, "Effects of Aircraft Emissions on Ozone, Cirrus Clouds, and Global Climate", (2000) 2:3 Air & Space Europe, 29

⁴³ Cames & Deubes, supra note 12s, supra note 12, at p. 28.

⁴⁴ Vlek, Sander, Vogels, Marli. "AERO – Aviation Emissions and Evaluation of Reduction Options" (2000) 2:3 Air & Space Europe 41

⁴⁵ David Fahey, "The Assessment of Aviation Cloudiness in IPCC Climate Change 2007 – The Physical Science Basis" ICAO Colloquium on Aviation Emissions with Exhibition, May 15 2007, presentation slides 3 and 7. Online: < <http://www.icao.int/EnvClq/Clq07/Documentation.htm> > (date accessed: 6 August 2007).

⁴⁶ Yaw Out Mankata Nyampong. *The Regulation of Aircraft Engine Emissions from International Civil Aviation* (LL.M. Thesis, Institute of Air and Space Law, McGill University, 2006) [unpublished] ("Yaw"), p. 12,

NO_x is the most studied of aviation gases, and its effect on ozone chemistry is well-known.⁴⁷ It reacts with other atmospheric gases to form substances with important greenhouse effects. Because of its relatively low residence time, its presence in the atmosphere is mostly restricted to areas of heavy air traffic, where it has regional impacts on climate change, called “hot-spots”.⁴⁸

NO_x causes an increase in ozone concentrations in the upper troposphere and upper stratosphere, as CO does, while sulfur and water concentrations have an opposite effect. NO_x concentrations at higher altitudes also have the opposite effect of decreasing ozone.⁴⁹ NO_x has no known climate change impact at ground level, but its effect on ozone production is linked to poor local air quality around airports.⁵⁰

Increases in NO_x concentrations in the upper troposphere destroy methane (CH₄), a GHG with a life span in the atmosphere of approximately 9 years.⁵¹ NO_x can therefore have a cooling effect on climate, competing with its warming effect resulting from ozone formation. However, the quantitative impact of CH₄ reductions is not well known; consequently, then net resulting effect of NO_x on climate change is not fully known⁵².

Unlike CO₂ and water vapor, aircraft NO_x emissions are dependant on factors other than fuel consumption, such as engine specifications and flight behavior. This fact is extremely relevant to

⁴⁷ 1999 IPCC Report.

⁴⁸ Cames & Deubes, *supra* note 12, at p. 30-31.

⁴⁹ 1999 IPCC Report.

⁵⁰ Cames & Deubes, *supra* note 12, at p. 31.

⁵¹ 1999 IPCC Report, at section 6.3.4.

⁵² Ulrich Schumann, “Effects of Aircraft Emissions on Ozone, Cirrus Clouds, and Global Climate”, (2000) 2:3 Air & Space Europe, 29

policymakers, since it implies that NO_x emissions must be measured at the output, and attributed to the emitter.⁵³

SO_x is not a GHG, and its presence in the atmosphere has a cooling effect on the climate; it reacts with oxidants in the atmosphere and produces sulfate aerosols,⁵⁴ which are believed to cool the climate by reflecting sunlight back into space.⁵⁵ However, SO_x greatly participates in the formation of contrails and cirrus clouds.⁵⁶ Today's engines emit approximately 0,8g of SO_x per kilogram of fuel burnt. Low-sulphur fuels that are expected to be introduced into the market by 2015 will emit half that amount.⁵⁷

Soot is by far the most damaging of aircraft pollutants health-wise, as it causes on average 52% of all marginal air pollution damages caused by surface level aircraft pollutants.⁵⁸ Surface level emissions have an important effect on local air quality and are the main source of aviation-related health damages. Though it is not the case for NO_x, most of the carbon monoxide, particulate matter and volatile organic compounds are emitted as surface-level emissions⁵⁹.

Surface level emissions typically stem from taxiing, sitting idle while waiting for traffic control clearance, and landing/take-off (LTO) cycles, as LTO emissions are confined to the first kilometer of atmosphere. Most of the pollutants emitted during this phase fall back to the surface within a few days⁶⁰.

⁵³ Cames & Deubes, *supra* note 12, at p. 55 and 58.

⁵⁴ Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual, p. 1.42.

⁵⁵ Piers M. de F. Forster, "It is premature to include non-CO₂ effects of aviation in emission trading schemes", (2006) 40 Atmospheric Environment 1117 (Forster), at p. 1118.

⁵⁶ Cames & Deubes, *supra* note 12, at p. 32-33.

⁵⁷ Jamin, *supra* note 17, at p. 306.

⁵⁸ Average calculated from Youdi Schipper, "Environmental Cost in European Aviation" (2004) 11 Transport Policy 141, 149, table 9.

⁵⁹ Youdi Schipper, "Environmental Cost in European Aviation" (2004) 11 Transport Policy 141, 148.

⁶⁰ Yaw, *supra* note 46 p. 17

Table1: Typical emission index levels for engine-operating regimes. Units are grams of pollutant per kilogram of fuel burnt (g kg-1)⁶¹

Species	Operating condition			Comments
	Idle	Take-off	Cruise	
CO ₂	3160	3160	3160	
H ₂ O	1230	1230	1230	
CO	25 (10–65)	<1	1–3.5	
HC (as methane)	4 (0–12)	<0.5	0.2–1.3	
NO _x (as NO ₂)	4.5 (3–6)	32 (20–65)	7.9–11.9	(Short haul)
	4.5 (3–6)	27 (10–53)	11.1–15.4	(Long haul)
SO _x (as SO ₂)	1.0	1.0	1.0	

c. Measuring aircraft emissions

Any environmental policymaking tool based on aircraft emissions must integrate a system for comprehensively assessing the amount of emissions each user is responsible for. In fact, art. 4(1) of the UNFCCC explicitly makes it an obligation for member states to periodically provide and publish information pertaining to “national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol”. These numbers must be calculated using methods approved by the member states, taking into account best available scientific knowledge.⁶²

The IPCC guidelines provide three specific methods for measuring aviation emissions: the tier 1, tier 2, and tier 3 methods.⁶³ ICAO recommends that States use these methods for calculating

⁶¹ G.P. Brasseur *et al.*, “European Scientific Assessment of the Atmospheric Effects of Aircraft Emissions” (1998) 32 *Atmospheric Environment* 2329, at p. 2354.

⁶² *United Nations Framework Convention on Climate Change*, 9 May 1992, 1771 U.N.T.S. 107, art. 4(1)a) and 4(2)c).

⁶³ The U.S. Greenhouse Gas Inventory uses a method similar to that used by the IPCC, as explained in annex 2 of the 2007 report: “Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005” (April 2007), annex 2. Online: <http://www.epa.gov/climatechange/emissions/usinventoryreport.html> (date accessed: 23 June 2007).

aviation GHG emissions, to insure consistency in the methods.⁶⁴ Tier 1 is the simplest but less accurate method for measuring emissions, and is not specific to aviation. It is merely a measure of the amount of fuel consumed, multiplied by a specific emissions factor calculated for each specific type of fuel.⁶⁵ This method is sufficiently accurate for measuring aircraft CO₂ emissions, as CO₂ emissions are directly proportional to fuel consumption, though methods that take LTO cycles into account are more appropriate for measuring aircraft emissions of other gases.⁶⁶

Tier 2 offers a method that is adapted to the specifics of aviation, in that aircraft emissions vary depending on the operations the aircraft is performing. Tier 2 separates the operations of an aircraft in two categories: those occurring below 3000ft (the landing and take-off cycles), and those occurring above 3000ft (the cruise phase). An emissions factor calculated for LTO cycles is multiplied by the number of LTO cycles performed, to yield the amount of LTO emissions. This number is added to the amount of emissions occurring during cruise phase, which is obtained by multiplying the amount of fuel used during cruise phase, by the cruise phase emissions factor.⁶⁷

Finally, tier 3 is separated into tier 3A and tier 3B methods. Tier 3A uses origin and destination data to determine cruise phase and LTO phase emissions separately, depending on the aircraft types. The tier 3B method uses full flight trajectory information, including air traffic information. It also uses engine performance data, and allows for constant updating of the model depending on

⁶⁴ Abeyratne, Ruwantissa "Emissions Trading – Recommendations of CAEP/7 and the European Perspective" 32/4-5 Air & Space Law 360, at p. 367.

⁶⁵ Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Workbook, pp. 1.1; 2006 IPCC Guidelines for National Greenhouse Gas Inventories, p. 3.58.

⁶⁶ Article 9, ICAO Draft Action Plan for Aircraft Engine Emissions. For information on possible error margins in NO_x emissions evaluations stemming from these methods, see literature referred to in Cames & Deubes, *supra* note 12, at p. 59-60.

⁶⁷ Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Workbook, pp. 1.20; 2006 IPCC Guidelines for National Greenhouse Gas Inventories, p. 3.59.

various changes, such as aircraft equipment changes and changes in air traffic change.⁶⁸ Tier 3 is obviously the most accurate method for measuring aircraft emissions, but it is also more complicated to implement.

It should be noted that national emissions relating to aviation include only domestic flights (flights departing and landing within that country). Flights departing from or landing in another country are considered international flights, and are not included in the IPCC calculations for national emissions. IPCC refers to fuels used in international transportation activities as “international bunker fuels”, and include NO_x, CO₂ and CH₄. Emissions from international transportation are reported based on location of fuel sales. Only aviation and marine transportation are included in this calculation system, as emissions resulting from road transportation (cars, trucks, and trains) are allocated to the country where the fuel was loaded.⁶⁹

⁶⁸ Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual, p. 1-47; 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2 Energy, p. 3.61.

⁶⁹ Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Workbook, p. 1.3 and 1-20; Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reporting Instructions, p. 1.4; “Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005” (April 2007), p. 2-13. Online: <http://www.epa.gov/climatechange/emissions/usinventoryreport.html> (date accessed: 21 June 2007)

III- The industry's response to environmental issues

This subsection will provide an overview of the technological advancements, air traffic control developments, and operational management strategies relevant to fuel efficiency and emissions reduction concerns, and will attempt to ascertain the current developmental status of energy replacements to fossil fuel combustion for the aviation industry.

a. Air traffic management strategies

The potential for aviation emissions reductions promised by operational advancements in air traffic control was explicitly recognized by the G8 in 2005. G8 members agreed to cooperate toward achieving these improvements.⁷⁰

IATA expects a 12% increase in fuel efficiency from air traffic management (ATM) alone:⁷¹

Efficiency is directly linked to environmental performance. Inefficient air traffic management results in 12% of unneeded CO₂ emissions. At current fuel prices that 12% inefficiency is a US\$12.56 billion cost. More direct routings, improved terminal operations and efficient fuel management are all part of a solution.

Other studies find that changes in ATM to be implemented within the next 20 years could reduce fuel consumption by 8 to 18%, and another 2 to 6% could be further reduced through various operational measures⁷².

⁷⁰ "Climate Change, Energy and Sustainable Development", The Gleneagles Communiqué, Gleneagles Plan of Action, article 8.

⁷¹ Article 4 "Partnership for Change with Air Navigation Service Provides" Edition 8, September 2006, Industry Times, IATA.

⁷² Caime & Deube, at p. 23, quoting the 1999 IPCC report.

Some argue that because traffic theory states that efficiency increases demand, it is not clear whether efficient ATM may actually be beneficial to the environment. However, air traffic is naturally limited in heavily populated areas by airport slot availability and airport size, not only ATM activities. It is possible that efficient ATM will indeed increase traffic in an already slot-constrained airport, but only if aircraft turn-over time is similarly increased. Some believe that issues of congestion at airports may also be addressed through a clarification of slot allocation, by setting up a more transparent legal framework.⁷³

Various techniques have been shown to lower emissions without creating possibilities for increased traffic, one of which is surface movement optimization. Instead of leaving aircraft in a queue on the taxiway with their engines running, virtual queues could be created at the gate, so that aircraft would turn their engines on only at the last minute. Similarly, aircraft could be grouped by size to avoid vortex wait⁷⁴.

In Europe, a new European single sky initiative called SESAME is in the process of being created. The goal of this project is to agglomerate and synchronize all 34 current ATC providers in Europe. According to IATA, such a system could eliminate delay-related emissions, which would translate into an annual saving of 12 million tons of CO₂.⁷⁵

⁷³ "Two Futures", (June/July 2005) Communiqué Airport Business 6, at p. 7

⁷⁴ John-Paul Clarke, "Operational Procedures for LAQ", May 15, presentation slides 12-16. Online: <<http://www.icao.int/EnvClq/Clq07/Documentation.htm>> (date accessed: 12 June 2007). Upon take-off, aircraft leave air disturbances behind, or vortexes, which increase in importance with aircraft size. These vortexes make it impossible for small aircraft to take-off immediately after large aircraft; they must wait until the vortex fades away. The wait is typically on the order of a few minutes.

⁷⁵ "Global Warming – The climate change impact of aviation", (2007) 47 Airline Fleet and Network Management, at p. 12.

b. Airline management strategies

Airlines have long been interested in reducing their fuel consumption to reduce costs. They have tried various management strategies in the past to increase load factors and avoid empty flights. They have tried lowering the weight of their aircraft by taking magazines out and lowering passenger consumption of food and beverages. Some airlines, such as American Airlines, have avoided painting their aircraft at all so as to reduce weight and save on fuel costs.

Efforts to increase load factors have also led to important fuel savings. The increased load factors are generally attributed to more efficient management strategies, particularly with respect to route planning, choosing aircraft sizes, establishing more appropriate scheduling, and novel marketing strategies, such as surprise trips and low stand-by fares. However, as explained in section IV(d)(i) below, it is unlikely that further increases in load factors will be achieved, at least for passenger flights in developed countries.

Contemporary tendencies in airline business strategies involve increasing network complexity and flexibility, partly through alliance agreements. The proliferation of these agreements has created a potential for reducing aircraft movements through deeper network integration and the removal of redundant flights. However, such agreements between natural competitors involve important competition law issues, which are addressed in section IV(d)(ii). The brief analysis performed in section IV(d)(ii) leads to the conclusion that legislators should provide further incentives for such agreements through increased flexibility and assurances of legal certainty.

Initially designed as a means of establishing a network better suited to respond to the needs of air travel, the hub-and-spoke system's spider web characteristics provide greater route options to passengers. However, they have raised many questions as to their actual efficiency. Some have suggested that the hub-and-spoke system may lead to unnecessary fuel burn⁷⁶ and more numerous aircraft movements, and that environmental considerations justify returning to the conventional origin-and-destination routes. This conclusion is not as straightforward as it may seem. One study has concluded that though origin-and-destination flights may lead to improvements in local air quality, emissions would actually increase at higher altitudes. Overall, the total reductions in CO₂ emissions, if any, would be negligible.⁷⁷

Apart from efficiency-oriented business strategies that happen to have positive effects on efforts to combat climate change, there have also been attempts to tackle the problem more directly.

Some airlines, perceiving their clientele's worry about atmospheric pollution and their contribution to it, encourage passenger to invest in market sinks. For example, Air Canada has a "Carbon Offset Program", whereby passengers may calculate how many emissions their flight is responsible for, and are encouraged to invest in a certified environmentally friendly project managed by the Toronto-based not-for-profit organization Zerofootprint, an amount sufficient to offset the emissions they are responsible for.⁷⁸ Virgin Blue has a similar program,⁷⁹ as do many other airlines. Section V(a)(vi)(2) provides an assessment of the potential environmental benefit of such programs.

⁷⁶ Dempsey & Gesell, *Airline Management*, at p. 305.

⁷⁷ Jamin, *supra* note 17, at p. 315.

⁷⁸ For further information, go to [http://flightoffsets.zerofootprint.net/\(S\(qctil0efc5keaxnczfxztz1jb\)\)/en/calc.aspx](http://flightoffsets.zerofootprint.net/(S(qctil0efc5keaxnczfxztz1jb))/en/calc.aspx) (date accessed: 10 July 2007)

⁷⁹ "Fly Carbon Neutral", Virgin Blue website. Online: <http://www.virginblue.com.au/carbonoffset/info/> (Date accessed: 6 August 2007).

Industry actors are also using other types of voluntary instruments. British Airways, for example, has stated it would improve fuel consumption by 30% by the year 2010.⁸⁰

Some airports are attempting similar endeavors. A UK airport announced in June 2006 that it would plant hundreds of trees over 3 years, close to airport runways, in an attempt to reduce the impact of aircraft carbon dioxide emissions.⁸¹

Airlines are also always interested in investing in fuel-efficient technological advances. An airline that is more fuel-efficient is more cost-efficient; it can offer more attractive prices to its consumers, and is therefore more competitive.

c. Technological advances

Today, aircraft engines are less pollutant and airframes are lighter. In fact, they are said to be 70% more efficient than they were 50 years ago.⁸² These efficiencies have led to considerable reductions in aircraft emissions per passenger-kilometer. However, these reductions have not compensated for the increase in emissions due to traffic growth, and it is doubtful further improvements will compensate for expected future growth in demand for air travel⁸³.

⁸⁰ Cames & Deubes, supra note 12, at p. 23.

⁸¹ "Aircraft emissions offset by tree-planting", 27 June 2006. Online: <http://www.eta.co.uk/news/newsview.asp?n=553> (Date accessed: 6 August 2007).

⁸² Jorn Madslie, "Planemakers confront green issues" (21 June 2007) BBC News. Online: <http://news.bbc.co.uk/2/hi/business/6223834.stm> (date accessed: 21 June 2007). However, the Dutch National Aerospace Laboratory suggests this number is exaggerated, since it was obtained by using emissions from the DH Comet 4, an aircraft particularly fuel guzzling compared to its 1960 contemporary, the Boeing 707. Cames & Deube quote similar figures at p. 23, while also mentioning disagreement on the figure.

⁸³ Vlek, Sander, Vogels, Marli. "AERO – Aviation Emissions and Evaluation of Reduction Options" (2000) 2:3 Air & Space Europe 41

On June 4, 2007, IATA challenged the aviation industry to annul all CO₂ emissions by 2050⁸⁴. Projected increases in fuel efficiency predict a reduced consumption of a maximum of 50% by 2050.⁸⁵ At the current state of technological advancement, taking into account best-case scenarios of reductions from better air traffic control and operational measures⁸⁶, demand for air travel would have to decline, and not increase, as is projected, for the aviation industry to come remotely close to achieving the IATA challenge.

However, it is highly doubtful that IATA would be targeting a drop in demand for air travel. Another possibility is that the IATA challenge may be addressed to the scientific community, to take the lead in developing engines that use non-carbon-based fuels. In fact, non-carbon based fuels is the only possibility for completely annulling CO₂ emissions from air travel.

i. Alternative fuels

The only other known alternative to carbon-based fuels is hydrogen. However, such engines would require large amounts of hydrogen, and such huge fuel tanks that until better compression technology is developed, this solution is not yet viable⁸⁷. In addition, the switch to hydrogen fuel would require considerable investment from the aviation industry, as engines would have to be fully redesigned and developed, fitted into aircraft adapted to the new design, which aircraft would then have to be financed and purchased by airlines.

⁸⁴ "IATA Calls for a Zero Emissions Future", IATA Press Release, 4 June 2007. Online: < <http://www.iata.org/pressroom/pr/2007-06-04-02>> (date accessed: 11 June 2007).

⁸⁵ Cames & Deubes, *supra* note 12, at p. 24. See also figures discussed further in this section.

⁸⁶ See section III- c. for further detail on projected increases in efficiencies through these strategies.

⁸⁷ "Assemblée de l'Association du transporteur aérien – les ambitions vertes du secteur aérien soulève le scepticisme", Le Devoir.com, 6 June 2007. Online: < <http://www.ledevoir.com/2007/06/06/146318.html>> (date accessed: 11 June 2007)

As further explained below, the timeline for introducing a new aircraft technology into the market is inevitably long. In terms of the technological phase alone, according to Rolls Royce's John Moran, it takes about 15 years to develop a new engine, and for it to pass all the security tests preceding its availability on the market⁸⁸. In his statement however, Mr. Moran was not talking about an engine using an entirely new technology, such as a hydrogen-based engine. It is currently estimated that there will be no alternative to the jet engine for the next 50 years at least.⁸⁹

In addition, the impact of hydrogen powered engines on climate change is not yet known, since their use would eliminate CO₂ emissions, but would increase water vapor, another GHG.⁹⁰ To top it off, hydrogen production is an energetically costly process, so that the net energy equation and resulting life-cycle analysis would likely not appear all that interesting.

Biodiesel has promising environmental potential as an alternative fuel since it produces a reduced amount of emissions. There are still a few technological issues that need to be resolved before such a fuel becomes available on the market, such as those pertaining to its performance at freezing points. In addition, the fact that its production competes with food production makes the widespread use of biodiesel unattractive.⁹¹

⁸⁸ John Moran, "Engine Technology Development to Address Local Air Quality Concerns" (15 May 2007), ICAO Colloquium on Aviation Emissions with Exhibition. Online: < <http://www.icao.int/EnvClq/Clq07/Documentation.htm>> (date accessed: 21 June 2007).

⁸⁹ "Global Warming – The climate change impact of aviation", (2007) 47 Airline Fleet and Network Management, at p. 11.

⁹⁰ David Lister, "IPCC Special Report on Aviation & the Global Atmosphere (1999) – an Historic Perspective", (14 May 2007) ICAO Colloquium on Aviation Emissions with Exhibition, presentation slide 10. Online: < <http://www.icao.int/EnvClq/Clq07/Documentation.htm>> (date accessed: 12 June 2007).

⁹¹ For further information on alternative fuels, refer to Dr. Lourdes Maurice, "Impact of Fossil Fuel Versus Alternative Fuels on Local Air Quality and Climate", ICAO Colloquium on Aviation Emissions with Exhibition, May 14. Online: < <http://www.icao.int/EnvClq/Clq07/Documentation.htm>> (date accessed: 12 June 2007).

However, research on these fuels is ongoing, and politicians recognize their potential in furthering environmental goals of combating climate change, as demonstrated by the Washington Pact. In February 2007 in Washington D.C., the U.S. and Europe agreed to, *inter alia*, further the development of such fuels, promote sustainable biomass cultivation and international trade of biofuels, and intensify cooperation on energy efficiency, renewable energies, and low-emission energy technologies.⁹²

For the moment, though hydrogen, biodiesel, and other fuel alternatives may have a promising future, they are unlikely solutions for the medium to short term.⁹³

ii. Short term technological improvements

There are two major technology-based fuel efficiency developments to have effects in the short term: the Boeing 787 Dreamliner, and the Airbus A380.

The Dreamliner is a pivotal advancement in airframe technology. As much as 50% of the new airframe is expected to be made of a lighter composite, and a one-piece fuselage section will eliminate some 1,500 aluminum sheets and 40,000 to 50,000 fasteners. The Dreamliner is expected to be 20% more fuel efficient than other aircraft, and less than half the efficiency

⁹² 2007 U.S.-EU Summit Statement: Energy Security, Efficiency, and Climate Change, (April 30 2007) The White House press release. Online: <http://www.whitehouse.gov/news/releases/2007/04/20070430-8.html> (Date accessed: 14 August 2007).

⁹³ Cames & Deubes, *supra* note 12, at p. 24.

increase is attributable to better engine performance. It is hoped that the new aircraft will enter service in 2008.⁹⁴

In creating the A380, Airbus paid particular attention to life-cycle analysis, working to ensure greater environmental performance throughout the manufacturing process, transport, maintenance, and end-of-life disposal. The greener manufacturing process includes a less damaging painting process, and reduced energy and water consumption during production. In addition, the aircraft has a double-deck cabin, offering twice the floor-space for passenger seating. In its all-economy class configuration, it can carry up to 853 passengers, thereby reducing overall fuel emissions per passenger kilometer.⁹⁵

iii. Future fuel efficiency projections

Current fuel savings project that by 2020, aircraft will emit 50% less CO₂, 80% less NO_x and 50% less noise, as shown in the table below. However, the British Royal Commission on Environmental Pollution considers these projections optimistic.⁹⁶

⁹⁴ Boeing web site. Online: <http://www.boeing.com/commercial/787family/background.html> (Date accessed: 28 August 2007)

⁹⁵ Airbus web site. Online: <http://www.airbus.com/en/corporate/ethics/environment/index.html> and <http://www.airbusa380.com/html/inside/index.shtml> (Date accessed: 28 August 2007)

⁹⁶ "The Environmental Effect of Civil Aviation in Flight", 22 March 2007, Royal Commission on Environmental Pollution, at p. 37.

Industry targets for emission reduction⁹⁷

Programme	Industry: ACARE	Engines			Engines and Airframes: ICCAIA/IPCC	
		ANTLE	CLEAN	Rolls-Royce	Scenario A	Scenario B
Target year	2020	2008	2015	2010	2050	
Fuel burn and CO ₂ formation (per passenger-km)	50%	12%	20%	10%	40-50%	30-40%
NOx (relative to CAEP/2 standards)	80%	60%	80%	50%	10-30%	50-70%
Noise	50%			50%	50%	

It is often difficult for scientists to accurately evaluate the full impact of a new technology on CO₂ emissions, as various criteria must be taken into account in performing this estimate. These include the speed of introduction of the new technology, socio-economic evolution, and the speed of globalization⁹⁸.

However, even if these target emission reductions are achieved, if traffic growth continues at its current annual rate these reductions will turn out to be insufficient. Potential technological improvements are not expected to counterbalance the rising aircraft emissions due to worldwide traffic growth.⁹⁹ Various studies show fuel consumption by aviation will continue increasing at a rate of 4% annually.¹⁰⁰

⁹⁷ "The Environmental Effect of Civil Aviation in Flight", 22 March 2007, Royal Commission on Environmental Pollution, at p. 22.

⁹⁸ Hans Schlager, ICAO Colloquium on Aviation Emissions with Exhibition, May 15, presentation slide 4. Online: <<http://www.icao.int/EnvClq/Clq07/Documentation.htm>> (date accessed: 12 June 2007).

⁹⁹ J.J. Lee *et al.*, "Historical and future trends in aircraft performance, cost and emissions" (2001) 26 Annual Review of Energy and the Environment 167.

¹⁰⁰ *Supra* note 23.

iv. Timeline for introducing new technology

Another issue with technological advancements is that historically, the timeline for adopting new technology in the aviation industry is particularly long. The reasons for this are two-fold: first, the technology is complex and has already been considerably improved. Any new improvements therefore require complex research, and must comply with stringent safety requirements before the technology may be used in the marketplace, as mentioned above. In addition, one cannot hope to market an aircraft with both a new, more efficient engine and a new, lighter airframe, because of the golden rule of the aviation industry. This rule states that as a precaution, one should not purchase an aircraft with both a newly designed airframe and engine. This rule may further lengthen the adoption of greener technologies in the aviation industry.

The second reason for which technological evolution in the aviation industry is slow is the high cost associated with the technology itself. Commercial aircraft typically have multi-million dollar price tags, and are financed based on a 10 to 15 year income generation period¹⁰¹. The replacement rate of technologies in the aviation industry is therefore quite low.

d. Conclusion on overall achievements

Compiling an expected 10 to 24% increase in efficiency from changes in air traffic management and operational efficiencies with a 50% drop in CO₂ emissions due to novel technologies, altogether over the next 20 years leads to an overall added fuel efficiency of 60 to 74% in 20 years. This still appears insufficient to compensate for the expected 3.7% to 6.6% annual traffic

¹⁰¹ Dempsey, Paul Stephen & Gesell, Laurence E. *Airline Management Strategies for the 21st Century*, 2nd ed. (Chandler Arizona: Coast Aire Publications, 2006), p. 319.

growth¹⁰², which yields a 74% to 132% increase in traffic over 20 years. Further strategies are therefore needed to stabilize this expected emissions growth, let alone reduce it.

e. A summary of ICAO's position

Founded by article 43 of the 1944 Convention on International Civil Aviation ("Chicago Convention"), the International Civil Aviation Organization is a specialized agency of the United Nations responsible for regulating civil aviation around the globe. To this end, it creates legally binding Standards and Recommended Practices (SARP) in the form of Annexes, which the member states are required to absorb into their national law, unless they notify differences.¹⁰³

ICAO has created various committees to address specific questions. The Committee on Aviation Environmental Protection (CAEP) is responsible for addressing ICAO's environmental issues.

i. Applicable standards on emissions: Annex 16, Vol. II

CAEP first created minimum engine standards for regulating aircraft emissions (CO, NO_x, HC and smoke) in 1981, has tightened the initial standard ten years later, but has failed to further develop appropriate emissions standards. Currently, these standards are considered minimal, and largely environmentally inefficient. Attempts to modernize this standard have yet to yield satisfactory results.

¹⁰² Cames & Deubes, *supra* note 12, at p. 103.

¹⁰³ Articles 37 and 38 of the *Convention on International Civil Aviation*, 7 December 1944, 15 U.N.T.S. 295 ("Chicago Convention").

These standards are found in Annex 16 to the Chicago Convention, Volume II, which regulates aircraft engine emissions standards through a certification process¹⁰⁴. Like any standard, this document must be incorporated into national law before having any binding effect. In Canada for example, the *Canadian Aviation Regulations*¹⁰⁵ limit engine emission levels to those specified in the *Airworthiness Manual*, for the issuance of type certificates¹⁰⁶. The Airworthiness Manual specifically refers to ICAO Annex 16 vol. 2 standard¹⁰⁷.

A detailed analysis of specific SARP applicable to aircraft emissions is beyond the scope of this work. It is sufficient for our purposes that their existence and environmental implications be mentioned.¹⁰⁸

ii. Developing an ETS for aviation

While CAEP has traditionally concentrated on technology-based standards, market-based options offer a potentially cost-effective approach to achieving environmental objectives. Because their use raises a number of important economic, legal and administrative issues, these must be carefully evaluated before any implementation decision is taken.

The ICAO process for evaluating the efficiency of an environmental policy is to first assess its technical feasibility, then its economic reasonableness, and finally, environmental benefit. This

¹⁰⁴ International Standards and Recommended Practices: Environmental Protection; Annex 16 to the Convention on International Civil Aviation, Volume II: Aircraft Engine Emissions, 2d ed. July 1993.

¹⁰⁵ SOR/96-433.

¹⁰⁶ *Ibid.*, s. 516.03

¹⁰⁷ As explained by Transport Canada, online:

<<http://www.transportcanada.ca/civilaviation/RegServ/Affairs/cars/Part5/Standards/516s.htm>> (date accessed 11 June, 2007).

¹⁰⁸ For a detailed analysis of this SARP, see Yaw, *supra* note 46.

process has often been criticized as too complex and environmentally inefficient, considering how conservatively it is being applied¹⁰⁹.

Priority in the emissions-related work at ICAO was given to a study of the market-based options. This involved the identification of a range of specific market-based options, including fuel and en-route levies, emissions trading and voluntary regimes, and the development of an evaluation framework which will allow for a transparent comparison of the strengths and weaknesses of the different options.¹¹⁰

In early 2001, CAEP reported on its assessment of market-based options. Following the submission of this report, CAEP started a working program for the development of an ETS for aviation, to be integrated with the Kyoto Protocol's international system.

ICAO recognized that emissions trading for aviation would be beneficial in the long term. It has encouraged states to develop such market-based measures, but has not taken any steps toward implementing one itself, nor will it take any in the near future. In the short term, it is relying on voluntary instruments to reduce emissions, as stated in resolution A33-7, and though it is refusing any role in setting up a voluntary, let alone compulsory, ETS for aviation, it is providing guidance and a forum of discussion to states who would be interested in implementing such a system.¹¹¹

¹⁰⁹ Elizabeth Duthie, "ICAO Regulations: Meeting the Environmental Need?" (2001) 3:3-4 *Air & Space Europe*, 27.

¹¹⁰ *Ibid.*

¹¹¹ Cames & Deubes, *supra* note 12, at p. 10. In particular, ICAO has published a guidance report entitled "ICAO Report on Voluntary Emissions Trading for Aviation" (VETS Report) (2007); ICAO Resolution A33-7: "Consolidated statement of continuing ICAO policies and practices related to environmental protection", Appendix I.

iii. Taxes and levies

In signing the Chicago Convention, member states agreed to ensure the application of the principle of non-discrimination, particularly when applying fees.¹¹² Consequently, a country perceiving a green tax from its national carriers would have to apply the same tax to other carriers landing in or taking off from its territory. It cannot choose to apply its territorial jurisdiction to some carriers and not to others.

The principle of reciprocity, a well-recognized principle of international law, would imply that state A whose national carrier is subject to environmental taxation from state B could start imposing the same taxation on state B's national carrier. The principle of non-discrimination would again take effect, requiring state A to impose a similar tax on its own national carrier within its own territory, as well as on all other carriers landing in or taking off from its territory. Logically, this situation would cause a snowball effect, and lead to global environmental taxation.

However, ICAO policy has always been to recommend against taxation for aviation¹¹³, particularly when a tax does not reflect of the true cost of the services provided, and is not directly related to those services.¹¹⁴ Accordingly, and following ICAO's specific policy guidance on the subject of fuel taxation¹¹⁵, most states prohibit jet fuel taxation for international transport.¹¹⁶

¹¹² Articles 11 and 15 of the Chicago Convention, *supra* note 102.

¹¹³ EU working document for ICAO 35th Assembly, *supra* note 18, at p. 3.

¹¹⁴ See, for example, article 24 of the Chicago Convention, *supra* note 102 waiving custom fees. Article 15 also recognizes the principle of non-discrimination in taxing for the use of airports and air navigation facilities.

¹¹⁵ ICAO's Policies on Taxation in the Field of International Air Transport, Doc. 8632.

¹¹⁶ ICAO Resolution A33-7: "Consolidated statement of continuing ICAO policies and practices related to environmental protection", Appendix I, par. 7. For example, jet fuel taxation is prohibited in Europe, particularly in the case of transport: Council Directive 2003/96/EC of 27 October 2003, art. 14 (1) b) and art. 14(2). Canada also exempts international air transport from fuel tax: Excise Tax Act, R.S., 1985, c. E-15, article 10.

ICAO has drawn a clear distinction between a tax and a charge:¹¹⁷

A charge is a levy that is designed and applied specifically to recover the costs of providing facilities and services for civil aviation, and a tax is a levy that is designed to raise national or local government revenues which are generally not applied to civil aviation in their entirety or on a cost-specific basis

This definition obviously poses a problem for any legislative intention of imposing environmental taxes on aviation. A “cost” to the environment is difficult to evaluate, particularly when dealing with a diffuse source of pollution like that created by aviation; unless a particularly large interpretation is given to the term “facility”, one can hardly see how this may include the atmosphere. Finally, a green tax would not necessarily apply uniquely to aviation, it is not designed to raise government revenue, nor is it set on a cost-specific basis. Rather, it is based on its dissuasive value.

Nonetheless, ICAO has recommended that environmental levies be in the form of charges, not taxes, and that “the funds collected should be applied in the first instance to mitigating the environmental impact of aircraft engine emissions; (...) such charges should be based on the costs of mitigating the environmental impact of aircraft engine emissions to the extent that such costs can be properly identified and directly attributed to air transport.”¹¹⁸

The following statement summarizes the political *status quo* of an international environmental policy for aviation, as reflected in ICAO’s current position on the question of green taxes:¹¹⁹

¹¹⁷ ICAO Resolution A33-7: “Consolidated statement of continuing ICAO policies and practices related to environmental protection”, Appendix I, par. 6.

¹¹⁸ ICAO 1996 resolution, confirmed at the 33rd assembly: *ibid.*, at par. 9-10.

¹¹⁹ EU working document for ICAO 35th Assembly, *supra* note 18, at p. 5.

The unwillingness of developing countries to commit themselves to more demanding policies before they see clear leadership from industrialized countries, combined with the lack of such action from several important industrialised partners such as Australia and the United States, makes it unlikely that significant progress through ICAO can be expected in the foreseeable future. Indeed, current ICAO policy as formulated by the ICAO Council in 1996 explicitly recognises that

‘... the development of an internationally agreed environmental charge or tax on air transport that all States would be expected to impose would appear not to be practicable at this time given the differing views of States and the significant organizational and practical implementation problems that would be likely to arise’.

IV- Environmental policymaking tools for regulating aviation

a. Types of policymaking tools

Environmental policymaking tools are typically classified in two large groups, depending on whether the tool is of a voluntary nature, or whether it is compulsory.

i. Compulsory instruments

The compulsory tools include green taxes, emissions trading systems, environmental impact statements, and direct policies, often referred to as “command and control”. This last category can be performance-based such as fixed emission quotas, or based upon technological requirements, which impose specific procedures or processes of production, or the use of the best available technology. Voluntary tools include labeling, eco-audits by the industry, and self-imposed voluntary agreements.¹²⁰ These tools are further discussed and assessed below.

The following are four examples of commonly used mandatory environmental policymaking tools, with a brief description¹²¹.

¹²⁰ Hatch, Michael T., ed. *Environmental Policymaking: Assessing the Use of Alternative Policy Instruments* (New York : State University of New York Press) 2005 (“Hatch”), p. 6-7.

¹²¹ Similar examples are given in Hatch, *ibid.*, p. 6; Hansjürgens, Bernd, ed., *Emissions Trading for Climate Policy: U.S. and European Perspectives* (Cambridge University Press, 2005) (“Hansjürgens”), p. 22.

1) Green taxes

Green taxes are meant to internalize the pollution cost of the production process. Taxes can also be used to discourage consumption and reduce emissions, in a price elastic industry¹²². However, the implementation process can be long and costly, because determining efficient levels of taxation requires careful studies of industry characteristics and in-depth understanding of consumer behavior, particularly regarding the price elasticity of demand.

2) Emissions Trading Systems

Emissions trading systems are market-based solutions that set a maximum amount of emissions as a target goal, and create a market whereby emissions allowances may be bought and sold. Industry actors may then perform their own assessment as to whether financial incentives to invest in greener technologies are greater than the cost of purchasing allowances. One of the major advantages of an ETS is clearly expressed in the following statement:¹²³

In theory, if properly designed and implemented, market-based instruments allow any desired level of pollution clean-up to be realized at the lowest overall cost to society, by providing incentives for the greatest reductions in pollution by those firms that can achieve these reductions most cheaply. Rather than equalizing pollution levels amongst firms (as with uniform emissions standards), market-based instruments equalize the incremental amount that firms spend to reduce pollution – their marginal costs (Montgomery, 1972, Baumol and Oates, 1988, Tietenberg, 1995). Command-and-control approaches could – in theory – achieve this cost-effective solution, but this would require that different standards be set for each pollution source, and, consequently, that policy-makers obtain detailed information about the compliance costs each firm faces. Such information is simply not available to the government. By contrast, market-based

¹²² This concept and its implications for the aviation industry are further discussed in section IV(d)(iii).

¹²³ Hansjürgens, supra note 120, at p. 64-65.

instruments provide for a cost-effective allocation of the pollution control burden among sources without requiring the government to have this information.

Emissions trading systems will be discussed in greater detail in section V.

3) Environmental Impact Statements

Environmental impact statements impose information requirements upon industry actors, mandating them to assess the risks, effects and costs of developing and implementing green technology. Such assessments are meant to encourage sound decision-making toward more sustainable solutions.

4) Best Available Technology

Technology-based or performance-based regulations impose Best Available Technologies (BAT) upon industry actors, or conversely, a maximum level of emissions. This tool makes compliance oversight easy, but imposes a heavy and costly information-acquisition burden upon legislators. ICAO uses a similar tool in its Annex 16, which sets minimal technological requirements for aircraft¹²⁴.

¹²⁴ These requirements are further examined in section III- d. i.

ii. Voluntary instruments

Voluntary tools are generally more flexible than compulsory methods, less costly and less complicated to implement, and compliance oversight is also usually simpler.¹²⁵ However, many argue that compulsory regulation is necessary and inevitable, because there will always be those who will attempt to lower costs by polluting further, and avoiding standards.¹²⁶ One of the weaknesses of compulsory regulation is that it leads to varying degrees of non-compliance, which authorities must combat by increasing and often costly oversight and enforcement mechanisms. This in turn increases the cost of implementation, which is often transferred to polluters through further increases in regulation costs. Polluters are then even more inclined to avoid compliance, thus completing the vicious circle. Compulsory regulation with a direct cost to consumers therefore becomes a delicate balance between setting the adequate cost of pollution internalization, and minimizing economic incentives of non-compliance. Inciting polluters to develop green technologies and to avoid the cost of their own pollution is an important goal of environmental policymaking, and tax breaks may be pivotal in encouraging those who do end up successfully developing or purchasing such technologies, effectively creating compliance incentives.

The most prevalent types of voluntary instruments, eco-labels and voluntary agreements are described below¹²⁷:

¹²⁵ As concluded from Hatch's overview of various policymaking tools, Hatch, *supra* note 119, p. 5-7.

¹²⁶ Hatch, *supra* note 119, p. 8.

¹²⁷ Similar examples are given in Hatch, *supra* note 119, p. 6; Hansjürgens, *supra* note 120, p. 22.

1) Labeling

Eco-labels are a marketing tool targeting environmentally conscious consumers. They are based on production or performance criteria used to certify compliance of a product, and because of the voluntary nature of the tool, they are fairly cheap to implement and manage. Consumer protection organizations often help ensure compliance.

2) Voluntary agreements

Voluntary agreements can include the voluntary disclosure of information in the form of reports or declarations of intent. They are meant to achieve greater cooperation between industry actors and policymakers for the elaboration of efficient and flexible methods.

b. Choosing an appropriate tool for aviation

i. Evaluating the environmental efficiency of a policy

The choice of a specific tool for a given sector of the industry must be preceded by a careful evaluation of its efficiency in attaining its environmental goal, its costs (both for implementation and oversight), risks, consequences, and incentive to comply:¹²⁸

No particular form of government intervention, no individual policy instrument – whether market-based or conventional – is appropriate for all environmental problems. Which instrument is best in any given situation depends upon a variety of characteristics of the environmental problem, and the social, political and economic context in which it is being regulated. There is clearly no policy panacea.

¹²⁸ Hansjürgens, *supra* note 120, at p. 24 and 72.

ICAO uses a three-fold test in determining the environmental efficiency of a policymaking tool. This test is set out in the first principle of its Draft Action Plan on Aircraft Engine Emissions, quoted below. The second principle is often described as the interrelationship test:

In addressing concerns associated with aircraft engine emissions, CAEP is guided by the following principles:¹²⁹

- * Measures to address emissions should take into account environmental need, technical feasibility and economic reasonableness.
- * Measures to address emissions should also take into account any potential implications for safety, which must not be compromised, and for aircraft noise. Measures aimed at one type of emission (for example, CO₂) or one emission-related problem (for example, climate change) should take into account any potential implications for other types of emissions or for other emission-related problems.
- * Measures to address emissions should be developed on a harmonized worldwide basis, wherever possible.

Similarly, the EU recognizes that choosing an environmental policy for aviation requires a careful examination of environmental effectiveness, policy consistency, equity with other modes of transport, availability of alternative modes of transportation, cost-effectiveness, and potential distortions of competition.¹³⁰

Economists who study environmental efficiency find that one of the fundamental criteria to be used in designing an appropriate tool lies in the cost of reducing emissions. In sectors like the transportation industry, the cost of developing and implementing better, less polluting technology varies depending on the mode of transportation. In such circumstances, it appears that taxes and

¹²⁹ Article 8, Draft Action Plan on Aircraft Engine Emissions", ICAO

¹³⁰ EU working document for ICAO 35th Assembly, *supra* note 18, at p. 7.

emission trading systems offer the most efficient solution, as opposed to other environmental policymaking tools like the ones discussed above (best available technology, labeling,...):¹³¹

Environmental regulators face many different combinations of instruments and criteria but a few examples may illustrate the type of issues at hand. If abatement costs vary considerably then efficiency dictates that market mechanisms such as taxes or tradable permits be used. These instruments lead to the equalization of marginal abatement costs, which implies that the environmental goal is reached at the least cost. (Our underlining)

Although an examination of how such a conclusion was reached goes beyond the scope of the present analysis, it is sufficient to mention that the cost of implementing and managing a policymaking tool that relates directly to the nature of the technology used, as opposed to the emissions created, is burdened by heavy variations in abatement costs.

ii. Green taxes vs. emissions trading systems

The choice between carbon taxes and emissions trading systems is an on-going debate amongst economists. Most agree that both these instruments provide abatement incentive, much more so than command-and-control instruments such as BAT. The ranking of these instruments according to the relative scale of incentive they provide is also an unsettled debate. A most convincing analysis of the environmental efficiency of these instruments leads to the conclusion that ultimately, the choice depends on a political will to favor either new technologies, or dynamic efficiency:¹³²

¹³¹ Hansjürgens, supra note 120, p. 24.

¹³² Hansjürgens, supra note 120, p. 57. Dynamic efficiency is a concept commonly used by economists, which was first developed by Austrian economist Joseph Schumpeter, and is explained in the following quote from Klauss F. Zimmermann, "Trade and Dynamic Efficiency" (1987) 40:1 Kyklos 73, at p. 74: "Since the seminal work of Schumpeter [1942], the central conflict between static and dynamic efficiency has been well recognized. As he

To sum up: high incentives to adopt new environmental technology are in many cases not dynamically efficient, and many dynamically efficient policies are not providing the greatest incentive for the diffusion of new abatement technologies. If we want maximal incentives for the adoption of new technologies (regardless the cost), we should go for taxes or BAT approaches. If, however, we strive for dynamic efficiency, we would achieve better results with tradable permits of either sort, A [auctioned]-permits or G [grandfathered]-permits.

A main part of the reasoning behind this hinges on the concept of innovative free-riding:¹³³

If the roles of innovators and adopters are not predetermined and if the time span between the introduction and the complete diffusion of the new technology is not large, it does not pay to assume the role of an innovator because “innovation free-riding” would be much more rewarding!

In the case of aviation, the “time span between the introduction and the complete diffusion of the new technology” is indeed quite large. The interplay between the incommensurably high costs associated with the technology (aircraft) and the relatively low profit margins airlines make, sustains the length of this time span. In addition, those who use the technology, who also happen to be those who would most likely be subject to a carbon tax or an ETS, do not actually develop it. Aircraft manufacturers and airlines have historically and legally been kept very separate, both for safety purposes, and to introduce more competition in the market. It is therefore not apparent whether innovation free riding would even be possible in this industry. Consequently, in the case

stated: ‘The first thing to go is the traditional conception of the *modus operandi* of competition. Economists are at long last emerging from the stage in which price competition was all they saw. As soon as quality competition and sales efforts are admitted into the sacred precincts of theory, the price variable is ousted from its dominant position. ... In capitalist reality as distinguished from its textbook picture, it is not that kind of competition which counts but the competition from the new technology, the new source of supply, the new type of organization...’ [p. 84], and: ‘The large-scale establishment or unit of control must be accepted as a necessary evil inseparable from the economic progress... In this respect, perfect competition is not only impossible but inferior, and has no title to being set up as a model of ideal efficiency’ [p. 106]”

¹³³ Hansjürgens, supra note 120, p. 55

of aviation, it is uncertain whether carbon taxes would actually be more incentive-efficient than ETS.

Another characteristic of the aviation industry is that aircrafts emit high amounts of greenhouse gases other than CO₂, a fact that favors fuel taxes over an emissions trading system that would only include CO₂:¹³⁴

When discussing climate policies one should also bear in mind that there are numerous other policies and taxes that are not *motivated* by an aim to reduce CO₂ emissions, but are equally or more important in controlling greenhouse emissions, the energy tax being one of the most important by raising the price of fossil fuels (as well as other energy sources). This fact has many implications for climate policy. In the case of fuels used for transport it means that in terms of achieving fossil CO₂ emissions reductions the *total* level of fuel taxation is more important than the level of carbon tax. In the longer term this might change, if non-fossil alternative fuels become more important, but as long as gasoline and diesel are the major transport fuels the level of fuel taxation will determine emissions, with the level of carbon taxation affecting them to a lesser extent.

1) The dangers of taxation: competition distortion

Industry actors who support emissions trading systems over taxation often make a contrary argument. They argue that considering airline tickets are already overly taxed and swallow up a large portion of the ticket price, further taxation would weaken the industry by driving consumers away, and would distort competition in favor of airlines that are already offering a cheaper product (LCC), who tend to have less polluting aircraft, or in favor of airlines who operate in countries where there is little or no taxation on fuel. Competition could also be distorted in favor

¹³⁴ Hansjürgens, *supra* note 120, p. 25.

of legacy carriers, for whom a fuel tax would represent a smaller portion of the total passenger fare, and be affect passenger who tend to be less price sensitive than the LCC clientele.

Direct government regulation is a mechanism that is often used to regulate big polluters. However, airlines are diffuse cross-border polluters, and more difficult to regulate. Direct environmental regulation of airlines is sure to distort on an international scale, from a carrier whose flag States impose costly regulation trickling down to consumers, to carriers whose flag states do not.¹³⁵

Such competition distortions of a free market economy could be avoided if fuel taxes are imposed internationally.

2) The dangers of taxation: tankering

International scales of taxing would also help avoid tankering. Tankering is a method widely used by airlines to lower their fuel costs, by simply filling the tank in a country where fuel is cheaper, even if the aircraft can reach its destination without additional fuel. The fuel savings are calculated by comparing the fuel price difference with the cost of flying with the added weight of unneeded fuel.

¹³⁵ Marc J. Haese, "Taxation of Aviation Fuel – an Aerospace Manufacturing Industry View" (2000) 2:3 Air & Space Europe 17.

If a tax on tanked fuel is added in the EU for example, there will be added incentive to tank outside the EU. A similar phenomenon will occur in the context of an upstream ETS for aviation: if fuel suppliers must participate in an ETS in the EU, whereby they are allotted emissions allowances for fuel sold, they will internalize fuel costs and prices will increase. This will provide an incentive for air carriers to tank outside the EU.¹³⁶

3) Avoiding the dangers of taxation through international agreements

Acknowledging that a tax must be imposed internationally means either that ICAO must act, or that a new international convention should be drafted to address this specific issue. However, ICAO has rejected the idea of an international environmental tax on jet fuel, as discussed in section III(d)(iii).

As for an international convention, the political process itself will inevitably be lengthy and tedious. In the meantime, a handful of countries may choose to start with a regional agreement, hoping to avoid tankering effects by renegotiating aspects of their bilateral agreements with other countries.

The EU appears poised to achieve a similar agreement with its economic partners to avoid negative economic impacts of its taxation system on aviation. Currently, air navigation is exempt from energy taxation within the EU, particularly for international transport. Member States may decide to waive this exemption for air service between those two countries.¹³⁷ Should member

¹³⁶ Further details on tankering are provided in section V- a. ii.

¹³⁷ Council Directive 2003/96/EC of 27 October 2003, art. 14 (1) b) and art. 14(2).

States decide to waive this exemption amongst themselves and apply a fuel tax that would also affect U.S. airlines providing service between those two countries, the new EU-U.S. bilateral agreement expressly provides that the issue will be addressed by the Joint Committee, a body composed of representatives of both the EU and the U.S. In other words, the EU and the U.S. have not excluded the possibility of a tax on international transport within Europe, but have agreed to discuss its implications should the issue arise.¹³⁸

In this agreement, the parties have also recognized the importance of environmental questions, agreed to cooperate on environmental issues, and agreed to specifically discuss the effect of environmental measures on traffic rights during a second stage of negotiations.¹³⁹ This last point is probably a reference to the EC proposal of December 2006 to include aviation into its ETS.

4) Conclusion

Green taxes appear more appropriate for regulating aircraft emissions than ETS, for two main reasons. First, compulsory ETS that are currently in place or being studied apply only to CO₂ and are therefore not meant to create incentives to lower emissions of other greenhouse gases. There are many such gases being emitted by aircraft engines, as mentioned in previous discussions. For an ETS to be environmentally effective, it must span a wide group of GHG. It must also have a large spatial scope and include numerous industries, to allow trading with those whose abatement costs are lower.

¹³⁸ EU-US Air Transport Agreement (30 April 2007), art. 11(6), art. 18(1) and art. 18(4) e). Online: http://ec.europa.eu/transport/air_portal/international/pillars/global_partners/us_en.htm (Date accessed 16 August 2007).

¹³⁹ The second stage of negotiations is scheduled to begin no later than 60 days after the date of provisional application of the Air Transport Agreement, which is set for 30 March 2008. *Ibid.*, preamble par. 8, art. 18(4) a), art. 21(1), art. 21(2) c), and art. 25(1).

Second, though significant investment is being made into new, greener technologies, there is a certain degree of skepticism as to how efficient an aircraft engine can be made to be. Many believe technological advancements will plateau in the near future. Common sense then dictates that the only way to truly lower aircraft emissions is to lower demand for air transport. This is also the only way to compensate for the discrepancy between projected fuel savings and growth in demand for air travel, as discussed in sections III(a),(b), and (c).

As will be discussed further,¹⁴⁰ demand for aviation does not tend to decrease proportionally to increases in prices. Studies have shown that airfares would have to be considerably higher, that is to say very heavily taxed, for demand for air transport to start decreasing. Many believe that politically, such high taxes are not feasible, as both industry actors and consumers will respond with ferocious opposition.¹⁴¹ This political argument alone may well be strong enough to overcome all other economic considerations that would anoint green taxes as the best environmental policymaking tool for aviation.

This argument is further strengthened by the fact that carbon taxes must constantly be adjusted to follow economic growth. In periods when the economy is booming, consumption increases and so do emissions. Green taxes should then also be reviewed and increased concomitantly with GDP growth. Such an adjustment would inevitably and frequently encounter strong opposition, as increases in taxation always do. This phenomenon is altogether avoided in the context of an ETS, because of the constant cap on emissions. An increase in consumption and emissions will create an immediate demand for emissions allowances, automatically causing the price to shoot

¹⁴⁰ See section IV- c. iii.

¹⁴¹ As explained by economist Richard D. Morgenstern, “the more narrowly focused the adverse impacts of a given policy, the more politically difficult it is to sustain that policy”. Hansjürgens, *supra* note 120, at p. 120. See also p. 71.

up. In such a system, economic incentive to combat climate change is self-adjusting. An ETS is clearly more suited than tax legislation to respond to changes in economic growth.¹⁴²

c. Proposals of a voluntary system

There has been some interest shown in various industries for voluntary systems towards emissions reductions, whether through voluntary participation in an ETS, purchasing carbon offsets, or developing greener technologies and marketing the efforts.¹⁴³

Experience with voluntary ETS has shown that the market tends to be flooded with an abundance of allowances because participants are typically sellers looking to make a profit. Allowance price is therefore being kept low, too low in fact to provide buyers with an incentive to significantly reduce emissions. Aviation will be allowance buyers, and it is doubtful they will willingly participate in a system that will finance reductions in other industries.

The inefficiency of voluntary ETS in attaining substantial reductions in emissions is due to the fact that no one wants to be the first mover; each is afraid of losing a competitive edge. This is particularly true in the aviation industry, because costs are already so high and profit margins are negligible. Historically, airlines have suffered the effects of destructive, cut-throat competition, particularly in the US, leading to unprecedented losses and a large number of bankruptcies.¹⁴⁴

¹⁴² Hansjürgens, *supra* note 120, at p. 28 and p. 70.

¹⁴³ Hansjürgens, *supra* note 120, at p. 171.

¹⁴⁴ Dempsey, Paul Stephen & Gesell, Laurence E. *Airline Management Strategies for the 21st Century*, 2nd ed. (Chandler Arizona: Coast Aire Publications, 2004), at pp. 216 and pp. 377.

Asking airlines to participate in a voluntary ETS, hoping their competitor will do the same, would be like asking them to forget the lessons of history.

As for voluntary instruments relating to technological improvements, the time span necessary to achieve substantial reductions may be too long to stop emissions growth from worsening and prevent public opinion from vilifying the industry. In addition, it is doubtful that the best case scenario for technological improvements will achieve sufficient reductions to account for predicted growth in demand, as discussed in sections III(a), (b), and (c).

d. Understanding aviation market specifics

Many possible solutions exist or are being investigated to increase efficiency, including air traffic management, operational management, and technological improvements. These possibilities are currently being developed by the aviation industry, and are insufficient to compensate for predicted traffic growth, as discussed in sections III(a), (b) and (c). Further reductions may only be achieved through compulsory regulation, as shown in the above section.

In drafting legislation, policymakers must be aware of certain particularities of the aviation industry when attempting to design an appropriate tool for regulating its emissions. The first of these issues concerns historical load factor trends, and the potential for further increases. The second pertains to legal issues stemming from airline alliances, and their consequences on increased network efficiency. Third, it is important for policymakers to understand consumer behavior in the aviation industry, and the relative inelasticity of demand.

i. Load factor trends

Aircraft load factors have already increased by about 10% world-wide since the 1990s. In 1991, annual scheduled service load factors were 62.3%, whereas for the first half of 2007, the average load factors were 73.7%.¹⁴⁵

It is unlikely that load factors will continue much beyond the 80% currently being experienced by North American carriers, which have the highest load factors in the world.¹⁴⁶ This is simply due to the nature of the industry. First, research has shown that an increase in load factors also increases the number of unhappy customers, because a higher percentage of flights will be full and unable to satisfy prospective customers. Airlines should therefore have a certain amount of excess capacity to insure customer satisfaction.¹⁴⁷ Second, an airline would not cancel a flight because its load factors are too low; its fixed costs are so high that it would rather fly almost empty than not fly at all:¹⁴⁸

The incremental costs of adding a passenger to a scheduled flight are nil (e.g., a bag of peanuts, a glass of Coca-Cola, a few gallons of kerosene in the wings, and sometimes, a sales commission and other minor distribution costs). But industry costs are disproportionately fixed, with fixed costs comprising between 80% and 90% of total costs. (...) But any ticket sold at a price above the relatively low variable cost level makes some contribution to fixed costs, however small; an empty seat makes absolutely no contribution.

¹⁴⁵ "Cargo Rebounds, Passenger Demand Steady", IATA Pressroom (2 July 2007). Online: <http://www.iata.org/pressroom/pr/2007-02-07-01.htm>; Annual Report 1995, IATA, at p. 8. Online: <http://www.iata.org/nr/contentconnector/cs2000/siteinterface/sites/about/file/ar95.pdf> (Date accessed: 1 August, 2007).

¹⁴⁶ "Monthly Traffic Analysis" (June 2007), IATA, at p. 3. Online: <http://www.iata.org/whatwedo/economics/index.htm> (Date accessed: 2 August 2007).

¹⁴⁷ Dempsey, Paul Stephen & Gesell, Laurence E. *Airline Management Strategies for the 21st Century*, 2nd ed. (Chandler Arizona: Coast Aire Publications, 2006), p. 49

¹⁴⁸ *Ibid.*, p. 80.

Consequently, there is little economic incentive to cancel flights with inherently low load factors, nor is there any incentive to regularly fly with full capacity. Load factors in the U.S. are already quite high, and it is unlikely they will increase further. Still, some improvement seems possible for cargo flights, whose load factors remain lower than for passenger flights.¹⁴⁹ However, cargo flights are unidirectional in nature, and low load-factors may be unavoidable.

Regulatory attempts to address aircraft emissions should therefore not directly target load factor increases. There is no room to significantly achieve better utilization of the current technology, at least in terms of individual flights, for passenger flights in developed countries.

ii. Efficiency provided by alliance agreements

However, in those situations and geographic areas where there is still room to increase load factors, legislators have power to provide airlines with further incentive to do so, by allowing better integration of alliance networks. A better integration of alliance networks would allow airlines to better respond to the market's need, synchronizing capacity with demand, and avoiding unnecessary aircraft movement. Airlines tend to exercise high degrees of caution when

¹⁴⁹ For example, cargo in Europe has seen similar increases in load factors: "Air freight loading efficiency in the EU improved in the early 1990s, but declined after peaking in 1997. The average load factor in the EU for aeroplanes, expressed as tonne-kilometers per available tonne-kilometer grew from 59% in 1980, to 65% in 1990, to 68% between 1990 and 1998." "TERM 2002 30 EU – Load factors for freight transport" Indicator fact sheet, European Environment Agency, at p. 3. Online: http://themes.eea.europa.eu/Sectors_and_activities/transport/indicators/technology/TERM30%2C2002 (Date accessed: 1 August, 2007). In comparison, passenger load factors in Europe for the first half of 2007 were 76,3%: "Monthly Traffic Analysis" (June 2007), IATA, at p. 3. Online: <http://www.iata.org/whatwedo/economics/index.htm> (Date accessed: 2 August 2007). For the U.S., see figure 7.3 on p. 362, Dempsey, Paul Stephen & Gesell, Laurence E. *Airline Management Strategies for the 21st Century*, 2nd ed. (Chandler Arizona: Coast Aire Publications, 2006). The results are similar on an international scale. In 1997 for example, international passenger load factors were 69,6%, whereas weight load factors, including all-cargo flights, were 61,4%: Annual Report 1998, IATA, at p. 17-18. Online: <http://www.iata.org/whatwedo/economics/index.htm> (Date accessed: 2 August 2007).

attempting to further the integration of their networks, since alliance agreements are intrinsically restrictive of trade and violate anti-trust laws. These legal issues are briefly discussed below.

Alliance agreements are contracts by which competing airlines may agree on such fundamental aspects of their business as capacity in the market and ticket prices; they may agree to pool costs and revenue, share ticketing and baggaging agents, computer reservation systems (CRS) and sales offices, frequent flyer programs, etc.¹⁵⁰ Such agreements are prohibited in most jurisdictions, though administrative authorities may, in most cases, provide antitrust immunity.

In the U.S., section 1 of the Sherman Act, the Clayton Act and section 41712 of the Federal Aviation Act provide the legal basis for action against unfair or deceptive practices, unfair methods of competition, contract combinations or conspiracies in restraint of trade (such as price fixing)¹⁵¹ in the aviation industry. The U.S. Department of Transportation (DOT) may grant antitrust immunity if it is in the public interest to do so:¹⁵²

The DOT must conclude that the alliance will not eliminate actual or potential competition so that the allied carriers would be able to raise prices above or reduce services below competitive levels. The DOT may not approve an inter-carrier agreement that substantially reduces or eliminates competition unless it is necessary to meet a serious transportation need or to achieve important public benefits which cannot be achieved by reasonably achievable alternatives that are materially less anticompetitive. Among the public benefits recognized are international comity and foreign policy considerations. Nowhere has DOT recognized the costs of consumer deception or the loss of competitive interline services.

¹⁵⁰ Dempsey, *supra* note 143, at pp. 622.

¹⁵¹ *Ibid.*, at p. 269-285.

¹⁵² *Ibid.*, at p. 286.

Once granted, anti-trust immunity may be reviewed 5 years later¹⁵³. The DOT's public interest test is a criterion which obviously provides it with a large measure of discretionary authority. One famous example of the consequences of such discretionary decision-making occurred in 1996, when antitrust immunity was refused to the American Airlines-British Airways alliance, on the basis that the British government had refused the U.S. government's demand for an open skies bilateral agreement and the transfer of take-off and landing slots at Heathrow airport to U.S. carriers.¹⁵⁴

In Europe, article 81 of the Treaty of Rome prohibits agreements or concerted practices that distort, prevent or restrict competition in the EU to an appreciable extent. Art. 81(1) of the Treaty of Rome provides examples of prohibited practices, which include price fixing and other practices commonly found in alliance agreements.¹⁵⁵ The European Commission may grant negative clearances, concluding that an agreement does not contravene to art. 81 if the following 4 conditions are fulfilled:¹⁵⁶

- (1) The agreement must contribute to improving the production or distribution of goods or to promoting the technical and economic progress,
- (2) consumers must get a fair share of the resulting benefit
- (3) the agreement may not impose restrictions which are not indispensable for the objectives under (1) and (2), and
- (4) the agreement may not afford the parties the possibility of eliminating competition in respect of a substantial part of the products in question.

¹⁵³ *Ibid.*, at p. 288.

¹⁵⁴ *Ibid.*, at p. 289.

¹⁵⁵ Dempsey, Paul Stephen *European Aviation Law* (Kluwer Law International, 2004), at p.14-17.

¹⁵⁶ S. 81(3) EC.

In particular, Council Regulation 3976/87 gave the Commission power to grant exceptions to agreements such as joint planning of capacity, revenue sharing not exceeding 1%, tariff consultation, slot allocation and scheduling, CRS, ground handling, interlining and catering.¹⁵⁷

In conclusion, airlines' incentive to increase the efficiency of air travel through a tighter-knit network with natural competitors may be prohibited by law, depending on the administration's decision to grant immunity. It may be environmentally beneficial to provide airlines with clearer guidelines on the legal limitations of immunity, or with further insurances of long-term immunity, so as to encourage them to strengthen their relationships and the inter-dependence on their alliance partner, should this strengthening lead to lower aircraft movements. In other words, more legal certainty is needed.

iii. Lowering demand: price elasticity for aviation

Consumer response to price increases is expressed in terms of elasticity of demand. If price increases directly reduces demand, demand is said to be elastic, and vice-versa. A price elasticity of -0.2 means that a 10% increase in price will cause a 2% drop in demand. Similarly, a price elasticity of 2 means that a 10% increase in price will cause a 20% drop in demand.

In order to determine the efficiency of a fuel tax, or how high a fuel tax must be in order to affect demand for air travel, and to what extent, one must determine the elasticity of demand for air transportation.

¹⁵⁷ Dempsey, Paul Stephen *European Aviation Law* (Kluwer Law International, 2004), at p.18.

Airlines often refrain from passing on costs to consumers, preferring to cut profit margins instead, to deter competition and attract consumers. Because fixed costs for scheduled aircraft are so high (80-90% of the ticket cost), it is preferable for an airline to sell a seat at a loss than to not sell it at all. So long as the ticket price is above the already low marginal cost, it may make some contribution to the fixed costs. Consequently, and contrarily to road transportation, a fuel tax may not affect air travelers to the same extent as that predicted by price elasticity studies.

Interestingly, price elasticity for aviation already appears to be lower than those calculated for road transportation. This is surprising because historically, air travelers have shown high degrees of price elasticity of demand, particularly the leisure traveler.¹⁵⁸ One research conducted for road transport, using data collected from 1929 to 1998 by various studies throughout most developed countries, found a price elasticity of demand of -0.25:¹⁵⁹

If the real price of fuel rises by 10% and stays at that level, the result is a dynamic process of adjustment such that the following occur:

(a) Volume of traffic will fall roundly 1% within about a year, building up to a reduction of about 3% in the longer run (about 5 years or so). (b) Volume of fuel consumed will fall by about 2,5% within a year, building up to a reduction of over 6% in the longer run.

The reason why fuel consumed falls by more than the volume of traffic is probably because price increases trigger a more efficient use of fuel (by a combination of technological improvements to vehicles, more fuel-conserving driving styles and driving in easier traffic conditions). A further probable differential effect is between high- and low- consumption vehicles, since with high prices, gas-guzzlers are more likely to be vehicles left at home or scrapped.

¹⁵⁸ Dempsey, Paul Stephen & Gesell, Laurence E. *Airline Management Strategies for the 21st Century*, 2nd ed. (Chandler Arizona: Coast Aire Publications, 2006), p. 64 and 413.

¹⁵⁹ Goodwin, Phil *et al.* "Elasticities of Road Traffic and Fuel Consumption with Respect to Price and Income: A Review" (2004) 24:3 Transport Reviews 275. Similar results are found by Espey, Molly "Explaining the variation in elasticity estimates of gasoline demand in the United States: A meta-analysis" (1996) 17:3 Energy Journal 49.

The reasons expressed in the above statement to explain why automobile fuel consumption decreases faster than demand for this mode of transportation do not seem applicable to aviation. Pilots are taught to fly such as not to consume excess fuel, and airlines with low-consumption aircraft don't usually choose to fly gas-guzzlers instead.

One 1995 study commissioned by the U.S. Department of Transportation reviewed 25 different price elasticity studies for aviation, and found that the price elasticity of demand ranged from -0.8 to -2.6.¹⁶⁰ Another study of price elasticity of air travelers also found a great variety of results, dependent on several factors: whether the traveler was a business or a leisure traveler, whether the flight was long, short, medium, or whether it was domestic or international. Statistical analysis of the results of various studies, using only those that carefully distinguished between the various categories, yielded the following results:

Summary of median elasticity values by type ¹⁶¹	
Category	Median Own-price Elasticity Value
All long-haul international business estimates	-0.265
All long-haul international leisure estimates	-1.040
All long-haul domestic business estimates	-1.150
All long-haul domestic leisure estimates	-1.104
All short/medium haul business estimates	-0.700
All short/medium haul leisure estimates	-1.520

The first obvious conclusion that may be drawn from these results is that the business traveler is considerably less price sensitive than the leisure traveler, except in the context of domestic flights, where the necessity of travel may be bypassed using telecommunication or by relying on

¹⁶⁰ Penner, Joyce E. *et al.* "Aviation and the Global Atmosphere, Special Report, from IPCC Working Groups I and III, at p. 10.3.3

¹⁶¹ David W. Gillian *et al.*, "Air Travel Demand Elasticities: Concepts, Issues and Measurement", (2004) Final Report for the Department of Finance Canada, table 5.1. Online: http://www.fin.gc.ca/consultresp/Airtravel/airtravStdy_e.html (Date accessed: 14 August 2007)

cultural similarity and understanding, legal and contractual certainty, and rapid access to the justice system. On the other hand, short-haul business travelers are fairly price insensitive, even for domestic flights, because such travelers usually attribute a high value to their time, the airfare being almost negligible in comparison. Short haul, leisure travelers will turn to less expensive modes of transportation; short-haul leisure travel has the highest elasticity because air travel competes with road trips.

Another study, conducted by the UK Department of Transportation, analyzed the impact of a fuel tax imposed on a global scale on air traffic growth rates. The study found that a 10% increase in fuel tax per annum, until it reaches 100% of the fuel cost 9 years later, would still yield an average annual growth rate of 3.8%.¹⁶²

Introduction of an aviation fuel tax

7.7 Aviation fuel is currently exempt from taxation because of international agreements under the Chicago Convention not to tax fuel used for international air travel. However, the possibility of removing that exemption has recently been discussed in a number of fora in response to concerns about the environmental impact of air travel, in particular the contribution of emissions of carbon dioxide and oxides of nitrogen from aircraft to global warming.

7.8 The sensitivity assumed that an environmental tax of 10% was introduced in 2006 and that this was increased by 10 percentage points every year for the next nine years until the tax were 100% of fuel costs in 2015. A number of simplifying assumptions were necessary:

- * The fuel tax was introduced globally, in a way that did not affect the existing fuel price differentials between countries, thereby eliminating the scope for leakage through increased tankering.

- * All the increase in fuel prices was passed through to fares. In practice airlines might absorb some of the increase through lower margins, or increase business fares more than leisure fares due to the generally lower fare elasticities for business passengers.

¹⁶² Air Traffic Forecasts for the United Kingdom 2000, (2000) UK Department of Transportation, at p. 7. Online: <http://www.dft.gov.uk/pgr/aviation/atf/airtrafficforecastsfortheuni281?page=7> (Date accessed: 2 August 2007)

7.9 The price elasticity of demand for air travel used was 1.0, reflecting a lower elasticity for business markets and a higher elasticity for leisure markets. Fuel costs were assumed to constitute 10% of total airline costs. The effect of supply side responses such as the introduction of more fuel efficient aircraft on the contribution of fuel costs to total costs were assumed to be limited between 2006 and 2020 because of the long operational lives of aircraft. The fuel tax was assumed to be phased in at 10% in 2006 followed by a 10 percentage point increase in the fuel tax rate per annum for the next nine years. This raises airline costs, all other things equal, by 1% per annum.

7.10 This sensitivity test produces a forecast of 300 million passengers in 2015, approximately 90% of the total in the central growth scenario. If the average annual growth rate between 2015 and 2020 in the central growth scenario is then applied to this figure the forecast for 2020 is 361 million passengers. This implies an average annual growth rate of 3.8%.

This growth rate is significantly high considering the importance of the tax being considered. It seems such a heavy tax would not affect natural growth rates by much. According to this same study, the predicted growth rate should no fuel tax be imposed at all, for the 1998-2020 period, is forecast at 4.4% for leisure travelers, and 5.5% for business travelers.¹⁶³

It should be noted that the above discussion applies to an ETS in the same way it does to fuel tax. For permit buyers in an ETS, the effect of emissions costs is the same as a fuel tax, if the quota price is at the same level: it increases the cost of air travel for consumers, assuming the cost is passed on to them. The only difference is that an ETS provides airlines with an economic incentive to purchase cleaner technology, and subsidizes emissions reductions in other sectors, by creating demand for emissions allowances. A fuel tax remains even if a cleaner technology is used, unless a tax break is specifically provided. Such an adjustable tax, based on the level of emissions and cleaner technology, would achieve no more than ETS offering high quota prices, with the added complication of continually tinkering with fluctuating taxation schemes.

¹⁶³ Air Traffic Forecasts for the United Kingdom 2000, (2000) UK Department of Transportation, at p. 4. Online: <http://www.dft.gov.uk/pgr/aviation/atf/airtrafficforecastsfortheuni281?page=4#a1009> (Date accessed: 2 August 2007)

In conclusion, elasticity of demand in the aviation industry is fairly low. This may help explain the results of a recent Ipsos MORI survey conducted in England, which found that 60% of respondents supported environmental taxes on airlines, even if they led to higher ticket prices.¹⁶⁴ Most consumers will keep traveling, but with a cleaner conscience. Consequently, current taxes on aviation in the UK are considered by the industry as “purely a revenue-raising measure with no environmental benefit, while the green lobby scorns an increase it believes will be totally ineffective”.¹⁶⁵

Airfares would have to be quite high to effectively discourage consumers from traveling, and airlines may be tempted to invest early in greener technology in case policymakers decide to make air travel expensive enough to significantly affect demand. Many argue that, politically, it may be wiser to let the airlines decide the cheaper option through market-based solutions, such as ETS. Whatever the case may be, it is essential that the green tax or the price of an emissions quota be sufficiently high to diminish demand for air travel, assuming the cost is passed on to the consumer, at least to a point where growth of demand slows down to the rate of technological improvement. As Jeff Gazzard, coordinator of the UK-based not-for-profit organization Aviation Environment Federation puts it, “Instead of 3-4% growth in aviation annually, I’d like to see 1-2%. That is the same as the technological improvement rate for reducing noise and emissions”¹⁶⁶

¹⁶⁴ “Global Warming – The climate change impact of aviation”, (2007) 47 Airline Fleet and Network Management, at p. 14.

¹⁶⁵ “UK case study: the green growth dilemma”, (2007) 47 Airline Fleet and Network Management, at p. 18.

¹⁶⁶ “Flyless Campaign Asks: ‘Is Your Journey Really Necessary?’”(June/July 2005) Communiqué Airport Business 30, at p. 31

V- Emissions trading systems for aviation

a. Designing an ETS suited for the aviation industry

Various criteria must be taken into account when designing an ETS, to ensure its environmental, economic and social effectiveness.

i. Methods of allocating allowances

Determining the number of allowances involved in an ETS is entirely dependant on the emissions reduction target. If the target is to reduce emissions by 5%, the total number of allowances distributed to ETS participants should correspond to 95% of what the aggregate amount of emissions from these participants would be without an ETS. This is where methods of calculating aircraft emissions discussed in section II(c) become important.

Choosing an equitable way to allocate these allowances can be a little trickier. Emissions allowances in an ETS can either be given away for free, or sold, for example, through an auctioning process. When emission rights are granted for free, the most logical method in determining which entities should be allocated how many rights, is to use historical emissions data. Allowances allocated through this method are referred to as grandfather rights. Another method would be to freely allocate rights, each year, based on performance criteria achieved the previous year.

One obvious consequence of grandfathering rights is that it creates barriers to entry, and distorts competition in favor of those actors who happen to already have a presence in the market. Not surprisingly, the heavy lobbying power of main industries is what has most contributed to the granting of grandfather rights.¹⁶⁷

Past experience in the aviation industry may create a concern that auctioning rights would provide LCC with an unfair advantage over legacy carriers. These carriers generally have a younger, more efficient fleets, and would have to purchase fewer rights to carry the same number of passenger across the same distances. The gap between cost per available seat mile (CASM) for legacy carriers and for LCC would therefore be widened, making it more difficult for legacy carriers to compete. However, past experience with ETS has been mostly with grandfathering rights, and has not shown any market distortion effects due to shifts in market power.¹⁶⁸

One way to balance out the injustice created by either system may be to adopt both. A portion of the allowances may be freely allocated, and the rest may be auctioned. The most appropriate proportion of free vs. auctioned rights may depend on industry characteristics, such as the ease with which new entrants access the market, their vulnerability to predatory practices, the cost and time needed to implement new technologies and procedures, etc. For example, the EU has granted at least 95% of emissions rights freely for the first trading period (2005-2007), and 90% for the second period (2008-2012), auctioning the rest. Before that, most other ETS in Europe and the U.S. had exclusively granted grandfather rights.¹⁶⁹ Still, the proportion of grandfathered

¹⁶⁷ Hansjürgens, *supra* note 120, p. 31, p. 90, and pp. 152.

¹⁶⁸ Hansjürgens, *supra* note 120, at p. 90.

¹⁶⁹ Hansjürgens, *supra* note 120, table 14.1, at p. 228.

rights in Europe is very high, and mostly attributable to the results of pressure from interest groups.¹⁷⁰

Many believe that the decision to auction or freely allocate rights, and the method of allocation are purely political decisions, and do not affect the actual efficiency of the ETS itself.¹⁷¹ The U.S. Congress and Budget Office concluded:¹⁷²

Selling allowances rather than giving them away would not increase the overall economic costs of the cap-and-trade program but would provide an opportunity to use the allowance revenue to reduce other economic distortions.

Grandfather rights can be used to mitigate the impact of carbon trading on certain actors, while profits stemming from auctioning them off can be redistributed to compensate those bearing the most costly burden. Both methods may be used to achieve similar results, though in both cases, it is difficult to tell who will be most heavily affected. Consequently, some participants will inevitably be overcompensated, others under compensated, and their natural competitiveness would be altered.¹⁷³

In the case of aviation, legacy carriers with older fleets will probably bare the highest costs of an ETS, and grandfathering rights or compensating them financially is an option for policymakers to consider. Proponents of environmental efficiency, on the other hand, may prefer to further tilt the balance, and see rights being granted to greener airlines, and not to those whose fleet is old and

¹⁷⁰ Hansjürgens, *supra* note 120, at p. 156.

¹⁷¹ Hansjürgens, *supra* note 120, at p. 70.

¹⁷² Comments on *Designing Elements of a Mandatory Market-Based Greenhouse Gas Regulatory System*, (13 March 2006) Congressional Budget Office, U.S. Congress, at p. 3.

¹⁷³ Comments on *Designing Elements of a Mandatory Market-Based Greenhouse Gas Regulatory System*, (13 March 2006) Congressional Budget Office, U.S. Congress, at p. 9.

inefficient. This method of allocation would encourage and indirectly finance the purchase of more efficient aircraft by helping greener airlines lower their overall costs and make their product even more affordable to consumers. Because LCC are generally the airlines with the newer, more efficient fleets, such a policy would further shift demand toward these carriers and strengthen their position in the market. However, making the LCC product more affordable may result in a further increase in growth. Decisions to introduce grandfather rights in the aviation industry therefore involve delicate issues, which must be carefully assessed.

One consideration which policymakers should take into account when choosing between grandfathering rights and auctioning them stems from an argument frequently employed by economists: if the rights are grandfathered, emitting entities will not suffer the full impact of the ETS, will not be internalizing their production costs, and these costs will not be passed on to consumers. These consumers will continue using the product at their usual rate, and emissions in that specific sector will not be reduced. Other sectors would have to compensate for the reduction, rendering the overall cost of reducing emissions more costly than if the rights had been auctioned. On the other hand, should firms decide to pass on the actual costs to consumers, they will be overcompensated for doing so, having received the rights for free.¹⁷⁴

Results from a study by Burtraw *et al.* on the impact of an ETS on the electricity sector lead to the same conclusions. This study has shown that auctioning permits may actually be more cost-

¹⁷⁴ Comments on *Designing Elements of a Mandatory Market-Based Greenhouse Gas Regulatory System*, (13 March 2006) Congressional Budget Office, U.S. Congress, at p. 21-23

effective to society than grandfathering them, and will therefore have a less negative impact on the economy, while attaining the same environmental goal:¹⁷⁵

It is not surprising that producers can expect to do the best under grandfathering (...). In fact, producer profits and asset values increase substantially compared to the baseline (absent a carbon policy), making producers better off with a carbon policy than without, but leaving consumers substantially worse off. This increase results because there is no cost associated with initially obtaining emission allowances under grandfathering. In competitive regions, producers can pass along the opportunity cost of emission allowances used at the marginal generation facility in the prices charged to electricity consumers even though the allowances were obtained at zero cost.

The same study found that although allocating permits through an auction was more efficient and most energy producers profited from the system, some did not. To compensate these producers for their losses, the authors consider the possibility of a hybrid auctioning/grandfathering system, and find that the proportion of grandfathered rights needed for compensation need not be very high:¹⁷⁶

Although some generators profit under an allowance auction, others, such as the existing coal-fired generators taken as a group, lose money as a result of the carbon policy. A hybrid approach to allowance allocation that combines an auction of the majority of the allowances with a targeted grant of a minority of the allowances would offset the losses. The grant allowances would be issued at no cost to those generators adversely affected by the policy. (...) For the group of losers, we find that it would be sufficient for the government to allocate at zero cost only 7.5 percent of the emission allowances in order to completely offset the losses within the electricity sector—that's about the difference in a baker's dozen.

¹⁷⁵ Dallas Burtraw *et al.*, "The Effect on Asset Values of the Allocation of Carbon Dioxide Emissions Allowances" (2002) 15:5 *The Electricity Journal* 51, at p. 55. A similar conclusion has been drawn from experience with the SO₂ emissions trading program in the US, which would have been an estimated 25% cheaper to implement had the rights been auctioned, and not grandfathered. Hansjürgens, *supra* note 120, at p. 67.

¹⁷⁶ *Ibid.*, at p. 58.

Again, identifying those most adversely affected by the system is no easy task, and will inevitably lead to under and overcompensation.

ii. Choosing ETS participants

An ETS can be applied either upstream or downstream, or a mix of both. In an upstream ETS, providers of fossil fuels become ETS participants, so that potential emissions are accounted for the moment they enter the economy (Ex: coal mines, oil refineries...). In the case of a downstream system, emissions allowances are held by those responsible for releasing emissions into the atmosphere (Ex: car owners).

In the case of aviation emissions, allowances can be given to aircraft operations, to fuel suppliers, to airport operators, to air traffic management suppliers, or even to aircraft manufacturers. The efficiency of the ETS will be greatly affected by the actors chosen to participate in the ETS.

It is often surmised that an upstream system would lower transactional costs and alleviate monitoring requirements and the administrative burden as a whole, because a lower number of participants would be involved than the large number of mobile participants in a downstream system.¹⁷⁷ In addition, an upstream model would create price incentives across the economy, whereas a downstream model would have to include each and every consumer of energy to have a similar effect.¹⁷⁸

¹⁷⁷ Hansjürgens, *supra* note 120, at p. 201. Comments on *Designing Elements of a Mandatory Market-Based Greenhouse Gas Regulatory System*, (13 March 2006) Congressional Budget Office, U.S. Congress, at p. 2.

¹⁷⁸ Hansjürgens, *supra* note 120, at p. 233. Comments on *Designing Elements of a Mandatory Market-Based Greenhouse Gas Regulatory System*, (13 March 2006) Congressional Budget Office, U.S. Congress, at p. 2.

Using kerosene and EU ETS allowance prices from March 2006, one study has shown that in such an upstream system, where fuel suppliers participate in the emissions trading system, and not the fuel consumers (aircraft operators), the model loses considerable efficiency. The study concluded that emissions trading systems could be avoided for a maximum of 20%, and a minimum of 10% of all fuel sold for aviation.¹⁷⁹ This is because of tankering effects: airlines would purchase fuel outside of the EU and save on fuel. The same study concluded that tankering would be advantageous for most aircraft within a 4000 km radius, particularly for southbound and eastward routes. An upstream model for aviation would therefore not be advantageous, and the ETS efficiency would be greatly compromised.¹⁸⁰

Another argument against the use of an upstream system for aviation is that for GHG other than CO₂, amounts of emissions depend on more factors than mere fuel consumption. Phases of flight, piloting behavior and engine characteristics must be taken into account.¹⁸¹ In fact, in all industries, fossil fuel input is proportional to CO₂ output, but other GHG emissions vary with methods of combustion. Consequently, industries (like aviation) for which emissions must be calculated at the output should also participate in a downstream system.¹⁸²

ETS designers should keep in mind that tankering effects are made possible by the nature of the aviation industry, a characteristic that is not commonly found in other industries. The conclusions of the previously mentioned study are therefore not applicable to other industries, and do not lead to a ruling out of an upstream system for industries whose output emissions are indeed in direct

¹⁷⁹ Martin Cames, "Tankering strategies for evading emissions trading in the aviation sector", (2006) Öko-Institut e.V. (Berlin, Germany), at p. 2.

¹⁸⁰ *Ibid.*, at p. 19.

¹⁸¹ For further information on emissions calculations for aviation, refer to IPCC suggestions described in section II (c)

¹⁸² Hansjürgens, *supra* note 120, at p. 116, p. 165 and p. 201.

proportion to fuel consumption. Hybrid upstream/downstream systems can and probably should be used in an ETS where GHG allowances other than just CO₂ are being traded.¹⁸³

In any event, for aviation, there would be considerably fewer participants in a downstream system as compared to road transportation, for example. The transaction cost savings that make upstream ETS so attractive to policymakers may actually be negligible in the case of aviation.

Finally, it is worth mentioning that the Kyoto Protocol calls for a downstream model, because each signatory state must account for the emissions created by its nationals.¹⁸⁴

Because aircraft emissions (other than CO₂) are not entirely dependent on fuel consumption, and also depend on engine characteristics, phases of flight and their relative duration, aircraft weight, etc., these emissions must be measured and accounted for at the output, by the emitter (the airlines). Choosing airlines as an ETS participant also eliminates the Kyoto Protocol complication caused by the question of who is responsible for international fuel bunkers.¹⁸⁵

iii. Scope and coverage

One key element in designing an ETS is its large scope, both in spatial and qualitative terms, primordial for ensuring its dynamical efficiency. The higher the number of actors involved, the larger the pool of allowances, the more flexible the trading system becomes. A larger ETS creates

¹⁸³ Hansjürgens, *supra* note 120, at p. 116-117.

¹⁸⁴ Kyoto Protocol, *supra* note 7, art. 2(1) (a) (v); art. 3(1)

¹⁸⁵ Cames & Deubes, *supra* note 12, at p. 70 and 81-82. See section II(c) for a description of fuel bunkers.

more potential for financing technological innovations in some sectors, and compensating for increasing emissions in other sectors.¹⁸⁶ Obviously, because aviation would be a net allowance buyer, an ETS applied to aviation would have to be an open ETS, that is, one where participants may trade with other industries. Aviation would then end up financing reductions in other sectors.

Widening the scope of the systems can be done both by including a larger number of industries into the system and by including more GHG.

Many arguments pertaining to the nature of aircraft emissions are made against the integration of aviation into an ETS. One of the issues raised is that the only GHG emitted by aviation that is covered by the Kyoto Protocol is CO₂, which accounts for only 30% of the climate change impact of aircraft emissions.¹⁸⁷ In addition, one author mentions that even if these other gases were covered by an ETS, there is a significant lack of scientific knowledge concerning the actual climate change impact of aircraft emissions, particularly considering largely differing residence time of these gases into the atmosphere.¹⁸⁸ Consequently, inclusion of aviation into an ETS would require either an overestimation or an underestimation of allowances to be allocated to aviation, and could only lead to unfair results.

However, contrarily to what this author concludes, this second argument does not provide sufficient justification to exclude aviation from a non-CO₂-based ETS altogether. A CO₂-based ETS for aviation would be a good start, and a system that includes other GHG aircraft emissions, an even better one. No system is perfect, but it may be perfected over time, as scientific

¹⁸⁶ Hansjürgens, *supra* note 120, at p. 201 and 233.

¹⁸⁷ Cames & Deubes, *supra* note 12, at p. 10-11.

¹⁸⁸ Forster, *supra* note 35.

understanding of the climate impact of aircraft emissions strengthens. The Kyoto Protocol acknowledges this in its article 9, requiring a periodical review of the Protocol in light of new scientific knowledge and assessments.

One study suggests the following flow chart be used to determine the radiative forcing impact of aviation, while warning that some of the CO₂ equivalences used are still subject to scientific debate. In such cases, the value yielding the lowest radiative forcing effect is used.

Figure 4: Method for the calculation of CO₂ equivalents for the climactic impact of international aviation.¹⁸⁹

¹⁸⁹ Cames & Deubes, *supra* note 12, at p. 67.

QuickTime™ et un
décompresseur TIFF (Uncompressed)
sont requis pour visionner cette image.

iv. Transactional costs

In the U.S., in the 1970s, the Environmental Protection Agency's (EPA) Emissions Trading Program required that each allowance transaction receive prior governmental approval. This inevitably increased the administrative burden on government as well as transactional cost, and

directly caused the failure of the program. Other programs that did not have such restrictions succeeded.¹⁹⁰

Managing an ETS can still be very costly for governments, even without the need to approve every transaction. It is vital that administrative costs be kept low, and that unnecessary government control be avoided. In addition, administrative costs related to impact assessment, allocation distribution, monitoring, controlling, penalizing, etc., may be recuperated through the profits made from the sale of allowances, or the portion of allowances that is not freely allocated. However, administrative fees added to allowance transfers should also be avoided, as they may hamper the efficiency of the system.

v. Temporal flexibility: banking and borrowing

Banking allows ETS users to keep unused emissions rights for future use. Past US experience with such systems has shown that target emissions reductions are more rapidly achieved if the possibility of banking is permitted, as banking provides an incentive for early action, dampening effects of future permit price increases.¹⁹¹

Further, for emissions reductions programs in which permissible emissions levels are reduced over time, banking of credits/allowances is important so that those credits/allowances generated in the early years could be used for compliance in later years. Banking provisions give generators the incentives to reduce emissions more rapidly than required and allow them greater flexibility in capital expenditures.

¹⁹⁰ Hansjürgens, *supra* note 120, at p. 66.

¹⁹¹ Fusaro, Peter C. & Yuen, Marion, ed. *Green Trading Markets: Developing the Second Wave* (Oxford, U.K.: Elsevier Science Ltd., 2005) ("Fusaro") p. 19

Borrowing provides current protection from high costs against a promise of future reductions.¹⁹²

This mechanism is generally perceived by environmentalists as simply a way to avoid reductions targets, associated costs, and violation penalties, if any.¹⁹³

vi. Safety valves

1) The general idea

It has been suggested that emissions trading programs include safety valves as a protection against exceedingly high prices. The safety valve could be triggered as soon as the allowance price reaches a certain value. This would cause the government to immediately release enough extra allowances into the market so as to stabilize the allowance price.¹⁹⁴ Obviously, this would inevitably lead to a failure to reach the initial emissions reduction target, but only at the point where the economic cost is considered too high.

Instead of flooding the market with new allowances, a government could choose to start selling mitigation fees as a safety valve against soaring allowance prices. This has already been done in the context of California's Regional Clean Air Incentives Market (RECLAIM), implemented in 1994. In 2000, booming demand for electricity made NOx allowance prices as high as 80,000\$ per ton. Instead of purchasing allowances at such prices, California allowed participants the

¹⁹² Hansjürgens, *supra* note 120, at p. 86-87.

¹⁹³ Hansjürgens, *supra* note 120, at p. 202.

¹⁹⁴ Comments on *Designing Elements of a Mandatory Market-Based Greenhouse Gas Regulatory System*, (13 March 2006) Congressional Budget Office, U.S. Congress, at p. 5 and p. 30-31.

possibility of purchasing “mitigation fees” at a cost of 15,000\$ per ton.¹⁹⁵ Many believe that had the RECLAIM program allowed the possibility of banking allowances, the prices would never have surged to the levels they had, causing the breakdown of the system.¹⁹⁶

2) Purchasing offsets

Purchasing offsets may also be incorporated into the ETS as an alternative to purchasing allowances. The Kyoto Protocol provides for the possibility of investing in carbon sinks to compensate for its GHG emissions, and can invest in creating carbon sinks to meet its Kyoto obligations.¹⁹⁷ Calculations of the importance of offset investments per unit GHG emissions are based upon a practice established by the IPCC and agreed upon by the parties, and methods of calculation are periodically reviewed according to updated scientific knowledge.¹⁹⁸

However, there seems to be limited scientific certainty pertaining to the efficiency of CO₂ absorption and absorption rates by so-called carbon sinks. Many scientists allege that CO₂ absorption is largely limited by the nutrients found in the soil, and plants can therefore absorb a limited amount of atmospheric CO₂, depending on nutrient storage in the soil.¹⁹⁹ Some even go so far as to suggest that “significant, long-term carbon sequestration in forest soil is unlikely”.²⁰⁰

¹⁹⁵ Hansjürgens, at p. 124.

¹⁹⁶ This idea is expressed by both A. Denny Ellerman and Richard D. Morgenstern, Hansjürgens, *supra* note 120, at p. 84 p. 127 respectively.

¹⁹⁷ Kyoto Protocol, *supra* note 7, art. 3(3), art. 6(1)

¹⁹⁸ Kyoto Protocol, *supra* note 7, art 5(3).

¹⁹⁹ Kees-Jan van Groenigen *et al.*, “Element interactions limit soil carbon storage” (2006) 103:17 PNAS 6571.

²⁰⁰ William H. Schlesinger & John Lichter, “Limited carbon storage in soil and litter of experimental forest plots under increased atmospheric CO₂”, (2001) 411 Nature 466

Consequently, allowing carbon sinks to compensate for emissions may be premature considering the scientific uncertainties relating to carbon sink efficiencies. In addition, investments in carbon offsets purchased today may only yield a substantial result, if any, in the future. In the meantime, anthropogenic emissions to be compensated by future, potential offsets, lead to runaway climate change. By the time the carbon offset purchase has any effect, if any, the problem has already been aggravated.²⁰¹

Recognizing the uncertainties associated with offsetting carbon emissions, the EU has temporarily rejected the idea as a way to compensate for aircraft emissions, at least until more scientific knowledge is acquired on the subject.²⁰²

Many airlines and firms are already offering their customers the possibility of offsetting their share of the emissions burden, by investing in carbon sink projects.²⁰³ Fundamentally, voluntary carbon offsets purchased by air travelers are nothing more than a marketing tool meant to appease guilty consciences, and act not as a deterrent for these price inelastic consumers, but merely as a means of keeping demand for air travel at its highest.

²⁰¹ Particularly considering carbon-cycle feedbacks, as explained by Peter M. Cox *et al.*, "Acceleration of global warming due to carbon-cycle feedbacks in a coupled climate change" (2000) 408 *Nature* 194. In this article, the authors calculate and show that terrestrial carbon sinks become less and less effective over time, eventually becoming carbon sources and balancing out oceanic carbon sinks, thereby significantly aggravating climate change predictions.

²⁰² EU's 6th Environmental Action Plan; Cames & Deubes, *supra* note 12, at p. 16-16.

²⁰³ The new trend is discussed in further detail in section III(a).

b. Design elements of the EU ETS

Through a preliminary description of the current ETS in place in Europe, this subsection sets the stepping stones toward an overview of the proposed ETS for aviation in the next section, in an attempt to assess its potential efficiency, advantages and disadvantages.

In 2005, the European Union opened trading in its new Emissions Trading System, pursuant to Directive 2003/87/EC “establishing a scheme for greenhouse gas emission allowance trading within the Community”.²⁰⁴

Under this directive, each member state is responsible for setting its emissions reduction goal, and to allocate allowances in conformity with this goal, to installations within its territory. The target reduction goal is set in the context of a national allocation plan, which must be defined in accordance with Kyoto Protocol obligations for target reductions within the EU, defined under EU law, taking into account emissions from sources not included in the ETS.²⁰⁵

Pursuant to article 10 of the Directive, member states must allocate at least 95% of the quotas for free for the first trading period, beginning 1 January 2005 and ending 31 December 2007. For the second period, beginning 1 January 2008 and ending 31 December 2012, at least 90% of the allowances must be freely allocated. Annex III of the Directive prohibits member states from freely allocating allowances in such a way as to unduly favor certain activities²⁰⁶, and provides

²⁰⁴ Title of Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC, *OJ L 275*, 25.10.2003, p. 32-46 (the “Directive”).

²⁰⁵ Article 9 and annex III, articles 1 and 2 of the Directive, *ibid.*

²⁰⁶ Article 11(3) and annex III, art. 5 of the Directive, *ibid.* “Unduly favor” is meant in the sense of a state aid, prohibited by articles 87 and 88 of the Treaty Establishing the European Community.

that national allocation plans shall specify manners in which new entrants may begin participating in the ETS.²⁰⁷

The EU ETS covers only one of the Kyoto Protocol GHG, namely CO₂. More precisely, art. 2(1) of the Directive provides that the ETS will apply to emissions from activities listed in Annex I, and greenhouse gases listed in Annex II, which lists the same 6 gases covered by the Kyoto Protocol.²⁰⁸ However, only CO₂ is listed in Annex I as the “emissions” from activities listed therein.²⁰⁹

As previously mentioned, CO₂ is the most easily measured GHG, as its output into the atmosphere is directly related to fuel consumption, independent of the method of consumption.²¹⁰ CO₂ also accounts for 80% of all GHG emissions in the EU.²¹¹ It therefore makes sense to begin trading with this one gas, in the hopes of eventually expanding the ETS to other gases. Starting in 2008, member states will have the possibility of including other gases into the ETS, subject to approval from the European Commission.²¹² However, some believe that scientific knowledge of radiative forcing caused by aircraft emissions is still insufficient to justify the inclusion of such other gases into the EU ETS.²¹³

²⁰⁷ Article 11 and annex III, art. 6 of the Directive, *supra* note 203. Reading into art. 11(3) of the Directive, this probably means that member states should not distribute all the allowances, and keep some to distribute to new entrants.

²⁰⁸ Annex A of the Kyoto Protocol, *supra* note 7. These gases are Carbon Dioxide, Methane, Nitrous Oxide, Hydrofluorocarbons, Perfluorocarbons, and Sulphur Hexafluoride.

²⁰⁹ Annex I of the Directive, *supra* note 203.

²¹⁰ For further details, see section II- c.

²¹¹ Hansjürgens, *supra* note 120, at p. 166.

²¹² Art. 24(1) of the Directive, *supra* note 203.

²¹³ Forster, *supra* note 35.

The EU ETS is a downstream system,²¹⁴ covering for the moment the following five major stationary emissions sectors: power and heat generation; mineral oil refineries; iron and steel; pulp and paper; and building materials (cement, ceramics and glass).²¹⁵

In terms of spatial flexibility, as previously described, plans for an EU ETS expansion to other sectors (to aviation, for example) are already underway. In addition, the Directive specifically provides for the possibility of bilateral agreements facilitating the integration of other ETS within the EU ETS.²¹⁶

The Directive imposes no restrictions on the behavior of the private sector, so long as it surrenders sufficient allowances to cover its emissions at the end of the year. Anyone can participate in the ETS, buying and holding allowances.²¹⁷ There are no restrictions neither on banking of allowances²¹⁸, nor on transactions. No prior consent is needed for a transaction to take place, and no fee is charged. Pooling of allowances amongst operators is even expressly permitted.²¹⁹

Monitoring and supervision is provided through periodical reports submitted by member states to the European Commission. These reports must cover, *inter alia*, the allocation of allowances and their fiscal treatment, reporting and monitoring guidelines adopted by member states, and compliance of participants with their ETS obligations.²²⁰

²¹⁴ Both economists Peter Zapfel and Bernd Hansjürgens agree on this, though economist and lawyer Michael Rodi believes the EU ETS to be an upstream system, since it also covers power plants. See Hansjürgens, *supra* note 120, at p.166, p. 234, and p. 192 respectively.

²¹⁵ Hansjürgens, *supra* note 120, at p. 166.

²¹⁶ Art. 25 of the Directive, *supra* note 203. This article refers to signatory parties to the Kyoto Protocol. See also Hansjürgens, *supra* note 120, at p. 169.

²¹⁷ Hansjürgens, *supra* note 120, at p. 168.

²¹⁸ Hansjürgens, *supra* note 120, at p. 168.

²¹⁹ Article 28 of the Directive, *supra* note 203.

²²⁰ Article 21(1) of the Directive, *supra* note 203.

One novel aspect of the EU ETS is that a penalty must be charged to an operator who has not surrendered, at the end of the year, sufficient allowances to cover for the emissions it is responsible for. The penalty is 40 Euros for the first trading period, and 100 Euros for the second trading period, per excess ton of CO₂ equivalent. This penalty must be paid in addition to the obligation to surrender, the following year, sufficient allowances to cover these excess tons of CO₂ equivalent to those emitted the previous year.²²¹ This penalty is to be subsequently revised on account of such factors as inflation, to ensure that it continues to serve its dissuasive function.²²²

A similar approach was taken in the US SO₂ trading program, where the penalty imposed for non-compliance was three times the previously forecast market price.²²³ This type of penalty has the advantage of not requiring revision as inflation and other factors fluctuate, and which always creates sufficient incentive to participate in the ETS.

One of the problems encountered by the ETS so far is that the price has shot down to an extent that it is much cheaper to purchase quotas than to invest in green technologies. It seems the European market has been flooded with quotas. As of 15 May 2006, there was less CO₂ being emitted than there were quotas to sell. This could be due either to false information initially provided by companies, or to a substantial decrease in emissions. Whatever the case may be, there is currently no real incentive to invest in environment-friendly technologies in Europe, other than possibly a company's desire to be seen in a positive light by its consumers. However, involving more allowance buyers into the ETS, as aviation would do, could cause the price to increase, which may create sufficient incentive for more R&D investment into new technologies.

²²¹ Articles 16(3) and 16(4) of the Directive, *supra* note 203.

²²² Article 30(2)g) of the Directive, *supra* note 203.

²²³ Cames & Deubes, *supra* note 12, at p. 92.

Another problem with the EU ETS is that the trading terms appear too short to allow companies to adequately plan their financing and other operations. Many companies feel that 5 years is still too short of a trading period. However, the fact that banking is allowed may dampen the negative impact of inadequate financial planning.²²⁴

c. Particularities of an ETS for aviation

With the predicted growth of the aviation industry higher than the rate of development of greener technologies and other emissions reduction methods, airlines are expected to be emissions allowances buyers²²⁵. It is argued that such a system would have little or no impact on the demand for aviation, because allowance prices would have to go through the roof before consumers stop purchasing aircraft tickets, considering the relative price inelasticity of the industry.²²⁶

This argument entirely misses the fundamental point of an open emissions trading system. An ETS is not meant to be equivalent to a tax, and emissions allowances are not meant to be sufficiently pricy to discourage demand in all sectors. Rather, the purpose of an ETS is to balance out the relative needs of the industries between themselves, so that those for which methods of lowering emissions are less costly may find it more advantageous to lower emissions, rather than to purchase quotas.

²²⁴ Fusaro, *supra* note 190 p. 19

²²⁵ As will the entire transportation sector: Hansjürgens, *supra* note 120, at p. 31.

²²⁶ "Global Warming – The climate change impact of aviation", (2007) 47 *Airline Fleet and Network Management*, at p. 13.

In other words, aviation will be an allowance buyer, and will help create a demand for allowances, and therefore encourage emissions reductions in other industries. A British Airways spokesman best explained the ETS mechanism in the following statement:²²⁷

If any sector created a demand for carbon allowances that couldn't be met the price would go through the roof and the potential buyers would think about doing something else rather than buying. That's how markets work. If individual airlines wanted to increase their carbon allowance beyond a certain point and they found that the price was exorbitant they might decide that they wouldn't grow that much.

An ETS for aviation would therefore have two important consequences. First, it would promote emissions reductions in other sectors, driving emissions allowances prices up because of their demand for it, and second, it could eventually cap the demand for air travel the moment allowances prices became too costly for consumers.

d. An overview of the EC's proposal to integrate aviation in its ETS

The current political context surrounding the development of a legal framework for regulating aircraft emissions can be best described as follows. The Kyoto Protocol imposes an obligation on member states to work through ICAO to pursue emissions reductions. After studying the question, ICAO concluded that the idea that it should regulate an ETS for aviation "(...) seemed sufficiently unattractive that it should not be pursued further". However, it agreed to provide guidance to states that wanted to include aviation into their own emissions trading programs.²²⁸

²²⁷ "Global Warming – The climate change impact of aviation", (2007) 47 Airline Fleet and Network Management, at p. 13.

²²⁸ Proposal for a Directive of the European Parliament and of the Council Amending Directive 2003/87/EC so as to Include Aviation Activities in the Scheme for Greenhouse Gas Emission Allowance Trading Within the Community, COM(2006) 818 final, 2006/0304 (COD).

The ICAO position is understandable in the sense that an ETS for aviation could only be environmentally effective if trading with other sectors were allowed; otherwise, the quota price would be so high that it would be equivalent to a green tax. Such a system could not be achieved merely under ICAO auspices. The most ICAO can do is promote the inclusion of the aviation industry in national, regional or international open ETS, and provide technical support in regards to, for example, accurately measuring aircraft emissions. For the moment, ICAO appears to be jealously guarding its jurisdiction.

After careful study of the question, the EU found that the most efficient solution, both economically and environmentally, for addressing aircraft emissions, would be by including them in its own ETS.²²⁹ The EU then held public consultations, which included scientific experts, industry stakeholders, environmental and consumer NGOs, and concluded that the public also preferred this solution to taxes and levies.²³⁰

The EU conducted an impact assessment to evaluate how the European aviation industry would be affected by its inclusion into a EU ETS and drew the following conclusions:²³¹

[S]ince every airline on each route covered by the scheme would be treated equally, airlines can be expected to pass on, to a large extent or even in full, compliance costs to customers. This would have only a small effect on forecasted demand growth: from business-as-usual levels of 142% to a minimum of 135% over the period 2005 to 2020 for all departing and arriving flights. Competition between airlines would not be significantly

(“EU proposal), at p. 3.

²²⁹ *Ibid.*, at p. 2.

²³⁰ *Ibid.*, at p. 4.

²³¹ *Ibid.*, at p. 5.

affected. The main difference between airlines is the length of journey undertaken, the age of the aircraft used and the payload carried. Therefore, carriers traveling shorter distances, using older aircraft or carrying fewer passengers or less freight would be affected to a greater extent than more fuel efficient carriers. Competition between airports and tourism would not be significantly affected. However, any risk to the latter would likely be decreased by including all departing and arriving flights in the scheme.

The specifics of the EU proposal for aviation are not too different from what we might expect them to be, in terms of the economic considerations dealt with in previous sections. Airlines would be the participants responsible for aircraft emissions allowances, and would be able to purchase allowances from other industries, as the EU ETS is an open trading scheme. They would also be able to purchase emissions offsets instead on quotas, as provided for in the Kyoto Protocol.²³²

Initially, the proposal called for all domestic flights to be accounted for by 1 January 2011, while international flights either landing in or taking off from the territory of an EU Member State would be included as of 1 January 2012. Because all such flights are covered, regardless of their nationality, competition distortion effects along these routes are avoided. When the EU Parliament backed the proposal on November 13, 2007, it decided that all flights should be covered by 2010, even the international flights.²³³

Some flights would be excluded from the scheme, such as military flights, flights containing government officials, flights performed under visual flights rules, flights performed for training

²³² Abeyratne, Ruwantissa "Emissions Trading – Recommendations of CAEP/7 and the European Perspective" 32/4-5 Air & Space Law 360, at p. 370.

²³³ *Supra*.note 228, at p. 368. See also EU Parliament's amendments online: <http://www.europarl.europa.eu/sides/getDoc.do?type=REPORT&reference=A6-2007-0402&language=EN&mode=XML> (date accessed: February 5, 2008).

purposes, or for the purpose of testing equipment, and flights with a minimum take-off weight below 5,700kg.²³⁴

For the years 2011 and 2012, the aviation industry would be allocated 75% of the total number of allowances equivalent to the sum of emissions from aviation in the years 2004, 2005 and 2006. For the following years, this amount will be continuously reduced, in order to maintain the environmental effectiveness of the EU ETS.²³⁵

The method of allocation of emissions allowances has yet to be determined, and the decision is left to the states themselves. Initially, each member state was to be required to suggest a percentage of allowances to be distributed for free, with the remaining quantity to be auctioned. The actual number of allowances that will be allocated for free throughout Europe would have been the average of the percentage suggested by the states. Now, the EU Parliament has amended this provision so that by 2010, 50% of the allowances are to be auctioned. Presumably, the other 50% will be allocated for free. This percentage may be increased for future periods.²³⁶

One issue that has raised many questions pertains to the interaction of ETS with other such systems. This issue has particular importance for aviation, as it raises the fear of double counting: an aircraft may be subject to an emissions-based policy both in the country of departure and the country of arrival.

²³⁴ Annex to the EU proposal, *ibid.*, article 1(b) and 1(c).

²³⁵ Article 3b of the Directive as amended by the EU proposal, *supra* note 227, provides that the total quantity of allowances to be allocated to the aviation industry starting 2013 is equivalent to 100% the historical aviation emissions. Article 3(r) of Directive 2003/87/EC as amended by the EU proposal defines "historical aviation emissions" as the average of annual emissions from years 2004, 2005 and 2006. This was substantially modified by the EU Parliament: see amendment 24 of its report online: <http://www.europarl.europa.eu/sides/getDoc.do?type=REPORT&reference=A6-2007-0402&language=EN&mode=XML> (date accessed: February 5, 2007)

²³⁶ Article 3c of the Directive as amended by the EU proposal, *supra* note 227. *Ibid.*, amendments 25 and 26.

The EU has acknowledged the issue, and has left the door opened for future negotiations and coordination with states wishing to impose a similar system on aviation, within their borders.

Article 25a of the Directive, as amended by the EU proposal states:

Where a third country adopts measures for reducing the climate change impact of flights departing from that country which land in the Community which are at least equivalent to the requirements of this Directive, the Commission shall amend this Directive to provide for flights arriving from that country to be excluded from the aviation activities [covered by this Directive].

e. An International ETS and the need for uniformity

Many American companies are expecting a carbon emissions trading system to become compulsory in the near future, and many are preparing for it, attempting to assess its financial impact and setting aside funds to deal with its costs²³⁷. Corporate America is expecting action on the part of their federal government primarily because more and more states in that country are acting to legislate emissions in response to pressure from public opinion, and corporations submitted to various state laws are seeking uniformity:²³⁸

In the U.S. SO₂ program, we saw something that we might see for GHG and for renewables. Because so many states started to put together their own regulations that companies operating in a multistate environments finally told the federal government they wanted some consistency in the regulations. That demand resulted in the 1990 Clean Air Act amendments which authorized the first successful emissions trading program for SO₂.

²³⁷ Fusaro, *supra* note 190, p. xix, p. 192-193, and pp. 91.

²³⁸ *Ibid.* p. 196.

By 2005, there were 28 states working on GHG initiatives, with New York State working on what may be the first mandatory U.S. emissions trading system.²³⁹

A similar phenomenon may occur across the Atlantic, and eventually worldwide: companies operating both in Europe and the U.S. will pressure their governments to insure their systems are uniform and interchangeable. This is particularly true for aviation, an industry that is international in nature, and whose emissions are particularly diffuse. Uniformity is also needed to avoid eventual registry-shopping, so that companies do not choose their country of nationality based on favorable emissions registry and rules, such as larger measurement units, more allowances, and lower prices. Only an international system may appropriately and efficiently regulate global GHG emissions.

The international community has been considering the possibility of creating an international emissions trading system, in response to Kyoto Protocol obligations, the EU initiative, and to pressure from environmental groups. However, at the time of writing, the world seems far from achieving this goal. As the BBC reports: “Last time the international community talked about them, at the UN climate summit in Nairobi in November [2006], it could not even agree when to start talks about talks.”²⁴⁰

Further efforts are also being hindered by the heated debate emissions trading systems have created, particularly within the corporate world, worried about the cost such a system may create, and the initial unpredictability of the price tag.

²³⁹ Fusaro, *supra* note 190, p. 202

²⁴⁰ Richard Black, “Climate curbs: Who will buy” (4 May 2007), BBC News website. Online: <http://news.bbc.co.uk/2/hi/science/nature/6623601.stm> (date accessed 11 July 2007)

Environmentalists themselves disagree on the mere idea of setting-up such a system, which they see as morally unacceptable “permit to pollute”, and not just as an economic incentive to develop greener technologies. But legally, the concept of a “permit to pollute” may well be a positive one. In most developed nations, dangerous activities are usually regulated by permit. The environment would be better off if polluting became a privilege granted by governments as a means to control the activity, instead of a free for all.

Though it has been the subject of much criticism, the EU initiative is an important leap forward in the current international environmental law context. One can only hope that it will trigger further important developments in the near future.

VI- Summary and conclusions

Globalization, the rapid expansion of the Asian market, and the relatively recent LCC phenomenon, have all contributed to making the aviation industry the fastest contributor to GHG in the world. LCC have facilitated and encouraged flying in all markets, even mature ones such as the European market, to such an extent that this mode of transportation is often being needlessly used and abused. Weekend adventures into unknown countries and far-away cities have replaced the classic get-away at a nearby bed & breakfast; commuting by plane has made it possible to work in expensive cities while avoiding the sky-high rents.

Though technological improvements, along with advances in air traffic control and airline management may help lower global aircraft emissions, these efforts are not sufficient to compensate for the rapid growth of the industry. Airfare is simply too low and demand too high, particularly considering the relatively low elasticity of demand.

While other industries are working toward internalizing their production costs, aviation has become a playpen. If immediate action is not taken to reduce the impact of aircraft emissions either directly, or by financing reductions in other sectors, airlines will be vilified as uncaring and greedy. From its privileged position as the portal to greater markets and unknown worlds, aviation will simply become a necessary evil. We will be as addicted to planes as many are to tobacco, helpless to stop.

So long as emissions are on the increase, so long as consumer behavior does not change and until acting green has become a moral obligation in all societies, all forms of economic incentives and legislative obligations should and will be used to combat climate change.

Lowering demand for air travel remains an important challenge. Although fuel tax presents appealing advantages in terms of incentives to reduce emissions, political considerations, dynamic efficiency, and the nature of aircraft GHG emissions require that an ETS designed to fit the particularities of the aviation industry be adopted. An ETS for aviation would provide the joint benefit of partly generating incentive to reduce emissions, while financing reductions in other industries.

An international open ETS would facilitate business operations for multinational corporations and companies with cross-border interests such as airlines, provide financial stability, and encourage economic development and project financing. Such a system would also help achieve the Kyoto Protocol goal worldwide, admittedly a reduction standard already perceived as too low by environmentalists, but nonetheless a big step toward further reduction by policymakers.

In the advent of the EU ETS's possible integration of aviation, and the upcoming 2008 international ETS provided for by the Kyoto Protocol, there is no real reason, other than political pressure and indecisiveness, for which aviation should not participate in international emissions trading.

BIBLIOGRAPHY

PRIMARY MATERIALS

INTERNATIONAL MATERIAL

“Climate Change, Energy and Sustainable Development”, The Gleneagles Communiqué, Gleneagles Plan of Action.

Consolidated statement of continuing ICAO policies and practices related to environmental protection, ICAO Res. A33-7.

Convention on International Civil Aviation, 7 December 1944, 15 U.N.T.S. 295.

Draft Action Plan on Aircraft Engine Emissions, ICAO

EU-US Air Transport Agreement (30 April 2007)

International Standards and Recommended Practices: Environmental Protection; Annex 16 to the Convention on International Civil Aviation, Volume II: Aircraft Engine Emissions, 2d ed. July 1993.

Policies on Taxation in the Field of International Air Transport, ICAO Doc. 8632.

Protocol on Substances that Deplete the Ozone Layer, 16 September 1987, 1522 U.N.T.S. 3.

Kyoto Protocol to the United Nations Framework Convention on Climate Change, 10 December 1997, U.N. Doc. FCCC/CP/1997/7/Add. 1;

United Nations Framework Convention on Climate Change, 9 May 1992, 1771 U.N.T.S. 107, 165;

NATIONAL LEGISLATION

European Union

Communication from the Commission - “Further guidance on allocation plans for the 2008 to 2012 trading period of the EU Emission Trading Scheme” /* COM/2005/0703 final */

Communication from the Commission to the Council, the European Parliament, the Economic and Social Committee and the Committee of the Regions - Air transport and the environment Towards meeting the challenges of sustainable development, /* COM/99/0640 final */

Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC, *OJ L 275*, 25.10.2003, p. 32-46.

Directive 2004/101/EC of the European Parliament and of the Council of 27 October 2004 amending Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the Community, in respect of the Kyoto Protocol's project mechanisms, Text with EEA relevance, *OJ L 338*, 13.11.2004, p. 18-23

Proposal for a Directive of the European Parliament and of the Council Amending Directive 2003/87/EC so as to Include Aviation Activities in the Scheme for Greenhouse Gas Emission Allowance Trading Within the Community, COM(2006) 818 final, 2006/0304 (COD).

Canada

Canadian Aviation Regulations, SOR/96-433

SECONDARY MATERIALS

BOOKS

Hatch, Michael T., ed. *Environmental Policymaking: Assessing the Use of Alternative Policy Instruments* (New York : State University of New York Press) 2005.

Dempsey, Paul Stephen & Gesell, Laurence E. *Airline Management Strategies for the 21st Century*, 2nd ed. (Chandler Arizona: Coast Aire Publications, 2006).

Dempsey, Paul Stephen & Gesell, Laurence E. *Air Commerce and the Law* (Chandler Arizona: Coast Aire Publications, 2004).

Dempsey, Paul Stephen *European Aviation Law* (Kluwer Law International, 2004)

Fusaro, Peter C. & Yuen, Marion, ed. *Green Trading Markets: Developing the Second Wave* (Oxford, U.K.: Elsevier Science Ltd., 2005).

Hansjürgens, Bernd, ed. *Emissions Trading for Climate Policy: US and European Perspectives* (Cambridge, U.K.: Cambridge University Press, 2005).

JOURNAL ARTICLES

Abeyratne, Ruwantissa "Emissions Trading – Recommendations of CAEP/7 and the European Perspective" (2007) 32:4-5 *Air & Space Law* 360

Bows, Alice, Anderson, Kevin L. "Policy Clash: Can Projected Aviation Growth be Reconciled

with the UK Government's 60% Carbon-Reduction Target?" (2007) 14:2 Transport Policy 103

Brasseur, G.P. *et al.* "European Scientific Assessment of the Atmospheric Effects of Aircraft Emissions" (1998) 32 Atmospheric Environment 2329.

Brown, R.C. *et al.* "Aircraft Exhaust Sulfur Emissions" (1996) 23:24 Geophysical Research Letters 3603.

Burtraw, Dallas *et al.*, "The Effect on Asset Values of the Allocation of Carbon Dioxide Emissions Allowances" (2002) 15:5 The Electricity Journal 51

Carlsson, Fredrik & Hammar, Henrik. "Incentive-Based Regulation of CO2 Emissions from International Aviation" (2002) 8 Journal of Air Transport Management 365.

Cames, Martin, "Tankering strategies for evading emissions trading in the aviation sector", (2006) Öko-Institut e.V. (Berlin, Germany)

Cames, Martine & Deuber, Odette, "Emissions trading in international civil aviation" (2004) Öko-Institut e.V

Dewes, Winfrid *et al.* "The AERONET Network – Emissions, Atmospheric Impact and Regulations" (2000) 2:3 Air & Space Europe 24.

Duthie, Elizabeth. "ICAO Regulation: Meeting Environmental Need?" (2001) 3:3-4 Air & Space Europe 27.

- "Europe's Aeroengine Community Targets Major Environmental Improvements" (2000) 2:3 Air & Space Europe 51.

Forster, Piers M. de F., "It is premature to include non-CO2 effects of aviation in emission trading schemes", (2006) 40 Atmospheric Environment 1117

Kees-Jan van Groenigen *et al.*, "Element interactions limit soil carbon storage" (2006) 103:17 PNAS 6571

Korster, Piers M. de F. *et al.* "It is Premature to Include non-CO2 Effects of Aviation in Emission Trading Schemes" (2006) 40 Atmospheric Environment 1117.

Goodwin, Phil *et al.* "Elasticities of Road Traffic and Fuel Consumption with Respect to Price and Income: A Review" (2004) 24:3 Transport Reviews 275

Green, Michael Gerard. "Control of Air Pollutant Emissions from Aircraft Engines: Local Impacts of National Concern" (1999) 5:2 Env'tl. Law. 513.

Haese, Marc J. "Taxation of Aviation Fuel – an Aerospace Manufacturing Industry View" (2000) 2:3 Air & Space Europe 17.

Jamin, Solomon *et al.* "Aviation Emissions and Abatement Policies in the United States: a City-Pair Analysis" (2004) 9 Transportation Research Part D 295.

Klug, Heinz G., Faass, Reinhard. "CRYOPLANE: Hydrogen Fuelled Aircraft – Status and Challenges", (2001) 3:3-4 Air & Space Europe 252.

Koroneos, C. *et al.* "Advantages of the Use of Hydrogen Fuel as Compared to Kerosene" (2005) 44 Resources, Conservation and Recycling 99

Lee, J.J. *et al.*, "Historical and future trends in aircraft performance, cost and emissions" (2001) 26 Annual Review of Energy and the Environment 167

Oberthür, Sebastian. "Institutional Interaction to Address Greenhouse Gas Emissions from International Transport: ICAO, IMO and the Kyoto Protocol" (2003) 3 Climate Policy 191.

Olsthoorn, Xander. "Carbon Dioxide Emissions from International Aviation: 1950-2050" (2001) 7 Journal of Air Transport Management 87.

Schipper, Youdi. "Environmental Cost in European Aviation" (2004) 11 Transport Policy 141.

Schumann, Ulrich. "Effects of Aircraft Emissions on Ozone, Cirrus Clouds, and Global Climate" (2000) 2:3 Air & Space Europe 29.

Simoës, André Felipe & Schaeffer, Roberto. "The Brazilian Air Transportation Sector in the Context of Global Climate Change: CO₂ Emissions and Mitigation Alternatives" (2005) 46 Energy Conversion and Management 501

Tol, Richard S.J. "The Impact of a Carbon Tax on International Tourism" (2007) 12:2 Transportation Research Part D 129.

Vedantham, Anu & Oppenheimer, Michael. "Long-term Scenarios for Aviation: Demand and Emissions of CO and NO" (1998) 26:8 Energy Policy 625.

Vlek, Sander, Vogels, Marli. "AERO – Aviation Emissions and Evaluation of Reduction Options" (2000) 2:3 Air & Space Europe 41.

Zimmermann, Klauss F. "Trade and Dynamic Efficiency" (1987) 40:1 Kyklos 73

MAGAZINE ARTICLES

Dobbie, Léonie & Eran-Tasker, Martin. "Measures to Minimize Fuel Consumption Appear to be of Greatest Importance to Airlines", (2001) 56:4 *I.C.A.O. Journal*, 24.

- "Flyless Campaign Asks: 'Is Your Journey Really Necessary?'" (June/July 2005) *Communiqué Airport Business*

-“Global Warming – The climate change impact of aviation”, (2007) 47 *Airline Fleet and Network Management*

Hupe, Jane. “Experts Reformulating Strategy for Alleviating Aviation’s Impact on the Environment”, (2001) 56:4 *I.C.A.O. Journal* 5.

Karmali, Abyd & Harris, Melinda. “A Recent Study Carried Out for ICAO Examined Options for an Emissions Trading System for International Civil Aviation”, 59 : 5 *I.C.A.O. Journal*, 11

-“Partnership for Change with Air Navigation Service Provides” Edition 8, September 2006, Industry Times, IATA

-“UK case study: the green growth dilemma”, (2007) 47 *Airline Fleet and Network Management*

THESIS

Nyampong, Yaw Otu Mankata, *The Regulation of Aircraft Emissions from International Civil Aviation* (L.L.M. Thesis, Institute of Air and Space Law, McGill University, 2005) [unpublished].

OTHER MATERIALS

2006 IPCC Guidelines for National Greenhouse Gas Inventories

2007 U.S.-EU Summit Statement: Energy Security, Efficiency, and Climate Change, (April 30 2007) The White House press release

Air Traffic Forecasts for the United Kingdom 2000, (2000) UK Department of Transportation

After the Stern Review: reflexions and responses. Paper A: “A case for action to reduce the risks of climate change”, 12 February 2007

Comments on *Designing Elements of a Mandatory Market-Based Greenhouse Gas Regulatory System*, (13 March 2006) Congressional Budget Office, U.S. Congress

EU’s 6th Environmental Action Plan

Gillian, David W *et al.*, “Air Travel Demand Elasticities: Concepts, Issues and Measurment”, (2004) Final Report for the Department of Finance Canada

“Impact of International Aviation on Climate Change: Preparation for the 35th Assembly of the International Civil Aviation Organization (ICAO)” (9 July 2004) Council of the European Union

Penner, Joyce E. *et al.* “Aviation and the Global Atmosphere, Special Report, (1999) IPCC Working Groups I and III.

Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories

Stern, Nicholas. *Stern Review: The Economics of Climate Change*, Executive Summary (30 October 2006).

Stern Review – SBAC's Response, 30 October 2006

"The Environmental Effect of Civil Aviation in Flight", 22 March 2007, Royal Commission on Environmental Pollution

WEB SITES

Airbus: <http://www.airbus.com/en/corporate/ethics/environment/index.html>

BBC

<http://news.bbc.co.uk>

Boeing <http://www.boeing.com/commercial/787family/background.html>

Carbon Tax Center

<http://www.carbontax.org/>

European Union www.europa.eu

European Environment Agency <http://themes.eea.europa.eu>

Global Policy Forum

<http://www.globalpolicy.org/socecon/glotax/carbon/index.htm>

IATA

www.iata.org

ICAO Colloquium on Aviation Emissions with Exhibition, May 2007 <

<http://www.icao.int/EnvClq/Clq07/Documentation.htm>>

Transport Canada

<<http://www.transportcanada.ca/civilaviation/RegServ/Affairs/cars/Part5/Standards/516s.htm>

U.S. Environmental Protection Agency

<http://www.epa.gov/climatechange/emissions/usinventoryreport.html>

Virgin Blue <http://www.virginblue.com.au/carbonoffset/info/>