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STRATEGIES FOR AIRLINES ON AIRCRAFT EMISSIONS AND CLIMATE CHANGE: SUSTAINABLE, LONG - TERM SOLUTIONS

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The purpose of this working paper is to evaluate possible strategies for airlines on aircraft emissions and climate change, including emissions trading. We set out in detail the nature of the problem airlines face in this regard, and conclude that *airlines should seriously consider supporting mandatory participation in an emissions offset market as part of a long-term strategy package* (including technological, operational and management elements) and as a sustainable solution to deal with the climate impacts of aviation. This solution does not preclude other, complementary measures and has a number of advantages such as flexibility.

We also suggest that, as a step prior to mandatory emissions offsets, airlines should introduce offsetting as an airline default – or *opt-out* – passenger emissions offset scheme. This would have the advantage of allowing airlines to take action in the immediate future which begins to fairly seamlessly absorb demands that they address the climate costs of aviation, and at little cost.

In our view the airline industry should be moving ahead of governments, and should steer the process of change *to build a cleaner sky*. The strategy package proposed here affords airlines an opportunity to get out ahead of governments and public opinion, and to adopt a proactive stance towards the risks and uncertainties presented by climate change. It also makes economic sense.

An **executive summary** of this paper is provided at pages 4 to 7.

30 pages of footnotes to this paper begin at page 57.

An expanded executive summary, together with other supporting material, is available from The Hodgkinson Group. **Contact details**, and information about The Hodgkinson Group and the paper's authors, appear at the end of the paper.

This paper is part of an ongoing project which examines airline strategies on aircraft emissions and climate change in greater detail. The results of that project will be published in a subsequent paper.

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EXECUTIVE SUMMARY

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2. Aviation and climate change – aviation growth trends and GHG emissions reductions (*pages 12 to 25*)

Aviation is one of the fastest-growing sectors of the world economy. Over the next 20 years more than 27,000 new aircraft will be delivered; the number of air travelers will double to 9 billion over the same period. Against this background of significant growth in air travel, and as a result of increasing awareness on the part of governments and the public with regard to climate change and its possible consequences, pressure is being placed on the aviation industry - and airlines in particular - to address the climate impacts of aviation.

A number of organisations such as the Intergovernmental Panel on Climate Change (IPCC), Oxford University, the Massachusetts Institute of Technology (MIT) and the Tyndall Centre, for example, have studied the impacts of aviation on the global atmosphere. These studies, together with reports from Royal Commissions and other inquiries, make the following points clear:

- the climate change impacts of aviation are significantly worse than those of its carbon dioxide emissions alone. Further, reference to aviation being responsible for 2% of global carbon dioxide emissions is misleading as the figure (a) is based on total anthropogenic carbon dioxide emissions in *1992* (as determined by the IPCC), not 2007; (b) does not take into account aviation's non-CO_2 greenhouse gas (GHG) emissions which significantly contribute to the climate change impacts of aviation; and (c) ignores growth in air travel;

- air travel demand is growing at unprecedented rates, yet substantial reductions of aviation GHG emissions are not possible in the short to medium term;

- not only are emissions from air travel increasing significantly in absolute terms but, against a background of emissions reductions from many other sources, their relative rate of increase is even greater. Put another way, "if the [recommended] reductions in carbon dioxide emissions from ground-level activities … are achieved, and the growth in air transport projected by the IPCC materialises, then air travel will become one of the major sources of anthropogenic climate change by 2050;"

- development of alternative jet fuels and aircraft technological developments, together with the development of more efficient operational practices and more efficient air traffic management systems and processes, will only partially offset the growth in aviation emissions;

- there is presently no systematic or compulsory incentive to reduce international aviation emissions;

- without government action to significantly reduce aviation growth within the UK, for example, aviation emissions may be greater than those forecast for all other sectors of the economy. As a result, aviation may exceed the carbon target for all sectors by 2050;

- as another example, "[i]f the aviation industry is allowed to grow at rates even lower than those being experienced today, the EU could see aviation accounting for between 39% and 79% of its total carbon budget by 2050, depending on the stabilisation level chosen. For the UK, the respective figures are between 50% and 100%;"

- the level of any carbon price faced by aviation should reflect the full contribution of emissions from aviation to climate change; and

- all other sectors of the economy would have to significantly decarbonise to allow the aviation industry to grow and to continue to use kerosene.

This last point is of particular concern as it raises the very real possibility of economic – and, thus, political – conflict between the airline industry and other sectors. This has the potential for unpredictable and destabilising outcomes.

3. Airline responses to the climate change problem so far (*pages 25 to 26 and page 32*)

The response of the airline industry to the climate change problem has to some extent been anomalous - that is, less proactive and more subdued - compared to that of other corporate and industry sector responses (although this is perhaps more true for North American airlines than for their European counterparts). The most common airline responses have been, broadly, as follows:

- continue - more or less - with business as normal;

- argue that the problem can – to a greater or lesser extent - be dealt with by improving air transport technology and infrastructure, by developing more efficient operational practices, and by calling for more efficient air traffic management systems and processes; and/or

- argue that a global solution should be developed, working through ICAO.

4. Possible airline action and adaptation strategies on aircraft emissions and climate change (*pages 27 to 28*)

Possible airline strategies for dealing with the greenhouse gas emissions problem include the following:

- continue with business as normal;
- improve air transport technology and develop alternative jet fuels;
- develop more efficient operational practices and call for more efficient air transport management systems and processes;
- support a cap-and-trade emissions trading scheme (ETS);
- support a cap-and-trade ETS with closed purchase of allowances;
- support a cap-and-trade ETS with open purchase of an industry allowance;
- support mandatory emissions offsets (support mandatory participation in an emissions offset market);
- as a preliminary step to support of mandatory emissions offsets, introduce an airline default – or *opt-out* - passenger emissions offset scheme; and/or
- introduce taxes and charges.

5. Assessment of possible airline strategies on aircraft emissions and climate change (*pages 29 to 57)*

A sustainable solution to the aviation GHG emissions problem must involve airline action and adaptation. After evaluating possible airline strategies, and analysis of the problems associated with inclusion of aviation in cap-and-trade emissions trading schemes, we conclude that airlines should seriously consider supporting mandatory emissions offsets as *part* of a forward-looking, long-term strategy package and a sustainable solution to deal with the climate impacts of aviation. Such action does not preclude other, complementary measures relating to technological, operational and management elements, which we suggest should also form part of a long-term strategy package. It does not preclude participation in an emissions trading scheme.

Carbon offsets “will only represent a sustainable solution if joined by improvements in technology and significant, international political action.”

We note that this strategy has not, as yet, been considered by airlines.

The inclusion of mandatory offsetting for some specified proportion of emissions has a number of benefits:

- purchase of offsets provides scope for new airline entrants and creates a stable market with comparatively greater long term predictability than under an aviation emissions trading scheme;

- such market provides more room for orderly airline expansion compared to expansion under an aviation ETS; and

- mandatory airline participation in an emissions offset market(s) is likely to promote innovation and technological solutions to the aviation climate change problem. As the price of offsets increases with demand, it is reasonable to anticipate the development of more sophisticated and diverse projects flowing from funds invested as a result of offsets purchased. Carbon offsets “do have their place in spurring innovation,” and offset firms “have prospered because they are able to produce emissions reductions more cheaply, and often more imaginatively, than those that are bound up in the red tape of the Kyoto process.”

Airline participation in an emissions offset market would encourage investment in and the development of new technology and new solutions as one part of a comprehensive climate strategy. Moreover, the nature of such mandatory participation, and the global industry involved, would give additional impetus to developments presently underway with regard to technologies which avoid, reduce or absorb GHG emissions - all matters of vital importance to the airline industry.

In our view the airline industry should (for a range of reasons) be moving ahead of – rather than waiting for – governments to take regulatory action, and should work on its own *strategy package* to present to governments. The aviation industry, not governments, should steer the process of change *to build a cleaner sky*.

We also suggest that, as a step prior to mandatory emissions offsets, airlines should introduce offsetting as an airline default – or opt-out – passenger emissions offset scheme. Such actions allows airlines to take action in the immediate future, thus absorbing demands that they address the climate costs of aviation in a least cost manner. It would also provide airlines with much-needed information as to public/ passenger sensibilities concerning the climate impacts of aviation and environmental charges (broadly defined) ahead of mandatory emissions offsets.

1. Introduction

Air transportation plays a substantial role in world economic activity, and society relies heavily on the benefits associated with aviation … Its customers represent every sector of the world's economy and every segment of the world's population ... [A]viation affects the lives of citizens in every country in the world, regardless of whether they fly …

Human-generated emissions at the Earth's surface can be carried aloft and affect the global atmosphere. The unique property of aircraft is that they fly several kilometers above the Earth's surface. The effects of most aircraft emissions depend strongly on the flight altitude and whether aircraft fly in the troposphere or stratosphere. The effects on the atmosphere can be markedly different from the effects of the same emissions at ground level …The rate of growth in aviation CO_2 emission is faster than the underlying global rate of economic growth, so aviation's contribution … to total emissions resulting from human activities is likely to grow in coming years.

- Intergovernmental Panel on Climate Change (IPCC),
Aviation and the Global Atmosphere[2]

Against a background of significant growth in air travel and aviation markets, and as a result of government and public focus on climate change and its consequences, pressure is being placed on airlines to reduce their greenhouse gas emissions. After examining the risks posed by climate change, this paper outlines the climate impacts of aviation and the difficult and unique challenges faced by airlines in dealing with their greenhouse gas emissions problem. Possible airline strategies for dealing with this problem are then assessed, and sustainable, long-term solutions for airlines identified.

2. Climate change, aviation and greenhouse gas emissions

2.1 Climate change

Scientific evidence now overwhelmingly shows that carbon dioxide and other greenhouse gases from human activities are changing the climate, and that this poses serious long term economic and political risks.[3] Climate change poses an urgent and significant problem for the world.[4] Put another way, climate change "is one of the greatest challenges of modern times."[5]

The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), "Climate Change 2007: The Physical Science Basis," (Working Group I) concludes that

> [g]lobal atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased markedly as a result of human activities since 1750 and now far

> exceed pre-industrial values … The global increases in carbon dioxide concentration are due primarily to fossil fuel use and land use change ….[6]

The IPCC has a "very high confidence"[7] that the globally averaged net effect of human activities since 1750 has been one of warming.[8]

Further,

> [w]arming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level … At continental, regional and ocean basin scales, numerous long-term changes in climate have been observed. These include changes in Arctic temperatures and ice, widespread changes in precipitation amounts, ocean salinity, wind patterns and aspects of extreme weather including droughts, heavy precipitation, heat waves and the intensity of tropical cyclones.[9]

The IPCC finds that "[m]ost of the observed increase in globally averaged temperatures since the mid-20th century is *very likely*[10]due to the observed increase in anthropogenic greenhouse gas concentrations … Discernible human influences now extend to other aspects of climate, including ocean warming, continental-average temperatures, temperature extremes and wind patterns."[11]

Following its summary of the physical science basis of climate change, the IPCC in April, 2007 released its assessment "of current scientific understanding of impacts of climate change on natural, managed and human systems, the capacity of these systems to adapt and their vulnerability:"[12] The IPCC concluded that "[s]ome large-scale climate events have the potential to cause very large impacts"[13] and that

> [o]bservational evidence from all continents and most oceans shows that many natural systems are being affected by regional climate change, particularly temperature increases … Much more evidence has accumulated over the past five years to indicate that changes in many physical and biological systems are linked to anthropogenic [man-made] warming …[14]

The extent of future vulnerability to climate change depends on "development pathways" taken.[15] More extensive adaptation than is presently taking place is needed in order to reduce vulnerability to, and the projected impacts of, future climate change. Sustainable development "can reduce vulnerability to climate change by enhancing adaptive capacity and increasing resilience." Over the long term, climate change effects will likely exceed the capacity of natural, managed and human systems to adapt which

> suggests the value of a portfolio or mix of strategies that includes *mitigation*, adaptation, technological development … and research. Such portfolios could combine policies with incentive-based approaches, and actions at all levels from the individual citizen through to national governments and international organizations.[16]

The May, 2007 IPCC Working Group III report, "Climate Change 2007: Mitigation of Climate Change,"[17] finds that global greenhouse gas (GHG) emissions increased 70% between 1970 and 2004[18] and that, with "current climate change mitigation policies and related sustainable development practices, global GHG emissions will continue to grow over the next few decades."[19] With regard to mitigation in the short and medium term,[20] the report found "much evidence" from both bottom-up and top-down studies that "there is substantial economic potential for the mitigation of global GHG emissions over the coming decades, that could offset the projected growth of global emissions or reduce emissions below current levels."[21]

IPCC Working Group III considers key mitigation technologies and practices that are (a) currently commercially available; and (b) projected to be commercialised before 2030. In the transport sector there are multiple mitigation options, but the effect of those options "may be counteracted by growth in the sector." Such mitigation options "are faced with many barriers, such as consumer preferences and lack of policy frameworks."[22] In terms of the aviation sector,

> [m]edium term mitigation potential for CO_2 emissions … can come from improved fuel efficiency, which can be achieved through a variety of means, including technology, operations and air traffic management. However, such improvements are expected to only partially offset the growth of aviation emissions. *Total mitigation potential in the sector would also need to account for non-CO_2 climate impacts of aviation emissions*.[23]

For aviation, in terms of key mitigation technologies and practices either currently available or projected, the report only refers to projected higher efficiency aircraft.[24] Further, when the report considers "selected sectoral policies, measures and instruments that have shown to be environmentally effective in the respective sector in at least a number of national cases," no aviation examples are available or provided.[25]

With regard to policies, measures and instruments to mitigate climate change, "a wide variety of national policies and instruments are available to governments to create the incentives for mitigation action" and there are advantages and disadvantages for any given instrument. For example, taxes and charges can set a price for carbon but cannot guarantee any particular emissions level. Similarly, emissions permits establish a carbon price through market mechanisms. However, "[t]he volume of allowed emissions determines their environmental effectiveness, while the allocation of permits has distributional consequences. Fluctuation in the price of carbon makes it difficult to estimate the total cost of complying with emission permits."[26]

Finally, "policies[27] that provide a real or implicit price of carbon could create incentives for producers and consumers to significantly invest in low-GHG products, technologies and processes."[28] And within each industry sector, "an effective carbon price signal could realize significant mitigation potential."[29]

Climate change, then, "presents very serious global risks."[30] In November, 2006 Sir Nicholas Stern's *The Economics of Climate Change* (the Stern Review) concluded in part that "climate change is a serious global threat, and it demands an urgent global response."[31] It finds that

> Climate change will affect the basic elements of life for people around the world – access to water, food production, health, and the environment. Hundreds of millions of people could suffer hunger, water shortages and coastal flooding as the world warms … Our actions now and over the coming decades could create risks of major disruption to economic and social activity, on a scale similar to those associated with the great wars and the economic depression of the first half of the 20th century.[32]

The Stern Review concludes that three policy elements are required for an effective global response to global warming and the resulting climate change (what the Stern Review refers to as "the greatest market failure the world has ever seen"[33]):

- the pricing of carbon (implemented through tax, trading or regulation);
- policy to support innovation and deployment of low-carbon technologies; and
- the removal of barriers to energy efficiency and to inform and educate individuals about responses to climate change.[34]

Both the Stern Review and prominent scientists refer to "dangerous" climate change. In the *Proceedings of the National Academy of Sciences*, published just before the release of the review, in September, 2006, scientists conclude

> data suggests that … probably the planet as a whole … is approximately as warm now as at the Holocene maximum and within ~1C of the maximum temperature of the past million years. We conclude that global warming of more than ~1C, relative to 2000, will constitute "dangerous" climate change as judged from likely effects on sea level and extermination of species ...[35]

The Tyndall Centre for Climate Change Research has said that avoiding dangerous climate change may ultimately require industrialised nations to cut emissions by between 80% and 95%.[36] And a 2006 report which builds on the scientific findings presented at the International Symposium on Stabilisation of Greenhouse Gas Concentrations - a conference attended by more than 200 scientists and representatives from international organisations and national governments, representing some 30 countries – examines "the long-term implications of different levels of climate change for different sectors and for the world as a whole."[37] The report, *Avoiding Dangerous Climate Change*,[38] finds that, since the release of the IPCC's Third Assessment Report in 2001,

> [t]here is greater clarity and reduced uncertainty about the impacts of climate change across a wide range of systems, sectors and societies. In many cases the risks are more serious than previously thought … Adaptation and alternative development pathways need to be taken into account in developing strategies to avoid dangerous anthropogenic climate change.[39]

The IEA *World Energy Outlook 2006* states that, on current energy trends, CO_2 emissions will increase by 55% between 2004 and 2030.[40] As the summary of the conference report makes clear, this "means that the world will, in the absence of urgent and strenuous mitigation actions in the next 20 years, almost certainly be committed to a temperature rise of between about 0.5 C and 2 C relative to today by 2050."[41]

A dwindling number of governments and corporations still claim that the scientific debate is not over and that action to combat climate change is not necessary, or that it is not necessary for the immediate future. These claims are, in mid-2007, no longer credible. The Royal Society, the UK's national academy of science, recently accused Exxon of misleading the public into thinking that the role of humans in climate change was still open to doubt, and of misrepresenting scientific opinion, including that expressed in an IPCC report.[42]

2.2 Aviation and climate change

(a) Growth in aviation markets, numbers of passengers and numbers of aircraft

> *[T]he airline industry is poised for an almost unprecedented boom, as a new generation of planes is combining with better business models and huge volume growth in new markets.*[43]

Air transport "is one of the fastest-growing sectors of the world economy."[44] 2006 and 2007 forecasts by Airbus, Boeing and the Airports Council International (ACI) demonstrate that there will be almost unprecedented growth in aviation markets and passenger and aircraft over the next 20 years (Boeing and Airbus) and in the number of air travellers to 2025 (ACI).

Boeing's July, 2006 forecast for 2006-2025 (its most recent[45]) is for an annualised global passenger traffic growth rate of 4.9% and cargo growth rate of 6.1% against worldwide average economic growth of 3.1%.[46] Boeing forecasts estimate that just over 27,000 new aircraft will be delivered over the next 20 years (more than doubling the current worldwide fleet of aircraft) for a total value of USD 2.6 trillion.[47] Similarly, Airbus' forecast, released at the end of 2006, stated that 22,700 new aircraft will be needed to met demand through 2025.[48]

ACI's 2007 forecast stated that the number of air travellers will double by 2025 to more than 9 billion per year; over the same period, air freight will triple.[49] Passengers travelling through its airports will grow at an average annual rate of 4%. The International Air Transport Association (IATA) forecasts international passenger traffic growth in the period 2006-2010 of 6.9% (Middle East), 5.7%

(Asia Pacific) and 5.1% (Africa). For the same period, in the same regions, IATA's 2007 forecasts for international cargo growth are, respectively, 5.8%, 6% and 5%.[50]

Aviation growth will be most significant in the Asia Pacific region.[51] Indeed, for ACI, Asian air travel will increase 9% annually.[52]

It should be noted that, notwithstanding forecast growth in aviation markets and passenger and aircraft numbers, and strong 2006 revenues, a weakening of the global economy could adversely affect aviation industry performance. Potential aircraft overcapacity – record aircraft orders – may be problematic,[53] as could oil price rises.

This is a time, then, of significant actual and forecasted aviation growth in the aviation sector. Section 2.2(c) of this paper explores some of the difficulties in addressing the climate impacts of aviation at a time of such growth, specifically "how to make room for the aviation industry?"[54] In order to address this question, close consideration must be given to the actual climate impacts of aviation; this is expounded in section 2.2(b). Our analysis of possible strategies for airlines on emissions and climate change is then set out in sections 3 and 4.

(b) Climate impacts of aviation[55]

A number of reports assessing the impacts of aviation on the global atmosphere, beginning with the 1999 IPCC report, are considered below. The footnotes refer to additional reports which also consider the climate impacts of aviation.

→ IPCC, *Aviation and the Global Atmosphere* (1999)[56]

In its 1999 report, the IPCC concluded that *in 1992* emissions of carbon dioxide by aircraft represented about 2% of total anthropogenic (or man-made) carbon dioxide emissions[57] about 13% of carbon dioxide emissions from all transportation sources.[58] However, during flight, in addition to carbon dioxide, aircraft engines also emit nitric oxide and nitrogen dioxide (together, NOx, which form ozone[59] at altitude), as well as oxides of sulphur, water vapour (resulting in contrails and cirrus clouds at altitude), hydrocarbons and particles. Uniquely, most of these emissions occur far above the earth's surface:[60]

> [a]ircraft emit gases and particles directly into the upper troposphere and lower stratosphere where they have an impact on atmospheric composition. These gases and particles alter the concentration of atmospheric greenhouse gases, including carbon dioxide (CO_2), ozone (O_3), and methane (CH_4); trigger formation of condensation trails (contrails); and may increase cirrus cloudiness - all of which contribute to climate change.[61]

Aircraft emissions of nitric oxide and nitrogen dioxide "are more effective at producing ozone in the upper troposphere than an equivalent amount of emission at the surface. Also increases in ozone in the upper troposphere are more effective at increasing *radiative forcing* than increases at lower altitudes."[62]

A 2006 Oxford University report by Cairns and Newson states:

> The combined effect of these other emissions is to add significantly to the climate change impacts of aviation, *over and above those caused by its CO2 emissions alone*.[63] The fact that aviation's climate impacts are 'significantly worse' than those caused by its carbon dioxide emissions is scientifically *uncontroversial*.[64]

Put another way, as stated in the May, 2007 IPCC Working Group III report, "Climate Change 2007: Mitigation of Climate Change,"[65] total climate change mitigation potential in the aviation sector "would also need to account for non-CO_2 climate impacts of aviation emissions."[66] Importantly, in an aviation context, "CO_2 is not the only gas"[67] that contributes to climate change.

As summarised in the report of a workshop held at MIT in June, 2006, which considered the impacts of aviation on climate change, "[a]ircraft emissions can alter the radiative budget of the Earth and contribute to human-induced climate change through several different ways."[68]

In order "to estimate the relative and absolute importance of various activities and emissions on climate,"[69] the IPCC uses the *climate metric* known as "radiative forcing," which is a globally averaged measure of the imbalance in radiation caused by the sudden addition of the activity or emission.[70] In the IPCC's calculation,

> [t]he Radiative Forcing Index (RFI) - the ratio of total radiative forcing to that from CO2 emissions alone - is a measure of the importance of aircraft-induced climate change *other than that from the release of fossil carbon alone*. In 1992, the RFI for aircraft is 2.7.[71]

As a result, "[t]he best estimate of the radiative forcing in 1992 is … about 3.5% of the total radiative forcing by all anthropogenic activities"[72] The 2002 Royal Commission on Environmental Pollution's *The Environmental Effects of Civil Aviation in Flight* confirmed this estimate.[73]

The major, large-scale environmental problem associated with the continuing expansion of aviation is the forcing of climate change.[74] While the IPCC calculations set out above refer to 1992, the IPCC also examined a range of growth scenarios for aviation to 2050. It concluded as follows:

> Over the period from 1992 to 2050, the overall radiative forcing by aircraft (excluding that from changes in cirrus clouds) for all scenarios in this report is a factor of 2 to 4 larger than the forcing by aircraft carbon dioxide alone. The overall radiative forcing for the sum of all human activities is estimated to be at most a factor of 1.5 larger than that of carbon dioxide alone.[75]

The 2002 Royal Commission on Environmental Pollution considered the IPCC's calculations to be conservative:

> In summary, we consider that the IPCC reference value for the climate impact of aviation is more likely to be an under-estimate rather than over-estimate. We conclude that, unless there is some reduction in the growth in the sector, or technology improves considerably more than was assumed by IPCC, by 2050 aviation will be contributing at least 6% of the total radiative forcing consistent with the necessary stabilisation of climate. A safer working hypothesis is that it will be in the range 6% - 10%.[76]

As the report of the workshop held at MIT (which considered the impacts of aviation on climate change) notes, "there has been no comprehensive attempt [since the 1999 IPCC aviation report] to update the science and the associated uncertainties [of the impacts of aviation on the global atmosphere]," although new information has become available.[77] That report, *Workshop on the Impacts of Aviation on Climate Change: A Report of Findings and Recommendations*, is considered further below.[78]

→ United States GAO,[79] *Aviation and the Environment: Aviation's Effects on the Global Atmosphere Are Potentially Significant and Expected to Grow* (2000)[80]

The United States General Accounting Office (GAO) states at the outset of its report that aviation "is one of the fastest-growing sectors of the world economy" and, thus, "the impact of aircraft emissions on the earth's atmosphere and climate is a concern for transportation planners and policymakers."[81] It concludes that aviation emissions "comprise a potentially significant and growing percentage of human-generated greenhouse gases and other emissions that are thought to contribute to global warming."[82]

For the GAO, aircraft emissions are potentially significant because:

- jet aircraft are the main source of human emissions released directly into the upper atmosphere;
- emissions (carbon dioxide and other gases and particles emitted by aircraft[83]) could have 2 to 4 times the effect of CO_2 alone on the atmosphere; and
- the IPCC concluded that "the increase in aviation emissions attributable to a growing demand for air travel would not be fully offset by reductions in emissions achieved through technological improvements alone."[84]

The GAO's conclusion is based on its assessment of the 1999 IPCC report – like other studies and reports considered here - together with "consultations with knowledgeable agency officials and other experts."[85] It also notes that while aviation, scientific and environmental experts argue that aviation will grow on a

global basis and increasingly contribute to human-generated emissions, those experts differ "in the rates of growth they project and the effects they anticipate."[86]

→ Royal Commission on Environmental Pollution, *The Environmental Effects of Civil Aviation in Flight* (2002)[87]

This report is considered above in the context of the IPCC assessment.

→ Waitz et al, *Aviation and the Environment* (2004)[88]

The report by Waitz et al – a report to the United States Congress – states that there is "a compelling case for urgent national [US] action to address the environmental effects of air transportation" and notes that "environmental concerns are strong and growing."[89] It notes that, "[a]s a result of growth in air transportation, emissions of many pollutants from aviation activity are increasing against a backdrop of reductions from many other sources,"[90] and that

> non-US concerns and regulatory action are increasingly setting conditions for the world's airlines and manufacturers. For example, within the European Union the climate effects of aviation are identified as the most significant adverse impact of aviation … However, there is considerable uncertainty in assessing the climate effects of aircraft …[91]

Further, "[b]ecause of the uncertainty in understanding the impacts of aviation on climate, appropriate technological, operational and policy options for mitigation are also uncertain."[92] Such uncertainties have, since the 2004 report, been reduced, just as "[s]ince the IPCC study, the scientific understanding of some of the chemical and physical effects (particularly contrails and the cirrus clouds they may induce) has evolved."[93]

The report cites the 1999 IPCC report[94] and the Royal Commission on Environmental Pollution.[95] and summarises the challenge of reducing aviation environmental impacts as follows:

> Reducing significant aviation environmental impacts in absolute terms is a challenging goal, especially when considered in light of the projected growth in aviation traffic … [and] these reductions will be difficult to sustain as traffic grows. Further, there are areas (such as NOx emissions) where technological improvements and operational procedures combined have not been enough to offset the increase in emissions associated with traffic growth.[96]

→ Sausen et al, *Aviation Radiative Forcing in 2000: An Update on IPCC* (1999) (2005)[97]

In general terms, Sausen et al confirm the IPCC conclusion that the total radiative forcing due to aircraft is 2 to 4 times that due to carbon dioxide emissions alone.[98]

→ Cairns and Newson, *Predict and decide: Aviation, climate change and UK policy* (Environmental Change Institute, University of Oxford) (2006)[99]

While this University of Oxford report assesses the implications of aviation growth in the UK, it presents at the outset a summary of existing statistics about the scale of aviation's contribution to climate change. One report summarised, that of the IPCC, is considered above. Another, a 2004 UK Department for Transport (DfT) White Paper, *The Future of Transport*, states that

> If UK aviation is defined as all domestic services plus all international departures from the UK, then the aviation sector currently contributes about 5.5% of the UK's CO2 emissions but, because of radiative forcing, 11 per cent of total UK climate change impact. [100]

For Cairns and Newson, the authors of the report,

> studies of the emissions from aviation all indicate that its climate impacts are considerably worse than the effects of its CO2 emissions alone. Moreover, the non-CO2 emissions have a powerful short-term impact on climate. This could be particularly important, given the urgent imperative to address climate change in the short-term to avoid runaway climate change.[101]

They conclude that

> [b]y 2050, the most *conservative estimate*[102] of aviation's future significance … suggests that, between 1990 and 2050, the carbon dioxide emissions from aviation will approximately quadruple. Other forecasts suggest that the carbon dioxide from aviation could grow by more than 10 times over that period … In addition to carbon dioxide, aviation emits other substances which have a range of additional climate impacts. One estimate suggests that, *in a period of 12 months*, the damage caused by CO2 contrails and NOx emissions from aviation is 36 times as bad as that caused by CO2 alone … [T]here is no doubt that the non-CO2 emissions from aviation add significantly to the climate impacts of aviation …[103]

→ Tyndall Centre for Climate Change Research, Anderson et al, *Growth Scenarios for EU & UK Aviation: Contradictions with Climate Policy* (Tyndall Centre for Climate Change Research) (2006)[104]

Both the IPCC report, *Aviation and the Global Atmosphere*,[105] and the Royal Commission on Environmental Pollution, *The Environmental Effects of Civil Aviation in Flight*,[106] are referenced here. With regard to the IPCC study, it finds that the reference scenario used to produce the IPCC's estimate of radiative forcing from aircraft[107] in 2050 (versus 1992) – about 14% of the total radiative forcing for 1992 – "assumes both lower aviation growth than that seen in the period up to 11 September 2001, and large technological advances."[108] It cites with approval the Royal Commission on Environmental Pollution's finding that "the IPCC reference value for the climate impact of aviation [is] more likely to be

an under-estimate than an over-estimate of aviation's contribution to radiative forcing."[109] And the study takes account of the IPCC's calculation of the radiative forcing caused by aviation emissions as 2.7 times higher than the radiative forcing of CO_2 emissions alone, but also provides estimates that don't take account of that 2.7 factor.[110]

The Tyndall Centre's conclusions with regard to aviation growth scenarios and trends as set out in this study, together with the conclusions of other studies, are outlined at section 2.2(c) below.

→ Next Generation Air Transportation System/Joint Planning and Development Office (NGATS/JPDO) Environmental Integrated Product Team and Partnership for AiR Transportation Noise and Emissions Reduction (PARTNER), *Workshop on the Impacts of Aviation on Climate Change: A Report of Findings and Recommendations* (2006)[111]

The penultimate report examined here, one of the findings and recommendations of the June, 2006 MIT workshop on the impacts of aviation on climate change, has been referred to above in footnotes qualifying and expanding on some of the earlier reports considered in this working paper, and is referred to again below in the context of aircraft technological developments. The report also deals with a number of reports and studies which have been considered in this paper.

The report makes findings in three areas:

- emissions in the upper troposphere and lower stratosphere (UT/LS) and resulting chemistry effects;
- contrails and cirrus; and
- climate impacts and climate metrics.

With regard to emissions in the UT/LS, the report notes that, since the 1999 IPCC report, substantial improvements have been made "in the chemistry-transport modeling tools used to evaluate the impacts of aviation NO_x emissions on O_3 and CH_4."[112] Nonetheless, it identifies uncertainties and gaps in evaluating aviation effects on climate, including:

- aircraft emissions of gases and particles;
- the fundamental NO_x and HO_x chemistry of the upper troposphere;
- lightning NO_x;
- plume processing of aircraft NO_x in the first 24 hours;
- coupling and feedbacks of tropospheric CH_4-CO-OH-O_3;
- climate change;

- "scavenging;" and
- transport and "mixing."[113]

With regard to contrails and cirrus,

> Aircraft-induced contrail-cirrus add significantly to the natural high cloud cover and have the potential, albeit with large uncertainties, for a relatively large positive radiative forcing (direct effect). Line-shaped contrails are only a portion of the total climate impact of aviation on the cloudiness. Recent correlation analyses between real-time regional-scale air traffic movements and the occurrence of contrail structures detectable with satellites, suggest the global coverage of persistent, spreading contrails (contrail-cirrus) and inferred radiative forcing might be underestimated by an order of magnitude or more, but large uncertainties remain.[114]

In terms of those uncertainties – and gaps – in contrail-cirrus and other aircraft-induced effects on cirrus clouds, they include plume particle processing; optical properties of contrails, contrail-cirrus and cirrus; detection and prediction of ice super-saturation; in-situ measurements of aerosol chemistry and small ice crystals; properties of heterogeneous ice nuclei from natural and anthropogenic sources; interactions between heterogeneous ice nuclei and cirrus clouds; incorporation of effects of aviation-induced
particles and cirrus into global models; representation of aerosols and contrails in global atmospheric models; and long-term trends in contrail-cirrus and cirrus.[115]

The third part of the report deals with climate impacts and climate metrics.[116] Uncertainties and gaps identified include optical properties of contrails, contrail-cirrus, and cirrus, as well as defining metrics for trade-offs. Further,

> There remain significant uncertainties on almost all aspects of aircraft environmental effects on climate, with the exception of the radiative forcing from the CO2 emissions. The ozone and methane RFs from NOx emissions are opposite in sign, so the extent to which they offset each other is an important uncertainty. Estimates for contrails and cirrus are particularly highly uncertain … The overall conclusion from … analyses is that significant uncertainties still remain in quantifying the impacts of aviation emissions on climate.[117]

→ Stern, *The Economics of Climate Change* (the Stern Review) (2006)[118]

The Stern Review was considered above in the context of climate change generally. One conclusion of the review is that it will become increasingly important to extend the coverage of carbon pricing and other measures to international aviation, and that "there is currently no incentive to reduce international aviation emissions."[119]

In terms of the climate impacts of aviation, the Stern Review finds that "CO_2 emissions from aviation are expected to grow over three-fold in the period to 2050, making it among the fastest growing sectors"[120] and that, between 2005

and 2050, “emissions are expected to grow fastest from aviation (tripling over the period, compared to a doubling of road transport emissions).”[121] It also finds that international aviation emissions are almost twice as great as domestic emissions and, most importantly for present purposes, that aviation’s impact on climate change is higher than simply the impact of its CO_2 emissions[122] (in this the review reflects similar findings in other studies referred to above), stating that

> the impact of aviation on climate change is greater than … figures suggest because of other gases released by aircraft and their effects at high altitude. For example, water vapour emitted at high altitude often triggers the formation of condensation trails, which tend to warm the earth’s surface. There is also a highly uncertain global warming effect from cirrus clouds (clouds of ice crystals) that can be created by aircraft.[123]

The review cites the IPCC figures concerning the radiative forcing of aviation as 2 to 4 times greater than the effect of CO_2 emissions alone.[124]

On the non-CO_2 effects of aviation, Stern notes that “there is no internationally agreed methodology for presenting the warming effects of emissions from aviation as CO_2e so it is excluded from emission estimates.”[125] The lack of an agreed international methodology gives rise to one of the key issues flowing from any study of the climate impacts of aviation: How to take account of the full contribution of aviation to climate change, not simply the impact of CO_2 emissions alone?[126]

Stern puts forward a number of possible solutions to this issue, among them setting high carbon taxes on aviation[127] and either inclusion of aviation in an existing emissions trading scheme or a closed aviation scheme:

> To account for the complete impacts of aviation within an ETS, some form of discounting could be used, analogous to the global warming potential factors that are used to convert GHG emissions to CO2 equivalent emissions. Alternatively, combining emissions trading with a tax could provide extra revenue.[128]

Put another way,

> [t]he level of the carbon price faced by aviation *should reflect the full contribution of emissions from aviation to climate change* … [T]he impact of aviation is two to four times higher than the impact of the CO2 emissions alone. This should be taken into account, either through the design of a tax or trading scheme,[129] through both in tandem, or by using additional complementary measures.[130]

The question as to how to reconcile aviation growth trends with effective, long-term climate policy is dealt with in section 4, the core part of the paper, which examines in detail possible airline strategies for dealing with the climate impacts of aviation.

(c) Aviation growth trends and carbon emissions reductions: "Making room for the aviation industry"[131]

> *If the reductions in carbon dioxide emissions from ground-level activities recommended in the Commission's Twenty-Second Report*[132] *are achieved, and the growth in air transport projected by IPCC materialises, then air travel will become one of the major sources of anthropogenic climate change by 2050*.
>
> - Royal Commission on Environmental Pollution, *The Environmental Effects of Civil Aircraft in Flight*[133]

In section 2.2(a), Airbus, Boeing, IATA and ACI forecasts with regard to growth in aviation markets, numbers of passengers and numbers of aircraft made were outlined. In section 2.2(b), a number of reports assessing aviation's contribution to climate change were considered. This section, ahead of an analysis of possible strategies for airlines on greenhouse gas emissions and climate change, briefly examines difficulties - or dilemmas - in addressing the climate impacts of aviation at a time of significant aviation growth, both actual and forecast. For this purpose, the UK and the EU are used as examples. As this paper is part of an ongoing project which examines airline strategies on climate change in greater detail, a subsequent report which sets out the results of such examination will look at jurisdictions additional to the UK and the EU.

→ Cairns and Newson, *Predict and decide: Aviation, climate change and UK policy* (Environmental Change Institute, University of Oxford) (2006)[134]

The Cairns and Newson report considered earlier at section 2.2(b) summarises a number of UK reports[135] and makes findings with regard to aviation CO_2 emissions and how they relate to UK emissions targets. From those reports it is clear that aviation emissions doubled between 1990 and 2000[136] and that, without the application of what Cairns and Newson term "economic instruments," aviation emissions

> are forecast to at least double again between 2000 and 2050, meaning that they will quadruple during a period in which overall UK emissions are aiming to reduce by 60% … By 2050, other sectors would have to reduce their emissions by even more than forecast – specifically, by about 71% - in order to compensate for the growth in aviation.[137]

A summary of data from studies in 2003 and 2004,[138] 2005[139] and 2006[140] produces the conclusion that, by 2050, aviation CO_2 emissions would have increased by between 4 and 10 times compared to 1990 levels and, hence, "aviation could account for between 27% and 67% of all UK target emissions by that point, requiring other sectors to cut their emissions by between about 71% and 87% of 1990 levels."[141]

The non-CO_2 climate effects of aviation were outlined at section 2.2 (b).

Cairns and Newson state as follows:

> [T]he carbon dioxide emissions from aviation are forecast to reach between 17.4 million and 44.4 million tonnes of carbon, at a time when the UK is attempting to limit the carbon emissions of all its activities to only 65 million tonnes of carbon. In addition, *the impacts of aviation will be significantly worse than those of its carbon dioxide emissions alone*. Hence, the implication is that a significant reduction in the projected growth of aviation is required and it will be impossible to reduce the UK's climate change impacts to the extent needed to meet international aspirations unless action is taken to curb aviation growth.[142]

Thus, the study concludes that there is an urgent need to introduce a policy of "demand restraint."[143]

→ Tyndall Centre for Climate Change Research, *Decarbonising the UK: Energy for a Climate Conscious Future* (Tyndall Centre for Climate Change Research) (2005)[144]

The Tyndall Centre study produces a number of "decarbonising the UK" scenarios with the aim of providing "a whole system understanding" of how the UK government can achieve a "true" 60% CO_2 reduction target by 2050.[145] With regard to aviation, its research "clearly demonstrates" that, absent government action to significantly reduce aviation growth, emissions from aviation will outstrip carbon reductions envisaged for all other economy sectors[146] - what it calls (with reference to both the UK *and the EU*) "a looming problem in the skies."[147]

In terms of its UK aviation scenario, the study states current aviation industry growth of about 8% per annum. Contrasting emission reduction profiles for both 550 and 450 ppmv atmospheric concentration of CO_2 with increasing aviation emissions,[148] it concludes that there are "severe" implications of allowing even "moderate" growth in aviation for the UK's carbon reduction obligation; 50% of the 550ppmv emissions is subsumed by aviation, and as against a 450ppmv stabilisation level, aviation "will exceed the carbon target *for all sectors* by 2050.[149] For more than any other industry sector, aviation "with its continued reliance on kerosene and its high growth rate, threatens the integrity of the UK long-term climate change target."[150] Moreover, it concludes that

> The [2003 UK Government's Aviation] White Paper supports continued aviation growth, with plans for new runways at Birmingham, Edinburgh, Stansted and Heathrow airports,[151] along with new terminals and runway extensions throughout the UK.[152] Within the earlier 2003 Energy White Paper, the UK Government outlined its plans to reduce carbon emissions by 60% by 2050. However, given the absence of an international agreement on how to apportion aviation emissions between nations, only domestic aviation emissions were included within this 60% target. Omitting the fastest growing emissions sector from the target cannot be reconciled with the Government's claim that the target relates to stabilizing carbon dioxide concentrations at 550ppmv. In other words,

> international aviation must be included if the UK Government is to make its 'fair' contribution towards the 550ppmv target."[153]

In terms of its EU aviation scenario, the study states current aviation industry growth at mean of 7.7% per annum. Contrasting emission reduction profiles for both 550 and 450 ppmv atmospheric concentration of CO_2 with increasing aviation emissions, it concludes that the EU 25's aviation sector takes up almost 40% of the total permissible emissions for all sectors in 2050 (the 550ppmv regime) and as much as 80% (the 450ppmv regime).[154] The projections "highlight … the conflict between a contracting carbon target and the EU's expanding aviation industry."[155]

After finding that technical and operational improvements will only offer small reductions in fuel burn, the Tyndall study further finds that the aviation industry "is in the unenviable position of *seeing the demand for its services grow at unprecedented rates, whilst at the same time being unable to achieve substantial levels of decarbonisation in the short to medium-term*."[156] Moreover, the Tyndall Centre views as revealing

> the enormous disparity between both the UK and EU positions on carbon reductions and their singular inability to seriously recognise and adequately respond to the rapidly escalating emissions from aviation. Indeed, the UK typifies the EU in actively planning and thereby encouraging continued high levels of growth in aviation, whilst simultaneously asserting that they are committed to a policy of substantially reducing carbon emissions. The research conducted within this project not only quantifies the contradictory nature of these twin goals, but also illustrates how constrained the responses are. Given that it may be many years before … a comprehensive international emissions trading system tied to an adequate emissions cap [is operational], ultimately the UK and the EU face a stark choice: to permit high levels of aviation growth whilst continuing with their climate change rhetoric or to convert the rhetoric into reality and substantially curtail aviation growth.[157]

→ Anderson et al, *Growth Scenarios for EU & UK Aviation: Contradictions with Climate Policy* (Tyndall Centre for Climate Change Research) (2006)[158]

This report develops aircraft emissions scenarios for the period 2002-2050 for each EU state[159] and compares those scenarios with national carbon "contraction and convergence" profiles[160] for 450 ppmv and 550 ppmv[161] CO_2 concentration stabilisation levels for EU member states.[162] The results

> show that a significant portion of annual emissions budget will be attributable to the aviation industry for the aggregated EU 125 nations, as is also the case when separated into the original EU 15 nations, the 10 new accession states and looking at the UK alone. If the aviation industry is allowed to grow at rates even lower than those being experienced today, the EU could see aviation accounting for between 39% and 79% of its total carbon budget by 2050, depending on the stabilisation level chosen. For the UK, the respective figures are between 50% and 100%.[163]

The study also finds that if the EU commits to "substantial long-term cuts" in CO_2 emissions, implemented on a contraction and conversion basis,[164] "it is unlikely that the level of UK aviation growth projected by DfT in the aviation White Paper will be accommodated within a European ETS alone."[165]

Moreover, applying the IPCC 2.7 uplift factor, the aviation industry's proportion of human-induced climate change significantly increases.

> Uplifted EU aviation emissions alone would exceed the 550ppmv contraction and convergence target for the EU by 2050, leaving no emissions space for any other sectors. Even by 2030, application of the 2.7 uplift factor shows aircraft taking 34% of the EU carbon allowance under the 550ppmv regime and 50% for the 450ppmv regime. As it appears unlikely that any alternative to kerosene as an aviation fuel will be in widespread use by 2030, permitting these emissions would require either major changes to EU energy supply and consumption or a commensurate purchase of emissions credits from elsewhere in the world.[166]

For Anderson et al, reconciling aviation emissions growth, economic growth on a global basis of more than 4% annually, and climate change targets at the level of 550ppmv or less "must be in doubt" and is a matter which "requires urgent investigation," even within any global emissions trading system.[167]

On the analysis as presented in this report, "all of the other sectors of the economy must significantly decarbonise to allow the aviation industry to grow and to continue to use kerosene up to 2050."[168]

→ Bows and Anderson, "Policy Clash: Can Projected Aviation Growth be Reconciled with the UK Government's 60% Carbon-Reduction Target,"*Transport Policy* (2007)[169]

Although not a detailed study or report,[170] this paper is included because it both updates 2005 and 2006 studies from the Tyndall Centre and deals with the impact of aviation growth from today to 2050 for both the UK and the EU, as well as with the implications for aviation and its inclusion in the EU ETS.

The paper's main points (in the order in which they are made) are as follows:

- CO_2 emissions from the EU's aviation industries are growing rapidly, and the UK's aviation industry is the fastest growing source of CO_2 emissions of any sector of the UK economy;[171]

- aviation industry emissions between now and 2040 are expected to grow rapidly, and such emissions growth "will have a profound effect on the UK as it attempts to significantly reduce its emissions from the economy as a whole;"[172]

- the UK government endorses a target of reducing UK CO_2 emissions by 60% by 2050. Inclusion of aviation in that target "has dramatic

consequences for other key sectors of the economy, many of which also have increasing emissions;" [173]

- "explicitly facilitating growth in aviation, where no short- to medium-term alternatives to using kerosene or step changes in fuel efficiency improvements are envisaged, will undoubtedly seriously constrain the emission space available in other sectors. Furthermore … [indications are] that under the 450ppmv stabilisation profile, *all* other sectors of the economy will need to significantly, possibly completely, decarbonise by 2050 if the respective carbon-reduction target is not to be exceeded;"[174] and

- emissions from international aviation are excluded from Kyoto and all other national and international climate change targets; "effective climate change targets must include, urgently, emissions from aviation … In the absence of explicit policies to curb aviation growth, global emissions from this sector will continue to grow rapidly as passenger demand outstrips substantially improvements in both fuel efficiency and carbon intensity … [T]he current very high emissions growth rates will result in the aviation industry being increasingly responsible for a large proportion of the EU's total carbon budget."[175]

→ European Federation for Transport and Environment and Climate Action Network Europe, *Clearing the Air: The Myth and Reality of Aviation and Climate Change* (2006)[176]

This July, 2006 report summarises the findings of a number of recent studies, some of which have been considered above. It examines 12 questions about the climate impacts of aviation in two parts - (a) the impact of aviation on climate change;[177] and (b) climate policy measures for aviation presently under consideration[178] - and is concerned with separating the "myth from the reality" in these areas.

On the climate impacts of aviation, the study concludes as follows:

> [I]n 2000, aviation was responsible for 4 to 9 per cent of the climate change impact of global human activity – the range reflecting uncertainty surrounding the effect of cirrus clouds … aviation has by far the greatest climate impact of any transport mode, whether measured per passenger kilometre, per tonne kilometre, per € spent, or per hour spend … [and] the importance of aviation for the economy and employment is far less than its importance for climate change.[179]

With regard to the climate impacts of aviation the most common airline responses have been, broadly, as follows (although there has been some difference in terms of response between European and North American airlines):

- continue - more or less - with business as normal. In this regard, compared with other industry and corporate responses to the problem, the airline industry response has been less proactive and more subdued;[180]

- argue that the problem can – to a greater or lesser extent - be dealt with by improving air transport technology and infrastructure, by developing more efficient operational practices, and by calling for more efficient air traffic management systems and processes; and/or

- argue that a global solution should be developed, working through the International Civil Aviation Organisation (ICAO) (IATA "urges" States "not to jump the gun on emissions trading but to wait for the ICAO Assembly's recommendations in September, 2007"[181]).

Possible strategies for airlines on climate change and aircraft GHG emissions are set out below, together with assessment of them.

3. "Difficult challenges:" Possible airline strategies for dealing with the greenhouse gas emissions problem

Aviation faces some difficult challenges. Whilst there is potential for incremental improvements in efficiency to continue, more radical options for emissions cuts are very limited. The international nature of aviation also makes the choice of carbon pricing instrument complex … and … [i]nternationally coordinated taxes are difficult to implement … the choice of tax, trading or other instruments is likely to be driven as much by political viability as by the economics …

- Sir Nicholas Stern,
The Economics of Climate Change (2006)[182]

Possible airline strategies for dealing with the greenhouse gas emissions problem are as follows:

- *continue with business as normal*;
- *improve air transport technology and develop alternative jet fuels*;
- *develop more efficient operational practices and call for more efficient air transport management systems and processes*;
- *support a cap-and-trade ETS*: airlines would be *allocated* allowances according to a baseline, and would be able to either sell their unused portion or would have to buy credits to ensure that their emissions are covered. Such schemes might either be closed or open. In a closed scheme, purchases have to be made from the same industry; in an open scheme, purchases can be made on an open market. The EC proposes to include aviation in the EU ETS in two phases, from 2011 and 2012;
- *support a cap-and-trade ETS with closed purchase of allowances*: aviation operators would be required to purchase the initial allowance, with the amount purchased determined by a baseline;
- *support a cap-and-trade ETS with open purchase of an industry allowance*: the *industry* would be allocated an allowance; *individual airlines*, however, would have to bid for their share;
- *support mandatory emissions offsets* (support mandatory participation in an emissions offset market);

- *as a preliminary step to support of mandatory emissions offsets , introduce an airline default – or* opt-out - *passenger emissions offset scheme*; and

- *introduce taxes and charges*.

These strategies are outlined and evaluated below.

4. Assessment and evaluation of possible airline strategies

The only way we are going to prevent having an amount of CO_2 that is far beyond the dangerous level is by putting a price on emissions.

- James Hansen (2007),
Director of the NASA Goddard Institute for Space Studies and Adjunct Professor of Earth and Environmental Sciences, Earth Institute, Columbia University[183]

4.1 Continue with business as normal

Companies are taking action now because doing nothing is a strategy that is running out of steam. Like it or not … industry is beginning to accept that the issue of climate change is not going away.

Abrahm Lustgarten, "For Sale: Pollution," *Fortune* (2006)[184]

Any airline strategy for dealing with the climate impacts of aviation - the aviation emissions problem - which involves, more or less, continuing with business as normal is, in our view, based on an inappropriate attitude to risk[185] and to climate change. At the very least airlines should do what should be done whenever faced with the probability of a serious loss - take precautionary action, such action including, amongst other things, engagement with governments. Avoidance of unanticipated shocks is one of a number of advantages such action offers. The most likely source of shocks is public opinion.

Demands are now placed on corporations to deal with their exposure to climate change risks. Put another way, businesses are affected by climate change. Lash and Wellington, writing in March, 2007 in the *Harvard Business Review*, state that:

> [i]nvestors already are discounting share prices of companies poorly positioned to compete in a warming world. Many businesses face higher … energy costs as governments around the globe increasingly enact policies placing a cost on emissions. Consumers are taking into account a company's environmental record when making purchasing decisions … Even in the United States … the debate is rapidly shifting from whether climate change legislation should be enacted to when and in what form .[186]

Further, "in the court of public opinion," companies "can be found guilty of selling or using products, processes, or practices that have a negative impact on the climate."[187] A study by the Carbon Trust concluded that airlines were particularly vulnerable in this regard[188] - up to 50% of brand value was at potential risk from climate change[189] (presenting, of course, opportunity for airline differentiation against competitors).

Corporations are increasingly:

(a) subject to standards, frameworks and "protocols" for dealing with climate change (ie *other* forms of demand); and

(b) the subject of reports which outline the business opportunities and risks associated with climate change.

With regard to (a), for example, the October, 2006 *Global Framework for Climate Risk Disclosure*[190] is a voluntary set of corporate social responsibility guidelines that makes climate change a measurable disclosure topic in shareholder reports. These guidelines are put together by leading institutional investors and environmental and other organisations. Four elements of disclosure are provided for in the framework:

- total historical, current and projected greenhouse gas emissions;
- strategic analysis of climate risk and emissions management;
- assessment of physical risks of climate change; and
- analysis of risk related to the regulation of greenhouse gas emissions.[191]

Similarly, the *Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard*, as revised, is the result of a partnership of businesses, NGOs and governments which provides a guide for corporations in quantifying and reporting their greenhouse gas emissions.[192] The Global Roundtable on Climate Change's statement, *The Path to Climate Sustainability*,[193] endorsed by "[l]eaders from key economic sectors and regions of the world,"[194] sets out a self-styled global framework for action on the part of governments and corporations to reduce climate change.[195] Further, the World Economic Forum announced in early 2007 an international partnership of seven organisations to establish a framework for climate risk-related reporting by corporations.[196]

With regard to (b) – reports which outline the business opportunities and risks associated with climate change – such reports include (in 2006) the Carbon Trust's *Climate Change and Shareholder Value*;[197] *A Three-Pronged Approach to Corporate Climate Strategy* by the Business for Social Responsibility;[198] Citigroup's *Investing in Solutions to Climate Change*;[199] *Business and Ecosystems* by the Earthwatch Institute et al;[200] and, in 2007, *Making Sense of the Carbon Economy* by Npower Business and Forum for the Future[201] and Citigroup's *Climatic Consequences: Investment Implications of a Changing Climate*.[202] In March, 2007, business leaders, financial services firms, asset managers, foundation endowments, pension funds, government officials and labor, in a project organized by Ceres and the Investor Network on Climate Risk, released a "Climate Call to Action," stating that businesses, investors and governments must act, and that such action must be taken "on a large scale over

a long period of time … much more [must be done] to mitigate climate risks and seize opportunities, but government action … is essential."[203]

For Npower and the Forum for the Future, "the changing requirements of politicians, investors, and customers are all too real. Smart companies, no matter what size or sector, are therefore already preparing for the transition to the low carbon economy;"[204] self-interest is a powerful motivator for change. Citigroup believes that, "as a direct result of pressure from consumers, litigants, and investors, there will, in the next few years, be a "tipping point"[205] in corporate behaviour with regard to climate change issues,[206] and that, from a corporate perspective, policies that are climate-friendly have a number of distinct advantages.[207]

If airlines resist demands to deal with their exposure to climate change risks (demands such as those outlined above), public pressure will likely build and result in an abrupt change in the business environment – one of the shocks referred to earlier. Even if pressure grows predictably, policy and regulatory changes may well be discontinuous.

Apart from avoiding shocks one advantage of a pro-active stance towards the risks and uncertainties presented by climate change is that it clearly makes economic sense. Writing in the March, 2007 edition of *Harvard Business Review*, authors from the World Resources Institute concluded that

> [c]ompanies that manage and mitigate their exposure to climate change risks while seeking new *opportunities* for profit will generate a *competitive advantage* over rivals in a carbon-constrained world.[208]

And Ceres and the World Resources Institute have concluded that "companies that take positive and proactive measures to mitigate climate risk may create a competitive advantage for themselves relative to the rest of their sector," such measures including corporate strategy to respond to regulatory action.[209]

Competitive advantage may be gained by addressing likely or anticipated regulatory proposals such as emissions trading schemes (ETS), for example, before possibly being required by government to participate in such schemes.[210] Corporations "with a head start … have the credibility to participate in, or even shape, the debate over how to further reduce emissions"[211] and combat climate change.

Another payoff for taking action - for example, becoming actively engaged with government - before being forced to do so is predictability and an input into steering the process of change. If the aviation industry is involved in the policy development and decision-making process (design of any ETS, for example), it is in a position to have early input into formulating policies that are likely to be less damaging and gain the advantage of lead time to allow adjustment to the resulting changes. Such action would as a result produce certainty, important because, as McKinsey says,

> uncertainty about future regulations is the biggest risk in the carbon equation: executives need long-term assurances on credits and emission levels to factor them into plans for expensive capital investments.[212]

A further advantage is that of focus. A proactive policy is more likely to focus the managerial capacity of the aviation industry on constructive policy initiatives. Another advantage is enhanced profitability. The Earthwatch Institute, the World Conservation Union, the World Business Council for Sustainable Development and the World Resources Institute together put the matter this way in late 2006:

> Businesses *are* affected by climate change, but the distribution of the impacts will vary. Those businesses that have implemented effective risk management strategies or have competitively positioned themselves will be more adaptable and could stand to benefit from climate change. Those that fail to recognize the risks and potential opportunities[213] may suffer decreased operational efficiencies and profit margins.[214]

In our view it is essential that, going forward, airlines move ahead of – or push – governments in order to speed up the process of regulatory change.[215]

Climate change is, of course, underway. Contrasted with other corporate and industry sector responses to the climate change problem, those of the airline industry have to some extent been anomalous - that is, less proactive and more limited – although perhaps more true for North American airlines[216] than for their European counterparts.[217] *Aviation Week* noted in March, 2007 that "the reaction by the aviation industry to the climate change issue so far has been subdued"[218] (although it also noted that the industry's tone - IATA's tone – "has become more strident"[219]). In mid-May, 2007, however, the Star Alliance

> endeavoured to take some control over the increasingly volatile discussion concerning commercial aviation's impact on the environment, announcing a transport and marketing partnership with leading conservation organizations while acknowledging that more forceful and unified communication is needed to defend the [airline] industry's position.[220]

Marion C Blakey, the FAA Administrator, has acknowledged "[t]here's a perception that somehow aviation doesn't care about the environment … Aviation must effectively manage its environmental impacts. There's nothing murky about that."[221] And in a different speech she stated that "[t]he fact of the matter in Europe is more and more often environmentalists are calling aviation a 'rogue industry,' lumped together alongside Big Tobacco …It's presumptuous to assume it won't happen here [in the US]." For Ms Blakey, together with congested airspace, "aircraft emissions may be the most serious barrier to aviation growth, at least in the long term."[222] In the view of the Chairman and CEO of US Airways, "[w]e have to get out in front and educate the consumer."[223]

The questions for airlines are action and adaptation.[224] The remainder of this section 4 sets out possible airline action and adaptation strategies on aircraft GHG emissions and climate change, and our assessment of them.

4.2 Improve air transport technology and develop alternative jet fuels

Another response of the aviation industry to pressure to reduce its GHG emissions is to devote resources to improving air transport technology and infrastructure, and to develop alternative jet fuels – that is, to invest in research and development.[225]

(a) Aircraft technological developments

Airbus' A380 is the largest passenger airplane built to date, and will carry more passengers further than any airplane before it. It will have "around 13% lower fuel burn than its closest competitor" [226] and, Airbus says, is "the sole aircraft employing [composites] in the centre wing box and rear fuselage … with increased use of carbon fibre reinforced plastic, and the first application of glass fibre-aluminium laminate on a civil airliner."[227]

However, the A380 has also been described as "a plane that stretches World War II-era design, with metal wings bolted onto a metal fuselage, to its absolute limit,"[228] and as "the last dinosaur of the aluminium age."[229] Moreover, the Tyndall Centre states that the A380 "continues to use high-pressure, high-bypass jet turbine engines that contain only incremental improvements over their predecessors."[230] And more generally, in relation to propulsion, as Bows and Anderson have noted,

> jet engines are a mature technology, and consequently the efficiency of the current fleet is not set to change substantially within the foreseeable future. Exacerbating this absence of a step-change in fuel efficiency is the long design life of aircraft, effectively locking society into current technology for at least the next 30-50 years.[231]

As for Boeing, its 787 "Dreamliner," designed from scratch,[232] is the first large commercial jetliner with a composite fuselage; almost the entire airframe is made of composites – carbon-fibre reinforced plastic[233] - and, as composites "weigh half as much as aluminium, but are stronger so that wings and other parts can be made slimmer and more aerodynamic,"[234] its lightweight design does make it far more fuel efficient than other jets.[235] Indeed, the 787 "promises to burn 20% less fuel than conventional planes."[236]

The 787 has been described as Boeing's "wise bet on a green future," with its development of "the first all-plastic plane:"

> Plastic planes are lighter, stronger and more energy-efficient. The Dreamliner's fuel costs are [US]$3 million less per year than those of similar aluminium planes – let alone the massive A380.[237]

Research being prioritised by Boeing in 2006 also focuses on low-cost aircraft and aircraft that use less fuel and are environmentally friendly (for example, an aircraft with main wings swept forward, not back, and miniature wings on the front), with work already commenced with engine companies on propulsion options.[238] In terms of reducing aircraft emissions, Boeing is working on replacing auxiliary power units with fuel cells, although commercial aircraft application is more than a decade away.[239] Airbus also plans to begin flight testing fuel cell technology this year – 2007 - and reports suggest that Boeing and Airbus may cooperate on this and other technological and environmentally-friendly initiatives.[240]

With regard to reducing aircraft emissions other aircraft technological research includes flying wing designs, lightweight materials, water injection in engines and hybrid laminar flow control.[241] Research by engine manufacturers also focuses on technology that reduces nitrogen oxides emissions, including emissions combustor technology, the commercial application of which may likely be seen in the next generation of narrow body Airbus and Boeing passenger aircraft.[242]

The most ambitious research is perhaps that being conducted by the newly formed DELcraFTworks, a Delft University of Technology (TU Delft) advanced aerospace technologies research centre. Its aim is to deliver by 2011 a concept for a post-2025 "ultra-green airliner,"[243] with goals for the airliner that include a 50% reduction of carbon emissions and an 80% reduction of nitrogen oxide emissions. TU Delft's business manager states that its "environmental goals are so ambitious that they will not be achievable without technological breakthroughs. What is needed are radical changes in technology that require a substantial amount of research."[244]

DELcraFTworks' project adviser states:

> The sustainability of air transport increasingly is becoming an issue. To prevent a situation where air travel is no longer environmentally and socially acceptable, a drastic departure is needed. Even the latest of airliners, such as the Airbus A350 and A380 or Boeing 787, continue to be based on the classic Boeing 707 design of the 1950s. If we want to fly substantially improved aircraft by 2025, we need to start looking for seriously different concepts today.[245]

Other "green aircraft" research includes the Silent Aircraft Initiative (SAI) led by the Cambridge-MIT Institute, and including companies such Rolls-Royce; its aim is to create an airliner that is inaudible outside a typical airport, with a blended wing and body, by 2030.[246] The aircraft would be made from composites; it would have no slots of flaps. And while its goal is aircraft noise reduction, SAI researchers state that it would use 25% less fuel than current aircraft.[247] Indeed, "airliners that are cheaper to run and contribute less to climate change may be more attractive than silent ones. That is why a slightly noisier alternative design by the same researchers that is even more fuel-efficient shows most promise."[248]

Notwithstanding such research aimed at "greener" flying, technology development efforts being undertaken by Boeing and Airbus "to address greening demands"[249] are not

> headline-making initiatives that either is particularly eager to discuss. With billions invested in current aircraft technology design, there's little appetite to trumpet early research into unorthodox approaches that often are radically different from current configurations.[250]

Moreover, as the Tyndall Centre concludes, and as reinforced by Bows and Anderson,[251]

> a combination of both long design runs (already 35 years for the Boeing 747) and design lives (typically 30 years), locks the industry into a kerosene-fuelled future.[252] If the A380 were to follow a similar path to the 747 it will, in gradually modified form, be gracing our skies in 2070. Consequently, decisions we make now in relation to purchasing new aircraft and providing the infrastructure to facilitate their operation have highly significant implications for the UK's and EU's carbon emissions profile from now until 2070.

(b) Alternative jet fuels

> *There would not appear to be any practical alternatives to kerosene-based fuels for commercial jet aircraft for the next several decades.*
>
> - IPCC, *Aviation and the Global Atmosphere*[253]

Concerns regarding aircraft emissions, significant increases in oil prices and the price of jet fuel are driving increased research interest in alternative jet fuels. And, as noted in an October, 2006 report, *Alternative Fuels and Their Potential Impact on Aviation*, from researchers at Boeing, NASA and MTU Aero Engines,

> demand for air travel continues to grow, so much so that the industry's rate of growth is anticipated to outstrip aviation's fuel-efficiency gains. Underlying this growth projection is an assumption that the industry will not be constrained by fuel availability or undue price escalations. Future crude oil production may not be able to keep pace with world demand … thereby forcing the transition to using alternative fuels.[254]

As IATA states, "there are no realistic low-carbon fuel technologies on the horizon for air travel."[255] Options for powering commercial jet engines with alternative jet fuels, such as biodiesel (made from soybeans, corn and other products), hydrogen (a long-considered alternative)[256] and synthetics (made by turning coal, oil shale or natural gas into a liquid that can act like traditional jet fuel), are being examined by government and industry.[257] Particular focus is on coal-to-liquid and gas-to-liquid, and also biomass-to-liquid, technology. Ethanol[258] is another option, but an "ethanol" aircraft "would have to be 35% heavier, be fitted with a larger engine, and result in an aircraft that uses 15% more energy on a 500-nautical mile mission."[259]

Difficulties associated with one or more of these alternatives include production, transportation, and their viability under harsh weather conditions. Further, at present, such alternative fuels are far more expensive that traditional fuels. And there are real questions as to whether viable options to kerosene actually exist.[260]

The report from researchers at Boeing, NASA and MTU Aero Engines, referred to above, concluded that

> the only current known drop-in alternative jet fuel was found to be a synthetic manufactured fuel. Alternative aviation fuels synthesized by using a Fischer-Tropsch-type process, are ideally suited to supplement, and even replace, conventional kerosene fuels … [However,] this fuel, and its manufacturing process, *does not help address global warming issues* …[261]

It further found that

> Another possible alternative, biofuel, could be blended in small quantities … with current jet fuel. This bio-jet-fuel blend can be derived from sustainable plant products, which makes it attractive as a step toward a "carbon neutral" fuel that will help address global warming issues. However, because of aviation's high-performance fuel specification needs, direct biofuels would need to go through an additional, possibly costly, fuel processing step.[262]

Other alternative fuels – liquid hydrogen and ethanol, for example, "result in airplane performance penalties."[263]

While the focus at present is clearly on making aircraft more efficient rather than producing alternative jet fuels, "[a]ny incremental fuel supply, especially if both environmentally friendly and economically viable, is something worth pursuing," as the Air Transport Association notes.[264] Further, as Boeing's director of environmental performance states, "[w]e are interested in alternative fuels because we want to make sure that there's fuel available for the future."[265] Nonetheless, while, as US Transportation Secretary Mary Peters noted in May, 2007, "the future lies in exploring alternative fuels,"[266] it does "take a long time to develop and validate alternate fuel sources … [and u]biquity of the alternative fuel source is also critical,"[267] all views with which the authors of the Boeing, NASA and MTU Aero Engines study would agree:

> For biofuels to be viable in the commercial aviation industry, significant technical and logistical hurdles need to be overcome. However, the task is not insurmountable, and no single issue makes biofuel unfit for aviation use. Aircraft equipment manufacturers and regulatory agencies will require a great deal of testing before biofuels can be approved. With adequate development, biofuels could play some role in commercial aviation fuel supplies.[268]

And, importantly,

> research and development in aviation biofuel needs to continue. If it is able to demonstrate additional benefits, such as exhaust pollutant and CO2 reduction, the fuel would become more attractive to aviation, especially in the case of carbon trading.[269]

Virgin Atlantic reportedly plans to make a 747 test flight in 2008 with one of the aircraft's four engines filled with a mixture of 60% kerosene and 40% from "alternative biofuels, " and with Virgin's long-term aim of running its fleet "at least in part on alternative fuel."[270] The report also notes the challenges in operating an

environmentally friendly airline, as well as problems associated with alternative fuels (such problems outlined above).[271] Another report notes that this and other developments take place, especially in Europe,

> have emerged in recent months as increasingly important for the aviation industry … In Britain, airplane emissions have become part of a public debate over whether flying is sinful. Airlines have also been looking for competitive advantages, especially in the crowded skies over the Atlantic Ocean …"[272]

(c) An industry-wide solution?

With regard to improving air transport technology, Virgin Atlantic Chairman Sir Richard Branson announced in late 2006, at the second annual Clinton Global Initiative, an investment of USD 3 billion in technologies to help combat global warming. He said that his companies "were already engaged in developing an aviation fuel not derived from oil, along with better processes for making bio-fuels from grasses and other crops."[273] IATA states that "technology is key" and points to fuel efficient engines, lighter materials and aerodynamic airframes.[274]

While we support this research, of course, we do not believe the probability that new technology will provide an industry-wide solution in the near term is sufficiently high that it *alone* can be relied on to solve the emissions problem in the foreseeable future; our overview of aircraft technological developments presented above confirms this. Unfortunately, as the report of the UK Royal Commission on Environmental Pollution points out, the basic gas turbine

> has been the dominant form of aircraft engine for some 50 years and there is no serious suggestion that this will change in the foreseeable future.[275]

Our assessment is shared by, amongst others, the House of Lords' European Union Committee. In its 2006 report, *Including the Aviation Sector in the European Union Emissions Trading Scheme*, the Committee considered research and development in air transport technology as an inadequate option to achieving the policy objective of reducing carbon emissions, but nevertheless worth pursuing (together with other options such as "raising awareness of air transport users").[276] Expressing its support for the conclusions of the European Commission, the Committee stated that:

> [i]n its impact assessment, the [European] Commission details the significant sums of money that have been devoted to the research and development of new technological and operational solutions to reduce aircraft emissions. Any resulting advances are likely to have a long lead time and thus the Commission judges this option as worth pursuing but unlikely to produce sufficiently urgent results for it to be the primary instrument for dealing with the climate impact of aviation.[277]

It is also clear that alternative jet fuels - while also worth pursuing - will not provide an industry-wide solution to the carbon emissions problem, for the reasons as outlined at section 4.2(b) above. Even if existing "significant technical and logistical hurdles"[278] can be overcome, biofuels can only in the foreseeable future "play *some* role in commercial aviation supplies."[279]

4.3 Develop more efficient operational practices and call for more efficient air traffic management systems and processes

An additional airline strategy to reduce emissions is to develop more efficient air transport operational practices.[280] Sir Richard Branson at the 2006 Clinton Global Initiative called for more efficient aircraft movements at airports, including the creation of "starting grids" for all aircraft departures, widespread adoption of "continuous descent" approaches by air traffic control authorities, and a reduction in aircraft weight.[281] Sir Richard stated that such measures would save over 150 million tones of carbon emissions a year. If airlines, airports, air traffic controllers and governments "seize these initiatives and ensure they're all implemented within two years … up to 25% of the world's aviation emissions can be cut."[282]

IATA, too, has called for optimised air traffic control (ATC) procedures, stating that "infrastructure and operations must be part of the [emissions] solution."[283] Its "industry-wide strategy to address climate change" calls upon "governments, airports and air navigation service providers to put their full weight behind further infrastructure improvements which could yield fuel efficiency benefits of up to 12% worldwide."[284] In a speech to a Civil Air Navigation Services Organisation conference, in February, 2007, IATA's Director-General and CEO said that

> You will all be aware that our industry is taking a beating in the environmental debate. Our critics may have lost perspective. Exaggerating our role in climate change … The UN's Intergovernmental Panel on Climate Change (IPCC) estimates that there is 12% inefficiency in Air Traffic Management globally. That 12% translates into up to 73 million tones of CO2 emissions and nearly US$13.5 billion in unnecessary fuel costs. Every minute of flying time that we can save. Reduces fuel consumption by about 62 litres. And CO2 emissions by 160 kilograms.[285]

In 2007, another airline trade association, the Air Transport Association of America, also called for new air traffic management systems as a way to achieve improvement in environmental performance.[286] The May, 2007 Eurocontrol Performance Review Commission calls for more efficiency from air traffic management by 2010, and fewer carbon emissions; "[a]ircraft flying in European airspace last year poured thousands of tonnes of global warming carbon dioxide into the sky unnecessarily just because of air traffic management inefficiency."[287] In terms of government initiatives, the 21 APEC economies in March, 2007 agreed to work cooperatively on operational air traffic management systems and processes to reduce aviation GHG emissions.[288]

While we support such operational practices - and support improving air transport technology and infrastructure – they cannot be relied on, by themselves, to solve the emissions problem in the foreseeable future, to provide a complete, industry-wide solution (despite IATA's CEO stating that, "[b]y optimising approach and departure procedures *we have a solution*"[289]). For example, the IPCC estimated that

> improvements in air traffic management (ATM) and other operational procedures could reduce aviation fuel burn by between 8 and 18%. The large majority (6 to 12%) of these reductions comes from ATM improvements which it is anticipated will be fully implemented in the next 20 years … The rate of introduction of improved ATM will depend on the implementation of the essential institutional arrangements at an international level.[290]

As a means of reducing carbon emissions, the House of Lords considers improving air traffic management and operations research and development as having the same utility as improving air transport technology and infrastructure.[291] Most recently, researchers have concluded that

> [i]mplications of … [airport and passenger] growth for carbon dioxide emissions and climate change are far reaching. Technological improvements in engine performance, airframe design and air traffic management are unlikely to offer reductions in emissions per seat kilometer flown for the global fleet of more than 1.4% per annum[292] … However, even with very conservative [UK] Government and industry projections of aviation growth,[293] such improvements still leave a 1.2-2.8% increase in emissions from the aviation industry each year.[294]

With regard to improvements in air transport technology, alternative jet fuels, development of more efficient operational practices and air traffic management systems and processes, our conclusions reflect those of the IPCC in May, 2007:

> Medium term mitigation potential for CO_2 emissions from the aviation sector can come from improved fuel efficiency, which can be achieved through a variety of means, including technology, operations and air traffic management. *However, such improvements are expected to only partially offset the growth of aviation emissions.* Total mitigation potential in the sector would also need to account for non-CO_2 climate impacts of aviation emissions.[295]

In our view, development of alternative jet fuels and aircraft technological developments, together with the development of more efficient operational practices and more efficient air traffic management systems and processes, should form *part* of a sustainable industry solution to dealing with the climate impacts of aviation. We set out in detail below what that sustainable solution could look like.

4.4 Support an emissions trading scheme or schemes

(a) Emissions trading schemes generally: "The core of any future international agreement to combat climate change?"[296]

Although improvements in aircraft and engine technology and in the efficiency of the air traffic system will bring environmental benefits, these will not fully offset the effects of the increased emissions resulting from the projected growth in aviation. Policy options to reduce emissions further include more stringent aircraft engine emissions regulations, removal of subsidies and incentives that have negative environmental consequences, market-based options such as environmental levies (charges and taxes) and emissions trading …

- IPCC, *Aviation and the Global Atmosphere*[297]

(i) Emissions trading schemes - an overview

For an international agreement to combat climate change to be sustainable in the long term it must:

- deliver greenhouse gas reductions successfully and efficiently;
- be compatible with different countries' varying political landscapes; and
- be economically sound in order to survive the vicissitudes of the global economic market.

Any policy response to climate change must therefore take these factors into account. Emissions trading is one such response which has been adopted by a number of countries around the world in the fight to reduce emissions.[298] Other policy responses, such as taxes, are generally seen as less flexible with higher compliance costs than emissions trading.[299] The primary advantages of emissions trading over other policy options are "dependability and the [market-based system's] potential to minimise the costs of achieving a given level of greenhouse gas abatement."[300]

(ii) Emissions trading – what is it?

Generally, emission trading schemes involve the use of emission permits or credits, issued by governments, which can be traded amongst participants and acquitted to cover emissions. Emissions trading utilises broad-based market mechanisms, through supply and demand, to create a price for emissions. By placing a price signal on emissions, emitters are incentivised to take action to reduce their emissions either by purchasing emissions units from other participants under the scheme or investing in abatement activities such as carbon sequestration or low emissions technologies. Trading schemes also allow for the development of financial instruments to manage risk, thereby creating more certainty in the market.[301]

Cap-and-trade emissions trading schemes are commonly used as they assure environmental outcomes by setting a total cap on the absolute quantity of emissions over a defined period. Participants in a cap-and-trade scheme must obtain sufficient tradeable units to compensate for their emissions. Under this type of scheme the regulatory authority allocates a certain number of tradable units to each participant based on their capacity output or some other quantitative measure. Participants with difficulty in remaining below their allocated emission limit then have a choice between taking measures to reduce their emissions (such as investing in more efficient technology or using less carbon-intensive energy sources) or buying extra allowances, whichever is most cost-effective for the participant.[302] Participants can therefore make independent economic decisions regarding lowest-cost abatement opportunities which are suitable to their business needs. It is very likely that the core of any future international agreement to combat climate change will exist in the form of a global emissions trading scheme.

(iii) The European Union Emissions Trading Scheme

The Kyoto Protocol[303] to the United Nations Framework Convention on Climate Change (UNFCCC)[304] (adopted in December, 1997) addresses global climate change by placing quantifiable obligations upon sovereign States to decrease their levels of greenhouse gas emissions.[305] The Kyoto Protocol (Kyoto) also forms the basis of the world's first and largest multi-country, multi-sector Greenhouse Gas emissions trading program - the European Union Emissions Trading Scheme (EU ETS). The EU ETS began operation on 1 January, 2005 and has paved the way for the development of trading schemes around the world. It should be noted, however, that the EU ETS operates independently of Kyoto's entry into force. Kyoto was negotiated between governments imposing emissions targets on countries; the EU ETS is a scheme aimed at targeted installations (mandatory participants under the scheme), based on the EU Directive and national legislation.[306] Kyoto provides a basic legal and operational framework for participating countries to integrate compatible domestic emission trading schemes with each other to create a larger market.

The main feature of the EU ETS the development of a broad-based market for the trading of carbon emissions and the use of market forces to create a price for carbon based on supply and demand. Implementation of the EU ETS constitutes effective policy, based on economic rationality and sound business, in order to achieve the EU's commitment to reduce emissions under multilateral agreements such as Kyoto.

The EU ETS covers six key industrial sectors and imposes caps on emissions of carbon dioxide (CO_2) from installations.[307] These include energy activities, production and processing of ferrous metals, mineral industry production and other activities. While aviation activities are not presently captured by the EU ETS, the EC proposes to include aviation in the EU ETS in two phases from 2011 and 2012 (see section 4.4(b) below).

At the heart of the EU ETS is the common trading "currency" of emission allowances (EUAs). One EUA equals the right to emit "one tonne of carbon dioxide equivalent during the specified period."[308] This transferable allowance facilitates the trading element of emission trading. The EU ETS consists of a "warm-up" phase from 2005-2007 and then successive 5-year periods, with the second phase from 2008-2012 coinciding with the Kyoto Protocol commencement period.

Under the scheme a fixed amount of EUAs are allocated by the National Allocation Plans (NAPs). These allowance allocations provide the legal right to emit. The total of all allowances allocated under the NAPs represent the total cap on emissions and is therefore a cap-and-trade scheme. Scarcity, being the "cap" or "limit" on the total number of allowances, creates the limited supply needed for a market to emerge[309].

Under Kyoto, Joint Implementation (JI) enables EU ETS installations to invest in emission reduction projects (for the benefit of the environment) and credit this saving towards their own emission targets[310] (JI projects yield credits known as "emission reduction units" or ERUs). Clean Development Mechanisms (CDMs) operate in the same way as JI; here, projects in countries without an emission target under the Protocol are covered[311] (CDM credits are called "certified emission reductions" or CERs). The EU scheme is the first in the world that recognises these credits as equivalent to EU ETS emission allowances (1 EUA = 1 CER = 1 ERU) and allows them to be traded under the scheme.

The EU ETS was specifically designed to be compatible with emissions trading as envisaged under Article 17 of Kyoto. This compatibility allows participating entities in domestic emissions trading programmes under the Directive to use credits generated by the other compatible emission mechanisms to offset reduction obligations under the EU ETS.

Compatibility with Kyoto mechanisms and the generation of linkages between domestic and international trading schemes not only increases the range of options available for participants in schemes to meet emission targets but also improves the liquidity and depth of the market (thus reducing compliance costs) in the rapidly emerging global market for emissions trading.

(b) Aviation emissions trading schemes

A number of regulatory mechanisms are available to governments to deal with the climate impacts of international aviation – for example, taxes, charges and emissions trading (emissions trading schemes were described above).[312] A number of difficulties attend the imposition of taxes and charges,[313] thus - in part – the recent focus of attention on aviation emissions trading. Such focus has been given impetus by the European Commission's (EC) proposed legislation to include aviation in the EU ETS. The EC's December, 2006 proposal[314] is briefly outlined below, together with ICAO guidance on and support for aviation

emissions trading in general. Such examination, together with other material, also reveals some of the difficulties that exist with aviation emissions trading schemes – whether "closed" or "open," regional or global.

As previously stated, the EU ETS,[315] a cap-and-trade system, commenced operation in January, 2005. It is the world's largest multi-country, multi-sector ETS, and the first international trading system for CO_2 emissions in the world,[316] covering all 25 EU Member States.[317] The aim of the EU ETS is to assist EU Member States achieve compliance with their commitments under the Kyoto Protocol. It comprises "over 11.500 energy-intensive installations across the EU, which represent close to half of Europe's emissions of CO_2."[318]

Aviation will be included in two phases under the EC's legislative proposal:[319] From 2011, emissions from flights within the EU will be covered (flights which depart from and arrive at an EU airport) and, from 2012, all international flights that arrive at or depart from EU airports. Thus, from 2012, the second year of operation, both EU and non-EU (ie foreign) aircraft operators are captured. The European Parliament's response to the EC's legislative proposal has been to call for the legislation to go further.[320]

Like taxes and charges, there are also problems associated with emissions trading schemes, specifically aviation ones;[321] Hardeman[322] notes in particular "the delineation of State jurisdiction with regard to the application of trading rules and emissions reductions obligations."[323] After looking at the nature of obligations under emissions trading, the point at which the emissions reduction obligation is applied, and jurisdiction over emissions sources and aircraft operators,[324] he determines – relevantly with regard to any inclusion of aviation in the EU ETS – that:

- including international aviation in the EU ETS could interfere with the sovereignty of other States or with ICAO's jurisdiction over the high seas;
- doubts exists as to whether the EU could include emissions from international
  aviation in the EU ETS without the mutual agreement of third States with regard to emissions occurring or originating outside the territory of parties to the EU ETS;[325]
- "it would seem legally possible for the EU to include in the EU ETS the emissions occurring within the combined airspace of EU Member States from all flights, regardless of the nationality of the operator;"[326] and
- including emissions occurring in the airspace of third States linked to flights departing from within the EU in the EU ETS would require the agreement of those States.[327]

Disagreement on aviation emissions trading exists between States - just as it does between airlines[328] - and particularly between the EU and the US[329] (EU-US disagreement also has existed on a range of other international aviation issues such as liberalisation of international air services agreements or "open skies" –

which also has implications for inclusion of aviation in the EU ETS and airline emissions generally[330]). The EU proposal is opposed by the United States; the US government and US airlines

> have protested more vehemently than any other region against Europe's trading plan. They … would prefer what is a global problem to be tackled at the world level through ICAO,[331] and are threatening legal action [on the basis that a regional scheme with purported application to non-regional airlines may violate the Chicago Convention][332] if the EC tries to impose carbon trading on US carriers.[333]

For John Byerly, inclusion of aviation in the EU ETS "is the antithesis of a global solution to what is a global problem. Europe can do what it wants with its own carriers [but the wider plan] is permissible only on the basis of mutual consent of the relevant foreign governments."[334]

With regard to such a "global solution," Article 2.2 of the Kyoto Protocol provides that Annex I parties "shall pursue limitation or reduction of emissions of greenhouse gases … from aviation … working through the International Civil Aviation Organization [ICAO] …;"[335] ICAO has been considering aviation emissions post-Kyoto. An article in the *ICAO Journal* in 1999 concluded that emissions trading appeared to be an effective policy tool for solving air pollution problems,[336] and in a 2004 article in the journal, reporting results of a study carried out for ICAO, emissions trading was characterized as "an effective means of reaching environmental objectives while minimizing the financial burdens on the participants."[337]

At its last regular session in 2004, the ICAO Assembly endorsed[338] "the further development of an open emissions trading system for international civil aviation and requested the Council of ICAO to provide further guidance to States for its implementation."[339] This resolution followed a similar 2001 resolution calling for continuing work on guidelines for an open emissions trading scheme for international aviation. Progress overall has clearly been slow.[340] Indeed for the EU and others – as evidenced by the EU's December, 2006 legislative proposal – the ICAO process is moving too slowly and causes "frustration and tension."[341]

ICAO's Committee on Aviation Environmental Protection (CAEP) met in February, 2007 and provided the following guidance to ICAO's 189 Member States, "for incorporating international aviation emissions into their emissions trading schemes, consistent with the United Nations Framework Convention on Climate Change process,"[342] to be considered at the ICAO Assembly meeting in September, 2007:[343]

- aircraft operators should be the accountable international aviation entity for purposes of emissions trading;

- obligations should be based upon total aggregated emissions from all covered flights performed by each aircraft operator included in the emissions trading scheme;

- in applying an inclusion threshold, States should consider aggregate air transport activity[344] and/or aircraft weight as the basis for inclusion;

- States should start with an emissions trading scheme that includes CO_2 alone;

- the IPCC definition of international and domestic emissions should be applied by States for the purpose of accounting for greenhouse gas emissions as applied to civil aviation;

- States will need to put in place an accounting arrangement that ensures that emissions from international aviation are counted separately and not against the specific reduction targets that States may have under the Kyoto Protocol; and

- with regard to trading units, States will need to consider economic efficiency,
environmental integrity and equity and competitiveness when making a choice.[345]

No guidance or comment was provided by CAEP on the *geographic scope* of any future aviation-inclusive ETS (see discussion of the proposed EU aviation-inclusive ETS above).[346] IATA welcomed the ICAO guidance.[347]

(c) Strategies: Support a cap-and-trade ETS

The EC proposes to include aviation in the EU ETS in two phases, from 2011 and 2012, as set out above,[348] thus creating the first aviation-inclusive ETS. In considering the financial impact of extending the EU ETS to aviation, IATA estimates that an open cap-and-trade scheme would increase average fares for intra-EU flights by 1.2 to 2.6%,[349] and would increase average fares for extra-EU flights by 2.2 to 4.6%[350] with EU ETS allowances at between €15 and €33.[351] The effect of this on the demand for air travel depends on price elasticity. Although there are estimates of elasticity of demand in the region of – 1. 5 - 0.7 it is difficult to attach much weight to these figures in a situation where there may be significant changes in wealth, income and leisure over the next few decades.[352] IATA estimates a reduction in passenger return trips of between 1.8% - 3.9% in 2012 from what they would have been without an ETS;[353] the European Commission provides similar figures, and states that "the associated costs per ticket are likely to be modest."[354] Both IATA and the EC agree that the effect on the growth of passenger numbers and profitability would be small.

Neither study addresses the question of the effects of competition and the potential detrimental consequences for the consumer or the issues of equity that arise from any distribution of allowances free of charge.[355]

The advantages of cap-and-trade ETS are well known. A market encourages the most efficient reduction of carbon emissions across the economy by giving those with the lowest cost reductions an incentive to produce the cuts and sell these on

to any firm with a higher cost of reduction – thus, cuts are only made by those with the lowest cost of reduction.

The problem with an ETS is that, with more than 27,000 new aircraft being delivered over the next 20 years, with the number of air travelers doubling over the same period to 9 billion,[356] and with a concomitant increase in emissions,[357] it may not have the capacity to solve the emissions problem. Some idea of the dimension and seriousness of this problem is provided with reference to just two indicative reports considered earlier in this paper. These reports found[358] - relevantly, and in summary – as follows:

- absent action to significantly reduce aviation growth, emissions from aviation will outstrip carbon reductions envisaged for all other economy sectors[359] - thus, with reference to both the UK and the EU, there is "a looming problem in the skies;"[360]

- the EU 25's aviation sector takes up almost 40% of the total permissible emissions for all sectors in 2050 (the 550ppmv regime) and as much as 80% (the 450ppmv regime).[361] The projections "highlight … the conflict between a contracting carbon target and the EU's expanding aviation industry;"[362]

- "[research results] show that a significant portion of annual emissions budget will be attributable to the aviation industry for the aggregated EU 125 nations, as is also the case when separated into the original EU 15 nations, the 10 new accession states and looking at the UK alone. If the aviation industry is allowed to grow at rates even lower than those being experienced today, the EU could see aviation accounting for between 39% and 79% of its total carbon budget by 2050, depending on the stabilisation level chosen. For the UK, the respective figures are between 50% and 100%;[363] and

- "[u]plifted EU aviation emissions alone would exceed the 550ppmv contraction and convergence target for the EU by 2050, leaving no emissions space for any other sectors. Even by 2030, application of the 2.7 uplift factor shows aircraft taking 34% of the EU carbon allowance under the 550ppmv regime and 50% for the 450 ppmv regime. As it appears unlikely that any alternative to kerosene as an aviation fuel will be in widespread use by 2030, permitting these emissions would require either major changes to EU energy supply and consumption or a commensurate purchase of emissions credits from elsewhere in the world ... [On the analysis presented here] all of the other sectors of the economy must significantly decarbonise to allow the aviation industry to grow and to continue to use kerosene up to 2050."[364]

This suggests that IATA and the EC may have understated the problems facing the airline industry. If an ETS was industry specific it would not work. If it were part of a larger scheme it would result in massive crowding out of allowances for other industries.[365] The only possible consequence of this would be for the price of carbon to rise until an equilibrium was reached with the amount of air traffic

significantly lower than the growth projections, and perhaps significantly lower than current levels. This again depends on such things as wealth distribution and demand elasticities.

This may not be a tenable situation. It would create a position where the aviation industry was significantly increasing the costs to producers of non-aviation goods such as power, food and other forms of transport.

If it is assumed that a new entrant to the industry will not be entitled to an allowance, this creates a *second* problem, Essentially, *the carbon emission entitlement is a free gift of a good that belongs to the public to an incumbent set of aircraft operators*, and indirectly to the relatively small portion of the world's population that uses air transport. This has a number of unattractive consequences. One is that it discourages competitors entering the transport field, even with better technology, because of the start up costs of having to buy carbon credits from existing participants. Another is that it raises genuine ethical issues about the distribution of resources. Apart from any moral issues there is a political issue. Even if the discussion is restricted to rich countries, it is difficult to see, for example, how the less wealthy, other industries and those that do not use air travel can be persuaded that it is acceptable for them to have to pay more for heating or foodstuffs so that the wealthy can continue to "consume" air transport.

A *third* problem with cap-and-trade is that it is likely to produce jump discontinuities at the threshold which creates problems for financial planning. If, as might be expected, the cap forces down carbon emissions, and there is a price differential between the allowance under the cap and purchases outside the cap, airlines would be faced with an upward spike in price per unit. This price may well prove to be difficult to predict. It will also place disproportionate weight on decisions at the margin which may lead to a suboptimal use of fixed resources.[366]

(d) Strategies: Support a cap-and-trade ETS with *closed* purchase of emissions allowance

Under a closed system, aircraft operators would be required to purchase the initial allowance, with the amount purchased determined by a baseline. This overcomes problems of equity but leaves the baseline problem and the problem of new entrants unsolved (as discussed above in section 4.4 (c)).

(e) Strategies: Support a cap-and-trade ETS with *open* purchase of an industry allowance

Under an open scheme, the *aviation industry* would be given an allowance; *individual aircraft operators*, however, would have to bid for their share. This would provide some scope for new entrants. However, under this type of scheme new entrants would be competing for shares of a fixed quantity, possibly resulting in bidding wars and price spikes. In addition, it is possible that an aircraft

operator with sufficient resources could gain control of a large share of the available credits. This could result in strategic interaction and instability: for example, one operator may attempt to buy sufficient credits to force other operators to reduce their activities with the result that others may attempt to take actions to protect their position. One result could be that the market price fluctuates wildly and independently of transport need.

No matter the form or design of any ETS, it is clear to us that any scheme will have the effect of forcing prices to rise.[367]

4.5 Support mandatory emissions offsets: The emissions offset market

> *[B]uying carbon offsets isn't an exercise in guilt. It's smart economics … That offsets are smart economics may be central to slowing carbon accumulation in the atmosphere.*
>
> - Gregg Easterbrook, *The New York Times* (2007)[368]

Offsets designate the emission reductions from project-based activities that can be used to meet the objectives of corporations[369] with regard to greenhouse gas mitigation;[370] a corporation avoids or reduces GHG emissions in one place so as to offset such emissions occurring in another place. Offsets may also be considered an indirect form of emissions trading; an offset may be indirect and part of an activity not associated with the original core activity of the offsetting industry.

GHG emissions, unlike "conventional pollutants"

> mix well in the atmosphere and can travel around the planet quickly. As a result, it doesn't really matter from the standpoint of global warming mitigation where a reduction takes place … Offsets are intended to take advantage of the radically different costs and practicalities of achieving GHG emission reductions by sector and geography.[371]

Offsets are generated from projects that avoid, reduce or absorb GHGs. Kollmuss and Bowell categorise most (carbon) offset projects in which corporations invest as broadly falling into three main categories - renewable energy, energy efficiency and sequestration projects[372] - and they also identify examples of projects not falling easily into those categories such as flaring of landfill gas and the reduction of emissions from industrial processes (projects that reduce non-CO_2 emissions).[373] Technologies that can be used in offset projects include renewable energy, energy efficiency, gas recovery or destruction and fuel switching – technologies which avoid GHGs – and technologies which sequester[374] or absorb GHGs (for example, carbon dioxide) such as biological sinks.[375] Late last year Ecosystem Marketplace and Business for Social Responsibility in their *Offsetting Emissions* listed 11 types of common GHG emissions offset projects in the US and globally.[376]

Offsetting is a basic principle of Kyoto.[377] As set out earlier in this paper,[378] Kyoto requires that Annex 1 countries[379] that have ratified the protocol to reduce their "carbon" emissions, as measured in six GHGs,[380] by an average of 5.2% in the period 2008-2012 as against 1990 (baseline) emissions.[381]

Three Kyoto "flexibility mechanisms," namely the Kyoto Mechanisms, can be used by Annex 1 countries (or Annex 1 parties) to fulfill their Kyoto obligations through emissions trading.[382] These mechanisms are Joint Implementation (JI),[383] Clean Development Mechanism (CDM)[384] and trading of Assigned Amount Units (AAUs). These mechanisms provide for either (a) project-based (CDM and JI); or (b) allowance-based (AAUs) transactions, and were referred to earlier in section 4.4(a).

With regard to *project-based* transactions, both CDM and JI are based on financing of projects by Annex 1 countries which result in net reduction of GHG emissions in developing countries (CDM) and Annex 1 countries (JI). Projects receive, or produce, emissions credits which can be used by developed countries to comply with their Kyoto emissions targets. Such project-based emissions reductions must be *additional* to what would have happened in the absence of the project taking place. Put another way, reductions must be additional to those that otherwise would occur. "Additionality" is the core concept of offset projects - "the integrity of project-based credits relies on the reduction of GHG emissions beyond what would have occurred in a business-as-usual scenario"[385] - and there are a number of difficulties associated with it, including additionality testing (there is no single test). [386] The Executive Board of the CDM has issued guidelines so that project additionality can be assessed.[387]

With regard to *allowance-based* transactions, Kyoto establishes a cap-and-trade system under which Annex 1 countries, based on their emissions reduction targets, are allocated allowances (AAUs); AAUs are exchanged through emissions trading.[388]

Kyoto, then, sets legally-binding emissions targets on developed nations that have ratified the protocol, and the Kyoto flexibility mechanisms[389] provide for emissions trading, incorporating both project-based and allowance-based transactions; offsetting is a Kyoto principle. It is a treaty-based, "compliance" or regulatory market. The EU ETS, a cap-and-trade scheme, is a primary instrument by which EU Member States can achieve compliance with their Kyoto commitments.[390] Non-Kyoto markets also exist which establish legally-binding emission reduction targets for participants; such markets include the Chicago Climate Exchange (CCX)[391] (in which participants *voluntarily* agree to such binding targets) and the New South Wales Greenhouse Gas Reduction Scheme,[392] a mandatory greenhouse gas emissions trading scheme for individual electricity retailers and certain other parties who buy or sell electricity in New South Wales, Australia. These three are the leading formal carbon markets.

In addition to Kyoto and legally-binding non-Kyoto markets, a voluntary emissions offset market exists. Most offsets are bought in this market.[393] Corporations (and individuals) purchase offsets from offset companies; "[c]ompanies from HSBC to Google to DuPont are increasingly engaging with

carbon offsets."[394] Corporations purchasing offsets in this market choose to do so to address their climate impacts, to meet self-imposed reduction targets. Offset companies use funds received to implement and then run projects that, as noted earlier, avoid, reduce or absorb GHGs.

This offset market is growing. The *Economist* puts it as follows: "As anxiety about climate change grows, the business of selling emissions offsets is increasing along with it."[395] In the past three years, the UK's main non-compliance offset providers have grown more than 60%.[396] More dramatically, reports show that the voluntary carbon market surged 1000% over the past two years.[397] The World Bank states that the voluntary market for reductions grew to an estimated USD 100 million in 2006 and that

> [s]ome of the more optimistic estimates for the size of the voluntary market by 2010 are as high as 400 MtCO2e (or almost as high as the CDM market is today) … Earlier this year, US analyst Trexler[398] estimated that US demand alone for offsets under the voluntary market could almost double annually from today to 250 MtCO2e by 2011. While such numbers may be hard to imagine today when the voluntary retail segment accounted for only about 20 MtCO2e in 2006, such a future is certainly possible.[399]

Further,

> according to industry figures, this voluntary carbon market has already prevented or sequestered hundreds of millions of pounds of carbon dioxide emissions. And the field is exploding. Two of the world's largest power companies, General Electric and AES Corporation, just announced plans to create 10 million tons of greenhouse gas offsets by 2010 to sell to commercial and industrial customers.[400]

The carbon market as a whole in 2006 grew to an estimated value of USD 30 billion, three times more than in 2005,[401] with reports that it could reach USD 2 trillion by 2012.[402]

In part as a result of such growth, some problems exist in this offset market.[403] No universal standard exists, for example, to evaluate, monitor and verify[404] or determine the quality of marketed carbon offsets or emissions offset projects (offset companies can, of course, choose to operate within the Kyoto Protocol, in which case emissions reductions are verified under a clear regulatory framework; a Certified Emission Reduction is a unit of GHG emission reductions issued pursuant to Kyoto's CDM, measured in metric tons of carbon dioxide equivalent, or CO_2e, and an Emission Reduction Unit is a unit of emission reductions issued pursuant to Kyoto's JI). Rather, there are a number of standards, protocols and methods of verification; the Carbon Trust, for example, lists seven main offset standards[405] and Kollmuss and Bowell, five.[406] Ecosystem Marketplace and Business for Social Responsibility lists six recommended decision criteria against certain categories for evaluating offset projects;[407] Clean Air-Cool Planet lists ten offset project quality characteristics.[408] In a study of voluntary offsets for air-travel carbon emissions, the quality of an offset company's project portfolio is demonstrated by additionality, avoidance of double accounting, a realistically

calculated baseline and emissions reduction projection, and an accounting for leakage. The project must also be permanent.[409]

It is clear to us that, as a result of recent and emerging developments with regard to the emissions offset market, these issues are clearly being dealt with, and that corporations[410] can examine recent, complementary standards and anticipate emerging standards and regulations whilst preparing to participate in such market. The GHG Protocol for Project Accounting is a recent accounting tool for quantifying the greenhouse gas benefits of climate change mitigation projects. [411] Together with the GHG Protocol Corporate Standard, which sets out standards and provides guidance for corporations and other organisations which are preparing a GHG emissions inventory,[412] they form the GHG Protocol Initiative "toward a common standard for business reporting on greenhouse gas emissions,"[413] the result of collaboration between the World Business Council for Sustainable Development and the World Resources Institute.

The ISO 14064 standard for GHG accounting and verification, launched in 2006, provides a global solution

> to the problems posed by the fact that governments, business corporations and voluntary initiatives were using a number of approaches to account for organization - and project-level GHG emissions and removals with no generally accepted validation or verification protocols.[414]

The standard, in three parts,[415] sets out clear and verifiable specifications for organisations and proponents of GHG emission reduction projects and has the following benefits:

- promotes consistency, transparency and credibility in GHG quantification, monitoring, reporting and verification;
- enables organizations to identify and manage GHG-related liabilities, assets and risks;
- facilitates the trade of GHG allowances or credits, and
- supports the design, development and implementation of comparable and consistent GHG schemes or programmes.[416]

In outline, it provides requirements for organisations, and individuals, to quantify and verify GHG emissions. The ISO 14064 process principles are regime neutrality, technical rigour, extensive participation and speed-to-market.[417]

And the ISO's 14065 standard, released in April, 2007,[418] sets out accreditation requirements for organisations that either verify or validate GHG emission claims or assertions; the aim of such verification or validation "is to give confidence to parties that rely upon a GHG assertion or claim, for example regulators or investors, that the bodies providing the declarations are competent to do so, and have systems in place to manage impartiality and to provide the required level of assurance on a consistent basis."[419]

Taken together, the ISO 14064 and 14065 standards "develop flexible, regime-neutral tools for use in voluntary or regulatory GHG schemes; promote and harmonize best practice; support the environmental integrity of GHG assertions; assist organizations to manage GHG-related opportunities and risks, and support the development of GHG programmes and markets."[420]

Building on the work of the ISO (specifically ISO 14064) are two complementary standards - the Voluntary Carbon Standard (VCS) and the Voluntary Gold Standard (VGS)[421] - the former to be launched in mid-2007[422] and the latter launched in 2006. The VGS[423] follows the Gold Standard[424] (the standards of which are higher than those of the CDM) and deals with smaller projects not CDM registered. The VCS, the work of the International Emissions Trading Association (IETA), The Climate Group and the World Economic Forum,

> seeks to provide a credible but simple set of criteria that will provide integrity to the voluntary carbon market ... The Voluntary Carbon Standard is a robust standard for the measurement and recognition of verified emission reductions created for voluntary use by corporations, organizations and individuals. The VCS is designed to be a global benchmark standard for project-based voluntary emission reductions that provides a degree of standardization to the voluntary carbon market …[425]

Finally, from June, 2007 a new standard for verified emissions reductions (VERs),[426] TUV SUD corporation's "Blue Registry," will be available.[427] It is a transparent certification database which "allows management of climate-change projects which are carried out under a simplified procedure outside the Kyoto Protocol. It [will] serve … as a contact point for project owners and parties purchasing or trading with emission credits."[428]

Notwithstanding the issues outlined above, "carbon offsetting makes sense."[429] Mandatory purchase of offsets for some specified proportion of emissions provides scope for new airline entrants and creates a stable market with some long term predictability compared to participation in an emissions trading scheme. The market for offsets also has the advantage of efficiency claimed for trading allowances since it encourages the least cost producers to provide – or, in this case, manufacture – the required offset. In some ways it has scope for greater flexibilities and overall efficiencies, as mentioned, as it is not constrained to be industry specific. Unlike a market for a fixed quantity of emissions, the market for offsets provides more room for orderly expansion (again, compared to participation in an aviation ETS).

Further, as the price of offsets increases with demand it is reasonable to anticipate development of more sophisticated projects and a mix of such projects flowing from funds invested as a result of offsets purchased. It is reasonable to expect that mandatory airline participation in an emissions offset market or markets would promote innovation and technological solutions to the aviation climate change problem; carbon offsets "do have their place in spurring

innovation,"[430] and offset firms "have prospered because they are able to produce emissions reductions more cheaply, and often more imaginatively, than those that are bound up in the red tape of the Kyoto process."[431] Moreover,

> [t]he most promising impact of carbon markets has been its impact on innovation as smart capital takes an early, long-term bet on the quickly growing emerging market for environmentally-oriented investment. A key indicator of interest in aligned and closely related fields is the record US$70.9 billion in clean technology investments in 2006,[432] with major investments (and announcements) from well-known investment banks.[433]

Airline participation in an emissions offset market would encourage investment in and the development of new technology and new solutions as one part of a comprehensive climate strategy. Moreover, the nature of such mandatory participation, and the global industry involved, would give additional impetus to developments presently underway with regard to technologies which avoid, reduce or absorb GHG emissions - all matters of vital importance to the airline industry.[434]

The World Bank reports that

> [t]he enormity of the climate challenge … will require a profound transformation, including in those sectors that "cap-and-trade" markets cannot easily reach. These include making public and private investments in research and development for new technology development and diffusion ...[435]

The emissions offset market can reach those sectors.

It is our position that airlines should seriously consider supporting mandatory emissions offsets – mandatory participation in an emissions offset market – *as part of a sustainable solution* to dealing with the climate impacts of aviation. This solution should also comprise technological, operational and management elements which, we suggest, should also form part of a long-term strategy package. It does not preclude participation in an emissions trading scheme.

This strategy has not, as yet, been considered by airlines.

A sustainable solution to the aviation GHG emissions problem must involve airline action and adaptation. As Bill McKibben and Aaron Clark note, carbon offsets "will only represent a sustainable solution if joined by improvements in technology and significant, international political action."[436]

4.6 As a preliminary step, introduce an airline default – or opt-out - passenger emissions offset scheme

One way in which airlines could begin to incorporate offsetting into any more inclusive strategy would be to introduce it as an airline default – or opt-out – passenger emissions offset scheme. This would allow airlines to take action in the immediate future, thus absorbing demands that they address the climate costs of aviation in a least cost manner. It would also provide airlines with much-needed information as to public/ passenger sensibilities concerning the climate

impacts of aviation and environmental charges (broadly defined) ahead of mandatory emissions offsets.

In outline, under this scheme, a distinct and separate surcharge for the full carbon cost of the flight would be made or levied in addition to the cost of the fare. Each passenger could *clearly* choose to pay any proportion of this surcharge. If no action is taken by the passenger to waive some proportion it remains at 100%. The details of the scheme would be completely transparent, and would be brought to the attention of the potential passenger at various points, or stages, in the booking/ ticket purchasing process; its terms would be made clear to those purchasing tickets at a point in time when they can make a meaningful decision. Further, formal acknowledgement would be made that a prospective purchaser has been informed, understands and accepts the surcharge (or a specified portion of it).

This is different from present schemes under which individuals can seek to buy offsets through or from some airlines[437] or third parties on a variable or ad hoc basis. Part of the difference is psychological. Studies show that there is a significant difference in presentation of options; most people choose the default setting. An opt-out carbon offset scheme would demand a conscious decision.

Such a scheme might also be expected to cause the travelling public to be more aware of the potential climate impacts of air travel, although such awareness has increased and is increasing dramatically. Why is public awareness a benefit to airlines? It appears to us that airlines would be well served with educated passengers (in terms of the potential climate impacts of air travel) that are treated as partners and that understand the airlines' position.

Our proposal – our proposed preliminary step for airlines with regard to emissions offsets - has the following properties:

- *Flexible*: The scheme could start, for example, with the possibility of a 100% waiver. As, or if, it became necessary for an airline or airlines to increase contributions to the carbon costs of air travel, the existing systems would allow a seamless and gradual increase to any desired level. It also, of course, precludes neither devotion of resources to improve air transport technology and infrastructure nor development of more efficient air transport operational practices. Indeed, its flexibility and simplicity are such that it is easy to replace.

  It also reinforces the need to deal with the aviation emissions problem through several mechanisms. It does not, of course, prevent airlines from simultaneously devoting effort to such mechanisms.

- *Informative*: What airlines presently lack is information on the sensibility of the public to offsets. This scheme would provide feedback on this issue and also on issues of the environmental price sensitivity of demand.

- *Efficient*: Not only would the scheme be relatively inexpensive for an airline to run, it would build in all the usual gains from efficiency. An airline

that can devise ways to cut its total emissions per passenger will be in a position to offer cheaper carbon offsets than its rivals.

- *Responsible*: It seems clear that airlines will be increasingly held responsible for the social costs of their actions. This initiative gives airlines a simple and workable means of accepting this responsibility before any decision is forced on them *and* provides a lead-in or a step prior to mandatory emissions offsets. It affords an opportunity for airlines to get out ahead.

- *Fair*: Finally, any scheme for altering air travel should be seen to be fair. As things presently stand those who travel least are implicitly subsidising those who travel most. An equitable balance of costs can only be reached through some sort of user pays scheme. It might be claimed that an increase in costs gives the wealthier members of society privileged access. While correct, this concern is misplaced. It is well established in economic thought that problems of inequality should be solved directly, and not through indirect transfers.

Such a scheme as we propose is simple for airlines to implement with minimal delays and cost. It would not present any first mover disadvantages; the emissions cost is set out separately from the price of the fare. In fact, we believe that this proposal may present a first mover airline with distinct advantages and opportunities. Not only would it be doing something positive, it would be seen to be doing something positive. This may have the effect of generating more support from private and business travelers.

There are a number of other issues relating to an airline default – or opt-out – passenger emissions offset scheme which are not considered in this paper. Such issues include implementation strategies, the operation of the scheme, specific offset arrangements and ensuring an appropriate means of guaranteeing purchasers that the scheme provides full offsets in a cost-effective manner. They also include legal and taxation matters as well as the operation of a default offset scheme in the context of successive carriage, interlining and code-sharing.

These issues have been considered in detail but are not included here as they fall outside the immediate scope of this paper. They are more fully laid out in a forthcoming paper which provides more definitive conclusions than those contained here.

4.7 Introduce taxes and charges

The aircraft emissions problem might also be addressed in part by introducing taxes, charges[438] or duties.[439] To be effective these instruments would need to be at a rate which, for example, reduces passenger numbers and demand for air travel sufficiently to overcome the industry growth problems discussed in this paper. It appears that the most efficient method of introducing taxes would be to link them directly to emissions by placing the burden on fuel consumed. Such fuel taxes would be consistent with offsetting, and they would provide airlines with certainty. They would not, however, represent a complete solution. Further, a number of problems attend the taxation of fuel for international air services, which is exempt under the Chicago Convention[440] and the majority of bilateral air services agreements.

Analysis of taxes and charges – given their unique nature and particular problems – will be considered in a subsequent paper.

5. Summary: Sustainable, long-term solutions for airlines

A broad-based consensus within the scientific community indicates that it is time for audacious goals and action.

- Business for Social Responsibility,
A Three-Pronged Approach to Corporate Climate Strategy[441]

This paper has examined the risks posed by climate change, the climate impacts of aviation and the unique challenges faced by airlines in dealing with their greenhouse gas emissions problem. After an assessment of possible airline strategies for dealing with the climate impacts of aviation – including the problems of including aviation in emissions trading schemes – we conclude that airlines should seriously consider supporting mandatory emissions offsets as *part* of a long-term, forward-looking strategy package and a sustainable solution to deal with the aviation emissions problem. Further, it is our view that airlines should not wait for but should move ahead of governments; airlines should steer the process of change to build a cleaner sky. It makes economic sense for airlines to adopt a proactive stance towards the risks and uncertainties presented by climate change.

Notes and references

1 David Hodgkinson and Professor Alex Coram are members of The Hodgkinson Group (www.hodgkinsongroup.com). The Group has advisors located around the world (see note on authors and The Hodgkinson Group at the end of the paper). **David Hodgkinson** was formerly Director of Legal Services at IATA, the organisation of the world's international scheduled airlines, in Montreal; **Alex Coram** is Professor of Political Economy, Aberdeen Business School, Robert Gordon University, Scotland. **Renee Garner** is a lawyer at Freehills in Melbourne, Australia. More detailed profiles can be found at the end of the paper.

2 Intergovernmental Panel on Climate Change (IPCC), *Aviation and the Global Atmosphere*, Joyce E Penner et al (Cambridge, Cambridge University Press, 1999): http://www.grida.no/climate/ipcc/aviation/index.htm. See http://www.grida.no/climate/ipcc/aviation/015.htm; http://www.grida.no/climate/ipcc/aviation/014.htm; and http://www.grida.no/climate/ipcc/aviation/016.htm.

3 Put another way, "The overwhelming scientific consensus is that anthropogenic climate change is a reality. Given that this is so, there is an urgent need to reduce greenhouse gas emissions and stabilise the concentrations of greenhouse gases in the atmosphere:" Kevin Anderson et al, *Growth scenarios for EU & UK aviation: contradictions with climate policy*, Tyndall Centre for Climate Change Research, Working Paper 84 (Norwich, Tyndall Centre for Climate Change Research,2006), p 11: http://www.tyndall.ac.uk/publications/working_papers/wp84.pdf.

4 Elizabeth Kolbert titles her groundbreaking book on climate change *Field Notes From a Catastrophe* (New York, Bloomsbury 2006).

5 Carbon Trust, *The Carbon Trust three stage approach to developing a robust offsetting strategy* (London, The Carbon Trust, 2006), p 2: http://www.carbontrust.co.uk/Publications/publicationdetail.htm?productid=CTC621.

6 IPCC, *Climate Change 2007: The Physical Science Basis – Summary for Policymakers*, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (http://www.ipcc.ch/SPM2feb07.pdf), p 2. The IPCC was established by the WMO and the UNEP "to assess scientific, technical and socio- economic information relevant for the understanding of climate change, its potential impacts and options for adaptation and mitigation" (http://www.ipcc.ch). Its Fourth Assessment Report "Climate Change 2007," presently being finalised, will include, in addition to the Working Group I, II and III reports considered here (the Working Group II report, "Impacts, Adaptation and Vulnerability," released 6 April, 2007, and the Working Group III report, "Mitigation of Climate Change," released 4 May, 2007, are considered briefly below), a Synthesis Report. The three Working Group reports "provide a comprehensive and up-to-date assessment of the current state of knowledge on climate change" (*supra*). The IPCC "remains the closest thing to a barometer for tracking the level of scientific understanding of the causes and consequences of global warming:" James Kanter and Andrew C Revkin, "Scientists Detail Climate Changes, Poles to Tropics," *The New York Times*, 7 April, 2007.
In addition to the IPCC Fourth Assessment Report and its predecessors, other scientific reports and studies include Frank Ackerman and Elizabeth Stanton, *Climate Change – the Costs of Inaction* (Boston, Global Development and Environment Institute, Tufts University, 2006): http://www.ase.tufts.edu/gdae/policy_research/CostsofInaction.html; James Hansen et al, "Global temperature change," *Proceedings of the National Academy of Sciences*, vol 103, no 39, 26 September, 2006, pp 14288-14293; Jim Hansen, "Global Climate Change: Is There Still Time to Avoid Disastrous Effects?" California Energy Commission and California Environmental Protection Agency, Third Annual Climate Change Research Conference, *Climate Scenarios, Impacts, and Adaptation Options in California: Status of Research Avtivites*, 13-15 September, 2006: http://www.climatechange.ca.gov/events/2006_conference/presentations/2006-09-13/2006-09-13_HANSEN.PDF; National Research Council, Committee on Surface Temperature Reconstructions for the Last 2,000 Years, *Surface Temperature Reconstructions for the Last 2,000 Years* (Washington, DC, National Academies Press, 2006); and Thomas R Karl et al (eds), *Temperature Trends in the Lower Atmosphere: Steps for Understanding and Reconciling Differences* (Washington, DC, Climate Change Science Program and the Subcommittee on Global Change Research, 2006): http://www.climatescience.gov/Library/sap/sap1-1/finalreport/default.htm. And see also S Pacala and R Socolow, "Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies," *Science*, vol 305, 13 August, 2004, pp 968-972.
For more popular studies and articles on climate change see Jim Hansen, "The Threat to the Planet," *The New York Review*, 13 July, 2006, pp 12-16; Elizabeth Kolbert, *Field Notes From a Catastrophe: Man, Nature, and Climate Change* (New York, Bloomsbury 2006); Eugene Linden, *The Winds of Change: Climate, Weather, and the Destruction of Civilizations* (New York, Simon and Schuster, 2006); Tim Flannery, *The Weather Makers: The History and Future Impact of Climate Change* (Melbourne, Text Publishing, 2005); Donald Kennedy et al (eds), *Science Magazine's State of the Planet 2006-2007* (Washington, DC, Island Press, 2006); Al Gore, *An Inconvenient Truth: The Planetary Emergency of Global Warming and What We Can Do About It* (New York, Rodale, 2006); "The heat is on: A survey of climate change," *The Economist*, 9 September, 2006; George Monbiot, *Heat: How to Stop the Planet From Burning* (Doubleday Canada, 2006); and Jared Diamond, *Collapse: How Societies Choose to Fail or Succeed* (New York, Viking, 2005).

7 At least a 9 out of 10 chance of being correct.

8 IPCC, *supra*, note 6, p 5.

9 *Supra*, pp 5 and 8. See also Hansen et al, *supra*, note 6, p 14288; the authors conclude "that global warming is a real climate change."

10 That is, a likelihood greater than 90%: *Supra*, note 6, p 4.

11 *Supra*, p 10. The IPCC states that "[c]ontinued greenhouse gas emissions at or above current rates would cause further warming and induce many changes in the global

climate system during the 21st century that would *very likely* [a likelihood greater than 90%] be larger than those observed during the 20th century …Anthropogenic warming and sea level rise would continue for centuries due to the timescales associated with climate processes and feedbacks, even if greenhouse gas concentrations were to be stabilized … Both past and future anthropogenic carbon dioxide emissions will continue to contribute to warming and sea level rise for more than a millennium, due to the timescales required for removal of this gas from the atmosphere:" *Supra*, pp 13 and 17. Summaries of and commentaries on the IPCC February, 2007 report include *The Economist*, "Climate Change: Heating Up," 10 February, 2007; Richard A Kerr, "Scientists Tell Policymakers We're All Warming the World," *Science*, vol 315, 9 February, 2007, pp 754-757; and Elisabeth Rosenthal and Andrew C Revkin, "Science Panel Calls Global Warming 'Unequivocal,'" *The New York Times*, 3 February, 2007.

12 IPCC, *Climate Change 2007: Climate Change Impacts, Adaptation and Vulnerability – Summary for Policymakers*, Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change: http://www.ipcc.ch/SPM13apr07.pdf.

13 *Supra*, p 17.

14 *Supra*, pp 2-3.

15 *Supra*, p 19.

16 *Supra*, p 19 (emphasis added). Summaries of and commentaries on the IPCC April, 2007 report include Agence France Presse, "Climate change impacts: Main points from IPCC summary," 6 April, 2007; James Kanter and Andrew C Revkin, "Scientists Detail Climate Changes, Poles to Tropics," *The New York Times*, 7 April, 2007; and the Science and Development Network, "Report sees 'climate divide' between rich and poor," 6 April, 2007: http://www.scidev.net/content/news/eng/report-sees-climate-divide-between-rich-and-poor.cfm.

17 IPCC, *Climate Change 2007: Mitigation of Climate Change – Summary for Policymakers*, Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 4 May, 2007: http://www.ipcc.ch/SPM040507.pdf. Summaries of and commentaries on the IPCC May, 2007 report include Andrew C Revkin and Seth Mydans, "Climate Panel Reaches Consensus on the Need to Reduce Harmful Emissions," *The New York Times*, 4 May, 2007; and IPCC, Contribution of Working Group III to the Fourth Assessment Report of the IPCC, *Presentation by the co-chairs*, 4 May, 2007: http://www.ipcc.ch/WG3_press_presentation.pdf

18 And that GHG emissions have grown since pre-industrial times: *supra*, note 17, p 2.

19 *Supra*, p 3.

20 That is, until 2030. For mitigation in the long term (after 2030), see pages 21-27 (*supra*).

21 *Supra*, p 10; "[i]n 2030 macro-economic costs for multi-gas mitigation, consistent with emissions trajectories towards stabilization between 445 and 710 ppm CO2-eq, are estimated at between a 3% decrease of global GDP and a small increase, compared to the baseline … However, regional costs may differ significantly from global averages" (*supra*, p 15).

22 *Supra*, p 18.

23 *Supra*; emphasis added.

24 *Supra*, p 13.

25 *Supra*, p 30.

26 *Supra*, pp 27-28.

27 Economic instruments, government funding and regulation.

28 *Supra*, note 17, p 28.

29 *Supra*.

30 Sir Nicholas Stern, *The Economics of Climate Change*, p i: http://www.hm-treasury.gov.uk/media/8AC/F7/Executive_Summary.pdf. The Stern Review can be found athttp://www.hmtreasury.gov.uk/independent_reviews/stern_review_economicsclimate_change/stern_review_report.cfm.

31 *Supra*, http://www.hm-treasury.gov.uk/media/8A8/C1/Summary_of_Conclusions.pdf, p vi.

32 *Supra*. The Review also finds that "[a]ll countries will be affected [by climate change]. The most vulnerable … will suffer earliest and most … The costs of extreme weather,

including floods, droughts and storms, are already rising, including for rich countries:" *supra*, p vii.

33 *Supra*, p viii.

34 *Supra*. On the Stern Review generally see *The Economist*, "Economics of Climate Change: Stern Warning," 4 November, 2006; John Cassidy, "High Costs," *The New Yorker*, 13 November, 2006; and Martin Wolf, "Climate change: no real energy for global action," *The Australian*, 9 November, 2006. For a critique of the Stern Review see Bjorn Lomborg, "The dodgy numbers behind the latest warming scare," *The Wall Street Journal*, 2 November, 2006 (http://www.opinionjournal.com/forms/printThis.html?id=110009182) and Paul Baer and Michael Mastrandrea, *High Stakes: Designing emissions pathways to reduce the risk of dangerous climate change* (London, Institute for Public Policy Research (IPPR), 2006). The IPPR study was commissioned "to develop estimates of emissions pathways that have a high likelihood of keeping the rise in the world's average surface temperatures above pre-industrial levels to below 2 degrees Celsius" (p 4). Its conclusions "go further than the Stern Review, which proposes a long-term goal to stabilize greenhouse gases at between the equivalent of 450 and 550 ppm CO2. That range has a medium to high risk of exceeding a 2 degree Celsius rise in temperature" (p 5). The report "suggests Lord Stern's analysis was too conservative and governments need to move further and faster. To minimize the risk of a 2C rise – seen as the threshold for dangerous climate change – the authors say global carbon dioxide emissions would need to peak between 2010 and 2013:" James Randerson, "Only a decade left to avoid climate change, says think tank," *Guardian*, 9 November, 2006.

35 James Hansen et al, "Global temperature change," *Proceedings of the National Academy of Sciences*, vol 103, no 39, 26 September, 2006, p 14288. Further, the US National Oceanic and Atmospheric Administration (NOAA) reported on 15 March, 2007 that the northern winter just ended was the warmest on record, and that the December, 2006-February, 2007 period was the warmest on record around the globe for land surface temperature: NOAA News Releases 2007, "NOAA Says U.S. Winter Temperature Near Average. Global December-February Temperature Warmest on Record," 15 March, 2007: http://www.publicaffairs.noaa.gov/releases2007/mar07/noaa07-016.html. And scientists from the US National Snow and Ice Data Centre and the National Center for Atmospheric Research reported research in March, 2007 in which a review of computer climate models suggested that global warming could transform the North Pole into an ice-free expanse of open ocean at the end of each summer by 2100: see Mark C Serreze et al, "Perspectives on the Arctic's Shrinking Sea-Ice Cover," *Science*, vol 315, 16 March, 2007, pp 1533-1536. See also Andrew Shepherd and Duncan Wingham, "Recent Sea-Level Contributions of the Antarctic and Greenland Ice Sheets," *Science*, vol 315, 16 March, 2007, pp 1529-1532.

36 Tyndall Centre for Climate Change Research, *Constructing energy futures*, Research Programme 1: http://www.tyndall.ac.uk/research/programme2/programme2.shtml. See also James Hansen et al, "Global temperature change," *Proceedings of the National Academy of Sciences*, vol 103, no 39, 26 September, 2006, pp 14288-14293, where the authors conclude that "data suggests that … probably the planet as a whole … is approximately as warm now as at the Holocene maximum and within ~1C of the maximum temperature of the past million years. We conclude that global warming of more than ~1C, relative to 2000, will constitute "dangerous" climate change as judged from likely effects on sea level and extermination of species" (at p 14288).

37 International Scientific Steering Committee, *Avoiding Dangerous Climate Change: Scientific Symposium on Stabilisation of Greenhouse Gases - Executive Summary of the Conference Report* (London, Department for Environment, Food and Rural Affairs, 2006), p 1:http://www.defra.gov.uk/environment/climatechange/research/dangerous-cc/pdf/avoid-dangercc-execsumm.pdf.

38 Hans Joachim Schellnhuber et al, *Avoiding Dangerous Climate Change* (Cambridge, Cambridge University Press, 2006): http://www.defra.gov.uk/environment/climatechange/research/dangerous-cc/pdf/avoid-dangercc.pdf.

39 International Scientific Steering Committee, *supra*, note 37, pp 1, 3.

40 0r 40 gigatonnes in 2030, an increase of 14 gigatonnes over the level in 2004: See

International Energy Agency, *World Energy Outlook 2006: Summary and Conclusions* (Paris, OECD/IEA,2006), p 5: http://www.worldenergyoutlook.org/summaries2006/English.pdf.

41 "Above a one degree Celcius increase, risks increase significantly, often rapidly for vulnerable ecosystems and species. In the one to two degree range, risks across the board increase significantly, and at a regional level are often substantial. Above two degrees the risks increase very substantially, involving potentially large numbers of extinctions or even ecosystem collapses, major increases in hunger and water shortage risks as well as socio-economic damages, particularly in developing countries:" Bill Hare, Potsdam Institute of Climate Impact Research, Germany (BBC News, "Climate report: the main points," 30 January, 2006: http://newsvote.bbc.co.uk/mpapps/pagetools/print/news.bbc.co.uk/1/hi/sci/tech/4661830.stm. The 2006 report, *Avoiding Dangerous Climate Change*, views a rise of 2 degrees celcius as sufficient to cause, amongst other things, decreasing crop yields in the developing and developed world, tripling of poor harvests in Russia and Europe, up to 2.8 billion people at risk of water shortage, total loss of summer Arctic sea ice, 97% loss or coral reefs and the spread of malaria in North America and Africa (*supra*, note 37).

42 Gerard Wynn, "Exxon misleads on climate change: UK Royal Society," *Reuters*, 20 September, 2006: http://go.reuters.com/newsArticle.jhtml?type=scienceNews&storyID=13553084&src=rss/scienceNews.

43 "Lining up for profits," *The Economist*, 12 November, 2005, p 73.

44 United States General Accounting Office, *Aviation and the Environment: Aviation's Effects on the Global Atmosphere Are Potentially Significant and Expected to Grow* (Report to the Honorable James L. Oberstar, Ranking Democratic Member, Committee on Transportation and Infrastructure, House of Representatives, GAO/RCED-00-57)(Washington, DC, United States General Accounting Office, 2000) p 4: http://www.gao.gov/archive/2000/rc00057.pdf.

45 As of March, 2007.

46 Boeing, 2006 *Current Market Outlook*: http://boeing.com/commercial/cmo/highlights.html.

47 Boeing, *supra*; the world airline fleet, according to Boeing, will grow from 17,330 to 35,970 aircraft. See also Boeing, *New Airplanes*: http://boeing.com/commercial/cmo/new.html.

48 Daniel Michaels, "Airbus, Boeing Forecast Clear Skies," *The Wall Street Journal*, 24 November, 2006.

49 Reuters, "Air travel rates expected to double," 31 January, 2007.

50 IATA, *Fact Sheet: Industry Statistics*, March, 2007: http://www1.iata.org/NR/rdonlyres/6B5FE6C7-7346-4728-8C16-E038D5E29676/0/FactSheetIndustryFactsMAR2007.pdf.

51 See Boeing, *2006 Current Market Outlook*: http://www.boeing.com/commercial/cmo/regions.html; http://www.boeing.com/commercial/cmo/index.html; http://www.iata.org/pressroom/pr/2005-10-31-01.htm; http://www.iata.org/pressroom/speeches/2006-02-20-01.htm; andhttp://www.iata.org/pressroom/speeches/2006-06-05-01.htm (IATA).

52 Reuters, *supra*, note 49.

53 See Jens Flottau and Robert Wall, "Reasons to worry: Good news on revenues could mask the next crisis for airlines," *Aviation Week and Space Technology*, 12 June, 2006, p 39.

54 Anderson et al, *supra*, note 3, p 6; the precise citation is "so as to make room for the aviation industry."

55 Section 2.1 above, in part, also considers aviation and climate change in the context of the May, 2007 IPCC Working Group III report, "Climate Change 2007: Mitigation of Climate Change," and the medium term mitigation potential for CO2 emissions from the aviation sector, together with the need for total mitigation potential in the sector to account for non CO2 climate impacts of aviation emissions.

56 IPCC, *supra*, note 2.

57 IATA states – incorrectly - in a variety of fora that "aviation is responsible for 2% of global

carbon dioxide emissions" (IATA, "Climate Change: Aviation's Climate Change Impact is Small:" http://www1.iata.org/whatwedo/environment/climate_change.htm); "[i]n all, aviation is only responsible for 2% of global CO2 emissions …" (IATA, "IATA industry-wide strategy to address climate change:" http://www1.iata.org/NR/rdonlyres/80F7AA1C-2CE1-40B0-A2D5-C9AE38259AC2/0/4153400Climatechangeflyer4.pdf); "[a]ir transport contributes a small part of global CO2 emissions – 2%" (IATA, "Debunking Some Persistent Myths about Air Transport and the Environment:" http://www.iata.org/nr/rdonlyres/11804248-06a7-44a2-a160-62f1953d9e44/0/bedunkingsomepersistentmythsaboutairtransportandtheenvironment.pdf); "[t]he UN attributes 2% of global carbon emissions to aviation" (IATA, "Orient Aviation – Green Skies Conference Hong Kong: Remarks by Giovanni Bisignani," 29 March, 2007: http://www1.iata.org/pressroom/speeches/2007-03-29-01.htm); "[i]t's 2 percent but it's 2 percent and 2 percent is still 2 percent …." (Andrew Drysdale, IATA vice-president, cited in "Aviation industry mounts efforts to answer critics and head-off emission curbs," Greenwire, 7 May, 2007: http://www.wbcsd.org/plugins/DocSearch/details.asp?type=DocDet&ObjectId=MjQ1Mjc); "[a]ir transport produces 2% of global CO2 emissions" (IATA, "Danger CO2W," advertisement: http://www1.iata.org/whatwedo/environment/campaign/index.htm); and "[a]viation currently represents 2 per cent of global anthropogenic carbon dioxide (CO2) emissions" (Andreas Hardeman, "A Common Approach to Aviation Emissions Trading," *Air & Space Law*, vol 32, no 1, February, 2007, p 3; Hardeman also states that, where his paper uses the term 'emissions,' "this means 'carbon dioxide (CO2) emissions:'" *supra*). Again, emissions of carbon dioxide by aircraft represented about 2% of total anthropogenic carbon dioxide emissions in 1992 - not 2007 - as determined by the IPCC; see Intergovernmental Panel on Climate Change, *supra*, note 2: http://www.grida.no/climate/ipcc/aviation/006.htm. The 2007 figure, given growth in air travel in the ensuing 15 years, is higher than 2%, the figure currently cited by IATA.

58 IPCC, *supra*, note 2 (ch 2).

59 A greenhouse gas.

60 As the Tyndall Centre notes, "[a]viation emissions are unusual in the altitude of their emission. Atmospheric chemistry at this altitude has particular characteristics, and aviation emissions have particular effects:" Anderson et al, *supra*, note 3, p 11.

61 IPCC, *supra*, note 2: http://www.grida.no/climate/ipcc/aviation/004.htm. The Tyndall Centre for Climate Change Research notes that "[p]rovisional research suggests that lowering flight altitude could significantly reduce contrail formation and hence cirrus production. However, operating at a lower altitude would probably increase fuel burn and hence increase carbon emissions. Whilst in terms of instantaneous radiative forcing there would be benefits in flying at lower altitudes, the small increase in long-lived carbon dioxide (100+ years compared hours/days for contrails and cirrus) would essentially increase the global warming potential. Given the different time scales, deciding whether the benefits of lower flight outweigh the disbenefits cannot be a solely scientific decision:" Tyndall Centre for Climate Change Research, *Decarbonising the UK: Energy for a Climate Conscious Future* (Norwich, Tyndall Centre for Climate Change Research, 2005), p 50:http://www.tyndall.ac.uk/media/news/tyndall_decarbonising_the_uk.pdf. The report of a workshop at MIT in June, 2006, which considered the impacts of aviation on climate change noted that "[a]lthough current fuel use from aviation is only a few percent of all combustion sources of carbon dioxide, the expectation is that this percentage will increase because of projected increase in aviation and the likely decrease in other combustion sources as the world moves away from fossil fuels towards renewable energy sources. In addition, aircraft nitrogen oxides released in the upper troposphere and lower stratosphere generally has a larger climate impact than those emitted at the surface, although some of the much larger surface emissions from energy and transportation sources also reach the upper troposphere:" Next Generation Air Transportation System/ Joint Planning and Development Office (NGATS/ JPDO) Environmental Integrated Product Team and Partnership for AiR Transportation Noise and Emissions Reduction (PARTNER), *Workshop on the Impacts of Aviation on Climate Change: A Report of Findings and Recommendations*, ReportNo Partner-COE-2006-004, August, 2006, p 13: http://web.mit.edu/aeroastro/partner/reports/climatewrksp-rpt-0806.pdf.

62 Emphasis added; IPCC, *supra*, http://www.grida.no/climate/ipcc/aviation/006.htm. In addition to increasing tropospheric ozone concentrations, aircraft NOx emissions decrease the concentration of methane, another greenhouse gas (*supra*).

63 Emphasis added.

64 Sally Cairns and Carey Newson, *Predict and decide: Aviation, climate change and UK policy*, Environmental Change Institute, University of Oxford (Oxford, Oxford University Press, 2006), p 16. The authors then set out why putting a precise value on "significantly worse" is problematic. The report of the MIT workshop in June, 2006 noted that "[b]ecause the IPCC identified contrails, contrail-cirrus, and modifications of cirrus by aircraft exhaust as the most uncertain components of the aviation impact on climate, the majority of recent studies have focussed on cloud processes, while a limited number of studies also addressed chemical effects:" Next Generation Air Transportation System/ Joint Planning and Development Office (NGATS/ JPDO) Environmental Integrated Product Team and Partnership for AiR Transportation Noise and Emissions Reduction (PARTNER), *supra*, note 61, p 20.

65 IPCC, *supra*, note 17.

66 *Supra*, p 18.

67 Keith P Shine and William T Sturges, "CO2 Is Not the Only Gas," *Science*, vol 315, 30 March, 2007, pp 1804-1805. Shine and Sturges write that "An increase in the concentration of a greenhouse gas causes a change in Earth's energy balance. This change, or radiative forcing, is a simple indicator of the climate change impact. The largest single contributor to radiative forcing is CO2 ... (p 1804).
"[The Kyoto Protocol] recognizes the importance of non-CO2 greenhouse gases. Emission targets for signatories to the Convention are given in terms of CO2-equivalent emissions; the signatories can choose to control emissions of several gases … to meet their targets. There remain issues concerning what emissions are included and excluded in the Kyoto Protocol and the method by which emissions of different gases are placed on a common "carbon-equivalent" scale. Nevertheless, it is clear that controlling non-CO2 greenhouse gas emissions can play a very important role in attempts to limit future climate change (*supra*).
"The contribution of a given non-CO2 greenhouse gas to radiative forcing depends on its ability to absorb infrared radiation emitted by Earth's surface and atmosphere … (*supra*).
"CO2 undoubtedly remains the single most important contributor to greenhouse gas radiative forcing, but the non-CO2 greenhouse gases are important both collectively and individually …" (*supra*, p 1805) (footnotes omitted).

68 Next Generation Air Transportation System/ Joint Planning and Development Office (NGATS/ JPDO) Environmental Integrated Product Team and Partnership for AiR Transportation Noise and Emissions Reduction (PARTNER), *supra*, note 61, p 17.
"Aircraft engines emit CO2 and water vapor, important greenhouse gases, that directly affect climate through their absorption and reemission of infrared radiation; [a]ircraft emit NOx (and HOx produced from water vapor emissions into the stratosphere) that modifies atmospheric ozone concentrations. Ozone affects the radiative balance of the climate system through both its shortwave and infrared (greenhouse effect) absorption; [t]hrough its resulting net production of upper tropospheric and lower stratospheric ozone, NOx emissions from subsonic aircraft also reduce the atmospheric abundance of CH4, another important greenhouse gas, through feedback effects on concentrations of tropospheric hydroxyl radicals (OH), the primary reactant for destruction of methane; [a]ircraft emit aerosols in the form of liquid particles containing sulfate and organics, and soot particles; … [and u]nder the right meteorological conditions, aircraft emissions of water vapor (and aerosols) can lead to formation of contrails and possibly result in effects on upper tropospheric cirrus clouds - these effects may exert spatially inhomogeneous radiative impacts on climate … The effect of aircraft emissions on atmospheric ozone concentration depends on the altitude at which the emissions are injected;" *supra*.

69 Royal Commission on Environmental Pollution, *The Environmental Effects of Civil Aircraft in Flight* (London, Royal Commission on Environmental Pollution, 2002), p 14: http://www.rcep.org.uk/aviation/av12-txt.pdf.

70 The IPCC describes radiative forcing as "the global, annual mean radiative imbalance to the Earth's climate system caused by human activities:" IPCC, *supra*, note 2,http://www.grida.no/climate/ipcc/aviation/064.htm. The report of the MIT workshop in

June, 2006, which considered the impacts of aviation on climate change noted that "[e]missions by aviation are responsible for a range of atmospheric changes that perturb the radiation budget and hence force climate change. In assessing the overall impact of aviation on climate, and to quantify the potential trade-offs in the climate impact of changes in aircraft technology, operations, or even the amount of aircraft traffic, it is important to place these different climate forcings on some kind of common scale. We refer to methods that attempt to achieve this as "metrics". Although their existing application to aircraft issues is much more limited, the general usefulness and uncertainties associated with metrics for climate change has been the subject of many published research studies. There are many difficulties in developing such metrics, which while not unique to aviation, are certainly exacerbated by the nature of aviation's impacts on climate … The most straightforward metric is the traditional one, namely radiative forcing (RF) at some given time due to the cumulative impact (both direct and indirect) of aviation emissions during some prior time period … For comparison of the climate impact of emissions, a whole class of metrics has been proposed … These aim to provide an exchange rate, so that each emission can be given a CO2-equivalence. The Kyoto Protocol to the UN Framework Convention on Climate Change has adopted the Global Warming Potential (GWP) concept as developed for the IPCC climate assessments to provide this equivalence ... it accounts for both the radiative strength of the climate change agent and its persistence in the atmosphere … [C]omplexity [associated with the GWP] led IPCC (1999) to reject the possibility of applying GWPs for aviation, although they did not recommend any alternatives …:" Next Generation Air Transportation System/Joint Planning and Development Office (NGATS/ JPDO) Environmental Integrated Product Team and Partnership for AiR Transportation Noise and Emissions Reduction (PARTNER), *supra*, note 61, pp 24-26.

71 IPCC, *supra*. Emphasis added.

72 *Supra*: http://www.grida.no/climate/ipcc/aviation/008.htm.

73 Royal Commission on Environmental Pollution, *supra*, note 69, p 15.

74 *Supra*, p 18.

75 IPCC, *supra*, note 2: http://www.grida.no/climate/ipcc/aviation/008.htm. As Bows and Anderson state, "[c]arbon dioxide emissions from the [aviation] industry are well understood, and therefore easy to compare with other sectors. However, aviation's full contribution to climate change has, potentially, a much greater impact than that of the carbon dioxide emissions alone; nitrous oxide, soot and water vapour, released at different altitudes in the atmosphere, cause additional warming. Combined with the production of condensation trails (contrails), under certain atmospheric conditions, and the likely consequent formation of cirrus clouds, aviation's instantaneous warming impact is estimated to be between 2 and 4 times that of the carbon dioxide emitted:" Alice Bows and Kevin L Anderson, "Policy Clash: Can Projected Aviation Growth be Reconciled with the UK Government's 60% Carbon-Reduction Target?," *Transport Policy* 14 (2007), pp 103-104.

76 Royal Commission on Environmental Pollution, *supra*, note 69, p 19.

77 Next Generation Air Transportation System/Joint Planning and Development Office (NGATS/ JPDO) Environmental Integrated Product Team and Partnership for AiR Transportation Noise and Emissions Reduction (PARTNER), *supra*, note 61, p 5.

78 See pages 18-19.

79 General Accounting Office.

80 United States General Accounting Office (GAO), *Aviation and the Environment: Aviation's Effects on the Global Atmosphere Are Potentially Significant and Expected to Grow* (Report to the Honorable James L. Oberstar, Ranking Democratic Member, Committee on Transportation and Infrastructure, House of Representatives, GAO/RCED-00-57)(Washington, DC, United States General Accounting Office, 2000) p 4: http://www.gao.gov/archive/2000/rc00057.pdf.

81 *Supra*, p 4. The report also notes (at p 4) that global aviation emissions of carbon dioxide "are roughly equivalent to the carbon emissions of certain industrialized countries …"

82 *Supra*.

83 Water vapour, nitrogen oxide and nitrogen dioxide (together, NOx), soot and sulphate.

84 US GAO, *supra*, note 80, p 5.

85 *Supra*, p 25. The GAO also "carefully considered where jet aircraft deposit the bulk of

their emissions, what types of emissions they produce, and how these emissions affect the atmosphere, both by themselves and in combination with each other:" *supra*.

86 *Supra*, p 5.

87 Royal Commission on Environmental Pollution, *supra*, note 69.

88 Ian Waitz et al, *Aviation and the Environment: A National Vision Statement, Framework for Goals and Recommended Actions*, Report to the United States Congress (Boston, Massachusetts Institute of Technology, 2004), a study mandated by the US Congress in December, 2003 as part of the *Vision 100 – Century of Aviation Reauthorization Act* (HR 2115, Public Law 108-176), p 4: see http://web.mit.edu/aeroastro/partner/reports/congrept_aviation_envirn.pdf. Stakeholders who participated in the study proposed a "National Vision for Aviation and the Environment" which, in part, states that "In 2025, significant … impacts of aviation community … local air quality emissions will be reduced in absolute terms, *notwithstanding the anticipated growth in aviation*. Uncertainties regarding both the contribution of aviation to climate change, and the impacts of aviation particulate matter and hazardous air pollutants, will be reduced to levels that enable appropriate action," *supra* (emphasis added). The vision statement is stated to be aspirational (*supra*, p 5).

89 *Supra*, p 11.

90 *Supra*.

91 *Supra*, p 12.

92 *Supra*, p 18

93 *Supra*.

94 *Supra*, note 2.

95 *Supra*, note 69.

96 Waitz, s*upra*, note 88, pp 4-5.

97 R Sausen et al, "Aviation radiative forcing in 2000: an update on IPCC (1999)," *Meteorologische Zeitschrift*, vol 14, no 4, pp 555-561 (the EU TRADEOFF project).

98 The report of the June, 2006 MIT workshop notes that, with reference to the Sausen et al study, "[a]n update of the IPCC (1999) radiative forcing (RF) from aviation for the "current" time period finds that, with one exception, the IPCC findings have not significantly changed, apart from the increase in air traffic from 1992 to 2000 (Sausen et al., 2005). The exception is RF from linear contrails, which appear to be at least a factor of three smaller. There is still no reliable estimate of RF from aviation-induced cirrus clouds. Based on recent correlation analyses some authors suggest that this RF might be dominating all other aircraft effects. It is critical that appropriate metrics be established before assuming relative climate impacts for various contributions based on potentially inappropriate metrics:" Next Generation Air Transportation System/Joint Planning and Development Office (NGATS/ JPDO) Environmental Integrated Product Team and Partnership for AiR Transportation Noise and Emissions Reduction (PARTNER), *supra*, note 61, p 11: http://web.mit.edu/aeroastro/partner/reports/climatewrksp-rpt-0806.pdf.

99 Cairns and Newson, *supra*, note 64. For summaries and analysis of the report see BBC News, "UK 'must act' on plane emissions," 17 October, 2006: http://news.bbc.co.uk/2/hi/science/nature/6056620.stm and Reuters, "Britain Must Cut Flights or Miss CO2 Targets," 17 October, 2006.

100 Department for Transport, *The future of transport – White Paper*, CM 6234 (London, The Stationery Office, 2004): http://www.dft.gov.uk/about/strategy/whitepapers/fot/.

101 Cairns and Newson, *supra*, note 64, p 17.

102 Emphasis added.

103 Cairns and Newson, *supra*, note 64, p 21.

104 Anderson et al, *supra*, note 3.

105 IPCC, *supra*, note 2.

106 Royal Commission on Environmental Pollution, *supra*, note 69.

107 Excluding cirrus clouds.

108 Anderson et al, *supra*, note 3, p 11.

109 *Supra*.

110 *Supra*.

111 Next Generation Air Transportation System/Joint Planning and Development Office (NGATS/ JPDO) Environmental Integrated Product Team and Partnership for AiR Transportation Noise and Emissions Reduction (PARTNER), *supra*, note 61.

112 *Supra*, p 6.
113 *Supra*; and pp 19-20, 28-29 and 42-46.
114 *Supra*, p 8.
115 *Supra*, pp 8-9 and 20-22, 29-37 and 46-52.
116 The report notes that, "[i]n assessing the overall impact of aviation on climate, and to quantify the potential trade-offs on the climate impact of changes in aircraft technology or operations, metrics for climate change are needed to place these different climate forcings on some kind of common scale. Radiative forcing (RF) has been used as a proxy for climate impact for well-mixed greenhouse gases. However, recent analyses have demonstrated that a unit radiative forcing from different climate change mechanisms does not necessarily lead to the same global mean temperature change (or to the same regional climate impacts). The concept of efficacy (E) has been introduced to account for this (i.e., E depends on the specific perturbation to the climate system, such as changes in ozone or aerosol distributions related to aircraft emissions). Hence, it is the product of E and RF that should be evaluated and intercompared for the various climate impacts from aviation. However, RF is not an emissions metric capable of comparing the future impact of different aviation emissions. The applicability of emission metrics, such as Global Warming Potentials (GWPs), have not been adequately tested and evaluated:" *supra*, pp 10-11, 22-27, 37-38 and 52-54.
117 *Supra*, pp 11, 22.
118 See Stern, *supra*, note 30.
119 *Supra*, p 485.
120 *Supra*, p 172, box 7.1.
121 *Supra*, Annex 7.c.
122 *Supra*, p 485.
123 *Supra*, p 342 (box 15.6).
124 *Supra*, p 342. The review, however, states that "this could be an *overestimate* because recent research … suggests the warming ratio is closer to 2. It could be an *underestimate* because both stimates exclude the highly uncertain possible warming effects of cirrus clouds" (342)(emphasis added). Moreover, "[t]he uncertainties over the overall impact of aviation on climate change mean that there is currently no internationally recognised method of converting CO2 emissions into the full CO2 equivalent quantity" (p 342, box 15.6).
125 *Supra*, Annex 7.c.
126 The IPCC noted in May, 2007 that "total mitigation potential in the [aviation] sector would also need to account for non-CO2 climate impacts of aviation emissions:" *supra*, note 17, p 18.
127 Whilst recognizing the difficulty in coordinating international aviation taxation: Stern, *supra*, p 485.
128 *Supra*.
129 The 2002 Royal Commission on Environmental Pollution notes on this point that "[a]ny inclusion of aviation emissions in an emissions trading scheme will also have to take into account the fact that the total radiative forcing of aviation is about three times that of the carbon dioxide emitted … Just as non-carbon dioxide greenhouse gases are accounted in terms of their global warming potential compared to carbon dioxide, so aviation emissions will need to be accounted to reflect their true contribution to climate change." For the Royal Commission, this means that "the aviation industry should acquire three carbon emission permits for each unit of carbon that it actually emits:" *supra*, note 69, p 36.
130 Stern, *supra*, p 341. Emphasis added.
131 Anderson et al, *supra*, note 3, p 6; the precise citation is "so as to make room for the aviation industry."
132 Royal Commission on Environmental Pollution, *Energy – The Changing Climate* (London, Royal Commission on Environmental Pollution, 2000): http://www.rcep.org.uk/newenergy.htm.
133 Royal Commission on Environmental Pollution, *supra*, note 69, p 37. Interestingly, at a May, 2007 ICAO Colloquium on Aviation Emissions, the ICAO Council president, Roberto Kobeh Gonzalez, opined that recent studies showed that the climate impacts of aviation

emissions were not as severe as previously thought: Aimee Turner, "ICAO aims to clarify impact of aviation on environment," *Flight International*, 22 May, 2007.

134 Cairns and Newson, *supra*, note 64.

135 Department of Trade and Industry, *Our energy future – creating a low carbon economy*, Energy White Paper (London, The Stationery Office, 2003): http://www.dti.gov.uk/files/file10719.pdf; Department of Trade and Industry, *The energy challenge*, Energy Review Report (London, DTI Publications, 2006): http://www.dti.gov.uk/files/file31890.pdf; Department of Trade and Industry, *Updated emissions projections: Final projections to inform the National Allocation Plan* (London, DTI Publications, 2004): http://www.dti.gov.uk/files/file26377.pdf; Department for Transport, *Aviation and global warming* (London, Department for Transport, 2004): http://www.dft.gov.uk/about/strategy/whitepapers/air/docs/aviationandglobalwarmingreport; and Department for Transport, *The future of air transport,* Aviation White Paper (London, Department for Transport, 2003): http://www.dft.gov.uk/about/strategy/whitepapers/air/thefutureofairtransportwhite5694.

136 While emissions from other activities fell by approximately 9%.

137 Cairns and Newson, *supra*, note 64, p 14.

138 Department for Transport, *The future of air transport*, *supra*, note 135, and Department for Transport, *Aviation and global warming*, *supra*, note 135.

139 Tyndall Centre for Climate Change Research, *supra*, note 61.

140 B Owen and D Lee, *Allocation of International Aviation Emissions from Scheduled Air Traffic – Future Cases, 2005–2050 (Report 3 of 3)*, Final Report to DEFRA Global Atmosphere Division (Manchester, Manchester Metropolitan University, Centre for Air Transport and the Environment, 2006): http://www.defra.gov.uk/science/project_data/DocumentLibrary/GA01060/GA01060_3754_FRP.pdf.

141 Cairns and Newson, *supra*, note 64, p. 15, noting that "[t]here are clearly some significant differences in these estimates, which partly derive from their assumptions about future aviation growth rates, improvements in technological efficiency and improvements in air traffic management" (*supra*). And, again, these are simply estimates of aviation's carbon dioxide impacts. As Cairns and Newson state, "aviation emits a range of other substances whose impacts on the climate are potentially very powerful:" *supra*, p 15.

142 *Supra*, note 64, p 22. Emphasis added.

143 *Supra*, p 97.

144 Tyndall Centre, *supra*, note 61. The EU is also considered in the Tyndall Centre study.

145 *Supra*, p 4. As part of its introduction, it states that "[t]he failure of governments to account for emissions from international aviation … has led to a serious underestimation of the actions necessary to achieve a true 60% reduction. Within the UK this is particularly evident; whilst the Government's Energy White Paper emphasizes the need for significant carbon reductions, the Aviation White Paper supports considerable growth in air travel. Research conducted … demonstrates the urgent need for coherent climate policy …:" *supra*.

146 *Supra*, p 47.

147 *Supra*.

148 Results of the study for both the UK and the EU are for carbon emissions alone. The study notes that "the altitude at which aircraft fly significantly exacerbates the warming created by carbon dioxide emissions. For example, contrails, cirrus clouds and greenhouse gases formed by aircraft induce additional warming effects which amplify the climate impact of the aviation industry. Such effects are omitted here due to both the very substantial scientific uncertainty associated with the size of the multiplier and disagreements about how, or indeed whether, such a multiplier should be applied. Where the multiplier is used as a simple "uplift" to carbon emissions, it is commonly in the order of 2.0 to 3.5 times the impact of carbon alone However, strictly speaking, such a comparison does not compare like with like:" *supra*, p 50.

149 *Supra*, p 49.

150 *Supra*.

151 Airport expansion, of course, is not limited to the UK; it is a global phenomenon. In the US, for example, a May, 2007 FAA report concluded that "[a] number of major US cities must expand existing airports in the next two decades, build new ones or find other

solutions to meet an increasing demand for air travel:" see US Department of Transportation, Federal Aviation Administration, *Capacity Needs in the National Airspace System, 2007-2025: An Analysis of Airports and Metropolitan Area Demand and Operational Capacity in the Future*, May, 2007 (Washington, DC, US Department of Transportation, Federal Aviation Administration, 2007): http://www.faa.gov/airports_airtraffic/airports/resources/publications/reports/media/fact_2.pdf; see also Errin Haines, "FAA: US airports must expand to meet demand," *USA Today*, 15 May, 2007. Further, US Transportation Secretary Mary E Peters said in May, 2007 that Atlanta should consider having multiple commercial airports and that, by 2025, airports in Atlanta, Chicago, Las Vegas and San Diego could be overwhelmed by passenger demand: Jim Tharper, "Atlanta told to consider second airport," *The Atlanta-Journal Constitution*, 15 May, 2007.

152 Department for Transport, *The future of air transport*, *supra*, note 135. Specifically, the White Paper stated: "7.3 The availability of sufficient airport capacity has the potential to become an important constraint on future growth across the UK without adequate and timely investment. Many airports in the UK are becoming increasingly congested as they attempt to cope with rising passenger numbers. In some cases, the capacity of terminals and runways is at, or near, saturation point ... 7.13 The Air Transport White Paper … supports the provision of two new runways in the South East in the period to 2030 - the first at Stansted (2011-12) and the second at Heathrow (2015-20) … Land at Gatwick will be safeguarded for a new runway in case conditions attached to a new Heathrow runway cannot be met ... 7.14 The White Paper also supports development at other airports including a new runway at Birmingham, around 2016 … It supports safeguarding land at Edinburgh for a new runway around 2020. And it supports additional terminal and airside development to make maximum use of existing runway infrastructure at a number of the larger regional airports, and additional terminal capacity at many of them ...": http://www.dft.gov.uk/about/strategy/whitepapers/fot/chapter7aviationandshippingd5705.

153 Tyndall Centre, *supra*, note 61, p 48.

154 *Supra*, p 49.

155 *Supra*. The European Commission states that aviation "contributes to global climate change, and its contribution is increasing. While the EU's total greenhouse gas emissions fell by 3 % from 1990 to 2002, emissions from international aviation increased by almost 70 %. Even though there has been significant improvement in aircraft technology and operational efficiency this has not been enough to neutralise the effect of increased traffic, and the growth in emissions is likely to continue in the decades to come:" http://ec.europa.eu/environment/climat/aviation_en.htm. Toward the end of 2005, the Commission adopted a Communication, "Reducing the Climate Change Impact of Aviation," (Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions, *Reducing the Climate Change Impact of Aviation*, COM(2005) 459, 27.9.2005; http://eur-lex.europa.eu/LexUriServ/site/en/com/2005/com2005_0459en01.pdf) which included an impact assessment and considered policy options. That Communication concluded, in part, that "the rapid growth [of aviation] undermines progress made in other sectors. If the growth continues as up to now, *emissions from international flights from EU airports will by 2012 have increased by 150 % since 1990. This growth in the EU's international aviation emissions would offset more than a quarter of the reductions required by the Community's target under the Kyoto Protocol.* In the longer run, aviation emissions will become a major contributor if current trends continue" (*supra*,p 2). The Commission, therefore, decided to pursue a new market-based instrument at Community level (as opposed to the levying of taxes and charges) and concluded that "the best way forward … lies in including the climate impact of the aviation sector in the EU emissions trading scheme" (Commission Staff Working Document, *Summary of the Impact Assessment: Inclusion of Aviation in the EU Greenhouse Gas Emissions Trading Scheme (EU ETS)*, COM(2006) 818, 20.12.2006, p 2; http://ec.europa.eu/environment/climat/pdf/aviation/sec_2006_1685_en.pdf). On 20 December, 2006, the Commission adopted a proposal for legislation to include aviation in the EU ETS. The EU's stated overall objective "is to address aviation's growing climate impact and ensure that it contributes to the EU's overall objective of limiting the increase in the global annual mean surface temperature to a maximum of 2°C above pre-industrial

levels." Its operational objective "is to include aviation in the EU ETS" (Commission Staff Working Document, *supra*, p 3). This proposal is examined in more detail in our consideration of strategies for airlines on emissions and climate change at 4.4 below.

156 *Supra*, p 50 ; emphasis added..

157 *Supra*.

158 Anderson et al, *supra*, note 3.

159 In so doing it takes into account fuel efficiency improvements and applies "uplift" factors with regard to radiative forcing. As stated earlier in this paper, the IPCC uses the metric, "radiative forcing," a globally averaged measure of the imbalance in radiation caused by the sudden addition of the relevant activity or emission. The IPCC calculated that the total radiative forcing caused by aviation in 1992 was approximately 2.7 times that caused by CO2 emissions alone; "uplift" is simply that 2.7 factor when applied. Anderson et al note that "there is substantial scientific uncertainty relating to both the size of the uplift factor that should be used, as well as to the method of simply "uplifting" carbon values for comparison with carbon emission profiles. Strictly speaking, such a comparison does not compare like with like:" *supra*, p 6.

160 The "contraction and convergence" principle "has gained increasing support as a method for apportioning global emissions to the national level. Under contraction and convergence, all nations work together to achieve collectively an annual contraction in emissions. Furthermore, nations converge over time towards equal per-capita allocation of emissions:" Tyndall Centre for Climate Change Research, *supra*, note 61, p 47. Bows and Anderson note that "[c]ontraction and convergence is an international framework for apportioning equitably a contracting global carbon dioxide emissions budget. Within this framework, the world's nations work together to set and achieve a global annual emissions target – contraction. In addition, nations converge towards equal per-capita emissions by an expressly defined year – convergence. By simultaneously 'contracting and converging,' such a policy requires all nations to impose targets from the outset:" *Supra*, note 75, p 104. See also J Cameron and A Evans, "What happens after Kyoto? More of the same or 'Contraction and Convergence'?," *New Economy*, vol 10, no 3 (2003), pp 128-131.

161 ppmv = parts per million by volume.

162 For the UK, "the 550ppmv contraction and convergence profile is consistent with the UK government's 2050 target of reducing carbon emissions by 60%:" Anderson et al, *supra*, note 3, p 6.

163 *Supra*. Further, "the scenarios for the UK were investigated in the context of what the impact on the other sectors of the economy might be. The scenarios show that all of the other sectors of the UK economy would need to reduce their carbon emissions significantly to allow the aviation industry to grow at even moderate rates. This would require a much more substantial investment in renewable energy, carbon sequestration, nuclear power, hydrogen and energy efficiency than would be the case with a low growth aviation sector:" *supra*.

164 On contraction and convergence see note 160.

165 Anderson et al, *supra*, note 3, p 7. The DfT's aviation White Paper has been examined in a number of reports and studies considered in section 2.2(b) above.

166 *Supra*, p 56.

167 *Supra*, pp 55-56.

168 *Supra*, p 58. The report concludes that "[d]espite the EU having a policy commitment to sustainable mobility, globally, air passenger kilometres have risen steadily over several decades and the UK has recently embarked on an extended period of government-backed aviation growth. This report shows the stark disjunction between aviation growth trends and effective, long term climate policy in both the UK and the wider EU:" *supra*, p 14.

169 *Supra*, note 75.

170 At least as against earlier Tyndall Centre reports.

171 Bows and Anderson, *supra*, note 75, p 103.

172 *Supra*, pp 105-106.

173 *Supra*, pp 104, 107.

174 *Supra*, p 107.

175 *Supra*, p 109.

176 European Federation for Transport and Environment (T&E) and Climate Action Network Europe (CAN-Europe), *Clearing the Air: The Myth and Reality of Aviation and Climate Change* (Brussels, T&E and CAN-Europe, 2006): http://www.transportenvironment.org/docs/Publications/2006/2006-06_aviation_clearing_the_air_myths_reality.pdf.

177 The questions asked in part 1 are: How much does air transport contribute to climate change?; how much more fuel-efficient have aircraft become?; how climate-intensive is aviation? how important is aviation economically?; and how well does the sector pay its way?

178 The questions asked in part 1 are: Should the EU go it alone, or is this a matter for ICAO?; will EU airlines suffer it if the EU goes it alone?; is a kerosene tax 'blunt and ineffective'?; should Value Added Tax be paid on international tickets?; are ticket taxes to fund development aid a good idea?; is emissions trading the best solution?; and are environmental measures for aviation bad for the poor? Some of these matters are taken up in sections 3 and 4 below.

179 European Federation, *supra*, note 176, p 4.

180 Mal Gormley, "Will Climate Change Challenge BizAv?," *Aviation Week*, 13 March, 2007.

181 IATA, "UN Guidelines on Emissions Trading Welcomed," *Press Release*, 17 February, 2007: http://www1.iata.org/pressroom/pr/2007-02-17-01.htm. Reports refer to IATA's increasingly strident tone: see, for example, Gormley, *supra*. On the problems associated with IATA's various climate-related statements and positions see notes 57 and 215. Interestingly, at a May, 2007 ICAO Colloquium on Aviation Emissions, the ICAO Council president, Roberto Kobeh Gonzalez, opined that recent studies showed that the climate impacts of aviation emissions were *not* as severe as previously thought: see Turner, supra, note 133.

182 Stern, *supra*, note 30.

183 James Hansen, "Climate Change: Why We Can't Wait," *The Nation*, 21 April, 2007; see http://www.alternet.org/module/printversion/50795. Or, as Daniel Kammen, Class of 1935 Distinguished Professor of Energy, University of California, Berkeley, has stated, "[i]In order to survive and thrive in the face of climate change, we need to establish and then put into practice - as quickly as possible – markets that utilize the value of carbon:" Daniel Kammen, "Climate Wise: A Currency for the Wealth, and Environmental Debt, of Nations," Climatebiz.com, April, 2007: http://www.climatebiz.com/sections/news_detail.cfm?NewsID=34997.

184 Abrahm Lustgarten, "For Sale: Pollution," *Fortune*, 24 August, 2006.

185 On risk generally see Peter L Bernstein, *Against the Gods: The Remarkable Story of Risk* (New York, John Wiley & Sons, Inc, 1998).

186 Jonathan Lash and Fred Wellington, "Competitive Advantage on a Warming Planet," *Harvard Business Review*, vol 85, no 3, March, 2007, pp 94-102.

187 *Supra*.

188 Carbon Trust, *Brand value at risk from climate change* (London, The Carbon Trust, 2005).

189 *Supra*, p 20.

190 *Global Framework for Climate Risk Disclosure: A statement of investor expectations for comprehensive corporate disclosure*, October, 2006: http://www.ceres.org/pub/docs/Framework.pdf.

191 *Supra*, p 1.

192 World Business Council for Sustainable Development (WBCSD) and the World Resources Institute, *Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard* (Washington, World Resources Institute and WBCSD, 2004); see http://www.ghgprotocol.org/DocRoot/7e9ttsv1gVKekh7BFhqo/ghg-protocol-revised.pdf. As the Protocol states, as "[g]lobal warming and climate change have come to the fore as a key sustainable development issue," and as "[m]any governments are taking steps to reduce GHG emissions through national policies that include the introduction of emissions trading programs, voluntary programs, carbon or energy taxes, and regulations and standards on energy efficiency and emissions," corporations "must be able to understand and manage their GHG risks if they are to ensure long-term success in a competitive business environment, and to be prepared for future national or regional climate policies. A well-designed and maintained corporate GHG inventory can serve

several business goals, including; [m]anaging GHG risks and identifying reduction opportunities; [p]ublic reporting and participation in voluntary GHG programs; [p]articipating in mandatory reporting programs; [p]articipating in GHG markets; [and r]ecognition for early voluntary action" (p 3).

193 The Earth Institute, Global Roundtable on Climate Change, *The Path to Climate Sustainability*, A Joint Statement by the Global Roundtable on Climate Change, 20 February, 2007: http://www.earthinstitute.columbia.edu/grocc/documents/GROCC_statement_2-19.pdf.

194 See "Companies Lay Out Global Framework to Fight Climate Change, GreenBiz.com, 21 February, 2007: http://www.greenbiz.com/news/news_third.cfm?NewsID=34623.

195 Rather more detail, however, is provided with regard to government than corporate action. In this regard, the statement "specifically calls on governments to set scientifically informed targets for global GHG concentrations, including ambitious but achievable interim goals for CO2, and to take immediate action in pursuit of those targets; to develop mechanisms that place a price on carbon emissions that is reasonably consistent internationally and across sectors in order to reward efficiency and emission avoidance and encourage innovation; establish policy initiatives to address energy efficiency and de-carbonization in all sectors; encourage the development and rapid deployment of low-emitting and zero-emitting energy and transportation technologies; and provide incentives to reduce emissions from deforestation and harmful land management practices; as well as other related actions: *Supra*.

196 See World Economic Forum, "New consortium created to develop standard framework for company reporting of climate risks," 26 January, 2007: http://www.weforum.org/en/media/Latest%20Press%20Releases/emissions_press_release.

197 Carbon Trust, *Climate change and shareholder value* (London, The Carbon Trust, 2006): http://www.carbontrust.co.uk/Publications/publicationdetail.htm?productid=CTC602. The report sets out a methodology for analysing shareholder value at risk from climate change.

198 Business for Social Responsibility, *A Three-Pronged Approach to Corporate Climate Strategy*, October, 2006: http://www.bsr.org/meta/BSR_Climate-Change-Report.pdf. The report provides a picture "of the efforts that companies will need to create an integrated climate change strategy ... Business has an opportunity to consider the full expanse of carbon and greenhouse gas emissions - across their company, their operations and the lifecycle of products and services - and to chart a course to carbon neutrality. The spectrum of needed actions spans from increasing the efficiency of energy use to offsetting emissions to shifting to decarbonized energy and renewables. This range - of efficiency, offsets and renewables - applies to all aspects of businesses, from materials to product design, raw material sourcing, service delivery and disposal, or the "end of useful life" of products. The span is broader than many companies consider, and it offers corporate managers a larger playing field in which to define ambitious, integrated and profitable climate change - focused strategies, goals and actions." It "offer[s] examples of what companies in a number of industries are doing to limit risk and liability, position for first mover advantage and expand their market share in the years ahead" (pp 3-4).

199 Citigroup, *Investing in Solutions to Climate Change*, 12 June, 2006: http://www.earthinstitute.columbia.edu/grocc/documents/Citi-WRIClimateReport.pdf. In addition to identifying twelve companies which Citigroup believes will benefit from climate change through their key climate technologies – the report, amongst other things, argues that companies selling products and services that address climate change legislation could benefit from the global trend toward tightening policies that constrain carbon emissions.

200 Earthwatch Institute, the World Conservation Union, World Business Council for Sustainable Development and World Resources Institute, *Business and Ecosystems*, Issue Brief: Ecosystem Challenges and Business Implications (Earthwatch Institute, the World Conservation Union, World Business Council for Sustainable Development and World Resources Institute, 2006): http://www.wbcsd.ch/DocRoot/Yfe91Zpuv9xjK8PThQmF/Business%20and%20Ecosystems_211106_final.pdf.

201 Npower Business and Forum for the Future, *Making Sense of the Low Carbon Economy*,

White Paper, April, 2007: http://www.forumforthefuture.org.uk/docs/publications/575/LowCarbonEconomy.pdf.

202 Citigroup, *Climatic Consequences: Investment Implications of a Changing Climate*, 19 January, 2006: http://www.pewclimate.org/docUploads/CIR%20--%20Climatic%20consequences%20Jan.%202007.pdf. In summary, Citigroup states that, "[f]or investors, the issue is not whether climate change is occurring. Today a variety of entities (governments, regulators, corporations, and individuals) are reacting to the perceived climate change threat, creating a number of near-term opportunities… Importantly, companies with international operations are increasingly subject to various emissions regulations and standards in key markets… [and e]ven when not facing imminent regulation, a growing number of corporations are pursuing various climate strategies …". Citigroup identifies 74 companies in 18 countries and across 21 industries "that seem well positioned to benefit from these trends:" p 1.

203 Ceres and the Investor Network on Climate Risk, *Imperatives of Climate Risk and Opportunity: A Call to Action from Leaders in Investing and Business*, 19 March, 2007: http://www.ceres.org/pub/docs/Call_to_action.pdf. The statement also says that "Climate change presents serious economic risks, not only for businesses and investments, but also for the global and U.S. economies. Where there are risks, there are also opportunities, and the business opportunities posed by climate change are significant. Climate change currently poses regulatory, legal, physical, and competitive risks for companies … Government inaction on climate change poses additional risks for businesses and investors … [and a]t the same time, addressing climate change presents a significant economic opportunity for America in the 21st century:" *supra*.

204 Npower Business and Forum for the Future, *supra*, note 201, p 10. The paper states that, as a starting point, all companies should demonstrate five things: An awareness of the climate impacts arising throughout the entire life-cycle of corporate operations - and a strategy that focuses effort where the impact is greatest and solutions most cost-effective; products and services that out-perform competitors in terms of climate impact and which, over time, provide solutions to climate change; a position on the contribution that the company - and its sector - will make in achieving local, national and global greenhouse gas reduction/stabilization targets; progressive and consistent engagement in the political debate around climate policy; and a full understanding of the risks and opportunities posed by climate change, with discussion at the board level; *supra*. With regard to engagement with climate change issues at board level generally, Yale University, Marsh and Ceres announced in September, 2006 a "collaborative effort to educate hundreds of independent corporate board members about the potential liabilities and strategic business opportunities that global climate change can create for companies:" GreenBiz.com, "Yale to Train Corporate Directors on Climate Change," 26 September, 2006: http://www.greenbiz.com/news/news_third.cfm?NewsID=34061.

205 On tipping points generally see Malcolm Gladwell, *The Tipping Point: How Little Things Can Make a Big Difference* (Boston, Little, Brown and Company, 2000).

206 The report states that "[c]onsumers are expressing growing interest in climate change, while the burgeoning number of climate-related regulations - ranging from usage of biofuels to building efficiency standards - means that individuals worldwide are increasingly aware of climate issues in their daily lives ... Litigants are forcing courts to rule on climate-related issues [and] ... Investors are concerned that corporations acknowledge the risks associated with climate issues:" Citigroup, *supra*, note 202, p 89.

207 The advantages are as follows: "They may lower costs, particularly if the company embraces energy efficient strategies in order to curb GHG emissions; [t]hey enhance the reputation of the corporate brand in the minds of consumers and corporate customers that care about climate issues; [t]hey may yield a "first-mover" advantage to a company that voluntarily adopts climate-friendly policies ahead of competitors that are forced to do so by regulators; [t]hey may lead to expanded market potential for new products and services; [and t]hey institutionalize a climate-friendly mentality and keep management alert to climate opportunities and threats that may have a material impact on the company's future operations …:" *supra*.

208 Lash and Wellington, *supra*, note 186 (emphasis added).

209 Ceres and World Resources Institute, *Questions and Answers for Investors on Climate*

Change, Fred Wellington et al (Washington, DC, Ceres and World Resources Institute , December, 2004).

210 For other ways in which corporations may gain competitive advantage see Daniel C Esty and Andrew S Winston, *Green to Gold: How Smart Companies Use Environmental Strategy to Innovate, Create Value, and Build Competitive Advantage* (New Haven, Yale University Press, 2006).

211 Todd S Thomson, "Green is Good for Business," *BusinessWeek*, 8 May, 2006, p 124.

212 Christoph Grobbel et al, "Preparing for a low-carbon future," *The McKinsey Quarterly*, No 4, 2004.

213 Earthwatch Institute, the World Conservation Union, World Business Council for Sustainable Development and World Resources Institute, *supra*, note 200, p 7. Such opportunities include the "[i]ntroduction of new businesses, products or services that reduce GHG emissions; [r]educed costs through energy efficiency improvements or switching to low-carbon fuels; [e]nhanced reputation and brand through corporate policies and proactive action to reduce GHG emissions …; [and e]arning a place at the policy-makers' table in response to timely and effective company action" (p 7).

214 *Supra*.

215 To date, no such push, or movement, has come from IATA, the trade association of international scheduled airlines. IATA will "wait for the ICAO Assembly's recommendations in September, 2007 … Efficiency must be our common vision in limiting the 2% of CO2 emissions attributed to aviation." As previously stated, the figure of 2% refers to emissions as so attributed in 1992 (see note 57; Lash and Wellington note that "[e]xecutives typically manage environmental risk as a threefold problem of regulatory compliance, potential liability … and pollutant release mitigation. But climate change presents business risks that are different in kind because the impact is global, the problem is long-term, and the harm is essentially irreversible:" *supra*, note 186. Notwithstanding the different risks and challenges that climate change represents for aviation business, in this case governments – ICAO – are leading, not IATA.

216 See Daniel Cusick, "US airlines gird for battle over growing emissions," *Greenwire*, 17 January, 2007. Cusick notes that "[t]o date, little attention has been paid in Congress or in corporate boardrooms to airlines' role in global warming as the industry and its supporters have been consumed with the burden of remaining profitable during an era of rapidly escalating costs:" *supra*. See also Doug Cameron, "US airlines warned of environmental backlash," *Financial Times*, 15 May, 2007.

217 See Roger Blitz, "US cool on climate change," *Financial Times*, 14 May, 2007. Blitz writes that "Sabre Airline Solutions, an airlines services consultancy, asked the leaders of 197 airlines around the world about their views on a range of issues, and found only three out of 62 North American airlines surveyed thought environmental concerns were a significant challenge. That compared with 31 out of 72 airline executives in Europe, the Middle East and Africa who described environmental issues as one of the three biggest challenges they would face in 2007."

218 Mal Gormley, *supra*, note 180.

219 *Supra*.

220 Brian Straus, "Star Alliance looks to shape environmental debate," *ATW Daily News*, 16 May, 2007: "SAS Group CEO Mats Jansson said the environment is the 'single most important question for aviation to deal with right now in order to achieve sustainable growth.' While the alliance reaffirmed its support for new airframe and engine technology and its demand for improved infrastructure, the newly announced Biosphere Connections tie-up with UNESCO's Man and the Biosphere Program gives the airline group both the opportunity to play its part in environmental protection and greater legitimacy when calling for more reasonable analysis of aviation's adverse impact:" *supra*.

221 Marion C Blakey, "Environmental Issues and Partnership," Emissions Colloquium, Quebec, Canada, 15 May, 2007.

222 Doug Cameron, "US airlines warned of environmental backlash," *Financial Times*, 15 May, 2007.

223 *Supra*.

224 With apologies to Business for Social Responsibility (BSR); BSR notes that "the questions for corporate strategists are action and adaptation:" Business for Social Responsibility, *supra*, note 198, p 34.

225 For an overview of alternative fuels and airframe and engine design, see Anderson et al, *supra*, note 3, pp 20-25. See also Bennett Daviss, "Green Skies Thinking," *New Scientist*, 24 February, 2007, pp 33-38.

226 Statistics at the Institute of Environmental Management and Assessment's website ("Airbus's A380-Environmentally Better?:" http://www.iema.net/news/envnews?cat=223&aid=4975).

227 http://www.airbus.com/en/corporate/innovation/. Note, however, Boeing's claim in its July, 2006 *Market Overview* (Current Market Outlook Presentation), Farnborough Air Show, that "[t]he technology breakthroughs of the 787 now make it possible for the smaller airplanes to have lower fuel consumption per seat than today's significantly larger airplanes. For example, the 787-9 consumes about 267 liters per seat while the much larger A380 consumes over 31 percent more at 351 liters per seat:" http://www.boeing.com/nosearch/exec_pres/cmo.pdf.

228 Emily Flynn Vencat, "Buckle your seat belts: Airbus, the French-German champion of European industry, is headed for a breakup," *Newsweek International*, 19 March, 2007.

229 *Supra*, citing a "former, high-level Airbus engineer."

230 Tyndall Centre for Climate Change Research, *supra*, note 61, p 50.

231 And the "A380 is likely to have a lifetime of around 30 years with very similar designs being constructed for, at least, the next two decades:" Bows and Anderson, *supra*, note 75, p 103. In this regard the report of the MIT workshop in June, 2006 (examined above) noted that it is necessary to understand trade-offs for aviation and climate change (for example, those among aircraft and fuel technology, aviation operations and policy options) as, amongst other reasons, "it is important to provide guidance to manufacturers and airlines as they seek to balance a variety of environmental, safety and performance objectives. This is particularly important because of the capital-intensive nature of the industry - roughly $10B for a new airplane development effort - and because of the long time-scales for development and use. Technology development and deployment may take 10 years, followed by a 20 year production period, followed by as long as 30 years in service. Therefore, airplane technology under development today may still be flying 50 years from now:" Next Generation Air Transportation System/Joint Planning and Development Office (NGATS/JPDO) Environmental Integrated Product Team and Partnership for AiR Transportation Noise and Emissions Reduction (PARTNER), *supra*, note 61, p 39.

232 J Lynn Lusford and Daniel Michaels, "After Four Years in the Rear, Boeing Is Set to Jet Past Airbus," *The Wall Street Journal*, 10 June, 2005. The 787 is a mid-size aircraft with a big jet range and, therefore, like the A380, attractive to a number of international Asia Pacific carriers. Although not a direct competitor of the A380 in terms of capacity, it represents Boeing's vision of international air travel as one in which passengers prefer to fly "point-to-point" rather than having to change planes at busy hub airports (Agence France-Presse, "Paris Air Show points to flight paths for aviation's future," *USA Today*, 20 June, 2005). Boeing believes that demand for point-to-point service will increase and traffic on major international routes will diminish as more routes are introduced.

233 A composite is formed when two or more materials with very different properties are combined together. Demand for composites, and carbon-fibre in particular, is anticipated to increase by 50% over the next 5 to 10 years; composites "have gained ground in aerospace because of their light weight, high strength, fatigue resistance and the ability to use manufacturing processes that can produce integrated structures with reduced parts count and assembly time:" Rob Coppinger, "Making Light," *Flight International*, 20-26 June, 2006.

234 Carol Matlock, "Airbus has a bad case of jet lag," *BusinessWeek*, 29 May, 2006, p 40.

235 See James Wallace, "New 787 plants a boon for economy," *Seattle Post-Intelligencer*, 29 June, 2006.

236 Matlock, *supra*, note 234.

237 Vencat, *supra*, note 228.

238 Dominic Gates, "Clean engines, wings that fold: Boeing dreams of futuristic jets," *The Seattle Times*, 5 May, 2006.

239 Douglas Barrie, "Cell Development," *Aviation Week & Space Technology*, 1 May, 2006, p 44.

240 Robert Wall, "Partners on Power? Airbus and Boeing mull cooperation on fuel cells for future aircraft," *Aviation Week & Space Technology*, 1 May, 2006, p 41. On the Boeing-Airbus competition, however, see John Newhouse, *Boeing Versus Airbus: The Inside Story of the Greatest International Competition in Business* (New York, Knopf, 2007).

241 See "New ideas to reduce emissions," *Flight International*, 8-14 November, 2006, p 25; and Greener by Design, *Mitigating the Environmental Impact of Aviation: Opportunities and Priorities* (London, Royal Aeronautical Society, July, 2005): http://www.greenerbydesign.org.uk/.

242 Douglas Barrie and Robert Wall, "Burning Issues," *Aviation Week and Space Technology*, 17 July, 2006, pp 140-142.

243 Joris Janssen Lok, "Dutch Dreams: University to open advanced technologies center to produce 'ultra-green' airliner," *Aviation Week & Space Technology*, 12 February, 2007, p 42.

244 *Supra*.

245 *Supra*.

246 See Graham Warwick, "Silent aircraft aims for 2025," *Flight International*, 7-13 November, 2006, p 32, and "Green aircraft: Silent skies," *The Economist*, 11 November, 2006. On Boeing's blended-wing plane, see Benjamin Tice, "Radical new Boeing aircraft takes flight," *Business 2.0 Magazine*, 13 March, 2007; Tice writes that "[o]riginally conceived by McDonnell Douglas and developed by NASA, the blended wing merges fuselage and wings and eliminates the tail, reducing drag. That makes it vastly more fuel-efficient than regular "tube-and-wing" jets, according to Boeing."

247 "Green aircraft: Silent skies," *supra*.

248 Warwick, *supra*, note 246.

249 Robert Wall, "Cleaner from Cradle to Grave," *Aviation Week & Space Technology*, 17 July, 2006, p 134.

250 *Supra*.

251 Bows and Anderson, *supra*, note 75.

252 The proposal by easyJet CEO Andy Harrison that 700 "dirty" aircraft in Europe be removed and that any machine built before 1990 be banned, would reduce emissions but does not, needless to say, offer either a comprehensive regional or global solution to the aviation emissions problem.

253 IPCC, *supra*, note 2: http://www.grida.no/climate/ipcc/aviation/010.htm (ch 6.2).

254 D Daggett and O Hadaller et al, *Alternative Fuels and Their Potential Impact on Aviation*, Washington, DC, National Aeronautics and Space Administration, October, 2006 (NASA TM-2006-214365; ICAS-2006-5.8.2), Paper prepared for the 25th Congress of the International Council of the Aeronautical Sciences, Hamburg, Germany, 3-8 September, 2006: "With a growing gap between the growth rate of petroleum production and demand, and with mounting environmental needs, the aircraft industry is investigating issues related to fuel availability, candidates for alternative fuels, and improved aircraft fuel efficiency. Bio-derived fuels, methanol, ethanol, liquid natural gas, liquid hydrogen, and synthetic fuels are considered in this study for their potential to replace or supplement conventional jet fuels. Most of these fuels present the airplane designers with safety, logistical, and performance challenges. Synthetic fuel made from coal, natural gas, or other hydrocarbon feedstock shows significant promise as a fuel that could be easily integrated into present and future aircraft with little or no modification to current aircraft designs. Alternatives, such as biofuel, and in the longer term hydrogen, have good potential but presently appear to be better suited for use in ground transportation. With the increased use of these fuels, a greater portion of a barrel of crude oil can be used for producing jet fuel because aircraft are not as fuel-flexible as ground vehicles:" p 1. See also Oren Hadaller, "Alternative Aircraft Fuels," *ASTM Standardization News*, April, 2007:http://www.astm.org/cgi-bin/SoftCart.exe/SNEWS/APRIL_2007/hadaller_apr07.html?L+mystore+vnga3188+1176411278.

255 IATA, *Financial Impact of Extending the EU ETS to Airlines*, 9 January, 2007.

256 See Rob Coppinger, "Green Light," *Flight International*, 23-29 August, 2005, pp 36-38.

257 See Allison Linn, "Researchers work to make alternative jet fuel affordable," *The Philadelphia Inquirer*, 19 June, 2006.

258 Alexei Barrionuevo, "The Energy Challenge: For Good or Ill, Boom in Ethanol Reshapes Economy of Heartland," *The New York Times*, 25 June, 2006.

259 Robert Wall and Douglas Barrie, "Seeds of Change," *Aviation Week & Space Technology*, 17 July, 2006, p 146, citing Carl E Burleson, director of the Office of Environment and Energy at the FAA.

260 *Supra*, p 145.

261 Daggett and Hadaller et al, *supra*, note 254; emphasis added.

262 *Supra*.

263 *Supra*. On ethanol, see Jeffrey Decker, "Corn to Run," *Flight International*, 16-22 January, 2007, pp 29-31.

264 Jet fuel is also more complex to refine: "Q&A on the Fuel-Related Challenges Facing US Airlines: ATA chief economist discusses the airline industry's energy situation," Air Transport Association (ATA), *News Room*, 21 June 2006: http://www.airlines.org/news/d.aspx?nid=9194. Further, as noted in the Q&A, airlines have no alternative to jet fuel.

265 Linn, *supra*, note 257.

266 Madhu Unnikrishnan, "Peters: Technology Key to Lower Emissions," *Aviation Daily*, 15 May, 2007.

267 Wall and Barrie, *supra*, note 259.

268 Daggett and Hadaller et al, *supra*, note 254, p 5. See also Jeffrey Decker, "Fuel for Change," *Flight International*, 16-22 January, 2007, pp 26-28. This makes the IATA position look less than credible: "IATA says there are hopes a synthetic jet fuel meeting all current specifications will be approved by the end of this year:" Steve Creedy, "IATA sets target for jet 'synfuel,'" *The Australian*, 29 September, 2006.

269 Daggett and Hadaller et al, *supra*, note 254, p 8.

270 David Millward, "Virgin plans biofuel aeroplanes," www.telegraph.co.uk, 25 April, 2007: http://www.telegraph.co.uk/news/main.jhtml?xml=/news/2007/04/24/nvirgin124.xml. See also David Robertson, "Virgin plans to fly 747 on biofuel in 2008," *The Times*, 24 April, 2007:http://business.timesonline.co.uk/tol/business/industry_sectors/engineering/article1695912.ece.

271 Millward, *supra*.

272 J Lynn Lunsford and Rod Stone, "Virgin Atlantic to Take Flight With Boeing's 787," *The Wall Street Journal*, 24 April, 2007:

273 Andrew C Revkin and Heather Timmons, "Branson Pledges to Finance Clean Fuels," *The New York Times*, 22 September, 2006; Sally Beatty, "Branson's Big Green Investment," *The Wall Street Journal*, 22 September, 2006.

274 IATA, "Environmental Summit – Remarks by Giovanni Bisignani, Director General and CEO, IATA," 25 April, 2006: www1.iata.org/pressroom/speeches/2006-04-25-01.htm.

275 Royal Commission on Environmental Pollution, *supra*, note 69, p 27.

276 House of Lords, European Union Committee, 21st Report of Session 2005-06, *Including the Aviation Sector in the European Union Emissions Trading Scheme* (London, The Stationery Office, 9 February, 2006), p 18: http://www.publications.parliament.uk/pa/ld200506/ldselect/ldeucom/107/107.pdf.

277 *Supra*, p 19.

278 Daggett and Hadaller et al, *supra*, note 254, p 8.

279 *Supra*; emphasis added.

280 Again, for an overview of air traffic management systems and processes see Anderson et al, *supra*, note 3.

281 Perry Flint, "Branson calls on airline industry to speed response to emissions," *ATW Daily News*, 28 September, 2006;

282 "Virgin Atlantic Chairman Sir Richard Branson Unveils Plans to Cut Carbon Emissions from Aviation by up to 25%, www.virgin-atlantic.com, 27 September, 2006: http://www.virgin-atlantic.com/en/gb/allaboutus/pressoffice/pressreleases/news/pr270906.jsp. See also editorial in *The New York Times*, "Fuel for Thought," 30 September, 2006; *Economist*, "Green business: Virgin territory," 30 September, 2006; and Sally Beatty, "Giving Back: Branson's Big Green Investment," *The Wall Street Journal*, 22 September, 2006.

283 IATA, "Environment Summit – Remarks by Giovanni Bisignani, Director General and

CEO, IATA," 25 April, 2006: http://www1.iata.org/pressroom/speeches/2006-04-25-01.htm.

284 IATA, "IATA industry-wide strategy to address climate change:" http://www1.iata.org/NR/rdonlyres/80F7AA1C-2CE1-40B0-A2D5-C9AE38259AC2/0/4153400Climatechangeflyer4.pdf; undated.

285 Giovanni Bisignani, "Key Priorities for Developing Next Generation ATM Systems," International Air Transport Association, 13 February, 2007: http://www1.iata.org/pressroom/speeches/2007-02-13-01.

286 Gregory M Lamb, "Flying the cleanly skies?," *USA Today*, 12 February, 2007, citing comments made by John Meenan, executive vice president of the ATA.

287 David Learmount, "Needless delays add to pollution," *Flight International*, 15 May, 2007.

288 See the Hon Mark Vaile MP, "APEC Economies to Reduce Aviation Greenhouse Emissions," *Media Release*, 30 March, 2007, 054MV/2007; the Hon Mark Vaile MP, "Australia Outlines Measures to Reduce Aviation Emissions," *Media Release*, 29 March, 2007, 052MV/2007; and Emma Kelly, "Maestro orchestrates emissions war at Sydney," *Flight International*, 10-16 April, 2007, p 11.

289 Emphasis added ("Better air traffic control can reduce GHG emissions – IATA," *Environmental Finance*, 15 February, 2007: http://www.wbcsd.org/plugins/DocSearch/details.asp?type=DocDet&ObjectId=MjI5MjM). A solution to what remains unclear but, presumably, not to the problem of the airline industry and carbon emissions.

290 IPCC, *supra*, note 2: http://www.grida.no/climate/ipcc/aviation/010.htm (ch 6.3).

291 House of Lords, *supra*, note 276, p 18.

292 As stated by the IPCC.

293 As Bows and Anderson note, UK aviation growth with regard to passenger numbers was 8% per annum between 2003 and 2004: Bows and Anderson, *supra*, note 75, p 105.

294 *Supra*.

295 IPCC, *supra*, note 17, p 18: http://www.ipcc.ch/SPM040507.pdf.

296 International Energy Agency, *Act Locally, Trade Globally: Emissions Trading for Climate Policy*, 2006: http://www.iea.org/bookshop/add.aspx?id=206.

297 IPCC, *supra*, note 2: http://www.grida.no/climate/ipcc/aviation/011.htm (ch 6.4).

298 For example, Norway introduced emissions trading in 2005, New South Wales (Australia) operates a mandatory baseline-and-credit scheme for electricity retailers, Japan and South Korea are running pilot schemes with limited number of companies, and parts of the United States have significant plans to implement trading schemes: Stern, *supra*, note 30, p 329.

299 Australian Government, Department of Prime Minister and Cabinet, Prime Ministerial Task Group on Emissions Trading, *Emissions Trading Issues Paper*, 7 February, 2007, p 4: http://www.dpmc.gov.au/emissionstrading/docs/emissions_trading_issues_paper.pdf.

300 Australian Greenhouse Office, *National Emissions Trading: Establishing the Boundaries*, Discussion Paper 1 (Canberra, Commonwealth of Australia, 1999): http://www.greenhouse.gov.au/emissionstrading/papers/paper1/pubs/emissions_1.pdf.

301 ISDA Japan Emissions Trading Working Group, *Proposal for the Establishment of the OTC Market for Emissions Trading*, May, 2004: http://www.isda.org/whatsnew/pdf/Emissions-Report_English-Summary.pdf.

302 Michael Jeffery, "Where do we go from here? Emissions trading under the Kyoto Protocol," *University of New South Wales Law Journal* (2001), vol 24, no 2, 40.

303 The Kyoto Protocol, opened for signature 11 December, 1997 (entered into force 16 February, 2005) ("Kyoto Protocol" or "Kyoto").

304 United Nations Framework Convention on Climate Change (UNFCCC), opened for signature 4 June, 1996 (entered into force 21 March, 1994).

305 Kyoto Protocol, Article 3.

306 David Freestone and Charlotte Streck, *Legal Aspects of Implementing the Kyoto Protocol Mechanisms Making Kyoto Work* (London, Oxford University Press, 2005), p 421.

307 Directive 2003/87/EC of the European Parliament and of the Council of 13 October, 2003 establishing a scheme for greenhouse gas emissions allowance trading within the EC and amending Council Directive 96/61/EC [1003] OJ L275/32 ("Directive"), Annex 1.

308 Directive 2003/87/EC of the European Parliament and of the Council of 13 October, 2003 establishing a scheme for greenhouse gas emissions allowance trading within the EC and amending Council Directive 96/61/EC [1003] OJ L275/32 ("Directive"), Article 3.

309 Stern, *supra*, note 30, p 332.

310 JI applies to countries that have agreed to an emissions target.

311 Kyoto Protocol, Article 12(2).

312 For an overview of such mechanisms see Allen Pei-Jan Tsai and Annie Petsonk, "Tracking the Skies: An Airline-Based System for Limiting Greenhouse Gas Emissions from International Civil Aviation," *The Environmental Lawyer*, vol 2, no 3, 1999-2000, pp 763-807. The authors state that "[r]apid growth in air travel is likely to increase significantly the GHG burden civil aviation places on the atmosphere," that "[a]ction is needed," and examine options for controlling civil aviation GHG emissions and methods for tracking, reporting and limiting GHG emissions from international civil aviation. They recommend "a system that establishes legally binding limits on total international civil aviation emissions from industrialized nations; sets those emissions caps at levels comparable to those already agreed upon by industrialized nations for other GHG emissions under the Kyoto Protocol; allocates GHG emissions allowances to air carriers for this time period; and affords carriers the flexibility to undertake emissions trading, providing market-based incentives for cost-effectively limiting and reducing GHG emissions in this important economic sector:" *supra*, p 763. Chris Hewett and Julie Foley, *Plane Trading: Policies for reducing the climate change effects of international aviation* (London, Institute for Public Policy Research, 2000). The authors review proposals for reducing GHG emissions from aviation and focus on market based options such as emissions trading and levies. In assessing policy options Hewett and Foley argue that five key criteria must be addressed: "The policy must be environmentally effective, economically efficient and technically and administratively feasible. The effects of equity and competitiveness must be examined and the policy should reflect or move towards the polluter pays principle." Finally, Fredrik Carlsson and Henrik Hammar, "Incentive-based regulation of CO2 emissions from international aviation," *Journal of Air Transport Management*, vol 8 (2002), pp 365-372, discuss how an emissions charge and a tradable emission permit system (in which the permits are auctioned) for international aviation should be designed so as to improve efficiency, and they compare the two. They find that they both have, more or less, the same characteristics. They do note that "[t]he choice of regulation is a political decision and it does not seem likely that an environmental charge or a tradable emission permit system would be implemented without consideration of the costs of the regulation." They also usefully note that "[t]here is no reason why the aviation sector should have a less stringent regulation than other sectors:" p 371.

313 See, for example, Hardeman, *supra*, note 57, pp 6-7.

314 Previously, in a July, 2006 resolution (not legally binding) on reducing the climate change impact of aviation, the European Parliament (EP) approved by a substantial majority setting up a *closed* aviation-specific emissions trading system as a preliminary step prior to possible inclusion of aviation in the EU's general ETS (European Parliament resolution on reducing the climate change impact of aviation (2005/2249 (INI): http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//TEXT +TA+P6-TA-2006-0296+0+DOC+XML+V0//EN&language=EN. The resolution also acknowledges the difficulties of selling into the EU ETS and restrictions associated with the proposed preliminary or pilot phase). According to the EP the scheme should initially cover "all flights to and from any EU airport (if possible also intercontinental flights transiting through EU air space), irrespective of the country of origin of the airline concerned (*supra*). While the international airline industry and its trade association are in general less hostile to the idea of emissions trading than to other policy options such as fuel and ticket taxes - although degrees of difference do exist between airlines (see "Climate change and aviation," http://www.Euractiv.com, 9 July, 2006: http://www.euractiv.com/en/sustainability/climate-change-aviation/article-139728; Karantzavelou, **"**EU must get emissions trading right says BA`s executive," traveldailynews.com, 11 April, 2006: http://www.traveldailynews.com/new.asp?newid=28978&subcategory_id=53; and the International Air Transport Association (IATA), "Aviation and the Environment – Killing Myths and Setting the Agenda," 25 April, 2006 [for IATA CEO Giovanni Bisignani,

"[e]missions trading may be a part of the solution. But it must be a global solution agreed through ICAO. We are in the process to achieve a result for the 2007 Assembly. There is no time to get distracted with local or regional schemes that will be less effective than a global solution:" http://www.iata.org/pressroom/pr/2006-04-25-02.htm]) - reaction to the EP proposal was nonetheless direct. The International Air Carrier Association (IACA) said that "[a]ny approach to aviation and the environment which calls for the simultaneous introduction of taxes on aviation fuel, VAT on airline tickets, environmental charges at airports and emissions trading scheme (ETS) totally ignores economic realities. Moreover the recommendation to set up a separate ETS scheme for aviation is totally unrealistic ("EU Parliament backs CO2 cap on air traffic," http://www.EurActiv.com, 5 July, 2006: http://www.wbcsd.org/plugins/DocSearch/details.asp?type=DocDet&ObjectId=MTk1OTA) .Lufthansa's head of environmental issues said prior to the resolution of the EP that the inclusion of air transport in the EU's ETS would have limited benefit, would represent an "unacceptable risk" for airlines and would cost the industry at least €500 million per year, if not much more (Helen Massey-Beresford, "Lufthansa warns of "little benefit" of aviation emissions trading," *Flight International*, 26 May, 2006).

315 Based on Directive 2003/87/EC of the European Parliament and of the Council, dated 13 October, 2003, "establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC;" see http://eurlex.europa.eu/LexUriServ/site/en/oj/2003/l_275/l_27520031025en00320046.pdf.

316 See http://ec.europa.eu/environment/climat/emission.htm; European Communities, *EU action against climate change: EU emissions trading – an open scheme promoting global innovation* (Brussels, European Communities, 2005): http://ec.europa.eu/environment/climat/pdf/emission_trading3_en.pdf.

317 The EU's national governments "are both independently and jointly tied to greenhouse gas emission reduction targets under the Kyoto Protocol. Under the Kyoto Protocol, the EU has to reduce its collective greenhouse gas emissions by 8% below 1990 levels during 2008-2012. This target is shared among the Member States under a legally binding burden-sharing agreement. In order to share the burden and to be able to tackle this burden in a cost effective manner, the European Union Emissions Trading Scheme (EU ETS) provides energy-intensive industries across the European Union with incentives to reduce their greenhouse gas emissions:" PricewaterhouseCoopers, *Building Trust in Emissions Reporting: Global Trends in Emissions Trading Schemes*, February, 2007, p 24: http://www.ukmediacentre.pwc.com/imagelibrary/detail.asp?MediaDetailsID=853.

318 EC Memo 05/84, *Questions & Answers on Emissions Trading and National Allocation Plans*, 8 March, 2005: http://europa.eu/rapid/pressReleasesAction.do?reference=MEMO/05/84&format=HTML&aged=1 &language=EN&guiLanguage=en

319 Commission of the European Communities, *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, 20.12.2006 (http://eur-lex.europa.eu/LexUriServ/site/en/com/2006/com2006_0818en01.pdf); EC Memo 06/506, *Questions & Answers on Aviation & Climate Change*, 20 December, 2006 (http://europa.eu/rapid/pressReleasesAction.do?reference=MEMO/06/506&format=HTML&aged=1&language=EN&guiLanguage=en); and European Commission, *Climate change: Commission proposes bringing air transport into EU Emissions Trading Scheme*, Press Release, IP/06/1862, 20 December, 2006: "Including civil aviation in the EU ETS is a cost-effective way for the sector to control its emissions and implements an approach endorsed by the International Civil Aviation Organization (ICAO). The proposed directive will cover emissions from flights within the EU from 2011 and all flights to and from EU airports from 2012. Both EU and foreign aircraft operators would be covered. Like the industrial companies already covered by the EU ETS, airlines will be able to sell surplus allowances if they reduce their emissions and will need to buy additional allowances if their emissions grow. Any increase in ticket costs resulting from the scheme is expected to be limited, and significantly lower than rises due to oil price changes in recent years. Environment Commissioner Stavros Dimas said: "Aviation too should make a fair contribution to our efforts to cut greenhouse gas emissions. The Commission will

continue to work with our international partners to promote the objectives of a global agreement on aviation. Bringing aviation emissions into the EU Emissions Trading Scheme is a cost-effective solution that is good for the environment and treats all airlines equally" …
The directive will treat all airlines equally, whether EU-based or foreign … It is estimated that by 2020 CO_2 savings of as much as 46%,or 183 million tonnes, could be achieved each year– equivalent for example to twice Austria's annual greenhouse gas emissions from all sources – compared with business as usual. To limit the rapid growth in aviation emissions, the total number of emission allowances available will be capped at the average emissions level in 2004-2006. Some allowances will be auctioned by Member States but the overwhelming majority will be issued for free on the basis of a harmonised efficiency benchmark reflecting each operator's historical share of traffic" (http://europa.eu/rapid/pressReleasesAction.do?reference=IP/06/1862&format=HTML&aged=0&language=EN&guiLanguage=en).
See also, by way of background prior to the December, 2006 legislative proposal, House of Lords, *supra*, note 276.

320 Aimee Turner, "Emissions pain in store for aviation," *Flight International*, 3-9 April, 2007, p 5. Additional measures include a closed aviation ETS and aviation fuel taxes, and not to completely oppose the proposal but to push for certain conditions in line with the European Parliament's July, 2006 resolution.

321 See Aimee Turner, "Emissions scheme under scrutiny," *Flight International*, 6-12 February, 2007.

322 Hardeman, *supra*, note 57, pp 3-18.

323 The question of geographic scope; the main issue is "whether States can integrate international aviation emissions from aircraft operators of other States in their emissions trading schemes without mutual agreement. Central to this discussion is the generic nature of the obligation placed on operators under an emissions trading scheme:" Hardeman, *supra*, pp 11-12.

324 On some of these issues see House of Lords, *supra*, note 276, ch 4 (pp 25-37) and ch 6 (pp 51-57).

325 "This is in line with the underlying philosophy for assigning responsibility for emissions under the Kyoto Protocol, which determines that a State is exclusively responsible for emissions occurring and originating inside its own territory, irrespective of the nationality of the operator of the emissions source:" Hardeman, *supra*, note 57, p 18.

326 "This would include: a. emissions from domestic flights within EU Member States; b. emissions from international flights between EU Member States; and c. emissions from all other flights departing from EU airports:" *supra*.

327 "In a similar fashion, prior agreement would be required to include emissions linked to flights originating in third States, including EU overflights and flights arriving at EU airports, recognizing that emissions over the high seas would fall under ICAO rules:" *supra*.

328 And not all EU airlines are supportive of aviation's inclusion in the ETS. Lufthansa's head of environmental issues has said that the inclusion of air transport in the EU's ETS would have limited benefit, would represent an "unacceptable risk" for airlines and would cost the industry at least €500 million per year, if not much more: Helen Massey-Beresford, "Lufthansa warns of "little benefit" of aviation emissions trading," *Flight International*, 26 May, 2006.

329 See, for example, Douglas Barrie and Robert Wall, "Charged Environment," *Aviation Week & Space Technology*, 7 November, 2005, p 90.

330 With regard to EU-US disagreement with regard to "open skies" issues, notwithstanding conclusion of a "first stage" open skies agreement, see, for example, Kevin Done et al, "Europe and US on 'open skies' collision course for the next stage," *Financial Times*, 23 March, 2007 and Allan I Mendelsohn, "US Aviation Policy - A Critique," *Air & Space Law*, vol 30, nos 4-5, September, 2006, pp 309-319.
In terms of implications for aviation climate impacts and incorporation of aviation into the EU ETS, the European Commission estimates that the US-EU open skies agreement will result in 25 million additional EU-US air passengers over the next five years, together with an increase in air freight, leading to approximately 3.5 million tonnes of extra CO2 emissions every year; 3.5m tones "falls in the middle of the range of the expected

reduction in emissions" flowing from aviation's inclusion in the EU ETS in 2011(European Federation for Transport and Environment (T&E), "ETS aviation gains likely to be wiped out by stage one "open skies" deal," *T&E Bulletin*, no 157, April, 2007, p 2). T&E concludes that "the open skies deal could completely offset emissions reductions from integrating aviation into the ETS. T&E director Jos Dings said: 'Just two weeks after the EU announced major new climate targets, it has given away airspace to American carriers but hasn't gained a clear mandate to combat emissions from those flights. This deal is therefore a serious setback to EU climate policy': " *supra*.

331 The International Civil Aviation Organization, a specialized agency of the United Nations created in 1944 under the Chicago Convention. It promotes the safe and orderly development of international civil aviation throughout the world. It sets standards and regulations necessary for aviation safety, security, efficiency and regularity.

332 In this regard Hardeman (*supra*, note 57, p 17) states that "Since Article 1 of the Chicago Convention does not allow free access to States' airspace, bilateral agreements are used to exchange traffic rights and lay down the commercial, technical and operational conditions for civil aviation services. Any changes to the conditions of operation must be agreed between participating States" (Article 6 of the Chicago Convention provides that "[N]o scheduled international air service may be operated over or into the territory of a contracting State, except with the special permission or other authorization of that State, and in accordance with the terms of such permission or authorization." Hardeman further notes that, "[t]o uphold the foundations of the international civil aviation regulatory framework enshrined in the Chicago Convention, the universal principles of territorial sovereignty, reciprocity and non-discrimination must be adhered to [Article 11 of the Chicago Convention provides that "the laws and regulations of a contracting State … shall be applied to the aircraft of all contracting States without distinction as to nationality"]. On matters that potentially affect these principles, such as the imposition of emissions reduction obligations under an ETS, prior agreement between States is therefore a prerequisite. Moreover, it respects the long-standing tradition in international aeropolitics that States find solutions through bi- or multilateral negotiation, rather than unilateral declaration" (footnotes omitted). On international air services see also David Hodgkinson, "Restrictions Across the Pacific: Australia's International Air Services Policy and the Problems of Liberalization," *Air & Space Law*, vol 31, no 6, November, 2006, pp 385-407 at pp 386-388.

333 "Carbon storm: Emissions Trading Scheme," *Airline Business*, 22 January, 2007.

334 *Supra*.

335 Kyoto Protocol to the United Nations Framework Convention on Climate Change, Article 2.2: http://unfccc.int/resource/docs/convkp/kpeng.pdf.

336 Sue Gander and Ned Helme, "Emissions trading is an effective, proven policy tool for solving air pollution problems," *ICAO Journal*, vol 54, no 7, September, 1999.

337 Abyd Karmali and Melinda Harris, "ICAO exploring development of a trading scheme for emissions from aviation," *ICAO Journal*, vol 59, no 5, September, 2004, p 11.

338 Through Resolution A35-5.

339 Roberto González, "Opening address by the President of the Council of the International Civil Aviation Organization (ICAO), Mr. Roberto Kobeh González, to the Seventh Meeting of the Committee on Aviation Environmental Protection (CAEP), " Montreal, 5 February, 2007: http://www.icao.int/icao/en/nr/2007/pio200701_e.pdf.

340 See Aimee Turner, "ICAO committee set to present guidance," *Flight International*, 6-12 February, 2007, and "Forecasts 2007: The EC is likely to find major opposition from the USA on its plan to charge carriers extra," *Flight International*, 2 February, 2007. With regard to the speed at which ICAO works, the editors of *Flight International* noted that "[t]he first thing ICAO should do is speed up its processes, because its members need results faster. It should become more transparent by improving the quality of its communications. Having facilitated consensus, ICAO's main job is to communicate what has been agreed. At present its style is bureaucratic": "Power broker," *Flight International*, 3-9 April, 2007.

341 Barrie and Wall, *supra*, note 329.

342 International Civil Aviation Organization, "Participants of ICAO Environmental Meeting Agree on Guidance for Aviation Emissions Trading," *ICAO News Release*, PIO 01/07, 16 February, 2007: http://www.icao.int/icao/en/nr/2007/pio200701_e.pdf.

343 Although some argue that there appears to be a risk that the ICAO general assembly meeting in 2007 "could fail to produce the "efficient and effective" policy on emissions charges the industry needs:" Robert Wall, "Airing Grievances," *Aviation Week & Space Technology*, 5 December, 2005, p 50. Further – and curiously - at a May, 2007 ICAO Colloquium on Aviation Emissions, the ICAO Council president, Roberto Kobeh Gonzalez, opined that recent studies showed that the climate impacts of aviation emissions were *not* as severe as previously thought: Turner, *supra*, note 133.

344 For example, CO2 emissions.

345 ICAO, *supra*, note 342. CAEP provided such guidance as "part of a package of recommendations from CAEP to address aircraft engine emissions directly attributable to aviation in relation to local air quality and global climate effects,
which includes the reduction of emissions by technological, operational and market-based measures. The meeting also considered long term technology goals for NOx (Nitrogen Oxides) and agreed on a proposal for guidance on aircraft emissions charges related to local air quality:" *supra*. See Brian Straus, "ICAO releases global emissions trading scheme guidelines," *ATW Daily News*, 21 February, 2007.

346 CAEP stated that, with regard to geographic scope, "the guidance recommends that States take into account an ICAO Council request that CAEP include the different options to geographic scope describing their advantages and disadvantages and start to address the integration of foreign aircraft operators under a mutually agreed basis, and continue to analyze further options:" *supra*. See also Aimee Turner, "CAEP charts path to tackle carbon," *Flight International*, 27 February – 5 March, 2007.

347 IATA, "UN Guidelines on Emissions Trading Welcomed," 17 February, 2007 (http://www1.iata.org/pressroom/pr/2007-02-17-01.htm). IATA's Director General and CEO stated that "Climate change is a global issue. And today's outcome clearly demonstrates that global solutions are possible. The only way forward is with a harmonised approach. Kyoto specifically tasked ICAO to lead the aviation industry's efforts in this crucial area ... We're pleased that ICAO has echoed IATA's call urging states not to jump the gun on emissions trading but to wait for the ICAO Assembly's recommendations in September, 2007. Unilateral action by states is not the answer. We need a global approach that provides a level playing field for airlines and avoids competitive distortions. It is critical that ICAO achieves consensus on the political issue of geographic scope at the September Assembly:" *supra*.
At an ICAO Colloquium on Aviation Emissions in May, 2007, ICAO Council president, Roberto Kobeh Gonzalez, asserted that "recent studies showed that the climate impacts of aviation emissions were *not* as severe as previously thought: Turner, *supra*, note 133.

348 See pages 42 to 45.

349 IATA, *Financial Impact of Extending the EU ETS to Airlines*, 9 January, 2007, p 8.

350 *Supra*.

351 *Supra*, p 3.

352 See Martijn Brons et al, "Price elasticities of demand for passenger air travel: a meta-analysis," *Journal of Air Transport Management*, vol 8, 2002, pp 165-175.

353 IATA, *supra*, note 349, p 9.

354 EC Memo 06/506, *Questions & Answers on Aviation & Climate Change*, 20 December, 2006 (Committee noted in 2006 that it had "severe doubts about the view that the impact upon emissions allowances prices, airfares and air travel will be modest, except in the short term:" House of Lords, *supra*, note 276, p 54, para 239.

355 Again, the House of Lords European Union Committee noted that "[e]conomic analysis suggests, however, that even if initial emissions allowances are distributed free of charge, airlines might still raise airfares in the medium term to cover the opportunity cost of those allowances. In that event, airlines would make windfall profits equal to the value in the market place of their free CO_2 allowances. This would strengthen the case for auctioning. Airlines, air fares and air-freight charges should come under close scrutiny for evidence of windfall profit taking in the event that allowances are issued free of charge:" House of Lords, *supra*, pp 35-36, para 148.

356 See page 12.

357 See sections 2.2(b) and (c).

358 With regard to the EU.

359 Tyndall Centre, *supra*, note 61, p 47.

360 *Supra*.
361 *Supra*, p 49.
362 *Supra*.
363 Anderson et al, *supra*, note 3, p 6.
364 *Supra*, pp 56 and 58.
365 Bows and Anderson note that "[i]ncorporating international aviation into the European Emissions Trading Scheme … is seen by many as a key step towards a consistent and sector-wide effort to combating climate change. However, as all of the EU nations are industrialised, they too will be looking to significantly reduce their carbon dioxide emissions from all of their sectors year-on-year … The inclusion of aviation's emissions in the EU ETS and the impact on permit prices is further complicated by the industry's very substantial growth … [T]he current very high [aviation] emissions growth rates will result in the aviation industry being increasingly responsible for a large proportion of the EU's total carbon budget:" Bows and Anderson, *supra*, note 75, pp 108 and 109.
366 And there are other problems. Business for Social Responsibility in its study, *A Three-Pronged Approach to Corporate Climate Strategy* (2006), notes that, to extend the EU ETS to aviation, the EU ETS "will need to learn from early challenges in the allocation of emissions allowances. The initial allocation provided allowances for free to existing polluters. Many were able to maintain their current levels of emissions by purchasing inexpensive credits from developing countries under the Clean Development Mechanism (CDM), which did not reduce total emissions in Europe. In addition, the price of carbon dropped precipitously in May of 2006, when it was discovered that the baseline for emissions was set with inadequate data:" *supra*, note 198, p 27.
367 Currently we have no good estimates of the price elasticity of international travel for substantial increases in fares.
368 Gregg Easterbrook, "Al Gore's Outsourcing Solution," *The New York Times*, 9 March, 2007, p 12.
369 Or individuals.
370 See the World Bank (Karan Capoor and Philippe Ambrosi), *State and Trends of the Carbon Market 2007*, Washington, DC, May, 2007, p 44: http://www.ieta.org/ieta/www/pages/getfile.php?docID=2281.
371 Clean Air-Cool Planet, *A Consumer's Guide to Retail Carbon Offset Providers* (Portland, Clean Air-Cool Planet, 2006), p vii: http://www.cleanair-coolplanet.org/ConsumersGuidetoCarbonOffsets.pdf. Kollmuss and Bowell put the matter thus: "Climate change is a non-localized global problem, which means that carbon reductions will have the same impact no matter where they are implemented:" Anja Kollmuss and Benjamin Bowell, *Voluntary Offsets For Air-Travel Carbon Emissions: Evaluations and Recommendations of Voluntary Offset Companies* (Boston, Tufts Climate Initiative, 2006), p 3: http://www.tufts.edu/tie/tci/pdf/TCI_Carbon_Offsets_Paper_Jan31.pdf. See also Hanson and Laitner, "An Integrated Analysis of Policies that Increase Investments in Advanced Energy-Efficient/Low-Carbon Technologies," *Energy Technologies*, vol 26, no 4 (2006), pp 739-755.
372 Or "emission-free energy generation, reduction of demand for energy, and sequestration:" Kollmuss and Bowell, *supra*, p 5.
373 *Supra*, p 16. They conclude, amongst other things, that "*Voluntary* offsets are of limited value to solve the increasing threat of climate change. They should not be seen as a way to buy "environmental pardons" … No *voluntary* approach to reducing greenhouse gas emissions should be allowed to delay or replace a mandatory federal [US] cap on carbon emissions or a worldwide tax on jet fuel. Yet voluntary carbon offsets do have their place in spurring innovation and financing carbon-reducing projects that would otherwise not have happened:" *supra*, p 1 (emphasis added).
374 On sequestration see Massachusetts Institute of Technology, *The Future of Coal: Options for a Carbon-Constrained World* (Boston, MIT, 2007): http://web.mit.edu/coal/The_Future_of_Coal.pdf; IPCC, *Carbon Dioxide Capture and Storage: Summary for Policymakers and Technical Summary*: http://arch.rivm.nl/env/int/ipcc/pages_media/SRCCS-final/SRCCS_WholeReport.pdf; Daniel P Schrag, "Preparing to Capture Carbon," *Science*, vol 315, 9 February, 2007; and

Ben Geman, "Coal's future hinges on carbon capture, sequestration – report," *Greenwire*, 14 March, 2007.

375 For further examples see Carbon Trust, *The Carbon Trust three stage approach to developing a robust offsetting strategy* (London, The Carbon Trust, 2006), p 8: http://www.carbontrust.co.uk/Publications/publicationdetail.htm?productid=CTC621.

376 The project types are methane capture and destruction from landfills; methane capture and destruction from livestock; methane capture and destruction from coal mines; industrial gas destruction; direct fossil fuel reduction; indirect fossil fuel reduction (RECs); reforestation – afforestation of native tree species; avoided deforestation of native tree species; reforestation – afforestation monoculture forestry; soil sequestration; and geological sequestration: Ecosystem Marketplace and Business for Social Responsibility, *Offsetting Emissions: A Business Brief on the Voluntary Carbon Market*, December, 2006, pp 8-9 (http://www.bsr.org/meta/BSR_Voluntary-Carbon-Offsets.pdf). See also Ricardo Bayon et al, *Voluntary Carbon Markets: An International Business Guide to What They Are and How They Work*. (London, Earthscan, 2006).

377 The UNFCCC pledges to stabilise GHG concentrations "at a level that would prevent Dangerous anthropogenic interference with the climate system." Its targets are not legally binding; those under Kyoto – for Annex 1 countries that have ratified the protocol – are.

378 See section 4.4(a) and (b).

379 Developed countries that have ratified Kyoto and have legally binding GHG emission reduction targets. Non-Annex 1 countries – developing countries – are not subject to any such targets.

380 Carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulfur hexafluoride. These gases absorb infrared radiation in widely varying degrees (for example, methane has a greenhouse impact that is 23 times that of carbon dioxide). As a result, targets can be achieved by tailoring reduction strategies to particular gases. CO2e (carbon dioxide equivalent) is the unit of measurement used to show the global warming potential of each of the six GHGs; CO2 is the reference GHG against which the other 5 GHGs are measured.

381 It imposes national caps on Annex 1 countries' emissions.

382 Article 17.

383 Article 6.

384 Article 12.

385 The Carbon Trust, *supra*, note 375, p 9. It notes further that "[w]hat constitutes business-as-usual is not straightforward to determine and a number of methodologies have been developed to define the baseline emissions against which the project is compared … The difference between the project emissions and the baseline emissions defines the number of emissions reduction credits that a project is entitled to …:" *supra*.

386 Kollmuss and Bowell write that "It is not necessary that the project is happening solely because of the carbon credits it produces but the anticipated benefits of the carbon offsets have to be a decisive factor for pursuing the project:" *supra*, note 371, p 9. For the World Bank, "gas emission reductions generated by Clean Development Mechanism and Joint Implementation project activities must be additional to those that otherwise would occur. Additionality is established when there is a positive difference between the emissions that occur in the baseline scenario, and the emissions that occur in the proposed project:" *supra*, note 370, p 43.

387 CDM Executive Board, *Tool for the demonstration and assessment of additionality* (Version 03): http://cdm.unfccc.int/methodologies/PAmethodologies/AdditionalityTools/Additionality_tool.pdf.

388 Only sovereign states can use AAUs.

389 Article 17.

390 Kollmuss and Bowell note that "Kyoto Kyoto enables a group of several Annex I countries to join together and form a so-called 'bubble' that is given an overall emissions cap and is treated as a single entity for compliance purposes. The EU, with its 25 member states, formed such a 'bubble' and created the EU Emissions Trading Scheme …:" *supra*, note 371, p 7.

391 See http://www.chicagoclimatex.com/ and also Jeff Goodell, "Capital Pollution Solution?,"

New York Times, 30 July, 2006, and Darren Samuelsohn, "Persistence starts to pay off for Chicago emissions market," *Greenwire*, 15 May, 2006; and

392 See http://www.greenhousegas.nsw.gov.au/.

393 See Fiona Harvey, "Beware the carbon offsetting cowboys," *Financial Times*, 26 April, 2006.

394 Business for Social Responsibility, *supra*, note 198, p 24.

395 "Ripping off would-be greens? A rapidly growing market is attracting some timely scrutiny," The *Economist*, 15 March, 2007.

396 Carbon Trust, *supra*, note 375, p 7.

397 Alice Kenny, "Environmentalists Clash Over Carbon Credits," *Ecosystem Marketplace*, 5 March, 2007: http://ecosystemmarketplace.com/pages/article.news.php?component_id=4846&component_version_id=7134&language_id=12.

398 M Trexler, "US Demand?," Presentation at the Point Carbon Market Insights 2007, Copenhagen, 13-15 March, 2007 (as cited in World Bank, *supra*, note 370, p 41).

399 World Bank, *supra*, p 41.

400 Kenny, *supra*, note 397.

401 World Bank, *supra*, note 370, p 3.

402 Business for Social Responsibility, *supra*, note 198, p 24, citing UNEPFI's *The Working Capital Report* (2005).

403 An outline of some of these problems and recent criticisms made of emissions offsets can be found in Steve Zwick, "US-Based Voluntary Offset Projects: Coming of Age?," Ecosystem Marketplace, 14 May, 2007: http://ecosystemmarketplace.com/pages/article.news.php?component_id=4964&component_version_id=7299&language_id=12; Zwick, "Comparing Apples and Oranges: In Search of a Standard for the Voluntary Carbon Market," *Ecosystem Marketplace*, 29 June, 2006: http://ecosystemmarketplace.com/pages/article.news.php?component_id=4431&component_version_id=6521&language_id=12; Allison Linn, "Carbon offset market raises questions," MSNBC.com, 22 May, 2007: Fiona Harvey and Stephen Fidler, "Industry caught in carbon 'smokescreen'," FT.com, 25 April, 2007; Dara Colwell, "Carbon Offsets: Buying Your Way Out of Responsibility," *AlterNet*, 11 April (posted) and 16 April (printed), 2007: http://www.alternet.org/story/50077/; A C Thompson and Duane Moles, "Don't Bet on Offsets," *The Nation*, 7 May, 2007; Barbara DeLollis, "Can you be travelling green by buying offsets?," *USA Today*, 3 February, 2007; Kenny, *supra*, note 397; Ben Elgin, "Another Inconvenient Truth," *BusinessWeek*, 26 March, 2007; and George Monbiot, *Heat: How to Stop the Planet from Burning* (Toronto, Doubleday Canada, 2006), pp 210-212.

404 By third parties.

405 Carbon Trust, *supra*, note 375, p 12.

406 Kollmuss and Bowell, *supra*, note 371, pp 14-16.

407 Ecosystem Marketplace and Business for Social Responsibility, *supra*, note 376, p 13.

408 Clean Air-Cool Planet, *supra*, note 371, p 3; the characteristic headings are additionality, baseline determination, benefit qualification; permanence; ownership; monitoring and verification; registration; offset cost; ancillary environmental benefits; and offset timing.

409 Kollmuss and Bowell, *supra*, note 371, p 8.

410 And individuals.

411 See http://www.ghgprotocol.org/templates/GHG5/layout.asp?type=p&MenuId=OTAy&doOpen=1&ClickMenu=Project%20Protocol.

412 See http://www.ghgprotocol.org/templates/GHG5/layout.asp?type=p&MenuId=ODg4&doOpen=1&ClickMenu=Corporate%20Standard. It covers the accounting and reporting of the six GHGs covered by Kyoto.

413 http://www.ghgprotocol.org/templates/GHG5/layout.asp?type=p&MenuId=ODQ5.

414 International Organization for Standardization, "New ISO 14064 standards provide tools for assessing and supporting greenhouse gas reduction and emissions trading," *Press Release*, 3 March, 2006, Ref 994: http://www.iso.ch/iso/en/commcentre/pressreleases/2006/Ref994.html.

415 ISO 14064-1:2006, Greenhouse Gases - Part 1: Specification with guidance at the organization level for the quantification and reporting of greenhouse gas emissions and removals; ISO 14064-2:2006, Greenhouse Gases – Part 2: Specification with guidance at the project level for the quantification, monitoring and reporting of greenhouse gas emission reductions and removal enhancements; and ISO 14064-3:2006, Greenhouse Gases – Part 3: Specification with guidance for the validation and verification of greenhouse gas assertions: *Supra*.

416 *Supra*. ISO 14064 objectives ISO 14064 objectives "are to enhance environmental integrity by promoting consistency, transparency and credibility in GHG quantification, monitoring, reporting and verification; enable organizations to identify and manage GHG-related liabilities, assets and risks; facilitate the trade of GHG allowances or credits; and support the design, development and implementation of comparable and consistent GHG schemes or programmes:" Chan Kook Weng and Kevin Boehmer, "Launching of ISO 14064 for greenhouse gas accounting and verification," 1SO Management Systems, March-April, 2006, p 14: http://www.iso.ch/iso/en/iso9000-14000/explore/grennhouse.pdf.

417 Chan and Boehmer, *supra*, p 16.

418 In full, *Greenhouse gases – Requirements for greenhouse gas validation and verification bodies for use in accreditation or other forms of recognition*; see International Organization for Standardization, "ISO 14065 standard – new tool for international efforts to address greenhouse gas emissions," *Press Release*, 17 April, 2007, Ref 1054: http://www.iso.org/iso/en/commcentre/pressreleases/2007/Ref1054.html). ISO 14065 "was developed by a working group of some 70 international experts from 30 countries and several liaison organizations, including the International Accreditation Forum. In addition, the United Nations Framework Convention on Climate Change (UNFCCC) has observer status. The working group combined expertise from ISO's Committee on Conformity Assessment (CASCO) and technical committee ISO/TC 207, *Environmental management*:" *supra*.

419 *Supra*.

420 *Supra*.

421 See *The Gold Standard for voluntary offsets*: http://www.cdmgoldstandard.org/uploads/file/GS_Flyer_06_web.pdf.

422 See http://www.v-c-s.org/.

423 For non-Annex 1 countries.

424 See http://www.cdmgoldstandard.org: "The Gold Standard is an independently audited, globally applicable best practice methodology for project development …".

425 International Emissions Trading Association and The Climate Group, "The Voluntary Carbon Standard: Verification Protocol and Criteria (Proposed Version 2)," pp 1-2: http://www.theclimategroup.org/assets/Voluntary_Carbon_Standard_Version_2_final.pdf. Steve Zwick cites Thomas Baumann, DNV Canada, the world's largest Designated Operational Entity (a DOE is an organisation accredited by the UN to certify and verify Kyoto offset projects): "The latest meeting by IETA members clarified that the VCS is not meant to replace or supplant any other existing standards, including ISO 14064. The VCS is meant to build on these efforts, and create a global benchmark" (Zwick, "Comparing Apples and Oranges: In Search of a Standard for the Voluntary Carbon Market," *Ecosystem Marketplace*, 29 June, 2006).
It should be noted that "units" or "allowances" generated by the voluntary market are not, in general, able to be traded outside the boundaries of the relevant scheme (the rules of the schemes are different); they are "non-fungible." Internationally applicable standards could make it possible for allowances – or units – to become fungible and tradeable instruments between market participants.

426 Verified Emission Reductions [VERs] is a Units of GHG emission reductions (traded on the *voluntary* market) verified by an independent auditor.

427 See http://www.netinform.de/ and TUV-SUD, " 'Blue Registry' brings more transparency to VER projects:" http://www.tuevsued.de/company/press/press_archive/blue_registry_brings_more_transparency_to_ver_projects#1176383868034779400275.
On the importance of a registry see Darren Samuelsohn, "Lessons from EU cap-and-trade woes: 'You need a registry'," *Greenwire*, 9 May, 2007.

428 TUV-SUD, *supra*.

429 Bill McKibben and Aaron Clark, "The Heat Is On," *Travel + Leisure*, May, 2007, p 86. Or, as the *Economist* noted, despite flaws, "the idea of carbon offsets is a good one:" *The Economist*, "Carbon offsets: Sins of emission," August, 2006, p 13.

430 Kollmuss and Bowell, *supra*, note 371, p 1.

431 "Carbon offsets: Ripping off would-be greens?," *The Economist*, 15 May, 2007.

432 New Energy Finance, "Clean Energy Deal Volume Hits $100bn," Press Release, 19 December, 2006 (www.newenergyfinance.com).

433 World Bank, *supra*, note 370, p 6. As the World Bank states in a footnote, "Among the most recent ones, see announcement of Goldman Sachs of further investment in the clean and renewable power generation sector, with a large equity stake in an IGCC project, which will include a significant amount of carbon capture and sequestration:" *supra*.

434 Further, as the House of Lords' European Union Committee noted in 2006, in the context of aviation entering the EU ETS, "technological improvements in the aviation industry will become even more urgent in order to reduce emissions while maintaining growth in air travel …:" House of Lords, *supra*, note 276, p 51.

435 World Bank, *supra*, note 370, p 7.

436 McKibben and Clark, *supra*, note 429.

437 These airlines include Continental, Virgin Blue, Delta, SAS and BA; see Bill Hensel, Jr, "Getting on board on emissions," Houston Chronicle, 22 April, 2007 (Continental); Wendy Frew, "Virgin's latest deal: cut-price carbon offsets," *The Sydney Morning Herald*, 22 March, 2007 (Virgin Blue); Associated Press, "Fly Delta, plant a tree," 18 April, 2007 and "Delta carbon offset program to take flight," *Atlanta Business Chronicle*, 18 April, 2007 (Delta); and Associated Press, "Airline introduces voluntary greenhouse fee," 14 March, 2007 and "Airline to charge for admissions," 15 March, 2007 (SAS).

438 Charges are problematic with regard to air transport; see, for example, Hardeman, *supra*, note 57, p 7.

439 On duties see Karen Mayor and Richard S J Tol, *The Impact of the UK Aviation Tax on Carbon Dioxide Emissions and Visitor Numbers*, Working Paper No 187, Economic and Social Research Institute (ESRI), April, 2007: http://www.esri.ie/UserFiles/publications/20070403135838/WP187.pdf.

440 Article 24.

441 Business for Social Responsibility, *supra*, note 198, p 12.

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The Hodgkinson Group (www.hodgkinsongroup.com) is an 11-member aviation consulting practice with advisors located in Australia, Canada, the United States and the United Kingdom. It provides regulatory, operational and strategic advice and reports, and legal advice through its law firm affiliate, to aviation industry participants. The Group's advisors have either held senior executive positions with or advised international and domestic airlines, governments, international organisations (including IATA and ICAO), air traffic control providers, airports, aircraft lessors, global corporations, financial institutions and aviation law firms.

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