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AVIATION REPORT:

Market Based Mechanisms to Curb Greenhouse Gas Emissions from International Aviation

WWF

WWF is one of the world's largest and most experienced independent conservation organisations, with over 5 million supporters and a global network active in more than 100 countries. WWF's mission is stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature, by conserving the world's biological diversity, ensuring that the use of renewable natural resources is sustainable, and promoting the reduction of pollution and wasteful consumption.

The Global Climate & Energy Initiative (GCEI) is WWF's global programme addressing climate change and a move to 100% renewable energy through engagement with business, promoting renewable and sustainable energy, scaling green finance and working nationally and internationally on low carbon frameworks. The team is based over three hubs – Mexico, South Africa and Belgium.

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Company Profile
Vivid Economics is a leading strategic economics consultancy with global reach. We strive to create lasting value for our clients, both in government and the private sector, and for society at large.

We are a premier consultant in the policy-commerce interface and resource- and environment-intensive sectors, where we advise on the most critical and complex policy and commercial questions facing clients around the world. The success we bring to our clients reflects a strong partnership culture, solid foundation of skills and analytical assets, and close cooperation with a large network of contacts across key organisations.

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1. EXECUTIVE SUMMARY

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1. Executive summary

Background

In June 2012, WWF International commissioned a study to examine options for the introduction of a global, market-based measure to address greenhouse gas emissions from international aviation with particular regard to the likely environmental, economic and political implications. Each of the options identified in this report was assessed with regard to WWF International's stated objectives, namely that a global Market Based Mechanism (MBM):

1. Achieves substantial greenhouse gas emissions reductions from international air transport in line with international efforts to keep global warming below 2 degrees Celsius above pre-industrial levels, with the emissions reduction objectives of the current European Emissions Trading System (EU ETS) system serving as a floor;

2. Generates financing for the Green Climate Fund to be used for climate change action in developing countries, at a scale in line with the findings of the World Bank and IMF report on Mobilizing Climate Finance, which was compiled for the G20 Finance Ministers;

3. Conforms to the existing principles and customary practices of ICAO and the Chicago Convention while accommodating the principle of Common but Differentiated Responsibilities and Respective Capabilities (CBDRRC) of the UNFCCC.

Global warming is a serious threat to people and ecosystems, and there is a strong case for dramatically reducing emissions of greenhouse gases, including carbon dioxide, to reduce that risk. Civil aviation accounts for 2 per cent of global CO_2 emissions and, when its non-CO_2 impacts are factored-in, contributes 4.9 per cent of the Earth's warming effect. Dramatic growth is forecasted in the demand for air travel over the next couple of decades in all geographic regions, with annual growth rates in Revenue Passenger Kilometres between 2010 and 2030 ranging from 3 to 6.2 per cent. Even allowing for new technology, fuel projections out to 2050 show a 270 per cent increase against 2006 levels, with levels in 2050 equivalent to 2,200 Mt of CO_2 per annum; this is approximately 11 per cent of global CO_2 emissions on a less than 2˚ C degree trajectory, approximately 7 per cent of global CO_2 on a 2-2.5˚ C degree trajectory, or 3 to 4 per cent of global CO_2 on a business as usual trajectory. According to UNEP, combined emissions from shipping and aviation may represent as much as 10.0 to 32.5 per cent of median total emissions in 2050.[1]

In-sector emission reductions from technology, operations and alternative fuels are unlikely to be sufficient to keep pace with the growth in traffic, and market-based measures (MBMs) may be able to meet the shortfall. For this reason, both industry and the International Civil Aviation Organisation (ICAO) have set their respective 2020 and 2050 goals based on CO_2 net of reductions purchased from other sectors.

[1] UNEP (2011) *Bridging the Emissions Gap*

Consideration of MBMs for the aviation sector

Article 2.2 of the Kyoto Protocol in 1997 required developed countries to pursue the limitation or reduction of emissions from international aviation working through ICAO. Since then, ICAO has been unable to reach a consensus on a global MBM despite many years of considering the role of levies on emissions, an aircraft efficiency charge, and open and closed emissions trading schemes. At the heart of this debate lies a perceived conflict between ICAO's principle of non-discrimination (the similar treatment of all carriers on a given route irrespective of nationality) with the UNFCCC's principle of Common but Differentiated Responsibilities and Respective Capabilities (CBDRRC). Many developing countries interpret CBDRRC to mean their airlines should not be subject to emissions reduction obligations, even in a sectoral context.

The absence of a global measure for international aviation (including the absence of a duty on fuel) makes it a logical target for other policy-making bodies and the sector has attracted significant attention. The UN Secretary General's High Level Advisory Group on Climate Finance (AGF) identified international aviation (and shipping) as a potential source of climate finance for developing countries, and subsequent work by the World Bank estimated that these sectors could generate $40 billion per annum by 2020 with a carbon charge of $25/tCO_2$. The work introduced the idea of compensating developing countries for their costs of participating in a global scheme, thus offering the possibility of breaking the deadlock hampering ICAO's considerations. According to the World Bank's analysis up to $24 billion could therefore be available annually , after rebates, from measures to reduce aviation and shipping emissions. The response by parties to ICAO to the suggestion of aviation contributing to climate finance has not been enthusiastic, however, it has led to renewed efforts within the organisation to reach agreement on a global MBM to deliver its goal of no net increase in emissions from 2020 onwards (setting a goal based on net reductions assumes that the carbon markets will play a role in offsetting the growth of aviation beyond 2020 levels).

In addition, the EU's 2008 decision to include aviation in its Emissions Trading System (ETS) from the start of 2012 has brought strong criticism and opposition from many non-EU states, adding to the pressure on ICAO to agree on a a global approach to MBMs. An ICAO decision to implement an appropriate global scheme could provide an acceptable solution for parties on all sides of the debate.

MBM options

ICAO plans to agree a proposal for a global MBM at its March 2013 Council meeting and has created a working group, supported by experts, to evaluate a range of options. The three options still under consideration include offsetting, offsetting with a revenue generation mechanism and a global cap and trade ETS. All the options rely on access to out-of-sector allowances and project credits through the carbon markets to allow the industry's gross emissions to grow above the 2020 target, but the fundamental difference is that a cap and trade system requires the creation of allowances for all emissions under the cap, thus covering all emissions from flights. Both the cap and trade option and the offsetting with a revenue distribution mechanism have the potential to raise revenues that could be used to fund further in-sector reductions, contribute to climate finance and/or compensate developing countries.

ICAO has ruled out further consideration at this time of an emission levy based solely on the objection that the 2020 environmental goal, without access to the carbon markets, would require a relatively high cost to influence demand (estimated in a report commissioned by ICAO to be in excess of $350/t$CO_2$). However, set at a lower rate, a fuel/carbon levy could generate significant revenue that, in part, could fund the purchase of emissions unit credits or allowances. Unlike ICAO's option for offsetting plus a revenue generation mechanism, this option would apply a price to all fuel sold or CO_2 emitted, raising more revenue and ensuring that the full environmental cost of flights is internalized. Like most levies, these are relatively straightforward to collect and administer, and could even be applied upstream on fuel suppliers to reduce the number of participants. This alternative approach has been assessed in this study, alongside options currently under consideration by ICAO.

The effectiveness of each option will be dependent on the design criteria selected, including decisions on the participants, the stringency of the environmental target, the availability and quality control of offsets, and the coverage of emissions which depend, in part, on exclusions and de minimis provisions affecting the treatment of small carriers, the size of aircraft and/or developing countries. The study considered these elements against a series of assessment criteria consistent with the approach being taken by ICAO (and, in relation to an MBM for shipping, by IMO) to determine how well each option performed against the study's objectives. The results are presented in full in Chapter 6. They are summarised here and in table 1 at the end of the executive summary.

CO_2 reduction: To date ICAO has focused its attention on CO_2 emissions as opposed to all GHG impacts. ICAO's aspirational 2020 climate change goal to cap further net emissions growth would limit emissions to approximately 660 million tonnes of CO_2 (MtCO_2) per annum. Without further intervention, aviation emissions are predicted to increase above 660 MtCO_2 per annum, reaching 800 MtCO_2 by 2025, 980 MtCO_2 by 2030, and more than 2,150 MtCO_2 by 2050. However, for many developed countries emissions would have to fall below current levels so that global warming stays below 2 degrees Celsius and to allow room for growth in emissions of developing countries. While ICAO's 2020 goal is used for assessment purposes, several States have called for more ambition and the environmental objective of a global MBM will be part of ICAO's future considerations.

Economic costs and benefits: The treatment of increased costs is the same for all four options, but there are differences in the way they are administered, the distribution of costs and benefits, and the revenue made available for spending. Under any of the four market-based instruments considered in this report, operating costs rise, although this is offset (to a degree) by action being taken in response to make both planes and airline operations more efficient. Higher operating costs in turn lead to higher freight rates and ticket prices. In travel markets, the distribution of costs between consumers and airlines is determined by the rate of cost pass-through. In general, the majority of costs will fall onto consumers. Vivid Economics (2007) has estimated cost pass-through rates of between 80 and 150 per cent, which means that at most 20 per cent of the direct costs of market based instruments fall onto airlines. However, even in scenarios with cost pass-through rates of more than 100 per cent, airlines may face reduced profits. If the profit reduction from selling fewer tickets (caused by higher prices) is greater than the increase in total profits from a higher profit per ticket (caused by cost pass-through greater than 100 per cent), then airlines will have lower profits. Between airlines, those with inefficient planes will lose volume, if they raise prices more than their competitors, and profitability, if they do not. Also, the economic benefits of reducing greenhouse gas emissions in this sector have not yet been quantified. For example, as the frequency and severity of extreme weather events increases, and a greater percentage of GDP must be devoted to responding to climate impacts, airlines will face losses that could be prevented by concerted action to reduce greenhouse gas emissions.

Mitigation potential: As each option acts on the same emissions target and faces the same BAU emissions, out-of-sector mitigation is identical for each of the four options considered: 0 $MtCO_2$ in 2020 rising to 180 $MtCO_2$ in 2030. Relative to other sectors, aviation has a high abatement cost. For in-sector mitigation, the results from the analysis are similar for all options. Combining price driven and non-price driven abatement, the total combined in-sector abatement is approximately 110 $MtCO_2$ per annum in 2020, rising to approximately 221 $MtCO_2$ per annum in 2030. Assuming that total abatement is split proportionally across national and international aviation (ICAO is only responsible for international aviation), and assuming ICAO's split between national and international aviation of approximately 63 per cent international to 37 per cent domestic, the results for international aviation are 69 $MtCO_2$ in 2020, and 139 $MtCO_2$ in 2030. Mitigation can also result from a reduction in demand. Using a range of values for price elasticity, from 0.2 to 1.5, the impact of a \$40/tCO_2 carbon price on passenger demand is expected to be a fall in demand of between 1-10%, and between 1-5% for air freight (where the elasticity range is 0.2 to 0.7).

Political acceptability: A global agreement will require the reconciliation of many divergent views. ICAO has been critical of aviation being singled out disproportionately as a source of climate finance and would prefer revenues to stay within the industry. Previous positions have been closely aligned to at least match the ambition being shown by industry. Industry is supportive of a global measure to avoid any double counting of emissions and multiple compliance requirements that could result from multiple national and regional measures. A wish to minimise cost and administrative burden, coupled with the experience of IATA's Airline Offset Programme, suggests a preference for the offsetting approach. The US position has generally supported a global solution, although previous statements have questioned the need for a global MBM. This position could be affected by the upcoming Presidential election. In contrast, the EU has expressed strong support for a global MBM, and has stated that it must show at least the same level of environmental benefit as offered by the EU ETS. Among developing countries, the BASIC states argue for CBDR to be taken into account, a position that the ICAO Assembly Resolution characterises as addressing the special circumstances and respective capabilities of developing countries. ICAO's President has stressed that a global agreement for the aviation sector does not have any adverse implications for developing country positions in the UNFCCC negotiations. Meanwhile, LDCs do not have strong representation on ICAO's Council. The use of revenues has not been explored in detail within ICAO. The on going work by ICAO on an MBM, and the use of revenues, is an opportunity to consider both issues.

Revenues

Of the four options considered, only three raise revenues in excess of those needed for funding the out of sector abatement required to keep net emissions constant post 2020. These are offsetting plus a revenue generating mechanism, cap and trade (based on 50% auctioning), and a carbon levy plus offsetting. Following the IMO's assumptions, the modelling uses a global carbon credit price of \$25/tCO_2 in 2020, rising to \$40 in 2030 (and the same level for levy and allowance price). Under these assumptions, the revenues associated with these options in 2030 will be \$3.6 billion, \$11,7 billion and \$26.3 billion respectively. Research into a shipping MBM by Vivid Economics highlights that this revenue may be less than the total financial flows caused; for some routes and products, changes in the competitiveness between producers, leading to higher market shares and profits for local producers, and lower market shares and profits for importers and exporters shipping their goods via air, can be much greater than the revenue-raising burden of the policy itself. Overseas producers who ship their goods via air and consumers who buy those goods now have to reckon the full environmental costs into their purchases. Local producers and competitors shipping by land or water gain because their lower environmental impacts become a cost advantage in the market. This is shown in figure 5 in the main body of the report. This demonstrates the considerable competitive advantage to overseas producers, at the expense of local producers and the environment, that has arisen in the absence of carbon pricing.

Revenue could be collected from aircraft owners, operators, fuel suppliers or States, but in practice only two are feasible: the aircraft operator as it has full geographic and emissions data for the aircraft, and fuel suppliers who hold records of all fuel sales. Both have some disadvantages: operators will have to document and aggregate a large number of transactions, increasing administrative expense (even if only marginally), while fuel suppliers may not have full knowledge of where the fuel is used (an important consideration if an MBM is limited to international routes and/or has exemptions).

In relation to the collection of revenues, States have experience and frameworks in place for collecting revenues whereas a central entity, such as ICAO, has limited financial capability and may need to develop or outsource this function. It would therefore be sensible to charge States with the collection of revenue.

The institution charged with holding and dispersing the funds will face particular challenges, such as political pressure and the need for transparency and accountability, which will influence the choice of fund holder and disburser. Out of three options - States, ICAO, and other international organisations with experience in this field - only the last one is viable. States are not internationally accountable and may be subject to domestic and international political influence. While ICAO may wish to retain political control over the apportionment of funds it has no experience of fund management, and may therefore wish to outsource the fund management and disbursement to another UN body such as the Green Climate Fund, the World Bank or a commercial bank.

Options for spending the revenue

The economic case for using revenues to support in-sector mitigation is not straightforward: abatement options that cost less than the prevailing in-sector carbon cost do not require a subsidy; airlines should implement these low cost options without a subsidy, since these will cut their carbon cost bill by more than the cost of implementing the abatement option. What about subsidising *additional* mitigation, over and above that which airlines would undertake by themselves? Abatement options that cost more than the prevailing carbon cost will carry a higher per-tonne mitigation cost than out-of-sector options, assuming that the prevailing carbon cost will be given by the price of other carbon credits. Spending revenue on procuring additional in-sector abatement is hence a needlessly expensive way of procuring emission reductions; more abatement could be had, at the same cost, outside the sector. However, if market failures are present, such as public goods that may include research and development costs, or imperfect knowledge about mitigation that could result in under-investment by airlines, there may be a role for in-sector expenditure. Revenues could be used to disseminate credible and reliable information about operational performance; if not yet available, this information could be created by funding tests of cost-effective mitigation technologies. This would provide reassurance and encourage uptake.

The options described above could generate approximately $7 billion through the purchase of carbon credits in 2030. An additional contribution comes from the options that raise revenues. A levy with offsetting could generate $26 billion per annum in 2030.

Revenues can be used to address CBDR and equity for developing countries. Possible means of doing so include the following.

Phased implementation. While phased implementation on a route-by-route basis is one option that would not require explicit spending of revenue, the increased burden on the participating sector to meet the sector-wide goal would result in an implicit redistribution of benefits and burdens.

Variable levy rates: In the levy with offsetting approach, all carriers could be included but at different rates depending on whether a route is developed to developed, developed to developing, or developing to developing (or by more complex means where the levy for each route takes account of GDP in the countries of arrival or departure). This approach is not as efficient as a single global price, as some relatively cheap mitigation options would not be implemented on routes with a reduced levy rate, forcing airlines on other routes to deliver additional mitigation at higher per-tonne costs. Like any differential pricing system, it would lead to a degree of competitive distortions.

Compensation payments or rebates: This includes all flights in the MBM, and makes lump sum payments to developing countries based on an assessment of the economic cost incurred. It might be a challenge to reach agreement on an appropriate methodology and eligibility, and compensation goes to national governments rather than those directly affected.

Reallocation of allowances in emissions trading systems: It is possible to give free allowances to countries (not airlines) based on country GDP. This approach could lead to some competitive distortion, windfall profits and reduce the revenue pool, but could be introduced with a fixed phase-out to allow for transition.

Technology transfer mechanism: Revenue-raising options could be supplemented by a technology cooperation or transfer mechanism, for example along the lines of the UNFCCC Technology Mechanism, funded out of MBM revenues.

In conclusion, measured against the study's objectives:

Option 1, offsetting: could deliver large volume of low-cost emissions reductions but there are concerns about its reliability of emissions impact, because of low trust in the quality of offsets. This option also generates no revenue for climate finance. Benchmarking is a promising means of allocating an offsetting liability but it could diminish the incentive to reduce emissions, indeed as proposed here, there is no incentive to reduce emissions below the threshold of 2020. It seems unlikely, considering aviation's exemptions from VAT (and fuel duty), that the sector would be unfairly burdened. The arrangement is legally and institutionally feasible but results in partial double counting with other instruments such as EU ETS, which would have to be reviewed if this or other MBM options are implemented.

Option 2, offsetting with revenue generation: the additional revenue generation (of up to $3.6 billion by 2030, assuming a 50% surcharge) increases the cost to the aviation sector and raises the in-sector incentive to reduce emissions, but it requires new institutional arrangements to distribute the revenue.

Option 3, cap and trade: this option offers greater potential for low cost global emissions reductions when it is linked to other sectors, and it is likely to encourage higher in-sector emissions reductions than offsetting schemes because it might operate with a higher emissions price. The financial impact on governments and airlines can be adjusted through grandfathering or benchmarking of free allowances, and in common with other options, cost is also passed on to customers. It allows a high degree of flexibility in design. This option could also deliver climate finance worth $8.2 billion in 2020 and $11.7 billion in 2030.

Option 4, levy with offsetting: the levy offers the greatest certainty in future carbon prices facing airlines, and thus can be an efficient mechanism for stimulating in-sector investment. It raises greater questions about institutional arrangements since it requires a price to be set by an administrative authority and revenue to be collected and distributed. It is also the option that can generate the most climate finance, estimated at $14.7 billion in 2020 and $26.3 billion in 2030.

None of the options raises competition concerns if they are applied universally. If, however, they are applied unilaterally or together with benchmarks, these might favour some firms, although good design might allow adjustments based on differential environmental impacts.

The levy scheme offers the best long-term dynamic incentive, and a trading scheme linked to other sectors also perform well in this respect. The offsetting schemes are vulnerable to manipulation of baselines and concerns about credibility, which might compromise effective emissions reductions, now and in future.

Table 1. **Summary of assessment**

Criterion	Option 1: Offsetting	Option 2: Offsetting with a Revenue Generation Mechanism	Option 3: Cap and Trade Emissions Trading System	Option 4: Carbon Levy with Offsetting
CO_2 reduction	Amount of CO_2 reduction from offsetting depends on targets; can deliver large net reductions with the application of a discount factor; concerns exist over additionality and quality of offsets; some in-sector mitigation incentive, but weakened due to offset price fluctuation, benchmarking (see below) and currently low offset prices	Same as offsetting, with two exceptions: — additional revenues can be used for additional mitigation — in-sector mitigation incentive is slightly stronger if the revenue generation mechanism increases the effective carbon cost that airlines face	CO_2 reduction from cap and trade depends on level of cap; can deliver large net reductions if linked to other carbon markets, otherwise CO_2 reduction limited by in-sector mitigation potential; mitigation incentive weakened by carbon certificate price fluctuation	In-sector CO_2 reduction depends on rate of levy; total net reduction depends on chosen target; stable and predictable in-sector carbon cost may deliver more mitigation for the same average carbon cost than more volatile instruments
Competition impact (to national airline industry)	Competition impacts of offsetting depend on how obligations for offsetting are shared out: — 'grandfathering', i.e. requiring each airline to keep net emissions constant post-2020, advantages larger or more emitting airlines relative to smaller or cleaner airlines; — 'percentage of emissions', i.e. requiring each airline to reduce net emissions by the same percentage amount; this favours more emitting airlines that still have lower cost mitigation options available, may lead to some distortion between smaller and larger airlines if larger airlines can achieve economies of scale in mitigation, but not otherwise; — 'benchmarking' does not lead to competitive distortions; cleaner airlines will gain (relatively), more emitting airlines will lose, but this is due to internalising previously unpaid pollution costs	Same as offsetting	Similar to offsetting, the competition impacts of a cap and trade ETS depend on rules of certificate allocation: — under 100 per cent auctioning, assuming no liquidity constraints there is no competitive distortion; may change working capital requirements; — 'benchmarking' has similar impacts to 100 per cent auctioning, but leads to a smaller change in working capital requirements — 'grandfathering', based on allocating certificates covering a certain percentage of historic emissions, is likely to lead to windfall profits and favours larger and more emitting airlines relative to smaller and cleaner airlines and new entrants; the larger the percentage of historic emissions covered, the larger the competitive distortion	A uniform carbon levy does not distort competition; cleaner airlines will face lower costs than more emitting airlines, but this is due to the internalisation of previously unpaid pollution costs
Cost	Minimises costs per RTK by making full use of least cost out-of-sector mitigation options; cost to industry is minimised by	Similar to offsetting, but with increased costs due to the revenue raising mechanism	Higher costs per RTK since all emissions are priced, not just those above a baseline; distribution of costs between	Higher costs per RTK since all emissions are priced, not just those above a baseline; costs are placed first on

Criterion	Option 1: Offsetting	Option 2: Offsetting with a Revenue Generation Mechanism	Option 3: Cap and Trade Emissions Trading System	Option 4: Carbon Levy with Offsetting
	only pricing emissions above the 2020 baseline; costs for passengers and freight customers depend on cost pass-through, which is driven by market structure rather than MBM instrument choice; danger of windfall profits as marginal costs are increased, leading to higher prices across the board, while infra-marginal costs are not affected, leading to higher profits on each infra-marginal unit		government and industry is given by rules of allocation for certificates. 100 per cent auctioning places all costs on industry and customers, while 100 per cent grandfathering represents a government-to-industry transfer placing costs on governments and customers and creating windfall profits; distribution of costs between industry and passengers, and industry and freight customers, depends on cost pass-through, which is driven by market structure rather than MBM instrument choice or auctioning rules	industry, then falling, depending on cost pass-through, on passengers and freight customers
Cost effectiveness	Costs of out-of-sector mitigation is independent of the instrument, instead driven by global carbon markets; volatile carbon costs may prevent some mitigation options below the prevailing price from going ahead, thereby increasing overall mitigation costs per tonne of CO_2 and the incentive for in-sector emissions may be diluted by benchmarking	Average cost of mitigation per tonne of CO_2 for this instrument is driven by a) global offset prices, and b) the cost per tonne of CO_2 of any mitigation options funded from the additional revenues raised; if these additional mitigation options cost more than the average global offset price, then total unit cost will be slightly higher than for pure offsetting, and vice versa for lower unit costs of additional abatement	Costs of out-of-sector mitigation is independent of the instrument, instead driven by global carbon markets; if aviation cap and trade ETS is not fully linked with other schemes, costs may be considerably higher due to limited in-sector mitigation options; volatile carbon costs may prevent some mitigation options below the prevailing price from going ahead, thereby increasing overall mitigation costs per tonne of CO_2	Stable and predictable carbon cost may lead to lower costs per tonne of CO_2 mitigated in-sector. Costs of out-of-sector mitigation is independent of the instrument, instead driven by global carbon markets
Fair burden on aviation compared to other sectors	This could be viewed as both economic and administrative burden. Economic burden should be assessed by taking into account the respective regulatory burden of each sector in relation to climate change mitigation effort. Given absence of VAT on aviation and if relevant duty on fuel and the limited existing geographical application of carbon prices to the aviation sector, coupled with the fact that other sectors are covered by emission obligations at a national level relative to 1990 levels, it is likely that aviation will not be unfairly burdened. Administrative burden is likely to be low, although monitoring,	Similar to offsetting. Additional revenue raised is unlikely to impose an unfair burden.	Similar to offsetting only, but with a greater compliance cost due to auctioning. However, more and more sectors covered by the EU ETS will face 100% auctioning	Similar to offsetting, with potential for higher or lower compliance cost

Criterion	Option 1: Offsetting	Option 2: Offsetting with a Revenue Generation Mechanism	Option 3: Cap and Trade Emissions Trading System	Option 4: Carbon Levy with Offsetting
	verification and a registry are cross cutting issues.			
Legislative feasibility	States could legislate nationally to require the surrender of offsets	As with offsetting, but mandating an existing UN body or creating a new body to oversee the distribution of revenues could require a treaty. Registry required	ICAO could develop guidance on how to harmonise distribution methodologies and MRV requirements without a new treaty, but if auctions generate revenues, the same issues arise as with offsetting plus a revenue generation mechanism. ICAO or another UN body will require a legal mandate to create aviation specific allowances. Registry required	If ICAO agrees the appropriate rate for a levy, could be introduced nationally. Some States may require domestic legislation to introduce a levy. Registry required to account for volume of offsets obtained
Design features and timescale	— All emissions above 2020 levels to be offset. Start date: 2020 — Requires definition of eligibility criteria for offsets. — Participants: operators — Annual compliance	— All emissions above 2020 levels to be offset. Start date 2020 — Agreed levy per transaction would give greater certainty over revenues but will need to be reviewed regularly (a percentage fee would vary with the offset price, leading to volatile revenues). — Requires definition of eligibility criteria for offsets. — All Participants: operators. — Annual compliance	— Cap set at 2020 levels. — Participants: operators — 50% auctioning, 50% free allocation based on benchmarked distribution. — Compliance required annually	— As with other offsetting options. — Participants: operators or fuel suppliers
Administration	Will require a registry for cancellation of offset credits. Existing international registries could be utilized. Administration and enforcement by States. Allocation of obligations may require a central body such as ICAO: offsetting obligations may be issued based on all operators offsetting above their 2020 activity levels but this may not be seen as fair to rapidly growing operators. Alternative approach could use benchmarking but will require an authority to calculate obligations for each operator.	As with offsetting, but with States collecting revenues and a central entity charged with distributing revenues in accordance with an agreed policy	States will be responsible for the administration of the scheme. As with offsetting plus revenue generation mechanism, States can collect revenues from auctions but a central entity is required for distribution. A central entity will also need to set cap, create allowances, calculate and oversee the distribution of allowances to States or operators, provide a template for harmonised approaches to MRV and aggregate surrendered allowances by state to ensure consistency with the cap. Will require a registry for the surrender and cancellation of allowances and offsets	Could be undertaken by States using existing mechanisms to collect revenue and taxation. A central entity will need to distribute revenues in accordance with an agreed policy

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Criterion	Option 1: Offsetting	Option 2: Offsetting with a Revenue Generation Mechanism	Option 3: Cap and Trade Emissions Trading System	Option 4: Carbon Levy with Offsetting
Rechanneling revenue	No revenue generated	Yes, approximately $3.6 billion available in 2030	Yes, approximately $11.8 billion available in 2030	Yes, approximately $26.3 billion available in 2030
Political acceptability	Likely to have lowest administrative cost and burden, and could be introduced quickly. Likely support from industry. Absence of revenue will make it difficult to compensate developing countries, so developing country issues may be difficult to resolve. Quality criteria for offsets will be a cross-cutting issue for all options	Similar to offsetting, but administrative complexity higher as need to collect and distribute revenues and need agreement on setting and reviewing an appropriate levy. However, generation of revenue can address developing country issues and offers higher degree of perceived integrity. In political terms this is the "middle ground" between offsetting only and the rigours and perceived complexity of a trading system	Given that the work on a global MBM is seen as a potential means to end the EU ETS dispute, it is unlikely that non-EU States will want to be seen to endorse a cap and trade scheme (although a global agreement at some level will create pressure for a global solution) compounded by the perception that this is administratively complex. However, it will have a higher environmental integrity than offsetting which could influence political thinking. Ability to generate revenues could address developing country issues	Likely to be viewed as a proxy kerosene tax which will raise legal concerns amongst ICAO's Contracting States.
Static versus dynamic mitigation incentive	Static incentive to reduce emissions below the required threshold; weak dynamic incentive, as marginal emission costs drop to zero once the threshold is reached	Same as offsetting, though the static incentive is stronger due to the higher carbon cost caused by the revenue mechanism; equally weak dynamic incentive	Strong dynamic incentive due to constant marginal costs	Strong dynamic incentive due to constant marginal costs
Compatibility with national and regional measures	Will require emissions to be offset above a 2020 cap so would partially double count emissions covered by the EU ETS and some national schemes such as the German environment levy (although these could be amended to avoid double counting). However, most national measures in effect (e.g. Swiss carbon tax) or proposed (e.g. Australian cap and trade system) only apply to domestic routes so will be complimentary to a global measure for international aviation	Same as offsetting	Will depend on degree of auctioning. Measured against the 2020 goal with 50% auctioning, by 2030, a global ETS introduced on this basis will apply a carbon price to approximately 65% of the sector's CO_2 emissions. The EU ETS, assuming existing design parameters for aviation of 15% auctioning and a cap of 95% of 2004-6, will apply a carbon price to a similar proportion of the international aviation emissions covered by the scheme	Will apply a price to all carbon emissions so will overlap with all national and regional schemes which include international aviation

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2. INTRODUCTION

2. Introduction and background

In June 2012, WWF International commissioned a study to examine options for the introduction of a global market-based measure to address greenhouse gas emissions from international aviation with particular regard to the likely environmental, economic and political implications. Each of the options identified in this report was assessed with regard to WWF International's stated objectives, namely that a global MBM:

1. Achieves substantial greenhouse gas emissions reductions from international air transport in line with international efforts to keep global warming below 2 degrees Celsius above pre-industrial levels, with the emissions reduction objectives of the current EUETS system serving as a floor;
2. Generates financing for the Green Climate Fund to be used for climate change action in developing countries, at a scale in line with the findings of the World Bank and IMF report on Mobilizing Climate Finance, which was compiled for the G20 Finance Ministers;
3. Conforms to the existing principles of the Chicago Convention and ICAO while accommodating the principle of Common but Differentiated Responsibilities and Respective Capabilities (CBDRRC) of the UNFCCC.

Recognising the need to tackle climate change, countries have agreed that "deep cuts in global greenhouse gas emissions are required ... to hold the increase in global average temperature below 2^{o}C above pre industrial levels"[2]. To achieve this, urgent action is required by countries and sectors to reduce emissions, including from bunker fuels from international aviation and maritime.

2.1 The aviation sector's contribution to climate change

The International Civil Aviation Organisation (ICAO) estimates that global carbon dioxide emissions from the civil aviation sector amounted to 630 million tonnes in 2005, representing 2 per cent of global CO_2 emissions. According to the International Energy Agency, emissions from civil aviation stand at 740 million tonnes per annum in 2010, amounting to 2.5 per cent of global CO_2 emissions.[3] Significantly, during the preceding decade, aviation was one of the fastest growing sources of greenhouse gas (GHG) emissions. Its impact on the climate is compounded further by the non-CO_2 effects of aircraft emissions which, when measured using radiative forcing[4], produce net additional warming effects over shorter timescales. These include:

Emissions of nitrogen oxides (NO_x): NO_x emissions at altitude increase atmospheric ozone concentrations and decrease the concentrations of methane that have warming and cooling effects on the Earth's surface respectively. These effects are not uniform and occur regionally. When averaged globally, NO_x emissions have a net warming effect.

Water vapour, soot and sulphates: Water vapour released by aircraft engines into the lower stratosphere acts as a greenhouse gas, while aerosol concentrations from aviation fuel use

[2] UNFCCC, Cancun, December 2010
[3] IEA (2012) CO_2 *Emissions from Fuel Combustion 2012 Edition*, Paris
[4] Radiative forcing (RF) is a measure of changes to the energy balance of the atmosphere in watts per square meter (Wm^{-2}).

have a small direct warming (soot) and cooling (sulphate) effect, although they may play a role in enhanced cloud formation. These impacts are relatively small compared to the effects of CO_2 and NO_x.

Contrails: Depending on the atmospheric humidity, the hot air from aircraft engine exhausts can combine with water vapour in the atmosphere to form ice crystals that appear as linear condensation trails (or contrails). These usually last a few hours, but can, in certain conditions, persist and spread into cirrus-like clouds which may last a few days.

Enhanced cirrus cloud formation: Cloud formation following persistent contrail formation is less well understood than other impacts, but both contrails and cirrus are thought to have warming effects. It is likely that condensation trails have a greater warming impact at night because they also act to reflect incoming radiation during daylight.

In its seminal 1999 report[5], the Intergovernmental Panel on Climate Change (IPCC) estimated that, taking the CO_2 and non-CO_2 impacts together, aviation at the time accounted for 3.5 per cent of the total warming of the climate attributed to anthropogenic activities (excluding cirrus cloud effects). As scientific understanding about the effect of aviation-induced cirrus cloud formation has improved, academics have become more confident about including these effects, and the most recent estimate increases aviation's share to 4.9 per cent of total warming[6]. To date, reflecting non-CO_2 effects in policy decisions has been complicated by the lack of an appropriate metric: although the radiative forcing index provides a means of comparing impacts, the scientific community has warned that it is based on historical emissions and is not suited to forward looking scenarios. While alternative temperature-based metrics are already emerging that may be better suited for policy, policy-makers have remained focused largely on CO_2 alone.

2.2 Forecast growth in the aviation sector

Forecasts suggest dramatic growth in demand for air travel over the next couple of decades, even in mature markets such as the US, while the Asia/Pacific region anticipates annual average growth rates in excess of 6 per cent per annum as shown in the following table.

Table 2. **Revenue Passenger Kilometre growth 2010-2030 by region**

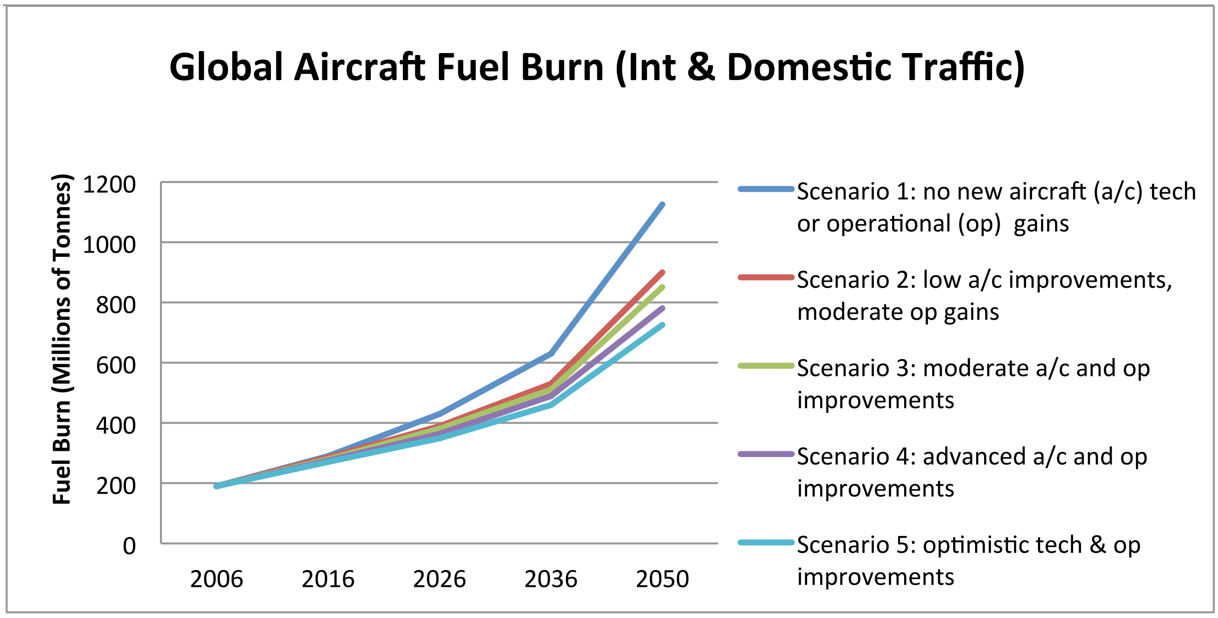
Region	Revenue Passenger Kilometre (RPK) Growth 2010-2030 (average % growth per annum)
Asia/Pacific	6.2
Latin America/Caribbean	5.5
Middle East	5
Africa	4.5
Europe	4
North America	3

Source: ICAO 2010 and AET

[5] Aviation & the Global Atmosphere, Intergovernmental Panel on Climate Change (1999)
[6] David S. Lee et al (2010) *Transport impacts on atmosphere and climate: Aviation*, Atmospheric Environment 44 (2010) 4678–4734

ICAO has modelled the associated fuel burn requirements for the period 2006 to 2050. From a baseline on 187Mt of fuel in 2006, under the most 'optimistic' scenario for the introduction of new aircraft technology coupled with advanced operational improvements, aviation is still estimated to require over 700 Mt of fuel by 2050 (equivalent to 2,200 Mt of CO_2)[7].

Figure 1. **Projectionss for global fuel burn in aviation, 2006 to 2050**



Source: ICAO Environment Report, 2010

Unabated, aviation emissions will increase significantly over the next 40 years. Even by 2020, emissions from the sector are forecast by the United Nations Environment Programme (UNEP) to rise as high as 1.16 $GtCO_2$ compared to a 0.63 $GtCO_2$ baseline in 2005[8]. Though there is some uncertainty in this prediction, it is not large: ICAO's own modelling shows 2020 emissions of approximately 1.0-1.1 $GtCO_2$. UNEP warns of the dangers of not tackling the rise in emissions from international aviation and shipping: these combined emissions will account for an increasing share of the total, representing as much as 4.0 to 5.7 per cent of median total emissions in 2020 and 10.0 to 32.5 per cent of the median total emissions in 2050. UNEP concludes that *"...it follows that the sum of emissions from all other sectors would have to proportionately decrease to ensure that total emissions do not exceed the emissions level consistent with a 2°C target."*

2.3 Industry goals to tackle GHG Emissions

The Air Transport Action Group (ATAG), representing airlines (IATA[9]), airports (ACI[10]), air navigation service providers and manufacturers, has developed industry-wide goals to a) improve fuel efficiency

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[7] ICAO (2010) *Environment Report 2010*
[8] UNEP (2011) *Bridging the Emissions Gap*
[9] IATA – International Air Transport Association

by 1.5 per cent per annum, b) ensure carbon neutral growth from 2020 and, c) reduce net carbon emissions by 50 per cent below 2005 levels by 2050. To achieve this, industry efforts have focussed on the role of operational and technological measures and the development of alternative fuels.

An independent assessment of each of these measures was undertaken by UNEP in *Bridging the Emissions Gap*. The estimated available efficiency improvements from operations (making more optimal use of airspace) is 3-10 per cent although it will be difficult to reconcile optimal operations with increasing traffic due to competing safety and capacity considerations. Technology improvements include the use of lighter airframe materials and changes in engine technology towards 'open rotor' and 'geared turbofan' engines. If realised, these technologies are likely to contribute more in the medium- to long-term. UNEP estimates the potential fuel efficiency improvements to be in the range 19-29 per cent by 2020 (relative to current technology) and 26-48 per cent by 2030. An effective ICAO CO_2 standard for aircraft might ensure that this is realised on time.

Test flights using a variety of potential biofuels have demonstrated their technical feasibility, but concerns remain about accounting accurately for lifecycle emissions, as well as the impact of large-scale production on land-use change and cost. Competition from other sectors for available biofuels is placing a constraint on the uptake by aviation. Consequently, a review by the UK's Committee on Climate Change (CCC) concluded that *"concerns about land availability and sustainability mean that it is not prudent to assume that biofuels in 2050 could account for more than 10 % of global aviation fuel"*. The CCC estimated that in its "likely scenario", the uptake of biofuels by 2020 would be no less than 2 per cent, a figure adopted by UNEP. The uptake of biofuels will also be dependent on future global prices for feedstocks. The weather can have a significant impact on feedstock prices, for example, the drought in the US in 2012.

2.4 The case for market-based measures (MBMs)

UNEP estimates the likely in-sector CO_2 emission reductions from technology, operations and alternative fuels to be around 100 $MtCO_2e$ per annum in 2020, representing 8.5 – 16 per cent of the sector's emissions. While the scale of these reductions increases with time, and while in-sector mitigation efforts should be encouraged, based on current knowledge it is difficult to envisage a scenario where continuous efficiency improvements will keep pace with forecast demand growth rates. Policy instruments, most notably market-based measures, are required to address the shortfall, a fact acknowledged by IATA in its four pillar strategy to achieve climate-related goals. Advocating positive economic measures, the airline association's strategy states "*To 'close the gap', we will need to deploy the fourth pillar – economic measures. 90 million tonnes of CO_2 will need to be offset in 2025 to maintain* [aviation] *emissions at 2020 levels and thus achieve carbon-neutral growth*"[11].

2.5 Consideration of MBMs in the International Civil Aviation Organisation (ICAO)

In 1997, Article 2.2 of the Kyoto Protocol required Annex I Parties (then, the developed countries) to pursue the limitation or reduction of emissions of greenhouse gas emissions from aviation bunker

[10] ACI – Airports Council International
[11] IATA (2009) *A Global Approach to Reducing Aviation Emissions*

fuels[12] working through the International Civil Aviation Organization (ICAO)[13]. Since then, despite an active work programme on MBMs, ICAO has struggled to find the political consensus to reach an international agreement on their application due in part to the conflicting principles underpinning the ICAO and UNFCCC processes. Focused on international aviation, ICAO operates on the basis of non-discrimination, with all carriers on a given route being given equal treatment irrespective of nationality of registration. Under UNFCCC, the principle of Common but Differentiated Responsibilities and Respective Capabilities (CBDRRC) recognises the different historic contribution and capabilities of developing and developed countries. To date under the UNFCCC, this has meant that developing countries have not been subject to emission reduction obligations and, consequently, they argue that their carriers should not participate in a global aviation measure. The reconciliation of ICAO and UNFCCC principles remains a fundamental obstacle to global agreement.

Exempting these carriers on routes where they compete with airlines registered in developed countries would create a competitive distortion, however. While ICAO has acknowledged the need to address developing country concerns, it has stressed that ICAO's own principles take precedence while maintaining that a sectoral agreement on aviation has no consequence for the continued validity of CBDRRC in the UNFCCC. While many developing country airlines on international routes are very competitive, governments from these States fear that an aviation agreement may set a precedent for the on-going climate negotiations. Exemptions and the use of climate finance to address equity or achieve no net incidence[14] on developing countries may all play a part in finding a solution; however, these considerations have not received substantive attention within ICAO to date.

ICAO's first response to Article 2.2 of the Kyoto Protocol was the establishment of a new working group under the Committee on Aviation Environmental Protection (CAEP). CAEP comprises around twenty States, largely those with an aeronautical manufacturing industry, and up until that point had focused its efforts on technical environmental standards for aircraft and engines, and operational procedures. The new working group (WG5), supported by the Forecasting and Economic Support Group (FESG) undertook a review of MBMs including:

- fuel/en-route emissions tax;
- revenue neutral aircraft efficiency charge;
- en-route emissions charge[15];

[12] Bunker fuel for aviation relates to the fuel consumed on international flights.

[13] ICAO is a specialised agency of the United Nations, created in 1944 by the Chicago Convention. It currently has 191 Contracting States and has its headquarters in Montreal, Canada. ICAO is not a regulator but develops standards and recommended practices for international aviation. ICAO has a remit to consider international aviation only. Domestic aviation (flights that arrive and depart within a State) is the responsibility of States. Thus, States have the freedom to introduce measures on domestic aviation that may not necessarily be in line with ICAO guidance and policies, such as the imposition of fuel taxes.

[14] No net incidence is a concept where developing countries would incur no incremental costs as a result of the introduction of climate measures. This could be achieved, for example, through a rebate mechanism to compensate for the impact on traded goods and personal travel, or the exemption of routes to/from developing countries.

[15] ICAO distinguishes between a tax and a charge on the following basis: *"a charge is a levy that is designed and applied specifically to recover the costs of providing facilities and services for civil aviation, and a tax is a levy that is designed to raise national or local government revenues which are generally not applied to civil aviation in their entirety or on a cost-specific basis"*. States are urged to refrain from introducing taxes but the policy is

- emissions trading with open access to carbon markets;
- emissions trading within the aviation sector only (closed scheme); and
- voluntary initiatives.

At its plenary session in 2001, CAEP recommended further work on an open emissions trading system, levies and voluntary initiatives, but concluded that:

- a closed trading system is not cost-effective due to the high abatement cost in the sector;
- fuel taxes are relatively straightforward to administer but raise significant legal issues concerning existing bilateral agreements and ICAO policies;
- a revenue-neutral aircraft efficiency charge could be administered in association with existing en-route charges (where they existed) to achieve a revenue neutral outcome, although the definition of an appropriate metric for benchmarking is complex[16];
- En-route emissions charges are consistent with existing ICAO policy provided the revenues are used to mitigate the environmental impact from emissions; it could also build on existing en-route charges.

At the subsequent ICAO Assembly in 2001, a Resolution narrowed the remit for further work, requesting CAEP to continue work specifically on an open emission trading system, an en route charge and voluntary measures.

Further work did not yield a specific proposal and by its 2004 Assembly a Resolution agreed an effective moratorium on the introduction of CO_2 emissions charges for international aviation, stating that:

> *"existing ICAO guidance is not sufficient at present to implement greenhouse gas emissions charges internationally" and urged "Contracting States to refrain from unilateral implementation of greenhouse gas emissions charges prior to the next regular session of the Assembly in 2007, where this matter will be considered and discussed again".*

The Resolution endorsed the development of an open emissions trading system for international aviation and requested further work on two approaches:

> "*Under one approach, ICAO would support the development of a voluntary trading system that interested Contracting States and international organizations might propose. Under the other approach, ICAO would provide guidance for use by Contracting States, as appropriate, to incorporate emissions from international aviation into Contracting States' emissions trading schemes consistent with the UNFCCC process. Under both approaches, the Council should ensure the guidelines for an open emissions trading system addressing the structural and legal basis for aviation's participation in an open emissions trading system, including key elements such as reporting, monitoring and compliance*".

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not legally-binding (as evident from the UK's introduction of Air Passenger Duty) and would not prevent the introduction of an international levy. Similarly, the Resolution distinguishes between emissions trading and levies, so a trading scheme that generated revenues would not constitute a tax.

[16] Although this work was not pursued at the time, the current work programme developing a CO_2 standard for new aircraft has produced a metric that would be capable of being used in conjunction with MBMs.

To comply with the Council's request, ICAO commissioned a study on emissions trading for the aviation sector from ICF consulting[17] which highlighted the difficulties that ICAO would face in administering a global scheme. On this basis, ICAO decided not to pursue a global system further and instead focused its attention on producing the guidance for States. The development of the guidance overlapped with the European Union's consideration of how to include aviation in the EU Emissions Trading System (ETS) leading to tensions on the options for geographical scope. In 2007, CAEP finally agreed the guidance which set out two approaches on this issue reflecting the differences of opinion. The first described a system where a State (or group of States) could include all carriers operating on relevant routes irrespective of nationality whereas the second could only include third country carriers with the permission of the appropriate State. The European member states expressed a strong preference for including all carriers on a given route (this is the basis of aviation's inclusion in the EU ETS), whereas other CAEP members, notably the US, argued that this was "extra-territorial" and could only be imposed with their mutual consent. At the 2007 Assembly, the majority of Contracting States favoured the latter "mutual agreement" approach, or expressed no preference, resulting in the ECAC[18] States lodging a reservation to the effect that it would not recognise the validity of the Resolution on this matter.

By 2010, ICAO's assessment of MBMs had effectively stopped, although a Market-based Measures Task Force (MBMTF) was established in 2007 (reporting in 2010) to look at some emerging issues including the potential role of offsets in the aviation sector and the linking of regional schemes.

2.6 Initiatives outside of ICAO

In the past few years, ICAO's lack of progress on adopting climate policies for the sector has made it increasingly visible to policy-makers and several national initiatives have been introduced to start pricing carbon emissions.

At the same time, bunker fuels are still on the agenda at the United Nations Framework Convention on Climate Change (UNFCCC) although progress has been limited. At its first meeting in 1995, the COP requested the Subsidiary Body for Scientific and Technological Advice (SBSTA) and the Subsidiary Body for Implementation (SBI) to address the issue of allocation and control of emissions from international bunker fuels. However, without any consensus on allocation, emissions from international aviation were excluded from the national commitments under the Kyoto Protocol although these are reported separately. Aviation continues to be discussed by the Ad Hoc Working Group on Long-term Cooperative Action under the Convention (AWG-LCA) in the context of the Bali Action Plan, under cooperative sectoral approaches and sector-specific actions. At the Durban Conference of Parties in 2011, the AWG-LCA process agreed to continue its consideration of issues related to addressing emissions from international aviation and maritime transport[19]. In Durban, Parties also agreed to launch a new negotiating process, the Ad Hoc Working Group on the Durban Platform for Enhanced Action (ADP). At the 2012 Bonn meeting, during the first workshop under the ADP to consider options and ways for increasing ambition and possible further actions, Parties

[17] "Designing a Greenhouse Gas Emissions Trading System for International Aviation", Final Report, ICF Consulting, May 2004.
[18] ECAC – European Civil Aviation Conference – an intergovernmental organisation representing 44 European States.
[19] Decision 2/CP.17, para.78

highlighted international aviation and maritime transport as sectors with significant mitigation potential emissions and showed emerging consensus on ICAO and IMO to play an important role in the context of the new ADP process.

Aviation is one of a number of potential sources that could contribute to the required $100 billion annual cost of funding climate adaptation and mitigation in developing countries by 2020. Following initial work by the UN Secretary General's High Level Advisory Group on Climate Finance (AGF) in November 2010 (which included an analysis of the potential for charges on international maritime and aviation fuel use), the G20 Finance Ministers requested the World Bank and the International Monetary Fund to explore ways of mobilising climate finance. The subsequent report[20] highlighted the role of the carbon markets and, in particular, included a proposal to introduce MBMs for international aviation and maritime bunker fuels as an innovative source of climate finance. An MBM for these sectors was considered justified as "*these international activities are currently taxed relatively lightly from an environmental perspective: unlike domestic transportation fuels, they are subject to no excise tax that can reflect environmental damages in fuel prices*". At a carbon charge of $25 per tonne of CO_2, it was estimated that around $40 billion per year by 2020 could be raised, reducing CO_2 emissions from each sector by around 5 to 10 per cent. The report acknowledged that treaty obligations and bilateral air service agreements could impede the application of fuel charges in international aviation and that, while "*the implementation of these charges need not be especially difficult in principle, new governance frameworks would be needed to determine how charges (or emission levels) are set, control use of revenues and monitor and implement compensation arrangements*". The report also included the first real examination of how to treat developing country concerns, proposing a scheme whereby all States participated but where the modest costs of compliance could be offset through a compensation scheme. Allowing for compensation to developing countries at around 40 per cent of estimated global revenues, a total of up to $24 billion would still be available for climate finance as well as financing for in-sector measures, from measures to address emissions from shipping and aviation. The AGF and G20 reports are inputs to the UNFCCC Work Program on long term finance, created in Durban, which will produce a report for consideration in Doha that may include bunkers as a financing option.

Frustrated by the lack of consensus within ICAO, the EU brought forward legislation[21] in 2008 to include aviation in its Emissions Trading System, which had been operating since 2005. This followed an earlier Communication[22] that made it clear that the EU preferred a global scheme through ICAO but that it would not wait indefinitely for action to be agreed. Aviation's inclusion in the EU ETS from 2012 represents the first mandatory regional measure to tackle the sector's rising emissions. The cap for the sector is set at 97 per cent of the average annual emissions between 2004-06 (declining to 95 per cent from 2013). The majority of allowances are distributed free of charge to operators through a benchmarking system based on activity: for 2012, the distribution is based on independently verified tonne-kilometre activity data recorded throughout the 2010 calendar year for each operator. In addition, 15 per cent of allowances are auctioned, and 3 per cent will remain in a special

[20] World Bank (2011) *Mobilizing Climate Finance*

[21] Directive 2008/101/EC - Amending Directive 2003/87/EC so as to include aviation activities in the scheme for greenhouse gas emission allowance trading within the Community: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32008L0101:EN:NOT

[22] Communication of the European Commission outlining plans to reduce the impact of aviation on climate change, European Commission, COM (2005) 459 Final, September 2005

reserve for later distribution to fast growing airlines and new entrants into the market. Some airlines have introduced surcharges at $3 (Delta) and €0.25 (Ryanair) per flight to cover their respective compliance costs. However, the decision to include all flights to and from EU airports has created political friction amongst non-EU States who believe that the system should not be extended to airlines registered outside the EU and that the EU is acting "extra-territorially" by including emissions outside of European airspace. A legal action mounted by US and Canadian airlines was quashed by the European Court of Justice, which found the legislation to be consistent with international law[23]. Nevertheless, political concerns remain and twenty-six States (including the US, China, India, Russia and Brazil) met in Delhi in September 2011[24] and Moscow in February 2012[25]to discuss potential retaliatory action. A further meeting, still excluding the EU member States, was held in Washington DC in July 2012 to focus on elements of a global way forward[26]. In the meantime, all airlines with the exception of ten carriers from India and China are fully compliant with the requirements of EU ETS to date.

Despite this opposition to aviation's inclusion, the EU has confirmed it is not considering changing its legislation[27] and made it clear that the Directive already provides for the exemption of incoming flights if States introduce equivalent measures; in addition 98 ICAO states are exempted overall from EU ETS because they fall under the legislation's *de minimis* provisions. Furthermore, the Directive explicitly foresees modifications of its provisions in case of an agreement on global measures to reduce greenhouse gas emissions from aviation. According to the EU Commission[28], such a measure would have to deliver more emissions reductions that the current EU system, be non-discriminatory in nature, and include mandatory requirements for action.

Both the on-going UNFCCC discussions on ways to mobilize climate finance and the EU ETS are exerting considerable pressure on ICAO and have created fresh momentum to make progress on the development of a global MBM. ICAO's desire to retain leadership on aviation and climate issues is threatened by discussions on how to raise climate finance, and it has been critical of the process expressing fears that the sector may be required to contribute disproportionately to the fund compared to other sectors while taking money out of the sector that may otherwise have funded emissions reductions. At the November 2011 session of ICAO's Council, the "Delhi Declaration" against the EU ETS was presented for adoption and approved[29], a procedure that requires a majority to be in favour. The adoption of this declaration is not legally binding since it is a political expression of the Council relating to the issue of the inclusion of international civil aviation in the EU ETS and its impact. It is anticipated that this may be the first step towards an Article 84 complaint[30]. ICAO will wish to avoid an Article 84 complaint as it will create deep divides amongst Council and the wider Contracting States. Therefore, a global measure is seen as a means of responding to the challenge

[23] Documents related to the ATA against the EU ETS: http://goo.gl/3lPH4
[24] http://pib.nic.in/newsite/erelease.aspx?relid=76388
[25] http://www.ruaviation.com/docs/1/2012/2/22/50/
[26] http://www.state.gov/r/pa/prs/ps/2012/08/195960.htm
[27] http://www.reuters.com/article/2011/06/08/eu-climate-aviation-idUSBRU01153520110608
[28] Comments and presentation by Jos Delbeke, DG Clima, to "A New Flightplan Conference", Brussels, 7 Feb 2012. Speech at http://ec.europa.eu/clima/news/docs/speech_en.pdf
[29] http://ec.europa.eu/clima/policies/transport/aviation/docs/minutes_icao_en.pdf
[30] Article 84 of the Chicago Convention provides a mechanism for dispute resolution: if a State makes a formal complaint against another State, the case is heard and ruled on by Council, with ultimate appeal to the International Court of Justice.

presented by the G20 discussions and AGF proposal on climate finance (both of which are recognised by UNFCCC), and of resolving the different positions surrounding EU ETS.

2.7 ICAO and MBMs in 2012

At its 37th Assembly in October 2010, ICAO committed to a series of climate related goals including achieving a global annual average fuel efficiency improvement of 2 per cent until 2020 and an aspirational global fuel efficiency improvement rate of 2 per cent per annum from 2021 to 2050. To deliver this goal, States have been asked to develop action plans showing the contribution of technological and efficiency improvements to aircraft and air traffic management systems. Meanwhile ICAO is in the process of developing a new aircraft CO_2 standard[31]. Furthermore, the Assembly Resolution set a medium-term aspirational goal to prevent any net increase in aviation emissions from 2020. For both goals, the Resolution introduces a de minimis threshold of 1 per cent of global activity (measured in Revenue Tonne Km – RTKs – by aircraft registered in a State). If a State is below the threshold it is not expected to contribute to the goals, and its airlines are exempt from participating in an MBM. The threshold is arbitrary and exempts developed countries such as Italy while including several developing countries. The Resolution was widely criticised and States have issued an unprecedented number of reservations covering the clauses on the goals[32] and the de minimis provisions (or, in the case of Canada, on the entire Resolution).

The Resolution also covered MBM issues, including a set of principles to guide States when introducing measures (this is reproduced in Annex A) and the need for ICAO Council to undertake work to develop a framework for market-based measures (MBMs) in international aviation[33]. More importantly, the Resolution called on the Council "*to continue to explore the feasibility of a global MBM scheme by undertaking further studies on the technical aspects, environmental benefits, economic impacts and the modalities of such a scheme, taking into account the outcome of the negotiations under the UNFCCC and other international developments, as appropriate, and report the progress for consideration by the 38th Session of the ICAO Assembly*". Although discussions in 2011 were confined to commissioning a consultant to study the de minimis provisions, pressure to find a solution to the EU ETS dispute has given the ICAO process renewed political momentum and the work to develop a global proposal has been accelerated with the Secretary General initially stating that he hoped to have a preferred option ready by the end of 2012.

[31] An engine NOx standard already exists for the landing and take-off (LTO) phase. While it does not apply to cruise NOx emissions, evidence suggests that there is a positive correlation between LTO and cruise NOx so that more stringent LTO limits will have cruise benefits. This relationship may not hold true for next generation of aircraft and is being kept under review.

[32] The EU, US and Australia criticised the 2020 goal for its lack of ambition, while leading developing countries felt it went too far and would be a constraint on growth.

[33] Work on a framework to support MBMs is running in parallel to ICAO's consideration of a global MBM. While a global MBM will want to ensure consistency with the framework, the framework is viewed by most States as an alternative to an agreement on a global MBM: in the absence of a global approach, the framework will seek to ensure that any regional or national schemes are introduced in a harmonised way, perhaps allowing linking in the future and ensuring that ICAO's principles are respected. The development of the framework is not addressed in this report.

To assess the possible options for a global MBM, ICAO's Council[34] has set up an Ad Hoc Council Group comprising the six Council States who serve as regional co-ordinators, supported by an expert working group. Work is currently underway to look at various approaches including offsetting by airlines, offsetting linked to a revenue generation mechanism, and a cap and trade emissions trading system. It is expected that the Ad Hoc group will report back to Council on the environmental, administrative, economic and legal aspects of each option at its November 2012 session. It is anticipated that Council will take a decision on the options in March 2013 before presenting the preferred approach to the rest of ICAO's member States at the 2013 Assembly (likely to be September/October). States can recommend other options for analysis with the approval of the President. Aiming for a decision at the November 2012 Council session would have allowed for slippage or protracted political discussions with two further Council sessions scheduled for March and June 2013; the extended timeline does not have any such "safety net" if a proposal is to be forwarded to the 2013 Assembly for its consideration.

Despite this, the combination of external pressure and the establishment of a working group process to provide the detail of a scheme represents the best opportunity to reach an agreement in ICAO on a global measure since the negotiations began.

[34] ICAO's Council is made up of 36 States: Argentina, Australia, Belgium, Brazil, Burkina Faso, Cameroon, Canada, China, Columbia, Cuba, Denmark, Egypt, France, Germany, Guatemala, India, Italy, Japan, Malaysia, Mexico, Morocco, Nigeria, Paraguay, Peru, Republic of Korea, Russian Federation, Saudi Arabia, Singapore, Slovenia, South Africa, Spain, Swaziland, Uganda, United Arab Emirates, United Kingdom and the United States. The six regional co-ordinators are: Denmark, Australia, Guatemala, Nigeria, UAE, and United States.

3. ANALYSIS OF THE RANGE OF OPTIONS FOR GLOBAL AVIATION INSTRUMENTS

3. Analysis of the range of options for global aviation instruments

3.1 MBM options under consideration by ICAO

ICAO's initial assessment of MBM options began with consideration of six options developed by consultants MVA Consulting in response to a brief to assess the impacts of ICAO's de minimis threshold on existing and planned MBMs, including existing national and regional schemes and potential designs for a global measure that could be implemented at a future date. In its report, MVA developed a range of options for analysis, including the application of:

- A global departure levy (option 1) – a fixed rate levy (varied by distance bandings) on each departing passenger on an international flight;
- A global carbon levy (option 2) – a charge/tax per tonne CO_2;
- Global offsetting (option 3) – airlines would purchase sufficient offsets to achieve a prescribed environmental outcome;
- A global emissions trading system (option 4) – a global cap and trade system;
- A global departure levy with offsetting (option 5) – a levy on passengers that would generate revenues that would be used to purchase sufficient offsets to achieve a prescribed environmental outcome; and
- A global carbon levy with offsetting (option 6) - a charge/tax per tonne CO_2 that would generate revenues that would be used to purchase sufficient offsets to achieve a prescribed environmental outcome.

For the purposes of the assessment it was assumed that the environmental outcome to be achieved in each case was no net increase in emissions from international aviation from 2020 (consistent with the aspirational goal expressed in the 37th Assembly Resolution). Against this specific criterion, both a departure levy and carbon levy (options 1 and 2) received a low ranking as, without access to the carbon markets, they incurred a high cost to achieve the goal (with the rate for a CO_2 levy estimated in the MVA study to be in excess of at $350 per tonne in 2026). Furthermore, a levy on passengers did not encourage improved efficiency. On this evidence, the Ad Hoc Council Group initially decided to proceed with four revised options, namely:

- Option 1: Global mandatory offsetting;
- Option 2: Global mandatory offsetting plus a revenue generating mechanism;
- Option 3: Global emissions trading (cap and trade);
- Option 4: Global emissions trading (baseline and credit), an option which was subsequently dropped.

No decisions on the detailed design of the options have been taken by ICAO to date. The following sections set out a range of possible approaches to the design of each option.

Option 1 Global mandatory offsetting: Under a global mandatory offsetting scheme, participants (either States or operators) would be required to acquire emissions units (these could be offsets, credits or allowances from existing market-based instruments that meet an agreed set of eligibility criteria) to offset emissions from international aviation above an agreed baseline. The environmental objective could be expressed as all emissions above a 2020 baseline or up to 100 per cent of total emissions. Similarly, the participant in the scheme introduces additional variables: if States are the participants, all individual States would be required to account for emissions from international flights departing from that State (using data from operators reporting to that State or from fuel sales); or from all international flights by operators registered in that State. If operators are the participants in the scheme, all individual operators must cover emissions from their international flights and report either to a central entity or to States (again, by State of registration or State of departing flight).

The global baseline can be distributed to individual participants by either:

- “Grandfathering” based on the participant’s own historical emissions;
- “Benchmarking” using an efficiency metric (for example, emissions per Revenue Tonne Kilometre - RTK); or
- “Percentage of Emissions” where each participant has to offset the same percentage of their emissions.

Option 2 Global offsetting plus a revenue generating mechanism: This option functions in the same way as option 1, but has an additional mechanism for generating revenue. The revenue is additional to the costs of purchasing offsets, raising revenue for agreed purposes such as climate change mitigation and adaptation. Design variables such as the participant and method of distribution are considered to be the same as for option 1. The revenue mechanism could take the form of a transaction fee on each emission unit surrendered (either a flat fee, or a percentage of the price per emissions unit), and an emissions price (a fixed price for emissions that each participant would pay for each tonne of emissions to be offset). The transaction fee/emissions price could be set to raise an agreed revenue generation goal, and could be administered by either States or a central entity.

Option 3 Global emissions trading (cap and trade): In the absence of a multi-sectoral global emissions trading system, this option creates a cap and trade system for the aviation sector where total international aviation emissions are capped at an agreed level. The fundamental difference with the offsetting options is the creation of allowances, referred to in this report as International Aviation Allowances (IAAs), for all the emissions under the cap. IAAs will be distributed to participants (either States or operators) using either the same methodologies as options 1 and 2 (free allocation of allowances using grandfathering or benchmarking), or auctioning allowances to raise revenue for agreed purposes. The most efficient method of distribution would be full auctioning. At the end of each compliance period, participants must surrender sufficient aviation allowances or other emissions units to cover all their emissions during that period and meet their compliance obligations. IAAs can be bought and sold although the market is likely to have a low level of liquidity as the sector will, overall, be a net buyer to fund its growth. For this reason, the option assumes that participants can acquire additional emissions units (non-IAAs) from other carbon markets.

Option 4 Global emissions trading (baseline and credit): ICAO’s Council agreed, at its June 2012 meeting, that no further analysis should be undertaken on this option as both an absolute and efficiency-based approach offered few benefits over offsetting: an “absolute” system would set an emissions baseline allowing participants to earn or buy tradable credits depending on their performance relative to the baseline. However, few participants will be in a surplus position given aviation’s forecast growth resulting in low market liquidity (as credits will only be issued for the gap between actual emissions and the baseline) and high costs. These costs could only be lowered by providing access to emissions units from other systems which makes it, in effect, an offsetting scheme.

Alternatively, an efficiency-based system would require participants to meet a fuel efficiency target. Given forecast growth, it is unlikely that efficiency improvements will be able to deliver an absolute emissions reduction goal without importing emissions units from outside the sector. Again, this option would effectively be the same as offsetting.

3.2 Design criteria for options

Many of the options share common design features that, depending on the eventual choice, will influence the integrity and ambition of an MBM.

> **Participants:** A global MBM will specify the participants who will be responsible for purchasing and cancelling offsets or surrendering allowances. In practice, the participants could be States, operators or, in an upstream scheme, the fuel suppliers. Fuel suppliers have not featured in ICAO's work to date: when recommended in the US Waxman-Markey Bill to establish a US trading programme, the airlines argued that this would reduce their flexibility to control costs as fuel suppliers would effectively add a fixed price to a gallon of fuel to cover their participation costs which would make it a levy from an aviation industry perspective. It is unlikely that airlines would support a global scheme based on fuel suppliers for similar reasons. The industry claims that there will be an additional complexity in differentiating the fuel sold and used on an international flight as opposed to a domestic flight, with some aircraft engaging in both activities from a single refuelling. However, it is likely that existing mechanisms are in place already to perform this calculation since many States apply a domestic fuel tax that will require accurate records for verification. While an upstream scheme may merit further consideration, ICAO's work to date on participants has focused on States and operators. Both approaches have advantages and disadvantages as shown in the following table:

Table 3. **Advantages and disadvantages of different types of participants**

Participants:	Potential advantages	Potential disadvantages
States	• Smaller number of participants.	• May be politically sensitive for States to agree to take responsibility for meeting a specific binding emissions goal on behalf of their airlines/operators, and in the case of an ETS, agree to participate in an auction; • States will recover the costs of compliance from general revenues or establish national-based revenue raising mechanisms to recover costs from the industry. • Would require a central entity to administer the scheme (set cap, distribute obligations, enforce). While ICAO could act in this capacity it is not a regulator; a new entity would require a mandate and perhaps a treaty to establish its authority. It could be politically difficult to agree a new treaty; • Difficult to take enforcement action against States in cases of non-compliance.
Operators	• May not require the establishment of a central entity to administer the scheme as States can perform this task (similar to the role of EU Member States under the EU ETS). Commonly agreed rules could ensure a harmonised approach. • Operators are not parties to the Chicago Convention which may reduce legal objections.	• Larger number of participants creates greater administrative burden; • ICAO has no mandate to interact with operators, although this is not an issue if States administer the scheme; • If States administer on the basis of all departing flights, could generate multiple compliance obligations for each operator, increasing administrative burden.

Source: AET

Notes: This discussion is continued in more detail in section 5

The disadvantages associated with obligated operators are largely administrative and are not as great as the political difficulties of participation by States. For this reason, operators appear to be the most suitable choice to be the participants in a global MBM.

Environmental target: Agreeing an environmental goal for an MBM will resurrect the discussions underpinning ICAO's adoption of an aspirational goal for no net increase in emissions from 2020 at the 2010 Assembly. The reservations made by States on this clause in the Assembly Resolution varied in their nature. Some States argued strongly in favour of more ambition: this included the US and Australia who advanced a case for no net increase in emissions from 2005 levels, while the EU Council had a mandated position to push for a target of 10 per cent below 2005 levels. This was counterbalanced by calls from developing countries that it was premature to agree medium-term targets without first undertaking studies on whether they could be achieved and at what cost to industry (and, by implication, the impact on growth). This was compounded by a lack of certainty on how developing country issues would be addressed. These political tensions remain, and it should be stressed that the Assembly goal (supported by industry) will still require a political discussion at Council and the next Assembly before being finalised.

It would be advantageous when designing an MBM to have a cap based on an historical year as the data already exists. In an alternative scenario where a system begins in the same year as the target, a cap and trade scheme will need a formula to calculate the volume of allowances to be generated in advance. This could be expressed as an historical base year plus an estimate of the likely growth out to 2020. The cap can be revised in subsequent compliance periods to take account of any differences between the actual and forecast levels in 2020. To give sufficient lead time to calculate the volume of allowances and prepare for the distribution of allowances the cap could, for example, be set at a level equivalent to a percentage of a future year baseline.

Availability, Environmental Integrity and Quality of offsets and allowances: Under all the options, participants will need to obtain sufficient emission units to meet their obligations. At present, ICAO has taken no decision on eligibility criteria, and the inclusion of units approved by legislation such as Assigned Amount Units (AAUs) and Certified Emissions Reductions (CERs)as well as non-legislative units, such as Voluntary Emissions Reductions (VERs), are all under consideration. In any decision on eligibility criteria, the overriding consideration is maintaining the environmental integrity of the reductions commitments – the offset arrangements must ensure that the atmosphere sees net emissions reductions of at least the level of the reduction commitments assumed, with no negative environmental impacts. The environmental integrity of an option could be enhanced by considering whether or not to limit access to certain types of emission unit based on quality. Quality includes additionality, sustainability benefits in host country and permanence and can be ranked in terms of performance:

Table 4. **There are a variety of options for offset projects**

Offset Project	Description
Gold Standard CERs	The Voluntary Gold Standard designation has sustainability benefits on top of the CDM.
European ETS (EU Allowances EUAs)	EUAs have the advantage of being created under a mandatory, capped regime with compliance; however they also currently face over-supply.
Clean Development Mechanism (CERs)	A recent study by the European Commission into the integrity of the CDM market highlighted several reservations about the performance of the CDM market despite acknowledging that it raised awareness of clean technologies, attracted finance, and helped countries gain experience[35]. These advantages were offset by criticism that CDM had delivered limited technology benefits; that the methods and guidance were insufficient leading to variations in baseline calculations; the lack of transparency and rigour in the verification process; and issues relating to competitiveness and scalability. As a consequence, the EU has introduced quality restrictions including requirements for all projects after 2012 to be located in the Least Developed Countries (LDCs). In any case, the CDM does not operate under an emissions cap, and so does not necessarily represent real emissions reductions.

[35] AEA (2011) *Study on the Integrity of the Clean Development Mechanism,* http://goo.gl/xMFlz

Offset Project	Description
Joint Implementation (Emission Reduction Units, ERUs)	ERUs from track 1 Joint Implementation (JI) projects are perceived to have low integrity as projects can be approved and credited unilaterally by the host country.
International Emissions Trading (AAUs)	AAUs are estimated to have approximately $10GtCO_2$ of surplus credits so unlikely to lead to any emissions reductions.
Voluntary Emission Reductions (VERs)	There is limited quality control for VERs as there is no regulatory oversight. This may affect credibility. Although standards exist, like the Verified Carbon Standard, they are generally less rigorous even than the CDM.

Source: AET

A recent report[36] from the OECD highlights the advantages of allowances over offsets from unregulated sources "*For an offset to be legitimate, the payment of a credit must go toward mitigation measures that would not exist otherwise, i.e. the mitigation must be additional. Such additionality is inherently elusive and hard to prove. The more cost-effective and feasible a mitigation project, the more likely it is to occur anyway, i.e. less likely it is additional*". A way to deal with this additionality problem is to include a discount factor that multiplies the amount of offsets needed to compensate for a given number of emissions.

In terms of the supply of credits there are currently no indications of supply shortages in the CDM market and the EU ETS. This situation is likely to persist in the short run. According to Bakker et al (2007), *"the potential supply of carbon credits is large compared to the likely demand up to 2020"*[37].

In the longer run, the supply situation is harder to predict. With regards to demand, based on ICAO forecasts for fuel burn, the estimated sector-wide annual reductions required to achieve no net increase in emissions from 2020 are shown in the following table for the years 2020-2030:

Table 5. **Emissions from international aviation and required sector-wide annual reductions**

Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Emissions from international aviation $mtCO_2$	657	683	711	739	769	800	832	866	901	938	976
Sectoral reduction required to meet 2020 goal $mtCO_2$	0	26	54	82	112	143	175	209	244	281	319

Source: ICAO CAEP 8

[36] OECD (2012) *Green Growth and the Future of Aviation*, http://goo.gl/Q9Btt
[37] Bakker, S., Arvanitakis, A., Bole, T., van de Brug, E., Doets, C., Gilbert, A. (2007) *Carbon credit supply potential beyond 2012 – A bottom-up assessment of mitigation options*, Amsterdam: ECN

It is essential that any MBM should directly encourage and reward emissions reductions within the sector, allowing the carbon markets to be an alternative only in circumstances where reasonably attainable in-sector reductions have been delivered. For this reason some

mechanism to limit the use of emission units might be considered, by applying the principle that offset mechanisms should be strictly supplemental to in-sector emission reductions below a set baseline. For example, an MBM could take account of ICAO's commitment to a 2 per cent per annum improvement in fuel efficiency before providing access to the carbon markets.

Generating revenue: Revenues can be generated through a transaction levy (option 2) or through an auction of allowances (option 3). The transaction fee could be a flat fee or a percentage of the price of the emissions unit. A flat transaction would be simpler and would not be affected by fluctuations in the carbon markets, making it easier to estimate and achieve a target amount of revenue (unlike a percentage-based approach). A flat fee could also be levied on all emissions and not solely the amount to be offset above the baseline. This would have required all participants to pay for their emissions irrespective of whether they were required to purchase offsets, and thus respected the polluter pays principle. While industry might have argued that this penalises airlines that are not growing, it would have ensured that every operator made a contribution based on their respective emissions. A flat fee is a viable approach under this option for option 2.

The Annex to Resolution A37-19 contains a number of guiding principles for the implementation of an MBM including the use of revenues, specifically that "*where revenues are generated from MBMs, it is strongly recommended that they should be applied in the first instance to mitigating the environmental impact of aircraft engine emissions, including mitigation and adaptation, as well as assistance to and support for developing States*". This can be interpreted to include both in- and out- of sector mitigation opportunities. Potential uses could include:

- Covering the administrative costs of the system;
- Using the revenue to finance additional emission reductions (using offsets) below the baseline or cap;
- Financing measures identified in States' action plans and regional initiatives such as R&D; improved air traffic management systems; and alternative fuels; and technical assistance to States, especially reflecting the special circumstances and respective capabilities of States, to help them modernize aviation systems to improve fuel efficiency;
- Contributing to broader mitigation and adaptation activities outside the aviation sector. This could include contributions to the Green Climate Fund;
- Help to ensure no net incidence on qualifying States who participate (as an alternative to a de minimis provision).

De Minimis and developing country issues: ICAO's introduction of a 1 per cent of RTK de minimis clause in its 37th Assembly Resolution has created difficulties for the design of an MBM. Firstly, many developing countries find themselves above the threshold, while some major developed countries are excluded. The Following table shows the 22 States (out of

191 Contracting States) that were above the threshold in 2009, representing over 82 per cent of international aviation activity.

Table 6. **States above the proposed de minimis threshold, and their share of total revenue tonne kilometres**

Ranking	State	RTK (million)	% Share	Cumulative %
1	US	54,372	15.14	15.14
2	China	28,789	8.02	23.15
3	Germany	26,243	7.31	30.46
4	UK	22,782	6.34	36.80
5	UAE	21,822	6.08	42.88
6	France	17,178	4.78	47.66
7	Republic of Korea	15,589	4.34	52.00
8	Netherlands	13,111	3.65	55.65
9	Singapore	12,973	3.61	59.26
10	Japan	12,665	3.53	62.79
11	Ireland	8,008	1.23	65.02
12	Canada	6,942	1.93	66.95
13	Australia	6,924	1.93	68.88
14	Thailand	6,539	1.82	70.70
15	Spain	6,361	1.77	72.47
16	Qatar	5,621	1.56	74.03
17	Malaysia	5,250	1.46	75.50
18	Russian Federation	5,168	1.44	76.94
19	India	5,086	1.42	78.35
20	Turkey	4,855	1.35	79.70
21	Luxembourg	4,688	1.31	81.01
22	Switzerland	4,009	1.12	82.12

Source: ICAO data 2009

States such as Italy, New Zealand, Portugal, Finland, Austria, Belgium, Sweden, Denmark, Norway, Poland, and Greece all fall below the threshold and would be exempt from having to contribute to the effort to achieve ICAO's goals. Furthermore, the de minimis is expressed as a simple percentage, so if States grow at the same rate, few will cross the threshold in the future. An alternative threshold would be 0.1 per cent of RTKs which would include the top 68 States by activity and cover 97.9 per cent of international aviation activity.

Irrespective of where the threshold is drawn, significant problems still remain for the design of an MBM. The exemption of carriers from de minimis States creates competitive distortions where they compete with non-de minimis carriers. As this breaches ICAO's policy of non-discrimination (equal treatment of all carriers on a given route), it may lead to pressure to exempt all carriers on routes where de minimis carriers operate, further limiting the coverage of a scheme and the resulting environmental benefit (in the region of a 20% reduction). While the Assembly Resolution notes that some States may take on a bigger commitment to ensure the sectoral goal is met, this would increase the costs to participants.

It is necessary to distinguish between the issue of a de minimis clause to avoid unreasonable administrative burden and other mechanisms to take developing country needs and capabilities into account. The EU ETS already provides a workable de minimis definition for administrative purposes:

- aircraft size or type (such as helicopters, aircraft under a specified maximum takeoff weight);
- types of operations (such as humanitarian and relief flights, medical flights or State aircraft);
- activity thresholds (such as the number of flights, total RTK or total emissions).

The application of similar provisions in a global MBM has merit, providing it does not result in competitive distortions.

The ICAO principle of "special circumstances and respective capabilities of States"[38] could be addressed through exemptions or a phase-in of obligations. It will be essential to ensure that any exemption to and/or from a State is based on all flights to avoid distortion. Any exemptions should be coupled with a phase-in approach to increase the coverage of the scheme over time. An alternative approach for the options that generate revenue would be the inclusion of all international flights, using the revenues to compensate States where appropriate: this could reconcile the need to take the circumstances of developing countries into account while ensuring that ICAO's principle of non-discrimination is upheld. Revenue could be channelled towards climate finance for developing countries, providing additional environmental benefits, although some revenues could be kept within the industry proportional to the emissions reductions made in-sector. The ability to generate revenue is therefore seen as a critical feature.

Administrative issues - MRV, compliance, registry: Monitoring, reporting and verification (MRV) activities are common to all the options, as is the need to have a registry to track the surrender or cancellation of emissions units. While each option may have specific requirements, the key factors will depend on who administers a scheme. The most straightforward approach would be for operators to interact with States, with ICAO publishing common templates and guidance to ensure a harmonised approach. States would report on the reported emissions obligations to ICAO so that the data can be aggregated and measured against the global goal. However, to perform this function, most States will need to introduce national legislation to create an enforceable framework, introducing possible lengthy delays while States seek the necessary national approvals. This could be overcome by having a central entity. ICAO is addressing the legal issues surrounding issues such as whether it can distribute compliance obligations to participants and how it would handle revenues. Consideration must also be given to the role that could be played by other institutions such as the World Bank or the international emissions register, although these, or a new entity, could require an international treaty to establish the necessary authorities, and that presents its own political challenges.

3.3 Other proposals

Aviation Global Deal Group (AGDG):[39] The AGDG has been a progressive voice amongst the airline community and has engaged in the international discussions on how to address aviation's impact on the climate. A central theme of its work has been the idea that a "patchwork" of sectoral measures

[38] This language is used in ICAO's Resolution as an alternative to UNFCCC's Common but Differentiated Responsibilities (CBDR).

[39] AGDG comprises Air France-KLM, Cathay Pacific Airways, Finnair, LOT Polish Airlines, Qatar Airways, Virgin Atlantic Airways, Virgin Australia, BAA and the Climate Group.

by States will result in an uncoordinated approach with the potential for duplication of effort and multiple reporting requirements all of which would add significant cost to airline operations. A global approach is seen as a more effective alternative and AGDG involvement has helped to move the debate forward. Early ideas included a tiered emissions trading scheme with the world divided into three regions grouped according to international development criteria, each with its own reduction obligation. Where flights occurred between two regions, the lower emissions obligation would apply. The aim behind this proposal was to include all flights to eliminate competitive distortions but address developing country concerns. The concept had many similarities to an earlier proposal put forward by the European Airlines Association (AEA). Since then, AGDG's thinking has developed and its most recent proposal is based around a four stage phased implementation leading to global cap and trade carbon trading. The first stage would see ICAO's 2013 Assembly agree a trajectory between 2016 and 2050 based initially on "carbon neutral growth" and working towards a 50 per cent net reduction by 2050. During the period up to 2016 it is envisaged that regional ETS schemes will be operating in Europe and Australia/New Zealand. Between 2016 and 2020, stage 2 would see the addition of regional ETS schemes in North America and South East Asia while all other flights outside of the boundaries of these scheme would use offsetting to realise the goal of carbon neutral growth (except all flights in and out of LDCs which would be excluded). Stage 3 (from 2020) would see the linking of regional ETS schemes before moving to a global trading system (from 2025) where auction revenues can be used for climate change initiatives in developing countries and a proportion directed to initiatives to accelerate the introduction of sustainable biofuels.

Industry recognition of the need to generate revenue and its use to address the needs of developing countries is welcome. However, the proposal makes bold assumptions about the feasibility of developing and introducing regional ETS schemes to such a short timescale. Given that the extension of the EU ETS to aviation took over six years from conception to commencement with a strong political mandate, this proposal seems unrealistic especially as there is no current political debate in some of these regions. The end point of the proposal is a global cap and trade scheme with auctioning: this design can be accommodated within ICAO's option 3 (which is likely to have an earlier start date, in 2020).

Lessons from the International Maritime Organisation's (IMOs) consideration of MBMs for international shipping: IMO's consideration of an appropriate MBM has been underway for over two years. One of the options is a mandatory ETS and another is a baseline and credit scheme based on its Energy Efficiency Design Index (EEDI). These are similar to ICAO's cap and trade and baseline and credit schemes, although in the latter case, this approach has more relevance to ships where there are a vastly superior number of different ship designs in operation. IMO has also analysed the role of a levy contributing to a GHG fund which could be used to purchase offsets to meet a defined environmental outcome.

The case for exploring fuel/emission levies: ICAO's rejection of a fuel or carbon levy was based solely on the high price that would be required to deliver the 2020 environmental goal without access to the carbon markets. However, set at a lower rate, a fuel/carbon levy could generate significant revenue that, in part, could fund the purchase of emissions unit credits or allowances. This shares many of the characteristics of ICAO's option 2 (offsetting plus a revenue generating mechanism) but would apply a price to all fuel sold or CO_2 emitted, raising more revenue. Although it could be argued that this has similar properties to a fuel tax, ICAO's Chicago Convention only prohibits fuel already on board an aircraft from being taxed. The majority of bilateral air service agreements do contain provisions that prohibit fuel taxation but, using ICAO's own definition, a levy on carbon could be interpreted as a charge for a collective service, providing it does not apply a price greater than the cost of carbon (in other words, it is a cost recovery mechanism). Applied upstream on fuel suppliers, this would involve fewer participants and be administratively simpler.

3.4 High-level summary of the merits and demerits of each approach

The objectives of this study are to assess MBM options against their ability to meet the following objectives:

1. Achieves substantial greenhouse gas emissions reductions from international air transport in line with international efforts to keep global warming below 2 degrees Celsius above pre-industrial levels, with the emissions reduction objectives of the current EUETS system serving as a floor;

2. Generates financing for the Green Climate Fund to be used for climate change action in developing countries, at a scale in line with the findings of the World Bank and IMF report on Mobilizing Climate Finance, which was compiled for the G20 Finance Ministers;

3. Conforms to the existing principles of the Chicago Convention and ICAO while accommodating the principle of Common but Differentiated Responsibilities and Respective Capabilities (CBDRRC) of the UNFCCC.

The ability of the three remaining ICAO options, plus an option for a carbon charge to satisfy these objectives is summarized in the table below.

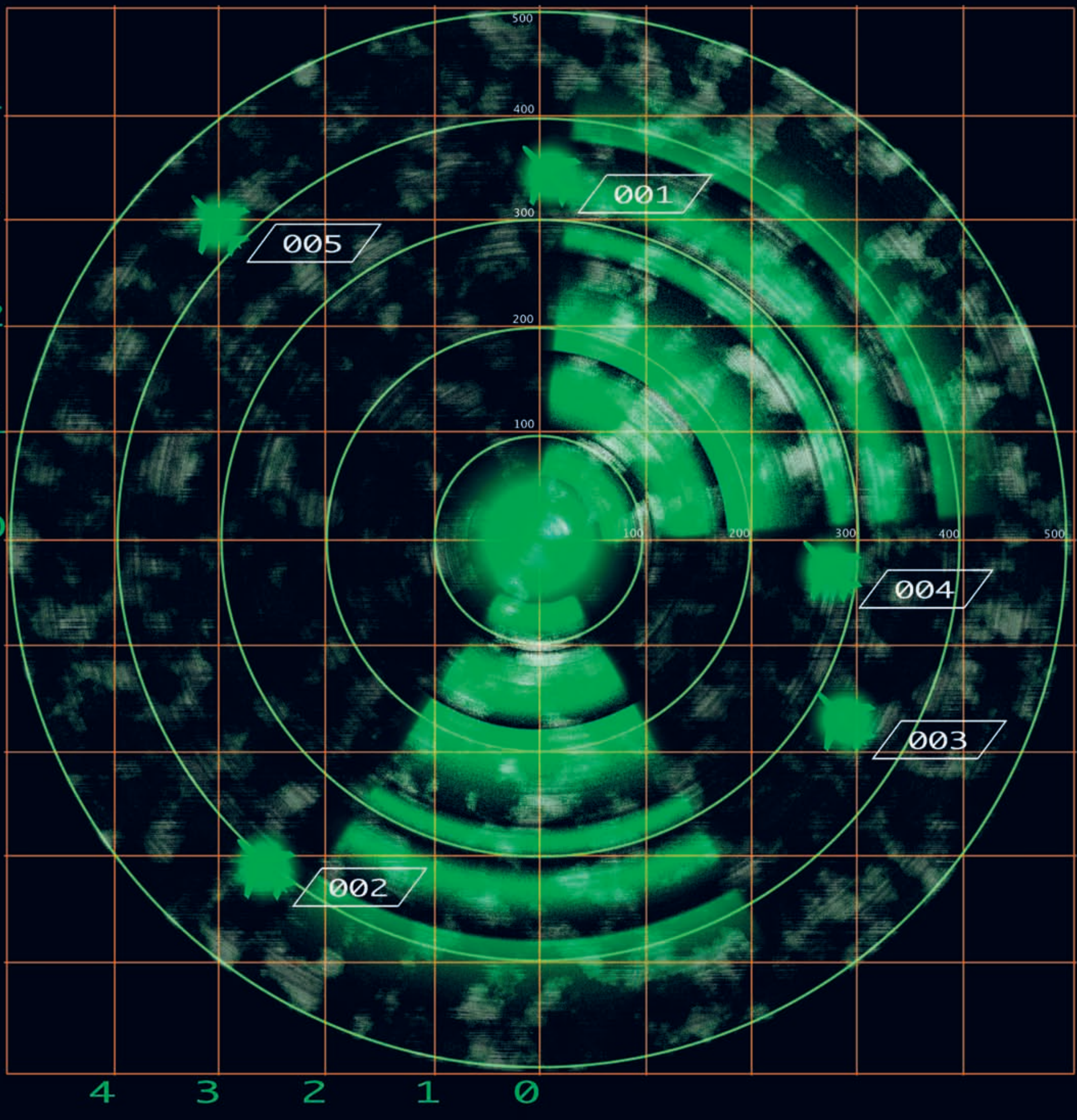
Table 7. **High-level summary of the merits and disadvantages of the options under consideration**

	ICAO Option 1	ICAO Option 2	ICAO Option 3	Alternative Option 4
	Offsetting by airlines	Offsetting by airlines or States with a revenue generation mechanism	Cap and trade ETS	Carbon levy with offsetting
Assumption regarding participant	Operators	Operators	Operators	Fuel suppliers
Achieves emissions reductions?	Capable of meeting net emission reduction goals, but low cost of credits is unlikely to drive additional in-sector reductions.	As option 1, but use of revenues could be used to generate additional benefits in and out of sector.	Same as option 2.	Same as option 2.
Generates finance?	No.	Yes. A fixed levy would provide the greatest certainty.	Yes, through auction of IAAs. Revenue potentially higher than in option 2.	Yes, more potential for revenue than options 2 and 3.
Consistent with ICAO and UNFCCC principles?	Yes, if de minimis provisions are applied to routes rather than carriers.	Yes, if de minimis provisions are applied to routes rather than carriers. Use of revenues could help address developing country issues under UNFCCC.	Yes, if de minimis provisions are applied to routes rather than carriers. Use of revenues could help address developing country issues under UNFCCC. Airlines for America (A4A) recent legal challenge to the EU ETS claimed that the trading scheme infringed several aspects of the Chicago Convention but these claims were rejected by the European Court of Justice.	Yes, if de minimis provisions are applied to routes rather than carriers. Use of revenues could help address developing country issues under UNFCCC. A levy on carbon could be perceived as a levy on fuel. The Chicago Convention does not prevent taxation of fuel uplifted, but it may create problems with Air Service Agreements, if characterised as a tax rather than a charge.
Legal compatibility?	Even with de minimis provisions, some developing countries may not consider this approach to be compatible with CBDR.	Institutional arrangements for handling revenues will need to be addressed.	Institutional arrangements for handling revenues will need to be addressed, as will the authority to create IAAs.	Institutional arrangements for handling revenues will need to be addressed.
Additional comments	Environmental integrity perceived to be low.	Potentially easier to administer than a trading system. Environmental integrity perceived to be low.	Assuming that there is low liquidity for IAA's, compliance will be achieved through the purchase of emission units from the carbon markets. In essence, this mirrors option 2 but with additional administrative complexities.	Administratively simple. Puts a price on all emissions, and can be annually reviewed to achieve the desired revenue target. This option differs from the levy option rejected by ICAO as it puts a price on carbon which is significantly lower than the assessment by MVA.
Overall comparative performance	Low	Medium	Medium	High

Source: AET

A detailed assessment of these options, including compatibility with the evaluation criteria being used by ICAO, is set out in the next Chapter.

4. COMPARISON OF INSTRUMENTS



4. Comparison of instruments

This section provides an economic comparison of the four options identified in chapter three of this report. It is structured into five parts, and begins by setting out the criteria that can be used for such an assessment, drawing on ICAO's criteria which are briefly outlined. Next, a brief discussion of ICAO's environmental goal is provided, which compares the goal of carbon neutral growth post 2020 with global emission targets. Following this is a qualitative discussion of the economic impacts of these instruments paying particular attention to explicit and implicit distributional effects. The fourth section is a quantitative assessment of the mitigation potential of the four options; mitigation potential is similar across all options. The chapter closes with a discussion of the political acceptability of the proposals.

4.1. Criteria for assessment

The options identified in chapter three can be assessed according to a variety of criteria. Apart from clearly important criteria like emissions reduction, cost effectiveness, and distributional impacts, there are a number of more subtle factors which are important, including legal compatibility with existing treaties and administrative complexity. This section compares criteria proposed by ICAO and the International Maritime Organisation (IMO), and synthesises them into a simpler set that can be used in the assessment of options.

ICAO criteria

ICAO provides an extensive list of evaluation criteria for the assessment of market based instruments for emissions reduction in aviation. This list covers all relevant aspects essential for the comparison of different instruments, and hence forms the basis for the assessment criteria used in this report. ICAO identifies 14 separate criteria (which in turn are divided into sub-criteria) structured into three categories: environmental, economic, and implementation. The criteria are

- Environmental: CO_2 reduction;
- Economics: global competitiveness, cost, cost effectiveness, carbon market, burden on aviation relative to burden on other sectors; and
- Implementation: legislative feasibility, design features and timescale, administration, technical feasibility of market based measures, rechanneling revenue, ability to reconcile the principle of CBDR with the Chicago Convention, ability to capture and report emissions reductions in State Action Plans, and political acceptability.

Each of these criteria is further broken down into a series of questions or dimensions that illustrate their precise characteristics. These details are shown in table 11 below. However, in striving for complete coverage, this set of criteria compromises on clarity, brevity, and on the clear distinction between each of the criteria. We therefore compare it with a more succinct set provided by the International Maritime Organisation.

The International Maritime Organisation's nine criteria

The IMO has also conducted extensive analysis of different market and non-market based measures to reduce emissions, and has provided a list of the principles that are used in its evaluations. This list is shorter than ICAO's, featuring nine rather than 14 criteria, and is more succinct, with fewer subcategories within each criterion[40]. There is considerable overlap between ICAO's and the IMO's criteria: for example, both consider CO_2 reduction, cost effectiveness, administrative simplicity, compatibility with existing treaties and legal commitments, and ability to support technology transfer. However, since the IMO's criteria are specifically designed to assess policies aimed at shipping, they lack elements such as compatibility with the Chicago Convention.

Synthesis

ICAO's criteria form the basis for the set of criteria used for assessment in this report. However, two changes were made. First, the criteria were simplified. This includes the removal of the 'carbon market' criterion, which is captured in cost and cost effectiveness criteria[41]; the 'technical feasibility' criterion, which is captured in the design features and administration criteria; and the merging of the principle of Common but Differentiated Responsibility (CBDR) with the Chicago Convention and the more general criterion of legislative feasibility. The criterion 'Ability to capture and report emissions reductions in State Action Plans' has been merged with the newly added criterion of 'Compatibility with national or regional measures'.

Second, two further criteria were added: firstly, the CO_2 reduction criterion is split into a static and a dynamic part. The static part captures the incentive that airlines have to achieve a certain level of abatement, while the dynamic part captures the incentive that airlines have to achieve on going improvements in abatement. This distinction is particularly evident with regulatory instruments, which create a strong static incentive to deliver the required reduction in CO_2 emissions, but provide almost no dynamic incentive for further incremental reductions. Secondly, the criterion 'compatibility with national or regional measures' is added. In a world in which no global agreement on action is reached, it would be a distinct advantage for a policy measure to allow national and/or regional action to go ahead.

The set of criteria resulting from this synthesis is displayed in Annex Btable 11. A full assessment of the four instruments against those criteria is given in chapter 6 of this report.

4.2 Discussion of environmental goals

ICAO's aspirational climate change goal, from 2020 onwards, is to cap emissions at their 2020 level, and to restrict all further growth to carbon neutrality. Given current projections of emissions from international aviation, this would cap emissions at approximately 660 mega tonnes of CO_2 ($MtCO_2$) in 2020. Uncapped emissions, referred to as the business as usual path, are predicted to increase above 660 $MtCO_2$, reaching 800 $MtCO_2$ by 2025, 980 $MtCO_2$ by 2030, and more than 2,150 $MtCO_2$ by 2050. This path is shown in figure 2 below.

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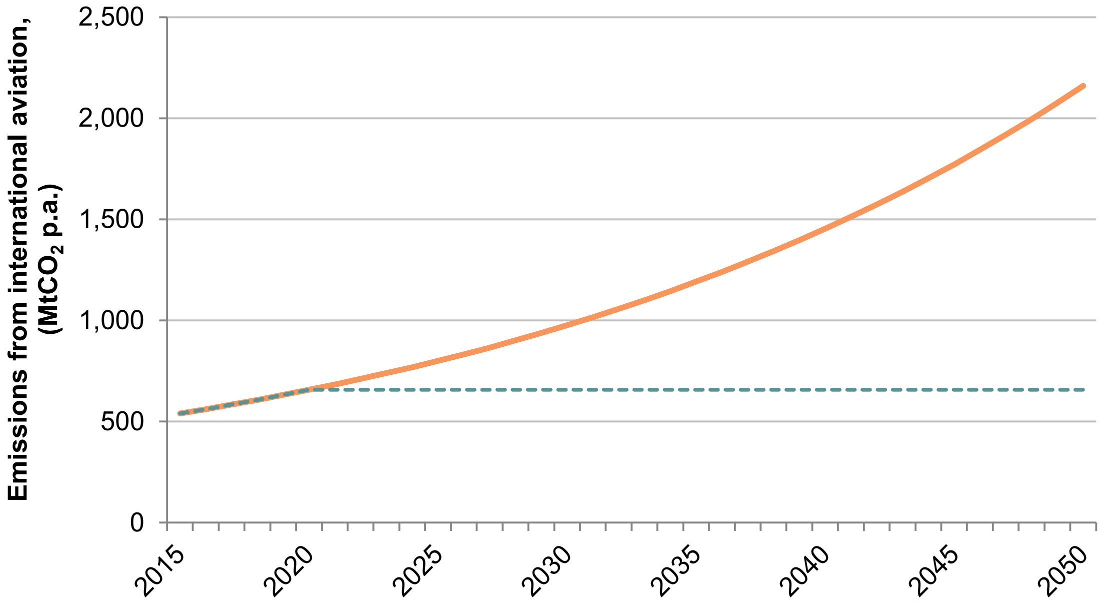
[40] The nine criteria are: (1) environmental effectiveness; (2) cost-effectiveness and impacts on trade and sustainable development; (3) incentive to technological change and innovation; (4) practical feasibility and implementability; (5) ability to transfer technology and resources to Least Developed Countries (LDCs) and Small Island Developing States; (6) compatibility with other existing conventions, such as the UNFCCC, the Kyoto Protocol and the World Trade Organisation; (7) administrative burden and legal aspects of national enforcement; (8) additional burden on individual ships, the shipping industry, and the maritime sector as a whole; (9) compatibility with the IMO's existing enforcement and control provisions.
Source: IMO (2010) *Reduction of GHG Emissions from Ships – Full report of the work undertaken by the Expert Group on Feasibility Study and Impact Assessment of possible Market-based Measures*, London

[41] An imperfect connection to international carbon markets would significantly increase costs and cost effectiveness.

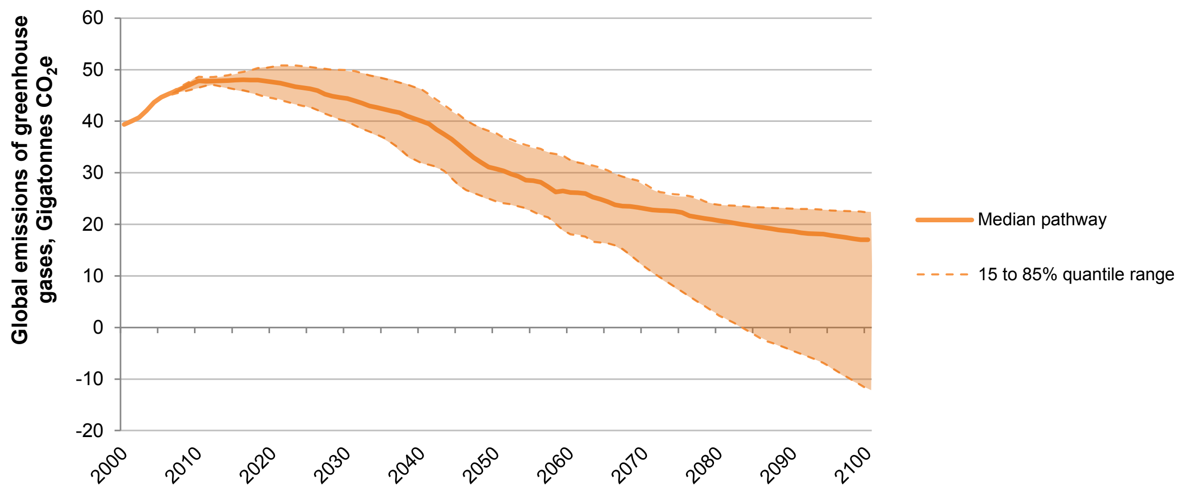
Figure 2. **Business as usual emissions are set to increase rapidly beyond 2020**



Source: Vivid Economics, based on CAEP projections

It is unclear whether the set of environmental goals that ICAO aspires to, together with action that will be taken in other sectors, is collectively sufficient to achieve another commonly accepted target: the goal of keeping global warming above pre-industrial temperatures to less than 2 degrees above pre-industrial levels, agreed at Copenhagen in 2009. One way of measuring what the 2-degree limit may mean for aviation is by looking at the global emissions path for 2 degrees stabilisation, shown in figure 3.

Figure 3. **Emissions pathways required to limit global temperature increases to between 2 and 2.5˚C**



Note: *The chart shows a set of pathways that are consistent with a 66 per cent likelihood of global temperature increases between 2 and 2.5 C˚ by 2100. The median pathway is shown as a solid line, while the shaded area indicates the 15 to 85 per cent quantile ranges*

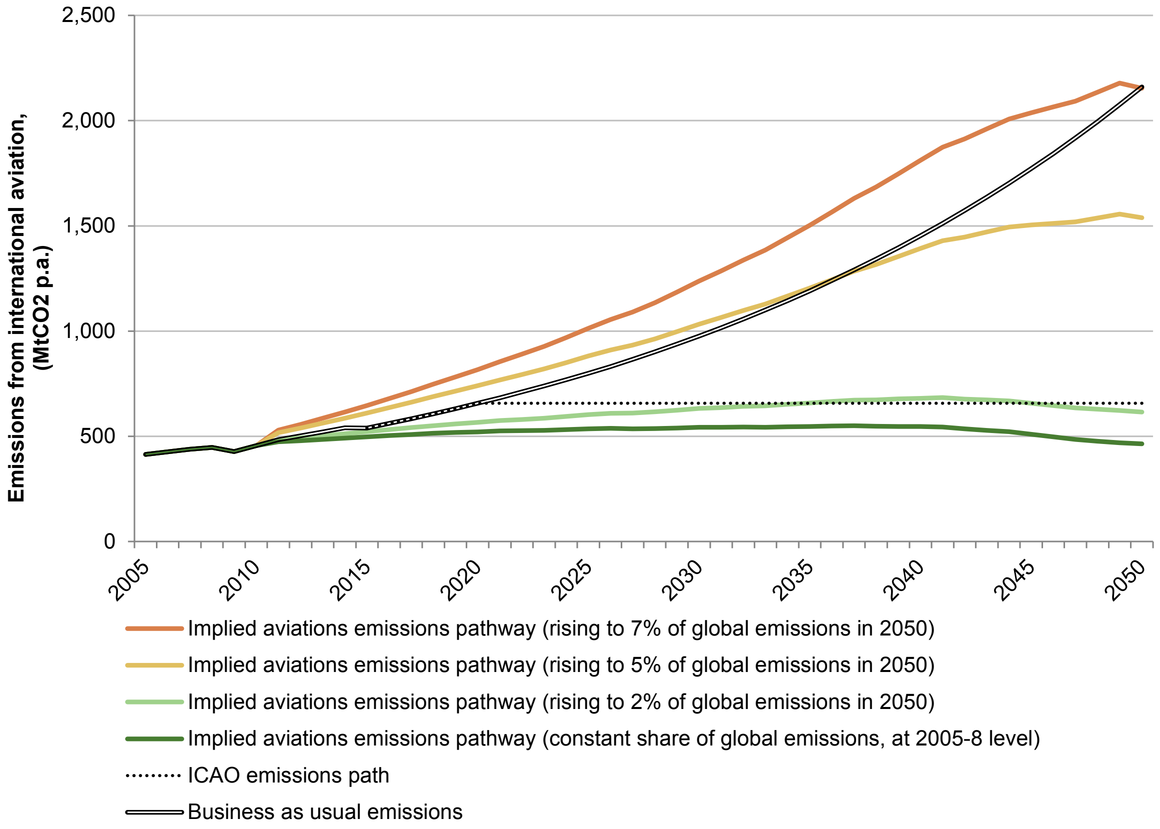
Source: *Rogelj, J., W. Hare, J. Lowe, D. P. van Vuuren, K. Riahi, B. Matthews, T. Hanaoka, K. Jiang & M. Meinshausen (2011) Emission pathways consistent with a 2C˚ global temperature limit. Nature Climate Change, 1, 413-418; and Vivid Economics*

Aviation emissions need not follow the precise path shown in figure 3 to be consistent with a 2 degree global warming limit – as long as other sectors 'pick up the slack' by reducing emissions by more than indicated in figure 3. To show the relative levels of ambition, figure 4 makes a comparison between ICAO's plan and scenarios in which the *share* of emissions from *international* aviation as a proportion of total emissions either stays constant, or is allowed to increase to 2, 5, or 7 per cent of total emissions, up from approximately 1.5 per cent today[42] (a higher share is more generous to aviation, allowing it to make proportionally smaller emission cuts than the average sector). Global emissions in figure 4 follow the median pathway shown in figure 3.

The figure shows that an ambition to keep constant the share of emissions from international aviation in the global total would imply a considerably more ambitious pathway (shown in dark green) than ICAO's plan (shown as the black dotted line). In other words, ICAO's plan is only consistent with a 2 degree global warming limit if other emitters reduce emissions by *more* than aviation to 'make room' for additional emissions from international aviation. Put another way, emissions from other sectors have to reduce their emissions more than average in order for aviation's less ambitious reduction target to be consistent with 2 degree warming.

[42] International aviation currently accounts for approximately 1.5 per cent of total global CO_2 emissions; total emissions from aviation, including both domestic and international, are currently approximately 2.5 per cent of the global total. These figures are based on IEA (2012), 'Emissions from Fuel Combustion 2012 edition', Paris.

Figure 4. **ICAO's projected path is only consistent with 2˚ to 2.5˚C warming if the share of emissions from international aviation remains below approximately 2 per cent of total global emissions**



Note: *International aviation emissions constituted 1.5 per cent of global emissions on average between 2005 and 2010; this is below the 2.5 per cent figure cited throughout the report, as it excludes domestic aviation.*

Source: *IEA (2012) "Emissions from Fuel Combustion 2012 edition", Paris, for aviation emissions 2005-10; Rogelj et al (2011) for global emissions consistent with 2˚ to 2.5˚C global warming; CAEP for ICAO emissions path*

4.3 Discussion of economic impacts

This section presents a qualitative discussion of how market-based instruments might affect global aviation. The common economic feature of the market-based instruments examined in this paper is that they all introduce a price on emissions. This price incentivises airlines, customers, and other stakeholders, and creates financial impacts, which are analysed and described in this section. This mechanism of impact is similar for all four instruments, whose main differences lie in the way they are administered (and hence in the administrative costs connected with each proposal), in the way that costs and benefits are distributed, and in the revenue that they make available for public spending. In addition, they may lead to different price levels and hence different economic and environmental impacts. Qualitative differences are compared in the overview table given in chapter 6, while the differences in revenue raised are shown in chapter 5.

How markets respond to market instruments

Market instruments for reducing CO_2 emissions put a price on carbon. Due to the mostly standardised composition of jet fuel, the effect of a carbon price is similar to an increase in the price of fuel. This increase in fuel prices is first felt by airlines. Keeping ticket prices constant, it would reduce their profits and hence reduce industry capacity in the long run. However, customers are willing to bear a certain increase in ticket prices while trimming demand in response. As a consequence, some of the cost is passed through to ticket prices.

The level of cost pass-through depends on a number of factors. First, it depends on the nature of market demand by customers (price elasticity of demand). Second, it depends on firm strategy: do airlines aim to maximise profits or maximise sales? Third, it is affected by the number and size of airlines competing in the same market, which is to say how customer demand is shared between them. All these considerations may vary between markets. An explanation of how to define markets in aviation is given in Annex B, which can be summarised as follows: for time-sensitive passengers, the markets are mostly point to point routes. For non-time-sensitive travellers, individual markets are slightly larger, and may include indirect routes, adjacent airports at either end, or alternative modes of transport. Markets for freight are separate and approximately continental in scope for non-time-sensitive goods, or point-to-point routes for time-sensitive goods.

The more elastic demand is, the lower cost pass-through is likely to be. Each percentage point increase in costs leads to a larger percentage fall in market demand, which reduces overall revenues. Depending on firm strategy, airlines curtail ticket price rises in markets with elastic demand. The opposite applies for inelastic demand: an increase in ticket prices leads to a proportionally smaller reduction in demand, thus increasing overall revenue. As shown in Vivid Economics (2007)[43], cost pass-through rates in inelastic markets might exceed 100 per cent, and might be as high as 150 per cent.

Firm strategy also influences cost pass-through rates. There is some evidence that airlines pursue sales or market-share maximisation strategies rather than profit maximisation, at least from time to time (see Vivid Economics 2007). Firms that aim to maximise sales or market share will adopt cost pass-through rates close to 100 per cent, acting as though they face a larger number of rivals. This means that in markets with inelastic demand, sales or market share maximising firms will increase ticket prices by less than profit maximising firms, while in markets with elastic demand the opposite result is likely to hold.

Lastly, the number of airlines in a given market affects cost pass-through rates. For markets with a large number of firms, cost pass-through is 100 per cent: if any given firm increases prices by more than that, it will be undercut by a rival and lose market share. If it increases prices by less than 100 per cent it will incur losses and lose investment. However, the situation is more complex in smaller markets. Depending on market demand characteristics, the number of firms, and firm strategy, cost pass-through can be either greater or smaller than 100 per cent. Given the market definitions outlined above, most markets for civil aviation feature only a handful of firms, usually between two

[43] Vivid Economics (2007) *A Study to Estimate Ticket Price Changes for Aviation in the EU ETS*, report prepared for the UK Department for Transport and UK Department for Environment, Food and Rural Affairs, London, http://goo.gl/mMFOw

and four. Cost pass-through can therefore deviate significantly in either direction from 100 per cent, with single-airline business routes most likely to see cost pass-through of more than 100 per cent, and multi-airline leisure routes most likely to see cost pass-through of less than (though close to) 100 per cent. However, as Vivid Economics (2007) found, average cost-pass through across the aviation industry is likely to be close to 100 per cent.

Impacts up and down the supply chain

Impacts up and down the supply chain vary depending on whether a good is a final good sold to customers, or whether it is an input into further production activities. Passengers are the end-consumers of transport services. In other words, there is no further supply chain into which passenger tickets are inputs. The downstream impact of market based measures on passenger markets is therefore limited to cost pass-through onto passenger tickets.

However, producers who purchase transport services to move freight use aviation as an input in the overall production process, which includes delivering a good to market. Consider the situation of an exporting producer who is faced with higher transport costs, caused by cost pass-through of a carbon price by airlines into freight rates. Its costs to serve customers have risen, so it will seek to obtain a higher price. While it feels the pressure of higher costs, its rivals supplying customers locally in the destination market are unaffected. These local producers have a choice. They can either increase output and take market share with the higher output resulting in prices close to those that prevailed before any freight rate increase, or they can hold back and allow prices to rise, enjoying larger margins. In most circumstances both effects occur, although market conditions can lead to either effect dominating. Whichever combination takes place, the foreign producer loses market share, or margin, or a bit of both. A third possibility is that they switch to transport by sea or land.

There are further downstream impacts on the consumers of goods that are freighted by air. The higher cost of supply of goods imported by air has pushed up prices or allowed local producers to gain market share. To the extent that prices rise, and in most cases they do, consumers are worse off. Facing higher prices, consumers cut back on their consumption, and demand falls.

This reduction in demand is felt by the producers, local and abroad. Foreign producers experience both the decline in overall consumer demand and, in most circumstances, some loss in market share. As a result, they export fewer goods and the volume of freight shipped by air falls somewhat. That, in turn, puts downward pressure on freight rates as airlines compete for a smaller market.

If these effects were large, market-based instruments might be an alarming prospect. However, for traded goods, with some important exceptions, they are small. The total cost increase is given by multiplying the amount by which freight rates increase with the proportion of total costs that freight rates constitute.

However, although these impacts are typically small, they are not uniform. The larger the proportion of freight costs as a share of total costs, the bigger the impact. Low value-to-weight/volume goods flown over long distances are the most affected, while high value goods flown over short distances are less affected. The distribution of these impacts between downstream firms and the final consumers of goods in turn depends on the same characteristics as cost pass-through in aviation itself. In inelastic markets with few firms, consumers will bear the costs as producers can pass on (more than) the entire cost increase. The opposite holds for elastic markets with more firms.

Distribution of costs

In summary, the costs of the scheme are borne by consumers, airlines and producers who ship their goods via air (who face costs due to both a reduction in quantity sold, and a reduction in profit margin). Those who gain from the scheme are the beneficiaries of any revenues raised (through auctioning or taxation), and local producers, who gain both in terms of market share and profit margin.

Under any of the four market-based instruments, as explained earlier, operating costs rise, although this is offset (to a degree) by action being taken in response to make both planes and airline operations more efficient. Higher operating costs in turn lead to higher freight rates and ticket prices.

In travel markets, the distribution of costs between consumers and airlines is determined by the rate of cost pass-through. As discussed above, this depends on the elasticity of demand in the particular market, on the number of airlines operating in the market, as well as on the strategies pursued by those airlines. The possibility of modal shift is reflected in the elasticity of demand: where alternative modes of transport are a good alternative (a close substitute), demand will be more elastic. However, in general the majority of costs fall onto consumers. Vivid Economics (2007) has estimated cost pass-through rates of between 80 and 150 per cent, implying that at most 20 per cent of the direct costs of market based instruments fall onto airlines. However, even in scenarios with cost pass-through rates of more than 100 per cent, airlines may face reduced profits: if the profit reduction from selling fewer tickets (caused by higher prices) is greater than the increase in total profits from a higher profit per ticket (caused by cost pass-through greater than 100 per cent), then airlines lose profits.

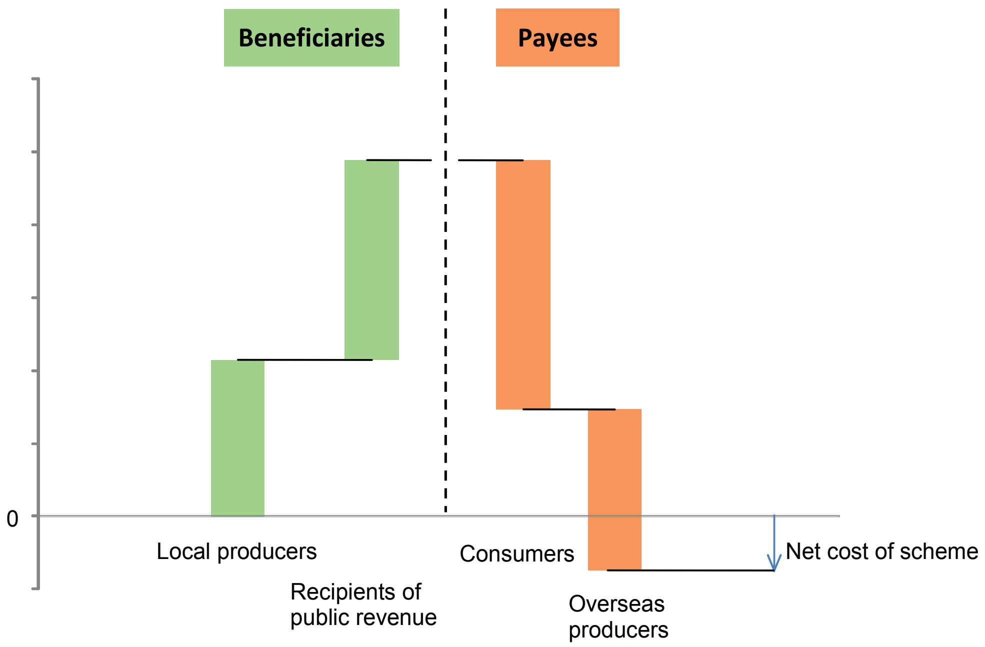
Between airlines, those with inefficient planes will lose volume, if they raise prices more than their competitors, and profitability, if they do not. Most airlines with inefficient planes will likely make a trade-off and lose a bit of both. Airlines with efficient planes will, relatively speaking, gain.

In freight markets this situation is slightly more complicated. Cost pass-through leads to an increase in freight rates, which in turn drives up the prices paid by consumers for the goods shipped by air. The amount by which final consumer prices increase depends on the increase in freight rates, the cost pass-through in the downstream market, and on the share of total costs that is constituted by transport costs (which in turn depends on the distance that the good is transported, and on the value-to-weight/volume ratio).

These price changes in turn have an impact both on the producers and consumers of goods transported by air. The higher freight prices benefit producers selling locally because of the reduced competition from imported goods. This may stimulate more local producers to enter the market, with initially higher margins being transformed into higher local output. On the other hand, these same producers may lose out in other markets that they service via air shipments. Producers who sell primarily locally will gain overall and those focused on exports will lose. For any given specific market, producers will be affected differentially and this can be assessed. In shipping, the size of these redistributional impacts is far bigger than the net cost of the instrument. This is likely to be true of aviation as well, although this remains to be shown by quantitative analysis.

In summary, with regards to freight markets the winners from a market-based mechanism are local producers; the losers are consumers and producers who ship their goods via air. This is illustrated in figure 5, which also shows the relative size of transfers between market participants vis-à-vis the net costs of the instrument. Within the aviation sector, those with the most carbon (i.e. fuel)-efficient planes stand to gain (at least relatively) and those with the least efficient lose. The precise pattern varies market by market and commodity by commodity. Finally, there are other categories of winners: the future generations who bear a reduced cost from climate change, and those persons today who receive the benefits of revenue raised from a market-based instrument. The latter category is discussed in more detail in chapter 5, where the potential magnitude and uses of revenues raised is considered.

Figure 5. **An illustration of the transfers between recipients and payees relative to the net cost of the scheme**



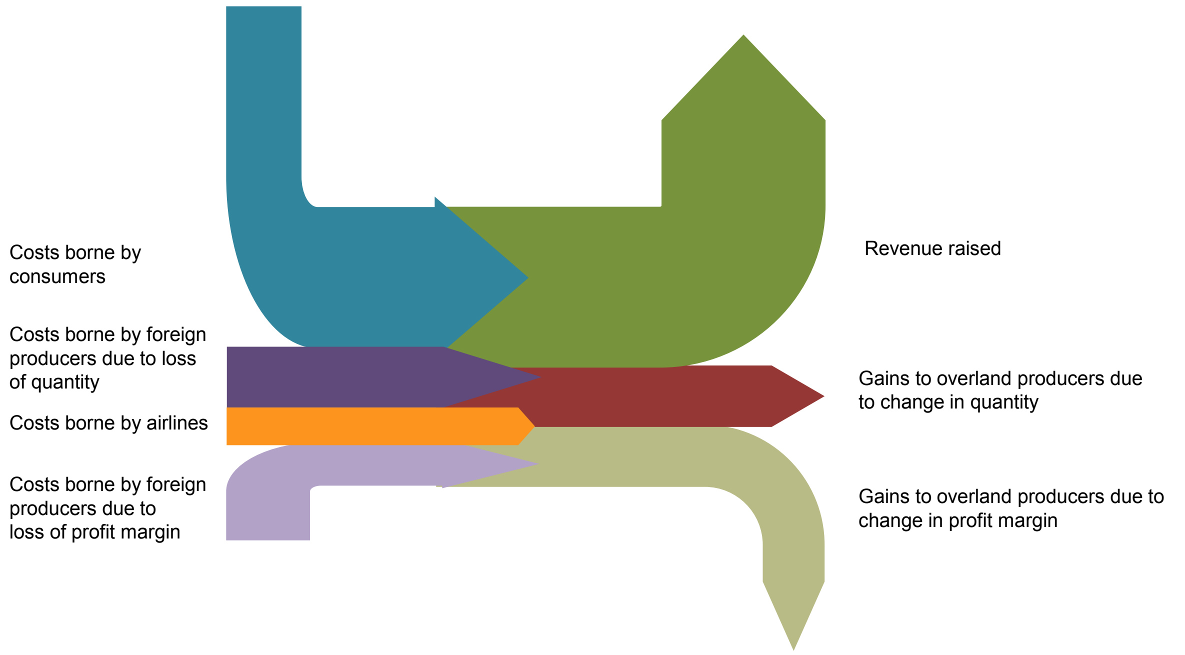
Source *Vivid Economics*

The flow of money and distributional impacts

Market-based mechanisms can bring about substantial transfers of money between market participants, raising questions of equity. This effect is more pronounced in the market for air freight than in the market for air travel. Within the market for air travel, distributional impacts are largely limited to three effects: transfers of profits or market shares from inefficient to efficient airlines, transfers from airlines and passengers to the revenue-raising authority, and transfers between passengers and airlines, depending on whether cost pass-through is larger or smaller than 100 per cent.

In the market for air freight[44], and in associated downstream markets, the situation is slightly more complex. The relevant flows of money are illustrated in figure 6. The increasing costs are partly borne by airlines, but, as discussed above, in fact they are often able to pass the majority of costs onwards into the freight rate. If freight rates are only a small proportion of total product costs, volumes of trade change little as a result. This means that it is possible that most of the costs are borne by consumers and overseas producers. Vivid Economics (2010) demonstrated that this is indeed the case for carbon pricing in shipping. The main flow of money is therefore from these consumers and overseas producers, and to a much smaller extent from airlines, to local producers and to the authorities collecting the levy or selling the emissions allowances.

Figure 6. **The flow of money in freight markets**



Source *Vivid Economics*

The total costs borne by these parties exceed the amount collected by the authorities, due to redistribution from foreign producers to local producers. Interestingly, in a quantitative analysis of these effects in shipping, the redistributive effect turned out to be considerably larger than the revenue raised. If the same holds true for aviation, two important points follow. The first is that the absence of carbon pricing – the presence of the carbon externality – has created considerable competitive advantage for overseas producers at the expense of local producers. Unsurprisingly, these overseas producers will resist attempts to introduce a carbon price to correct this externality.

[44] Air freight is considerably more expensive than shipping or transport by truck or rail. Goods that are air freighted hence tend to be either high value-per-weight products (caviar, flowers), fast selling products with short product cycles (electronics), or urgent products (medical supplies, critical spare parts, commercial and government documents).

The second is that there may be strong political resistance by the losers to the introduction of carbon pricing.

Geographic analysis of impacts with particular regard to Least Developed Countries (LDCs)

There are four considerations that are particularly relevant for a geographic analysis of the impacts of market based measures in aviation. These four are the relative fleet age and composition; the role and prominence of goods and services in the national economy that are complementary with aviation; the net impact of the gain to local producers and losses to exporters from increased freight rates; and the impact of higher freight costs on domestic consumption. While the effects of each of these can be described qualitatively, they can only be ascertained through empirical quantitative assessment. A conclusive analysis of the geographic impacts of market based measures must hence await a more extensive and quantitative piece of analysis.

The first factor that may affect the geographic distribution of impacts is the age and composition of airline fleets. As pointed out in the analysis of market impacts above, the introduction of a carbon price will lead to relative gains for efficient airlines, and relative (and absolute) losses for inefficient airlines. To the extent that airlines of LDCs operate on average older and less efficient fleets, and competitors from developed countries operate on average younger and more efficient fleets, the former airlines will lose market share and profits while the latter stand to make relative gains. This factor could hence lead to a larger share of the overall costs falling onto LDCs and other countries with relatively old and inefficient fleets.

The second factor that is of particular relevance here is the importance of goods that are complementary to air travel, such as tourism. Any market based instrument will push up the price of air travel, and will hence lead, all else being equal, to a reduction in the number of passengers. Goods that are complementary to air travel, for example aircraft maintenance or travel amenities, or jointly produced, for example foreign vacations, will therefore also see a fall in demand. The impact of this effect is hard to estimate without detailed quantitative work. However, countries that rely strongly on tourism are likely to face a fall in demand.

The third factor in assessing the geographical impact is driven by the shift from foreign to local producers in markets where air-lifted goods are competitive. Whether a country loses or gains from this shift depends on the balance of two effects: first the gains that local producers in LDCs make because of increased costs faced by competing importers; second the losses that exporting producers in LDCs face because they now face higher costs for exporting into foreign markets. The losses to exporting producers are likely to be small whenever a good cannot be produced locally in the export market. In such a situation exporters do not lose market share to local producers, and only suffer from the contraction of the overall market. Markets with sizeable local producers on the other hand will see stronger shifts away from importers and towards local producers. Whether or not LDCs stand to gain or lose from this effect hence depends on the particular market configurations of import-competing and exporting firms.

The fourth and last factor is related to the shift from foreign to local producers. As mentioned above, in the absence of local producers, importers are able to pass more of the cost increase from higher freight rates through to consumers. This represents a welfare loss to these consumers, who must now face higher prices and cut back their consumption. Countries that import large amounts of goods via air, and can neither produce these goods locally nor import them via an alternative mode of transport are therefore likely to bear greater welfare losses.

These four factors are likely to work in different combinations and intensities for each individual country. A thorough assessment of the relative geographical impacts is therefore only possible via an empirical study that shows which countries bear larger burdens, and which countries bear lighter burdens, from carbon pricing in aviation. This has not been undertaken to date; since this information is likely to be of high relevance to international negotiations, further work in this area would be valuable.

4.4 Discussion of mitigation potential

For each of the four instruments selected above, it is possible to illustrate potential in- and out-of-sector mitigation. Out-of-sector mitigation consists of carbon offsets paid for by the aviation industry, which represent mitigation delivered mainly or wholly in other sectors. This can include CERs from the Clean Development Mechanism, or EUAs from the European Emissions Trading System. Other certificates may become available as new emission trading schemes, such as the Australia, New Zealand, or Japan scheme, come into operation. In-sector mitigation consists of emission reductions within the aviation industry itself, for example via improved fuel efficiency or more efficient routing. The results of this analysis are summarised in table 8 below.

Table 8. **The mitigation potential in international aviation of all four options is estimated to be the same, the absence of variation in this table reflects the absence of detail in the data**

	Mitigation potential in international aviation under each instrument, ($MtCO_2$)							
	2020				2030			
Instrument	Out of sector	In sector, price-driven	In sector, non-price-driven	Total	Out of sector	In sector, price-driven	In sector, non-price-driven	Total
1. Offsetting by airlines*	-	45	24	69	180	98	41	319
2a. Offsetting by airlines plus a revenue raising mechanism (50% surcharge)	-	45	24	69	180	98	41	319
2b. Offsetting by airlines plus a revenue raising mechanism (10% surcharge)	-	45	24	69	180	98	41	319
3. Emissions trading – cap and trade	-	45	24	69	180	98	41	319
4. Carbon levy and offsetting	-	45	24	69	180	98	41	319

Note: The reasons for which both in and out of sector mitigation is identical across all four instruments are given in the text of this section

Source: Vivid Economics

Out-of-sector mitigation

Out-of-sector mitigation is calculated using a similar methodology for every instrument: business as usual (BAU) emissions are taken from ICAO forecasts. In-sector mitigation (discussed below) is subtracted from these BAU emissions to give actual expected emissions. Out of sector mitigation is imputed to be the difference between actual expected emissions and the 2020 emissions baseline. This methodology results in the same result for each of the four instruments considered: zero out-of-sector mitigation in 2020[45], and approximately 180 $MtCO_2$ per annum in 2030. Note that this number assumes that the baseline for carbon neutral growth is the projected BAU emission level for 2020 (657 $MtCO_2$ p.a. for international aviation). If actual expected emissions, i.e. BAU less in-sector emissions (589 $MtCO_2$ p.a.), for 2020 are used as the baseline, then the amount of out of sector mitigation necessary to meet this lower baseline increases to 250 $MtCO_2$ in 2030 (though the result is still zero for 2020).

Why are equal emission reductions projected for each of the four instruments? Each instrument acts on the same emissions target, and faces the same BAU emissions; furthermore, as explored below, each instrument is expected to deliver approximately the same in-sector abatement. With all three relevant variables fixed, out of sector mitigation is constant across the four instruments.

In-sector mitigation

The methodology for in-sector mitigation is slightly different. For each policy instrument an in-sector carbon cost is calculated. This is the cost that an airline avoids by emitting one less tonne of carbon. For option 1, under straightforward offsetting, this avoided cost is precisely the prevailing offset price. For option 2, under offsetting plus a revenue raising mechanism, the avoided cost is the prevailing offset cost plus the percentage or flat rate surcharge levied via the revenue raising mechanism. For option 3, under a cap-and-trade emissions trading scheme the avoided costs will be the prevailing certificate price; given fully fungible offsets, this price will be equal to the global offset price, as airlines and traders would arbitrage between the two types of emission allowances until prices converge. Theoretically, the avoided cost could be lower than the global offset price if a sufficient quantity of in-sector mitigation options is available at a pre-tonne cost lower than global offset prices. However, this situation is extremely unlikely to hold for aviation. For option 4, a carbon levy, the avoided costs are given by the rate of the levy. For modelling purposes, this rate is assumed to track the global offset price. In sum, all instruments except for option 2 lead to a carbon cost that is equivalent to global offset prices. Option 2 leads to a carbon cost of the global offset price plus the revenue raising surcharge.

Global offset price assumptions are taken from the IMO[46], with $25 per tonne of CO_2 in 2020 (at 2010 prices), and $40/$tCO_2$ in 2030. This is the in-sector carbon cost for all options, except for option 2. Depending on the value of the surcharge , option 2 leads to an in-sector carbon cost of

$37.50/$tCO_2$ in 2020, rising to $60/$tCO_2$ in 2030 (assuming a 50 per cent surcharge)or $27.50/$tCO_2$ in 2020, rising to $44/$tCO_2$ in 2030 (assuming a 10 per cent surcharge); a higher or lower percentage surcharge would imply a correspondingly higher or lower in-sector carbon cost.

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[45] Out of sector mitigation is zero in 2020 as the cap is set to 2020 emissions levels. Hence no out of sector mitigation is necessary in 2020, and therefore none is expected in the model. Individual airlines or countries may nevertheless decide to purchase offsets in or before 2020. Actual out of sector mitigation may therefore be larger than anticipated here.

[46] IMO (2010) *Reductions of GHG Emissions from Ships – Full report of the work undertaken by the Expert Group on Feasibility Study and Impact Assessment of possible Market-based Measures*, London, http://goo.gl/15duv

In-sector carbon prices are then combined with a marginal abatement cost (MAC) curve, which indicates the amount of abatement that can be delivered in aviation at or below a certain price, to arrive at an amount of in-sector abatement for each instrument.

This analysis is further subdivided into price driven abatement and non-price driven abatement. Price driven abatement includes both operational measures and technology options that airlines may introduce in response to price signals. Non-price driven abatement includes all other abatement that cannot be implemented unilaterally by airlines, and that may be delivered administratively (and independently of price signals); examples of this include changes to air traffic management, mandated operational procedures such as take-off and landing procedures, and changes to air space regulation.

The results from this analysis are similar for all options, due to the shape of the MAC curve, shown in figure 7. While option two leads to a higher in-sector carbon cost, there are no additional abatement options that are triggered by this slightly higher price that are not also triggered by the lower price of options one, three and four, see figure 7. For global aviation, each instrument is expected to trigger approximately 71 $MtCO_2$ of price driven abatement in 2020, and 156 $MtCO_2$ in 2030. In addition, the MAC curve indicates that 39 $MtCO_2$ of non-price driven abatement are possible by 2020, rising to approximately 66 $MtCO_2$ by 2030. This leads to total combined in-sector abatement of approximately 110 $MtCO_2$ per annum in 2020, rising to approximately 221 $MtCO_2$ per annum in 2030.

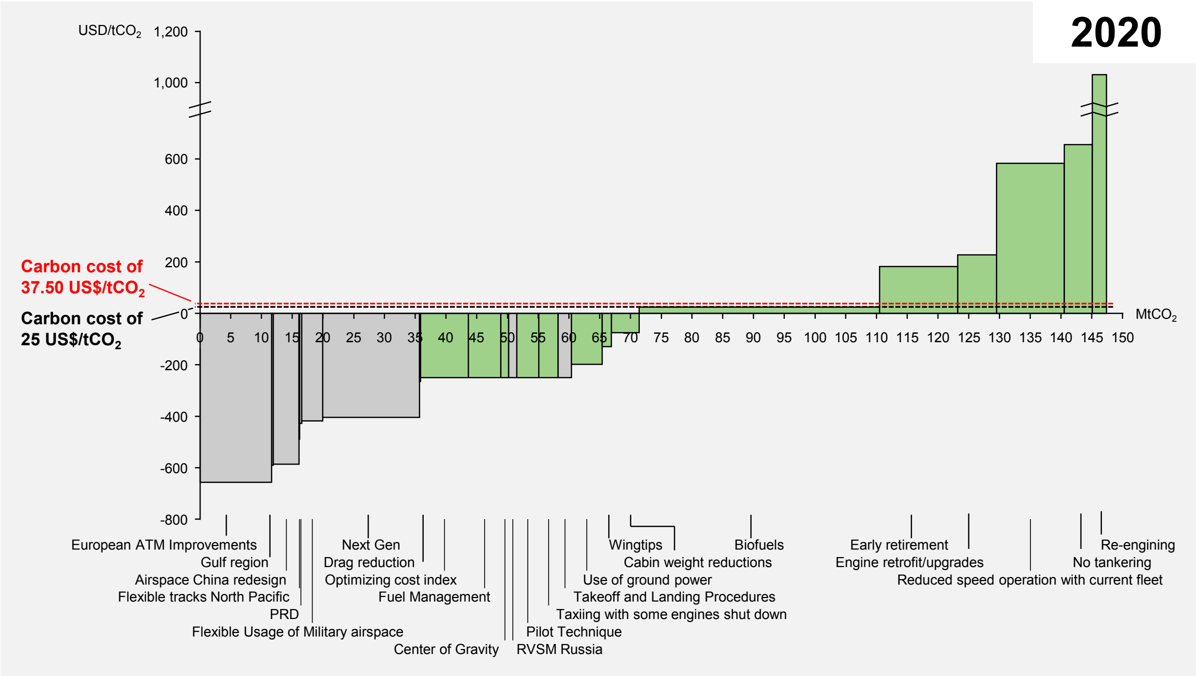
Assuming that total abatement is split proportionally across national and international aviation, and assuming ICAO's split between national and international aviation of approximately 63 per cent international to 37 per cent domestic, the results are as follows for international aviation: by 2020, each instrument is expected to trigger approximately 45 $MtCO_2$ of price driven abatement; together with approximately 24 $MtCO_2$ of non-price driven abatement, this gives a total of 69 $MtCO_2$ of abatement from international aviation in 2020. For 2030, the figures are 98 $MtCO_2$, 41 $MtCO_2$, and 139 $MtCO_2$ per annum for price-driven, non-price driven, and total abatement.

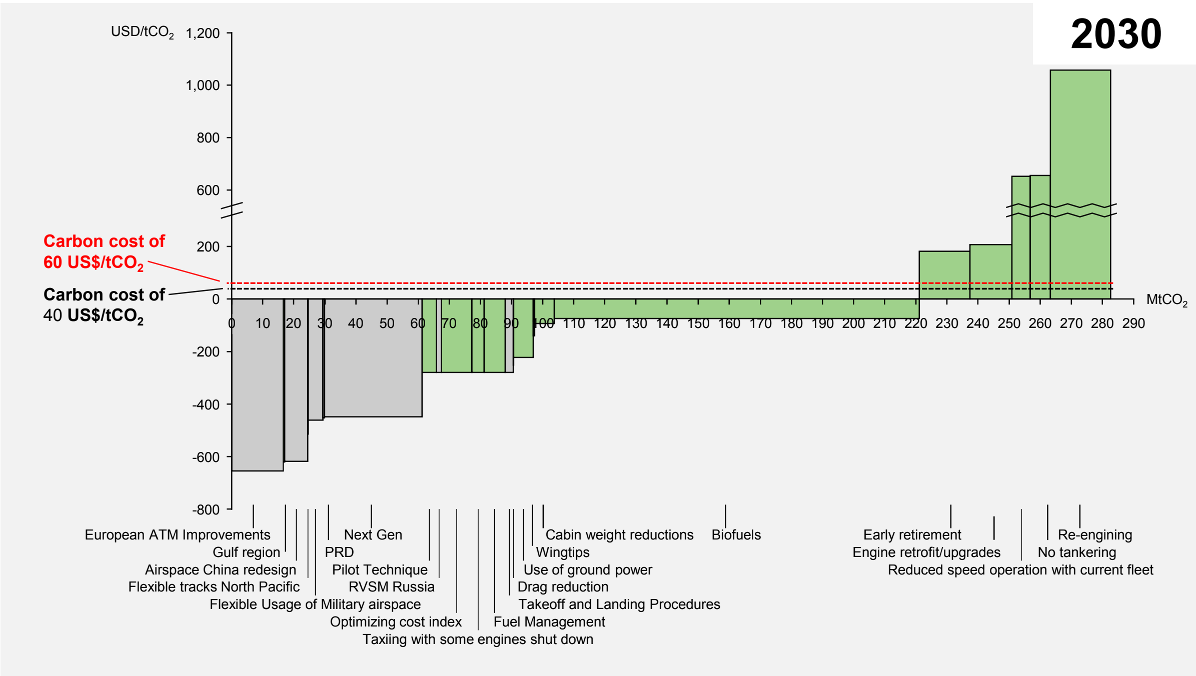
Box 1. **A lower global offset price would change the distribution between in-sector and out-of-sector mitigation, but is unlikely to affect the total amount of mitigation**

Lower global offset prices are unlikely to affect the total mitigation potential identified. Instead, lower offset prices would alter the *distribution* of mitigation between in-sector and out-of-sector mitigation: a lower price would, for most of the MBMs here considered, lower the in-sector carbon cost faced by airlines. This would reduce the total amount of in-sector mitigation. However, if the baseline of 2020 emissions remains unaffected, any reduction in in-sector mitigation will have to be compensated for by an increase in out-of-sector mitigation, so that net emissions remain the same.

An exception to the rule identified above is the following: if lower global offset prices affect the 2020 baseline underlying the post-2020 carbon neutral growth (CNG) pledge, total mitigation volumes may be affected. If, for example, lower global offset prices lead to less mitigation prior to 2020, the baseline for post-2020 CNG would be shifted up. However, the same mechanism could work the other way: lower offset prices, while reducing in-sector mitigation, might actually stimulate more out-of-sector mitigation prior to 2020, leading to a lower baseline of net emissions in 2020, and consequently more overall mitigation.

Figure 7. **110 and 221 $MtCO_2$ of in-sector mitigation can be triggered by market based instruments in 2020 and 2030 respectively**





Note: *Price driven abatement (shown in green) includes the following technologies: wingtip devices, engine upgrade, re-engining, early retirement of aircraft, reduced speed with redesigned fleet, algae oil-based biofuel, optimised flights using cost index, use of ground power, taxiing with some engines shut down, improved fuel management, cabin weight reductions, improved pilot technique, centre of gravity measures, reduced speed with existing fleet (no redesign), no fuel tinkering*

Non-price driven abatement (shown in grey) includes the following: takeoff and landing procedures, NextGen related Air Traffic Management (ATM) improvements, European ATM improvements, flexible tracks North Pacific, Pearl River Delta ATM improvements, Chinese airspace redesign, flexible use of military airspace, Gulf region airspace redesign

Source: *IATA and Vivid Economics*

These in-sector abatement calculations ignore the demand reduction effect of increasing ticket prices, and this is discussed below. Market based measures cause cost increases for airlines; these are (to a variable degree) passed through to passengers and freight customers; to the extent that these customers respond by reducing the number of miles flown, emissions will decrease further. This effect has been ignored in the calculations above.

Mitigation from a reduction in demand

The demand destruction effect can be illuminated in two ways: first, the cost increase caused by a market based measure for CO_2 mitigation can be compared to other more familiar cost increases, for example those caused by higher oil prices. This allows for a qualitative comparison with historic demand effects. Second, drawing on estimates of price elasticity of demand, an approximate estimate of the range of demand impacts can be made. This gives an indication of the demand effects that may be expected going forwards.

The impacts on demand of an MBM can be illuminated by comparing the cost increase from a carbon price with the historic cost shocks from oil price volatility. IATA reports the average price of jet kerosene as approximately $35 per barrel in 2003, rising to more than $125/bbl in 2008, and again in 2011.[47] This cost increase of approximately $90/bbl translates into a cost increase of $0.25 per tonne-kilometre, assuming fuel consumption of 0.36 kg per tonne-kilometre[48]. At CO_2 emissions of 1.14 kgCO_2 per tonne-kilometre, this fuel cost increase is the equivalent of a $220/t$CO_2$ carbon price. Similarly, a $20/t$CO_2$ carbon price is approximately equivalent to an $8/bbl jet kerosene cost increase. This indicates that the cost increase expected from an MBM lies well within the historic costs shocks to aviation from oil price volatility.

The demand-side impacts can be further put into context by an illustrative calculation of expected demand reduction. A key driver in any such calculation is the price elasticity of demand (PED), which describes how customers react to a change in price. A high PED (>1) states that customers are very price sensitive: small changes in price lead to large changes in quantity demanded. The reverse holds for a low PED (a PED between zero and one). Estimates of PED for air travel cover a wide range, from 0.2[49] to 1.5[50]. Using this range of PED estimates, and drawing on IATA cost data, the impact of a $40/t$CO_2$ carbon price on passenger demand is expected to be a fall in demand of between one and ten per cent. A lower carbon price of $25/tCO2 would lead to a fall in demand of between less than one and approximately six per cent.

For air freight the range of PED estimates is narrower, from 0.2 to 0.7[51]. This implies a demand reduction of between one and five per cent for a $40/t$CO_2$ carbon price.

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[47] IATA, *Industry Statistics Fact Sheet 2012*, accessed at http://www.iata.org/pressroom/facts_figures/fact_sheets/Documents/industry-stats-mar2012.pdf

[48] Fuel consumption figure taken from Eyers, C., Norman, P., Middel, J., Plohr, M., Michot, S., Atkinson, K., and Christou, R. (2004), *AERO2k Global Aviation Emissions Inventories for 2002 and 2025*, Farnborough, UK

[49] CE Delft (2005) *Giving wings to emission trading – Inclusion of aviation under the European emission trading scheme (ETS): design and impacts*

[50] OXERA (2003) *Assessment of the Financial Impact of Airlines of Integration into the EU Greenhouse Gas Emissions Trading Scheme*, BAA External Emissions Trading Steering Group

[51] Australian government, http://www.bitre.gov.au/tedb/pdf/table9A02.pdf

Discussion of underlying data

The marginal abatement cost curves used for this analysis are IATA's global 2020 and 2030 MAC curves, shown in figure 7. A detailed description as well as comparisons between these MAC curves and two alternatives, the UK Department for Transport's (UK-only coverage), and the UK Omega research programme's (UK and Europe coverage) is shown in box 2 below.

Box 2. **There are large differences between marginal abatement cost curve studies; IATA's results lie between those of two alternative studies.**

Marginal abatement cost (MAC) curves are a key ingredient to almost any abatement analysis as they allow a prevailing carbon price to be translated into expected abatement. Given the important role that MAC curves play, it is important to understand the robustness of their predictions and the plausibility of their assumptions.

One way of assessing a MAC curve is to compare it to a number of alternative MAC studies, in order to see if there are large discrepancies either in predicted abatement or in underlying assumptions. The MAC curves used in this report are produced by IATA's Aviation Carbon model. Two alternative MAC studies are published by the UK Department for Transport (DfT) and the Omega project, an academic research project located in the UK. While these MAC curves do not cover the same scope of emissions as IATA's, they allow for instructive comparisons by considering the proportion of total emissions that they deem abatable. An in-depth comparison between the MAC curves from IATA, DfT and Omega is shown in **Erreur ! Source du renvoi introuvable.** below.

Comparing IATA's study to the two alternatives reveals three things: first, all three studies share broadly similar fuel price assumptions, though IATA's assumptions are on the high side (USD 126/bbl compared to USD 101/bbl for Omega and USD 95/bbl for the DfT). Second, the three studies predict very different amounts of abatement: while Omega sees abatement of more than 50 per cent of underlying emissions as possible by 2020, the DfT reaches a far more conservative estimate of 6 per cent. Third, IATA's predictions lie between the other two, both with regards to short run abatement achievable by 2020, and with regards to medium term abatement achievable by 2030.

Table 9. **IATA's MAC curves lie between Omega's and DfT's in terms of proportional abatement deemed possible**

Year	Source	Coverage	**Underlying emissions** ($mtCO_2$)	**Total abatement** (% of underlying emissions)	**Abatement below USD65/tCO_2** (% of underlying emissions)	**Fuel price** (2012USD/ bbl)
2020	Omega	UK domestic flights only	3	54%	26%	101.05
2020	**IATA**	**Global aviation**	**889**	**17%**	**12%**	**126.00**
2020	DfT	All flight departing UK airports	43	6%	3%	95.49
2025	Omega	Emissions from AEA member airlines	180	63%	30%	107.57
2030	**IATA**	**Global aviation**	**1258**	**22%**	**18%**	**126.00**
2030	DfT	All flight departing UK airports	48	15%	5%	107.73

Note *The following 36 airlines are AEA members: Adria Airways, Aegean Airlines, AeroSvit, airBaltic, Air Berlin, Air France, Air Malta, Alitalia, Austrian, British Airways, British Midland International (BMI), Brussels airlines, Cargolux, Croatia Airlines, Cyprus Airways, Czech Airlines, Lufthansa, DHL, Finnair, Iberia, Icelandair, Jat Airways, KLM, LOT Polish Airlines, Luxair, SAS, Swiss International Airlines, TAP Portugal, TAROM, TNT Airways, Turkish Airlines, Ukraine International Airlines, Virgin Atlantic*

Source *Vivid Economics*

5. POTENTIAL REVENUE AND FUND DISTRIBUTION

5. Potential Revenue and fund distribution

It is unusual for public funds to be raised supra-nationally. With rare exceptions such as the levy on Certified Emission Reductions, tax raising arrangements do not extend beyond regions and even within regions there is usually a high level of fiscal sovereignty at the state level. This is in part because the resultant between-country transfers which supra-national fundraising causes are politically unwelcome. Aviation, shipping and the auction of Assigned Amount Units (under the Kyoto Protocol or its successor, if it has one) are possibly the only current candidates for a global revenue-raising base, and this fact has attracted attention (United Nations, 2010; World Bank, 2011). Consequently these funds are uniquely qualified to be used for combating global problems while also being unique in the political difficulties they face.

5.1. What amounts of revenue are in play?

Out of the four options considered, only three will raise revenues in excess of those needed for funding out of sector abatement. These are option 2, offsetting plus a revenue raising mechanism; option 3, cap and trade; and option 4, carbon levy plus offsetting. Option 1, offsetting by airlines, would return no revenue.

The revenues available from the three revenue-raising options range from no revenue in 2020 to approximately $26 billion per year in 2030. These amounts are shown in table 10, while the assumptions underpinning these calculations are shown in box 3 below.

Table 10. **Revenues from mitigation instruments in aviation range from zero to more than $40 billion per annum**

	Revenues raised, 2012$ per annum					
	2020			2030		
Instrument	Relevant quantity ($MtCO_2$)	Relevant price ($)	**Revenue raised ($m)**	Relevant quantity ($MtCO_2$)	Relevant price ($m)	**Revenue raised ($m)**
2. Offsetting by airlines*	-	-	-		-	-
2c. Offsetting by airlines plus a revenue raising mechanism (50% surcharge)	-	12.5	**-**	180.4	20	**3,607**
2d. Offsetting by airlines plus a revenue raising mechanism (10% surcharge)	-	2.5	**-**	180.4	4	**721**
5. Emissions trading – cap and trade	328.5	25	**8,213**	328.5	40	**11,757**
6. Carbon levy and offsetting	588	25	**14,696**	837.5	40	**26,283****

* *No revenue is raised from this option as financial flows occur exclusively between airlines and project developers. Nevertheless, this option may increase private climate finance flows as airlines are likely to purchase emission offset certificates on the open market.*

** *$7.2bn of the total revenue raised ($33.5 billion) are used to purchase 180.4 million offsets at a price of $40/tCO_2$ in order to reduce emissions from aviation from 837.5 $MtCO_2$ to the 2020 level of 657 $MtCO_2$. This leaves a net revenue of $26.3 billion.*

Source: Vivid Economics

Box 3. **The following assumptions are made in the revenue calculations for the selected instruments**

- For all options: the 2020 level of international aviation emissions, and hence the sectoral cap, is assumed to be 657 $MtCO_2$, in line with CAEP's projections of aviation emissions. The revenue yielded by each of the options is dependent of the choice of target, in the following manner: under cap and trade, a tighter target would reduce revenues as the quantity of auctioned certificates is decreased without a commensurate increase in price (since price is determined by global carbon credit markets); under a carbon levy and offset scheme, net revenue would also decline, since more gross revenue would be dedicated to purchasing offsets in order to attain the tighter target. However, under option 2, airline offsetting plus a revenue raising mechanism, revenues would increase, as airlines would have to purchase more offsets to reach the tighter target, thus paying more into the revenue raising mechanism.
- For all options: the global carbon credit price is assumed to be $25/$tCO_2$ in 2020 and $40/$tCO_2$ in 2030, in 2012 prices, in line with IMO assumptions[52];
- For option 2: the revenue raising mechanism is a percentage surcharge on the value of carbon credits. The percentage surcharge could take a range of values; in order to illustrate this, two calculations are show, one for a surcharge of 50 per cent and one for a surcharge of 10 per cent. The relevant price is the prevailing global carbon credit price less the surcharge. The relevant quantity is the excess of aviation emissions over and above the 2020 cap (hence quantity, and therefore revenue, is zero in 2020).
- For option 3: revenue is raised via the auctioning of 50 per cent of the emission certificates for aviation. Given a cap of 657 $MtCO_2$, this amounts to a constant quantity of approximately 329 $MtCO_2$ of certificates. The aviation cap and trade scheme is assumed to be fully integrated with other global emission trading schemes, such that the price will be given by global carbon credit prices: if aviation certificates were more expensive, airlines would purchase alternative carbon credits, until the price of aviation certificates falls sufficiently; equally, if aviation certificates are cheaper than global carbon credit, then airlines and traders will purchase those until they have been bid up to the level of global carbon credit prices.
- For option 4: revenue is raised via a carbon levy imposed on each tonne of CO_2 emitted by airlines. The levy rate is assumed to be in line with global carbon prices, so that it is $25/$tCO_2$ in 2020 and $40/$tCO_2$ in 2030. Part of this revenue is used to purchase emission offsets to reduce net emissions from aviation to 657 $MtCO_2$ per annum. The revenue left over after these purchases have been made is the net revenue available for other purposes from this instrument

[52] IMO (2010) op. cit.

While the revenues raised from an MBM in aviation are considerable, it may be the case that the financial flows triggered by an MBM in aviation far exceed the revenue raised. A commercially confidential analysis conducted by Vivid Economics in the shipping sector showed that on certain routes the revenue raised through an MBM may be less than 15 per cent of the total financial flows caused by the MBM. This is because the total costs borne by local consumers, ship owners and overseas producers, as well as the gains for local producers far exceed the revenue raised.

The fact that the redistribution effect may be relatively large suggests a key consequence. The absence of carbon pricing – the presence of the carbon externality from aviation – may have created considerable competitive advantage for producers that ship their goods via air, at the expense of local producers. These producers may resist attempts to introduce a carbon price to correct this externality.

5.2 Institutional options for collecting revenue

The administration of revenue collection has three aspects: the obligated party from whom the revenue is collected, the agency charged with revenue collection, and the institution which holds the funds and disburses them. In this section, the options for each of these are discussed.

There are four possible parties who could be obligated under an international aviation scheme, aircraft owners, aircraft operators, bunker fuel suppliers, and States; of these only aircraft operators and bunker fuel suppliers are feasible. Between the two feasible options, there are minor differences relating to the geographic matching of emissions across States and differences in administrative cost.

One option which can probably be discarded as infeasible is the aircraft owner. The owner has access to the aircraft log but does not hold information on fuels; nor does he or she have operational control. The first reason suggests that it might be difficult for the owner to maintain required records relating to emissions; the second reason suggests that emission costs might not influence his or her behaviour.

The aircraft operator, on the other hand, has operational control over the aircraft and access to records of bunker consumption and the aircraft log. The operator thus has full geographic and emissions data on the aircraft. However there are many operators and aircraft and an obligation on operators will have to document a large number of transactions. Such an obligation is administratively expensive. It would only be beneficial to incur these costs if the scheme is operated on a geographically fragmented pattern.

The third option is the bunker fuels supplier. The bunker supplier holds records of all fuel sales, but not of where it is used. There are fewer bunker fuels suppliers than aircraft operators and fewer supply locations than aircraft, so the administration of obligated parties could be simpler and cheaper. However, some accuracy in the geographical attribution of emissions might be lost without the operators' involvement, albeit there would be ways of allocating emissions geographically based on flight movements by airport or country. It might also be more difficult to enforce compliance and payments from fuel suppliers, because few sanctions are immediately available. For transgressing aircraft operators on the other hand there exists the sanction of banning them from participating airports.

The fourth option, obligating States, has numerous disadvantages and can probably also be discarded. First, obligated States may pass on the obligation to one of the first three options, in which case it is more transparent and efficient to place the obligation directly on one of them. In addition, individual States may place it on different actors, leading to complications and distortions if fuel suppliers, aircraft owners, or aircraft operators are obligated in one place, but not another. Second, placing the obligation on States would open up the possibility of States paying for the costs of the MBM from general taxation, or from non-CO_2 related aviation taxation, thereby reducing the carbon cost faced by aviation and heavily diluting the behavioural incentive.

In summary, out of the four possible parties that could be obligated, only two are viable: aircraft operators and bunker fuel suppliers. The choice between these two depends on the administrative costs and enforceability, as well as on the data that is needed to operate the aviation MBM; depending on these two factors, either operators or bunker fuel suppliers may be the preferred option.

Next comes the choice of collection agency. Here there is a choice of two agencies, at state level or international. The candidates for the state level agencies are tax authorities or environmental regulators. They benefit from existing financial and regulatory relationships with the obligated parties, the capability to handle compliance and the systems to handle financial transactions. In any options which include some degree of national apportionment or earmarking of revenues, state-level collection of revenues may simplify the handling of revenues and promote greater trust and willingness to participate in the system on the part of national governments.

In contrast an international body such as ICAO, while it has existing regulatory relationships with obligated parties, has very little financial capability and would need to develop or outsource this function. The IMO is in the same position for shipping. On the other hand, a central collection of funds might prevent malpractice by States and facilitate the timely collection of revenues. The third aspect is the institution which holds and disburses the funds. This institution will be charged with at least three challenging tasks: resisting lobbying, which is likely to be intense given the scale of wealth being distributed; demonstrating accountability and good governance; and building the scale and expertise needed to distribute large sums efficiently. In addition, if it is placed directly in charge of expenditure programmes, it may be charged with demonstrating value for money. Appropriate selection criteria for this institution are hence commensurably tough, taking the difficulty of the institution's tasks into account.

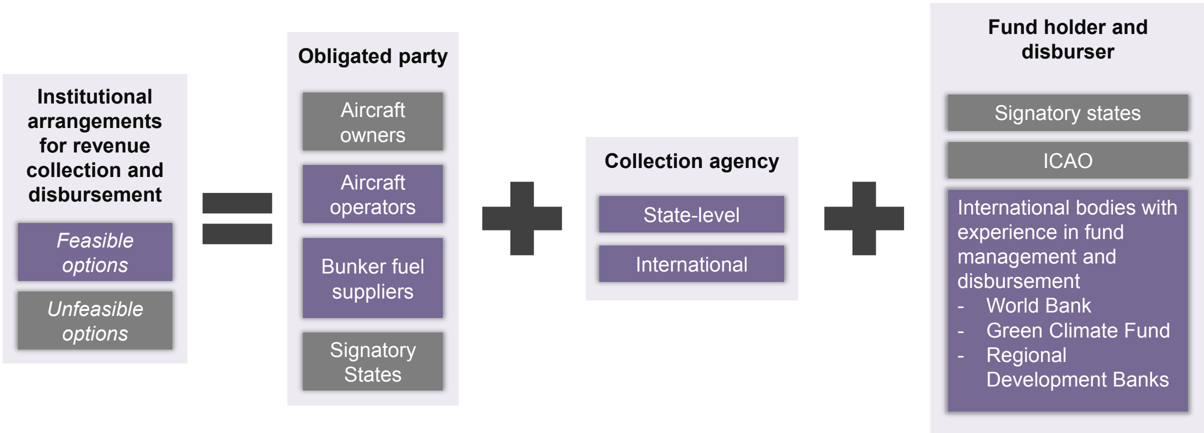
Signatory States are not a suitable candidate. They may, in many, but not all cases, have the capability to hold and disburse funds. However, due to national sovereignty they are not internationally accountable; in addition, they may be subject to intense domestic and international political or lobbying influence.

ICAO might find it difficult to make a strong case for itself. It has no experience in holding and dispersing large funds, and would have to build the necessary structures, rules and expertise from the ground up. There may be other UN bodies which are better equipped for the task, with the appropriate treasury and expenditure functions, and the political skills, the Green Climate Fund, the World Bank, IFC and regional development banks are examples.

Thus, while ICAO may wish to retain political control over the apportionment of funds, setting the policy and the broad allocation, it might be advised to outsource the funding and disbursement operations to a global fund (for adaptation, mitigation and development funding) or a similar agency (for R&D). If compensation arrangements are introduced, then ICAO is likely to have to oversee these, since they are political, even if it employs a financial institution to handle the transactions.

The available options for each of the three aspects of revenue collection, the obligated party from whom the revenue is collected, the agency charged with revenue collection, and the institution which holds the funds and disburses them, are presented in Figure 8 below.

Figure 8. **The administration of revenue collection has three aspects, and there are feasible and unfeasible options for each**



Source: Vivid Economics

5.3 Options for spending the revenue

There are three main options for spending additional revenue raised from a market-based mechanism (MBM):

1. supporting in-sector mitigation;
2. deploying it as climate finance (e.g. investing in out-of-sector mitigation and adaptation);
3. using it to remedy adverse equity impacts such as the incidence of the MBM on developing countries.

These three options will be considered in turn, starting with in-sector mitigation.

5.3.1 In-sector mitigation

The case for using revenues to support in-sector mitigation is not straightforward: once a market based mechanism is in place, airlines and other firms in the aviation market face a cost for every

tonne of carbon emitted. As long as they act in response to the cost, they will implement all mitigation options cheaper (per tonne of CO_2 abated) than the carbon cost they face, since these options reduce their total cost. If airlines or other firms are unable to afford these mitigation options (or the carbon cost), then this is a sign that the product they offer is not commercially viable once all true costs are included; it is not a justification for subsidising in-sector abatement. In other words, abatement options with a cost below the in-sector carbon cost do not require a subsidy to be implemented[53]. Another possibility, besides subsidising the in-sector abatement that is in any case rational for airlines to undertake, is spending the revenue to deliver *additional* in-sector abatement, over and above the abatement available below the prevailing carbon cost. However, this is an unnecessarily expensive way of procuring abatement: if all in-sector mitigation options at or below the prevailing offset cost have been implemented, then the next in-sector mitigation options that are available will cost more than the in-sector carbon cost. Spending revenue on these more expensive in-sector mitigation options would destroy value, since the same abatement could be had (outside the sector) at a lower cost, assuming that the carbon price created by the MBM inside the aviation sector is at or above the level of traded carbon credits from other sources.

However, there is one valid reason for supporting in-sector mitigation. Market failures may prevent companies from spending as much on mitigation as is economically rational. Public goods are one such class of market failure: these are goods that, once produced, benefit anyone who chooses to take advantage of it and are not exhausted through consumption. Public goods have a strong incentive to free-ride, and hence a tendency for free markets to under-provide these public goods. This market failure can be addressed through public provision of the good in question, or through public subsidies for the production of the good. Research and development in aviation may be such a public good; and if it is, there is a good case for using the revenues from an MBM to fund it.

A related relevant market failure may be the absence of full information about mitigation options. Airlines may under-invest in available and cost-effective mitigation technologies if they are unsure about the operational performance of these technologies, or if they fear that there are hidden risks associated with them. Revenues from an MBM could be used to test mitigation technologies and to disseminate credible and reliable information about operational performance. This could help to provide reliable information and could increase the adoption rate of cost-effective in-sector mitigation technologies.

In summary, neither subsidising airlines so that they can afford cost-effective mitigation options, nor subsidising them to procure additional abatement is justified. A valid rationale for spending revenues from an MBM within the sector is to overcome market failures. A market failure that appears relevant to aviation is the case of public goods. Both research and development and information concerning the risks and performance of mitigation options exhibit the features of public goods, and may hence benefit from publicly funded intervention. Subsidising available mitigation technology on the other hand does not appear to have an economic rationale.

5.3.2 Climate finance

Through the purchase of out-of-sector carbon credits, aviation may contribute substantial flows of climate finance, independent of any revenue raised. Taking the prevailing carbon credit price to be $40/t$CO_2$ in 2030, all options would elicit approximately $7 billion of climate finance per annum in 2030 through the purchase of around 180 MtCO_2 worth of carbon credits. For comparison, this

[53] Airlines are likely to be able to afford these options, as projected cost pass-through rates are near, and in some cases above, 100 per cent (see Vivid Economics 2007). However, even if an airline were unable to afford these measures, there remains no rationale to subsidise it: if a firm is unable to make a profit once all the costs of its production process are accounted for, then it should reduce output.

would constitute more than three times current offset flows (estimated to be $2 billion in 2011)[54]. Acknowledging that future prices for carbon credits are surrounded by considerable uncertainty, a comparison in terms of quantity may also be helpful: given BAU forecasts and the pledge of carbon neutral growth post 2020, aviation may require approximately 180 million carbon credits in 2030; this is more than the entire global market for credits from CDM and JI projects in 2011, estimated at 'roughly 160 million credits per annum'[55]. However, further placing the expected demand from aviation into context, the EU ETS features the creation of approximately 2 billion ETS allowances per year. Depending on the carbon trading schemes that aviation will be linked to, the impact of an MBM for aviation on carbon markets may hence be substantial.

Besides the flow of climate finance triggered by the use of carbon credits to achieve carbon neutral growth post-2020, aviation could make an additional contribution to climate finance from the revenues raised by an MBM. The significance of this contribution can be compared with existing climate finance flows, as well as with possible revenues from an MBM in shipping.

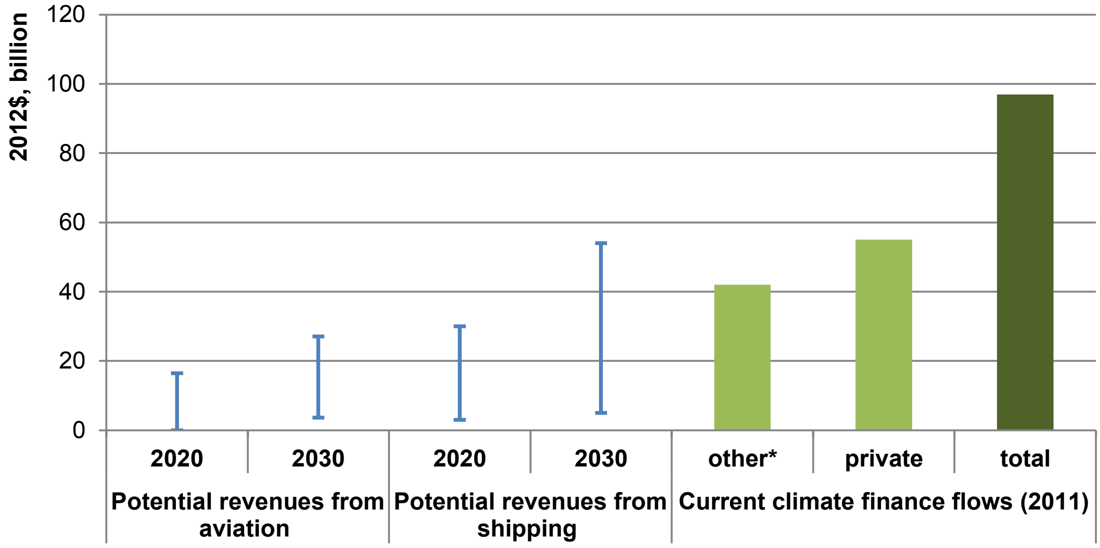
According to the Climate Policy Initiative, a total of $97 billion of climate finance is currently flowing into low carbon and climate resilient development activities[56]. Of this $97 billion, $55 billion are private finance flows (excluding carbon offset flows), while the remainder are a mix of bilateral, multilateral and direct aid flows, as well as carbon offset flows and private philanthropy. Compared to these flows, revenues raised from aviation could make a significant contribution: the top-end estimate of $26 billion in 2030 would constitute an increase of more than 60 per cent relative to current climate finance flows. However, by 2030 climate finance flows are expected to be significantly larger than they are at present, which would reduce the percentage size of revenues from aviation as a proportion of the total.

A comparison can also be made with the potential revenues raised from a market based instrument in shipping. Under the IPCC's A1B emission scenario, the revenue that could be raised from shipping ranges from $3 billion (GHG Fund with additional contributions) to $27 billion (central estimate for a Port State Levy) per annum in 2020. By 2030, this would increase to a range of $5 billion (GHG Fund with additional contributions) to $49 billion (Port State Levy) per annum[57]. Three out of the nine proposals considered for shipping are not envisaged to raise any net revenue.

A graphical comparison of these three groups of flows is shown in figure 9 below.

[54] Ibid.
[55] Ibid.
[56] Ibid.
[57] IMO (2010) op.cit.

Figure 9. **The potential revenues from aviation are smaller than those that can be raised from shipping, but would make a significant contribution to climate finance flows**



Note: *Figures for aviation and shipping indicate ranges; figures for existing climate finance flows indicate point estimates*

** Other climate flows include bilateral and multilateral aid flows (incl. leverage through multilateral and bilateral development banks), offset trading, and philanthropy*

Source: *Climate Policy Initiative 2011, IMO 2010, and Vivid Economics*

5.3.3 Equity-incidence and developing countries

A third use of potential revenues, beside overcoming in-sector mitigation market failures and supporting climate finance, could be to ameliorate the impact of the mechanism on developing countries; either reducing or eliminating net incidence on them. This in turn raises two questions: first, what is the likely size of such an impact? Second, what can be done about it, or more precisely, which instruments are best suited for remedying the impact?

Regarding the first question, the mechanics of the impact of an MBM on developing countries has been described in section 4.3 above. Summing up the earlier discussion, the net impact is driven by four factors: fleet age and composition; the role and prominence of goods that are complementary with aviation; the net impact of competitiveness shifts from exporters/importers to local producers; and the impact of higher costs on domestic consumption. These four factors are likely to work in different combinations and intensities for each individual country; an accurate assessment of the size of impacts is hence only possible on a country-by-country basis, requiring extensive research and calculations.

Regarding the second question, there are a number of options for remedying the impact of an MBM on developing countries.

First, the introduction of an MBM could be phased in over a longer time horizon for developing countries, allowing them to grow more prosperous before being affected. This could be implemented on an airline by airline basis, though this would lead to a distortion of competition along routes served by both developed and developing country airlines. Furthermore, developing countries would not be fully shielded from the introduction of an MBM, as developing country airlines would still eventually be subject to it. Implementing it on a route by route basis is hence preferable economically. This measure would not require the explicit spending of raised revenue; however, if the aviation sector as a whole is to achieve carbon neutral growth, and if flights to developing countries are exempted from the selected MBM, then the burden on other flights would be higher. The redistribution of benefits and burdens would happen implicitly and invisibly under this approach. This might be a drawback, as parties may disagree over the effective monetary size of this compensation mechanism, or it might be advantageous, as no direct physical flows of money would take place.

A second option within a levy scheme is to include all flights in the scheme from the start, but to vary levy rates depending on whether a route is developed to developed, developing to developed, or developing to developing country. Indeed, instead of having only three levy rates, it would be possible to design a mechanism that would calculate individual levy rates for each route, depending on the levels of GDP in the countries of departure and arrival, and potentially on other measures, such as level of climate action taken. An example of a methodology for setting individual rates for different countries can be seen in chapter 8 of Vivid Economics (2012)[58]. However, this approach has two difficulties: first, an agreement needs to be reached between all parties on the appropriate method of calculating levy rates; second, this approach departs from the most efficient solution: a single global price for carbon.

A third option for ameliorating the impacts is to include all international flights in the MBM, but to make lump sum payments to developing countries based on an assessment of the economic costs to each country. This approach suffers from two challenges: first, agreement between all relevant countries on the appropriate methodology for calculating lump sum payments (both eligibility and amount) is likely to be extremely challenging to achieve, since large amounts of potentially untied additional government revenue are in play; second, how to ensure that national governments will use the revenues to deal with climate mitigation and adaptation.

Two further alternatives exist for emissions trading schemes, both based on the reallocation of emissions allowances: first, it is possible to give free allowances to countries (not airlines) based on country output. This might be worth exploring: countries whose economies are growing but poor might find it appealing. Second, lump sums of free allocation could be given to countries independent of their output, based on some alternative metrics. Like the grandfathering approach, this solution has the virtue of revaluing automatically with changes in allowance prices. The second arrangement is broadly similar to the lump sum free allocation arrangements under the EU ETS. While they may lead to some competitive distortions, windfall profits to the sector, and reduce the pool of potential revenue (by reducing the number of certificates that could be auctioned), they might be justified as transition arrangements with a fixed phase-out.

Finally, these options for transferring either money or allowances to developing countries could be supplemented by a technology transfer mechanism, for example the UNFCCC Technology Mechanism. Such a mechanism could be funded out of MBM revenues, and could be operated by an already existing institution, such as the UNFCCC. This would allow developing countries to better react to an MBM, thereby reducing any unequal impacts that an MBM might have.

[58] Vivid Economics (2012) *Carbon taxation and fiscal consolidation in Europe*, London, http://goo.gl/f4Bse

6. SUMMARY OF OPTIONS

6. Summary of options

The strengths and weaknesses of each option against the assessment criteria are set out in the table below:

Criterion	Option 1: Offsetting	Option 2: Offsetting with a Revenue Generation Mechanism	Option 3: Cap and Trade Emissions Trading System	Option 4: Carbon Levy with Offsetting
CO_2 reduction	Amount of CO_2 reduction from offsetting depends on targets; can deliver large net reductions with the application of a discount factor; concerns exist over additionality and quality of offsets; some in-sector mitigation incentive, but weakened due to offset price fluctuation, benchmarking (see below) and currently low offset prices	Same as offsetting, with two exceptions: — additional revenues can be used for additional mitigation — in-sector mitigation incentive is slightly stronger if the revenue generation mechanism increases the effective carbon cost that airlines face	CO_2 reduction from cap and trade depends on level of cap; can deliver large net reductions if linked to other carbon markets, otherwise CO_2 reduction limited by in-sector mitigation potential; mitigation incentive weakened by carbon certificate price fluctuation	In-sector CO_2 reduction depends on rate of levy; total net reduction depends on chosen target; stable and predictable in-sector carbon cost may deliver more mitigation for the same average carbon cost than more volatile instruments
Competition impact (to national airline industry)	Competition impacts of offsetting depend on how obligations for offsetting are shared out: — 'grandfathering', i.e. requiring each airline to keep net emissions constant post-2020, advantages larger or more emitting airlines relative to smaller or cleaner airlines; — 'percentage of emissions', i.e. requiring each airline to reduce net emissions by the same percentage amount; this favours more emitting airlines that still have lower cost mitigation options available, may lead to some distortion between smaller and larger airlines if larger airlines can achieve economies of scale in mitigation, but not otherwise; — 'benchmarking' does not lead to competitive distortions; cleaner airlines will gain (relatively), more emitting airlines will lose, but this is due to internalising previously unpaid pollution costs	Same as offsetting	Similar to offsetting, the competition impacts of a cap and trade ETS depend on rules of certificate allocation: — under 100 per cent auctioning, assuming no liquidity constraints there is no competitive distortion; may change working capital requirements; — 'benchmarking' has similar impacts to 100 per cent auctioning, but leads to a smaller change in working capital requirements — 'grandfathering', based on allocating certificates covering a certain percentage of historic emissions, is likely to lead to windfall profits and favours larger and more emitting airlines relative to smaller and cleaner airlines and new entrants; the larger the percentage of historic emissions covered, the larger the competitive distortion	A uniform carbon levy does not distort competition; cleaner airlines will face lower costs than more emitting airlines, but this is due to the internalisation of previously unpaid pollution costs
Cost	Minimises costs per RTK by making full	Similar to offsetting, but with increased	Higher costs per RTK since all emissions	Higher costs per RTK since all emissions

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Criterion	Option 1: Offsetting	Option 2: Offsetting with a Revenue Generation Mechanism	Option 3: Cap and Trade Emissions Trading System	Option 4: Carbon Levy with Offsetting
	use of least cost out-of-sector mitigation options; cost to industry is minimised by only pricing emissions above the 2020 baseline; costs for passengers and freight customers depend on cost pass-through, which is driven by market structure rather than MBM instrument choice; danger of windfall profits as marginal costs are increased, leading to higher prices across the board, while infra-marginal costs are not affected, leading to higher profits on each infra-marginal unit	costs due to the revenue raising mechanism	are priced, not just those above a baseline; distribution of costs between government and industry is given by rules of allocation for certificates. 100 per cent auctioning places all costs on industry and customers, while 100 per cent grandfathering represents a government-to-industry transfer placing costs on governments and customers and creating windfall profits; distribution of costs between industry and passengers, and industry and freight customers, depends on cost pass-through, which is driven by market structure rather than MBM instrument choice or auctioning rules	are priced, not just those above a baseline; costs are placed first on industry, then falling, depending on cost pass-through, on passengers and freight customers
Cost effectiveness	Costs of out-of-sector mitigation is independent of the instrument, instead driven by global carbon markets; volatile carbon costs may prevent some mitigation options below the prevailing price from going ahead, thereby increasing overall mitigation costs per tonne of CO_2 and the incentive for in-sector emissions may be diluted by benchmarking	Average cost of mitigation per tonne of CO_2 for this instrument is driven by a) global offset prices, and b) the cost per tonne of CO_2 of any mitigation options funded from the additional revenues raised; if these additional mitigation options cost more than the average global offset price, then total unit cost will be slightly higher than for pure offsetting, and vice versa for lower unit costs of additional abatement	Costs of out-of-sector mitigation is independent of the instrument, instead driven by global carbon markets; if aviation cap and trade ETS is not fully linked with other schemes, costs may be considerably higher due to limited in-sector mitigation options; volatile carbon costs may prevent some mitigation options below the prevailing price from going ahead, thereby increasing overall mitigation costs per tonne of CO_2	Stable and predictable carbon cost may lead to lower costs per tonne of CO_2 mitigated in-sector. Costs of out-of-sector mitigation is independent of the instrument, instead driven by global carbon markets
Fair burden on aviation compared to other sectors	This could be viewed as both economic and administrative burden. Economic burden should be assessed by taking into account the respective regulatory burden of each sector in relation to climate change mitigation effort. Given absence of VAT on aviation and if relevant duty on fuel and the limited existing geographical application of carbon prices to the aviation sector, coupled with the fact that other sectors are covered by emission obligations at a national level relative to 1990 levels, it	Similar to offsetting. Additional revenue raised is unlikely to impose an unfair burden.	Similar to offsetting only, but with a greater compliance cost due to auctioning. However, more and more sectors covered by the EU ETS will face 100% auctioning	Similar to offsetting, with potential for higher or lower compliance cost

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Criterion	Option 1: Offsetting	Option 2: Offsetting with a Revenue Generation Mechanism	Option 3: Cap and Trade Emissions Trading System	Option 4: Carbon Levy with Offsetting
	is likely that aviation will not be unfairly burdened. Administrative burden is likely to be low, although monitoring, verification and a registry are cross cutting issues.			
Legislative feasibility	States could legislate nationally to require the surrender of offsets	As with offsetting, but mandating an existing UN body or creating a new body to oversee the distribution of revenues could require a treaty. Registry required	ICAO could develop guidance on how to harmonise distribution methodologies and MRV requirements without a new treaty, but if auctions generate revenues, the same issues arise as with offsetting plus a revenue generation mechanism. ICAO or another UN body will require a legal mandate to create aviation specific allowances. Registry required	If ICAO agrees the appropriate rate for a levy, could be introduced nationally. Some States may require domestic legislation to introduce a levy. Registry required to account for volume of offsets obtained
Design features and timescale	– All emissions above 2020 levels to be offset. Start date: 2020 – Requires definition of eligibility criteria for offsets. – Participants: operators – Annual compliance	– All emissions above 2020 levels to be offset. Start date 2020 – Agreed levy per transaction would give greater certainty over revenues but will need to be reviewed regularly (a percentage fee would vary with the offset price, leading to volatile revenues). – Requires definition of eligibility criteria for offsets. – All Participants: operators. – Annual compliance	– Cap set at 2020 levels. – Participants: operators – 50% auctioning, 50% free allocation based on benchmarked distribution. – Compliance required annually	– As with other offsetting options. – Participants: operators or fuel suppliers
Administration	Will require a registry for cancellation of offset credits. Existing international registries could be utilized. Administration and enforcement by States. Allocation of obligations may require a central body such as ICAO: offsetting obligations may be issued based on all operators offsetting above their 2020 activity levels but this may not be seen as fair to rapidly growing operators. Alternative approach could use benchmarking but will require an authority to calculate obligations for each operator.	As with offsetting, but with States collecting revenues and a central entity charged with distributing revenues in accordance with an agreed policy	States will be responsible for the administration of the scheme. As with offsetting plus revenue generation mechanism, States can collect revenues from auctions but a central entity is required for distribution. A central entity will also need to set cap, create allowances, calculate and oversee the distribution of allowances to States or operators, provide a template for harmonised approaches to MRV and aggregate surrendered allowances by state to ensure consistency with the cap. Will require a registry for the	Could be undertaken by States using existing mechanisms to collect revenue and taxation. A central entity will need to distribute revenues in accordance with an agreed policy

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Criterion	Option 1: Offsetting	Option 2: Offsetting with a Revenue Generation Mechanism	Option 3: Cap and Trade Emissions Trading System	Option 4: Carbon Levy with Offsetting
			surrender and cancellation of allowances and offsets	
Rechanneling revenue	No revenue generated	Yes, approximately $3.6 billion available in 2030	Yes, approximately $11.8 billion available in 2030	Yes, approximately $26.3 billion available in 2030
Political acceptability	Likely to have lowest administrative cost and burden, and could be introduced quickly. Likely support from industry. Absence of revenue will make it difficult to compensate developing countries, so developing country issues may be difficult to resolve. Quality criteria for offsets will be a cross-cutting issue for all options	Similar to offsetting, but administrative complexity higher as need to collect and distribute revenues and need agreement on setting and reviewing an appropriate levy. However, generation of revenue can address developing country issues and offers higher degree of perceived integrity. In political terms this is the "middle ground" between offsetting only and the rigours and perceived complexity of a trading system	Given that the work on a global MBM is seen as a potential means to end the EU ETS dispute, it is unlikely that non-EU States will want to be seen to endorse a cap and trade scheme (although a global agreement at some level will create pressure for a global solution) compounded by the perception that this is administratively complex. However, it will have a higher environmental integrity than offsetting which could influence political thinking. Ability to generate revenues could address developing country issues	Likely to be viewed as a proxy kerosene tax which will raise legal concerns amongst ICAO's Contracting States.
Static versus dynamic mitigation incentive	Static incentive to reduce emissions below the required threshold; weak dynamic incentive, as marginal emission costs drop to zero once the threshold is reached	Same as offsetting, though the static incentive is stronger due to the higher carbon cost caused by the revenue mechanism; equally weak dynamic incentive	Strong dynamic incentive due to constant marginal costs	Strong dynamic incentive due to constant marginal costs
Compatibility with national and regional measures	Will require emissions to be offset above a 2020 cap so would partially double count emissions covered by the EU ETS and some national schemes such as the German environment levy (although these could be amended to avoid double counting). However, most national measures in effect (e.g. Swiss carbon tax) or proposed (e.g. Australian cap and trade system) only apply to domestic routes so will be complimentary to a global measure for international aviation	Same as offsetting	Will depend on degree of auctioning. Measured against the 2020 goal with 50% auctioning, by 2030, a global ETS introduced on this basis will apply a carbon price to approximately 65% of the sector's CO_2 emissions. The EU ETS, assuming existing design parameters for aviation of 15% auctioning and a cap of 95% of 2004-6, will apply a carbon price to a similar proportion of the international aviation emissions covered by the scheme	Will apply a price to all carbon emissions so will overlap with all national and regional schemes which include international aviation

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Performance of the options against WWF's stated objectives

There are three criteria in this paper for assessing the performance of the MBM options.

1. Achieves substantial greenhouse gas emissions reductions from international air transport in line with international efforts to keep global warming below 2 degrees Celsius above pre-industrial levels, with the emissions reduction objectives of the current EUETS system serving as a floor;
2. Generates financing for the Green Climate Fund to be used for climate change action in developing countries, at a scale in line with the findings of the World Bank and IMF report on Mobilizing Climate Finance, which was compiled for the G20 Finance Ministers;
3. Conforms to the existing principles of the Chicago Convention and ICAO while accommodating the principle of Common but Differentiated Responsibilities and Respective Capabilities (CBDRRC) of the UNFCCC.

The first asks whether the emissions reductions objectives are consistent with stabilisation of atmospheric emissions and temperature control. The offsetting options are perhaps compelling in their contribution to this aim, with the levy and cap and trade more effective in reducing emissions, but in all cases the emissions outcome depends more on political determination than the instrument choice.

The second criterion relates to revenue raising capability. Three of the options have the potential to generate revenue, but only the levy gives the level of control needed to collect a specified amount of revenue, and so it performs the best on this criterion. Again, it is subject to political discretion as to how well it might be used to collect revenue.
The third criterion asks whether the options conform to the principles of existing international agreements. The instruments could be adapted to confirm with the principles, perhaps by modifying the obligations placed upon airlines operating flights to and from countries of different levels of development, or through the distribution of revenues.

Taking each option in turn

Option 1, offsetting: could deliver large volume of low-cost emissions reduction but there are concerns about its reliability of emissions impact, because of imperfect trust in offsets. Benchmarking is a promising means of allocating an offsetting liability but it could diminish the incentive to reduce emissions, indeed as proposed here, there is no incentive to reduce emissions below threshold of 2020. It seems unlikely, considering aviation's exemptions from VAT (and fuel duty), that the sector would be unfairly burdened. The arrangement is legally and institutionally feasible but results in partial double counting with other instruments such as EU ETS.

Option 2, offsetting with revenue generation: the additional revenue generation increases the cost to the aviation sector and raises the in-sector incentive to reduce emissions, but it requires new institutional arrangements to distribute the revenue.

Option 3, cap and trade: this option offers greater potential for low cost global emissions reductions when it is linked to other sectors, and it is likely to encourage higher in-sector emissions reductions than offsetting schemes because it might operate with a higher emissions price. The financial impact on governments and airlines can be adjusted through grandfathering or benchmarking of free allowances, and in common with other options, cost is also passed on to customers. It allows a high degree of flexibility in design.

Option 4, levy with offsetting: the levy offers the greatest certainty in future carbon prices facing airlines, and thus can be an efficient mechanism for stimulating in-sector investment. It raises greater questions about institutional arrangements since it requires a price to be set by an administrative authority and revenue to be collected and distributed.

None of the options raises competition concerns if they are applied universally. If, however, they are applied unilaterally or together with benchmarks, these might favour some firms, although good design might allow adjustments based on differential environmental impact.

The levy scheme offers the best long-term dynamic incentive, and a trading scheme scheme linked to other sectors also perform well in this respect. The offsetting schemes are vulnerable to manipulation of baselines and concerns about credibility in ways which would reduce the emission savings that they require in the future and might reduce the effective emissions savings today.

Annex A – Extract from ICAO Resolution A37

"The guiding principles for the design and implementation of market-based measures (MBMs) for international aviation:

a) MBMs should support sustainable development of the international aviation sector;

b) MBMs should support the mitigation of GHG emissions from international aviation;

c) MBMs should contribute towards achieving global aspirational goals;

d) MBMs should be transparent and administratively simple;

e) MBMs should be cost-effective;

f) MBMs should not be duplicative and international aviation CO_2 emissions should be accounted for only once;

g) MBMs should minimize carbon leakage and market distortions;

h) MBMs should ensure the fair treatment of the international aviation sector in relation to other sectors;

i) MBMs should recognize past and future a evements and investments in aviation fuel efficiency and in other measures to reduce aviation emissions;

j) MBMs should not impose inappropriate economic burden on international aviation;

k) MBMs should facilitate appropriate access to all carbon markets;

l) MBMs should be assessed in relation to various measures on the basis of performance measured in terms of CO_2 emissions reductions or avoidance, where appropriate;

m) MBMs should include *de minimis* provisions;

n) where revenues are generated from MBMs, it is strongly recommended that they should be applied in the first instance to mitigating the environmental impact of aircraft engine emissions, including mitigation and adaptation, as well as assistance to and support for developing States; and

o) where emissions reductions are achieved through MBMs, they should be identified in States' emissions reporting."

Annex B – Criteria used in assessment

Table 11. **The simplified ICAO criteria together with two supplementary criteria used in the assessment of instruments**

Category	Criterion	Description
Effectiveness	CO_2 reduction	— total net reduction — reduction measured in CO_2/RTK
Efficiency and equity	Competition impact	— Distortionary impacts caused as measured by redistribution of gross value added — Carbon leakage incentive
	Cost	— Cost per RTK — Cost to industry — Cost to government — Cost to passengers
	Cost effectiveness	— Cost per tonne of CO_2 mitigated
	Fair burden on aviation compared to other sectors	— Prevailing carbon cost in aviation not significantly higher than in other parts of the economy
Implementation criteria	Legislative feasibility	— Compatibility with existing legislation, incl. WTO rules, Kyoto Protocol, UNFCCC, etc.; in particular the ability to reconcile the principle of CBRD with the Chicago Convention — Need for new legislative mechanisms to implement instrument
	Design features and timescale	— Complexity of design — Availability of similar experience — Technical feasibility
	Administration	— Administrative burden on stakeholders — Ease of monitoring and enforcement
	Rechanneling revenue	— Consistency with technology transfer support mechanisms — Contribution to climate finance
	Political Acceptability	— Qualitative judgement on political acceptability
Supplementary criteria	Static versus dynamic mitigation incentive	— Encourage a certain level of emissions reductions (static) versus encouraging incremental and additional emission reductions (dynamic)
	Compatibility with national and regional measures	— Consistency of instrument with potentially more ambitious mitigation policy from individual countries or regions — Ability to capture and report emissions reductions in State Action Plans

Annex C – market definition in aviation

The purpose of market definition

The purpose of market definition is to describe the competitive constraints operating on firms. By establishing the boundaries of the market, one can identify the number of firms and their market shares in order to undertake the necessary modelling.

Exercises that involve drawing boundaries between markets can involve a degree of judgement. This judgement can be informed with reference to practical principles established by competition authorities, who have needed to arrive at an objective and workable methodology.

Approaches to market definition

Approaches to market definition all draw a distinction between product and geographic markets, and base their definitions on the rule that a market is something 'worth monopolising'. An example of the approach taken by competition authorities is the EC Guidelines (1997) on market definition.

Articles 85 and 86 of the Treaty of Rome define the relevant market in the following way:

> *'A relevant product market comprises all those products and/or services which are regarded as interchangeable or substitutable by the consumer, by reason of the products' characteristics, their prices and their intended use. ... The relevant geographic market comprises the area in which the undertakings concerned are involved in the supply and demand of products or services, in which the conditions of competition are sufficiently homogeneous and which can be distinguished from neighbouring areas because the conditions of competition are appreciably different in those areas'.*

This definition is applied in three tests. Firstly, the SSNIP (small significant nontransitory increase in prices) test is applied to identify the potential for demand-side substitution. The test was developed by the US Department of Justice (see DoJ, 1997) and asks whether a hypothetical monopolist with control over a product would be able to impose a SSNIP profitably. If it could not, then the scope of the market has to be widened until the test is passed. The price increase chosen in the test is usually 5%.

Secondly, the potential for supply side substitution is tested in an assessment of the costs of shifting production. Finally, potential competition can be considered, although, because it is difficult to assess, it may only be considered once the first two tests have been applied.

Indications of the geographic scope of markets are visible in customer patterns, product differentiation, regulatory barriers, the costs of setting up distribution networks, and technical standards. There may be evidence of inter-regional price differences and customer opinions. Indications of the product scope of markets are visible in the variation of product characteristics and intended use. In addition, analysts may look at past price changes for evidence of co-variance, and also consider customers' views, the costs of switching and evidence of similar price elasticities.

Competition authorities' perspectives

Several cases considered by competition authorities and courts in the aviation sector have addressed the question of market definition. A selection of these are described below.

ECJ decision (1989), Ahmed Saeed Flugreisen

An early reference to a point-to-point definition of a market is the European Court Justice decision in the case of Ahmed Saeed Flugreisen (1989).

> *'The test to be employed is whether the scheduled flight on a particular route can be distinguished from the possible alternatives by virtue of specific characteristics as a result of which it is not interchangeable with those alternatives and is affected only to an insignificant degree by competition from them'.*

European Court of First Instance (1994)

In this case, there is a discussion of the role of substitute airports when applying a market definition of city pairs.

> *'In the Commission' s view, a certain degree of substitutability exists between Heathrow and Gatwick, but the fact that both those airports are congested means that substitutability does not necessarily operate.'*

European Commission (1999a)

The European Commission offered the following comments on market definition in the British Airways and Virgin case.

> *'The products in question are flights to and from United Kingdom airports. This group contains several different product markets defined by the origins and destinations of passengers' journey and the extent to which the passengers are time-sensitive or price-sensitive. For example non-stop, fully flexible business tickets from Heathrow to a major business centre like New York will constitute a separate product market as the business people who purchase such tickets would only consider substituting a similar London-New York ticket for their journey. At the other end of the scale, restricted, advance booked economy tickets from London to Paris could be part of a wider product market. Non-time-sensitive and price-sensitive leisure*
>
> *travellers will consider alternative means of travelling to Paris, and many of the tickets might be sold to non-time-sensitive travellers making a lengthy but economical journey to a point beyond Paris who would also consider another stopping-off point.'*

British Airways argued that the European Commission was departing from its own guidance by not applying the SSNIP test and appealed to the European Court of Justice. The Court ruled against British Airways in 2007.

European Commission (1999b)

The airlines argued that there is a global market for scheduled passengers and cargo and that there is network-based competition following liberalisation. The Commission maintained that networks are a supply-side feature and point-to-point is a demand-side feature. In general, freight is point-to-point, but the market is wider than for passengers as indirect routing may take place. Also, freight transport is often multi-modal, making catchment areas larger. The Commission concluded that for freight, the geographic market is continental.

The Commission also concluded that, since the percentage of indirect travellers is below 5%, indirect routes apply no real competitive constraint on most point-to-point routes.

European Commission (2002)

In 2002, the European Commission considered a partnership that would eliminate competition on 33 routes between Germany and Austria. The Commission required Austrian Airlines and Lufthansa to give up slots and reduce ticket prices where the routes offered no alternative competition. In reaching this decision, it identified high barriers to entry including slot shortage and the pooling of frequent-flyer programmes.

The parties argued that they compete on the basis of hubs and networks, not individual routes. The Commission rejected this argument, stating that the consumers considered the product to be a service between two points. Although charter flights might be a substitute for some leisure passengers, business passengers would not accept them.

The Commission made a distinction between point-to-point and transfer passengers, with the latter having more choice on where to make connections.

The parties argued that all European airlines were potential competitors. However, the Commission disagreed explaining that airlines often focus on their own hubs, not competing for other cities, and that there are barriers to entry in setting up new routes.

European Commission (2003)

In 2003, the European Commission investigated collusion between British Airways and Iberia. It carried out market testing which showed that all London airports, including Luton, are substitutes for non-time-sensitive travellers, but not for time-sensitive travellers. It concluded that low-cost carriers are substitutable for non-time-sensitive travellers and 'a not unsubstantial percentage' of time-sensitive travellers. It argued that charter flights are not substitutes due to their different characteristics, at least for time-sensitive travellers.

European Commission (2004), Air France and Alitalia alliance

The European Commission did not apply the SSNIP test, but based on a variety of market evidence concluded that:

> *'every combination of point-of-origin and point-of-destination should be considered to be a separate market from the customer's point of view'*

It concluded that the merger would reduce competition on city-pairings between France and Italy. It confirmed, through market research, that some customers are time-sensitive and some are non-time-sensitive. Airlines discriminate between these customers primarily on the basis of schedule flexibility. The two groups do not entirely coincide with business and leisure, for example, as weekend travellers can be quite time sensitive.

It also concluded that indirect flights are no substitute for short-haul flights, and that journeys should be compared on the basis of time, not distance. Finally, the Commission noted that congested airports restrict entry and thus reduce competition:

> *'The Commission's experience in this field shows that the main barrier to market entry lies in the scarcity of take-off and landing rights and the highly congested European airports'.*

CAA (2007)

A review of long-haul markets by the UK CAA summarised the evidence on competition authorities' approach to defining long-haul markets. The paper stresses that authorities have generally agreed on the need to distinguish between time-sensitive and non-time-sensitive passengers, although these have been variously defined as business vs. leisure, economy vs. premium class, or based on ticket flexibility. However, the definition of the breadth of the long-haul market has varied to reflect market circumstances. For example, in its 1998 decision on the BA-American alliance the European Commission defined the transatlantic market for non-time-sensitive passengers as all those travelling between Western Europe and the US, reflecting BA's base at Heathrow that allowed a large volume of feed services from Western Europe. By contrast, in its 2001 decision on the United-US Airways alliance the market was defined as individual city pairs on each side of the Atlantic because neither airline had major hub operations in Western Europe, although indirect flights appearing in reservation systems were still included.

In 2004, the CAA argued that indirect flights between London and Chennai were likely to be in the same market as direct flights because of the infrequency of direct flights. The EC has generally applied the rule that indirect flights are in the same market if they appear on reservation systems and have a connection within 150 minutes.

Passengers connecting through UK airports, rather than originating or terminating in the UK may also form a separate market because the route is only a segment of their journey and they may have a wider choice of routing options than direct passengers.

The airports to be included in the relevant market at a city node should also be assessed on a case-by-case basis. For example, the Competition Commission defined Heathrow as a separate market to other London airports in 2000 for time-sensitive passengers because of the frequency of routes and connections at Heathrow.

Other empirical evidence

A central element of the SSNIP test is whether an entrant can enter rapidly to make profits and exit without incurring significant fixed costs. Bailey and Panzar (1981) expressed optimism that this mechanism would exert a major effect on airlines following deregulation. However, Bernstein cites evidence that fare prices on routes with fewer competitors are on average higher, suggesting that there are barriers to this kind of uncommitted entry: 'Advertising and the short-run losses associated with inauguration of service on a new route seem to be sufficient sunk costs to inhibit contestability in the airline industry'.

Additional industry features which tend to reinforce a narrow definition of the market are the use of loyalty programmes and travel agent commission override programmes (TACOs), which raise the costs of switching.

An important market definition issue identified by the European Commission, among others, is price discrimination between, for example time-sensitive and non-time-sensitive consumers. Evidence for price discrimination is extensive; Salop (1978), Frank (1983), Borenstein and Rose (1991). Borenstein and Rose (1994) conclude that the expected difference in fares between any two customers is high, at 36% of the airline's average ticket price. The degree of price discrimination is higher in more competitive markets.

Summary of market definition

- For passengers, individual markets exist between each pair of points of origin and departure.
- The market may be expanded where empirical evidence suggests that any of the following offer reasonable substitutes: alternative airports at each end of the journey, particularly in large cities; indirect routes; and, alternative modes of transport such as road and rail.
- This could lead to a very narrow (between two airports) or a broader area definition of the market depending on the individual features of the route and its utilisation. Consideration of a range of market definitions is therefore appropriate.
- Each of these markets should typically be sub-divided between time-sensitive and non-time-sensitive customers. While there is a general correlation between these categories and business and leisure travellers, the match is not perfect.
- There is a separate market for freight, which can be considered as continental in scope where the freight is time-sensitive and similar to business where it is not.
- There is no clear evidence that a separate market for low-cost carriers is required, but there is evidence that the sector exhibits its own dynamics and that such evidence may emerge in the future.

- Long-haul routes may have particular characteristics, for example a greater incidence of transfer passengers and a differing composition of time-sensitive and non-time-sensitive passengers. It is possible that this may create different markets for short-haul and long-haul flights, which in this paper are separated on the basis of whether flights have an EU or non-EU destination.

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AVIATION REPORT

6.2%

Annual increase in air travel estimated to 2030
Dramatic growth is forecasted in the demand for air travel in all geographic regions, with annual growth rates in Revenue Passenger Kilometres between 2010 and 2030 ranging from 3% to 6.2%

4.9%

of the Earth's warming effect caused by civil aviation
Civil aviation accounts for 2% of global CO_2 emissions and, when its non-CO_2 impacts are factored-in, contributes 4.9% of anthropogenic contributions to global warming

274%

Unchecked, there will be a 274% increase in fuel used by airlines in the next 38 years
Fuel projections out to 2050 show a 274% increase against 2006 levels, with levels in 2050 equivalent to 2,200 Mt of CO_2 per annum, approximately 7% of global CO_2 on a 2˚C degree trajectory, or 3% to 4% of global CO_2 on a business as usual trajectory

$ 10 BILLION

Aviation could contribute $10 billion per annum in climate finance by 2020
The UN Secretary General's High Level Advisory Group on Climate Finance identified international aviation and shipping as a potential source of climate finance for developing countries, and subsequent work by the World Bank estimated that these sectors could generate $40 billion per annum by 2020 with a carbon charge of $25/t CO_2

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To stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature.

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