WORLD ECONOMIC FORUM

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POLICIES AND COLLABORATIVE PARTNERSHIP FOR SUSTAINABLE AVIATION

Report prepared with the support of Booz & Company

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We would also like to refer to the parallel World Economic Forum/ Booz & Company project on “Repowering Transport”, which looked at energy use in the broader transportation sector including land transport, maritime shipping and aviation. All figures related to energy use, CO_2 emissions and mitigation options for aviation are consistent between the two projects.

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Executive Summary

Mobility and transportation interlink the global economy. Aviation is an important enabler for the trade of goods, tourism, services and the socioeconomic development of nations. Significant growth of aviation is expected in the next decades, especially in developing countries in Asia (particularly India and China) and the Middle East. Aviation CO_2 emissions currently account for approximately 2% of total CO_2 emissions and are expected to grow significantly with traffic growth.

With raising awareness of aviation's CO_2 impact on climate change, the global aviation industry demonstrated leadership in 2009 by devising a strategy for achieving aggressive CO_2 emission reductions through technological, operational and infrastructure improvements, subject to government investment in the aspects under government control and a regulatory environment conducive to aviation industry investment. Provided the necessary public-private sharing is enabled, the industry committed to collective CO_2 emission goals including an annual average 1.5% fuel efficiency improvement through 2020, net carbon neutral growth from 2020, and 50% net CO_2 emission reductions by 2050 compared to 2005 values.[i] Meanwhile, ICAO, in its process of developing emission goals for international aviation in its 37th Assembly in October 2010, agreed on collective international aviation goals of an annual average 2% fuel efficiency improvement through 2020 and aspirational goals of an annual average 2% fuel efficiency improvement from 2021 to 2050, as well as considering carbon neutral growth from 2020.[ii]

Meeting these ambitious goals despite the anticipated high aviation demand growth poses a significant challenge. The industry's 2050 goals, in particular, leaves an 85% CO_2 emission reduction gap compared to the business-as-usual approach, even though what is defined as "business as usual" in this case assumes continual industry investment in more fuel-efficient aircraft to replace older aircraft and expand the worldwide aircraft fleet to meet demand.

To allow the aviation industry to accommodate growing traffic demand and at the same time reach its ambitious CO_2 goals through 2050, significant additional effort is required in a number of fields that have the potential to further reduce aviation's carbon footprint. The most promising carbon abatement levers in aviation are infrastructure improvements, additional R&D especially for radical new aircraft technologies and in particular aviation biofuels. Global market-based measures, such as emissions trading and offsetting, may be useful to complement the foregoing. To overcome the implementation challenges, a set of opportunities exist in the areas of policy, partnerships and financing as well as information and education. Significant leadership opportunities need to be taken by the industry to reach the CO_2 goals.

Positive incentives (e.g. fiscal) are seen as having the most potential to increase investment in reducing carbon in the aviation industry. Incentives should be targeted at the best investor in emission reduction in the value chain. Green levies and taxes currently in implementation or discussion in a number of countries are not seen as viable options to achieve the industry's CO_2 reduction goals. Levies and market mechanisms take money out of the industry without significant emission reduction effect, if the money raised is not reinvested in CO_2 emission reduction projects, and the industry has fewer funds available to invest in emission reduction measures. For any measures geared towards marginally decreasing air travel (e.g. through increasing price), the potential negative macroeconomic effects on gross domestic product (GDP) and economic development must be considered.

The most promising leadership opportunities identified for the industry to pursue are:

- **Aviation infrastructure**: Information and education of policy-makers on the criticality and urgency of implementing aviation infrastructure improvements on the air traffic management (ATM) and airport level
- **Additional aircraft R&D**: Work with policy-makers to develop financial and legal incentives to increase investment into incremental R&D for radical new aircraft technologies
- **Aviation biofuels**: Work with policy-makers to develop financial incentives, legal incentives and standards, and to drive vertical partnerships with stakeholders along the entire biofuel value chain
- **Market-based measures (MBM)**: Actively engage and support governments working with ICAO in the development of a global sectoral MBM approach for aviation through partnerships with experts from the carbon finance community, and ensure that any measures that are developed focus on incentivizing the parties best placed to make the CO_2 abatement investment

The industry must further engage in currently ongoing policy discussions regarding the regulation of aviation CO_2 at the international and national levels, particularly with respect to proposals to include aviation in national or regional emissions trading schemes, the development of a sectoral MBM approach through ICAO and proposals that the aviation industry contribute to the United Nations Framework Convention on Climate Change (UNFCCC) Green Climate Fund to support developing countries in climate change mitigation and adaptation.

The Forum hopes this report will support a wider multistakeholder dialogue among industry, government stakeholders and non-governmental communities to build a practical enabling environment that is conducive to catalysing a step change in private and public sector action to decrease aviation CO_2 emissions, develop and deploy revolutionary new technologies, and provide sustainable investment choices at scale and speed.

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1. Introduction

The World Economic Forum is an independent, international organization integrating business, political, intellectual and other leaders of society into a community committed to improving the state of the world. The Forum's Industry Partners have addressed climate change topics since 2005. The Climate Change Initiative in 2010 engaged stakeholders in building a practical framework of action based on the outcomes of the United Nations Climate Change Conference 2009 in Copenhagen (COP15).

Emissions from international aviation were excluded from the national United Nations Framework Convention on Climate Change (UNFCCC) negotiations, and the mandate for developing a regulatory framework for emissions from international aviation was assigned to the International Civil Aviation Organization (ICAO), a specialized UN body. In this context, the Forum's Aviation, Travel & Tourism Industry Partnership community's 2010 "Policy and Collaborative Partnership for Sustainable Aviation" initiative facilitated a multistakeholder public-private dialogue.

The objective of the project was to identify supportive policy frameworks, innovative partnerships, financing, and information and education approaches to help the aviation industry reach its voluntary CO_2 emission reduction goals while supporting sustainable growth and minimizing competitive distortion.

The project integrated stakeholders from the aviation industry, international organizations, industry associations, financial institutions, development banks and academia, as well as select experts and non-governmental organizations (NGOs).

The overall conclusion of the report is that, in order to achieve the aviation industry's ambitious emission reduction goals, industry and governments will need to collaborate to ensure the implementation of the key CO_2 abatement levers – aviation infrastructure improvements, technology research and development, and aviation biofuels – is driven forward and supporting policies are put in place. Positive incentives (e.g. fiscal incentives) are seen as having a higher potential to increase investment in reducing carbon in the aviation industry than green levies and taxes, which are currently being implemented or discussed in different countries. In regard to the development of market-based measures (MBM), also, the expected negative effects on the industry and the wider global economy have to be taken into account. Such measures would lead to a money outflow from the aviation industry, which could lead to less investment in CO_2 emission reduction within the industry and thus could have a seriously negative long-term effect on the CO_2 footprint of the aviation industry. Besides policies, partnerships and financing, information and education of stakeholders, especially governments, are critical to drive forward emission reduction.

The World Economic Forum will continue to facilitate the necessary multistakeholder dialogue with a focus on biofuels in 2011.

2. Project Approach

This report has been assembled as a result of the Forum 2011 Policy and Collaborative Partnership for Sustainable Aviation project. It was developed with the support of Booz & Company and based on a wide range of inputs, including a detailed CO_2 baseline model until 2050 with different technology scenarios based on previous industry analysis, a literature review of published studies, an expert survey, and input from multistakeholder discussions with involved industry partners, associations, NGOs and academic experts (for a list of involved and consulted organizations see Section 1).

After a review of the socioeconomic importance of the aviation industry, aviation's expected growth in the next decades was analysed based on different existing studies and previous projections. In particular, the carbon model developed and generously shared by IATA was extended to 2050. The extended forecasting was based on industry analysis, ICAO FESG (Forecasting and Economic analysis Support Group) forecasts, Manchester Metropolitan University (MMU) forecasts, etc. The resulting CO_2 baseline was compared to the long-term CO_2 emission goals that the aviation industry committed to in June 2009 prior to the COP15 climate change negotiations. In the context of the emerging gap between the CO_2 baseline and the collective industry goals, different scenarios were modelled to analyse the potential of all identified CO_2 emission abatement levers to help the aviation industry reach its targets. The emission abatement levers analysed were: Operations Improvements, Infrastructure Improvements, Additional Research and Technology for Airframes and Engines, Early Aircraft Retirement, Biofuels, CO_2 Emission Reduction in Other Sectors through Emissions Trading and Offsetting, and Limiting Air Traffic Growth.

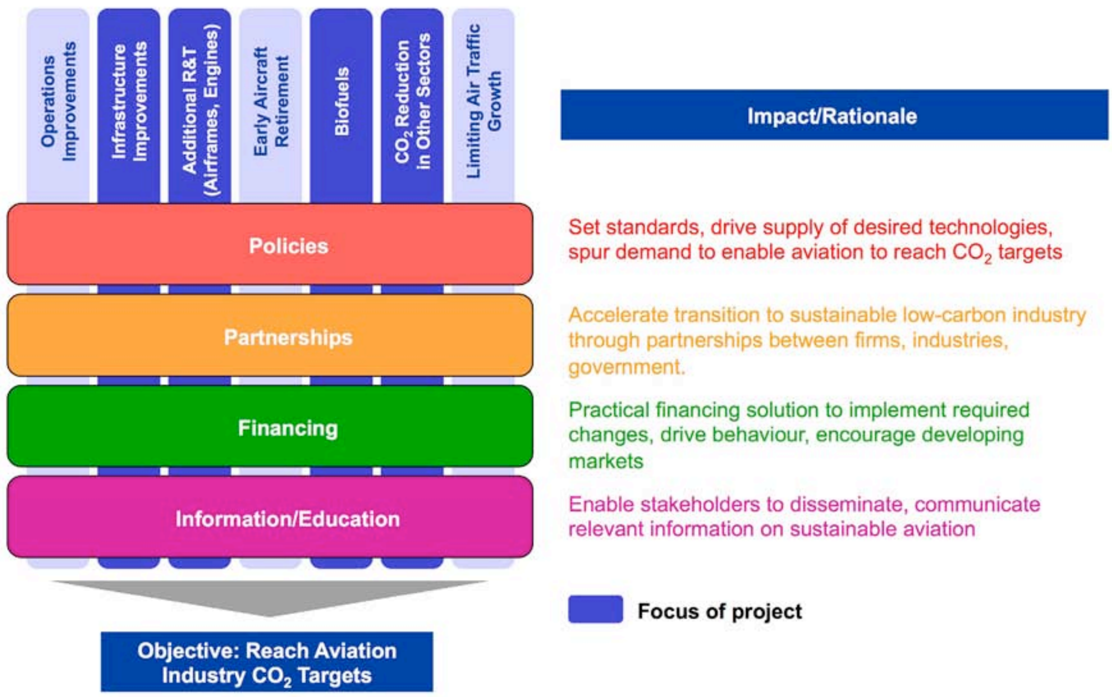
The project then evaluated which opportunities exist in general in regard to policy, partnership, financing, and information and education that could support the implementation of the abatement levers.

Finally, the project evaluated the CO_2 abatement levers with the highest carbon reduction potential and the largest need for multistakeholder involvement – namely, Infrastructure Improvements, Additional Research and Technology for Airframes and Engines, Biofuels, and CO_2 Emission Reduction in Other Sectors through Emissions Trading and Offsetting – against the framework of which different policy measures, partnerships, financing mechanisms, and information and education opportunities could best support the implementation of these abatement levers.

The framework utilized and presented below (see Figure 1) was applied in all multistakeholder meetings, interviews, and the conducted expert survey (for results of expert survey, see Appendix).

A deep dive with a special focus on India is included in the appendix, based on an in-depth meeting held at the World Economic Forum's 2010 India Economic Summit (see India deep dive in Appendix).

Figure 1: Evaluation Framework



3. Socioeconomic Importance and Competitiveness of Aviation

Mobility and transportation interlink the global economy. Aviation is an important enabler for the trade of goods, tourism, services and the socioeconomic development of nations. Besides connecting people, increasing choices and creating additional business opportunities, aviation is also important for defence, political, peacekeeping and humanitarian concerns.

Approximately 2 billion people and more than 43 million tons of freight (35% of exported goods by value)[iii] are transported by aviation. Many nations, such as remote island states (e.g. in the Caribbean) and countries in Africa depend highly on aviation. For many countries with vast surface areas, such as the United States, China and Russia, a significant percentage of domestic transportation is based on aviation.

The aviation industry significantly contributes to GDP and employment. In 2007, the aviation industry contributed US$ 426 billion to global GDP directly, as well as an additional US$ 490 billion indirectly and US$ 620 billion through induced and catalytic effects in tourism – this does not yet cover other additional catalytic effects (e.g. from trade). The direct, indirect and induced contribution represented 2.3% of GDP. Including catalytic effects from tourism, contribution of aviation equalled 3.2% of GDP. Aviation's contribution to employment equalled 5.6 million jobs directly and 33 million jobs in total, including direct, indirect, induced and catalytic jobs. Value added per employee is four times higher in aviation than in the economy overall. For 2026, GDP contribution is expected to rise to US$ 973 billion directly and an additional US$ 1.1 trillion indirectly, and 1.5 trillion through induced/catalytic (tourism) effects.[iv] Moreover, a study conducted by Frontier Economics showed that the aviation industry generates higher net benefits than other comparable sectors. Net benefits in terms of gross value added to the United Kingdom's national GDP relative to CO_2 emissions were estimated at approximately GBP 175 per ton of CO_2 for aviation, approximately GBP 160 per ton of CO_2 for road transportation, and approximately GBP 60 per ton of CO_2 for the energy sector.[v] Only limited opportunities exist to replace aviation with other means of transport, such as high-speed trains or shipping, because passenger journeys over 1,500 km, with no practical alternatives, account for 80% of aviation emissions.[vi]

The negative macroeconomic effects of reduced aviation activity reach far beyond the travel-related sectors. This became visible in spring 2010, when the shutdown of a large part of the European airspace due to an ash cloud cost the European economy around €5 billion, according to IATA. Due to the obvious negative macroeconomic effects, the CO_2 abatement lever limiting air traffic growth was excluded from further discussion in this report.

The highly regulated nature of the aviation sector subjects its players to a series of national and international restrictions that prevent meaningful consolidation and capacity sharing at the international level and have been cited as leading to over-capacity, downward pressure on fares, and consequently unprofitability.[vii]

Airlines historically have not generated high enough returns on assets and invested capital, and their profit margins have been insufficient to cover their cost of capital. In recent years, the sector has faced increased economic difficulties due to volatility from global crisis events like 9/11, Severe Acute Respiratory Syndrome (SARS), volcanic ash clouds, and the financial crisis that led to limited access to credit.

In light of the above, any aviation sustainability discussions must be conducted in the context of the global socioeconomic importance of the industry and the existing economic realities of the industry.

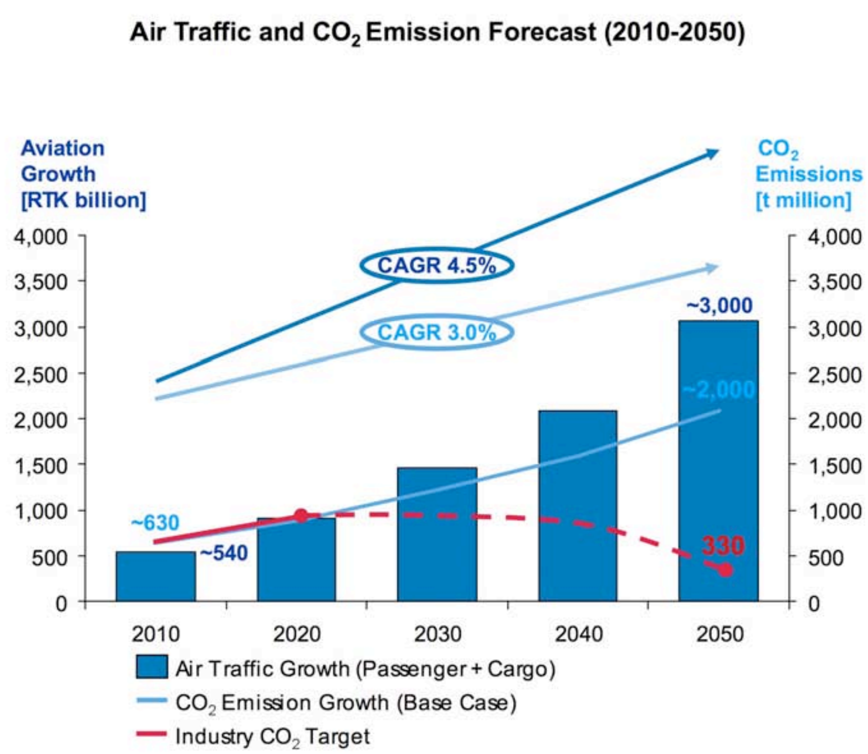
4. Aviation Demand Growth Discloses Gap to Industry CO_2

The aviation industry has a long historic track record of fuel efficiency gains and thus carbon reduction. While aviation traffic more than doubled over the last 20 years on a revenue passenger kilometre basis, CO_2 emissions grew only 50% during the same time period, which represents fuel efficiency improvements of approximately 1.5 to 2% per year, or a reduction in total energy intensity of over 60% since 1970. Fuel efficiency improvement is a key motive for the aviation industry due to high and further rising fuel costs. These achievements should be recognized as they demonstrate the industry's willingness to take leadership and action on the matter of fuel efficiency improvement and emission reduction.

Aviation emissions currently account for approximately 2% of total CO_2 emissions.[viii] However, significant aviation demand growth is expected for the future, with highest growth rates in Asia (particularly China and India) and the Middle East. Growth is mainly driven by GDP growth, which currently equals 8.7% per year for developing Asia, including China and India, despite the financial downturn.[ix]
Increased GDP is enlarging the middle class of these countries that has the disposable income to spend in travel- and tourism-related activities. The Asian Development Bank observed that Asia's consumers spent an estimated US$ 4.3 trillion in 2008, which represented one-third of OECD (Organisation for Economic Co-operation and Development) consumption expenditure, but will spend US$ 32 trillion by 2030, which would represent 43% of worldwide consumption.[x]

The aviation baseline analysis undertaken in this project (see Figure 2) shows that, while demand for passenger and cargo is projected to grow by 4.5% per year, from 540 billion revenue tonne kilometres (RTK) to 3,000 billion RTK from 2010 to 2050 (4.5% growth per year), CO_2 emissions will grow at a lower rate of 3% per year (from 630 million tons in 2010 to approximately 2,000 million tons in 2050).
This CO_2 Base Case calculation assumes industry fleet improvements to replace old aircraft and cover demand growth with newer more fuel- and CO_2-efficient aircraft, resulting in approximately 1.5% fuel efficiency improvement of the overall in-service fleet per year. Thus, the Base Case assumes significant investment by airlines in aircraft with lower CO_2 profiles, including the introduction of more than 70,000 new aircraft from 2010 to 2050 at an estimated cost of more than US$ 6 trillion.[xii] With growing aviation demand and public awareness of aviation's CO_2 impact on climate

Figure 2: Air Traffic and CO_2 Emission Forecast versus Industry CO_2 Targets (2010-2050)



change, in June 2009, the global aviation industry demonstrated leadership by devising a strategy for achieving aggressive CO_2 emission reductions through technological, operational and infrastructure improvements, subject to government investment in the aspects under government control and a regulatory environment conducive to aviation industry investment. Provided the necessary public-private sharing is enabled, the industry committed to collective CO_2 emission goals including an average 1.5% fuel efficiency improvement per year through 2020, net carbon neutral growth from 2020, and 50% net CO_2 emission reduction by 2050 compared to 2005 values. Meanwhile, ICAO, in its process of developing emission targets for international aviation in its 37th Assembly in October 2010, agreed on international aviation targets of an average 2% fuel efficiency improvement per year through 2020 and aspirational targets of an annual average 2% fuel efficiency improvement from 2021 to 2050, as well as considering carbon neutral growth from 2020.[xiv]

Meeting these ambitious goals despite the anticipated high aviation demand growth poses a significant challenge. The industry's 2050 goal, in particular, leaves an 85% CO_2 emission reduction gap compared to the Base Case (see above), despite significant, continuous industry investment in newer, more fuel-efficient aircraft. As such, the gap between estimated Base Case emissions of approximately 2 billion tonnes and the industry target of 330 million tonnes in 2050 would equal almost three times today's total aviation CO_2 emissions of approximately 630 million tonnes. In this context, significant additional measures and collaboration of the industry and governments are necessary to achieve the goals and enable sustainable development of the aviation industry.

5. Carbon Reduction Potential of Key CO_2 Abatement Levers

A number of levers that could enable the aviation industry to further reduce its CO_2 emissions beyond the anticipated reductions from fleet improvements at historical rates (Base Case, see Section 3) have been identified and analysed by the industry. Levers directly related to the aviation industry include operations improvements on the air traffic management side (continuous climb, continuous descent approach, direct routes, virtual taxi queues, speed control in cruise for terminal congestion) and the industry side (improved fuel management, reduced weight of seats, centre of gravity optimization, optimization of load factors), infrastructure improvements [e.g. performance-based navigation, such as Single European Sky ATM Research (SESAR) or NextGen; improved airspace redesign, especially in China, Russia, and Europe; airport infrastructure improvement], additional research for aircraft technologies including radical new technologies, early aircraft retirement, and aviation biofuels. In recognizing the time factor needed for the implementation and rollout of many of the identified levers, the industry is conscious of the possibility of governments imposing market-based measures (MBM) that would factor in emission reductions in other sectors by permitting aviation to trade credits with or offset its emissions in those other sectors.

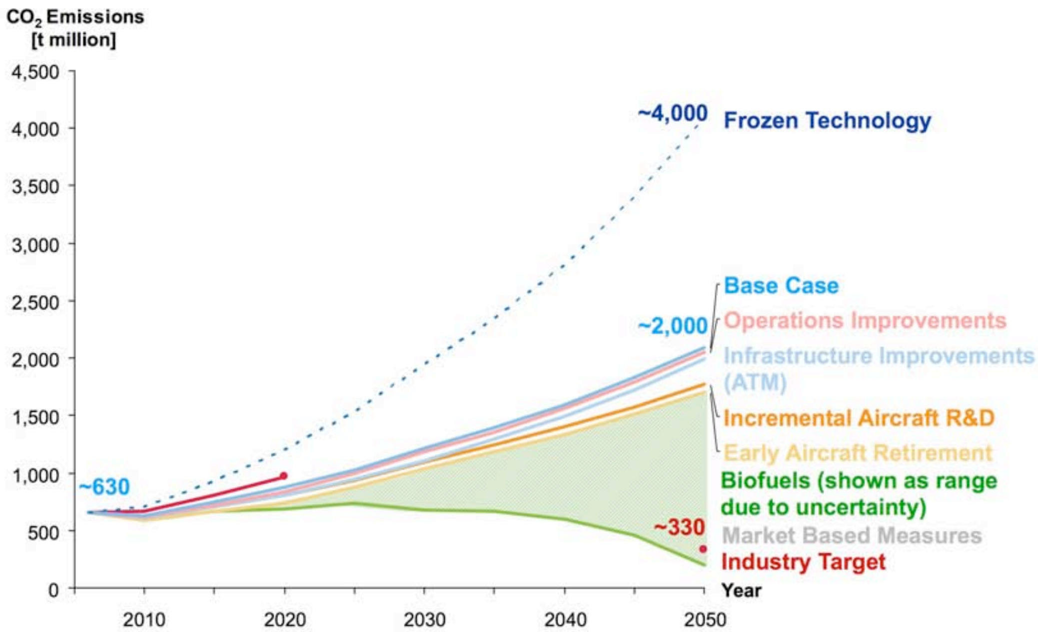
In this context, the project conducted a detailed strategic scenario analysis on the potential of the different CO_2 abatement levers (see Figure 3). The analysis was developed based on the extension of previous industry analysis to 2050 (see Figure 4) to allow for direct comparison with the targets. In addition to passenger and cargo traffic, emissions from smaller business aircraft have also been considered.[xv]

The analysis highlights that, to achieve its CO_2 reduction targets, the industry and other relevant stakeholders, such as national and regional governments, need to implement a combination of the levers identified. It also highlights those that are the most important to make the step change for the industry.

Operations[xvi] improvements, including improved fuel management, continuous descent approach, reduction of cabin weight (e.g. through use of lightweight seats), and centre of gravity optimization, need to be implemented by airlines. Operations improvements are partly dependent on infrastructure improvements (e.g. technical infrastructure required to implement continuous descent approach). The Collaborative stakeholder Decision Making (CDM) approach supported by ATM infrastructure can help optimize competing airlines' use of constrained resources. CDM efforts are part technology and procedures, and part policy agreements on equitable sharing of constrained resources. Virtual taxi queues that keep aircraft from burning fuel waiting on taxiways are a good example of CDM. The industry is already accelerating implementation of operations improvements through best practice sharing (e.g. through IATA "Green Teams" and ICAO Circulars).

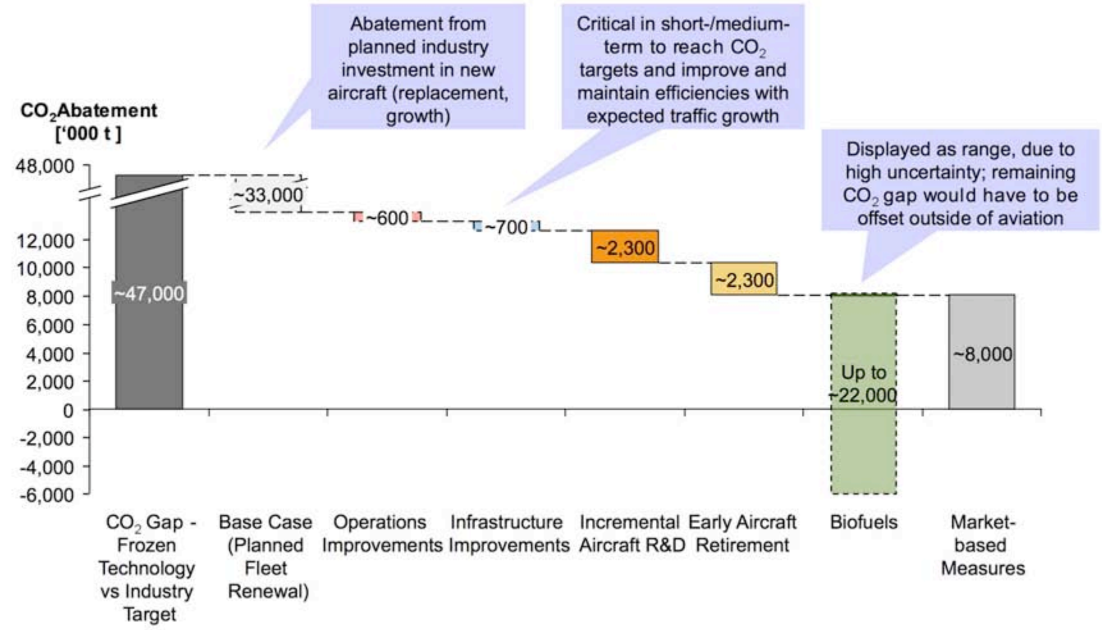
Infrastructure[xvii] improvements, including ATM improvements like NextGen in North America and SESAR in Europe, are critical and urgent. The implementation of these measures is important to improve or at least maintain current operational efficiency levels with forecasted demand growth. It should be noted, however, that the implementation of these measures will result in CO_2 efficiency improvements in the period of implementation and early

Figure 3: CO_2 Abatement Potential of Levers



Source: ICAO, FESG, industry analysis, World Economic Forum/Booz & Company analysis

Figure 4: Cumulative CO_2 Abatement Potential until 2050



Source: World Economic Forum/Booz & Company analysis

years thereafter. These measures will continue to benefit the industry long term; however, they will unlikely lead to further long-term CO_2 efficiency gains, considering the high expected demand growth.

Incremental research for radical new aircraft technologies, such as, for example, blended wing body airframes and open-rotor engines, could further increase fuel efficiency beyond the 1.5% fuel efficiency improvement per year, which industry technology experts anticipate to be achievable through gradual improvements of existing technology. In the expert discussions, it was estimated that additional investment in research for radical new aircraft technologies today could lead to an additional fuel efficiency improvement of aircraft types that will be introduced to the market from 2030 by approximately 10% – (in addition to the fuel efficiency improvements derived from gradual improvement of current technologies already anticipated in the Base Case (see Section 3).

Early aircraft retirement options[xviii], such as a government-supported early aircraft retirement programme, could have the potential to accelerate fleet CO_2 efficiency improvement. The graphs (Figure 3 and Figure 4) show the CO_2 abatement that could be achieved with a continuous retirement of all aircraft of age 20 and above and replacement with the most efficient available new aircraft models of the respective same size. This would lead to approximately 600 narrow body and approximately 100 wide body aircraft having to be replaced on average per year until 2050. Forced retirements would have significant financial consequences, if the airlines were not compensated (see Section 5).

Biofuels, especially sustainable second-generation biofuels with low life-cycle emissions (e.g. from algae, energy crops such as jatropha and salicornia, forestry waste, and to some extent sugar cane) that do not compete for land and water with food crops constitute a promising lever for CO_2 abatement in aviation. The easiest way to implement, especially also to leverage existing distribution infrastructure, has been shown to be through blending with existing jet fuel (so called "drop-in" biofuels). However, to reach the industry's long-term CO_2 reduction target, 13.6 million barrels of sustainable second-generation aviation biofuels per day would be required in 2050.[xix] The CO_2 abatement potential of biofuels is particularly difficult to estimate due to a number of uncertainties, including technological and market uncertainties, investment required for marketing and distribution, and competition for biofuels with other modes of transports. On the one hand, biofuels alone could be sufficient to close the emission gap, or, on the other hand, they may prove to offer only limited CO_2 abatement.

Market-based measures (e.g. emissions trading and/or offsetting) may offer the opportunity for the aviation industry to cost-effectively reduce its emissions through emissions trading and project offsetting options similar to the Kyoto Clean Development Mechanism (CDM) or Joint Implementation (JI) mechanisms, as long as cheaper options for CO_2 emission reduction are available in other sectors. However, due to the likely money outflow from the aviation industry, potential negative impact on industry investment in new aircraft technology and the negative macroeconomic effects from reduced air traffic, also must be considered (see Section 2).

6. Estimated Cost of Implementation of CO_2 Abatement Levers

The project also estimated the required investment costs for the implementation of the different CO_2 abatement levers. Given that projected fleet replacements through 2050 are part of the Base Case in this analysis, the costs noted below would be additional to the US$ 6 trillion the airlines are estimated to spend in newer, more fuel-efficient aircraft through 2050.

For **operational improvements**, discussed in the previous section, an additional investment of US$ 12 billion would be required until 2030, based on a previous industry analysis.[xx] As it can be assumed that most of the operational improvement opportunities identified today will have been implemented and become common practice by 2030 (e.g. use of lightweight seats, continuous descent approach) no additional cost was estimated for implementation for the time between 2030 and 2050. Airlines have large incentives to implement the improvements due to the economic net benefit through the expected fuel savings. Operations improvements are therefore not covered in more detail in this document, though it should be noted that such improvements typically require up-front capital investment by the airlines.

Infrastructure improvements in the area of ATM, such as performance-based navigation SESAR, NextGen, and improved airspace redesign in China and Russia (presented in Section 4), require an additional total investment of approximately US$ 58 billion by the year 2030, based on detailed industry analysis.[xxi] It should be noted that only a part of these funds has already been committed by governments for the implementation of NextGen in the USA and SESAR in Europe. However, additional infrastructure improvements will be required, especially in regard to aircraft equipage and airport infrastructure and for additional ATM upgrades that may be needed after 2030. Previous industry analysis shows that infrastructure improvements can be implemented at a net benefit after consideration of fuel savings.

To incentivize a manufacturer to **increase R&D for radical new aircraft technologies** that would lead to these technologies becoming more mature and available to be built into new aircraft generations from 2030, approximately US$ 10 billion could be sufficient today, according to industry and academic experts.[xxii] If this investment could be made today, this would represent a cost-efficient way to reduce aviation's CO_2 footprint in the future.

Analysis of a possible **early aircraft retirement** programme (i.e. retirement of all in-service aircraft after 20 years of operations instead of the current up to 40 years) concluded that such a programme would be extremely costly to implement because of the high residual values of old aircraft and the high financing costs for new aircraft. In fact, the project estimated that if such a policy was continuously used in the years between 2010 and 2050, it would cost approximately US$ 680 billion on a global basis.[xxiii] Therefore, because of the high cost (by far the highest cost per tonne of CO_2 reduction of all reviewed abatement levers) and limited CO_2 abatement potential, early aircraft retirement is not seen as an economical option for significantly reducing CO_2 emissions. Early aircraft retirement is not considered further in this document.

With regard to the development of s**econd-generation biofuels** for transportation, the International Energy Agency (IEA) has estimated that, between now and 2050, an estimated US$ 320 billion to US$ 480 billion is needed.[xxiv] As aviation would require a significant portion of second-generation biofuels of the total amount of biofuels produced in the same period, it can be concluded that a significant portion of the total investment has to be attributed specifically to the development of second-generation biofuels for aviation.

Finally, with respect to the investment needs for emission reduction in other sectors, through an emissions trading scheme (ETS), the price of carbon would dictate how much the utilization of this measure would cost to the industry.

Many of the discussed abatement levers should be implemented because they are attractive from an economic perspective (negative net cost after consideration of fuel savings). Currently, however, many are not being implemented, or are not implemented as rapidly as they should be, because of either inadequate or counterproductive policies; limited partnerships; a lack of an enabling environment for partnerships; a lack of information sharing between and education of all stakeholders, including governments and customers; or, finally, a shortage or unavailability of financing at a national, regional and global level.

This section will give a general overview of policy, partnership, financing and information and education options that could help accelerate implementation of the CO_2 abatement levers in aviation.

7. Opportunities to Accelerate Aviation's Move to Lower Emissions

7.1 Policy Options

The purpose of policies should be to support the aviation industry in becoming a sustainable low-carbon sector. Presently, a number of policies that exist hinder the industry in its ability to implement CO_2 emission reduction measures. As such, these policies should be removed and replaced with policies that provide direction and stability to the market and ensure that competitive distortion within international aviation is avoided. Also, a rationalized regulatory framework needs to be put in place to support enablers of technological, operational and infrastructure improvements and to prevent or minimize measures that are counterproductive to this. Overall, a global approach seems most appropriate for aviation as international aviation operates between different countries and regions, and any uncoordinated national or regional policy would be likely to lead to competitive distortion. However, it has to be acknowledged that the implementation of global policies is very difficult and slow and needs some type of supranational organization to evaluate a proper implementation of the policy. Although national and regional policies could be more quickly agreed upon and implemented and more easily enforced under consideration of national sovereignty concerns, a patchwork of national or regional policies has to be avoided, as it leads to increasing complexity, decreasing transparency and likely competitive distortion between countries and carbon leakage (e.g. longer flights to avoid flying through a region with CO_2 levies or emission trading). Thus, a global policy that encourages countries to adopt consistent and complementary national policies and programmes would be expected to be most effective for this global industry.

To develop global policies, different principles need to be considered to ensure fair treatment of players, countries and regions. Moreover, to gain international agreement, different stages of national economic development have to be taken into account. For example, if a principle of causation is used as the basis for developing the policy, a CO_2 emission reduction cost would be allocated to those players that cause the emissions, irrespective of country or level of development. However, if the principle of equal treatment and non-discrimination (which is the basis of ICAO policy structures) is applied, then all states have to be treated equally on a global basis, with no regional differentiation other than special exceptions that might be provided in the case of demonstrated special need. Finally, if the principle of common but differentiated responsibilities (CBDR), which is endorsed by UNFCCC, is implemented, then it is the duty of states to equally share the burden of environmental protection but with differentiated responsibility based on the different material, social and economic development stages of the states as well as on their historical contributions to global environmental impacts. At the same time, it must be recognized that, under any of these principles, the relative development and economic status of the country in which an airline is registered may or may not be mirrored by the airline. For example, several highly competitive, world-class airlines are headquartered and registered in developing countries.

Concrete policy options that could be leveraged to support the aviation industry's move towards lower carbon emissions fall into the following categories.

Fiscal incentives such as tax breaks, depreciation incentives, lump sums, grants or subsidies can incentivize the supply (manufacturers) and demand (airlines) sides. They are particularly effective in early stages of technology development, as they reduce the risk of investment and lower total costs of R&D and technology. At the same time, financial incentives give more flexibility to industry players than standards and regulation.

Tax breaks can be introduced for investment in R&D (e.g. for new airframes, engines, biofuels) or for purchase of more efficient aircraft or fuels with lower carbon emissions. They are very attractive to foster investment from players within the aviation industry and very effective in channelling investment into the desired areas (e.g. R&D). On the other hand, they do not give large incentives to those players that are less profitable and thus do not pay taxes. However, global fiscal policies are hard to define and implement, as nations and regions operate under different and, on many occasions, incompatible legislation.

Depreciation incentives could help to accelerate fleet turnover. They have mainly the same advantages and disadvantages as tax incentives. To ensure that faster depreciation has a real impact on CO_2 emission reduction, it has to be reviewed in depth how this faster depreciation of planes by more profitable carriers affects the market for used planes.

Lump sums or grants that give a fixed amount of money to all players (e.g. cash premium for aircraft R&D or early aircraft retirement), or other mechanisms that facilitate aircraft purchase financing and that are not bound to profitability like tax incentives, have the advantage of benefiting all players equally. Furthermore, an advantage is that a total limit can be set for available funds so that the programme ends afterwards. The effect of such policies highly depends on the criteria (e.g. cash premium for early aircraft retirement is only given if the aircraft is replaced by a model with a certain specified CO_2 efficiency increase). The timing for such programmes should be aligned with the timelines for introduction of new technology to ensure the highest effect.

Subsidies can help to overcome the price differences between conventional technology and new technologies (e.g. conventional jet fuel versus more expensive aviation biofuels). They should be reduced step-wise as supply of new technologies increases and production becomes more economical due to increasing scale and learning curve effects.

The aviation industry could draw from examples of fiscal incentives used successfully in other industries (see Figure 5).

For fiscal incentives, policy-makers have to ensure their good intentions do not lead to potentially undesired outcomes. Poorly designed fiscal incentives, despite the intention to increase eco-friendliness, could lead to high spending with little effect on CO_2 reduction; that is, a cash premium to accelerate fleet renewal could have little impact if the effects on the secondary market for aircraft are not taken into account or if tax incentives and grants to foster R&D merely substitute existing or planned industry R&D programmes with government-sponsored programmes or channel research into few areas ("putting all eggs into one basket").

Standards and regulation, such as an aircraft CO_2 standard, fuel standard or labelling standard, might encourage aviation players to develop and adopt new, more CO_2-efficient technologies or approaches (e.g. precedence engine noise in the past). These policies, however, do not have much of an effect if the new technology is still in the early R&D phase and not available in the market for purchase. If introduced once technology is proven, standards and regulation can significantly accelerate manufacturing scale up and technology rollout. For example, the aviation biofuel specification that is currently in development can stimulate additional R&D and accelerate its production.

A technology/CO_2 standard that, for example, requires aircraft to meet certain CO_2 emission levels such as the new CO_2 standard for new aircraft proposed and under development by ICAO, creates an enabling environment for manufacturers to improve CO_2 efficiency of new aircraft generations. However, manufacturers already have a high incentive to reduce fuel burn and thus carbon emissions because of the weight and the constantly appreciating and increasingly fluctuating

Figure 5: Examples of Recent Successful Financial Incentives in Other Industries

Automotive – Cash for Clunkers

- Cash incentive scheme to promote replacement of old, high-emission vehicles with new, efficient cars
- Set up by most Western governments to alleviate impact of financial crisis on automotive industry
- Commonly linked to age or emission requirements for applicable vehicles
- Environmental impact disputed

Automotive – Leaded Gas (US)

- Clean Air Act of 1970 imposed regulations on car makers to use catalytic converters to meet new standards
- New catalytic converters required customers to buy unleaded gas
- Financial incentives for oil companies to produce efficient unleaded fuels
- Tax differences between leaded and unleaded gas accelerated switch

Energy – Wind/Solar (Germany)

- Introduction of feed-in tariffs in Germany to encourage deployment of renewable energy technologies
- Different rates for technologies
- Level of support declines over time by 1% per annum
- CO_2 emission savings estimated at 52mT by 2010 at cost of €2.4 billion

Property – HOME STAR (US)

- Programme proposed in US in 2009 to encourage homeowners to retrofit existing homes and improve energy efficiency
- Financial incentives via tax credits up to US$ 12,000 per home
- Approximate cost of US$10 billion per annum

price of fuel, which represents about 30% of all costs of their customers' operations. Such technology standards, if introduced for all in-service aircraft, could put carriers with older fleets at a disadvantage, which could especially impact the airlines from certain developing countries and those airlines otherwise not in a capital position to re-fleet when such standards go into effect. Further, care would have to be taken to avoid technology-forcing provisions that might unduly compromise safety.

A fuel standard, such as a blending mandate that requires a certain percentage of jet fuel to be from renewable sources (drop-in), could help spur production and make the investment in aviation biofuels more attractive and secure. However, it has to be considered that a fuel standard would be impossible to meet as long as second-generation biofuels are not available at commercial scale and producers might have higher incentives to use biomass for other purposes.

Labelling standards and accreditation (e.g. ISO number type) that give customers transparency on CO_2 efficiency (e.g. by aircraft, by airline) would allow for market-based competition between airlines on a CO_2 efficiency basis as well. Airlines could thereby position themselves as particularly CO_2 efficient and thereby obtain a competitive advantage as customer awareness for ecological and climate change matters increase. The difficulty with such standards is that CO_2 efficiency of flights highly depends not only on the fuel efficiency of the plane but also on criteria such as length and load factors of the flights, which are not determinable for a specific flight until just before take-off.

The following examples (see Figure 6) describe standards and regulations from other industries that show potential for transfer into the aviation sphere.

Green levies (on tickets, aircraft, fuel, CO_2) are intended by policy-makers as a way to disincentivize the industry from emitting CO_2. However, green levies are not effective, as they do not have a clear correlation with reduction of CO_2 and can distort market competition. They are specifically not effective in situations where new, more efficient technologies are not yet available for purchase. They take out money from the industry that could be used to invest in green technology without ensuring that governments use the money for "green investment" rather than balancing the treasury.

Ticket levies are charged on a per ticket basis and are relatively easy to administer. The fees are covered by the airlines or, where possible, are passed on to the passengers or customers in the case of air cargo. Often, ticket levies are linked to the distance flown and less often to aircraft fuel burn. The effect is that ticket levies can reduce CO_2 emissions through increasing prices, which can limit or marginally reduce demand. They thereby can exclude segments of society with less spendable income from aviation and impact destinations that are highly dependent on tourism receipts. The negative macroeconomic effects of reduced air traffic, especially to the economies of developing nations, are presented in Section 2 of this report.

Figure 6: Examples of Successful Standards in Other Industries

Automotive – Emission Standard (CA)	Automotive – Biofuel Drop-In (EU)	Food Industry – Labeling Standard (US)
• More stringent vehicle emission standards than federal regulations set by California • Adoption of standards by other states (e.g. NY, MA, CT) • Adherence to standards necessary for manufacturers to sell vehicles • New standards induced introduction of special filters for diesel cars	• Regulation set by EU to ensure minimum proportion of biofuels in transport energy consumption • 5.7% biofuel target by 2010, 10% biofuel target by 2020 • Regulation criticized for failing to reduce GHG emissions and adverse effects	• Labelling standard introduced in the US by Food and Drug Administration (FDA) • Requires consistent statements of nutrient and ingredients on packaged food to give customer more transparency • Applies to imported and domestically produced food

Source: European Environment Agency, EPA, FDA, World Economic Forum/Booz & Company analysis

Recent examples in Europe (shown in Figure 7) demonstrate the limited effectiveness of ticket levies in CO_2 reduction, which often lead to competitive distortion.

For example, the United Kingdom's Air Passenger Duty (APD), as first introduced in 1994 and since replaced, did not put differentiated pressure on airlines (e.g. did not recognize the CO_2 efficiency of the plane or fleet). As such, more CO_2-efficient airlines were penalized despite being more efficient. Furthermore, most airlines simply passed the additional cost on to customers. The increased price, albeit penalizing travellers with more expensive tickets, did not have the desired effect of decreasing overall demand. There is a very high price elasticity in ticket pricing, and a combination of the general desire to travel by many – especially a growing middle class in developing countries – and the overall desire by nations to continue to attract the lucrative business and leisure tourism market, will likely render the increase in ticket pricing inefficient in reducing demand beyond very marginal effects. At the same time, one should consider that shifts to other modes of transport could lead to CO_2 leakage in the sense that emissions increase in the alternate sectors.

An aircraft levy is, for example, an annual levy on an individual aircraft depending on type, age or fuel burn. The advantage is that this type of levy can be easily applied to passenger and cargo planes. The challenge is that the number of flights per year, distances flown, or load factors are not considered, thus the levy has no correlation to usage and actual CO_2 emissions. As such, this levy could put an unjust burden on the airlines from certain developing countries that have older fleets.

A fuel levy (i.e. tax on jet fuel comparable to existing taxation of gasoline) considers the principle of causation. Such a tax, though, is against existing bilateral agreements and would thus require significant policy amendments on a global level. Without alternative fuels being available, fuel levies would only put an additional burden on airlines for which fuel already costs more than 30% of total costs and therefore could only have a marginal effect.

A CO_2 levy would have the same implications as those described previously for fuel levies. Moreover, it would have higher administrative costs as a result of the difficulties in measuring, monitoring and reporting of CO_2 emissions by all carriers.
Based on the preceding argumentation, all types of levies have to be evaluated, taking into account the negative macroeconomic effect (see Section 2) and the structural and financial difficulties they pose on the aviation industry.

Figure 7: Examples of Recent European Ticket Levies

APD (United Kingdom)

- Air Passenger Duty (ADP) first charged in 1994
- Applies to a/c >20 seats and take off weight >10t
- Varies according to destination and travel class
- Currently four rates £10/£20 (Europe), £40/£80 (Other)
- Forecast: GHG emission reduction 0.75mT per year by 2010-2011
- No plans to eliminate APD once EU ETS is implemented in 2012
- Funds collected do not go to environmental projects
- No direct effect on CO_2 emission reduction, only indirect effect through increased price and decreased demand if cost is passed on to customers
- Competitive distortion

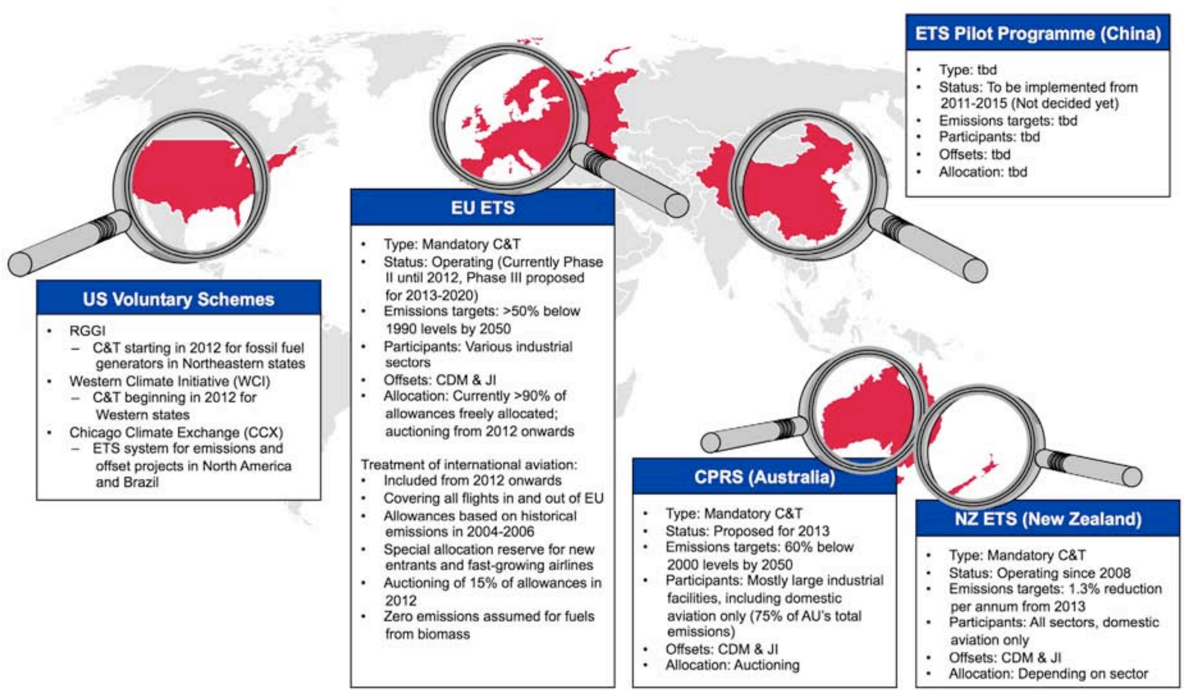
Air Travel Tax (Germany)

- Air travel tax introduced in January 2011
- Price varies according to travel distance
  - €8 for short-haul flights
  - €25 for flights >2,500 km
  - €45 for long-haul flights
- Applies to flights leaving and arriving in Germany
- Exemption for transfer passengers and noncommercial flights
- Projected to result in €1 billion burden on aviation
- Intention to cut tax once EU ETS is implemented in 2012
- Imposed solely to consolidate budget deficit
- No direct effect on CO_2 emission reduction, only indirect effect through increased price if cost is passed on to customers
- Competitive distortion

Departure Tax (Netherlands)

- Introduction of an additional departure tax in July 2008
- Varied according to travel distance
  - €11.25 for short-haul flights
  - €45 on flights >2,500 km
- Expected additional revenue of €300 million could not be achieved
- Led to competitive distortion
- Estimates of €1.3 billion in lost revenue for Dutch economy
- Eventually scrapped in July 2009

Figure 8: Examples of Current and Planned ETS Schemes



Source: European Commission, Australian Government, U.S. Committee on Energy and Commerce, New Zealand Government, World Economic Forum/Booz & Company analysis

Emissions trading schemes (ETS) or offsetting represent another policy option that may be an economically efficient means to reach CO_2 targets, as long as CO_2 abatement is possible at a lower cost in other sectors and such schemes are set up correctly. By putting a price on carbon and giving legal incentives in the form of longer-term policy security, an ETS may incentivize investment into low-carbon technologies. However, due to the likely money outflow from the aviation industry, the potential negative impact on industry investment in new technologies and negative macroeconomic effects from reduced air traffic also must be considered (see Section 2). The effects of an ETS highly depend on the concrete specification [e.g. cap and trade with free allowances, cap and trade with auctioning of allowances where revenues to the administrating government are reinvested in aviation efficiency, options to trade credits with other sectors and/or ETS schemes, or ETS with or without project offsetting options similar to Kyoto CDM, JI, or UN REDD (Reducing Emissions from Deforestation and Forest Degradation) projects that provide a link to a developmental agenda].

While international aviation has been excluded from the Kyoto Protocol and any national emission targets so far and the aviation bunker fuels discussion was deferred to ICAO in the UNFCCC climate negotiations, international flights from and to the EU will be included in the EU ETS from 2012, though it has to be noted that a number of carriers have objected to this and initiated legal challenges. As a number of countries (see Figure 8) have implemented or proposed to implement ETS, it is conceivable that, in the future, pressure to include aviation in ETS in one way or another will increase. It will be critical for the aviation industry to continue to work through ICAO (as recognized by UNFCCC in the outcomes of COP16 in December 2010) to develop a global sectoral market-based measure approach to prevent competitive distortion and increased complexity with proliferation of a patchwork of national schemes.

Developing a global sectoral ETS scheme will be challenging, as it will have to take into consideration existing agreements and treaties (e.g. Chicago Convention, Kyoto Protocol, bilateral agreements between states).[xxv] To address the legal hurdles, individual nations can commit to individual voluntary action plans that acknowledge a global policy or alternatively plurilateral agreements need to be negotiated with the same scope. Further legal constraints may also exist in regard to using policy frameworks such as ETS or levies to raise funds to finance CO_2 abatement mechanisms for the aviation industry, as national legislation of different countries does not allow for earmarking of such funds.[xxvi]

With regard to offset programmes, currently there are a limited number of projects (especially Kyoto-related projects, such as CDM and JI) that are not open to aviation. Additional opportunities might lie in enabling projects in African countries that are currently not eligible for Kyoto CDM projects.

When setting up an MBM approach for aviation, the different stages of development of countries and especially the resilience of small and remote island states that depend highly on tourism has to be considered. A number of suggestions on how to structure MBMs have been proposed by different organizations. For example, the Aviation Global Deal (AGD) Group, which includes the Climate Group, made a proposal that maintains equal treatment among airlines by requiring all airlines to participate in a fuel-based emissions trading scheme but differentiates among countries by earmarking some of the revenues generated for projects in developing countries. The Association of European Airlines (AEA) made a Global Approach Proposal (GAP) segmenting countries into three blocks according to maturity of their aviation markets with different emission reduction targets. Under the AEA GAP approach, for all traffic between two blocks, the lowest target will be applied to all airlines regardless of nationality.[xxvii] In conclusion, one of the main challenges for the development of a coherent and effective aviation climate change policy framework is a non-existent overall global climate change policy framework. This void leads to insecurity on national levels.

Overall, to ensure policies are effective in reaching their objectives, it is critical that policy-makers evaluate what types of policies (e.g. incentives versus disincentives for supply versus demand side) are most effective in the respective situation. Policies that are introduced have to be in line with the respective stage of technological development. For example, for new technology development for airframes and engines and second-generation aviation biofuels, policies have to be introduced that support the early development stages of those technologies, otherwise policies will have a very limited effect or no effect at all in moving the aviation sector towards the desired outcome of further reducing emissions.

7.2 Partnership Options

Different types of partnerships could be leveraged to drive the aviation industry decarbonization efforts. They fall into the following categories.

Intra-industry partnerships. These are partnerships between different aviation players (e.g. airlines, manufacturers) mostly with the objective to reduce costs and risk, for example, by sharing the R&D, manufacturing and distribution among the different partners and gaining advantages of scale. At the same time, they could also further increase access to new innovative technologies, manufacturing experience, or R&D resources and/or assist the partners in gaining a better market position, for example, through increased credibility or increased speed to market.

Crossmodal partnerships. These are partnerships with players from different modes of transport (e.g. automotive, maritime shipping). These partnerships are best to enable the sharing of knowledge and reduce risk and cost for R&D of technologies that could be used in different areas (e.g. lightweight materials, biofuels). Crossmodal discussion or collaboration would also be beneficial on the government side, where different types of ministries (e.g. aviation, energy, road transport, development) should collaborate to define a holistic framework for the development of the transportation sector, which would help ensure a level playing field between different modes of transport and beyond. Some hurdles for crossmodal partnerships lie in different needs of specific modes of transport (e.g. biofuels for aviation with different specifications than biofuels for road transport), but, still, commonalities should be leveraged.

Vertical partnerships. These are partnerships occurring along the value chain that seem especially promising on the biofuel side where airlines, energy, chemicals and biofuel companies, distributors, and stakeholders from the agricultural sector should work together. Collaboration with multinational players is critical, especially to secure large amounts of project capital or with technical innovation niche players to obtain access to the newest second-generation biofuel technology. Partnerships with bio-refineries can mitigate risk through different possible output products.

Public-private partnerships (PPPs). These partnerships between players from the private sector and government seem promising, especially in the field of infrastructure improvements and implementation. Airport operators, Air Navigation Service Providers (ANSP), technology providers and the public sector working together can increase speed of implementation, access to technical expertise and skills, and access to public funding.

Partnerships with the financial community. These partnerships can lead to specific financing projects set up to advance the implementation of specific climate change prevention measures. Development banks, for example, could be engaged to set up a specific green fund that could also be leveraged by aviation or to fund biofuel projects, which was rarely the case with past funds. Engaging development banks has the advantage that these institutions have longer time horizons and require lower returns than capital market investors and might be willing to take somewhat higher risks than commercial banks, if projects are related to the development agenda (e.g. airport infrastructure improvements or biofuel development in developing countries).

7.3 Financing Options

Supply-side as well as demand-side financing options have to be considered. Supply-side financing includes the financing of the initial cost of development of different new technologies, financing of large-scale manufacturing, and distribution. Demand-side financing includes financing of the initial acquisition of the new technology products (e.g. a new type of more efficient aircraft and new more expensive biofuels).

Different financing options are more effective at different stages of technology development (see Figure 9) because of different risk levels, time horizons and interests of the respective stakeholders.

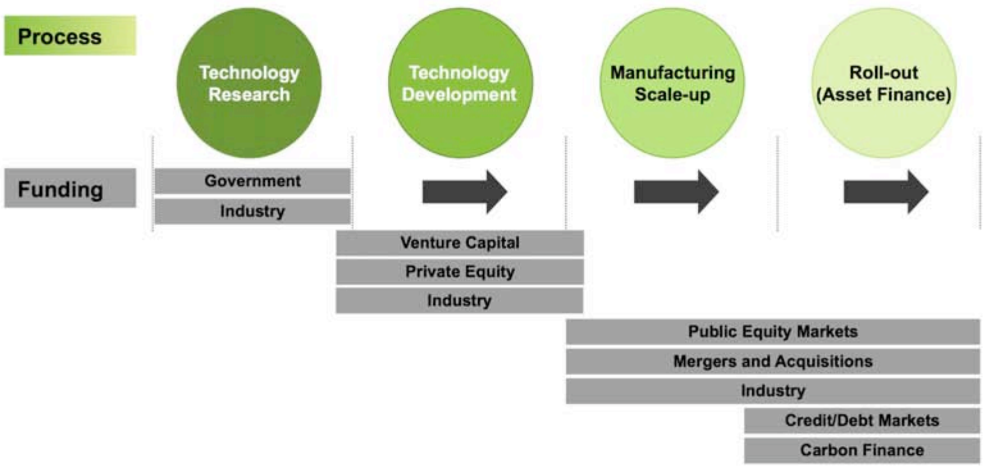
Sources of financing in the early technology research stage are government and industry funding. In the phase of technology development, optimally venture capital, private equity and industry funding can be leveraged. During the manufacturing scale-up phase, public equity markets and additional industry funding (e.g. also through mergers and acquisitions in cases were smaller players are bought up by larger financially stronger players from within the industry or even from other industries) become available. Finally, in the technology roll-out phase credit and debt financing and carbon finance options represent additional funding options.

An innovative approach to financing early-stage new technology developments in aviation could be the development of a producers' risk fund to which aviation industry players contribute funds that are then invested in new technology (aircraft technology, aviation biofuel) projects. This would allow the industry stakeholders to share risk in early development stages.

The donor community could also be involved as an additional financing option in the earlier stages of development (e.g. Rockefeller Foundation, Bill & Melinda Gates Foundation).

Multilateral development banks (MDBs) should be engaged more by the aviation industry in developing countries. So far, MDBs have been engaged in financing aviation-related projects mainly focused on building airports and, to some extent, air-traffic control infrastructure in developing countries. More recently, MDBs have engaged in financing climate change – related projects through specific funds. However, such funds have not yet been widely used for aviation-related projects, but mainly for projects in the areas of energy efficiency (see Figure 10). The project has found that

Figure 9: Financing Options by Stage of Development[xxviii]



Source: Bloomberg New Energy Finance with UNEP and SEFI, "Global Trends in Sustainable Energy Investment 2010", World Economic Forum/Booz & Company analysis

WORLD ECONOMIC FORUM

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Figure 10: Examples of Climate Change Engagement of MDBs

Climate Investment Funds

- Collaboration of countries and multilateral development banks (e.g. African Development Bank, Asia Development Bank, World Bank)
- Pair of financing instruments designed to support low-carbon and climate-resilient development
- Comprises two trust funds with specific scope and objective
  - Clean Technology Fund for investments in clean technologies
  - Strategic Climate Fund for specific climate change challenges (e.g. deforestation)
- Amount pledged by 13 countries: US$ 6.1 billion

World Bank – Green Bond

- AAA-rated bond by World Bank launched in 2008
- Aims to stimulate and coordinate public and private sector activity combating climate change
- Issuance of more than US$ 1.5 billion in green bonds since 2008
- Raised funds go to projects selected by World Bank that seek to mitigate climate change or help affected people adapt to it
- Examples of mitigation projects:
  - Greater efficiency in transportation, including fuel switching and mass transport
  - Funding for new technologies that results in significant reductions in greenhouse gas emissions

SECCI

- Sustainable Energy and Climate Change Initiative (SECCI) by the Inter-American Development Bank
- Aims to provide comprehensive sustainability options in areas related to the energy, transportation, water and environmental sectors
- Initiative consists of four strategic pillars:
  - Renewable Energy and Energy Efficiency
  - Sustainable Biofuel Development
  - Access to Carbon Markets
  - Adaptation to Climate Change
- Funded by IDB, Spain, Germany, Italy, Finland, United Kingdom and Japan

Source: The World Bank, IADB, CIF, World Economic Forum/Booz & Company analysis

there exists a very interesting opportunity to engage MDBs in discussions with the aviation sector for the increased financing of green aviation infrastructure (e.g. airports, ATMs) as well as biofuel development. However, some consideration may need to be given to potential negative competitive effects on airlines from developed countries if they do not have access to such programmes while their direct competitors do.

7.4 Information and Education Options

Another opportunity to speed up implementation of CO_2 abatement levers in aviation exists from a perspective of increased information sharing and education.

Within the aviation industry, it has to be ensured that all carriers, including those in developing countries, understand what the best practices (e.g. in regard to aircraft operations) and the latest technologies are (e.g. increase understanding of potential of biofuels, CO_2 reduction potential of new aircraft types) and how they can make use of them. Currently, IATA Green Team and ICAO Circulars are engaging in this process to share information between carriers. Similar efforts need to be carried out for airport operators and ANSPs.

Outside of the aviation industry, it is critical that the aviation industry continues to educate policy-makers on the challenges and the needs of the industry and work collaboratively with governments on developing the most appropriate policies that help the industry to become more CO_2 efficient. The sense of urgency of implementation of such policies has to be stressed. Policy-makers should be engaged at the secretary level as well as the mid policy-maker level.

Information and education campaigns for stakeholders from other industries, i.e. energy, chemicals, and biofuels, should also be carried out by the aviation sector to continuously raise awareness of the opportunities for biofuels for aviation. **Other modes of transport** should be included in these information and education campaigns, as this can help structure more coherent policy frameworks for the entire transportation sector.

The aviation sector should also consider developing educational/information campaigns targeted at the travelling public. These campaigns should focus on raising the awareness of the CO_2 challenge faced by the aviation sector and highlight the opportunities that the sector has. Airport club lounges and flights, for example, could provide a good opportunity to disseminate promotional material and other types of communications. For example, with higher awareness, passengers today could already make a conscious choice of offsetting flight emissions through voluntary offsetting programmes offered by a number of airlines or carry fewer bags and/or less weight when they fly.

8. Road Map for Sustainable Aviation Growth

For the four most promising carbon abatement levers identified in Sections 4 and 5 – aviation infrastructure improvements, additional research for radical new aircraft technology, aviation biofuels, and market-based measures – the project specifically discussed the most critical implementation challenges and identified the most promising policy options as well as innovative approaches for partnerships, financing, and information and education. In a survey, 30 senior industry and academic experts as well as senior representatives from international organizations and industry associations highlighted where they see the key challenges and the most promising measures to support the implementation of the four key CO_2 abatement levers. The results show that a number of concrete leadership opportunities exist, and the different impacts and time scales of the abatement options must be considered. The following sections give a detailed overview of the survey results and the outcomes of the multistakeholder discussion held at different project meetings for each of the four key CO_2 abatement levers.

8.1 Aviation Infrastructure

Aviation infrastructure investments are critical to maintaining or improving today's high levels of operational efficiency, considering the expected air traffic growth. From an international aviation emission perspective, the focus of aviation infrastructure improvements is on the introduction of new ATM systems and processes. Airport infrastructure emissions are not addressed, as they are accounted for within national targets of the UNFCCC negotiations. However, from a country perspective, it is important to highlight that both ATM modernization and improvement of existing airport infrastructure and the development of new greenfield airports must be considered.

In the survey conducted, the following **challenges** are considered most critical:

- Insufficient political will to speed up decision-making and implementation
- Regional and national issues with ATM ground infrastructure and existing constraining policies
- Insufficient information and education of policy-makers and the public on ATM challenges and necessary improvement measures

Other challenges identified are:

- Lack of global ATM metrics and targets
- Existing airspace organization (airspace reserved for military versus commercial use)
- Lack of access to new ATM technologies and financing
- Insufficient airport capacity and the need for new airports, runways and inclusion of cargo in airport planning
- Lack of a holistic transport policy across different transport modes
- Optimization of the synchronization between all stakeholders with agreed-upon road maps at the regional level and coordination between regions

The **key measures** seen as most promising to overcome those challenges are related to **information, education, and policy**. In particular, respondents highlighted the need for:

- Additional information and education of policy-makers, airport operators, ANSPs, pilots and the public on existing infrastructure challenges, the potential of new ATM technologies, and best practices; particularly on the government side, additional information is critical to increase the political will to overcome national boundaries and to organize ATM on a supranational level to improve traffic flow
- Legal incentives that include policies that give clarity and reduce risk for private investment in infrastructure improvements; such policies could be, for example, a multimodal transport road map or improved foreign direct investment (FDI) policies
- The establishment of standards, such as a global ATM standard, or standards for the interoperability of aircraft ATM equipment, and global or regional standards for airport infrastructure

Other measures still considered to have a large potential to drive infrastructure improvement implementation are fiscal incentives and tax breaks for private sector investment and for carriers to invest in ATM equipment for new and in-service aircraft. Governments should consider incentives to give priority access to aircraft with more modern ATM equipment and minimizing ATM delay impact on airports with more sophisticated infrastructure.

Funding will need to come from governments, at least initially. However, as governments will unlikely be able to provide all the required funds, priority has to be put on involving capital markets and private equity (PE) players as soon as possible. MDBs can play a major role in developing countries, e.g. through the establishment of specific green funds. MDBs already finance airport infrastructure to some extent today, but specific green funds like those established by the World Bank in the past have not yet been used to finance aviation projects.

On the **partnership** side, more PPPs should be established for new airport development, infrastructure improvements, the implementation of new ATM technologies and partnerships with the financial community (e.g. special programmes set up for aviation by development banks).

Infrastructure improvements are especially important in developing countries to ensure that these countries are able to experience positive economic returns provided through the growth in trade, tourism and service that efficient ground air-transport infrastructure and air-navigation services can bring. An example of a successful initiative is the Egyptian government's NAVISAT initiative that has the objective to provide satellite-based ATM services for Africa and the Middle East and that was initially financed with the help of the African Development Bank (AfDB).

8.2 Additional R&D for New Aircraft Technologies

Additional focus by both manufacturers and policy-makers is needed on R&D of radical technologies, such as a blended wing body aircraft or open-rotor engine. Once they are more mature, these new technologies could help to improve fuel efficiency and, thereby, CO_2 efficiency of future generations of new aircraft, which in turn could significantly influence the industry's long-term CO_2 footprint.

The largest **challenges** identified in regard to incremental aircraft and engine R&D are:

- A lack of existing policies to support and incentivize research and technology for new radical aircraft technologies
- The long lead times for new aircraft technology development (up to 10 to 20 years from early R&D to commercialization in new aircraft types)
- That the further development of conventional aircraft technology will only allow for gradual improvement of aircraft fuel efficiency in the future (likely not beyond 1.5% improvement per year due to the high degree of maturity of existing technology); therefore, radical new aircraft technology is required to achieve higher efficiency improvements in the future
- The current lack of investment for scaling and commercialization of new radical technologies due to their high technological risk and uncertainty

Other challenges identified include differing stakeholder interests, such as the immediate interests of manufacturers not always being aligned with those of the airlines due to the high sunk costs for the development of a certain aircraft generation and the potential misalignment of development road maps. Also additional infrastructure modifications at airports might have to be implemented for the operation of more radically new aircraft.

To address these challenges, **policy measures, information and education** are seen as most effective. In particular, the following areas have been identified:

- Financial incentives such as tax breaks for research and technology would be necessary to incentivize manufacturers and academia to invest more in R&D, especially for radical new technologies.
- Legal incentives could give more policy clarity and reduce risk of investment; examples of legal incentives that could be implemented are government loan guarantees or efficiency standards.
- Education of policy-makers is critical to increase the sense of urgency for new policies in the aviation R&D sphere.

Also discussed as important was the introduction of standards such as the CO_2 standard currently under development by ICAO's Committee on Aviation Environmental Protection (CAEP), or a labelling standard to increase transparency for customers as an incentive to invest in R&D and new technology. However, in regard to standards, it must be considered that, due to changing flight conditions (e.g. environmental conditions, load factors), emissions and CO_2 efficiency of any given flight can differ.

As to **partnerships**, the industry is already extensively partnering on R&D initiatives. However, opportunities exist for manufacturers to increase their collaboration with players in other industries, to share risk, and to leverage benefits from exchange of technology (e.g. lightweight materials developed for aviation could be leveraged to help decarbonize road transport).

Government **funding** is seen as the most important source of new incremental investment, followed by increased investment from the industry and financial system. One proposal considered was the development of special recognized research funds supported by the airline operators, for example in exchange for free carbon credits under an ETS (see Section 7.4). Capital market funding and funding from commercial banks should be increased but are not yet likely to be available at the current early technological development phase.

Additional research conducted, besides the expert survey, shows challenges and proposed policy options for aircraft technology by stage of development (see Figure 11)

Figure 11: Aircraft Technology Policies by Stage of Development

Process	Technology Research	Technology Development	Manufacturing Scale-up	Roll-out (Asset Finance)
Policy Challenges	• Increase the volume of early-stage research • Improve the flow of funding to promising research • Transfer academic research into commercial environment • Don't write off promising technologies too early	• Identify scalable, lab-proven technologies • Increase availability of equity • Provide soft debt where it is required for equity to achieve target returns • Establish clear performance milestones • Avoid chasing fads • Don't try to pick winners, but cull losers aggressively	• Develop a replicable blueprint for large volume roll-out • Provide support to close cost gap with mature technologies • Ensure availability of debt despite technology, market and policy risk • Support/create lead customers	• Protect public budgets • Avoid locking in uncompetitive market structures • Shift emphasis to "polluter pays" rather than maintaining subsidies forever
Policies To Address Challenges				
Fiscal Incentives	• R&D tax credits • Capital gains tax waivers	• Development zones (e.g. demonstration prototypes)	• Accelerated depreciation • Investment tax credits • Production tax credits	• Carbon tax
Standard/ Regulation			• Green certificates • Technology standards for a/c	• Best available technology requirement for new a/c
Aviation ETS		• Price on carbon as basis to attract (external) investment • Free EST allowances in return for R&D investment	• Price on carbon as basis to attract (external) investment	• Use of proceeds from ETS to support asset purchases
Capital Market Incentives	• Incubators • National laboratories • Prizes • National/State-funded VC • R&D grants	• Project grants • Mezzanine/Subordinated debt funds • Venture loan guarantees	• Green bonds • Loan softening/Loan guarantees • Senior debt funds	• Technology transfer funds

8.3 Aviation Biofuels

As discussed in Section 4, biofuels have a large CO_2 abatement potential within the aviation industry and can, therefore, be considered a technological game changer for the aviation industry. Research and test flights conducted in recent years (e.g. Air New Zealand test flight in 2008, Continental and Japan Airlines test flights in 2009, TAM Airlines in 2010) have proven that even the current in-service fleet, without any engine or aircraft modification, could fly on biofuels of a defined technical specification. Test flights have been conducted with 50% blends of biofuels with regular jet fuel. In the long term, it is expected that aircraft could fly on up to 100% biofuel. Different technology routes for the production of aviation biofuels exist. FT (Fischer-Tropsch) alternative fuels have already been qualified for 50% use in aviation in 2009, HRJ (Hydrotreated Renewable Jet) specification is expected in early 2011, and FRJ (Fermentation Renewable Jet) specification options are being evaluated.

However, the cost of the biomass feedstocks and processing to produce second-generation ("drop-in") biofuels (e.g. from forestry waste, agro waste, energy crops such as jatropha, salicornia and algae) is still significantly higher than for conventional jet fuel. The required investment in R&D for sustainable second-generation biofuels and the follow-on commercialization of these new manufacturing technologies is substantial and has been estimated by different sources in the hundreds of billions of US dollars (see the Executive Summary). At the same time, there will likely be intense competition for both the sustainable biomass resources and scarce R&D funding between the different modes of transportation (e.g. renewable diesel for ground transport) and with the chemicals industries (e.g. renewable polymers) where the risks, costs and margins for the renewable products will very likely be more attractive. The energy and chemicals industries have few incentives to invest in the aviation biofuels niche market if other less risky and volatile or higher margin options exist for the use of biomass.

As such, the **challenges** considered as most likely to reduce incentives for the scaling of aviation biofuels are:

- Current lack of large-scale investments for R&D and maturing of biofuel technology, scale-up of manufacturing and wider supranational supply chain management; current lack of government, industry and capital market funding [support for R&D and scaling provided by the US government through Air Force biofuel programmes and through

US Commercial Aviation Alternative Fuels Initiative (CAAFI) cosponsored by the Aerospace Industries Association (AIA), Airports Council International – North America (ACI-NA), the Air Transport Association of America (ATA), and the Federal Aviation Administration (FAA); European Sustainable Way for Alternative Fuels and Energy for Aviation (SWAFEA) efforts still much smaller]
- Market failures due to the uncertainty around policy, the legal system and incentives
- Lack of sustainable feedstock availability, especially of appropriate sustainable second-generation type (e.g. algae, energy crops, forestry waste) and scalability of sustainable second-generation drop-in biofuels (the aviation industry's 2050 goal alone would require seven times today's total global amount of first-generation biofuels but of a sustainable second-generation type)

Other major challenges are:

- The lack of global standards for biofuels, such as a sustainability standard based on life-cycle emissions or a decarbonization standard that regulates how biofuels are considered under an ETS (e.g. zero-emissions versus life-cycle emissions)
- Competition with other modes of transportation to secure aviation's fair share of biofuels in the future is seen as a challenge (e.g. competition with renewable drop-in diesel for ground transport); however, co-production with diesel may provide a route to earlier adoption by refineries, if higher overall yields and cost advantages can be achieved
- On the government side, the perceived insufficient collaboration between ministries (e.g. aviation, land transport, energy, agriculture, development) to ensure biofuel policies are developed based on a holistic view
- Long timelines for the scale-up of manufacturing facilities and distribution infrastructure; for the latter, the challenge could be partly overcome through percentage drop-in rates and use of the existing infrastructure

To ensure access and availability of aviation biofuels, the following policy, partnership, financing, and information and education measures have been identified as most important to introduce:

Policies
- Fiscal incentives for supply chain members (farmers, refineries, distributors) to engage in R&D; demonstration scale and commercial production; fiscal incentives for airlines to buy and use biofuels; and incentives to foster capital market investment (e.g. governments could introduce a supportive pricing policy that makes investment by commercial producers and technology pioneers attractive)
- The development of global standards, including sustainability standards for biofuels based on life-cycle emissions, standards that govern the consideration of biofuels in emissions trading, standards for emissions monitoring and reporting, drop-in fuel standards and specifications (as currently under development by ICAO), or labelling standards that would allow airlines to position themselves as environmentally conscious if they use biofuels
- Legal incentives, such as the introduction of policies that establish a level playing field for all modes of transport in their competition for biofuels (e.g. governments and ministries of aviation setting up blending mandates for aviation fuels); blending mandate targets should be implemented in a phase-wise manner

Partnerships
Vertical partnerships along the entire value chain of biofuel production, refinement and usage should be developed further. Stakeholders to be involved are airlines, energy, chemicals, biofuel producers, agriculture players, and distributors. Successful partnership models discussed in the project were in particular innovative vertical models in developing countries that involve stakeholders along the entire value chain from government land owners to technology providers, farmers engaged through a village franchise system, and major oil and gas companies and distributors, and taking local peculiarities into account (e.g. unique concepts of Nandan Biomatrix in India, see India Deep Dive in Appendix).

Funding
Significant government funding (directly or through loan guarantees) is required, especially in the current early high-risk stage of R&D and scale up (especially also if an ETS is introduced, the funds raised from potential auctioning of carbon credits or funds raised through green levies should be reinvested here).
The financial community, such as MDBs, should follow in earlier stages; capital markets [carbon finance community, PE and venture capital (VC)] and commercial bank credit and debt financing would have to follow in later stages. MDBs are likely to be the next investors after governments, as aviation biofuels can be promoted also from a developmental agenda perspective if larger-scale projects are set up in developing countries.

Other funding measures still considered to be valuable to implement include industry-side financing, such as through innovative new financing ideas like a producers' risk fund. Depending on how such a fund is set up, the industry can contribute to the fund, which can invest in biofuel projects, thereby reducing the risk for any single producer in the early development and scaling stage. Early commercialization of aviation biofuels is crucial to be able to rapidly drive down the cost curve and achieve prices that will be acceptable to the aviation industry. Intra-industry and crossmodal partnerships also should be leveraged further. Existing industry partnerships on aviation biofuels are the Sustainable Aviation Fuel Users Group (SAFUG), including members such as Air France, British Airways and Lufthansa, and affiliate members such as Airbus, Boeing, Embraer and UOP (Honeywell), or the Brazilian Aviation Biofuels Alliance ABRABA.

For **information and education opportunities**, more emphasis should be put on informing governments at the secretary level as well as the mid-level policy-maker level on the potential of sustainable biofuels for aviation and the new policies required. Simultaneously, the aviation industry must engage more with the potential biofuel producers from energy, chemicals and agriculture to inform and educate on the market potential of aviation biofuels and partnership opportunities. The public should be made aware of the advantages of sustainable second-generation biofuels to overcome reservations that might exist due to land use problems and competition with food production with traditional first-generation biofuels. Leading institutions should conduct sustainability studies in partnership with proponents to leverage their expertise for analysis. Media and not-for-profit organizations should be sensitized for the topic to increase the spread of information and awareness inside and outside of the aviation industry. Successful test results and demonstrations of biofuel-powered flights should be shared and publicized intensively to improve awareness and inspire.

Levies and/or taxes on current jet fuel or CO_2 emissions are seen as least promising for the scale-up of aviation biofuels, as they withdraw money from the industry without any direct impact on investment into biofuels or CO_2 emission reduction in general and do not give direct positive incentives to potential biofuel producers. As long as the biofuels are not available on a large scale, carriers do not have an alternative to buy more CO_2-efficient fuels and thus have only the choice to pay the tax.

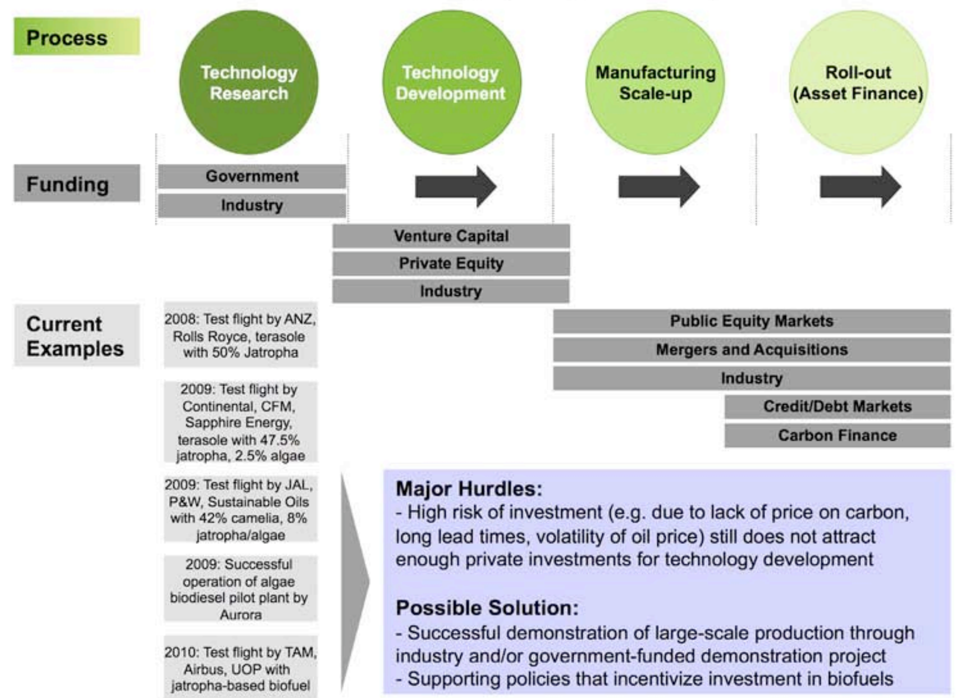
Research in addition to the expert survey shows challenges and proposed policy options for aviation biofuels by stage of development (see Figure 12).

Figure 12: Biofuel Policies by Stage of Development

Process	Technology Research	Technology Development	Manufacturing Scale-up	Roll-out (Asset Finance)
Policy Challenges	• Increase volume of R&D • Improve flow of funding to promising R&D • Transfer academic research into commercial environment • Do not write off promising technologies too early	• Identify scalable, lab-proven technologies • Increase availability of equity • Establish performance milestones • Do not try to pick winners, but cull losers aggressively	• Develop replicable blueprint for large volume roll-out • Support closing of cost gap with mature technologies • Ensure availability of debt despite high risk • Support lead customers	• Ensure energy diversity (support higher cost techn.) • Protect public budgets • Avoid locking in uncompetitive market structures • Shift emphasis to "polluter pays"; do not maintain subsidies in long term
Policy Options				
Fiscal Incentives	• R&D tax credits • Capital gains tax waivers	• Development zones (e.g. demonstration plants)	• Accelerated depreciation • Investment tax credits • Production tax credits	• Carbon tax
Standard/ Regulation			• Drop-in rate • Green certificates • Renewable fuel standards	• Best available technology requirement
Aviation ETS		• Price on carbon as basis to attract (external) investment	• Price on carbon as basis to attract (external) investment	• Carbon cap and trade • Credits for biofuels
Capital Market Incentives	• R&D grants • Incubators, competitions • National laboratories • Natl/State-funded VC	• Project grants • Mezzanine/Subordinated debt funds • Venture loan guarantees	• Green bonds • Loan softening/Loan guarantees • Senior debt funds	• Technology transfer funds • Infrastructure funds • Policy risk insurance

Source: World Economic Forum - "Green Investing 2010", World Economic Forum Booz & Company analysis

Figure 13: Biofuel Financing by Stage of Development

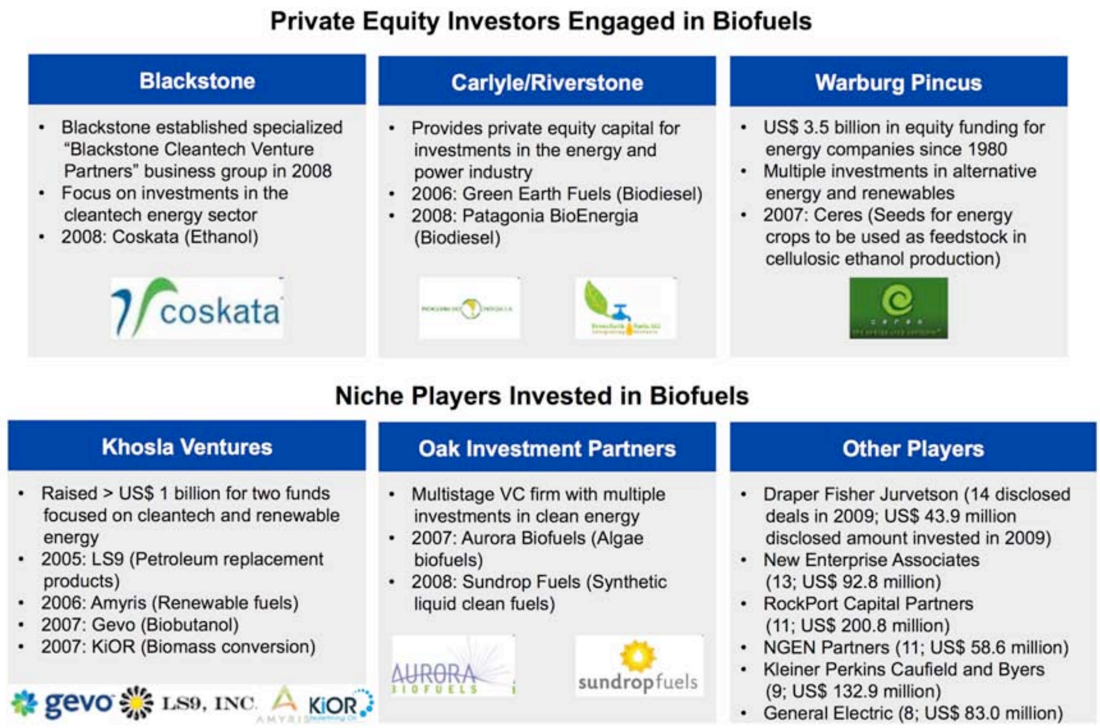


Source: Bloomberg New Energy Finance with UNEP and SEFI, "Global Trends in Sustainable Energy Investment 2010", Boeing, Airbus, Biodiesel Magazine

Financing options (see Figure 13) also depend highly on stage of technology development due to the different investment horizons, expected returns and risks the different types of investors are expecting.

At the current stage, private equity investors are tapping into biofuels, but investments are mainly coming from niche players (see Figure 14).

Figure 14: Examples of PE Investors Engaging in Biofuels



Source: Company information; Bloomberg New Energy Finance, World Economic Forum/Booz & Company analysis

Biofuel development opportunities should also be evaluated from a developmental agenda perspective, and opportunities should be explored, especially in developing countries such as India and China and in African countries where a large availability of unutilized degraded and marginal land and labour resources exist, supplemented by a suitable agroclimate. Private sector developers need to take leadership initiatives and develop exemplary business models for guidance and evolution of a sustainable advanced biofuel industry. Leveraging private sector capabilities, by way of public-private partnership, joint research and development programmes, can bring mutual benefits to the players and beyond.

In recent months, the topic of aviation biofuels has obtained significant attention – for example, in February 2011, a conference was held to outline the results of the two-year feasibility and impact assessment of the SWAFEA study initiated by the European Commission on alternative aviation fuels. A large scale-up of biofuels was confirmed as a required contribution to the 2020-2050 industry and ICAO emission targets. To overcome the aviation biofuel deployment challenges, a number of policy instruments were evaluated to incentivize advanced biofuel development and levelling the playing field for aviation and ground transportation fuels, as well as, for example, the setting up of a European "network of excellence" to bring together technical expertise and provide an integrated approach to alternative aviation fuels.[xxix]

It has to be noted that rapid progress is being made in the biofuel R&D programmes and the industry expects to see more initiatives and potentially several commercial-scale plants to be built in 2011 for second-generation biofuels based on micro algae.

On the carrier side, Lufthansa announced in November 2010 that, pending biofuel certification, the company will begin in 2011 a six-month trial of a weekly scheduled flight of an Airbus A321 from Hamburg to Frankfurt with one of the engines using a 50:50 mix of biofuel and traditional jet fuel.[xxx]

8.4 Market-based Measures (Emissions Trading, Offsetting)

Emission reductions in other sectors, through measures such as ETSs or project offsetting, may be an economically efficient option for the aviation industry to meet CO_2 targets, as long as CO_2 abatement is possible at a lower cost in other sectors and such schemes are set up correctly. The key role of MBMs should be to facilitate the implementation of cost-effective reduction measures within the aviation industry and, via offsetting in other sectors, provide a way to cover any shortfall in emission reductions not achieved via other industry measures. MBMs become counterproductive when paying for emissions credits from other sectors reaches a level that threatens aviation's ability to invest in measures for abatement within the sector. It also can provide an option for emission reduction in the interim until other emission abatement levers are available on a larger scale within the industry (e.g. aviation biofuels). MBMs can help not only to reduce future growth of emissions but also to deliver CO_2 reductions compared to today's aviation emission levels in other sectors.

An MBM policy that includes ETS and offsetting opportunities is, on the one hand, seen as a major option to reduce risk and uncertainty and thus attract more capital market investment into the discussed abatement areas (e.g. aircraft R&D and biofuels). On the other hand, an MBM scheme that extracts money from the industry could lead to lower investments in new aircraft technology and other CO_2 abatement initiatives by industry players due to financial constraints. An MBM scheme might also be taken as an excuse not to invest in CO_2 emission reduction within aviation, thereby neglecting the negative long-term effect on the carbon footprint of the aviation industry. To overcome this dilemma, if an ETS is put in place, it has to be ensured that governments still invest in aviation infrastructure (especially ATM) improvements and that industry players are incentivized to invest in emission reduction within the industry. In addition, in the development of the ETS, it is critical that the scheme is targeted at incentivizing the best investment, including the fuel/engine/airframe manufacturer. An ETS solely targeted at simply drawing airlines funds would miss the intention.

Current perception and opinion about MBMs for aviation differ among stakeholders from different regions. In Europe, with EU ETS having been in place for national emissions and the inclusion of international aviation in EU ETS from 2012, stakeholders have accommodated the idea that an ETS can help achieve ambitious emission reduction targets. Concerns are mainly seen in countries introducing separate taxes on aviation, which leads to competitive distortion and potentially double counting if they are not removed when ETS is implemented. On the other hand, in regions in which no or few regulatory mandates exist for carbon emission reduction, the introduction of MBMs is seen as much more critical. In large countries, such as the United States, it also has to be considered that a large proportion of air traffic is domestic and thus also a larger portion of aviation CO_2 emissions may have to be dealt with in the UNFCCC negotiation on national emission targets rather than under ICAO.

In the overall project survey, the following challenges were rated as most critical for the development of an MBM approach:

- A global ETS scheme is needed to avoid a patchwork of regional schemes and competitive distortion, but a global scheme is hard to negotiate and implement, and nothing similar has been created. Current UNFCCC discussion addresses only national aviation, not international aviation. The ICAO 37th Assembly resolution mandates the council with the support of member states to undertake work to develop a framework for MBM in international aviation (see Paragraph 13) and proposes a feasibility study of a global MBM scheme by the council with the support of member states and international organizations (see Paragraph 18). Ideally, despite the difficulty in implementation, both international and national aviation should be included in a global scheme to avoid operating in different systems.
- Emissions must be counted only once and no double counting should occur.
- There is a risk that, with money flowing out of the aviation industry without any CO_2 efficiency gains within aviation, the long-term effect on aviation is not considered.

Other challenges include:

The need for an aviation-specific ETS scheme that allows for trading with other sectors
The risk of carbon leakage, competitive distortion, and legal conflicts[xxxii] with existing agreements, including the Chicago Convention, if only some flights fall into national or regional schemes
The uncertainty surrounding the use of funds generated through an ETS (e.g. through auctioning of credits or penalties); currently, most schemes foresee the use of funds by national treasuries with no direct link to environmental projects or a specific industry
The lack of availability of offset projects that are open to aviation (e.g. Kyoto CDM or JI projects currently not available for international aviation) and the perceived lack of transparency of offset projects in general

From the survey, it appears that the **most critical measures** proposed if an MBM approach should be implemented for aviation are:

- Development of a global overall ETS scheme
- Development of a global aviation-specific ETS scheme that allows for trading with other sectors (as is currently under consideration in ICAO)

Further measures on the **policy** side are that it has to be ensured that credits from project offsetting are recognized under aviation ETS schemes (e.g. making CDM, JI and REDD projects available to aviation) and the issuance of carbon credits to early movers who voluntarily invest in new technology or broader CO_2 emission reduction initiatives within the industry. Policy should further ensure that all or at least a portion of the funds raised from aviation under an ETS (e.g. from auctioning of credits or penalties) is earmarked to be reinvested for CO_2 emission reduction within aviation.

On the **information and education side**, continued efforts should be made by the industry and its associations, building on the vast work conducted by IATA, to educate and inform policy-makers to increase awareness and ensure that policy-makers understand the benefits of recognizing voluntary emission reduction investments of the industry, such as through free carbon credits. Customers should be educated more on voluntary offsetting opportunities. As for partnership efforts, the project partners consider collaboration with the carbon finance and carbon market community and with developing countries and MDBs important. The latter could help to increase availability and transparency of offsetting projects and thereby support the developmental agenda and help to obtain buy-in from stakeholders from developing countries.

Partnerships should be established with entities from the carbon finance community [e.g. Carbon Markets and Investors Association (CMIA)] or with development banks that support the establishment of carbon offset projects in developing countries.

Other market mechanisms as potential alternatives to an ETS could also be considered. For example, a carbon contract as proposed by Dieter Helm and Cameron Hepburn[xxxiii], under which the government would auction off carbon contracts for the supply of emission reductions over a long-term horizon that provides a forward revenue stream with long-term price certainty and that could be used to secure project finance, could be discussed for the aviation sector.

9. Conclusion

To allow the aviation industry to accommodate growing traffic demand and at the same time reach its ambitious CO_2 goals through 2050, significant additional effort is required in a number of fields that have the potential to further reduce aviation's carbon footprint. As previously discussed, the most promising levers are infrastructure improvements, additional aircraft R&D, aviation biofuels and market-based measures for emissions trading or offsetting. In each area, a number of challenges and opportunities to overcome those challenges exist – mainly in the areas of policy, partnerships, financing, information and education. Significant leadership opportunities need to be taken by the industry to ensure it can grow and still reach its CO_2 targets.

Overall positive incentives (e.g. fiscal) are seen as having more potential to increase investment in reducing carbon in the aviation industry. Green levies and taxes, as are currently in implementation or discussion in a number of countries, are not seen as viable options to achieve the industry's CO_2 reduction targets. If not set up well, levies and market mechanisms take money out of the industry without significant emission reduction effect if the money raised is not reinvested in CO_2 emission reduction projects and the industry has fewer funds available to invest in emission reduction measures. Only a limited indirect effect on emission reduction is likely to occur with such measures through the cost increase of air travel if carriers pass costs on to customers and the likely slight air traffic decrease. In addition, the potential negative macroeconomic effect of more expensive and thus reduced air travel on GDP and economic development must be considered (see Section 1).

The findings from the project multistakeholder discussion and survey are in line with those of other studies, such as the recent Norton Rose study, "The Way Ahead – Transport Survey 2010", in which incentives are ranked as most likely and fines and penalties are seen as least likely to trigger sustained investment in green technologies in all transport sectors including aviation.

The industry needs to take an active leadership role to achieve its targets through the implementation of CO_2 reduction levers previously discussed. Possible leadership opportunities include:

- **Aviation infrastructure** – Provide information and education of policy-makers on criticality and urgency of implementing aviation infrastructure improvements on the ATM and airport level
- **Additional aircraft R&D** – Work with policy-makers to develop financial and legal incentives to increase investment in incremental R&D for radical new aircraft technologies
- **Aviation biofuels** – Work with policy-makers to develop financial incentives, legal incentives and standards and to drive vertical partnerships with stakeholders along the entire biofuel value chain
- **Market-based measures** – Actively engage and support governments working with ICAO in the development of a global sectoral MBM approach for aviation through partnerships with experts from the carbon finance community and ensure that any measures that are developed focus on incentivizing the parties best placed to make the CO_2 abatement investment

At the same time, the industry must further collaborate in currently ongoing policy discussions. In the context of UNFCCC deferring emissions from international aviation to ICAO in the COP15 negotiations in 2009 and the COP16 negotiations in Cancun in December 2010, the industry has the opportunity to work together with ICAO to further shape and influence how emissions should be reduced in aviation. In particular, the industry should engage further in the following discussions:

- Inclusion of international flights from and to the EU under EU ETS from 2012 and proposal of adjustments to ultimately get to a worldwide consistent ETS scheme
- The recent ICAO 37th Assembly resolution on climate change agreed on emissions targets, though legally nonbinding, of a 2% average fuel efficiency improvement per year until 2020 and aspirational targets of a 2% average annual fuel efficiency improvement until 2050 and considering carbon neutral growth from 2020; a number of states filed reservations, especially with regard to the proposed de minimis rule that defines a threshold of 1% of global traffic (22 states above threshold, 168 states below threshold) for development of national action plans to reduce aviation CO_2 emissions and that is now also considered for MBMs
- The report of the UNFCCC Advisory Group on Climate Change Financing released in November 2010,[xxxiv] which proposed different options on how international aviation could contribute a portion to the agreed-upon US$ 100 billion of additional funding per year by 2020 from developed countries to support mitigation and adaptation activities in developing countries; options proposed for aviation are either an MBM approach or taxes, such as a levy on jet fuel or on passenger tickets of international flights

The Forum hopes this report, in recognizing the potential of multistakeholder dialogue, will lead industry and government stakeholders to engage in a wider discussion among themselves and with non-governmental communities to build a practical enabling environment. This environment should be conducive to catalysing a step change in private sector action to decrease aviation CO_2 emissions, develop and deploy revolutionary existing and new technologies, and provide sustainable investment choices at scale and speed. A shorter white paper of the Policy and Collaborative Partnership for Sustainable Aviation project was distributed to participating aviation stakeholders at the World Economic Forum Annual Meeting in Davos, Switzerland.

10. Appendix

Assumptions of Scenario Analysis

Air Traffic Forecast

The air traffic forecast to 2050 (see Figure 15) was developed based on previous industry adjustments of FESG forecast of air traffic until 2026 and extension to 2036 extrapolated to estimated 2050 traffic based on the average of different scenarios considered in the FESG CAEP8 report. Cargo traffic adjustment is based on industry and Airbus estimate

Frozen Technology – CO_2 Emission Forecast

The CO_2 emission forecast is based on expected air traffic forecast (see previous) and fuel and CO_2 efficiency of current in-service aircraft fleet. No technology improvements and no fuel or CO_2 efficiency improvements are anticipated. It is a theoretical value, as current in-service fleet will have to be replaced over time based on lifetimes of aircraft and will not be replaced by aircraft of similar type but newer, more efficient models.

Base Case – CO_2 Emission Forecast

Base Case calculation assumes ongoing future fleet improvements for fleet replacement and to cover growth according to aircraft retirement curves based on FESG and industry analysis. Introduction of new aircraft generations with fuel efficiency increases per aircraft generation are in accordance with industry estimates and past improvements. Base Case includes total introduction of more than 70,000 new aircraft from 2010 to 2050 at an estimated cost of more than US$ 6 trillion. No operations, infrastructure or policy changes are anticipated.

Infrastructure Improvement Scenario

The infrastructure improvement scenario includes performance-based navigation (SESAR, NextGen); improved airspace redesign (China, Russia); flexible routing (North Pacific); Pearl River Delta airspace design; and flexible use of military airspace based on 2009 industry analysis until 2030. High 2030 efficiency levels are kept constant until 2050 in spite of traffic growth, but with no assumed additional efficiency improvements per year beyond 2030. The rationale is that SESAR and NextGen are already deemed to achieve 95-97% efficiency and it would be difficult to reach an even higher efficiency.

Operations Improvement Scenario

This scenario includes APU usage decrease, single engine taxi, cost index optimization, improved fuel management, continuous descent approach, pilot

Figure 15: Studies Referenced in FESG CAEP8 Report for 2050 RPK Forecast

Study	Description	Underlying Assumptions
CONSAVE	• Commissioned by the European Commission • Scenarios developed by DLR • Quantified with AERO-MS model	• Optimistic: Vigorous technological innovations to overcome potential barriers arising from high growth • Pessimistic: Low demand for air travel/ long distance trips due to changes in lifestyle and societal criticism
FTG traffic forecast rolled forward	• Extension of previous FESG forecast (2006-2026, extended to 2036)	• Scenarios based on expert judgment and reflecting regional differences in market maturity • Rates of growth continue to reduce over time
MMU	• Studies by the Manchester Metropolitan University (MMU) based on IPCC SRES	• Four marker scenarios based on the IPCC 1999 method with some qualitative interpretation of the detailed SRES storylines
MMU update of FESG projections from IPCC	• MMU update of FESG projections produced in the IPCC 1999 Special Report using a mathematical function	• Emission scenarios primarily designed for driving global circulation models and to develop global climate change scenarios • Update of IPCC 1999 scenarios using the SRES GDP projections

WEF Aviation Forecast 2050

- Average of optimistic and pessimistic scenarios from all examined studies techniques, reduced cabin weight and centre of gravity optimization based on 2009 industry analysis until 2030. Beyond 2030, it is expected that identified operations improvements will have become common practice, thus high 2030 efficiency levels are kept constant until 2050, with no additional estimated efficiency improvements per year.

Additional Aircraft R&D Scenario

The scenario assumes 10% additional fuel efficiency of new aircraft types introduced in 2030 (see Figure 16) compared to most efficient aircraft anticipated to be available in Base Case (see above).

Early Aircraft Retirement Scenario

The calculation assumes a retirement scheme that leads to all aircraft of more than 20 years of age being replaced by the newest, most CO_2-efficient available aircraft type of the same size at the time of replacement. This would imply that over the period until 2050 on average an additional 600 narrow body and an additional 100 wide body aircraft would need to be replaced each year.

Biofuel Scenario

The highest biofuel potential (maximum of displayed range) assumes continuous shift to 95% drop-in of sustainable second-generation biofuels (jatropha, salicornia, algae) with up to more than 90% lower life-cycle CO_2 emissions than conventional jet fuel.

Figure 16: Overview of Radical New Aircraft Technologies

	Description	Limitations	Improvement
Blended wing bodies	• Improved airframe aerodynamics through a flattened profile and wing structures that are smoothly blended to the body	• Low-speed control issues require sophisticated computer flight-control systems	• Additional 15% to fuel efficiency improvement from evolutionary innovation
Open rotor engines	• Fan blades are not surrounded by a casing • Removes some of the trade-offs between diameter, weight and drag	• Requires high level of engine/ aircraft integration • Only considered for narrow-body aircraft	• Additional 15% to fuel efficiency improvement from evolutionary innovation
N+3[1] (MIT)	• MIT designed long-range (H series) and domestic aircraft (D series) • Improved aerodynamics by using a bubble structure (D) and triangular shaped hybrid wing body	• More engine stress • A/C approximately 10% slower, but time loss could be offset by quicker loading due to planes' wider bodies	• Up to 70% fuel burn reduction
N+3 (goal set by NASA)	• Expected entry into service 2030-2035	• n/a	• > 75% fuel burn reduction

Cost/Time Estimates

- High levels of expenditure (in the magnitude of tens of billions of pounds) are likely to be required to develop and demonstrate new radical technologies. New technologies would have to be available in tandem with new generation aircraft types to have significant impact.
- Experts estimate that incremental US$ 10 billion funding would provide sufficient incentive for some manufacturers to start building third-generation planes today with estimated 10-15 years time to market (in line with approximate 10 years from initial large-scale investment to market introduction of previous plane types).

1) N+3 refers to 3rd generation new a/c type

Source: UK CCC report *Meeting the UK aviation target – options for reducing emissions to 2050*, MIT reports, MIT interview

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Project Partner Survey Results

The survey presents responses of 30 senior industry and academic experts as well as senior representatives from international organizations and associations on key challenges and most promising measures to support the implementation of the four identified key CO_2 abatement levers (see Figure 17).

Figure 17: Project Survey Results

	Challenges	%	Measures (Policy, Partnership, Financing, Information/Education)	∅ Rating
Infrastructure Improvements (ATM, Airports)	Insufficient political will to speed up decision making and implementation	25.0%	Information/education of policy makers, airport operators, ANSPs, pilots and public (on existing challenges, potential of new technologies, best practices)	1.57
	Regional/national issues with ATM ground infrastructure and existing constraining policies	19.1%	Legal Incentives (policies that give clarity and reduce risk, e.g., multimodal transport roadmap, ETS policy; improved foreign direct investment (FDI) policies)	1.55
	Insufficient information/ education of policy makers and public on ATM challenges/ improvement measures.	11.8%	Standards (global air traffic management (ATM) standard, standards for interoperability of aircraft ATM equipment, global/ regional standards for airport infrastructure)	1.55
	Lack of global ATM metrics and targets	10.3%	Fiscal incentives/ tax breaks (for private sector investment, for carriers for investment in new ATM equipment for new and in service aircraft)	1.29
	Airspace organization (military vs. commercial) which prevents optimal routing	8.8%	Government funding of airport/ ATM improvements (if applicable charge back to airports or aircraft operators over time)	1.27
	Lack of wholistic transport policy (intermodal)	8.8%	Green Levies (e.g., levies for aircraft without modern ATM equipment, levies for airports with less sophisticated infrastructure/ ATM equipment)	1.24
	Insufficient airport capacity (need for new airports/ runways/ inclusion of cargo)	8.8%	Funding through capital markets (low carbon finance, PE/VC)	1.19
	Access to new ATM technologies and financing	5.9%	Public-private partnerships (PPPs) for new airport development/ infrastructure improvement, implementation of new ATM technologies	1.14
	Insufficient ground handling efficiencies/ customs clearance etc. at airports	1.5%	Funding through Multilateral Development Banks (MDBs) (e.g., long-term, low interest loans, specific green funds)	1.09
	Global issues with interoperability of technical aircraft ATM equipment	0.0%	Partnerships with financial community (e.g., with MDBs for financing of airport/ ATM improvements, with capital markets through specific green funds)	1.05
Addl. Aircraft R&D	Lack of existing policies to support/ incentivize research and technology for new radical aircraft technologies	22.2%	Financial incentives (e.g. tax breaks for research and technology for new radical technologies)	1.74
	Long lead times for new technology development	20.6%	Education of policy makers to increase sense of urgency for new policies	1.72
	Conventional aircraft technology will only allow for gradual improvement of aircraft fuel efficiency in the future (likely not beyond 1.5% improvement/year)	14.3%	Legal incentives (policies that give clarity and reduce risk, e.g., government loan guarantees for investment in research for new radical technologies, ETS policy that puts price on carbon as basis for attracting additional capital market investment)	1.60
	Current lack of investment for scaling/ commercialization of new radical technologies due to high risk/ and uncertainty	14.3%	Standards (e.g., CO2 standard for new aircraft, labeling standard to increase transparency for customers)	1.42
	Radical new technologies (e.g., open rotor engine, blended wing body aircraft) to further improve fuel/ CO2 efficiency are currently still in very early R&D stage	12.7%	Research and technology partnerships between different aircraft manufacturers (intra-industry) or with manufacturers in other industries (cross-modal)	1.39
	Different stakeholder interests, e.g. interests of manufacturers not always aligned with interests of airlines due to high sunk costs for aircraft development	11.1%	Government funding	1.35
	Radically new a/c types could require modification of existing infrastructure (airports etc.) which would required additional investment	3.2%	Funding from within aviation industry, e.g., through recognized research funds (operators abound funds in exchange for carbon credits)	1.26
	Challenge to ensure new research and technology investment is incremental and does not replace/planned existing research of manufacturers	1.6%	Capital market funding and funding from commercial banks	1.26
			Education of public on aircraft CO2 standards/ labeling standard etc.	1.11
			Partnerships with financial community	1.06
Aviation Biofuels	Current lack of large scale investments for scale up of manufacturing/ distribution (lack of government as well as capital market funding)	18.6%	Fiscal incentives (e.g., for aviation biofuel R&D and manufacturing, for airlines to buy and use biofuels, tax breaks for private sector investment)	1.65
	Market failures for investment in aviation biofuels due to uncertainty around policy, legal system, incentives	16.9%	Vertical partnerships along the value chain between airlines, manufacturers, land owners (agriculture, government), energy/ chemicals companies, biofuel niche players, biorefineries, distributors etc., e.g., through long term purchase/ production agreements	1.63
	Lack of feedstock availability esp. of sustainable 2nd generation type (e.g., algae);	13.6%	Standards (sustainability standards for biofuels based on lifecycle emissions, standards for consideration of biofuels under ETS, standards for emission monitoring/ reporting, drop-in fuel standards, drop-in fuel specifications, labeling standard to allow airlines to position themselves as green if they use biofuels)	1.58
	Scaling of sustainable 2nd gen. biofuels (aviation 2050 target would require 7x today's total global 1st gen. biofuels of 2nd gen. type)	11.9%	Government funding for initial high risk phase of biofuel R&D and scale up (e.g. reinvestment of funds raised through ETS or green levies)	1.55
	Lack of global standards for biofuels (e.g., sustainability standard based on lifecycle emissions, de-carbonization standard for consideration of biofuels under ETS etc.)	10.2%	Funding from financial community, e.g. capital market (carbon finance community, PE/VC) and multilateral development banks (MDBs) in earlier stage, commercial bank credit/ debt financing in later stage	1.53
	Competition with other sectors for limited biofuel resources; lack of equal playing field (e.g., due to existing biofuel policies for land transport)	10.2%	Legal incentives (e.g., policies that give clarity and ensure level playing field for all modes of transport, prioritization of biofuels for aviation as no alternatives available existfor example through incentives for other modes of transport to switch to electrification; ETS policy that puts price on carbon and thus reduces risk for investment in biofuels)	1.50
	Insufficient collaboration between ministries (aviation, energy, agriculture, development) to ensure wholistic view of biofuels	8.5%	Industry funding, e.g., producers risk fund (industry contributes to specific aviation biofuel risk fund, fund invests in biofuel projects) as solution in early stage	1.47
	Long timelines for scale up of manufacturing facilities/ distribution infrastructure (latter could be partly overcome with % drop-in)	6.8%	Information/ education of governments (secretary as well as mid-level policy maker on potential of sustainable biofuels for aviation), potential producers from energy/ chemicals/ biofuel/ agriculture (on market potential, partnership opportunities within aviation), the public (on advantages of sustainable 2nd gen. biofuels to overcome land use problems/ competition with food production and labeling standards)	1.47
	Emerging different fragmented national/ regional standards	1.7%	Intra-industry partnerships between different airlines (collaborate on large scale biofuel projects) or between biofuel manufacturers (collaboration on R&D)	1.39
	Uncertainties on development of jet fuel prices with land transport trend to electrification (higher supply -> less expensive; lower production -> more expensive)	1.7%	Cross-modal partnerships between airlines and players from road transport/ automotive or maritime (biofuel development, policy definition)	1.11
			Green levies (e.g. on current jet fuel or CO2 emissions)	1.05
Market Based Measures (ETS, Offsetting)	Global ETS scheme needed to avoid patchwork of regional schemes but hard to negotiate/implement (nothing similar has been done before)	20.0%	Global aviation specific ETS scheme that allows for trading with other sectors	1.70
	Emissions need to be counted on global level, no double-counting	16.7%	Global overall ETS scheme	1.55
	Money flowing out of aviation industry without any CO2 efficiency gains within aviation, lack of consideration of long-term effect on aviation	16.7%	Information/ education of policy makers to ensure recognition of voluntary emission reduction investments of the industry, e.g. through free carbon credits for voluntary investment in new more CO2 efficient technology or biofuels	1.45
	Aviation specific ETS scheme required that allows for trading with other sectors (probably easier/faster to implement than overall global scheme; consideration in UNFCCC Advisory Group on Climate Change Financing report, ICAO in lead)	13.3%	Consideration of offset credits in aviation ETS scheme (e.g., making CDM, JI, REDD projects available to aviation etc.)	1.40
	Carbon leakage, competitive distortion and legal issues (against Chicago Convention) if some flights fall into national/ regional schemes (e.g. inclusion of intl. aviation under EU ETS from 2012)	11.7%	Carbon credits for early movers that (voluntarily) invest in new technology/ CO2 reduction within aviation	1.38
	Uncertainty of use of funds generated through ETS (e.g. through auctioning of credits) as often not reinvested in CO2 emission reduction measures	10.0%	Policy that assures (portion of) funds raised from ETS (e.g. from auctioning) are earmarked to be reinvested for CO2 emission reduction within aviation	1.36
	ETS or mandatory offsetting puts financial burden on aviation industry likely leading to negative macroeconomic effect	5.0%	Education of customers on offsetting opportunities (for voluntary offsetting)	1.21
	Lack of availability (e.g., current Kyoto mechanisms CDM, JI not open to aviation) and transparency of offset projects	5.0%	Collaboration with developing countries and MDBs to increase availability and transparency of offsetting projects and support developmental agenda	1.20
	Challenge with acceptance of certain types of offset projects (e.g. biofuel projects in developing countries)	1.7%	Collaboration with carbon finance and carbon market community	1.19
	Carbon leakage if shift occurs between different modes of transport (e.g. towards shipping if only intl. aviation is put under new CO2 regulation)	0.0%	ETS scheme should be considered only as last option/ temporary option for aviation industry to reach its CO2 emission reduction targets	0.70

	(Options in Survey: Pick 3 most important challenges)		(Rating Options in Survey: Unimportant = 0; Important = 1; Very Important = 2)
Red	Top 3 (picked most often)	Dark green	Very Important (Average >= 1.5)
Light orange	Other Important (picket at least by one participant as top 3)	Light green	Important (Average >=1)
White	Not seen as key challenge (not picked as top 3 by any participant)	White	Less important/ unimportant (Average <1)

Deep Dive – Sustainable Aviation in India

In India, the current situation and the expected aviation growth lead to sustainability challenges. Aviation has a significant contribution to India's GDP. Civil aviation was valued at approximately US$ 5.6 billion in 2008, which represents approximately 5% of GDP. Around 30% of foreign trade is handled by air. Since the start of the liberalization of aviation in India in the 1990s, a rapid transformation has taken place. Today, private airlines account for more than 75% of the domestic aviation market, and 15 domestic carriers operate more than 400 planes.

Challenges exist in regard to updating and expanding aviation infrastructure to keep up with demand growth that will require further capacity increases in the form of extensions of the Mumbai and Delhi airports (already occurred) as well as new greenfield airports. Aviation fuel demand is rising, but India does not possess major domestic fuel reserves, which poses a new challenge in terms of energy security. At the same time, rising demand and fuel burn lead to a rising challenge in regard to CO_2 emissions. All challenges will increase in the next decade. With an estimated 15% compound annual growth rate for passenger air traffic, a need for more than 1,000 new aircraft arises until 2020.[xxxv] Combating the sustainability challenge will require further infrastructure development and improvement. The Investment Commission of India estimates the need for US$ 30 billion for airport infrastructure alone until 2020. In addition, a large need exists for alternative fuels to ensure security of supply as well as leverage their emission reduction potential. Aviation infrastructure and biofuels are already focus topics in India, but still require more attention.

In regard to infrastructure on the ATM side, the implementation of performance-based navigation (PBN) is currently ongoing and, according to the implementation plan of the Airports Authority of India (AAI), will be completed by 2016. Satellite navigation is planned [GPS-Aided Geo Augmented Navigation (GAGAN) project]. Recent issues with radar blackouts at major airports, including Delhi and Mumbai, underline the need for new technology. On the airport side, India currently has 124 major airports, including 12 international airports (2010). Congestion is increasing, especially at metro airports like Delhi or Mumbai. The first airport improvements and new greenfield airports are ongoing or planned. The AAI plans to spend approximately US$ 3 billion in the next five years on metro and non-metro airports.

Two exemplary projects demonstrate India's current focus on aviation infrastructure:

ATM Example – GAGAN System

- India currently developing GPS-Aided Geo Augmented Navigation (GAGAN) system
- Joint project of AAI and Indian Space Research Organization (ISRO) scheduled to be completed by June 2013
- Fight management system (FMS) based on GAGAN should help save time and cost by managing climb, descent and engine performance profiles of aircraft and precision approach and landing guidance
- GAGAN overlay to cover airspace from Africa to Australia, compatibility with similar systems in US, Europe and Japan
- Estimated cost of Rs 774 crore (US$ 175 million)

Airport Example – Delhi Airport Modernization

- Modernization of Indira Gandhi International airport
- Project carried out by Delhi International Airport Limited (DIAL), a JV led by GMR Group, which has been managing the airport since 2006
- Project includes third runway, taxiways, apron, new domestic departure terminal, new Terminal 3 to cater for 37 million passengers per year
- With new Terminal 3, airport has become India's and South Asia's most important aviation hub, with a current capacity of handling 46 million passengers and more than100 million passengers by 2030
- Original planned capital expenditures of Rs 8975 crore (US$ 1.797 billion)

However, significant additional improvement potential exists in regard to aviation infrastructure, especially from a policy perspective. Indian industry experts see a large need for an overall long-term master plan for multimodal transport, including aviation and especially cargo. In addition, more regional airports and alternative airports for major cities are seen as critical, which would require a more differentiated policy than the current rule that no second airport can be built within a 150 kilometre radius of an existing airport, and possibly the privatization of more airports. On the ATM side, a need for improved airspace management and improved ground handling procedures exists. Overall, aviation should be included in India's growth plan to allow the country to become a major aviation hub in Asia. Additional incentives are desired to drive more private investment into the sector.

On the partnership side, public-private partnerships have proven to be a successful model for implementation.2

Improved airport and ATM infrastructure is critical, as it will also create opportunities for the development of other industries and can add additional value to the community.

Biofuels are also already a focus area in India. However, currently the focus of the Indian government on biofuels is mainly on biodiesel and bioethanol for land transport and existing policies and incentives (e.g. land/tax incentives, drop-in rate ambition, national biofuel policy see example following) put aviation at a disadvantage. The focus is on energy security and the developmental agenda, as biofuel cultivation gives an opportunity to increase the income of poor farmers, and is less on emission reduction. Large potential is seen in growing jatropha on marginal land but higher yields on fertile land, and the use of fertilizers still lead to competition with the food chain and higher CO_2 emissions from a life-cycle perspective. Jatropha can ensure energy security but, from a life-cycle emission perspective, it does not allow for the very high CO_2 emission reduction required to reach the overall aviation industry CO_2 targets. The scale-up of large biofuel projects is still limited. As to specific aviation biofuels, an advisory group was recently established led by Directorate General of Civil Aviation (DGCA). An interministerial group (ministries of environment, new and renewable energy, and external affairs) is developing a road map for aviation biofuels.

The following two examples show currently ongoing biofuel initiatives in India:

Biodiesel Example

- India approved a National Biofuels Policy in 2008 (final announcement in December 2009) to meet 20% of diesel demand with biodiesel by 2017
- To reach target, taxes and duties on biodiesel were scrapped
- Several state governments took the lead and established own biofuel policies
- Well-funded government programmes for rural development set up to subsidize large-scale biodiesel plantations
- State Bank of India signed MoU with D1 Mohan, a JV of D1 Oils, to give loans to local farmers; farmers expected to pay back loans from earnings from selling Jatropha seeds to D1 Mohan

Aviation Biofuel Example

- Indian Oil Corporation (OCL) and UOP/ Honeywell have plans to set up a consortium with the airline and defence industry to develop aviation biofuels in India, with a focus on sustainable green fuels from non-food sources that could reduce GHG emissions by 80% and provide a local alternative source for fuel
- Pratt & Whitney Canada signed a collaboration agreement with the governments of India and Canada for a joint research project on alternative jet fuel; Hyderabad-based Infotech Enterprises, two Indian oil companies, IIT andfour Canadian research institutions are participating in the programme

Going forward, Indian aviation experts see an increased need for governments to put in place clear policies, including incentives and penalties, and to ensure a balance of cultivation of food versus energy crops. As the current biofuel policy puts aviation at a disadvantage, the recent ICAO resolution should be leveraged to obtain government buy-in and amend policies to ensure a level playing field for aviation. An increase in collaboration between different ministries (e.g. MNRE, energy, aviation) is seen as critical.

As to financing options, money raised from for example the recently introduced levy on coal with revenues of approximately US$ 500 million per year should be reinvested in aviation biofuels, and the new fund the Indian government is setting up and also bilateral funds flowing into India from abroad should be leveraged.

Carbon credits should be given for investment in biofuels in India, and biofuel projects should also potentially be considered under CDM.

As to information and education opportunities, awareness needs to be particularly strengthened within the aviation industry (e.g. with the help of biofuel test flights as part of larger complete biofuel projects).

On the partnership side, increased collaboration between the aviation industry and biofuel producers and state governments is needed. A good example of an innovative partnership model is demonstrated by the following example from Nandan Biomatrix.[xxxvii]

Jatropha Biofuel in India – Nandan Biomatrix Case Study

NANDAN® BIOMATRIX

- Nandan Biomatrix (NBL) based in Hyderabad is involved in nutraceuticals and biofuels (four global registered patents for Jatropha hybrid development with high yields of >3t oil per ha)
- Moved from R&D to demonstration stage, plan to develop sustainable Jatropha plantation on approximately 800,000 ha for producing 2.8m tons of biodiesel by 2017 (compare: India's policy of achieving 20% biodiesel by 2017 implies indicative production target of 16m tons of biodiesel by 2017; India has total potential waste land of approx. 40m hectares=400,000 km²)
- Company uses unique, vertically integrated business approach from Jatropha seed to oil and beyond, including information and education (information centers, workshops, training to farmers)
- NBL's business model adopted specific implementation methodologies based on differing socioeconomic and geopolitical scenarios in different states of India
- The company has established partnerships with India's largest oil marketing company, Bharat Petroleum Corporation, and infrastructure leader, Shapoorji Pallonji, and PPPs with local governments, universities and farmers
- In different models, NBL plays role of technology provider (bio energy planting material, professional advice) that later buys back Jatropha crops from farmers
- Depending on the model, Jatropha is either grown on government-owned waste land by local farmers under a scheme linked to India's National Rural Employment Guarantee (NREGA) scheme or farmers engage in contract farming on their own land through an innovative franchise model (franchisee is local person from village or NGO that encourages farmers to plant Jatropha and coordinates efforts; farmers do not pay for NBLs services directly, but cost is deferred and recovered from farmer as part of a loan repayment agreement once economical yields have been achieved)
- To provide financial services to resource-deficit farmers, NBL has tied up with various Indian national banks and the Agriculture Insurance Agency
- Company is member of working group of Ministry of New and Renewable Energy and working committee of Biodiesel Society of India and has received numerous awards, including India's "Business Wizard Award 2010", "Social and Corporate Governance Award 2010", "Emerging India Award 2009" (CNBC TV), Best Green SME Award 2009", "Best Business Model 2007" (Frost & Sullivan)
- With right policies and price in place for aviation biofuels, NBL sees good opportunity in the future to also develop aviation biofuels

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i. IATA Press Release, "Tough Targets and a Global Sectoral Approach – Aviation's Copenhagen Commitment", 6 October 2009, http://www.iata.org/pressroom/pr/Pages/2009-10-06-01.aspx.
ii. ICAO Assembly – 37th Session, report of the executive committee on agenda item 17 (climate change), resolution 17/2, October 2010. Although the ICAO resolution is not legally binding and a number of member states placed reservations on parts of the resolution, it still communicates the intention of member states.
iii. ATAG/Oxford Economics, "Economic & Social Benefits of Air Transport", 2008.
iv. ATAG/Oxford Economics, "Economic & Social Benefits of Air Transport", 2008.
v. Frontier Economics, "Economic Consideration of Extending the EU ETS to Include Aviation", 2006.
vi. ATAG/Oxford Economics, "Economic & Social Benefits of Air Transport", 2008.
vii. Brian Havel, International Aviation Law Institute, De Paul University, "Briefing Paper for the World Economic Forum - Global Aviation Framework for Climate Change", August 2010.
viii. IPCC Special Report on Aviation and the Global Atmosphere (1999) and IPCC Fourth Assessment Report (2007). Note that this includes CO_2 emissions from general and military aviation, and doesn't include radiative forcing index due to aviation emissions. According to latest World Resource Institute data from 2005, commercial aviation emissions account for 1.9% of total CO_2 emissions. CO_2 emissions stated do not consider CO_2 equivalents for other greenhouse gas emissions.
ix. IMF, World Economic Outlook and Global Financial Stability Report, July 2010.
x. ADB article, "Asia's Expanding Middle Class Presents Huge Opportunity for Region, World – Report", 19 August 2010. Middle class defined as people consuming between US$ 2 and US$ 20 per day.
xi. For assumptions of air traffic Base Case model, see Appendix/Assumptions of Scenario Analysis/Air Traffic Forecast.
xii. For assumptions of CO_2 Base Case model, see Appendix/Assumptions of Scenario Analysis/Base Case – CO_2 Emission Forecast
xiii. IATA Press Release, "Tough Targets and a Global Sectoral Approach – Aviation's Copenhagen Commitment", 6 October 2009, http://www.iata.org/pressroom/pr/Pages/2009-10-06-01.aspx.
xiv. ICAO Assembly – 37th Session, report of the executive committee on agenda item 17 (climate change), resolution 17/2, October 2010. Although the ICAO resolution is not legally binding and a number of member states placed reservations on parts of the resolution, it still communicates the intention of member states.
xv. Aviation and CO_2 emissions growth for aircraft operated by commercial airlines with more than 20 seats and business aircraft based on World Economic Forum/Booz & Company analysis based on ICAO, FESG forecasts, and previous analysis by IATA, GAMA & IBAC, UK CCC.
xvi. Including improved fuel management, continuous descent approach, reduced cabin weight, centre of gravity optimization based on detailed analysis until 2030 conducted by the industry in 2009. Beyond 2030 high 2030 efficiencies kept constant, no additional estimates included for further operations improvements to be implemented after 2030 beyond currently already identified one-off opportunities that are expected to have been implemented by 2030.
xvii. Including performance-based navigation (SESAR, NextGen), improved airspace redesign (China, Russia), airport infrastructure improvement based on detailed analysis until 2030 conducted by the industry in 2009. Beyond 2030, high 2030 efficiencies kept constant, no additional estimates included for further infrastructure improvements to be implemented after 2030 beyond currently already identified opportunities. Assumed that with aviation demand growth, any additional infrastructure investments can likely only maintain today's efficiencies but will not lead to further efficiency increases beyond today's levels.
xviii. Calculation assumes retirement scheme that leads to all aircraft of more than 20 years of age to be replaced by the newest most CO_2-efficient aircraft type of the same size at the time of replacement. For detailed assumptions, see Appendix/Assumptions of Scenario Analysis/Early Aircraft Retirement Scenario.
xix. Assumes continuous shift to 95% drop-in of sustainable second-generation biofuels (algae, salicornia) with up to more than 90% lower life-cycle CO_2 emissions than jet fuel. Assumptions based on E4Tech study for UK CCC, "Review of the potential for biofuels in aviation – Final report for CCC", August 2009; Stratton, Wong, Hileman, "Life Cycle Greenhouse Gas Emissions from Alternative Jet Fuels", PARTNER Project 28 report, version 1.2, June 2010.
xx. Calculation based on industry analysis conducted by IATA and shared with the project.
xxi. Calculation based on industry analysis conducted by IATA and shared with the project.
xxii. Expert estimate; interview with Ian Waitz, Massachusetts Institute of Technology, Department of Aeronautics and Astronautics and discussion with involved industry experts.
xxiii. Calculation based on dynamic fleet model (IATA fleet model extended by project team to 2050 based on

industry expert discussion). Assumption of average cost for replacement of wide body aircraft of US$ 160 million narrow body aircraft of US$ 45 million. Assumption that fleet is replaced at age 20 by newest model of respective size category. Includes residual market value for old planes (approximately 18% after 20 years of service based on industry depreciation average) and financing cost for new aircraft for first seven years (break even point for investment).

xxiv. IEA, "Energy Technology Perspectives 2008". Estimate of development cost of second-generation biofuels for transportation from today until 2050: US$ 320-480 billion. IEA estimates second-generation biofuels supply: 26EJ of energy in 2050 (23% of transportation energy demand). World Economic Forum/Booz & Company calculated aviation biofuel scenario to reach aviation 2050 CO_2 target requires 28EJ of second-generation biofuels in 2050, thus also up to 100% IEA estimated R&D investment would have to be considered to come from aviation.

xxv. Brian Havel, International Aviation Law Institute, DePaul University, "Briefing Paper for the World Economic Forum - Global Aviation Framework for Climate Change", August 2010.

xxvi. Brian Havel, International Aviation Law Institute, DePaul University, "Briefing Paper for the World Economic Forum - Global Aviation Framework for Climate Change", August 2010.

xxvii. The concept of setting targets and applying MBMs on a route rather than a unilateral country basis has been endorsed by the World Tourism Organization (UNWTO); this approach not only would resolve conflict between Chicago and UNFCCC provisions but also could provide, irrespective of the airline base, for reduced emission targets or exemptions for routes to poorer countries, which are heavily dependent on tourism and often the most vulnerable to climate change.

xxviii. Bloomberg New Energy Finance with UNEP and SEFI, "Global Trends in Sustainable Energy Investment 2010", http://www.rona.unep.org/documents/news/GlobalTrendsInSustainableEnergyInvestment2010_en_full.pdf.

xxix. GreenAirOnline, "Action required now if alternative aviation fuels are to help meet emissions targets, concludes major European study", http://www.greenaironline.com/news.php?viewStory=1062.

xxx. Lufthansa, "World premiere: Lufthansa first airline to use biofuel on commercial flights", http://presse.lufthansa.com/en/news-releases/singleview/archive/2010/november/29/article/1828.html.

xxxi. See ICAO Assembly – 37th Session, report of the executive committee on agenda item 17 (climate change), resolution 17/2, October 2010.

xxxii. Brian Havel, International Aviation Law Institute, DePaul University, "Briefing Paper for the World Economic Forum – Global Aviation Framework for Climate Change", August 2010.

xxxiii. Carbon contracts and energy policy: An outline proposal, Dieter Helm and Cameron Hepburn, New College and St. Hugh's College, Oxford, October 2005.

xxxiv. UNFCCC Report of the Secretary-General's High-Level Advisory Group on Climate Change Financing, November 2010.

xxxv. India Ministry of Civil Aviation, FICCI (Federation of Indian Chambers of Commerce and Industry), IBEF, Boeing/Airbus estimates, World Economic Forum/Booz & Company analysis.

xxxvi. India Ministry of Civil Aviation, FICCI (Federation of Indian Chambers of Commerce and Industry), Airports Authority of India, World Economic Forum/Booz & Company analysis, outcome of discussion at private event at the World Economic Forum's 2011 India Economic Summit.

xxxvii. India Ministry of Civil Aviation, World Economic Forum/Booz & Company analysis, outcome of discussion at private event at the World Economic Forum's 2011 India Economic Summit.

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