Market-Based Measures

Overview Of CAEP/5 Analysis of Market-Based Measures

By Nancy Young and Michael Mann

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This article provides an overview of the economic analysis that was conducted by the Forecasting and Economic analysis Support Group (FESG) of ICAO's Committee on Aviation Environmental Protection (CAEP) for its fifth meeting (CAEP/5) in January 2001. That analysis was done into the various market-based measures that might be used to reduce carbon dioxide (CO_2) emissions from aviation.[1] The analysis focused on the economic and environmental impacts of three types of market-based measures: emissions trading, environmental levies, and voluntary measures. To conduct the analysis, ICAO/CAEP used the Aviation Emissions and Evaluation of Reduction Options Modelling System (AERO-MS), developed by the Government of the Netherlands (see Part 5).

The work was performed by ICAO/CAEP in response to provisions in ICAO Assembly Resolution A32-8, under which the ICAO Assembly called for the ICAO Council, through CAEP, to assess policy options, including "an en-route levy or a fuel levy to address global emissions …and on other market-based measures such as emissions trading." Since no specific policy measure was defined by the ICAO Assembly for study, ICAO/CAEP established the parameters of the study through a consensus process.[2]

Background

For the purposes of the analysis, the three types of market-based measures were assessed against three alternative hypothetical emissions reduction targets, which were defined by ICAO/CAEP. The most stringent target was an actual overall reduction of 2010 emissions to 95% of their 1990 level, roughly in line with the average of targets for ICAO Member States under the Kyoto Protocol climate change treaty. The two other emission targets were 50% and 25% in projected emissions increase between 1990 and 2010. To perform the analysis, a base case was established first, projecting what fuel burn and emissions might be expected without market-based measures. Based on forecast inputs provided by ICAO/CAEP's FESG, the AERO-MS model estimated that in the base case (with no additional policy action) global air traffic would increase by 85% between 1992 and 2010, while total fuel use would increase by only 40%, reflecting improved aircraft fuel efficiency over that period. As the amount of fuel burned has a direct relationship to the amount of CO_2 that is released, projecting expected fuel burn and resulting emissions was important for identifying the potential effects of the various market-based measures.

To conduct the analysis, FESG had to identify and agree on various assumptions. Important among these was that total air transport demand (in the base case), measured in terms of revenue ton kilometres (RTKs), would increase at an average annual growth rate of 5.25%, while airport and airspace capacity to meet that projected demand would be unconstrained. The analysis also assumed that all cost increases to airlines due to market-based measures would be fully passed on to customers through higher passenger fares and freight rates. FESG also had to establish agreed figures for price elasticity of demand and projected fuel efficiency improvements. So as to not unduly complicate the analysis, and so that the potential effects of the market-based measures could be isolated, FESG assumed that fuel prices would remain constant over the study period.

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[1] This article reports FESG's work, as presented in its CAEP/5 working paper, "Economic Analysis of Potential Market-Based Options for reduction of CO2 Emissions from Aviation," CAEP/5-WP/24.

[2] CAEP had established a dedicated working group, "Working Group 5," to study potential market-based options. This group developed the design parameters for the options subject to analysis. Working Group 5's work is presented in the information paper presented to CAEP/5 entitled "Market-Based Measures, report from Working Group 5 to the Fifth Meeting of the Committee on Aviation Environmental Protection," CAEP/5-IP/22.

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Measures Evaluated

Once the market-based measures and CO_2 reduction targets to be assessed were defined, and the study assumptions were agreed, the analysis of the three types of market-based measures commenced. Below is a description of these measures, followed by a summary of the study findings.

Emissions Trading

Under a CO_2 emissions trading system, an overall target or cap is set and a market for carbon is established, allowing participants to buy and sell permits, the price of which is set by the market place. If the CO_2 abatement costs that face participants are lower than the permit price, they will have an incentive to take abatement actions to meet any targets applicable to them and to try to generate permits they can sell. If abatement costs facing a particular participant exceed permit prices, that participant will have an incentive to buy permits to meet their targets, rather than taking the more expensive abatement actions. Under an open emissions trading system, aviation would be free to trade with other sectors that are included within the scheme. A closed trading system on the other hand, would be limited to the aviation sector. Under a trading system, the environmental impact will be determined by the cap that is set, while the economic impact will depend on the level of permit prices. The CAEP analysis assessed both open and closed emissions trading.

Environmental Levies

Environmental levies include taxes and charges with the objective of creating an economic incentive to reduce emissions. In essence, taxes and charges raise costs to the airlines. To the extent that these costs are passed on to the consumer, they can have the effect of reducing demand (i.e., reducing flying, and therefore the emissions from flying). Alternatively, or in addition, taxes and charges can induce the adoption of abatement measures, to the extent that those measures are less costly than enduring the full effect of the tax or charge that would otherwise be applied. So, in this case the economic impact will be determined by the level of the charge or tax set, while the environmental impact will depend on the extent to which the tax or charge induces emissions-reducing behaviour. The measures considered in the CAEP analysis included a fuel tax, an en-route emissions tax, and en-route emissions charges with proceeds recycled to the aviation sector. A revenue neutral en-route emissions charge was also tested.

Voluntary Measures

Voluntary measures can involve unilateral action by industry or agreement between industry and government to reduce emissions beyond a base case. They are similar to emissions trading in that they typically are based on an overall cap on emissions, but, unlike with trading, the cap is not always enforceable. Voluntary measures to limit or reduce emissions might include such things as voluntary emissions trading, carbon offsets, operational changes, and/or technology investments. However, given that the emission reduction targets set in the study were observed to require "very costly" measures that "would induce significant demand effects," specific voluntary measures were not fully analyzed, because it was believed that industry would not voluntarily agree to actually meet such targets. Thus, after initial screening analysis, only a "hybrid" voluntary agreement scenario, combining voluntary early aircraft retirement with open emission trading, was subjected to detailed analysis.[3]

Key Findings

The emissions trading measures were tested using several allowance prices, ranging from $5 to $100 per tonne of CO_2. Two alternative mechanisms for distributing allowances to airlines were used: auctioning (airlines must purchase all permits needed to cover their emissions, including baseline emissions), and grandfathering (distribution of permits up to a certain baseline free of charge). Of the market-based measures studied, an open emissions trading system, whereby aviation is free to trade with other sectors, was found to be the most economically efficient approach for achieving CO_2 emission reduction targets. The open system had relatively modest impacts on airline costs and demand, when compared with the impacts from taxes and charges. For example, with allowances auctioned at an allowance price of $25, there would be a 2.5% demand reduction and $17bn per year (1992 US$) increase in airline costs to meet the least stringent target

[3] A description of the screening process and of the findings regarding the screening process are presented in FESG's detailed information paper, "Report on Economic Analysis of Potential Market-Based Options for Reduction of CO_2 Emissions from Aviation," CAEP/5-IP/9, which also was presented at CAEP/5. The quotations here are from Section 6.1.12 of that paper.

of a 25% reduction in the growth of emissions. With allowances grandfathered, the demand reduction for this target is estimated to be 1% and the cost penalty is reduced by 90%, with a $1.6bn annual increase in airline operating costs.[4] Among the measures studied, an open emissions trading system was found to be the only way to achieve the most stringent targets under the assumptions applied,[5] with all other options giving rise to substantially greater increases in airline costs as well as demand reductions.

With aviation expected to be a net purchaser of permits due to the high cost of abatement action within the sector,[6] most of the emissions reductions would be achieved by other sectors, particularly under scenarios where allowance prices were assumed to be low. As noted above, including different sectors in one scheme encourages efficient behaviour (in this case, encouraging those who can reduce emissions at lower costs to do so), providing a more cost-effective way of reducing emissions than if the measures employed are limited to the aviation sector. This explains why the impact on airline costs and traffic levels is less pronounced under open emissions trading than with environmental levies.

A closed emissions trading system limited to the aviation sector was found to be less economically efficient and not capable of achieving stringent emissions targets under the permit prices assumed. Although this mechanism works differently from emissions-related levies, its economic and environmental impacts would be identical to that of environmental levies.

If environmental levies are used to achieve the study's CO_2 reduction targets, they would need to be set at very high levels. For example, to meet the most stringent Kyoto Protocol reduction target (a 5% reduction from 1990 emission levels), a fuel or en-route emissions levy would need to be set at around 8 times the fuel price used in the base year (1992). An environmental levy of this scale was found to have substantial implications for airline costs (up by almost 80%), with demand reductions of around one third, arising from higher ticket prices. Even under the most relaxed emission reduction target, a levy equivalent to doubling the fuel price would be required. Analysis showed that the cost of meeting the three targets was between $47bn and $245bn per year in 1992 US$.

Where the proceeds of environmental levies were assumed to be re-channelled back into the aviation industry to provide an incentive for more rapid fleet replacement, the adverse effects on demand and airline operating costs were somewhat dampened. The analysis showed that such a system would be a viable option for achieving the less stringent targets analysed. Options identified, but not considered in any detail, for re-channelling proceeds included their use for: accelerated retirement of older aircraft, funding technology improvements, and improving ATC systems to reduce delays.

A revenue neutral CO_2 charge, whereby less fuel efficient aircraft would pay higher en-route charges, with compensating savings for more fuel efficient aircraft, was found to result in only modest reductions in CO_2 emissions. Such an instrument would only be feasible for achieving more relaxed emission reduction charges than considered in this study.

A combined/hybrid system of voluntary measures to retire old aircraft early and open trading was found to be less efficient than open trading on its own, but more efficient than environmental levies. Because of the high cost of implementing abatement measures within the aviation sector, the study found that voluntary measures on their own would likely achieve only the more relaxed targets.

To the extent that a particular market-based measure aimed at reducing CO_2 has the effect of reducing demand, the study noted that it would also result in a reduction of other emissions such

[4] To meet the Kyoto-like target of a 5% reduction in emissions from a 1990 baseline, open emissions trading was estimated to cost $63 billion annually, if permits were auctioned.
[5] A key assumption in this regard was that the airlines would have full access to emissions permits, although the source of those permits was not identified.
[6] Abatement actions by the airlines are projected to be more costly due to several factors, including the fact that airlines already are motivated by the high cost of jet fuel (typically, the greatest or second greatest cost center for an airline, next to labor) to be highly fuel efficient, and the current unavailability of viable alternative fuels or carbon sequestration options.

as oxides of nitrogen (NO_x). However, the study noted that operational or technology-related abatement measures taken in response to such policies may have adverse effects in increasing NO_x and noise, as there are interrelationships between these parameters in aircraft operation.

Where targets are applied regionally, for example assumed to apply only to developed countries, environmental benefits were found to be correspondingly smaller, and the risk of economic distortions caused by such actions as destination switching and tankering of fuel, as well as potential competitive distortions, were identified.

Summary

In response to a request from the ICAO Assembly, CAEP performed an extensive assessment of the relative economic and environmental impacts of various market-based measures that might be employed to limit or reduce CO_2 emissions. While this analysis was concluded in 2001, CAEP has reaffirmed the validity of this work since, subject to the assumptions used.

Under the analysis, "open emissions trading" was found to be the most economically efficient approach, as compared with taxes and charges and voluntary measures for meeting the specified targets and the only viable one capable of meeting the most stringent (Kyoto Protocol) emission reduction targets. Under this measure, a significant part of the emissions reductions would be realized outside of aviation, with aviation likely to be a net buyer of emissions from other sectors, unless allowance prices were extremely high.

Environmental levies (taxes or charges) would need to be set at very high levels to meet stringent CO_2 reduction targets, with substantial increases in airline operating costs and demand reductions arising from higher ticket prices. Where the proceeds of levies were assumed to be re-channelled back to the airline industry, for example to enable more rapid fleet replacement, these impacts were somewhat dampened and this was found to be a potentially viable measures for achieving the less stringent targets.

For targets less restrictive than those used in the analysis, a revenue neutral charge and voluntary agreements were found to be viable options.

Overview of ICAO Guidance on Emissions Trading

By Andreas Hardeman
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This article presents a brief overview of the guidance material that ICAO has developed on emissions trading to assist Contracting States in developing and implementing their own aviation emissions trading schemes, and it offers some advice and practical information they might be able to use.

International Aviation and Emissions Trading

Pressure on the world community to address climate change issues is continuously increasing. Although aviation's share is relatively small, the contribution from the aviation sector is growing in relation to the total global impact on climate change from other sectors. In evaluating alternative approaches to addressing aviation's impact on the global climate, relative to other market-based measures, it was decided at the fifth meeting of ICAO's Committee on Aviation Environmental Protection (CAEP) that an emissions-trading system would be a cost-effective measure to limit or reduce CO_2 emitted by civil aviation in the longer term, provided that the system is an open one across economic sectors[1]. This potential for open emissions trading was also recognized when the Kyoto Protocol to the UNFCCC laid the groundwork for an international open emissions trading scheme via the inclusion of Article 17.

There are a number of reasons why the inclusion of international aviation in an emissions trading scheme is challenging. One issue, which has been controversial throughout the work of ICAO CAEP, is the geographic scope. Including emissions from stationary sources is geographically simple, because emissions physically occur within the territory of a given State. However, this is not the case for emissions from non-stationary sources, such as from international aviation, which by definition is not geographically contained wholly within one State. This certainly adds complexity in designing an emissions trading scheme including aviation.

Furthermore, unlike domestic aviation, international aviation is not listed in Annex A to the Kyoto Protocol and is not a sub-category of any other source listed. Therefore, emissions from this activity are not taken into account in the calculation of assigned amounts of Annex I Parties and are not subject to the limitation and reduction commitments of Annex I Parties under the Kyoto Protocol. Article 2.2 of the Kyoto Protocol states that Parties "included in Annex I shall pursue limitation or reduction of emissions of greenhouse gases not controlled by the Montreal Protocol from aviation…bunker fuels, working through the International Civil Aviation Organization".

The exclusion of international aviation emissions from assigned amounts under the Kyoto Protocol means that their inclusion in emissions trading under Article 17 of the Kyoto Protocol is not provided for. In addition, the UNFCCC and Kyoto Protocol confer no guidance in relation to emissions trading schemes that are not provided for in either of these agreements, such as those developed by Parties or groups of Parties.

It is obvious from the description above that ICAO CAEP had a most challenging assignment and furthermore it was a complex and new area in many other ways, with little or no experience to build upon, in particular with respect to aviation participation. Nevertheless, it succeeded in presenting a clean draft guidance document to CAEP/7 (February 2007) thanks to the combination of mixed expertise, hard and constructive work and the willingness to compromise. CAEP agreed to recommend to the ICAO Council that it adopt the guidance on emissions trading for aviation and publish it prior to the forthcoming Assembly.

After subsequent intense discussions, the Council decided to publish the guidance document as a draft document with a foreword by the President of ICAO emphasizing that there are different views on the issue of geographic scope in the Council on whether Contracting States could integrate international aviation emissions from aircraft operators from other Contracting States without their agreement. The President concluded his foreword by stating that "In line with the emphasis from the last Session of the Assembly on ICAO taking a leadership role in all aviation matters related to the environment, I believe that this guidance material is an important step in advancing our knowledge of possible alternative

[1] "Market-Based Measures:" Report from Working Group 5 to the fifth meeting of the Committee on Aviation Environmental Protection. CAEP/5-IP/22. 5/01/01.

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measures to address aviation emissions and provides the basis for sound discussions, deliberations and decisions as a way forward on emissions trading at the upcoming 36th Session of the ICAO Assembly."

Guidance On Emissions Trading

The scope of the guidance material extends exclusively to international civil aircraft operations and does not include State aircraft, which covers military, customs, and police services. The guidance focuses on those aspects of emissions trading that require consideration with respect to aviation-specific issues; it identifies options and offers potential solutions where possible.

The guidance on emissions trading is not of a regulatory nature. It is recognized that the guidance material may not provide the level of detail necessary to assist ICAO Contracting States in addressing every issue that might arise, given that there may be unique legal, technical or political situations for particular States. It is therefore advised that ICAO Contracting States use the guidance material as supporting material, to be shaped and applied to specific circumstances. It is a new area and the guidance may need to be revised as the world of emissions trading and aviation develops over time.

The guidance on emissions trading addresses the aviation-specific options for the various elements of trading systems, such as:

- Accountable entities
- Emission sources included
- Emission species included
- International and domestic emissions
- Geographical scope (jurisdiction)
- Trading units (integration and linking)
- Types of trading systems
- Allowance distribution (benchmarking)
- Monitoring, reporting, verification, and enforcement

Each of these elements is briefly addressed below. For more detailed information the guidance material and its glossary are available on the ICAO website at:
http://www.icao.int/icao/en/env/document.htm.
In addition, the ICAO website offers more general material on emissions trading at:
http://www.icao.int/icao/en/env/aee.htm.

Accountable Entities

Possible accountable parties discussed are: aircraft operators, fuel suppliers, air navigation service providers, airport operators, and aircraft manufacturers.

The guidance recommends that the aircraft operator should be selected as the entity that is accountable for emissions from international aviation.

Emission Sources and Inclusion Threshold

The guidance recommends that obligations under the scheme implemented should be applied on the basis of the total aggregated emissions from all applicable flights performed by each aircraft operator included in the scheme. To establish an adequate balance between emissions coverage and administrative burden regarding "small operators" the guidance recommends that States consider applying an inclusion threshold for aircraft operators based on aggregate air transport activity (e.g. CO_2 emissions) and/or aircraft weight.

Emissions Species Included

The guidance recommends that States start with an emissions trading scheme that includes CO_2 alone, while not precluding inclusion of other non-CO_2 aircraft emissions that contribute to climate change, as scientific understanding of their effects evolves.

International and Domestic Emissions

The guidance recommends that States use the IPCC (Intergovernmental Panel on Climate Change) definition of international and domestic emissions for the purposes of accounting greenhouse gas emissions as applied to civil aviation as States' reporting obligations in the UNFCCC process are based on the IPCC definition.

Geographic Scope

This was the most controversial issue. Based on advice from the Council, the guidance material outlines advantages and disadvantages regarding approaches for inclusion of foreign aircraft operators in the scheme. One approach is for inclusion through mutual agreement between the State or States responsible for administering the scheme. The other approach is that State(s) operating a scheme that would seek the inclusion of foreign aircraft operators without distinction as to nationality.

Also discussed in the document are different options for the architecture of geographic coverage based on routes, as well as on airspace.

Trading Units (Integration & Linking)

As international aviation emissions are not covered in national Kyoto Protocol inventories, options are discussed on how to integrate international aviation emissions in a scheme open to other sectors in consideration of the current Kyoto accounting system. The general assumption is that aviation is a net buyer of allowances. Several linking options are discussed: borrowing of AAU's (Kyoto allowances), no allocation of allowances, buying of allowances above non-tradable baseline or above tradable baseline. Gateway or clearing house mechanisms[2] can be considered if it is deemed necessary to prevent net selling of aviation allowances into the scheme. Whatever the choice, States are advised to put in place an accounting arrangement that ensures that emissions from international aviation are counted separately and not – whether deliberately or inadvertently – against the specific reduction targets that States may have under the Kyoto Protocol.

Types Of Trading Systems

This discussion includes different trading systems such as: cap and trade systems, credit systems, absolute and relative trading systems, and project-based mechanisms such as the clean development mechanism (CDM) and joint implementation (JI) under the Kyoto Protocol. Different approaches to generate a baseline or a cap for aviation are discussed as well.

Allowance Distribution Through Benchmarking

Aircraft operators may receive their allowances at the start of a trading period either from auctioning or through amounts distributed by the authority. Auctioning or grandfathering allowances based on historic emissions are not aviation-specific issues. The guidance therefore focuses on benchmarking as a distribution method applied to aviation under a benchmarking approach whereby allowances are distributed according to a specific formula based on a benchmark parameter that reflects the amount of emissions in relation to a level of activity representative of the sector.

A range of potential methodologies and parameters can be considered, including using revenue ton kilometers (RTK) or available ton kilometers (ATK).

Where States choose benchmarking over grandfathering or auctioning, the guidance recommends that a benchmark parameter be designed that: focuses on emissions performance of aircraft, rewards previous investments in new technology, provides incentives to operate the most emissions efficient aircraft in the most efficient way into the future, and avoids unintended distributional effects between different business models as much as possible.

Monitoring, Reporting, Verification, and Enforcement

Monitoring and reporting of emissions is an important element of any trading system and is indeed aviation specific. For monitoring and reporting the guidance recommends that, when possible the method with the highest accuracy should be applied. Calculations based on actual trip-fuel data relating to each individual flight is the preferred option and should perhaps be encouraged. Both the accuracy of the reported data as well as the environmental effectiveness of the emissions trading system would benefit from this approach.

If actual trip-fuel data cannot be easily obtained, emission modelling techniques can be used to calculate estimates. The level of detail for data can range from actual flight movement data with full flight trajectory information, to origin and destination data. For those trading entities that cannot meet high reporting standards, a minimum reporting standard based on emission modelling techniques that are consistent across the sector could be applied.

For verification of data and methods employed, the guidance suggests that it be carried out by an accredited organisation independent of the organisation whose data are being verified, with the aim of verifying the reliability, credibility and correctness of the data. An entity that meets the auditing criteria normally required by the State would be ideal to carry out a predefined verification procedure. ICAO is one of the organizations, along with State accredited verification entities, that could facilitate or assist such verification.

Finally, the guidance discusses enforcement and notes that various options are available for penalties that might be used. These include: different monetary penalties, restricting noncompliant participant's rights under the trading system, and reducing the number of allowances assigned for subsequent periods. States could consider penalty systems that may be in use for other sectors, and apply similar penalties to international aviation when it is feasible and practical.

Reference

1. This article is based largely on information developed by CAEP as contained in the CAEP/7 Report (Doc 9886) and on Andreas Hardeman and Kalle Keldusild 's presentation entitled, "Guidance on Emissions Trading for Aviation", ICAO Colloquium on Aviation Emissions, 14 – 16 May 2007.

[2] a clearing house mechanism would refer to a central point where aircraft operators would jointly settle their allowances to ensure that there would be no net flow of aviation allowances into the scheme.

Voluntary Emissions Trading for Aviation

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With a view to provide information on the various voluntary initiatives currently being undertaken, ICAO/CAEP developed a Report on Voluntary Emissions trading for aviation. That report describes the general nature and practical experiences of various types of voluntary emissions trading schemes. It also explores how voluntary trading schemes, based on current understanding and practical possibilities, could be considered and perhaps further developed for use by aviation. The full report is available on the ICAO website.[1] .

The following article summarizes the highlights of the report.

Discussion and understanding of voluntary trading systems requires addressing three important questions, as follow:

1. What exactly do we mean by voluntary trading?
2. How can voluntary trading be made to work?
3. What would be reasons for participating in voluntary trading?

To start with the first question, the report defines a voluntary trading scheme as any scheme in which participation by a State is not mandatory. Although, that may seem clearcut, one could legitimately ask the question, for example; Does the conclusion of a voluntary agreement still qualify as "voluntary", if the only alternative is exposure to strong regulatory action, such as taxes, for example?

Further, it is important to bear in mind that voluntary initiatives can range from unilateral actions at the company level to negotiated agreements between governments and sectors. Also, in practice, many voluntary agreements are in fact combined with some sort of incentive and/or disincentive measures. That is why schemes that involve some kind of government incentive for companies to participate also fall under the definition of "voluntary" used in the report.

Voluntary Trading Options for Aviation

The report describes four approaches for setting up Emission Trading Schemes (ETS) for voluntary trading in the aviation sector, focusing on aircraft operators as the main players. The report does not pass judgment as to the desirability or the merits of the different options.

1. Group of Airlines Decides To Create its Own ETS

For example, airline alliance partners might set up an ETS among themselves. This would be a sectoral trading system that could be designed in a way that would allow participants to purchase credits outside the scheme in order to meet their targets and minimize costs.

2. Airline Sector Creates a New ETS Together with Other Sectors

Under this approach, members of a national air transport association might get together, for instance, the national energy companies and the agricultural sector join foces to establish and participate in a national emissions trading scheme.

3. Airline or Group of Airlines Unilaterally Joins an Existing ETS

As part of national efforts to drive technology efficiency and reduce emissions, an airline or a group of airlines could choose to participate in an existing trading scheme administered by another group such as: its own government, a third party government, or a commercial entity such as an independent trading platform.

In addition to the above three options, more direct mechanisms may also be considered, for example:

4. Airline or Group of Airlines Compensates for its Carbon Emissions

Under this scenario, airline players could decide to compensate directly for their emissions through investments in carbon-offset projects that can play an important role in addressing climate change impacts from aviation. A carbon offset facility can either be run by the airline(s) itself (possibly as an option for passengers/customers) or by an independent service provider. In either case, money is paid into a fund that sponsors specific projects to reduce or avoid emissions from sources or remove emissions from the atmosphere through so-called sink projects.

[1] http://www.icao.int/icao/en/env/vets_report.pdf

Key Considerations when Developing a Voluntary ETS

The second important question to deal with when trying to understand voluntary trading systems is "How can it be made to work?". The report mentions a number of considerations that are key in designing a voluntary trading scheme that is both workable and credible. These include, for example, the following:

Environmental Results:

How stringent are the environmental targets? With what degree of certainty will these results be achieved? How likely are entities to participate and how broad is the emissions coverage under the agreement? and; What factors might undermine achieving the environmental results?

Overall Cost and Cost-Effectiveness:

Does the option have adverse effects on the cost-effectiveness of control (i.e. the cost per tonne of CO_2 reduced)? Or; Does it adversely affect overall control costs (i.e., the total costs of abatement plus purchase/sale of emission allowances and/or credits) for the aviation sector (domestic or international)?

Political Acceptability:

How will the trading scheme be viewed by the relevant stakeholders, including airlines and other industry parties that have an influence on aviation emissions but are not direct participants in the agreement (e.g. engine manufacturers, air traffic controllers, governmental and non-governmental bodies, etc.)?

Benefits of Voluntary Trading Schemes

The third question related to understanding voluntary trading schemes is; "What would be reasons for participating in voluntary trading?" To answer this question, the report advances a number of reasons why voluntary emissions trading schemes could be an attractive option for addressing aviation emissions:

Flexibility:

Voluntary trading schemes are not necessarily constrained by the framework of international agreements. This could allow early action under a voluntary framework while discussions on a possible mandatory approach are ongoing.

Cost Containment:

Successful voluntary measures can help minimize costs, compared with regulatory actions. Of course, as the report observes, the incentive to pursue voluntary trading diminishes as the cost of achieving a reduction target approaches that of potential regulations. Therefore, voluntary measures should be cost-effective and have low administrative and transaction costs.

Competitiveness:

Voluntary trading has potential to attract broad geographic participation by both States and airlines. Also, since operators would be unlikely to participate in voluntary trading if there's a risk of undermining their ability to compete, the competitive impacts of a voluntary scheme are likely to be small.

Learning by Doing:

A key benefit of voluntary trading might derive from "learning-by-doing", offering the important advantage of allowing participants to develop skills and learn trading strategies that may be useful as emissions trading schemes are developed in the future.

The CAEP report then goes on to describe key elements of various voluntary trading schemes, including: emissions trading schemes in Japan and the UK, Chicago Climate Exchange, Montreal Climate Exchange, European Climate Exchange, Asia Carbon Exchange, as well as airline carbon offset programs.

One aspect discussed in the report which is worth particular attention, especially in light of current developments, is the increasing interest among private and corporate airline customers who want to voluntarily offset their flight-related CO_2 emissions. For a number of years now, consumers have been able to do so through independent carbon offset providers who sponsor projects aimed at reducing carbon emissions. Initially many of these were through reforestation but they are increasingly related to renewable energy and energy conservation projects in non-Annex I countries. While the overall contribution of these schemes to global emissions reduction is still quite small at the moment, as the report notes there seems to be potential for this type of activity to multiply over time[2].

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[2] Since CAEP/7 the number of airlines introducing carbon offset facilities has steadily increased. At the time of writing British Airways, SAS, Air France/KLM, Lufthansa, Cathay Pacific, Qantas, Air New Zealand, Air Canada, Delta Airlines, Continental, Virgin Blue, Flybe Please see article on carbon-off-set and the ICAO web site for information on the ICAO aviation methodology for calculating aviation carbon offset emissions

Getting Airlines Involved In Voluntary Trading

The last chapter of the report looks at a number of possible ways for airlines to become involved in some form of voluntary emissions trading. Four broad ways are considered in which this might be done.

Firstly, airlines might consider participation in an existing voluntary emissions trading scheme. However, the report finds that there would appear to be very little opportunity for this,either because these schemes are not open to new participants, or they are limited to certain countries, or they do not appear to be easily adaptable for participation by airlines.

Secondly, airlines might consider developing a carbon offset capability. This could either be done as a service offered to customers, or alternatively it could be funded directly by the operator itself. An important difference between these two options – besides the funding – is that in the first case, there is no predetermined amount of emissions reduction, while in the second case there would be.

Thirdly, airlines could consider the development of voluntary agreements as a precursor to an emissions trading system. Such agreements should then include an enforceable commitment to achieve emissions reductions below an appropriate baseline; for example, using a voluntary fuel efficiency target. To the extent that voluntary trading would be part of a voluntary agreement between government and industry partners, the ICAO Template for Voluntary Measures may be a useful reference document, although in that case the ICAO Template would have to be adapted for this specific purpose.

Finally, one could envision the establishment of an aviation-only voluntary emissions trading scheme. The report notes that given the greater worldwide focus by governments on solutions to climate change issues, the likelihood of government support for this type of solution would be expected to increase over time.

The Way Ahead

The final section of the CEAP report addresses future developments and describes some of the commonalities and differences between voluntary and mandatory trading schemes, making reference to the ICAO Guidance on Emissions Trading for Aviation addressed earlier in the previous article. It briefly discusses the role that ICAO could potentially play to encourage and support the development of voluntary schemes that interested Contracting States and international organizations might propose. While recognizing that ICAO may not wish to be directly involved in setting up voluntary emissions trading schemes, it is suggested it could play an important facilitator role, by:

- Providing a forum to develop and review voluntary emissions trading schemes;
- Encouraging the use and recognition of such schemes;
- Providing technical information to support such schemes;
- Encouraging consistency between such schemes;
- Facilitating or assisting in the verification of aviation emissions data.

Reference

1. This article is based largely on information developed by CAEP as contained in the CAEP/7 Report (Doc 9886).

A Proposed Emissions Trading Scheme For Aviation

By Niels Ladefoged

Niels Ladefoged is a policy officer in the Clean Air and Transport Unit of the European Commission's Directorate-General for the Environment. He has been working on environmental aspects of EU air transport policy since 2001 and has been responsible for developing the Commission's new strategy on aviation and climate change. Before joining the Commission, Mr. Ladefoged worked for the Danish Energy Administration on a number of issues ranging from energy demand forecasting to renewable electricity support schemes. Niels Ladefoged has a Master of Science in Mechanical Engineering with specialisation in energy conversion and emissions.

In December 2006 the European Commission proposed draft legislation to bring aviation CO_2 emissions within the European Union's Greenhouse Gas Emissions Trading scheme ("EU ETS"). The proposal aims at reconciling the aviation sector's future growth in Europe with the need for significant reductions in global greenhouse gas emissions from all sectors.

The Unique Status of International Aviation

International air transport is different from most other sectors in terms of how its greenhouse gas (GHG) emissions are accounted for under the 1992 United Nations Framework Convention on Climate Change (UNFCCC). Emissions from international flights are not included in the national GHG emission totals reported by Parties to the UNFCCC, and are therefore not subject to the quantified emissions limitations accepted by the developed countries which ratified the Kyoto Protocol (see article on 2006 IPCC Guidelines for National Greenhouse Gas Inventories, earlier in this chapter).

Instead, the parties negotiating the Kyoto Protocol agreed to include an explicit, collective obligation for developed countries (i.e. "Annex I countries") to pursue the limitation or reduction of emissions from aviation, working through the International Civil Aviation Organization (ICAO).

This means that the collective nature of the obligation on parties which is a key part of the legal and political pressure, and drives States to implement mitigation measures for other sectors, does not apply to international air transport.

Moreover, the fundamental role of the principle of "*common but differentiated responsibilities*" under the UNFCCC and the explicit distinction between Annex I countries and other countries in the Kyoto Protocol's provision on aviation emissions has made it difficult for ICAO Contracting States to agree on specific measures to be implemented uniformly by all nations. The reluctance of developing countries to commit themselves to more demanding policies, combined with the lack of leadership from industrialized countries has prevented this from happening.

ICAO Policy on Emissions Trading

However, at the 34th session of the Assembly in 2001, ICAO took an important decision by endorsing the idea of using "open" emissions trading for international aviation emissions[1]. Following three years of further studies on options for implementation, ICAO's Committee on Aviation Environmental Protection (CAEP) at its sixth meeting in 2004, concluded that a global, aviation-specific emissions trading system based on a new legal instrument under ICAO auspices "*…seemed sufficiently unattractive that it should not be pursued further*". This was a logical decision given that the institutional infrastructure required for open (cross-sector) trading by definition is not specific to aviation and to a large extent already exists or is being developed under the UNFCCC or by its parties.

ICAO instead decided to pursue implementation by developing guidance for Contracting States to facilitate the incorporation of international aviation into the State's existing emissions trading schemes. This approach is consistent with the principle of "*common but differentiated responsibilities*" as it enables States to decide individually whether or not to implement emissions trading in their country taking into account their level of development, and whether they have an emissions trading scheme in place. By definition, it requires an initiative from the State in question as only the States themselves can amend their own schemes to incorporate aviation. It is this approach which the European Commission has proposed for implementation in Europe.

[1] As opposed to a "closed" system, "open" emission trading refers to a system in which emissions rights can be traded across sectors and not just within a given sector. Open trading is generally considered more economically efficient.

In parallel with work on the proposal, the Commission and EU member States have actively participated in the development of ICAO guidance on emissions trading. The guidance material has benefited greatly from experiences with Europe's existing scheme, as well as findings from studies on aviation specific issues conducted by the Commission as part of developing its own strategy.

The EU Strategy - Emissions Trading as Part of a Comprehensive Approach

In September 2005, the European Commission issued a Communication on reducing the climate change impact of aviation[2]. The Communication recognized that the rapid growth in emissions in the aviation sector undermines progress to reduce emissions made in other sectors, and that a comprehensive approach with several elements is necessary. It stated that this approach must include: more research into cleaner technologies, further improvements in air traffic management, and continued development of ICAO technical standards. It also emphasized that the combined effect of these measures would not be sufficient to offset the growth in aviation emissions. It concluded that market-based measures should also be considered and that including aviation in the EU ETS would be the most cost-efficient and environmentally effective way forward. It therefore indicated that the Commission would put forward a proposal for European Union legislation by the end of 2006.

The Commission's strategy was widely welcomed by EU governments and other EU institutions. Several initiatives have been taken to implement the various elements, of which the proposed emissions trading scheme is just one. Other examples include the "Single European Sky" and "SESAR"[3] initiatives aimed at improving air traffic management and, more recently, the "Clean Sky" Joint Technology Initiative (JTI) presented in June 2007. The latter will set up a public-private-partnership, pooling aircraft industry and Commission resources into targeted large-scale research programmes dedicated to the objective of significant emissions reductions from future generations of aircraft and engine technologies. The EU's Seventh Research Framework Programme will contribute $ 800 million, a sum that will be matched by industry.

The EU Emissions Trading Scheme

The EU ETS is the cornerstone of the EU's market-based strategy to reduce greenhouse gas emissions as cost-effectively as possible. The EU ETS began operation on January 1, 2005 and sets a mandatory cap on the absolute emissions from around 10,600 large energy intensive installations across the EU. It covers around 2 billion tonnes of CO_2 or about half the EU's total CO_2 emissions.

Under the scheme, operators are allocated allowances, each giving them a right to emit one tonne of carbon dioxide per year. The total number of allowances allocated sets a limit on the overall emissions from the activities covered by the scheme. By April 30th each year, operators must surrender allowances to cover their actual emissions. Operators can trade allowances so that emissions reductions can be made where they are most cost-effective. In addition to allowances allocated under the scheme, operators can also use credits from emission-reduction projects under the Kyoto Protocol's Joint Implementation (JI) and Clean Development Mechanism (CDM) to cover their emissions. The EU ETS is already a major driver for the global carbon market and European demand for credits represents a large part of the investments generated in developing countries through the CDM (see Box 1).

Main Features of The Proposed Trading Scheme For Aviation

On December 20, 2006, the Commission adopted a legislative proposal to extend the EU ETS to aviation. The proposal is accompanied by a detailed impact assessment evaluating the pros and cons of various design options, and the magnitude of likely economic, social and environmental effects.

An important objective of the proposal is to provide a model for aviation emissions trading that can be a point of reference in the EU's contacts with key international partners and to promote the development of similar systems worldwide. The Commission also supports the objective of a global agreement aimed at effectively tackling aviation emissions as part of worldwide efforts to mitigate climate change.

[2] See http://ec.europa.eu/environment/climat/aviation_en.htm
[3] SESAR : Single European Sky ATM Research

Benefits Of Carbon Trading For Developing Countries

Just as measures to combat climate change will benefit Europe and other developed nations, they are also in the long-term interest of less wealthy countries. Since vulnerable populations are the first to suffer the impact of floods, storms, droughts and the other effects of climate change, developing countries have every interest in joining the global effort.

But also in a shorter timescale, the carbon market and not least the EU ETS create tangible benefits in terms of inward investments in countries all over the world through the Clean Development Mechanism (CDM) and Joint Implementation (JI) projects under the Kyoto Protocol. Examples of countries which already benefit substantially from such projects are:

- India - 459 projects in pipeline, amounting to 278 Mt[4] CO_2 eq.
- Brazil - 190 projects in pipeline, amounting to 148 Mt CO_2 eq.
- China - 177 projects in pipeline, amounting to 519 Mt CO_2 eq.
- Mexico - 132 projects in pipeline, amounting to 57 Mt CO_2 eq.
- Other countries – 316 projects

EU ETS is a key driver for these investments, and the expected market for JI and CDM in the EU ETS of up to 1.3 billion tonnes over 2008-12.

Source: New Carbon Finance

The key aspects of the proposal are as follows.

Scope

- At its start in 2011, only flights between EU airports would be included in the scheme. From 2012 this would be extended to all flights arriving at or departing from an EU airport;

- The scheme would not apply to flights arriving from any third country that puts in place equivalent measures to reduce the climate change impact of aviation;

- The scheme would only cover CO_2 emissions. The Commission will carry out a study and evaluation of the options to address nitrogen oxide (NO_x) emissions and put forward a further proposal, supported by an impact assessment, by the end of 2008.

Allocation

- In contrast to the existing EU scheme, the method of allocating allowances would be harmonized at EU and not at Member State level;

- The total number of allowances to be allocated to the aviation sector would be determined by reference to average emissions from aviation in the years 2004-2006;

- The majority of allowances would be allocated free of charge on the basis of a benchmark to aircraft operators which submit an application (the earliest application relating to 2008 data).

- In the first period, a small proportion of allowances (expected to be around 3%) would be auctioned. Thereafter, the percentage auctioned would be decided in the light of the results of the general review of the EU ETS due for completion later this year;

- Auctioning proceeds would be used to mitigate and adapt to the impacts of climate change and to cover administrative costs (see Box 2).

Access to Reduction Options in Other Sectors

- If necessary, aircraft operators would be able to buy allowances from other sectors in the scheme to cover increases in their emissions;

- Aircraft operators would also be able to use project credits – so-called Emission Reduction Units (ERUs) and Certified Emission Reductions (CERs) - from the Joint Implementation or Clean Development Mechanisms (JI/CDM) provided for in the Kyoto Protocol up to a harmonized limit equivalent to the average of the limits applied by EU Member States for other sectors in the EU ETS;

[4] Mt : Million Tonnes

Use Of Auctioning Revenues

The Commission has proposed that any proceeds from the auctioning of these allowances should be used to mitigate greenhouse gas emissions to: adapt to the impacts of climate change, fund research and development for mitigation and adaptation, and cover the costs of administering the scheme. The use of auctioning proceeds should in particular fund contributions to the Global Energy Efficiency and Renewable Energy Fund (GEEREF), and measures to avoid deforestation and facilitate adaptation in developing countries.

GEEREF is an innovative global risk capital fund set up by the European Commission in 2006 to mobilize private investment in energy efficiency and renewable energy projects in developing countries and economies in transition.

GEEREF will help to provide clean, secure and affordable energy supplies to some of the 1.6 billion people around the world who currently have no access to electricity. It will do so by accelerating the transfer, development and deployment of environmentally sound energy technologies. This will combat both climate change and air pollution, and will contribute to a more equitable distribution of Clean Development Mechanism projects in developing countries.

The Commission is investing $ 80 million into GEEREF over four years. Additional pledges, including those from Germany, Italy, and Norway, bring the total amount of investment so far to $ 122 million. This funding is expected to mobilize additional risk capital of between $ 300 million and $ 1 billion in the longer term. GEEREF should be operational and making initial investments before the end of 2007.

Administration

- Like other participants in the Community scheme, aircraft operators would have to monitor their emissions of carbon dioxide and report them to the competent authority. Member State by March 31st each year. The reports would be independently verified to make sure that they are accurate. The basic principles for monitoring, reporting and verifying of emissions set out in the proposal would be elaborated by guidelines;

- Aircraft operators would be the entities responsible for complying with the obligations imposed by the scheme;

- In order to avoid duplication and an excessive administrative burden on aircraft operators, each aircraft operator, including operators from third countries, would be administered by one Member State only;

The full proposal and supporting impact assessment can be accessed on the Commission's website at the following address:
http://ec.europa.eu/environment/climat/aviation_en.htm

Next Steps

It is emphasized that this is currently a *proposal* for legislation, and as such has no legal force. Before it can become European law it must be adopted by the Council of Ministers and the European Parliament. This process is known as the co-decision procedure and could take between one and three years. Once adopted there will be a further period for EU Member States to make the necessary legislative and administrative arrangements to implement the legislation.

The Commission presented its proposal after an open public consultation in 2005 accessible to all stakeholders via the Internet and after detailed discussions with any stakeholders expressing an interest. However, the Commission remains open to discuss any aspect of its proposal with stakeholders in and outside of Europe. As the proposal must be agreed by both the Council of Ministers and the European Parliament to become law, it is equally important to discuss potential concerns and possible remedies with the EU Member States (who together will define the position of the Council of Ministers), as well as members of the European Parliament.

Voluntary Emission Reduction Schemes and the Way Forward

By Katsuhiro Yamaguchi

Mr. Yamaguchi is a Professor at the Graduate School of Public Policy, University of Tokyo, where he is in charge of the International Transport Policy Research Unit. Before that he was Director of Planning and Research, Civil Aviation Bureau, Ministry of Land, Infrastructure and Transport, Government of Japan. There, he was responsible for a variety of aviation policy issues, ranging from airport construction, planning and financing, to global warming issues. He has been on leave from that department since 2005 when he assumed his current position. Mr. Yamaguchi holds a Bachelor of Law and a Master of Business Administration.

This article discusses voluntary emission reduction schemes in air transport and tries to find the path that could lead to sustainable growth. It is composed of three parts. First, it addresses basic issues by defining key concepts involved in voluntary emission reduction schemes. Second, as a case study, the unilateral commitment by Japanese airlines is described and analyzed, and an econometric analysis identifies the impacts of such an action. Finally, the paper concludes by highlighting key factors for identifying "The Way Forward."

Basic Issues and Definitions

Before discussing this subject in detail it is important to understand two basic concepts related to the reduction of emissions; the exact meaning and approaches to emission reductions, and the schemes that are used to achieve them.

Emission Reductions

The most orthodox definition of "emission reductions" is when the level of emission is projected into the future by the business as usual (BAU) case and then reduced by introducing new initiatives, such as installing new efficient aircraft and engines, improving operational efficiency, utilizing alternative fuel, etc.

The second approach is what is often referred to as an offset by which the end user pays money to mitigate what he/she has emitted. For example, approximately three tons of CO_2 emissions per passenger would be caused by a round trip journey between Tokyo and Montreal. Under the offset scheme, the carrier involved would provide money to an institution that would offset the environmental footprint of that flight by taking such actions as tree planting, carbon storage, etc. Some claim that this is not a true "reduction" since it may only serve as an excuse for pollution. However, it is believed that if the offset is executed properly, it would contribute to stabilize net emission levels. Today, there are numerous offset programs in operation throughout the world, although accreditation of programs and standardization of the method of calculating CO_2 emissions from specific trips, are both issues that need to be resolved. There is currently an initiative in ICAO to develop a standard methodology for the assessment of aviation emissions for offsets schemes (see article on the *Carbon Offset Project*).

The third way to look at emission reductions is in terms of units of reduction. Emissions are a product of CO_2 intensity and the level of output. Thus, reductions may be achieved through decreases in CO_2 intensity or in the absolute emission level. This difference is important because intensity targeting is more equitable when there is discrepancy in growth of output.

Voluntary Schemes

There are a number of issues that need to be addressed in explaining the meaning of voluntary emission reduction schemes and programs. First, it is important to define "who" is taking the voluntary action. Normally, we have the end users such as the airlines or passengers/shippers in mind when voluntary action is discussed. Other intermediate parties and stakeholders such as airports, aircraft/engine manufacturers, fuel suppliers, ATC providers, etc., are usually regarded as infrastructure rather than as end users. Measures taken by these groups are equally as important as steps taken by the end users, but the end users do not have direct control over the infrastructures. Thus, it should be noted that we are basically focusing in this article on actions taken by the end users when referring to voluntary actions.

There can also be various types of voluntary schemes, some of which are linked to other mechanisms, and others which are not. The unilateral commitment by airlines in Japan is an example of the latter. There are other schemes that have linkages to agreements among governments or that exist because of participation in an emission trading scheme. This leads to categorizing voluntary schemes in terms of whether incentives are provided or not. Unilateral commitments usually do not involve monetary incentives because social returns are what make them work. In many programs, some sort of reward is provided when a target is achieved and penalties are imposed when targets are missed. Voluntary Emissions Trading Systems (ETS) in UK and Japan offer tax-breaks and subsidies for participants that meet targets.

Finally, a clear distinction should be made between voluntary schemes and market-based options. Market-based options usually involve taxation, charges, or emission caps and are essentially a mechanism to offset social costs when the exact causes of emissions cannot be identified.

Air Transport in Japan: A Case of Voluntary Emission Reductions

The best way to understand how a voluntary emissions program works and to get a sense of its impact is to look at an actual case study such as the voluntary emission reduction scheme that was implemented for air transport in Japan.

CO_2 Emissions and Domestic Air Transport In Japan

The transport sector in Japan, is estimated to be responsible for 20% of total domestic green house gas (GHG) emissions, with air transport covering 4% of that, making it a relatively small sub-segment. Also, due to the utilization of modern aircraft and substantially larger fleet sizes, the CO_2 intensity of air transport in Japan has been approximately 20% below that of the average for global international air transport.

In Japan, as with most developed nations, the automobile makes up the major sub-segment of transport, accounting for two-thirds of total transport emissions. One characteristic that makes Japan's overall transport system relatively efficient is the extensive utilization of high-speed railways.

After Japan signed the Kyoto Protocol in 1997, the airline industry initiated a voluntary plan as part of multi-sectoral program implemented by Nippon Keidanren (Japanese Business Foundation). The target was set at 10% reduction in CO_2 intensity between 1990 and 2010. This voluntary plan was consolidated into the overall transport-sector program by the Ministry of Transport and then into the National Global Warming Prevention Package (NGWPP). Originally, intensity targeting was used for that target, but in 2002 the revised version of the NGWPP converted this target into absolute levels.

This 20% lower level of CO_2 in Japan shows how aircraft size can have a significant effect on CO_2 intensity. Average aircraft size in Japan is about 20-30% larger than the global average which accounts for about half of the intensity gap (elasticity is -0.5). Also, average aircraft age of the Japanese commercial fleet is about 20% younger than the global average, which is the other major factor that accounts for the difference. The following figure illustrates this difference caused by different fleet characteristics.

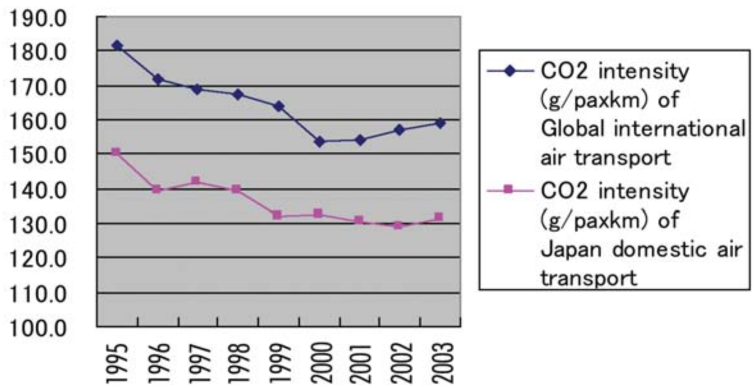

Table 1: Voluntary CO_2 Reduction Plan In Domestic Air Transport In Japan.

Year	Action Taken	Emission Reduction Targets	Related Events
1997	Airline voluntary plan initiated as part of multi-sectoral program by Nippon Keidanren (Japan Business Federation)	CO2/ASK -10% by 2010 (base year 1990)	COP3
1998	Airline voluntary plan consolidated into transport-sector program by Ministry of Transport		COP4
1999	Voluntary plan incorporated into the Global Warming Prevention Package	CO2/ASK -7% by 2010 (base year 1995)	COP5
2002	CO2 intensity target is converted into CO2 emission level in the Global Warming Prevention Package (version 2)	1.1 MT-CO2 reduction by 2010 Japan ratifies	COP3
2004	Airlines achieved 1.77 MT-CO2 reduction (CO2/RPK -14%)		COP10/MOP1
2005	Reduction target revised and incorporated into the legal framework of National COP3 Achievement Plan	1.9 MT-CO2 (CO2/RPK -15%) reduction by 2010	COP3 comes into effect

A follow-up was done in 2004 that revealed that the airline industry was doing very well and had in fact already accomplished the target. So, in response to a government request for a revised target, the airlines came up with the current target to reduce emissions to 1.9 CO_2-MT; which is equivalent to a 15% reduction in intensity from 2005 to 2010. Table 1 lists the calendar of events that led to this.

The performance of domestic air transport in Japan has been quite promising and we can see from Figure 1 that it has achieved sustainable growth when compared to the BAU case.

In 1985 CO_2 intensity for the air transport sector was 30% higher than for private automobiles but by 2005 the situation was reversed with the CO_2 intensity for the air transport at 25% below private automobiles. In fact, air transport is the only subsegment of the transport sector that has reduced CO_2 intensity.

Impact Of The Voluntary Plan

The logical question at this point was whether the emission reductions observed could be attributed directly to the implementation of the voluntary plan. To determine this, an econometric analysis was conducted to see exactly what was behind the change in CO_2 intensity. The equation that was used to estimate this scenario was as follows:

$$\ln(CO2/paxkm) = c + \alpha_1 t + \alpha_2 d + \alpha_3 \ln(dis) + \alpha_4 L/F + \alpha_5 \ln(capa) + \varepsilon$$

The dependent variable ($CO_2/paxkm$), is the amount of CO_2 emitted per revenue passenger-kilometer (RPK), and it is a function of five(5) variables as follows:

Natural log is taken for variables using "*ln*." Technological and operational improvements are captured by the time trend (*t*). A dummy variable for 1998 and onwards (*d*) is included to see if there is any systematic change after the voluntary plan. Constants are: average stage length (*dis*), load factor (*L/F*), and average aircraft size (*capa*). ε is the error term. The dependent variable is expressed in log form so that the time trend (*t*) could be seen as annual improvements, and the dummy variable (*d*) as a shift from the trend. The equation was estimated by autoregressive model (AR1) using 1985-2005 data.

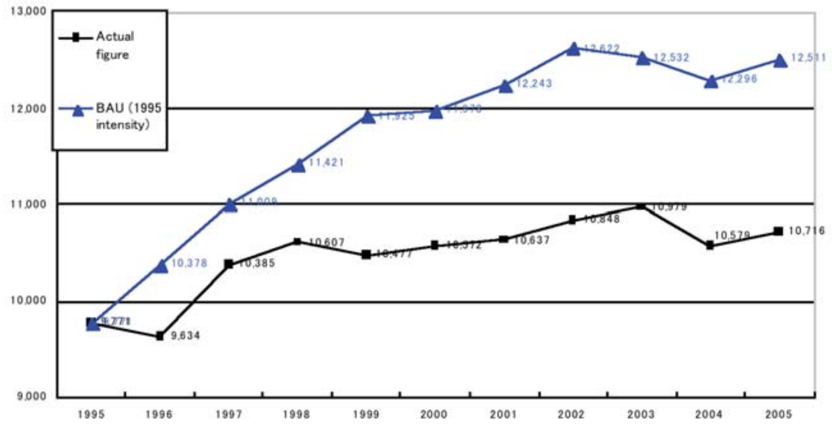

Figure 1 – CO_2 emissions from domestic air transport in Japan.

The result of the regression analysis is listed in Table 2. From 1985 to 2005, a 1.1% per annum efficiency gain is observed. In addition, there is a clear sign of a one-time efficiency gain of 3.6% after 1998. Other year dummies were tested and the best fit was 1998. To enhance robustness, a similar analysis of US domestic and global international air transport markets was conducted. There were no signs of systematic change after 1998 in these markets.

Table 2 – Results of the econometric analysis.

parameter	estimate	standard error	t-statistics
c	6.90	0.35	19.45**
t	-0.011	0.001	-11.44**
d	-0.036	0.008	-4.52**
In(dis)	0.26	0.09	2.95**
L/F	-1.24	0.06	20.98**
In(capa)	-0.49	0.07	-7.03**
rho	-0.37	0.20	-1.90

Dependent variable: In(CO2/RPK)
**: Significance, p<0.01 Adjusted R2: 0.982

Based on this analysis, it appears that voluntary measures had a clear impact on CO_2 intensity improvements in Japan. This has a number of policy implications for international air transport. For example, would voluntary measures worldwide serve as a gateway to sustainable growth? Which is appropriate for targeting internationally; CO_2 intensity or absolute levels? What is unique about international air transport compared with domestic air services?

The Way Forward

Based on what we know to-date, it is difficult to draw conclusions about these questions. However, there are some implications that should be taken into account when we consider the next step.

The following two graphics put the current CO_2 emissions situation into perspective by depicting international aviation and marine CO_2 emissions from fuel consumption. Figure 2 shows total CO_2 emissions from air and marine transport fuel combustion in terms of tons, while Figure 3 shows those same emissions as a percetage of total global CO_2 emissions.

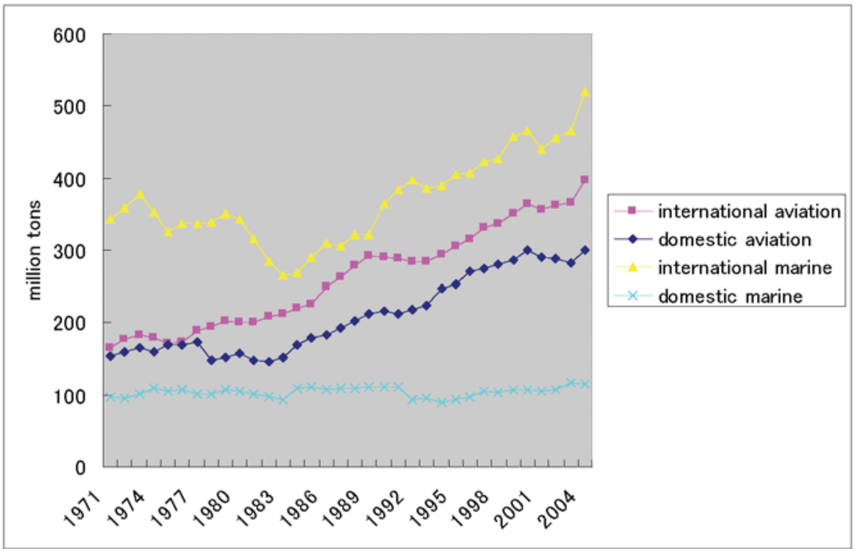

Figure 2 – CO_2 emissions from air and marine transport fuel combustion.
Note: international aviation and marine data are for "international bunker fuel."
Source: International Energy Agency.

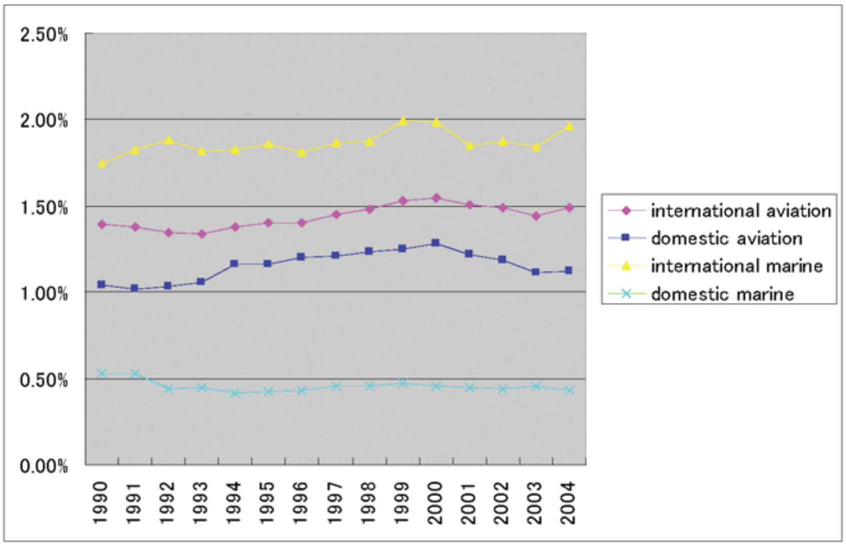

Figure 3 – CO_2 emissions from air and marine fuel combustion as a percentage of aggregate global CO_2 emissions.
Note: international aviation and marine data are for "international bunker fuel."
Source: International Energy Agency.

Past Trends and What Lies Ahead

From 1990 to 2004, global international air transport in RPK increased from 556 billion to 2,015 billion; a growth rate of approximately 6% per annum[1]. During the same period, total CO_2 emissions from global air transport increased from 290 million tons to 397 million tons; 2.2% growth per annum. The air sector's share of global CO_2 emission is relatively low and quite stable at 1.5%[2]. This performance is quite significant since the 3.8% difference between the 6% growth in output and the 2.2 % CO_2 emission increase represents an improvement in CO_2 intensity.

During the same period, global CO_2 emission per GDP fell by only 1.0% per year. ICAO/CAEP forecasts a 4.3 % annual growth in RPK for the period 2000 to 2020. The question then becomes; how much in CO_2 emission increases from this output growth could be offset by CO_2 intensity improvements, and is there a need for additional reductions?

Special Features of International Air Transport

The basic objective of overall GHG mitigation policy is to stabilize its concentration levels. There is no doubt that in order to stop the atmospheric concentration from rising, GHG production must be controlled. However, is it rational to apply the same framework to international air transport as to other sectors?

It is believed my many that there are important aspects of international air transport that deserve special attention such as:

- International air transport, together with international maritime transport, facilitates international trade and cross-border mutual understanding. This unique role needs to be taken into account.

- The global political economy is complex. Not only does international air transport involve 190 contracting states (both North and South), but in addition to governments, it consists of multiple stakeholders such as airlines, aircraft/engine manufactures, airports, ATC providers, fuel industry, etc.

[1] ICAO statistics compiled and calculated by the author. Two major factors are behind demand growth; economic growth and reduction in airfare. Between 1990 and 2004, global GDP grew by 2.6% per annum and average airfare declined by 3.4% per annum.
[2] IEA international bunker fuel data compiled and calculated by the author.

- The very fact that international air transport involves cross-border operations requires coordination among multiple nations. Thus, steps taken by individual states often have multiple extra-territorial effects.

Clearly, policy formulation needs to be based on international multi-agent collective goal-setting. There should be a clear distinction between general global warming prevention policies and schemes to mitigate CO_2 emissions in international air transport.

The Way Forward

Figure 5 depicts the governance structures for various reduction schemes. The left-hand side shows the regulatory and market-based measures; "hard governance." On the right-hand side, the "voluntary schemes" are listed. They are based on internal motivations. The obvious questions arise. Why are there differences in the governance structure? Which type should be chosen under what circumstances?

If we place emphasis on technology-driven dynamic sustainability it may be appropriate to start off with the soft governance and encourage stakeholders to take their own initiatives. The global political economy of international air transport is too complex to jump on the first solution that comes along. In the medium-term we may move on to something strict. As the expression goes, "More haste, less speed."

CO_2 emission targeting for aircraft manufacturers by independent experts initiated in ICAO/CAEP is a good starting point. CO_2 intensity targeting could also be effective and fair for the airlines, whether the scheme is voluntary or not. As we have demonstrated above with the Japanese experience, international air transport does have the capability of improving efficiency.

Thus, "the way forward" with respect to global aviation emissions depends on what consensus can be reached by the international air transport community in terms of what has to be done, who should be responsible for what; as well as time-frames to accomplish the goals set. The first step would be to reach consensus on the extent to which aviation contributes to global warming and then send out a credible and convincing message to that effect. Confrontation is counter-productive. In the international aviation community, we all need to move forward in the same direction. To this end, ICAO is expected to serve as a continuing forum for policy formation. The welfare of future generations rests on all of our shoulders.

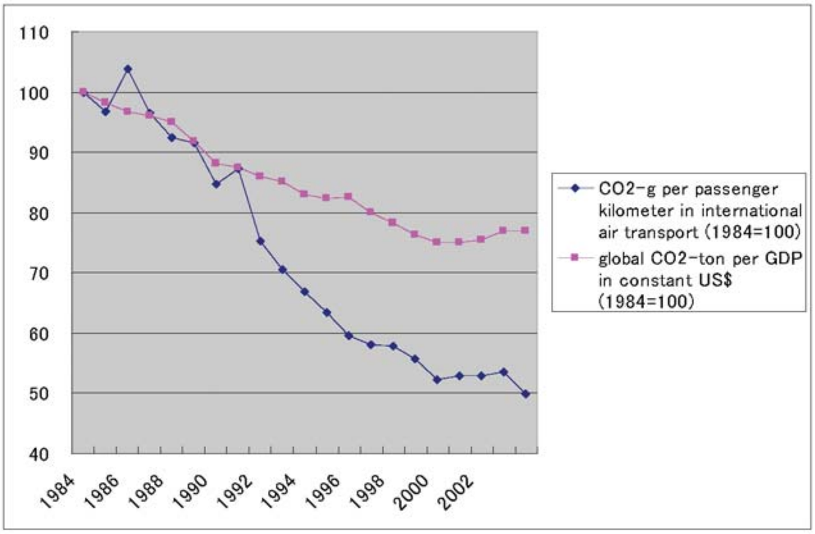

Figure 4 – Comparison of CO_2 intensity levels.
Note: CO2 per passenger kilometer in international air transport: (1)/(2) 1984=100.
Sources:
(1) CO_2 emission: CO_2 Emission from Fuel Combustion (International aviation bunker fuel[3]), International Energy Agency.
(2) International scheduled passenger kilometers performed: ICAO data.
Global CO_2-ton per GDP in constant US$: (3)/(4) 1984=100.
(3) Global CO_2 emission: CO_2 emission from fuel combustion, International Energy Agency.
(4) GDP in constant US$ (2000): World Economic Outlook Database, International Monetary Fund.

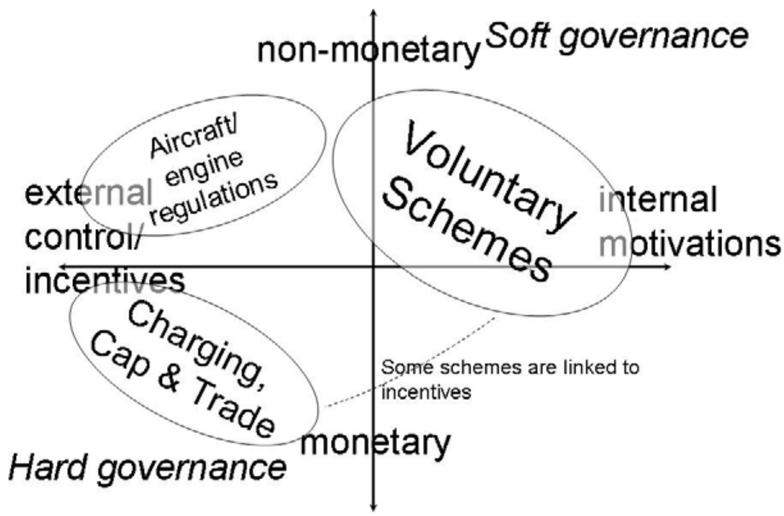

Figure 5 – Governance structures of various schemes and policy options.

[3] Appropriated by revenue share of international air passenger transport using ICAO data on international scheduled air transport passenger and cargo revenues.

Aviation Carbon Offsetting

By Peter Clarke and
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The purpose of this article is to provide a description of carbon offsetting and an update of ICAO's efforts in this area. Specifically, the article explains the concept of carbon offsetting, discusses the factors involved in calculating per-passenger air travel emissions and describes some existing per-passenger aviation emissions methodologies. The article concludes with a summary of ICAO's ongoing work to evaluate per-passenger aviation emissions calculators outlines ICAO's efforts to develop a credible and transparent guideline for aviation carbon offsetting to be used by consumers and offset programme providers alike.

What is Carbon Offsetting?

Human activities, including aviation, release a number of greenhouse gases (GHG) such as carbon dioxide (CO_2), in the atmosphere and methane (CH_4) and nitrous oxide (N_2O). The impact of these gases on the climate is complex and is dependent on a host of variables (including atmospheric concentration and relative molecular impact).

Simple everyday actions such as turning on a light, driving to work or flying to a conference utilize fossil fuels. These actions, therefore, produce carbon emissions that contribute to climate change. It is therefore very important that those performing these actions become involved in a concerted and coordinated global effort to reduce the amount of energy they consume.

One way that an individual or organization can help with this effort is through voluntarily offsetting their carbon emissions. 'Carbon offsetting' is the action of compensating for (or 'offsetting') the GHG emissions associated with a given activity, by reducing emissions elsewhere. While offsetting lessens the impact of an individual's actions and raises awareness of his or her personal carbon footprint, it does not actually reduce the emissions contributing to climate change.[1]

Consumers can voluntarily purchase emission reduction credits (or 'offsets') that result from projects that have reduced carbon emissions in some way. Since climate change is a global issue, these carbon reducing projects may occur anywhere in the world.

Some examples of carbon offsetting projects that reduce greenhouse gas emissions are:

- forestation ;
- capture and destruction of greenhouse gases resulting from processes associated with landfill and wastewater treatment facilities;
- large or small scale renewable energy or energy efficiency projects;
- land-use improvement (such as agro-forestry, reforestation, soil conservation); and,
- reducing energy-related emissions through fuel-switching (such as replacing oil-fired burners with natural gas ones).

There are many retail companies that will sell carbon offsets to individuals or organizations interested in voluntarily compensating for the impact that their activities have on the climate, including air travel. Of course, in order to offset emissions from an activity, the quantity of greenhouse gases arising from that activity must be accurately calculated. Difficulties frequently occur, either when accounting for the effectiveness of a project to offset greenhouse gases, or when calculating the emissions to be offset, or both.

Approach to Calculation of Carbon Emissions

Numerous methodologies for calculating per-passenger emissions specific to the aviation industry have been proposed by a range of stakeholders (non-governmental organizations, airlines and for-profit companies). These existing methodologies are not harmonized and differ in terms of transparency, variables included, and formulas used to allocate emissions to the individual passenger.

Determining the per-passenger emissions from a given flight is a complex problem, with many factors that must be considered. The ability to extract and cross-reference vast amounts of difficult-to-access and current data is required, and as a result, primarily explicit assumptions are generally considered a necessity in addition to user inputs and information from existing databases.

[1] Consultation on establishing a voluntary Code of Best Practice for the provision of carbon offsetting to UK customers. Department for Environment, Food and Rural Affairs. January 2007.

The process of determining per-passenger has two stages, firstly calculating total flight emissions and then a per-passenger allocation. The former can be thought of as the total amount of carbon emissions associated with a specific flight, while the per-passenger allocation addresses the distribution of the total flight emissions on a passenger level.

Total Flight Emissions

The following is a non-exhaustive summary of the factors to be considered when calculating total flight emissions.

Gases and Particles that Impact Climate:

The combustion of jet fuel (kerosene) results in gases and particles that have an impact on the climate, including, carbon dioxide (CO_2), nitrogen Oxides (NO_x), and for example water vapour, unburned hydrocarbons and sulphate and soot particles.

For purposes of comparison and standardization, the common practice in climate science is to apply a multiplier called the 'global warming potential' (GWP), resulting in an equivalent amount of carbon dioxide (CO_2). For instance, the GWP of methane is 21; so every tonne of methane is equal to 21 tonnes of CO_2 in terms of its impact on the climate.

Another measure of GWP is known as the Radiative Forcing Index (RFI), which multiplies the amount of CO_2 actually emitted by a factor, accounting for the impact of the other emitted molecules and cloud formation. Although this issue was introduced by the IPCC in 1999, it, has since agreed that the RFI should not be used as an emissions metric since it does not account for the different residence times of different forcing agents.

Meteorological Conditions:

The weather conditions have a large impact on the amount and type of GHG gases (including some pollutants) associated with a flight for two reasons. First, engine performance varies significantly depending on the atmospheric operating conditions. Second, pollutants emitted from engines may react differently in the atmosphere depending on the weather conditions.

Due to the enormous volume of data required, most calculators do not include these effects or assume that they are negated on average. For instance, the increased fuel consumption due to a headwind will be negated by the decreased fuel consumption with a tailwind on the return journey.

Aircraft Type:

Emissions for a given flight are also heavily dependent on the combination of airframe, and engine and their configuration. Separate manufacturers may offer engines for use on a given airframe. Additionally, different configurations may be possible for a given airframe/engine configuration.

Apart from these differences, the age and maintenance history of a given aircraft will have an effect on the emissions. For instance, a recently overhauled engine will likely have better performance than an engine that is about to be overhauled.

Many calculators employ a 'representative' aircraft to address this issue, which generally involves determining an average, weighted or most common aircraft used on a given flight. However, total flight emissions are highly dependent upon the type of aircraft, and reductions in accuracy may occur due to these simplifications.

Flight Path and Cycle:

Of course, one of the main contributor to total flight emissions is the distance traveled. The shortest distance between two points on the globe is called the 'great circle distance'.

However, aircraft rarely, if ever, travel only the great-circle distance to their destination, as there are a number of flight phases, such as landing, take-off, approach and holding patterns that may be necessary due to air traffic movement and control requirements. In addition, in many instances, there may be intermediate stops that add significantly to the total distance traveled. For instance, a flight from Montréal to Prague may land in London.

Finally, during phases of flight such as run-up, taxiing, take-off, cruise, descent and landing, engine operations (and the resulting emissions rates) are radically different. For instance, the thrust setting for an engine during take-off is likely to be much higher than that for the cruise portion of the flight.

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Most calculators require that the user input origin and destination airports or cities; in some cases, the user is asked to supply a distance traveled, which very few travelers are likely to know..

When these factors are not averaged on the whole, various methods are employed to determine fuel consumption rate, including multiplication factors, thrust to fuel consumption ratings and averaged fuel consumption ratings. Typically, these are then correlated with factors representing the phases of flight for those engine settings.

Per-Passenger Allocation

Once the total emissions for a flight have been determined, those emissions must then be allocated to a passenger on that flight.

Aircraft Configuration:

Seating arrangements, even within a single airframe type, can vary significantly from aircraft to aircraft. For instance, one aircraft may be configured to carry a small number of dignitaries, while another may be configured to hold as many seats as possible. As the total emissions are not significantly effected by payload, the number of seats on a flight is an important factor.[2]

However, not all of the available seats on a given flight are necessarily filled. The ratio of the number of filled seat to the total number of seats is called the "load factor".

Many calculators assume an average aircraft configuration and load factor, over an origin/destination pair, region or airline. Few calculators allocate for increased carbon emissions to less dense seating arrangement.

Cargo:

Along with passengers and their luggage, aircraft normally carry a certain amount of other cargo, which is not associated with the passengers on the flight. A fraction of the emissions attribuable to the freight on a flight should therefore not be allocated to passengers.

Some calculators utilize an average freight loading factor, distributing the remaining emissions as discussed above to the passengers on-board.

The interaction of these and other factors not discussed here leads to a per-passenger emissions calculation. However, discrepancies between results are common, due to the range of available data and number of assumptions required.

Existing Per-Passenger Emissions Calculators

There is a range of online retail tools in existence for calculating the emissions associated with a given flight. Each of these calculators uses some combination of implicit or explicit assumptions, user inputs and information from databases. In the section above, the general steps required along with the current common practices (for those calculators where that information is publicly available) of per-passenger calculators were outlined.

Airlines frequently develop partnerships with these companies to assist their customers who wish to offset the carbon from their travel. However, some airlines have independently developed carbon calculators, taking advantage of available and more specific in-house data. Table 1 shows a listing of some common per-passenger emissions calculators and their basic methodologies:

Summary of ICAO's Carbon Offset Project

Aware of the potential environmental benefits as well as the high likelihood for consumer confusion surrounding the issue of carbon offsetting, ICAO has secured the services of experts from ICF to develop a Carbon Offset Project and publish a guideline methodology to calculate the per-passenger emissions of carbon dioxide associated with a given flight. The intention is to provide a reference tool based on this methodology for any user interested in an emissions estimate, using an open and transparent methodology. It also intends to promote the use of this methodology to entities interested in providing carbon offsets with a view to harmonizing the assessment of aviation emissions.

The project involves :

- identifying and reviewing existing methods and available data;
- developing an ICAO approved methodology;
- testing and validating the methodology;
- providing a web-based reference tool; and,
- disseminating the methodology through the ICAO website.

[2] DLR 2000: Databases with emissions profiles of civil jets. Research project 10506085 as commissioned by the German Federal Environmental Agency, TÜV-Rheinland, DIW, Wuppertal Institute for Environment, Climate and Energy.

Table 1: Comparison of existing carbon offset calculators.

Calculator	Basic User Inputs					Specific Variables			
	Flight Number	Seat Class	City Pair	By Airport	Round Trip or One Way Option	Specific Aircraft Type	Virtual or Average Aircraft	Freight Variable	Load Factor
1	N	N	Y	Y	Y	N	Y	N	N
2	N	N	Y	Y	Y	Y	Y	Y	Y
3	N	N	Y	Y	Y	N	Y	Y	Y
4	N	N	Y	Y	Y	N	NA	N	N
5	N	N	N	N	N	N	NA	N	N
6	N	N	Y	Y	Y	Y	N	N	Y
7	N	N	Y	Y	Y	N	NA	N	N
9	N	Y	Y	Y	Y	Y	Y	Y	Only for national airlines.

Source: ICF

ICAO Methodology

The aim of the methodology is to provide per-passenger CO_2 emission estimates that are based on industry averages in a reasonable and transparent manner, while accounting for all relevant factors. These relevant factors may include a passenger load factor and a freight factor based on recent historical route averages. The allocation between the passengers and the freight carried by the aircraft may be based on a revenue mass basis to ensure that neither is allowed to “piggyback” on the other.

In order to account for the differences in capacity the methodology will also provide cabin class factors based on the additional space required for premium seating arrangements. These factors may be based on industry averages as determined by ICAO.

The underlying dataset of the methodology may be that of the EMEP/CORINAIR Emissions Inventory Guidebook (EIG) which is the recommended dataset from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. This dataset includes similar aircraft types in representative aircraft groups. For each of the representative aircraft, discrete mission distances and accompanying fuel burn totals are reported. With the simplifying assumption that all fuel is burned to form carbon dioxide, it is possible to estimate the carbon dioxide emissions associated with any length of flight by interpolation.

The methodology will detail how the data of EIG is combined with the schedules databases maintained by ICAO in order to establish route specific average emission factors. The underlying factors supporting this tool can be updated annually by ICAO and provided in a common format to enable users to update their versions of the carbon dioxide calculator.

The reference tool will require only a minimum amount of information to be provided to it and will report the per-passenger emissions for a given city pair or a series of city pairs in tonnes of carbon dioxide per passenger.
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ICAO has endeavored to engage all interested industry stakeholders throughout the development process, and as a result, the methodology will reflect this consensus approach. The methodology is currently under development and will be evaluated by ICAO/CAEP.

This ICAO tool is part of ICAO’s continuing commitment to support the UN’s efforts to deal with climate change, and it will provide guidance to those participating in carbon offset programme.