Guidance Material for the Development of States' Action Plans

Towards the Achievement of ICAO's Global Climate Change Goals

VERSION 1.0

12 September 2011

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Acronyms

ACI	Airports Council International
APU	Auxiliary Power Unit
ANSP	Air navigation service provider
ATAG	Air Transport Action Group
CAEP	Committee on Aviation Environmental Protection
CAA	Civil Aviation Authority
CANSO	Civil Air Navigation Services Organization
CNS/ATM	Communications, Surveillance and Navigation System/Air Traffic Management
CO_2	Carbon dioxide
CDM	Clean development mechanism
EF	Emission factor
GHG	Greenhouse gas
IATA	International Air Transport Association
IDB	Inter-American Development Bank
IPCC	Intergovernmental Panel on Climate Change
LTO	landing/take-off cycles
MBM	Market-based measure
NGO	Non-governmental organization
RTK	Revenue-tonne-kilometre
tkm	Tonne-kilometre
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
WB	World Bank

Introduction

Action plans are a means for States to communicate to ICAO information on activities to address CO_2 emissions from international aviation. The level of information contained in an action plan should be sufficient to demonstrate the effectiveness of actions, and to enable ICAO to measure progress towards meeting the global goals set by Assembly Resolution A37-19.

This guidance document is divided into five parts, each focusing on a different aspect of an action plan. There is no specific requirement in terms of the level of detail to be provided and hence, the guidance is generic and applies to all types of action plans, ranging from simple compilations of data, to elaborate reports. ICAO has developed a web interface (**Error! Hyperlink reference not valid.**http://portal.icao.int/ APER group) that facilitates the preparation of action plans and their submission to ICAO.

Users are encouraged to submit their action plans through the web interface: http://portal.icao.int, APER group (Refer to Part 1, "Contents of an Action Plan", paragraphs 7 and 8, for more detailed information.)

Background

In October 2010, the 37th ICAO Assembly adopted Resolution A37-19: *Consolidated Statement on continuing ICAO policies and practices related to environmental protection – Climate change*, that replaced Appendices I through L of Resolution A36-22. Resolution A37-19, together with Resolution A37-18, supersede Resolution A36-22 and constitute the *Consolidated Statement on continuing ICAO policies and practices related to environmental protection*.

The outcome of the 37th Assembly represents a milestone in the continuing efforts of ICAO to address greenhouse gas (GHG) emissions from international aviation. The provisions in Resolution A37-19 build upon ICAO's past achievements and incorporate new elements relating to international aviation and climate change. Specifically:

- Further endorsement of the global annual average fuel efficiency improvement of 2 per cent until 2020 and the global aspirational goal of 2 per cent annual fuel efficiency improvement from 2021 to 2050;
- A medium-term global aspirational goal of keeping the global net carbon emissions from international aviation from 2020 at the same level;
- Further work to explore the feasibility of a long-term global aspirational goal for international aviation;
- Development of a global CO_2 Standard for aircraft, by 2013;
- Facilitation of developing and deploying sustainable alternative fuels for aviation;
- Development of a framework for market-based measures (MBMs), including further elaboration of the guiding principles adopted by the 37th Assembly, and exploration of a global scheme for international aviation;
- Concrete steps to assist States to contribute to ICAO's global efforts;
- *De minimis* provisions to ensure that States with small contributions to global air traffic are not burdened disproportionately; and
- Action plans outlining States' policies and actions, annual reporting on international aviation CO_2 emissions, basket of measures and specific assistance needs.

The 37th Assembly also decided that the ICAO Council should undertake further work in order to make progress on a number of issues contained in Resolution A37-19 where States expressed concerns. These issues include the medium-term global aspirational goal and its implementation aspects, and MBMs, including the *de minimis* provision.

Provisions of A37-19 relating to action plans

A central element of Resolution A37-19 is for States to voluntarily prepare and submit action plans to ICAO.

There are several provisions in Resolution A37-19 which refer to States' action plans. Specifically, the Assembly:

- In paragraph 9, "*Encourages* States to submit their action plans outlining their respective policies and actions, and annual reporting on international aviation CO_2 emissions to ICAO";
- In paragraph 10, "*Invites* those States that choose to prepare their action plans to submit them to ICAO as soon as possible preferably by the end of June 2012 in order that ICAO can compile the information in relation to achieving the global aspirational goals, and the action plans should include information on the basket of measures considered by States, reflecting their respective national capacities and circumstances, and information on any specific assistance needs";
- In paragraph 12, "*Resolves* that a *de minimis* threshold of international aviation activity of 1 per cent of total revenue ton kilometres should apply to the submission of States' action plans as follows:

    a) States below the threshold are not expected to submit action plans towards achieving the global goals; and

    b) States below the threshold but that otherwise have agreed to voluntarily contribute to achieving the global goals are expected to submit action plans".

Furthermore, in paragraph 11 of Resolution A37-19, the Assembly "*Requests* the Council […] to provide guidance and other technical assistance for the preparation of States' action plans prior to the end of June 2012, in order for States to conduct their necessary studies and to voluntarily submit their action plans to ICAO".

This document has been prepared in response to the above-mentioned request and provides guidance to States to help them prepare their action plans in accordance with the provisions of ICAO Assembly Resolution A37-19. It is designed for use by those responsible for the preparation of an action plan.

About this guide

The specific aims of this guide are:

- To provide an overview of the action plan preparation process (i.e. tasks, activities and outputs);
- To help States better understand the objectives and expected outcomes of the action plan preparation process;
- To highlight the need for cooperation and collaboration between and among various stakeholders in the preparation of action plans; and
- To assist States in considering the basket of measures from which they might select their actions.

This guidance has been developed with the goal of accommodating the various levels of experience among States in the development of similar national reports. It is expected that in addition to facilitating the preparation of an action plan, this guide will contribute to improving the reporting of CO_2 emissions and the implementation of mitigation projects for international aviation.

This document is comprised of the following parts:

Part 1: Introduction to action plans

Part 2: Estimation, reporting and verification of CO_2 emissions

Part 3: Selection of measures

Part 4: Analysis methods and tools

Part 5: Assistance needs

Although not specifically mentioned here, there are inter-related issues, such as financial needs, research activities, transfer of technology, capacity building (including education, training and public awareness), and information and networking, which form integral elements of an action plan. These issues will be addressed specifically in Parts 3, 4 and 5 of this guide.

Part 1: Introduction to action plans

In many respects, the development of an action plan resembles the execution of any project, potentially involving activities such as securing resources, assembling a team, planning and implementing various tasks. This part of the guide provides generic guidance on some of the key aspects of the development process. It does not prescribe any specific activities since it is up to individual States to decide upon any arrangements (organizational, legal, procedural etc.) that they may need to put in place in accordance with their national conditions and circumstances.

Purpose of an action plan

The aviation sector often plays a central role in the national economy of any State, affecting numerous economic sectors and contributing to its further development. As such, any measures to limit or reduce the impact of international aviation on the environment, pursuant to the global aspirational goals agreed by the ICAO Assembly, should be an integral part of the broader sustainable development priorities and objectives of a State. This would contribute towards promoting the sustainable growth of international aviation while ensuring consistency with any overarching GHG emissions limitation or reduction efforts in the State.

In accordance with paragraphs 9 and 10 of Resolution A37-19, an action plan can help:

1. States:
   - to report on international aviation CO_2 emissions to ICAO;
   - to outline their respective policies and actions;
   - to provide information on the basket of measures considered, reflecting their respective national capacities and circumstances, and on any specific assistance needs; and

2. ICAO:
   - to compile information in relation to the achievement of the global aspirational goals;
   - to facilitate the dissemination of economic and technical studies and best practices related to aspirational goals;
   - to provide guidance and other technical assistance for the preparation of States' action plans; and
   - to identify and respond to States' needs for technical and financial assistance, with a view to responding appropriately through the development of a process and mechanism for the provision of assistance to States.

It is clear from the above that an action plan is a tool that a State can use to showcase and communicate both at the national and international level, its efforts to address GHG emissions from international aviation. In addition, through the development of an action plan, a State could:

- fine tune actions that are already being implemented;
- identify and quantify the environmental benefits of actions already planned or initiated to address other issues;
- consider how it may voluntarily contribute to the ICAO global aspirational goals for international aviation;
- identify appropriate future mitigation measures and activities;

- identify barriers and constraints in the implementation of future actions and how they could be overcome, including through access to financial resources, building national capacities and technology transfer;
- consider options to track the implementation of actions; and
- bring together all stakeholders involved in the design and implementation of actions, such as aircraft and engine manufacturers, air carriers, air navigation service providers, airport operators, local authorities, etc.

Publicly available information released by States in the context of their action plans can also be used by financing institutions and international or multilateral organizations that could assist States in overcoming identified barriers by providing financial resources, transfer of technology and capacity building assistance.

Scope of an action plan

In accordance with Resolution A37-19, action plans should incorporate information on activities that aim to address CO_2 emissions from international aviation, including national actions, as well as activities implemented regionally or on a global scale in the context (or as part) of bilateral and regional/multilateral agreements.

It should be noted that most aviation-related measures would affect both domestic and international operations. To the extent possible, States should separate the information provided for international aviation. The impact of measures on domestic aviation may be considered as a co-benefit of ICAO's global aspirational goals.

Emissions from airport and/or ground support equipment operations are considered as domestic emissions and are beyond the scope of Resolution A37-19. However, some States may address the issue of international aviation by taking a holistic approach and consider the aviation sector as a whole. In such cases, States could provide relevant additional information to help explain their strategies.

Contents of an action plan

For action plans to fulfil their purpose in accordance with the provisions of Resolution A37-19, it is suggested that they contain the following useful information:

- contact details of the authority and/or person(s) responsible for the compilation and submission of the action plan;
- annual historic (and, as far as possible, projected) fuel consumption and CO_2 emissions from international aviation. Although any available data would be welcome, in order to assess progress towards the global goals, the years 2010, 2020, and 2050 should be provided;
- statement on which definitions were used to differentiate between domestic and international emissions (see Part 2 of this guidance);
- statement on the voluntary contribution of the State to the global aspirational goals, including (as appropriate) a base year or baseline;
- list of actions to address CO_2 emissions from international aviation, distinguishing between those that are already in place and those that are being considered for future implementation. For each action, a brief description could be provided to outline how it may contribute towards that State's voluntary contribution to the global aspirational goals of ICAO (see Appendix B for a list of potential mitigation activities); and

- description of any specific needs (for example, financial, technological, capacity building) for the implementation of future actions.

States in a position to do so may provide more detail in their action plans in order to showcase their activities and/or solicit assistance for the future implementation of specific actions. In providing information on ongoing and future actions, it could be indicated which actions are the direct result of policy-making at the government level and which are being driven by other stakeholders (solely or in cooperation with State authorities) such as engine and aircraft manufacturers, air carriers, airport/local authorities, non-governmental organizations (NGOs), etc. Other action-specific information that may be provided includes:

- indication of the type of action (e.g., operational, technological, market-based, etc.);
- time horizon (start date and date of full implementation);
- anticipated change in fuel consumption and/or CO_2 emissions indicating appropriate metrics (e.g., specific metric (L/tkm) or general metric (t fuel used));
- economic cost and how it may be covered (e.g., domestic sources, regional funding, international assistance, etc.);
- expected co-benefits (mainly for domestic aviation, but others could also be reported, if appropriate);
- references to any relevant legislation; and
- description of the process used for selecting the mitigation actions.

Furthermore, States may provide additional explanatory information that may highlight the specific conditions of the State (e.g. a general introduction on the role of international aviation in the State).

Should confidential data be collected (for example, from individual air carriers or on specific international routes), appropriate procedures should be followed, including for the designation and treatment of such information in accordance with the applicable national legislation and regulations. To protect confidentiality, certain data may not be reported to ICAO or, if reported, could be aggregated to ensure that no competiveness issues arise. A State could improve transparency by explaining in its action plan how confidential information has been treated.

Every effort is being made to ensure that reporting action plans to ICAO is as simple and flexible a process as possible. States are free to submit their action plans in any format they wish to. To assist with the collection of information to be included in the action plans, a template is provided in Appendix A.

To facilitate the submission of action plans and minimize the burden on States, ICAO has developed a dedicated web interface that can be used to upload and submit action plans electronically (http://portal.icao.int, group APER). Following the template in Appendix A will help States to organize the information in the same order that it will be requested on the website. Instructions for the on-line submission, as well as training materials, including a step-by-step guide and examples, can be downloaded from the ICAO website (http://portal.icao.int group APER) and is also available as a print-out in Appendix B.

In order to obtain access to the action plan web interface, States' action plan focal point(s) must create an account on the ICAO Portal. The steps to create a new user account are as follows:

1. Access the ICAO Portal at the following link: http://portal.icao.int/
2. As there is no pre-existing Portal username/password, click the **REQUEST AN ACCOUNT** option.

3. Click the **OK** button on the pop-up message to indicate this is your first Portal account.
4. In the pop-up window, enter APER (all caps and no space) in **PLEASE ENTER A GROUP NAME YOU WISH TO SUBSCRIBE: APER**
5. Click the **OK** button.
6. Enter the necessary information in the New User Account form.
7. Click the **SUBMIT REQUEST** button.
8. When these steps are completed, you will receive confirmation that you have been granted or denied access (if granted, the email will include your username and password).

Should the action plan focal point(s) already have an ICAO secure Portal account, instructions to gain access to the action plan interface are as follows:

1. Log on to http://portal.icao.int with your secure site login credentials.
2. Click on the **PROFILE** link on the right hand top corner.
3. A new window pops up; click on **GROUP SUBSCRIBE/UNSUBSCRIBE** in the left side menu.
4. Enter the group name (**APER**) you are requesting access for in the **SUBSCRIBE TO** field and the **JUSTIFICATION** for your request.
5. Click the **SUBMIT CHANGES** button.
6. When these steps are completed, you will receive an email confirmation that you have been granted or denied access to the group in question.

The web interface allows States to upload their action plans and/or additional supporting documentation as electronic documents. Supporting documentation or an action plan submitted in a language other than the six official languages of the UN will not be translated by the ICAO Secretariat. Furthermore, it is emphasized that if a State submits its action plan in a language other than the six official languages of the UN then the State should also use the web interface to provide (at least) the minimum information described above in English. If the State does not do so, the submitted information will not be processed by the ICAO Secretariat.

The planning process

As described in paragraph 10 of Resolution A37-19, action plans should be prepared and submitted to ICAO preferably by the end of June 2012. This provides a time horizon against which a plan for the preparation of an action plan can be formulated.

Some of the key steps in the planning process may be the following:

- Preparatory activities, including:
    - Administrative and organizational arrangements; and
    - Identification of national conditions;
- Estimation of historical CO_2 emissions from international aviation;
- Identification of actions to mitigate CO_2 emissions;
- Determination of the State's voluntary contribution to the global aspirational goals.

The schematic in Figure 1 provides an indicative sequence of the various steps, including a top-down and bottom-up approach that may be adopted. In both cases, the whole process is an iterative one that can be refined based on experience gained with the implementation of mitigation projects. Brief descriptions of the various steps are provided below.

Preparatory activities: The first step in developing an action plan is to develop a timeline for its completion and to secure the commitment of all stakeholders involved with civil aviation matters in the State. This may include:

> *Administrative and organizational arrangements:* To accomplish all necessary actions, all relevant stakeholders (from the public and private sectors) would need to be involved taking into consideration their specific expertise and know-how. Depending on the complexity of the aviation sector in a State, small working teams may be established to carry out specific technical tasks. For more information, refer to Appendix D.
>
> *National context*: The development of international aviation in a State and its impact on the national economy depends on various parameters and factors that are specific to the State concerned. The identification of such parameters and factors at an early stage of the process would help ensure that mitigation activities are realistic in terms of their expected effectiveness and ease of implementation. For more information, refer to Appendix E.

CO_2 emissions from international aviation: This is a key part of an action plan as it provides the opportunity to determine the historical levels of CO_2 emissions from international aviation and to identify mitigation opportunities. Reported CO_2 data will assist ICAO in assessing the overall emissions trends and track progress towards the achievement of the global aspirational goals of ICAO. For more information, refer to Part 2 of this guide.

Identification of mitigation actions: In addition to any actions already in place, future mitigation actions could be selected by considering the basket of measures that has been developed by ICAO (see Appendix C for a list of potential mitigation activities). Performing cost-benefit/cost-effectiveness and/or risk assessment analyses, while identifying any barriers to implementation, including lack of financial or human resources, technological needs, etc., could assist in the prioritization of mitigation actions, identification of those actions that could be implemented immediately, and/or those actions that would require assistance for their future implementation. Market instruments outside the traditional aviation domain such as the two project-based mechanisms of the Kyoto Protocol - Joint Implementation and Clean Development Mechanism (CDM) - could be identified as a potential source of financing and offsets to meet goals for international aviation. For more information, refer to Parts 3 and 4 of this guide.

Voluntary contribution: As provided for in Resolution A37-19, States could, on a voluntary basis, contribute to the global aspirational goals. This determination can be done based on a bottom-up or top-down approach as illustrated in Figure 1. Although not specifically required, a State, while considering a specific contribution level, may select a point of reference, such as a historical base year or a future baseline. ICAO will compile all submitted information, in order to compute the overall progress towards the global aspirational goals. For more information, refer to Parts 3 and 4 of this guide.

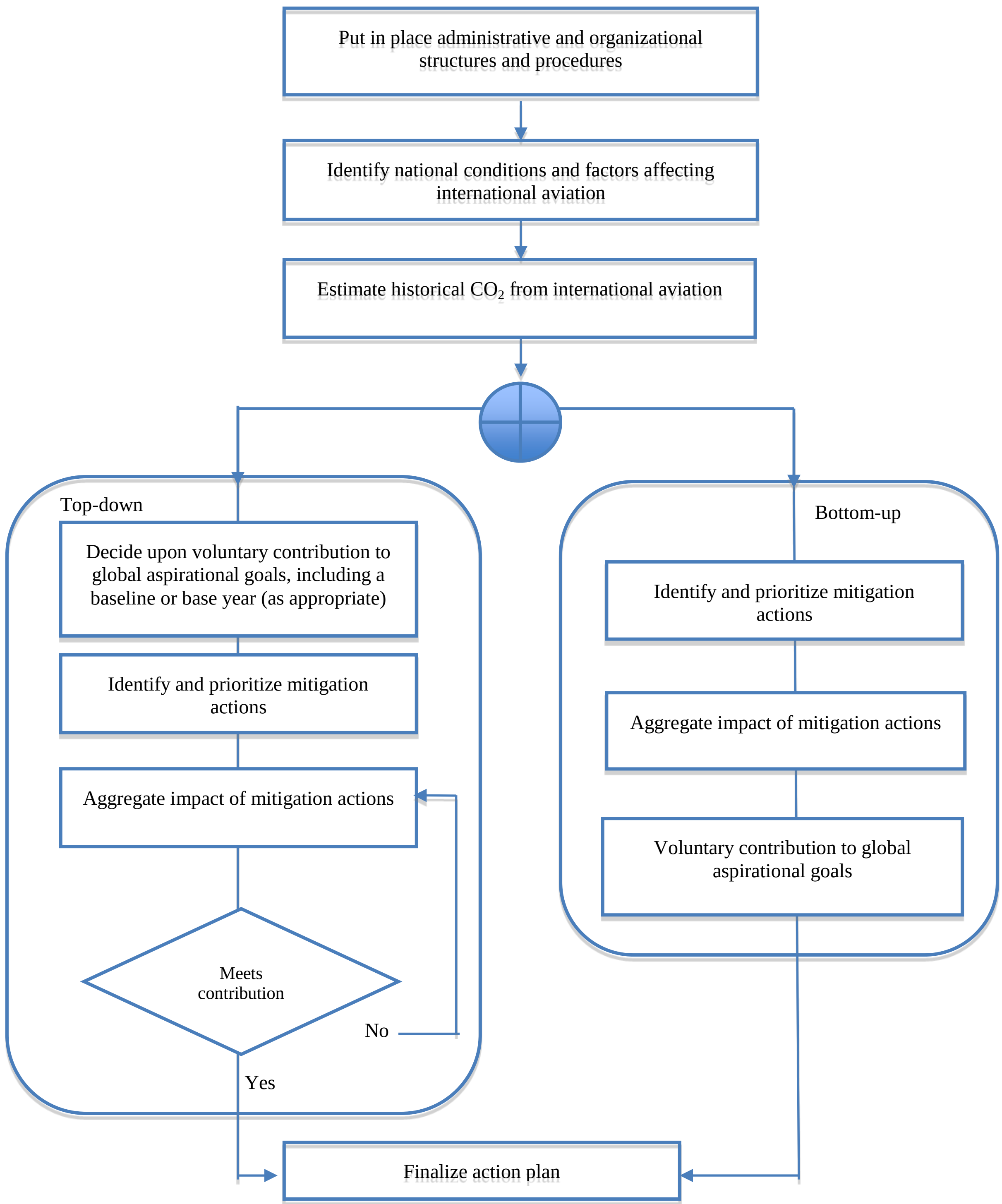

Figure 1. Indicative sequence of steps for developing an action plan

How States can monitor progress

To monitor progress towards the implementation of their action plans, States may regularly collect data from all relevant stakeholders reflecting their accomplishments, as well as the challenges they face in realizing their mitigation actions. Sharing this information with ICAO would enable the Organization to determine progress toward the global aspirational goals and to identify any assistance requirements of States.

Updated information could be provided on the most recent trends in CO_2 emissions and the implementation status of mitigation actions. For the latter, this could include: results of mitigation activities (in terms of CO_2 emissions reductions); adjustments made to previously reported mitigation activities (including termination); new activities planned and expected results; and any adjustments to the overall voluntary contribution of the State.

States could provide updates once every three years, preferably by the end of the year, prior to the year during which a regular ICAO Assembly session is scheduled[1]. To submit updated information, States can use the web interface developed by ICAO (http://portal.icao.int). For instructions on how to gain access to the web interface, refer to Part 1, "Contents of an Action Plan", paragraphs 7 and 8.

The Secretariat will compile the reported data and make them available, in a timely manner, for the consideration of the Council, and Assembly. Summary reports may also be published for the general public as part of the information-sharing mandate of the Organization.

How ICAO can help

ICAO has developed guidance material and an interactive website and has conducted training workshops to support States in the development of their action plans. In addition, ICAO Secretariat staff will be dedicated to assisting States in the development and implementation of their action plans, and can be contacted at actionplan@icao.int.

[1] Based on the current schedule, the first such update would be due by the end of December 2015.

Part 2: Estimation, reporting and verification of CO_2 emissions

Introduction

GHG emissions data is a key element of an action plan. Emissions from aviation arise from the combustion of jet fuel and aviation gasoline, and are roughly composed of about 70 per cent CO_2[2].

This part of the guidance is intended to help States establish a process for estimating their CO_2 emissions from international aviation in support of the development of an action plan and for their use in monitoring its implementation. It provides general guidance for the estimation, reporting and verification of CO_2 emissions from international aviation and is divided into the following sections:

1) Background;
2) International and domestic emissions;
3) Estimation of emissions and methodological issues;
4) Verification of emissions estimates; and
5) Reporting additional information on emissions estimates.

Appendix F contains additional information on general aspects of a GHG inventory process that may be useful for States that do not have a systematic way to estimate, report and verify GHG emissions. For those States that have already established such a system (for example, a national system as required under Article 5, paragraph 1, of the Kyoto Protocol), the procedures that have been put in place should be used to ensure that the estimation, reporting and verification of CO_2 emissions in action plans were undertaken in accordance with the recommendations in this guide.

Background

For States to successfully complete this part of their action plans, it is necessary that:

- they use a nationally-applicable definition for distinguishing between domestic and international operations;
- they have selected an appropriate methodology (see section on "Methodological issues" below); and
- they have access to the necessary information, such as activity data and emission factors.

Given that the focus of the work on action plans is on international aviation, distinguishing between emissions resulting from domestic and international flights is a critical aspect of the action plan process. This guide does not contain any specific recommendation regarding which definition should be used (see section below for a description of applicable definitions). Each State is free to select the definition that best suits its actions to address CO_2 emissions from aviation. However, it is emphasized that once a

[2]According to the 2006 IPCC *Guidelines for National Greenhouse Gas Inventories*, other gases emitted by aircraft include H_2O (a little less than 30 per cent) and less than 1 per cent each of NO_x, CO, SO_x, NMVOC, particulates, and other trace components including hazardous air pollutants. Little or no N_2O emissions occur from modern gas turbines. Methane (CH_4) may be emitted by gas turbines during idle and by older technology engines, but recent data suggest that little or no CH_4 is emitted by modern engines.

decision on a specific definition has been taken, it should be used consistently to avoid biases in emissions estimates.

> The minimum information to be reported by States on CO_2 emissions from international aviation would comprise the following:
>
> - Statement on what definitions were used to differentiate between domestic and international emissions; and
> - Total fuel consumption, CO_2 emissions and RTK from international aviation, beginning in 2010.

Note: The ICAO Form M — Fuel Consumption and Traffic — International and Total Services, Commercial Air Carriers (ICAO Fuel Form) is the official means by which ICAO will measure progress towards the global goals. ICAO is working on the development of tools and procedures that would enable the Organization to collect information from different sources and in different formats in order to report global CO_2 emissions from international aviation to the United Nations Framework Convention on Climate Change (UNFCCC) in response to the request by the ICAO Assembly. This task is separate from the work on action plans.

As explained in Part 1 of this document, updates of action plans could be provided once every three years (see section on "How States can monitor progress" in Part 1). As part of such an update, States could provide CO_2 emissions for the latest year available. They could also provide CO_2 emissions estimates for other (intermediate) years, if available.

In case a State recalculates its CO_2 emissions (for example due to the availability of better activity data, use of a different methodology, etc.), then revised estimates should be reported to ICAO.

International and domestic emissions

Within ICAO, specific definitions, based on flight stages, have been developed and are being applied for the collection of fuel consumption and traffic data from States. A flight stage is defined as the operation of an aircraft from take-off to its next landing and is classified as either international or domestic based on the following:

- **International**: A flight stage with one or both terminals in the territory of a State, other than the State in which the air carrier has its principal place of business.

- **Domestic**: A flight stage not classifiable as international. Domestic flight stages include all flight stages flown between points within the domestic boundaries of a State by an air carrier whose principal place of business is in that State. Flight stages between a State and territories belonging to it, as well as any flight stages between two such territories, should be classified as domestic. This applies even though a stage may cross international waters or over the territory of another State.

Furthermore, the following clarifications apply to the above-mentioned definitions:

1) In the case of multinational air carriers owned by partner States, traffic within each partner State should be reported separately as domestic and all other traffic as international.

2) "Foreign" cabotage traffic (i.e. traffic carried between city pairs in a State other than the one where the reporting carrier has its principal place of business) should be reported as international traffic.

3) A technical stop should not result in any flight stage being classified differently than would have been the case had the technical stop not been made.

Based on the above, it is clear that in the context of ICAO reporting forms, States are required to report data that are relevant to their national air carriers and other air carriers whose principal place of business is in that State or are registered in that State.

Other definitions for domestic and international aviation have been developed (for example, by the Intergovernmental Panel on Climate Change (IPCC) and are applied irrespective of the nationality of the carrier (see Appendix G). They are based on whether the departure and arrival airports for a specific flight are in the same or in different countries. These definitions are being used for the estimation and reporting of GHG emissions from domestic and international aviation under the UNFCCC. Specifically, the criteria of the IPCC for defining international and domestic aviation (applying to individual legs of journeys with more than one take-off and landing) are as follows:

Journey type between two airports	Domestic	International
Departs and arrives in same State	Yes	No
Departs from one State and arrives in another	No	Yes

For their selection, States could consider the specific characteristics of the two definitions as summarized in Table 1.

Table 1. Characteristics of the ICAO and IPCC definitions for domestic and international aviation

	ICAO definitions	IPCC definitions
What is included	• Differentiation between domestic and international flights • Commercial scheduled and non-scheduled fights • National carriers • Carriers registered in the State • Carriers whose principal business is in the State	• Differentiation between domestic and international flights • All commercial flights (scheduled, non-scheduled, on-demand, etc.) • All carriers irrespective of where they are registered
What is not included	• Carriers registered in other States • Commercial on-demand flights	
Compatibility	• ICAO Fuel Form • ICAO statistical information system	• Reporting requirements under the UNFCCC • CAEP work on MBMs

Estimation of emissions and methodological issues

The methodological information presented in this section addresses CO_2 emissions as a result of air traffic movements for scheduled and non-scheduled commercial civil services. Methodologies to estimate emissions from non-aircraft ground operations (e.g., ground transport, airport operations, etc.) are not described here. If estimates of such emissions are relevant for action plans and need to be calculated, the reader can use the methodological resources that are provided in the References section.

Note: Emissions from non-aircraft ground operations are considered domestic emissions and form part of the national GHG emissions inventory of a State, prepared in accordance with the requirements of the UNFCCC. To avoid duplication of effort, it should be verified if calculations of these emissions have already been made in the State.

Methodological issues

In general, the amount of CO_2 that is emitted from the combustion of fuels can be calculated by multiplying the amount of fuel burned by an appropriate emission factor. For the case of CO_2 emissions from the combustion of conventional aviation fuel, States should use the emission factor of the ICAO Carbon Emissions Calculator methodology (3.157 $kgCO_2$/kg fuel). If the amount of fuel is available in volume units (for example in litres) the density factor of the fuel should be used to convert it into mass units. If data are not available to determine a country-specific density factor value, then the value provided in the ICAO fuel form (0.8 kg/litre) should be used.

For the purposes of an action plan, two methodologies (*Aggregated* and *Disaggregated*) could be used based on the availability of fuel consumption data:

- *Aggregated* methodology: based on the use of aggregate fuel consumption data collected by States and reported to ICAO through the ICAO Fuel Form; and

- *Disaggregated* methodology: based on the availability of detailed information for individual flight stages.

Other methods do exist, but are not described here in detail (see Appendix G for a brief discussion on the 2006 IPCC methodologies)[3] . For more detailed information, refer to the resources listed in the References section.

Note: In the absence of fuel consumption data, States could obtain a first-order estimate of the total CO_2 emissions from international operations by using information on movements for all city pairs assuming great circle distances and emission factors for specific aircraft (similar to the methodology that has been employed for the ICAO *Carbon Emissions Calculator*).

[3] Another relevant guidance document is the EMEP/EEA Air Pollutant Emission Inventory Guidebook (formerly referred to as the EMEP CORINAIR Emission Inventory Guidebook). For the most recent version of the EMEP/EEA guidebook, it was ensured that the methodological approach is consistent with that of the IPCC 2006 *Guidelines for National Greenhouse Gas Inventories*. In effect, this means that both documents contain the same methods.

Aggregated methodology

The *Aggregated* methodology is based on the use of readily available information. It requires minimum additional resources and effort and can be applied on the basis of the fuel consumption data collected by a State and reported through the ICAO Fuel Form. The methodology can be used by the national authority responsible for collecting the information from air carriers and reporting to ICAO, as well as by the air carriers themselves.

Specifically, States are required to report to ICAO total fuel used by each aircraft type in the fleet of individual air carriers according to the following categories:

1) international scheduled services;
2) international non-scheduled services (excluding on-demand flights); and
3) international total (scheduled and non-scheduled, excluding on-demand flights).

States should report the mass of fuel uplifted in metric tonnes for all aircraft in each aircraft type in an air carrier's fleet. There should be no distinction between fuel types. Fuel uplift can be determined based on the measurement by the fuel supplier, as documented in the fuel delivery notes or invoices. Alternatively, fuel uplift can also be established using aircraft onboard measurement systems. The data should also include fuel consumed by the auxiliary power units (APU). In addition, States are asked to provide the percentage of biofuel contained in the total fuel used (both international and domestic).

Using the information reported in the ICAO Fuel Form, CO_2 emissions for international services can be calculated by:

- first, estimating the amount of biofuel used (see Box 2 for the treatment of biofuels);
- second, estimating the amount of conventional fuel (e.g., jet fuel) used; and
- third, estimating CO_2 emissions by multiplying the fuel consumption figures (biofuel and conventional) by appropriate emission factor values.

Box 1. Example using the Simplified methodology

Let us assume that a State reports the following figures in an ICAO Fuel Form:

- Aircraft type: Boeing 737
- Fuel consumed (international scheduled services): 2,000 tonnes
- Fuel consumed (international non-scheduled services): 1,500 tonnes
- Fuel consumed (international total): 3,500 tonnes
- Total services (international and domestic): 5,000 tonnes
- Per cent biofuel: 30% (assuming that the same figure applies to both domestic and international fuel use)

The total CO_2 emissions from international services can be calculated as follows:

Step 1: biofuel international = 3,500 x 30% = 1,050 tonnes

Step 2: international jet fuel = 3,500 – 1,050 = 2,450 tonnes = 2.45 kt

Step 3: CO_2 jet fuel = 2.45 x 3.157 = 7.735 kt CO_2

Note: If the biofuel used is not of purely biogenic origin, then additional CO_2 emissions from its combustion would need to be calculated.

Disaggregated methodology

The *Disaggregated* methodology relies on the use of specific fuel consumption data for individual flight stages and could be aggregated for different aircraft types and (if possible) city pairs. It requires more resources and effort, compared to the *Aggregated* methodology, and may be better suited for use by individual air carriers who would then report aggregate data to the national authority responsible for submitting information to ICAO. Using such a detailed methodology would enable the identification of large sources of emissions and mitigation opportunities, and the monitoring of progress in the implementation of specific actions.

The methodology would require the following data for individual flight stages:

- Total fuel consumption; and
- Specific fuel characteristics, such as calorific value, carbon content, and type and percentage of biofuel in the total fuel amount.

The calculation of CO_2 emissions for individual flight stages would be based on the disaggregated information collected by air carriers. Once all data have been collected, CO_2 emissions for individual flight stages can be calculated using the same steps as those for the *Aggregated* methodology.

Box 2. The treatment of biofuel

Sustainably produced aviation biofuel is one of the most promising technological innovations which is expected to significantly contribute to the sustainable growth of aviation. By replacing conventional jet fuel with equal amounts of biofuel, significant reductions in life-cycle CO_2 emissions can be achieved.

To avoid double counting, or over or under-reporting of CO_2 emissions, it is important to assess the biofuel origin so as to identify and separate fossil from biogenic feedstocks.

In the absence of international agreement and specific ICAO guidance on lifecycle analysis methodologies, biofuel will be treated as zero net emissions for the purposes of the action plans. This is based on the assumption that the amount of CO_2 absorbed by the plants used to produce the biofuel is equal to the amount of CO_2 emitted during the combustion of the biofuel. It should be noted that if a life-cycle analysis for biofuel is undertaken, additional sources of GHG emissions could be identified (at the farm level, such as from the use of fertilizers or from potential clearing of forest land, and at the fuel production process).

Note: GHG emissions at the farm level and during the biofuel production process are usually taken into account within a national GHG inventory of a State as they are considered domestic activities. Care should be taken to avoid double counting of such emissions.

Use of models

States can use other methodologies, including the Committee on Aviation Environmental Protection (CAEP)-approved models as well as their own national models, to estimate CO_2 emissions from aviation. To ensure transparency, States are encouraged to briefly explain, in their action plans, which methods/models they have used.

Some States may encounter difficulties in the collection of the required data from the aircraft operators under their jurisdiction. In such cases, emissions and fuel consumption estimates could be generated in accordance with the requirements of the methodologies described in this guidance by applying one of the four CAEP-approved models (for a brief description, see Box 3): AEDT; AEM III; AERO2k; and FAST.

Box 3. Descriptions of the four CAEP approved GHG aviation models

The United States Federal Aviation Administration (FAA) has developed the Aviation Environmental Design Tool (**AEDT**), with support from the Volpe National Transportation Systems Center, the Massachusetts Institute of Technology and the Logistics Management Institute. The AEDT computer model is used for estimating aircraft emissions (CO_2, CO, HC, NO_X, H_2O and SO_x modeled as SO_2) over the whole flight regime, including the landing and take-off cycle, and cruise. With regard to scope, the model is capable of analyses on an aircraft, airport, regional, and global level. Various operational, policy and technology-related scenarios can be evaluated using this model to assess their potential effects on global aircraft emissions. The AEDT model is based on the best available data and methodologies (e.g.EUROCONTROL's Base of Aircraft Data (BADA), Boeing Climb Out Program (BCOP), Society of Automotive Engineers Aerospace Information Report 1845 (SAE-AIR-1845)), and undergoes periodic updates to maintain currency.

AEM (Advanced Emission Model) is an aircraft stand-alone system developed and maintained by the EUROCONTROL Experimental Centre (EEC) in Brétigny, France. This system is used to estimate aviation emissions (CO_2, H_2O, SO_x, NO_x, HC, CO, Benzene, VOC, TOG) and fuel burn. It analyzes flight profile data, on a flight-by-flight basis, for air traffic scenarios of almost any scope (from local studies around airports to global emissions from air traffic). AEM uses several underlying system databases (aircraft, aircraft engines, fuel burn rates and emission indices) provided by external data agencies in order to assure the quality of the information provided. The fuel burn calculation comes from EUROCONTROL's Base of Aircraft Data (BADA). This system information is combined with dynamic input data, represented by the air traffic flight profiles.

The **AERO2k** project was supported through the European Commission Fifth Framework programme and was developed by a consortium led by QinetiQ (United Kingdom) with DLR (Germany), NLR (Netherlands), EUROCONTROL, Airbus (France), Manchester Metropolitan University (United Kingdom) and the Department of Trade and Industry (United Kingdom). AERO2k developed a new four dimensional (4-D: latitude, longitude, height and time) gridded database of global aircraft emissions of priority pollutants using improved methodologies and analytical tools The emissions can be displayed in a 4-D grid. AERO2k works by combining a global aircraft movements database with data on fuel flow provided by a separate commercial model, PIANO, which is an aircraft performance model.

The **FAST** model (Future Aviation Scenario Tool) was developed for the United Kingdom Department for Trade and Industry and follows the same approach as the peer-reviewed global aviation emissions model ANCAT/EC2. The FAST model works by combining a global aircraft movements database with data on fuel flow provided by a separate commercial model, PIANO, which is an aircraft performance model. These data on aircraft and engine types allow calculation of emissions via a recognized and validated algorithm that corrects certification (ICAO databank) data for altitude.

These CAEP-approved models have the capability to calculate fuel burned and emissions throughout the full trajectory of flight segments using aircraft and engine-specific aerodynamic performance information. They can generally specify output in terms of aircraft, engine, airport, region, and global totals, as well as by latitude, longitude, altitude and time, for fuel burn and emissions of CO, hydrocarbons (HC), CO_2, H_2O, NO_X, and SO_X. When used to prepare an annual inventory submission, the models calculate aircraft emissions from input data that take into account air-traffic changes, aircraft equipment changes, or any input-variable scenario.

Verification of emissions estimates

It is advisable that to carry out the verification of emissions data both at the air carrier level and at the State level. Specific checks and comparisons that can be undertaken are described below:

- If the *Disaggregated* methodology is used, the CO_2 estimates could be checked with those from the use of the *Aggregated* methodology. Any major discrepancy (e.g., larger than ± 10 per cent) between the emissions estimates should be investigated.

- If national factors were used instead of default values, it would be appropriate to consider any quality control review associated with the publication of the emission factors. A comparison of the default values to national factors would provide further indication regarding the applicability of the factors.

- Comparisons of current data to historical activity data or model outputs would help identify data problems.

- Checks should be performed to ensure the correct implementation of the differentiation of emissions between domestic and international aviation.

- Data can be checked with productivity indicators such as fuel per revenue-tonne kilometre (RTK).

- Independent experts who are familiar with the source category and who understand inventory requirements could review the CO_2 emissions estimates. This could include an independent, objective review of calculations, assumptions or documentation of the emissions inventory.

- Other consistency checks would include checking whether the method for computing emissions, sources of data, emission factors, density factors, and traffic weights are consistently applied.

- Cross-check with other data sources for e.g. fuel uplift could be cross-verified with jet fuel concessionaires at each airport or departures data could be checked with the airport authorities or with schedules filed with the civil aviation authority (CAA) of the State.

Reporting additional information on emissions estimates

In addition to the minimum information to be reported in the action plans (see "Background" section above) States that wish to provide more detailed data are free to do so with no restriction on the type and detail of such information, including historical data. Additional information could include, but is not limited to, the following:

1) For the *Aggregated* methodology, the ICAO Fuel Form could be used as the basis for providing CO_2 emissions data. This would require the introduction of extra columns that States could use to report their emissions data;

2) For the *Disaggregated* methodology, States may provide the following information:

- Flight schedule, completed by the aircraft operator on a flight-stage basis;
- Coverage (e.g., commercial international operations of scheduled and charter flights, for aircraft with a maximum take off mass >=5,700 kg) distinguishing commercial, international, scheduled, charters, excluded flights/operators;

- For each city pair (IATA code or ICAO designator code):

  a) Aircraft type
  b) Number of departures;
  c) Fuel burnt (kg);
  d) CO_2 emissions;
  e) RTK;
  f) Type and proportion of alternate fuel used, if any; and
  g) Volume of carbon offsets purchased, if applicable.

States may also provide CO_2 emissions from domestic aviation for information purposes.

Part 3: Selection of measures

Objective

The objective of this part is to provide States that choose to prepare their action plans with the necessary guidance on how to select measures to limit or reduce CO_2 emissions from international aviation. It includes sections on baseline establishment, feasibility and emissions reduction potential of measures, prioritisation and selection of measures, expected results, metrics and implementation.

Overview

The final result of this process may be presented as two separate tables as follows:

*(minimum data to be entered)

Baseline

Year	Total fuel (litres)	International fuel (litres)	Total CO_2 emissions	International CO_2 emissions

Expected action plan results

Year	Total RTKs	International RTKs*	Total fuel (litres)	International fuel (litres)*	Total CO_2 emissions	International CO_2 emissions*

Two metrics related to ICAO's global aspiration goals stated in Assembly Resolution A37-19 are: "volume of fuel used per revenue tonne kilometres" (paragraph 4); and "net CO_2 emissions" (paragraph 6).

These two metrics would be preferable in expressing a State's expected results and measuring progress. States may however use other metrics that better suit their needs.

Establishment of the baseline

Although the establishment of a baseline is optional, it would provide States with the ability to assess their contribution to the global goals and to identify whether or not the planned actions are "additional". The baseline provides a depiction of future international aviation emissions in the absence of additional action and offers a basis of comparison of alternative future scenarios (courses of action). It may serve as an input to cost-benefit and cost-effectiveness analyses.

The baseline scenario corresponds to the scenario that reasonably represents the civil aviation CO_2 emissions that would occur in the absence of action. This corresponds to the business as usual or do-nothing additional scenario. States will need to carefully consider how to define their baseline with regard to which elements are and are not included. For example, States may decide to exclude from their baseline any actions or measures already taken, but which will limit or reduce emissions in the future. Alternatively, they may wish to include such actions in the baseline, so that the baseline will be used to assess the impacts only of new, additional actions or measures. Whichever approach is chosen, it will be important that States make explicit the assumptions behind the baseline they establish. The time horizon of a baseline scenario is not limited to the present, and should correspond to the time horizon (to be) set for the goals.

The following section will describe the way a baseline is established, including air traffic and emissions projections over the time horizon considered.

The establishment of a baseline involves the following steps:

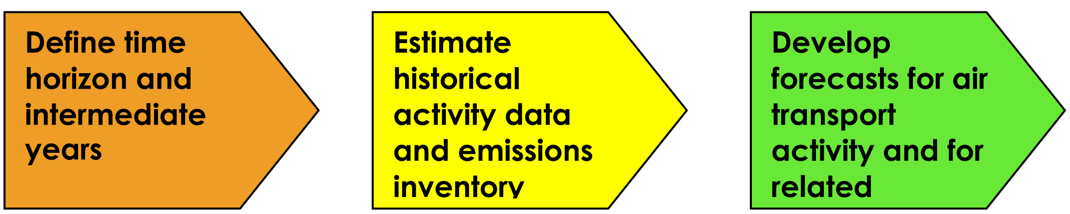

Figure 2. Steps for the baseline establishment

1. ***Time horizon and intermediate years selection***: These should include the time horizon and intermediate years set by ICAO for its goals (2020, 2050 at a minimum and any other years);
2. ***Estimate historical activity data and emissions inventory***: Historical air transport activity data are normally readily available within operators, airports and civil aviation authorities. Baseline emissions should be related to the air transport activity data and would be estimated according to the methodology, described in Part 2 of this guidance;
3. ***Develop forecasts for air transport activity and for related emissions in the baseline scenario****:* Forecasts for air transport activity may be readily available since many States develop such forecasts on a regular basis, while others may have prepared them for other planning purposes. Forecasting emissions may be done using techniques of various levels of complexity. Similar to the tiered approach to developing emissions inventories, as described by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (hereinafter referred to as the IPCC 2006 Guidelines), States have the option to select the technique that is most suitable to them.

Additional information and guidance on establishing baselines and expected results is contained in Appendix H.

Forecast of air transport activity

Air transport activity is typically measured in terms of RTK. Other measures can be used for various purposes. These include: revenue passenger kilometres, number of passengers, tonnes of cargo, departures, flight hours, etc.

ICAO's *Manual on Air Traffic Forecasting* (Doc 8991) provides guidance on air traffic forecasting techniques and includes some case studies.

Global and regional (Africa, Asia/Pacific, Europe, Middle East, North America, Latin America and Caribbean) long-term forecasts for passenger and freight traffic are prepared by ICAO on a regular basis. The latest set of these forecasts are contained in Circular 313, *Outlook for Air Transport to the Year 2025.*

More detailed long-term regional air traffic forecasts are also available: *Asia/Pacific Area Traffic Forecasts 2010-2030* (Doc 9961), *Africa-Indian Ocean Regional Traffic Forecasts 2008 – 2028* (Doc 9939) and *Caribbean/South American Regional Traffic Forecasts 2009 - 2030* (Doc 9940).

Emissions forecasts

Emissions are related to air traffic, but also depend on the fleet in service, on air carriers and airport operations, as well the provision of air navigation services. Consequently, forecasting emissions from civil aviation requires taking these factors into consideration.

The three tiers of methods for the estimation of emissions from civil aviation, described in the IPCC 2006 Guidelines, can be used to project emissions based on the available air traffic forecasts.

Review of the basket of measures, their feasibility and emissions reduction potential

Introduction

Assembly Resolution A37-19 states that for States that choose to prepare their action plans "the action plans should include information on the basket of measures considered by States, reflecting their respective national capacities and circumstances, and information on any specific assistance needs".

Various measures could be taken by States, air carriers, airports and air navigation service providers to reduce emissions from civil aviation. As noted in Assembly Resolution A37-19, the High-level Meeting on International Aviation and Climate Change in October 2009 (HLM-ENV/09) endorsed the Programme of Action on International Aviation and Climate Change, which included global aspirational goals in the form of fuel efficiency, a basket of measures and the means to measure progress.

The basket of measures was classified according to the following categories:

1) Aircraft-related technology development;
2) Alternative fuels;
3) Improved air traffic management and infrastructure use;

4) More efficient operations;
5) Economic / market-based measures; and
6) Regulatory measures / other.

Reference material that may be relevant to the implementation of these measures is provided in Appendix I and a list of examples of measures actually implemented is provided in Appendix J.

When considering the feasibility of measures, it is important to consider the practical implications of implementation, such as understanding the steps required, the resources needed, the timing of measures and the entity responsible for carrying out which tasks. States will need to understand how and when they could introduce different measures. For example, measures which require legislation may take longer, may need to be started sooner and are resourced differently from other measures which could be implemented immediately. These sorts of considerations could impact upon the choice of some measures over others and will help States to plan the implementation of the action plan.

In general, emission reduction/limitation measures can be classified into the following five categories:

1) Aircraft-related technology development

This category includes medium-term, long-term, and longer-term measures. Work under ICAO/CAEP is underway to develop a global CO_2 certification Standard for aircraft, aiming for its completion by 2013. Medium-term measures include retrofits and upgrade improvements on existing aircraft, optimizing improvements in aircraft produced in the near to mid-term.

Long-term measures include purchase of new aircraft, while longer-term measures include the adoption of revolutionary new designs in aircraft/engines and the setting of more ambitious Standards.

Most of these measures tend to have a significant emissions reduction potential. However, they are capital intensive and would take time to deliver benefits. Some of the measures such as the purchase of new aircraft cannot be justified on the sole grounds of environmental goals. It is assumed that the fleet plans of most States and/or operators are developed to address anticipated traffic growth and to replace ageing aircraft. Nevertheless, such measures may be made more feasible and attractive should funding and other assistance be made more accessible.

The feasibility analysis and estimation of emissions reduction potential of longer term measures can only be conducted by manufacturers, their respective States and ICAO. Despite the substantial amount of research and analysis requirements, the various stakeholders have gone through several similar exercises in the past. This type of analysis is normally conducted at a global and regional level, and the segmentation of its results to individual States would be a complex undertaking.

2) Alternative fuels

Unlike other measures, the use of alternative fuels does not require substantial investment by aircraft operators and may lead to significant emissions reductions if implemented. Substantial investments would still be required by producers and possibly distributors. As a result, States would be required to provide incentives and support to such initiatives. Benefits will depend on the timely availability of such fuels, their lifecycle emissions reduction and the time profile of their introduction. Guidance on the use of alternative fuels for civil aviation is available in ICAO's Global Framework for Alternative Aviation

Fuels (GFAAF), the International Air Transport Association's (IATA) 2010 *Report on Alternative Fuels*[4] and the Air Transport Action Group's (ATAG) *Beginner's Guide to Aviation Biofuels*[5]. Information regarding worldwide initiatives on the development and deployment of sustainable alternative fuels for aviation is also available through the GFAAF[6].

3) Improved air traffic management and infrastructure use

Two decades ago, ICAO adopted the strategy to improve the use of communication, navigation and surveillance/air traffic management (CNS/ATM) systems to globally address the limitations of air navigation systems. One of the main objectives of the adopted strategy was to improve the efficiency of air traffic management which would lead to reduction in fuel burn and emissions. Problems associated with the provision of air navigation services using conventional CNS systems relate, among other things, to airspace fragmentation and lack of homogeneity, inefficient routing and ATM planning leading to possible congestion with related fuel burn penalties.

In the process of developing their national and regional plans for the implementation of CNS/ATM systems, most States have conducted research, studies and analyses to select the system(s) components and to estimate the benefits stemming from implementation. Environmental benefits (including emissions reduction potential) may not have been included. In this case, a complementary analysis may be needed, which would cover the estimation of environmental benefits from more direct routing, reduced congestion, and improved response to airspace users' operational preferences. Such analysis would cover the impact of a more efficient air traffic management, ground operations, terminal operations (departure, approach and arrival), en-route operations, airspace design and usage, aircraft equipment and capabilities. Guidance on the assessment of these measures can be found in ICAO's *Air Traffic Services Planning Manual* (Doc 9426), *Manual on Airspace Planning Methodology for the Determination of Separation Minima* (Doc 9689), *Global Navigation Satellite System (GNSS) Manual* (Doc 9849), *Global Air Navigation Plan* (9750), *Performance Based Navigation Manual* (Doc 9613), *Global Air Traffic Management Operational Concept* (Doc 9854), *Manual on Global Performance of the Air Navigation System* (Doc 9883) and *Manual on Air Traffic Management System Requirements* (Doc 9882).

Airport infrastructure measures related to reducing aircraft emissions at airports include measures such as improving the efficient use and planning of airport capacities, the installation and use of terminal support facilities (such as Fixed Electrical Ground Power and Pre-conditioned Air) to reduce aircraft APU usage and the construction of additional taxiways and runways to provide direct terminal access and reduce congestion.

Measures taken to improve and modernize ground-service equipment, ground handling vehicles, airport fleet, vehicles, and public transport and ground access to airports will improve the associated aviation-related emissions. This should benefit a State's national GHG inventory for general activities, but these emissions are not the subject of States action plans and improvements in these emissions are not covered by ICAO's global goals for international aviation.

The feasibility and the emissions reduction potential of such measures may be assessed by airports with input from airlines regarding taxiing and APU usage. Guidance on the assessment of these measures is provided in ICAO's *Airport Planning Manual* (Doc 9184), *Aerodrome Design Manual* (Doc 9157),

[4] http://www.iata.org/ps/publications/Documents/IATA%202010%20Report%20on%20Alternative%20Fuels.pdf
[5] http://www.enviro.aero/Content/Upload/File/BeginnersGuide_Biofuels_WebRes.pdf
[6] www.icao.int/AltFuels

Airport Air Quality Guidance Manual (Doc 9889) and in the Airport Council International (ACI) *Guidance Manual on Airport Greenhouse Gas Emissions Management*[7].

It should be noted that the majority of these measures involve systems or equipment which are expected to be in service over the long-term and require substantial investment. While their emission reduction potential may be significant in many cases, their implementation cannot be justified solely on environmental grounds.

4) More efficient operations

Unlike the first three categories of measures, emissions reduction may be achieved in the short-term and with minimum investment through improved aircraft operations and management. Improvements can be introduced in pre-flight procedures (centre of gravity, take-off weight, flight planning, taxiing, APU) as well as in-flight procedures (take-off and climb), cruise, descent, holding and approach) and post-flight maintenance procedures (airframe and engine maintenance and aerodynamic deterioration).

Guidance is provided in ICAO's *Manual on Aircraft Operations* (Doc 8181), *Operational Opportunities to Minimise Fuel Use and Reduce Emissions* (Circular 303), Airbus' *Getting to Grips with Fuel Economy*[8] (and technical documentation and guidance) and Boeing's *Fuel Conservation Strategies* [9] (and technical documentation and guidance).

5) Economic / market-based measures

Economic and market-based measures are policy tools that are designed to achieve environmental goals at a lower cost and in a more flexible manner than traditional regulatory measures. ICAO has been developing policies and guidance material, as well as collecting information on various MBMs, including emissions trading, emission-related levies (charges and taxes), and emissions offsetting.

Emissions-trading (or "cap and trade") is a system whereby the total amount of CO_2 (or GHG) emissions from participants in the system is capped. Allowances, in the form of permits to emit CO_2, are allocated or auctioned to participants in the system. Participants are then free to buy and sell the allowances. At the end of each year, participants are required to surrender allowances to account for their actual emissions. Participants can emit more than their allocation by buying allowances from the market. Conversely, an installation that emits less than its allocation can sell its surplus allowances. The environmental outcome is not affected because the total amount of allowances allocated is set. This emissions trading between participants in the scheme enables a fixed environmental outcome (total emissions cannot go above the level of the cap) to be achieved at least cost, as those sectors where abatement opportunities are cheapest are incentivised to reduce emissions in order to sell their surplus allowances to other sectors where abatement is more costly, such as aviation.

To respond to the request from its 35th Assembly, ICAO developed the *Guidance on the Use of Emissions Trading for Aviation* (Doc 9885) by identifying options and recommendations on various elements of incorporating international aviation into an open emissions trading scheme. In addition, ICAO conducted a scoping study on issues related to *Linking Open Emissions Trading Systems Involving International Aviation*, and the study report was approved in 2010. It summarizes the benefits and risks of

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[7] http://www.airports.org/cda/aci_common/display/main/aci_content07_banners.jsp?zn=aci&cp=1-4612-4615%5E35476_725_2__

[8] http://www.aiaa.org/pdf/student/01_Airbus_Fuel_Economy_Material.pdf

[9] http://www.boeing.com/commercial/aeromagazine/articles/qtr_02_10/5 /

linking trading systems, and describes possible future options for linking trading systems involving international aviation.

Emissions-related levies generally refer to charges or taxes designed to address emissions from international aviation. Whilst they cannot guarantee a specific environmental outcome, they have potential advantages compared to other market-based measures, in terms of simplicity for administration, quickness for implementation, and low transaction costs. ICAO's *Policies on Charges for Airports and Air Navigation Services* (Doc 9082) make a conceptual distinction between a "charge" and a "tax", in that 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. The ICAO Council adopted a policy statement on 9 December 1996 in the form a resolution, wherein the Council strongly recommends that any emission-related levies be in the form of charges rather than taxes, and that the funds collected should be applied in the first instance to mitigating the environmental impact of aircraft engine emissions. In addition, the report of the Group on International Aviation and Climate Change (GIACC) noted some specific considerations regarding the application of taxes and "acknowledged that taxation of fuel raises policy and legal issues".

Emissions offsetting involves compensating for the emissions resulting from aviation operations with an equivalent amount of emissions reductions or uptake from specific mitigation projects. The accurate estimation of emissions from air-travel is essential to identify the amount of emissions to be offset. With a view to providing appropriate and harmonized information on CO_2 emissions from air-travel and thus avoiding the proliferation of various different methodologies, ICAO developed a globally accepted *Carbon Emissions Calculator*, which is available on the ICAO website (www.icao.int). ICAO also examined the potential for emissions offsetting for aviation, and the study report was approved in 2010. There is the possibility of using offsetting at a global sectoral level, either in a regulated emissions trading system or purchased using emission levies. These options offer some interesting possibilities for the future.

6) Regulatory measures / other

These measures include airport movement caps/slot management, requirements for the use of sustainable alternative fuels, and enhancing weather forecasting services, among others. Proper assessment would be needed to assess the feasibility and emission reduction potential of each measure.

Prioritization and selection of mitigation measures

Depending on the State, prioritization/ranking may or may not be a pre-requisite to the selection of measures. This may be an initial step in the decision process, the final outcome of which may depend on other considerations.

Prioritization can be performed for individual measures[10], or for scenarios (a combination of two or more measures).

Prioritization of individual measures or scenarios is done by ranking them and establishing a priority list according to certain criteria such as their cost-effectiveness or cost-benefit ratios. Typically, this criteria

[10] See sample chart developed by ATAG/McKinsey for airlines in Appendix L.

or metric would be the average cost associated with the reduction of a unit of emissions (for example dollars per tonne of CO_2).

A cost-effectiveness or cost-benefit analysis may be performed prior to the prioritization exercise.

There are two possible approaches to select measures:

Progressive approach

Measures are ranked individually and added progressively to achieve the goal(s):

1) Prioritize individual measures;
2) Start with the measure having the highest priority (more cost-effective, for example);
3) Assess whether the goal would be achieved, if yes go to 5;
4) Add the next measure on the priority list and go back to 3; and
5) Prepare a summary of all measures retained, their emission reduction potential and their costs.

Scenario approach

Measures are combined in scenarios and ranked in combination:

1) Define scenarios by combining two or more measures;
2) Prioritize scenarios;
3) Prepare a comparison table of all scenarios that achieve the goal(s), summarizing their costs and benefits and impact on stakeholders;
4) Rank the various scenarios according to certain criteria; and
5) Select the best scenario.

Figure 3 summarizes the process of review, assessment and selection of measures.

Figure 3. Baseline establishment, review, assessment and selection of measures

Expected results and metrics

Expected results represent the projected fuel consumption and CO_2 emissions (i.e. after implementation of mitigation actions) that the State envisages to reach. It may be provided in terms of annual emissions (or emissions reductions) or in terms of a metric.

The metric can be expressed in terms of per cent change reduction in emissions or in relation to an activity (such as air traffic). Results expressed in absolute terms may take one of the following forms:

- The State or the organization (air carrier, airport, air navigation service provider) will achieve reductions of ---% in CO_2 emissions by year --- compared to year ---- levels, or the average annual reductions till ---- year will be ---% with a base year of ----;
- It could be a statement of zero growth in net emissions relative to a specified base year; and
- It could be a combination of 1) and 2) above.

Metrics expressed in relation to an activity usually take the shape of a ratio: emissions level divided by the corresponding activity level, or vice versa.

Implementation

The development and submission of an action plan is not the end-goal, but the beginning of a multi-year effort to reduce the impact of international aviation on the global climate, while ensuring that aviation continues to grow in a sustainable manner. After the action plan has been finalized, a State will need to set in motion a process to implement the relevant measures in the action plan.

Various stakeholders will be involved in, and actively contribute to, the implementation of the selected measures. Continuous consultation and coordination between the various stakeholders will be essential to the successful implementation of the action plan.

The table in Appendix N identifies some of the stakeholders that may be involved in each measure.

The State will need to monitor the implementation of all activities.

At the same time, States will need to continue to work through ICAO to ensure that the needs identified by States are met, in accordance with the practices and policies of the Organization, for the successful implementation of mitigation actions for which additional action at the international level would be necessary. Areas in which such assistance could be provided include gaining access to financial resources, building national capacities, receiving technological or technical assistance.

Part 4: Analysis methods and tools

Objective

The objective of this part is to provide States **that choose to prepare their action plans** with the necessary guidance on how to assess the economics of the various measures found to be feasible and for which an emissions reduction potential has been estimated. It also provides guidance on how to manage risks.

Economic and financial assessment

Several techniques may be used to assess the economics of emissions reduction measures which can be assessed individually or in combination (scenarios). The most widely used techniques are cost-benefit analysis and cost-effectiveness analysis. For a cost-benefit analysis, both costs and benefits are expressed in monetary values, while for a cost-effectiveness analysis, benefits do not need to be monetized.

This part presents the analytical methods, describes the evaluation techniques and recommends an evaluation process.

Analytical methods

Cost-benefit analysis

The prospective economic viability of a project (in this case, emission reduction measure or set of measures) depends on the extent to which the total benefit from the project exceeds its total cost.

A cost-benefit analysis is a logical and consistent conceptual framework for the evaluation of projects. It gives an indication of the total economic welfare effects of a project by comparing all costs and benefits. It requires that both the costs and the benefits be described in monetary terms.

There are two main approaches used for comparing costs and benefits: the Net Present Value approach and the Snapshot approach. Both approaches are described in detail in the following section.

Using the aggregate values for the costs and benefits provided by these techniques, the following two alternative measures of the over-all viability of the project can be calculated:

a) Benefit/cost ratio = $\dfrac{\text{benefit}}{\text{cost}}$

b) Net Present Value = benefit minus cost

If measure a) is greater than one, or if measure b) is greater than zero, the project is economically viable (given the assumptions embodied in determining the benefits and costs).

Cost-effectiveness analysis

Cost-effectiveness analysis is sometimes used to evaluate projects when it is not practical to translate the benefits of the project into monetary terms. Since costs cannot be directly compared with benefits on the basis of a common unit of account, the approach cannot indicate in clear quantitative terms whether the main objective of a project warrants the cost involved. Rather, it can be used to assist the decision-maker to choose among several alternative ways of achieving a broadly defined objective in a way which has the potential to minimize the costs and maximize the benefits. The costs of prospective investment projects are quantified in present value terms and the benefits are described as fully as possible. The projects are then assessed and compared in a judgmental fashion. An attempt should be made to estimate the principal impacts or benefits in physical units, even if it is not possible to assign monetary values on such measures. Cost-effectiveness ratios for each project can then be computed by dividing the present value of the costs of the investment, by the measure of its principal impact.

Least-cost approach

It is expected that the estimation of the monetary value of the future benefits from the implementation of emissions reduction measures will be more difficult than the estimation of costs. In some situations, it may be acceptable to avoid attempting to evaluate these benefits and to restrict the analysis to determining the costs of achieving the set goals. This approach is particularly relevant where the key issue is ranking options from among several competing solutions. The analysis will suggest the "least-cost" option for providing the required quality and range of services.

This method of analysis is a simplification of cost-effectiveness analysis. The purpose is to compare the costs associated with several alternative ways of achieving a specific objective. There is no attempt to quantify the benefits associated with the alternatives; the latter are assessed only on the basis of their costs (in present value terms), the lowest cost option being the preferred one. This approach is relevant whenever it can be reasonably assumed that the benefits of the options will be similar.

Evaluation techniques

Net present value technique

Net present value technique or life cycle methodology is a rigorous approach to developing a measure of the expected economic performance of a project. A net present value analysis focuses on the annual cash flows (monetary values) of costs and benefits related to the project. The net present value of a project is equal to the present value of its benefits net of (or minus) the present value of its costs. The present value of benefits (or costs) is the sum of the discounted cash flows of benefits (or costs) to the present (base year) at a given discount rate. An equivalent approach to determine the net present value of a project is to discount the yearly net benefit stream (benefit minus cost) to the present at the same discount rate. The costs and benefits in cash flow terms are unlikely to be distributed evenly over time. Often, there will be large capital expenditures in the early years of a new project followed by many years of benefits and possibly some additional costs associated with administration or operations.

As many projects to reduce aviation's climate change impact will occur over several years, comparisons are made on the basis of "present values". The present values (i.e. current year capitalized values) of each stream of cash flows associated with each cost or benefit item over the project lifetime can be determined by a process of discounting the future cash flows. Costs that occur in the future will not have the same value as those accruing today. This is because society is not indifferent to having a dollar today and a dollar at a future date. It displays a "time preference". Discounting future cash flows takes into account the time value of money. Discounting will be discussed in further detail in the next section. The present values of all these future costs and benefits can then be aggregated to form the project's net present value.

Sometimes, benefits cannot be expressed in monetary terms. The costs (measured in monetary units) can be capitalized and brought back to one base year, but discounting physical units is not so obvious and has to be substantiated. Discounting is particularly needed when the measures to be compared have different implementation time profiles.

Snapshot approach

Other approaches are available for determining the measure of economic viability. One such approach, called the “snapshot” approach, is based on accrual accounting concepts. It involves choosing a future year, for example, the year by which the stated environmental goal would be achieved, and then comparing benefits to the costs exclusively in that year. The choice of the future year is critical and has to be made carefully. In a way, the snapshot approach is the reverse of the net present value method. Instead of capitalizing (as present values) the projected cash flows, the upstream investment costs are transformed into a time stream of equal yearly costs (annualized). These costs together with the yearly variable costs are compared with the benefits, usually for the designated future year. The annualized investment cost is the annual payment on the loan. Several alternative option cases can be compared for the same designated future year, which allows the analyst to carry out comparative evaluations of the options on a completely consistent basis. The snapshot approach can be repeated for different future years for each of the options being studied, which would in effect provide the analyst with a time-series of results.

Evaluation process

An economic evaluation of policy measures or projects measures may involve several steps. The typical steps are described in Figure 4:

Figure 4. Steps of the economic evaluation process

Choosing an evaluation procedure, evaluation methods and tools

Before an economic analysis can begin, the analysis method and the evaluation technique to be employed in the analysis should be identified. The section on analytical methods above provides information on the two most commonly used analysis methods: cost-benefit analysis and cost-effectiveness analysis. The preceding section describes the various evaluation techniques that an analyst might employ. To ensure comparability, the same procedure, methods and tools should be employed for all of the measures considered.

Identifying the baseline (base-case)
Guidance on the establishment of the baseline is provided in Part 3.

Identifying the emissions reduction measures that will be considered

Depending on the assessment of emissions reduction potential of available measures performed, according to the guidance provided in Part 3, it is possible to select one or more measures for the analysis.

Determining and using key assumptions

A number of assumptions need to be made throughout the economic analysis process because the analysis will be made over a certain number of years in the future. In undertaking economic analysis, it is important to define clear and realistic assumptions. In addition, the assumptions that are used should be well-documented with supporting data.

With the exception of any assumptions which are specific to a particular emissions reduction measure and which should be explicitly noted in the analysis, the assumptions for the analysis undertaken for each measure should be the same.

Identifying, quantifying and evaluating the costs and benefits of alternative scenarios relative to the base-case

Appendix O includes an attempt to identify the benefits, co-benefits and costs of the various measures available.

Risk management

The implementation of any set of emissions reduction measures may entail various risks of a technical, operational, managerial, financial or political nature. It is advisable that these risks be determined and managed.

The objective of risk management is not to eliminate risks, but to identify and evaluate them in a comprehensive and consistent manner. This will improve the awareness of decision- makers of such risks and help them reduce their effects.

In this section, guidance will be given to States on how to identify risks, how to analyze them and how to mitigate their impact.

Risk management encompasses risk analysis, risk evaluation and the development of mitigation plans. Risk analysis includes risk identification, estimation of the probability of occurrence, and the estimation of the potential impact. Risk evaluation aims at ranking risks according to their potential impact and the likelihood of their occurrence. The development of risk mitigation plans also includes the determination of the potential causes.

Risk analysis

Risk identification

The identification and description of risks constitutes the basis of risk management. The identification of risks is based on the definition of specific goals, requirements or specifications associated with the mitigation measure(s) under study and relating to technical, operational, managerial, financial or political aspects. In a perfect environment, one would expect these goals, requirements or specifications to be fully achieved or met. However, in the real world, several factors might cause a deviation from the expected outcome. In order to identify risks, the analyst should examine the goals, requirements and specifications one by one and identify the possible factors that might affect their realization. This is mainly a judgmental process.

Technical risks

Technical risks include the risks stemming from a possible mismatch between the technical specifications and the actual performance of the mitigation measure. Technical risks include also the implementation risks associated with the possible difficulties in implementing new technical systems.

Operational risks

These risks are related to the success of the implementation of new operational measures and maintenance of new technical systems. They may include integration risks, maintainability risks, safety risks, human factors' risks, etc.

Political risks

These risks are associated with Government policy and stakeholders' support.

Economic and financial risks

These risks are related to the uncertainty associated with the value of future benefits and costs. They may include benefit estimation risk, cost estimation risk, currency or exchange rate risk, funding risk, inflation risk, interest-rate or cost of capital risk.

Managerial risks

These risks address the likelihood of undesired events associated with managerial decisions such as the complexity to manage the implementation of the measure(s) and the risks of obtaining and using applicable resources and activities, and the schedule risk which considers the likelihood that the measure will be completed within the specified schedule.

Estimation of the probability of occurrence

To every identified risk, a probability of occurrence level has to be associated through a well-defined rating scheme. The choice of the rating scheme and the assignment of these levels should be performed in a consultative manner. One simple scheme could be to assign low, medium or high probability of occurrence to each risk. Another scheme could be to assign a number ranging between 0 and 5 or between 0 and 10 or any other agreed range. The following methods, among others, may be used in the estimation process:

- Expert interview;
- Analogy;
- Review of implementation plans; and
- Delphi technique.

Estimation of the potential impact

A measure or rating of the potential impact of each risk is required. This rating is performed in a similar manner to the rating of the probability of occurrence. One simple rating scheme could be to assign minor, moderate and substantial potential impact to each risk. Another scheme could be to assign a number ranging between 0 and 5 or between 0 and 10 or any other agreed range. The same methods described above could also be used in the estimation of the potential impact.

Risk evaluation

Assignment of a risk score to each risk factor

Each risk factor should be assigned a risk score. The score is a number which provides an idea about the severity of the risk. Typically, risk factors with high probability of occurrence and substantial potential impact would have the highest scores and conversely, risk factors with low probability of occurrence and minor potential impact would have the lowest scores.

Assignment of weights to each risk factor

In order to come up with a risk score for the implementation option concerned, it is necessary to recognize that all risk factors do not have the same importance. Each risk factor should therefore be assigned a weight. The total of all weights should be equal to 1 and weights should not change from an implementation option to another. Weights could also be assigned by risk category.

Determination of a risk score to each implementation option

The risk score of an implementation option is equal to the sum of the products of the risk score of each risk factor by the corresponding weight.

Ranking of implementation options by risk score

Risk analysis could form part of the selection procession or may only be performed for the selected implementation option. In the former case, the severity of risks associated with each option is taken into consideration in the selection process. The ranking of options by risk score would help the decision maker make an informed choice.

Risk mitigation

Identification of the potential causes of risks

Once the implementation option is selected and in order to develop risk mitigation plans, it is necessary to identify the potential causes of the risks involved in the selected option. The identification of potential causes of risks may be performed for all other alternative options, but such identification is not required since it is mainly needed in the development of the mitigation plan, which is prepared only for the selected option.

Development of mitigation plans

An appropriate mitigation plan has to be prepared for the selected implementation option, in order reduce the impact of the potential risks through the implementation of properly defined actions, if such risks materialize.

Part 5: Assistance needs

Paragraph 10 of Resolution A37-19 states that "the action plans should include information on the basket of measures considered by States, reflecting their respective national capacities and circumstances, and information on any specific assistance needs".

The voluntary preparation of States' action plans will assist States to identify their basket of measures to limit or reduce CO_2 emissions from international aviation, as well as specific assistance needs to implement such measures, including financing, technical assistance and training/capacity-building. In turn, it will allow ICAO to address States' specific needs, in terms of facilitating access to the required assistance.

Identification of assistance needs

The financial assessment of the action plan provides an excellent forecast of when funding will be required. Funding may come from internal or external sources. Funding for the required investment may come in various forms, such as accumulated profits, government contribution, commercial debt financing (including loans and leasing), bond issues and equity financing. External sources of financing for environmental initiatives and the mitigation of climate change actions exist, and are expanding.

The ICAO Environment Branch website on financing[11] provides some background information, a description of climate change financing mechanisms and financing mechanisms for aviation. Appendix P contains a list of climate funds that are accessible through www.climatefundsupdate.org and on the World Bank website, www.climatefinanceoptions.org .

During the ICAO Colloquium on Aviation and Climate Change in May 2010, the UNFCCC, World Bank (WB) and Inter-American Development Bank (IDB) presented information relevant to climate financing[12]. The ICAO Environmental Report 2010, Chapter 7 – Financing, also provides information related to climate financing mechanisms and opportunities for aviation.

[11] www.icao.int/icao/en/Env2010/ClimateChange/Finance.htm
[12] www.icao.int/CLQ10/

For example, the WB and the IDB have already started considering options relating to the funding of projects for the production of alternative fuels for aviation. The WB has various instruments (for example, Global Environment Facility, Climate Investment Funds – www.climateinvestmentfunds.org) that could be used to finance alternative fuels that are sustainable and which have a positive GHG reduction effect. The WB is examining sustainable alternative fuels and is working towards defining an appropriate strategy and policy framework for financing their deployment in developing countries.

The IDB, as one of the oldest regional development banks, is active in the area of providing funding (loans, guarantees, grants) to Central and South American States. The Sustainable Energy and Climate Change Unit (INE/ECC), was formed in 2009 to help provide sustainability options in areas related to the energy, transportation, water and environmental sectors as well as building climate resilience in key priority areas vulnerable to the impacts of climate change. The IDB recognizes the relevance of developing alternative fuels for the aviation sector, and as a part of its new Climate Change Strategy, has identified sustainable biofuels as a priority. Given previous work supporting the development of sustainability standards and financing within the traditional biofuels sector, there may also be opportunities for the IDB to support the emerging aviation biofuels sector.

In order to successfully implement the selected measures, States may identify additional assistance needs, such as technical assistance, training and capacity-building. Early identification and communication of such assistance needs would help ICAO to consider the development of processes and mechanisms to address them.

Appendix A

Template for States' Action Plans on CO_2 Emissions Reduction Activities

This template has been developed to assist States intending to prepare and submit an Action Plan outlining their policies and actions for addressing CO_2 emissions from international aviation, to ICAO. An action plan is a tool that a State can use to showcase and communicate, both at the national and international level, its efforts to address GHG emissions from international aviation.

In many respects, the development of an action plan resembles the execution of any project, involving activities such as securing resources, assembling a team, planning, and implementing various tasks. The structure of the action plan is intentionally simple in order to facilitate a straightforward communication of the actions that a State intends to take and their expected results.

This template is generic and can be used for all types of action plans, ranging from simple compilations of data, to elaborate reports. The level of information presented should be sufficient to clearly demonstrate the effectiveness of the actions implemented by a State and for ICAO to determine the anticipated global benefits from these actions.

This template is divided into 3 sections:

- Section 1 – Background information and contacts
- Section 2 – Baseline and expected results
- Section 3 – Mitigation measures

Please note that in the References Part of the guidance, there is a list of all available documentation to help States develop their action plan.

Please note that ICAO has developed a web interface to simplify the action plan submission to ICAO, and can be accessed at https://portal.icao.int/APER (this is the preferred method for submitting an action plan). Instructions for accessing the web interface are presented in Part 1, "Contents of an Action Plan", paragraphs 7 and 8.

Alternatively, if you are unable to access the portal, you may fill out the template in hard copy.

Once you have completed the template with all your measures, you can submit it to ICAO via email at actionplan@icao.int, or by mail, by sending the completed template to the following address:

Environment Branch Air Transport Bureau
International Civil Aviation Organization
999 University Street
Montréal, Québec
H3C 5H7
Canada

ICAO assistance is also available at actionplan@icao.int, or through the ICAO Regional Office to which your State is accredited.

Section 1 - Contact and background information

Please refer to **Part 1, Introduction to Action Plans,** of the guidance document.

1.1 Contact Information

Please provide below the contact information for the focal points within your State for your action plan. Please note that the first point of contact entered should be the individual responsible for submitting the action plan to ICAO.

Name of the Authority ……………………………………………………………………………..
Point of Contact ……………………………………………………………………………………
Street Address ……………………………………………………………………………………..
Country ………………………………………………………………………………………
State/Province ………………………………………………………………………………
City ……………………………………………………………………………………………
Telephone Number ………………………………………………………………………………..
Fax Number ……………………………………………………………………………………
E-mail address …………………………………………………………………………………….

***Please note that you can provide as many contacts as necessary and one individual per mitigation measure is encouraged.**

1.2 Current state of aviation within the State

Please provide any information related to the current state of aviation in your State that you wish to highlight. The objective is to provide a general introduction to the role of international aviation in your State.

Please note that you can attach any supporting documents in this regard to your action plan.

Section 2 - Baseline and expected results

The objective of this section is to provide States with the necessary guidance on how to select measures to limit or reduce CO_2 emissions from international aviation. It includes sections on baseline establishment, feasibility and emissions reduction potential of measures, prioritization and selection of measures, expected results, metrics and implementation.

Please see **Part 2, Estimation, Reporting and Verification of CO_2 Emission**s and **Part 3, Selection of Measures,** of the guidance.

Instructions:

Please describe here the estimated baseline of fuel consumption and CO_2 emissions for international aviation within your State.

Then, enter the expected results table the projected fuel consumption and CO_2 emissions (i.e. after implementation of mitigation actions) that your State envisages to reach.

Please note that this year-by-year description of the projected RTK, fuel consumption, and CO_2 emissions can be done consecutively or periodically.

2.1 **Baseline**

YEAR	TOTAL FUEL (litres)	INTERNATIONAL FUEL (litres)	TOTAL CO_2 EMISSIONS (kg)	INTERNATIONAL CO_2 EMISSIONS (kg)

2.2 **Expected Results**

YEAR*	TOTAL RTK	INTERNATIONAL RTK *	TOTAL FUEL (litres)	INTERNATIONAL FUEL (litres)*	TOTAL CO_2 EMISSIONS (kg)	INTERNATIONAL CO_2 EMISSIONS (kg)*

* minimum data to be entered

2.3 **Metric used to measure progress**

There are two metrics related to ICAO's global aspiration goals, as stated in Assembly Resolution A37-19: "volume of fuel used per revenue tonne kilometres"; and "net CO_2 emissions".

Please describe the metric that will be used to measure progress towards the expected results:

- Volume of fuel used per revenue tonne kilometres (RTK)
- Net CO_2 emissions

- Specify your own

2.4 Supporting Documents

In order to compute how your action plan will contribute toward the achievement of the global goals established by Resolution A37-19, please describe in this section the process used to develop the baseline and target, such as methodology, activity data, emission factors, and assumptions (brief explanation of data sources and rationale for their selection), quality analysis/quality control procedures and how they have been implemented, and verification procedures for the reported data.

Point of contact for Section 2:

Section 3 - Measures to mitigate CO_2 emissions

Assembly Resolution A37-19 states that for States that choose to prepare their action plans "the action plans should include information on the basket of measures considered by States, reflecting their respective national capacities and circumstances, and information on any specific assistance needs".

Various measures could be taken by States, air carriers, airports and air navigation service providers to reduce emissions from civil aviation.

Different categories constituting the basket of measures were identified and endorsed by the High-Level Meeting on International Aviation and Climate Change:

1) Aircraft-related technology development;
2) Alternative fuels;
3) Improved air traffic management and infrastructure use;
4) More efficient operations;
5) Economic / market-based measures; and
6) Regulatory measures / other.

Please refer to **Part 3, Selection of Measures**, **Appendix I, Reference Material for the Implementation of Mitigation Measures, and References** section of the guidance for material that may be relevant to the implementation of these measures and **Appendix J, List of Examples of Measures Implemented or Planned** for a list of examples of measures already implemented.

Instructions:

Please enter below the measure to mitigate CO_2 emissions to select from among the basket of measures for inclusion in your action plan. For each action identified, you will be asked to provide information regarding its schedule for implementation and its associated incremental improvements / benefits.

For each new measure:

Start by entering the name of the measure as it is known in your State (Title) and provide a brief description. Then, identify the type of measure by first selecting the category of the measure, then the type and sub-type. Please describe the process used for selecting the mitigation actions in the supporting documents area.

Please note that for each action, the following information (if applicable and available) can be provided:

- Description of the action and indication of its type (e.g., operational, technological, market-based etc.)
- Time horizon (start date and date of full implementation)
- Anticipated change in fuel consumption and/or CO_2 emissions
- Economic cost and how it will be covered (e.g., domestic sources, regional funding, international assistance etc.)
- Expected co-benefits (mainly for domestic aviation, but others could also be reported, if appropriate)
- Identification of any barriers to implementation and assistance needed
- Reference to any relevant legislation

3.1 Description

Title	
Description	
Category	
Measure	
Action	
Start date	
Date of full implementation	
Economic cost	
Currency	
Reference to existing legislation	
If a new legislation is proposed	
Compliance to the legislation Voluntary Mandatory N/A	
Assistance needed	
Assistance needed (you can select more than one) ○ Finance ○ Technology ○ Technical support ○ Education ○ Research ○ Other	
Currency for financial assistance	
List of stakeholders involved	

3.2 Incremental improvements / benefits for each measure

Please inscribe below the anticipated improvements/benefits associated with this specific measure. A measure can have several anticipated improvements for different years.

YEAR			
Improvement in Total Fuels (Litres)			
Improvement in Total Fuels (%)			
Improvement in International Fuels (Litres)			
Improvement in International Fuels (%)			
Improvement in Total CO_2 Emissions (kg)			
Improvement in Total CO_2 Emissions (%)			
Improvement in International CO_2 Emissions (kg)			
Improvement in International CO_2 Emissions (%)			
Anticipated co-benefits			

3.3 **Additional information**

3.4 **Point of contact for this measure:**

— END OF ACTION PLAN —

Appendix B

Templates and Examples

The following templates present a step-by step guide and set of examples to assist States in the preparation of the action plan.

These templates and examples are also available on the ICAO APER website at: https://portal.icao.int/APER/Documents/Templates%20and%20Examples.xls

For more information, please see Appendix H.

Appendix C

Basket of measures to limit or reduce CO_2 emissions from international civil aviation

1) Aircraft-related Technology Development
    a. Aircraft minimum fuel efficiency standards
    b. Aggressive aircraft fuel efficiency standards, setting standards for the future
    c. Purchase of new aircraft
    d. Retrofitting and upgrade improvements on existing aircraft
    e. Optimizing improvements in aircraft produced in the near to mid-term
    f. Avionics
    g. Adoption of revolutionary new designs in aircraft/engines

2) Alternative Fuels
    a. Development of biofuels
    b. Development of other fuels with lower lifecycle CO_2 emissions
    c. Standards/requirements for alternative fuel use

3) Improved Air Traffic Management and Infrastructure Use
    a. More efficient ATM planning, ground operations, terminal operations (departure, approach and arrivals), en-route operations, airspace design and usage, aircraft capabilities
    b. More efficient use and planning of airport capacities
    c. Installation of airport infrastructure such as Fixed Electrical Ground Power and Pre-Conditioned Air to allow aircraft APU switch-off
    d. Construction of additional runways and taxiways if used solely to relieve traffic congestion
    e. Collaborative research endeavours

4) More efficient operations
    a. Best practices in operations
    b. Optimized aircraft maintenance (including jet engine cleaning/washing)
    c. Selecting aircraft best suited to mission

5) Economic / market-based measures
    a. Voluntary inclusion of aviation sector in emissions trading scheme
    b. Incorporation of emissions from international aviation into regional or national emissions trading schemes, in accordance with relevant international instruments
    c. Establishment of a multilateral emissions trading scheme for aviation which allows trading permits with other sectors, in accordance with relevant international instruments
    d. Establishment of a framework for linking existing emissions trading schemes and providing for their extension to international aviation, in accordance with relevant international instruments
    e. Emissions charges or modulation of landing/take-off (LTO) charges, in accordance with relevant international instruments
    f. Positive economic stimulation by regulator: research programs, special consideration and government programs/legislation and accelerated depreciation of aircraft
    g. Accredited offset schemes

h. Explore extension of CDM
i. Taxation of aviation fuel, in accordance with relevant international instruments

6) Regulatory measures / Other
   a. Airport movement caps / slot management
   b. Enhancing weather forecasting services
   c. Requiring transparent carbon reporting
   d. Conferences / workshops

Appendix D

Administrative and organizational arrangements

The preparation of an action plan is likely to require a variety of skills and competencies to carry out a range of activities through the involvement of relevant stakeholders. In some instances, this could be achieved by establishing a State team. Most States have already employed such a State team approach for the preparation of other national reports in the context of various multilateral agreements under the UN (for example, national communications under the UNFCCC, national reports in the context of Agenda 21, ICAO reporting forms).

One of the key prerequisites for such an approach is the development of clear roles and responsibilities relating to all aspects of an action plan. The success of the approach depends on its implementation process. One of the principal stakeholders at the national level would be an executing body with the overall responsibility (often as mandated by national legislation) to deal with, and coordinate actions on, international aviation and climate change in the State. Examples include, but are not limited to: national authorities (such as the Civil Aviation Authority); departments or ministries (such as the Transport or Environment Ministry); and specialized national agencies. It is important that the appropriate executing body be identified at an early stage of the process, as it will make it easier for the personnel to be appointed and for specific roles and responsibilities to be allocated.

In order to maximize efficiencies and ensure that all relevant stakeholders are involved, it may be necessary to establish small working groups on particular technical issues. The form and working methods of such teams would be decided on a case-by-case basis taking into account the specific needs of a State. Such teams may comprise experts drawn, as appropriate, from the public and private sectors, professional associations, local communities and authorities, and NGOs. Although the number of teams depends on national conditions, two that can be readily identified are:

- A group on GHG inventory matters that would undertake all activities relating to the estimation of CO_2 emissions, including the collection of activity data and identification of appropriate emission factors; and
- A group on mitigation activities that would be responsible for collecting information relating to programmes containing measures to mitigate GHG emissions from international aviation.

An indicative list of responsibilities for these two groups is presented in Table 2.

In cases where expertise in specific areas of an action plan is missing or lacking, capacity building and training should be arranged prior to initiating any tasks or activities. This would ensure that all experts have the necessary know-how to carry out their respective tasks in an efficient and timely manner. States that have identified specific capacity building needs are encouraged to inform ICAO in order for the Organization to explore options for facilitating technical training, as appropriate. The focus of such training would be on the use of available resources (such as GHG inventory guidelines, mitigation models and tools) and would be conducted, preferably, at the national level.

Another equally important element is for all information generated or collected during the action plan process to be documented and archived for future use. Many States have well-established systems for the collection and processing of aviation-related information, and its submission to ICAO. Such systems involve database management processes for archiving data and other relevant information. Experience in the use of such systems would be valuable for the development and/or strengthening of procedures to archive, store and retrieve information required for action plans. Furthermore, having such systems in place would greatly facilitate regular future updates and periodic reporting.

Table 2. Indicative list of activities for different parts of an action plan

CO_2 emissions data	Mitigation activities
• Identification of input data, taking into consideration data gaps and areas for improvement; • Collection of available activity data to fill data gaps; • Identification and development of methods for overcoming inventory data gaps if there are no available data; • Identification of barriers to obtaining existing data and proposal of solutions; • Archiving relevant data; • Calculation of emissions for all relevant years; • Description of procedures and arrangements undertaken to collect and archive data for the preparation of CO_2 emissions, as well as efforts to make this a continuous process, including information on the role of the institutions involved; • Preparation of a report on the CO_2 emissions to be included in the action plan.	• Development of baseline and mitigation scenarios based on CO_2 emissions data and future development plans; • Liaison and consultation with stakeholders on relevant aspects such as technological solutions and financial aspects of mitigation; • Cost-benefit analysis of different mitigation options; • Assessment of technological needs for different mitigation options; • Identification, formulation and prioritization of programmes containing measures to mitigate GHG emissions from international aviation; • Assessment of institutional capacity-building requirements to sustain mitigation work and the related legal and institutional frameworks; • Preparation of a report on mitigation activities to be included in the action plan.

States are encouraged to incorporate information on a point or points of contact in their action plans. Such information would help ICAO clarify any issues that may arise during the compilation of the reported information.

Appendix E

National context

Through its action plan, a State has the opportunity to detail its national and, if relevant, regional development priorities and objectives that serve as the basis for addressing the impact of international aviation on climate change. Such information would provide the background to help the reader understand, *inter alia*, a given State's conditions, its national capacities, as well as the options available for addressing its CO_2 emissions from international aviation, within the broader context of sustainable development.

Providing information on their national context is optional and it is at the State's discretion to decide both the contents and details of this part of their action plans. The information that could be included in this regard may contain any of the following:

- Historical development of international aviation in the State;
- Structure of the aviation sector in the State;
- Specific geographical or other characteristics that influence the development of international aviation (e.g., a land-locked State may rely more on international aviation for the transport of goods and passengers in and out of its national borders);
- Population that is affected by international aviation and how (e.g., employment statistics related to the aviation sector in the State);
- Economic information related to the contribution of international aviation to the various sectors of the national economy (including, as appropriate, energy, transport, industry, mining, tourism, agriculture, fisheries, health and services sectors);
- Education, including scientific and technical research institutions focusing on aviation-related issues;
- Effects of past efforts to bring about changes in the international aviation sector of the State (e.g., past investments to improve the fuel efficiency of the fleet);
- Potential synergy between the activities and policies relating to international aviation and those relating to domestic aviation;
- Linkages with actions undertaken by the State in the context of other relevant multilateral agreements, such as the UNFCCC; and
- Any other information considered relevant by the State.

Information on socio-economic and environmental conditions of the State could be presented in summary tables, charts and maps to enhance the presentation of the communicated data.

Appendix F

General aspects of an inventory process

In general, a GHG inventory constitutes a systematic approach for the determination of GHG emissions and removals from all anthropogenic activities. In relation to action plans for international aviation, the scope of the work is limited to the estimation, verification and reporting of CO_2 emissions as a result of fuel used for international flights.

Despite the narrow focus, the inventory process to be put in place for the purposes of an action plan should ensure the precision and reliability of CO_2 estimates through, for example, the fulfilment of certain criteria. Internationally accepted criteria (applicable also to CO_2 emissions from international aviation) are laid out in the IPCC 2006 Guidelines. According to these guidelines, GHG inventories must be:

- *Transparent*: There is sufficient and clear documentation such that individuals or groups other than the inventory compilers can understand how the inventory was compiled and can assure themselves of the quality of the data;
- *Complete*: Estimates are reported for all relevant activities and gases. Where data are missing, their absence should be clearly documented;
- *Consistent*: Estimates for different inventory years, gases and categories are made in such a way that differences in the results between years and activities reflect real differences in emissions. Inventory annual trends, as far as possible, should be calculated using the same method and data sources in all years and should aim to reflect the real annual fluctuations in emissions and not be subject to changes resulting from methodological differences;
- *Comparable*: The GHG inventory is reported in a way that allows it to be compared with GHG inventories from other countries; and
- *Accurate*: The GHG inventory contains neither over nor underestimates, so far as can be judged. This requires undertaking all efforts to remove bias from the inventory estimates.

Compiling a GHG inventory

Compiling a GHG inventory is a step-by-step process that includes the collection of data, estimation of emissions, monitoring and verification, uncertainty assessment and finally, reporting[13]. These steps are briefly described below.

<u>Data collection</u>: Collection of data is a fundamental part of the inventory preparation that often involves the initiation and maintenance of a data collection program that covers the evaluation of existing sources of data and planning of new emission measurements and surveys, as well as the use of statistical information published by international organizations.

<u>Uncertainty assessment</u>: Estimates of uncertainty are needed for all relevant sources, greenhouse gases (CO_2 being the main GHG), inventory totals as a whole, and their trends.

<u>Time series consistency</u>: Ensuring the time series consistency of inventory estimates is essential for establishing confidence in reported inventory trends. Methods for ensuring time-series consistency in

[13] In general, a GHG inventory process would involve other steps, such as the identification of major sources of GHG emissions. Since this guide refers to one specific source (CO_2 emissions from international aviation), such general steps have been omitted.

cases where it is not possible to use the same method and/or data over the entire period should be considered. In addition, time series consistency should be considered when recalculating estimates for previous years.

Quality Analysis, Quality Control and Verification: A quality analysis/quality control system is an important part of the inventory development process and involves techniques for verifying inventory data using external data sources.

Figure 5 illustrates the key steps of a typical inventory cycle. Quality control measures should be implemented at each step and should be documented accordingly.

1) The inventory compiler should identify the appropriate method for estimation of CO_2 emissions given the particular national circumstances. The selection of methods will be determined by the availability of data and resources.
2) Data collection should follow the selection of the appropriate methods. Data collection activities should consider time series consistency and establish and maintain good verification, documentation and checking procedures (quality analysis/quality control to minimise errors and inconsistencies in the inventory estimates. Data on uncertainties should, if possible, be collected at the same time. Quality analysis/quality control activities should continue throughout this process to minimise errors and document data sources, methods and assumptions. The results of the data collection may lead to refinement of the methods chosen.
3) Emissions are estimated following the methodological choice and data collection. Care should be taken, especially if the data are incomplete for some years.
4) Once the inventory estimates are complete, the next step is to perform an uncertainty analysis to decide whether additional data should be collected.
5) Following the completion of the final quality analysis checks, the final step in the inventory process is to report the inventory.

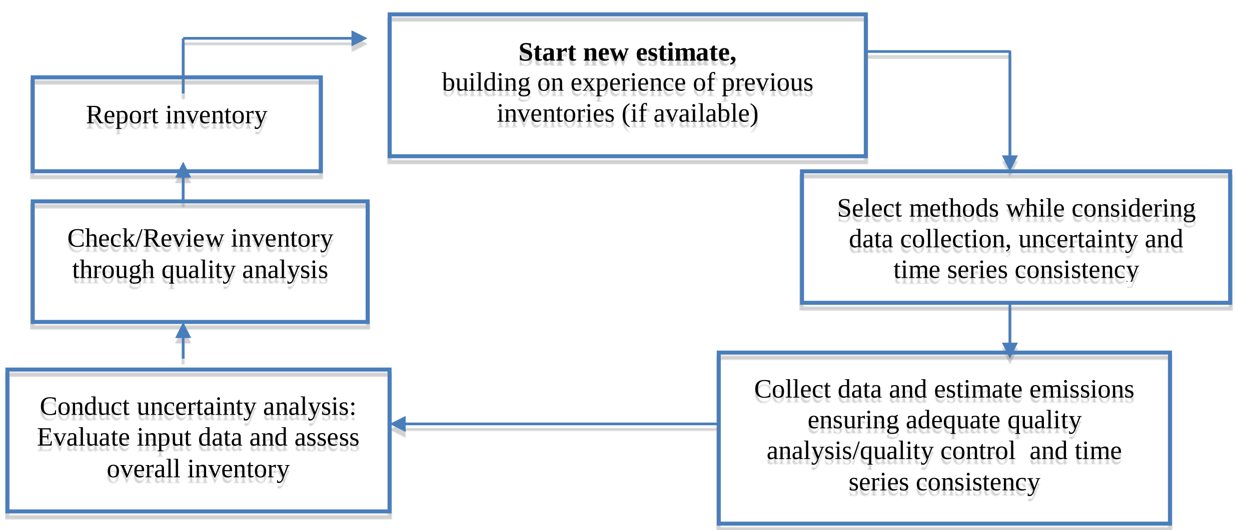


Figure 5. Schematic of the inventory process (adapted from the 2006 IPCC Guidelines)

Appendix G

IPCC methodologies for estimating GHG emissions from aviation

The 2006 IPCC guidelines provide three methodological tiers for estimating CO_2 emissions from international aviation. All tiers distinguish between domestic and international flights, which are defined using criteria (see table below) that apply irrespective of the nationality of the carrier.

The choice of methodology depends on the type of fuel, the data available, and the relative importance of aircraft emissions. All tiers can be used for operations using jet fuel, as relevant emission factors are available for this fuel type. The data requirements for the different tiers are summarized below:

- Tier 1 is based on an aggregate quantity of fuel consumption data (no distinction is made between LTOs and cruise phase) multiplied by average emission factor;
- Tier 2 is based on the number of LTOs and fuel use. Distinction is made between emissions generated during the LTO and cruise phases of flight. Default or nationally-specific emission factors for CO_2 could be used;
- Tier 3 methods are based on actual flight movement data, either: for Tier 3A origin and destination data or for Tier 3B full flight trajectory information.

The resource demand for the various tiers depends in part on the number of air traffic movements. Tier 1 should not be resource intensive. Tier 2, based on individual aircraft, and Tier 3A, based on origin and destination pairs, would use incrementally more resources. Tier 3B, which involves the use of sophisticated models, requires the most resources.

Emissions estimates for the cruise phase become more accurate when using Tier 3A methodology or Tier 3B models (such as the CAEP-approved models AEDT, AEM III, AERO2k, and FAST or other national models). Moreover because Tier 3 methods use flight movement data instead of fuel use, they provide a more accurate separation between domestic and international flights.

Criteria of IPCC for defining international and domestic aviation (apply to individual legs of journeys with more than one take-off and landing)

Journey type between two airports	Domestic	International
Departs and arrives in same State	Yes	No
Departs from one State and arrives in another	No	Yes

Source: 2006 IPCC Guidelines (http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf)

Appendix H

Baselines and expected results

In the context of action plans, a baseline, is defined as the level of fuel consumption, CO_2 emissions, and traffic (expressed in RTK) that can be expected across a time horizon (for example, 2020 or 2050) and that would occur in the absence of action. In contrast, expected results represent the projected fuel consumption and CO_2 emissions (i.e. after implementation of mitigation actions) that the State envisages to reach.

A baseline facilitates comparison against, and is indicative of, fuel efficiency improvements that happened in the past. In this regard, a baseline does not incorporate measures (including new technologies or alternative fuels), which a State expects will contribute to fuel efficiency rate improvements in the future and have not been considered in the past.

It is emphasized that States are not required to establish a baseline. This appendix provides information relating to how a State could develop a baseline if it decides that it would be an appropriate element of its action plan.

Note: As explained in Part 1 of this guide, States could periodically (for example every three years) review the action plans that have been reported to ICAO. As part of such a review, States could update the previously submitted baseline or base year estimates and the expected results and submit this updated information to ICAO.

General approach

The approach described here is based on the extrapolation of past trend data in order to determine future levels of fuel consumption and traffic. The main assumption made is that past (historic) data on both fuel consumption and traffic are available.

Historical annual fuel consumption and RTK data should, in general, be available in all States. This information could be either actual (for example collected from airlines and/or fuel providers) or modeled using CAEP-approved models or other national models developed by a State.

Note: If this information is not readily available, States could contact ICAO for assistance.

Box 4. Fuel efficiency metric

The approach is based on the use of the rate of efficiency improvement over time, which can be gauged using the following metric:

$$\text{Fuel efficiency} = \text{Volume of fuel/RTK} \quad (1)$$

This metric is an indicator of the efficiency of fuel usage (in liters) per tonne of revenue load carried (passengers, freight and mail).

Depending on the availability of historic data, the general approach can be implemented using two different methods:

- **Method 1**: State has access to data for a specific time period (typically 5-10 years, but longer periods would be desirable);
- **Method 2**: State has access to data for past two years.

If two or more years' worth of historic data are not available, a State can use an alternative method (referred to as **Method 3**), which is equivalent to a base year approach.

An indication of the data requirements for each method and potential sources of data are provided in Table 3.

Table 3. Data requirements for the three baseline methods and sources of data for the application of the baseline methods

Data type	**Data requirements for:**			**Source of data**	**ICAO role**
	Method 1	**Method 2**	**Method 3**		
Time series data fuel consumption	Yes	N/A	N/A	State – Either actual, or through tier models	Assist in Tier 3A updates
Current and one point in the past fuel consumption	N/A	Yes	N/A		
Only current fuel consumption	N/A	N/A	Yes		
Current activity data	Yes	Yes	Yes	State- Reported by State	Provide information based on the ICAO database
Historical activity data	Yes	Yes	N/A		
Forecast activity data	Yes	Yes	Yes	State - Planning authorities, other stakeholders	Forecasts methodology, regional forecasts, historical growth rates of RTK

Methods 1 and 2

The specific steps for developing a baseline using Methods 1 and 2 are as follows:

1. Obtain historical annual data for fuel consumption (volume of fuel) and traffic (RTK);
2. Divide the fuel consumption data by the traffic data to obtain the fuel efficiency metric (as per equation (1) in Box 4) for each past year;
3. Determine the past trend of the fuel efficiency metric;
4. Use the past trend as an approximation of future development of the fuel efficiency metric (in the absence of any additional mitigation measures);
5. Determine how the RTK will evolve in the future either by considering national forecasts (or projections) data or by using default regional growth rates (see for example Box 5);
6. Determine the forecasted (or projected) volume of fuel as follows:

$$\text{Volume of fuel} = \text{Fuel efficiency x RTK} \quad (2)$$

Note 1: Once the volume of fuel has been determined, CO_2 emissions can be estimated by converting the fuel data from volume to mass units as described in Part 2 and then multiplying with the default emission factor of 3.157 tCO_2/tfuel.

Note 2: While most changes in the actual development of fuel efficiency over time can be viewed against the efficiency measures taken by a State over time, if a State has more sophisticated techniques (including models) to relate fuel efficiency to other variables such as fleet age, investments etc., then such techniques and/or models should be applied.

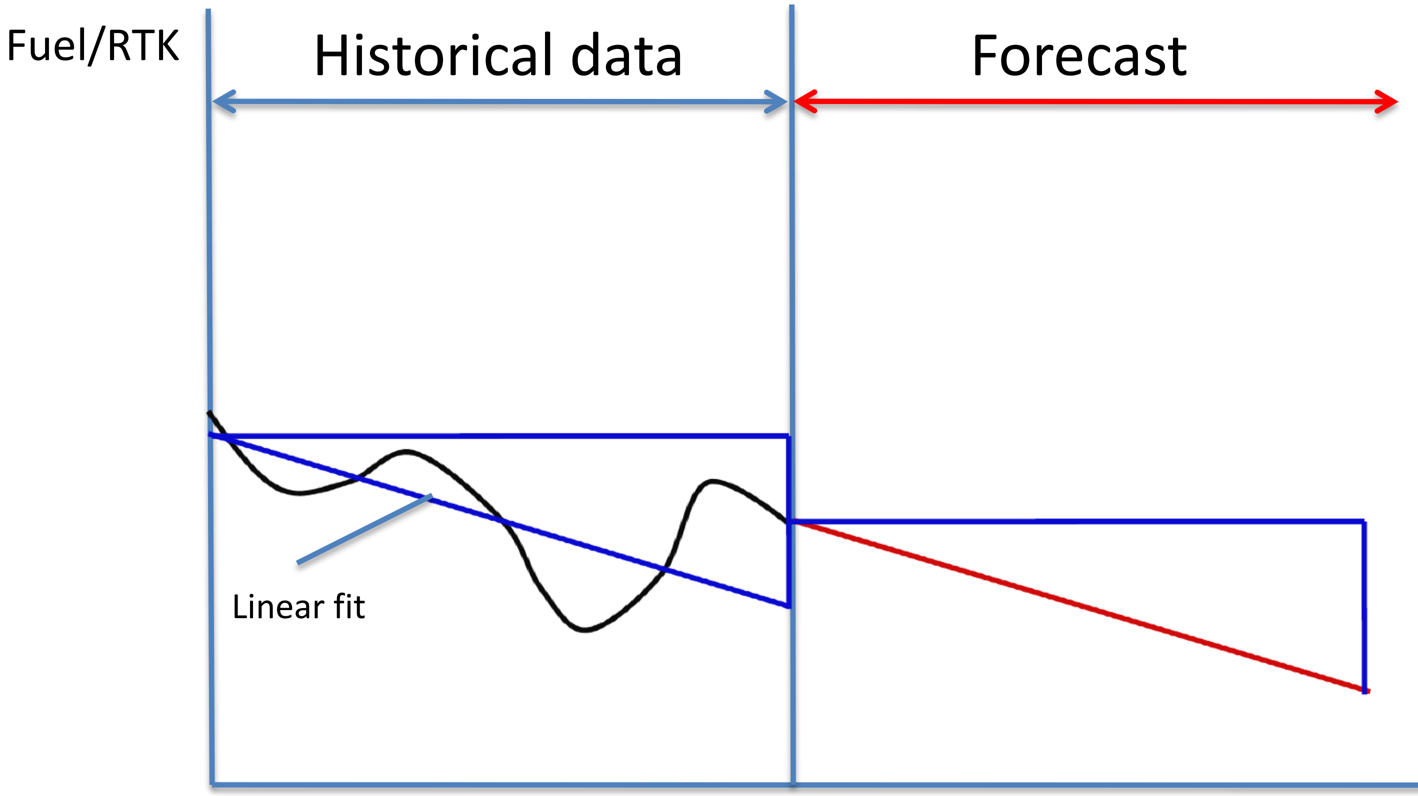
Box 5. Examples of default regional growth rates in international RTK

Region	Outlook to 2025
Africa	5.3%
Asia Pacific	7.1%
Europe	4.7%
Latin America and Caribbean	5.2%
Middle East	6.7%
North America	5.8%
World	6.0%

Source: ICAO Circular 313 – Outlook for Air Transport to the Year 2025

For step 3 above, establishing the trend of historical data would require:

- For **Method 1**, determining the best fit for all points in the time series available (see figure 6); and
- For **Method 2**, assuming a linear fit between the two points available (see figure 7).



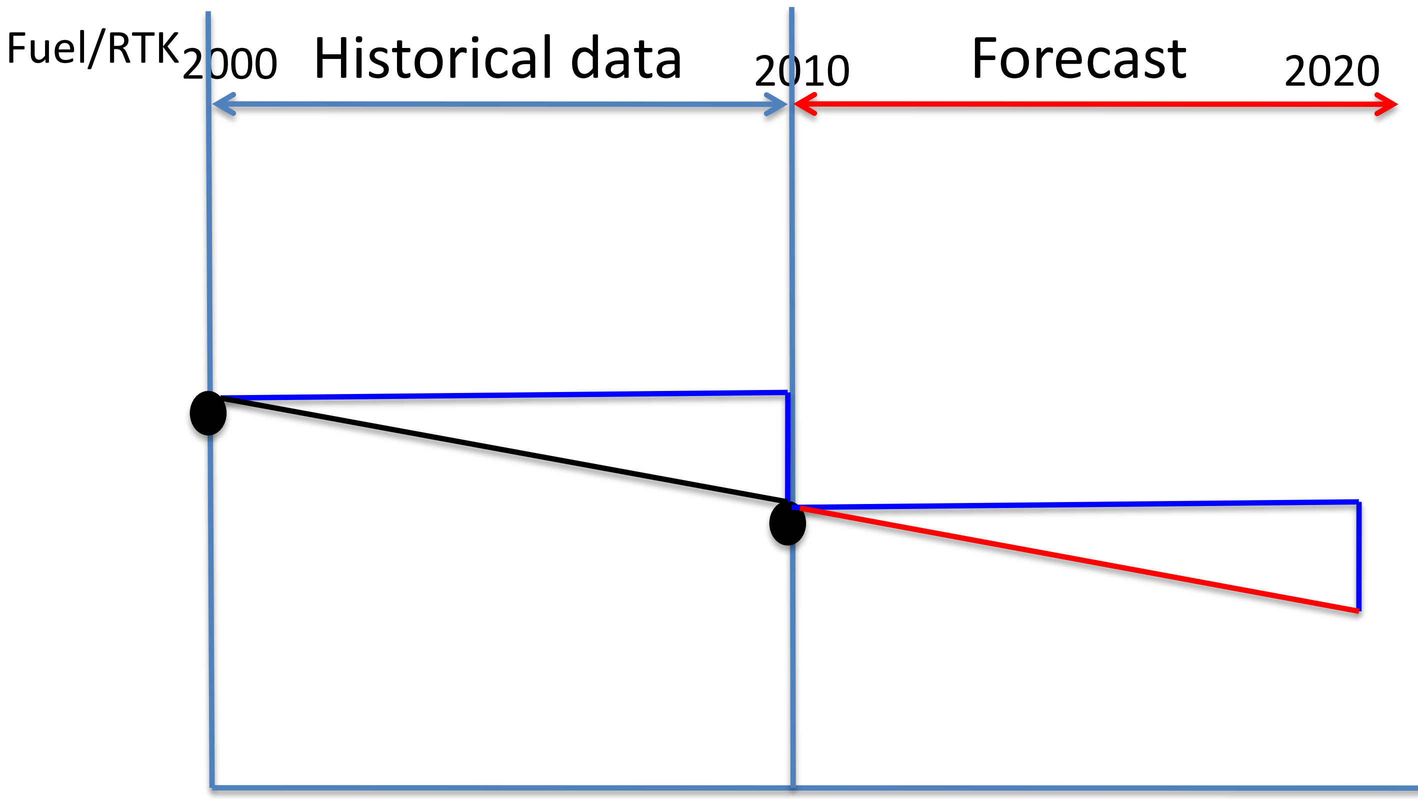


Figure 6 **Figure 7**

2000 2010 2020

Method 3

The specific steps for Method 3 are as follows:

1. Obtain data for fuel consumption (volume of fuel) and traffic (RTK) for the latest available year;
2. Determine how the RTK will evolve in the future by considering national forecasts (or projections) data or by using default regional growth rates (see for example Box 5);
3. Determine the forecasted (or projected) volume of fuel for the near future (typically 5 years* - but could be longer - after the base year) assuming the same growth rate as for the RTK as follows:

$$\text{Volume of fuel}_{\text{year } n+1} = \text{Volume of fuel}_{\text{year } n} \times (1 + \text{RTK growth}) \quad (2)$$

* For example if the State has data available for 2010, the near future projections could extend to the period 2011-2015.

Expected results

As mentioned in Parts 1 and 3 of this guide, a State could establish a consultative process with its key stakeholders to determine the efficiency improvements that can be expected in the future either from measures that are already in-place and are to be accelerated or new measures that could be implemented in the future. Such stakeholders may include, but are not limited to:

- Air carriers registered in the State;
- ANSP providers;
- Alternative fuel providers; and
- Regulators.

Note: For the case of biofuel, the baseline fuel consumption and the fuel efficiency metric will not change, but the CO_2 emissions will reflect the expected reductions.

Methods 1 and 2

Once a baseline has been established (using Methods 1 or 2) for fuel consumption, the impact of additional interventions is taken into consideration in order to determine the expected future fuel consumption as a result of mitigation measures.

The approach involves the subtraction of fuel savings due to improvements considered by the State. This is illustrated in Figure 8 (although shown for Method 1, the same approach is applicable to Method 2).

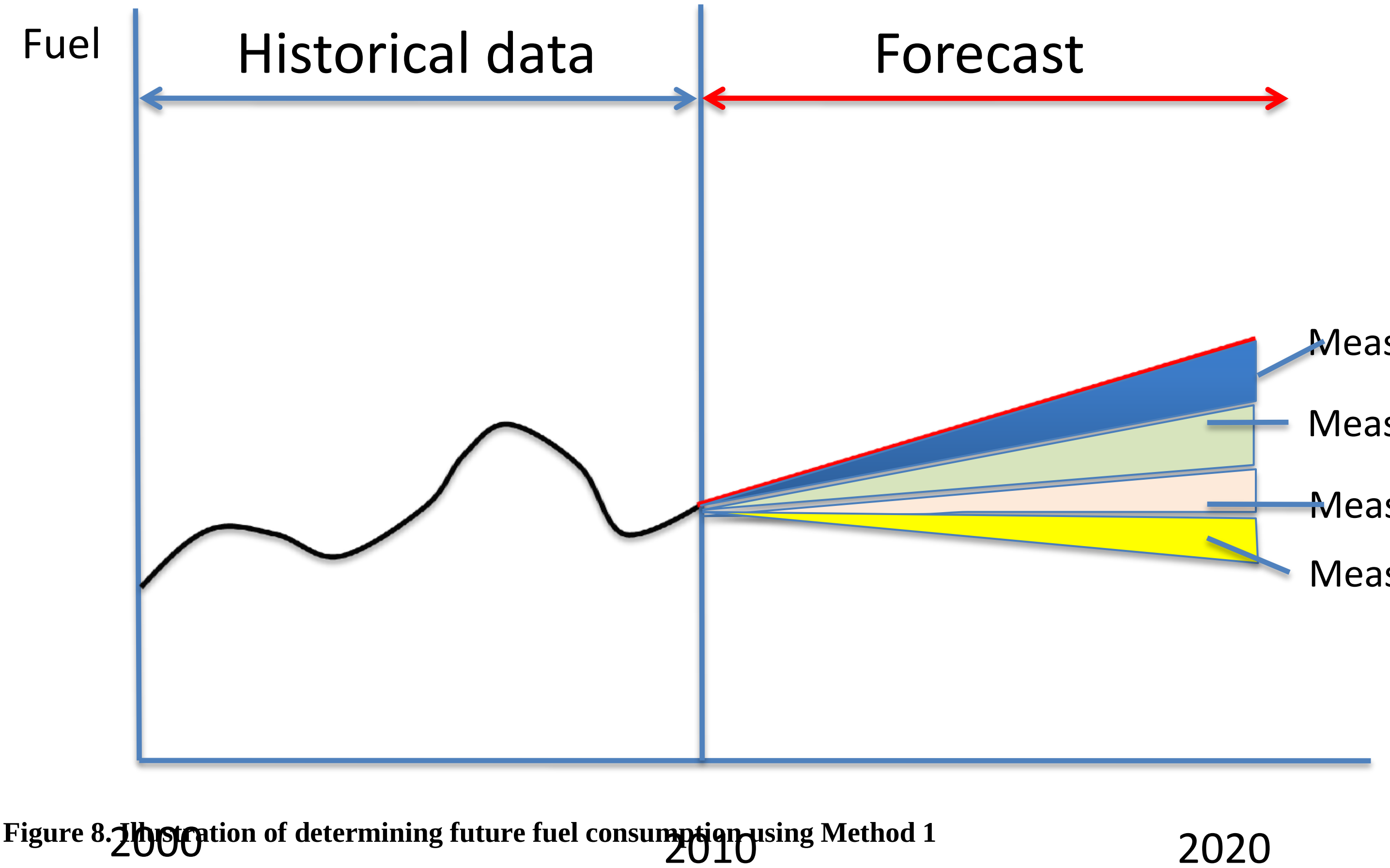


Figure 8. Illustration of determining future fuel consumption using Method 1

Method 3

For Method 3 the approach is slightly different. After the State has determined the near future anticipated fuel savings from the basket of measures considered, it subtracts these savings from the unabated projected fuel consumption (see Figure 9).

The trend of the 'after measures' fuel consumption is then used to extrapolate the fuel consumption for future years such as 2020 and beyond.

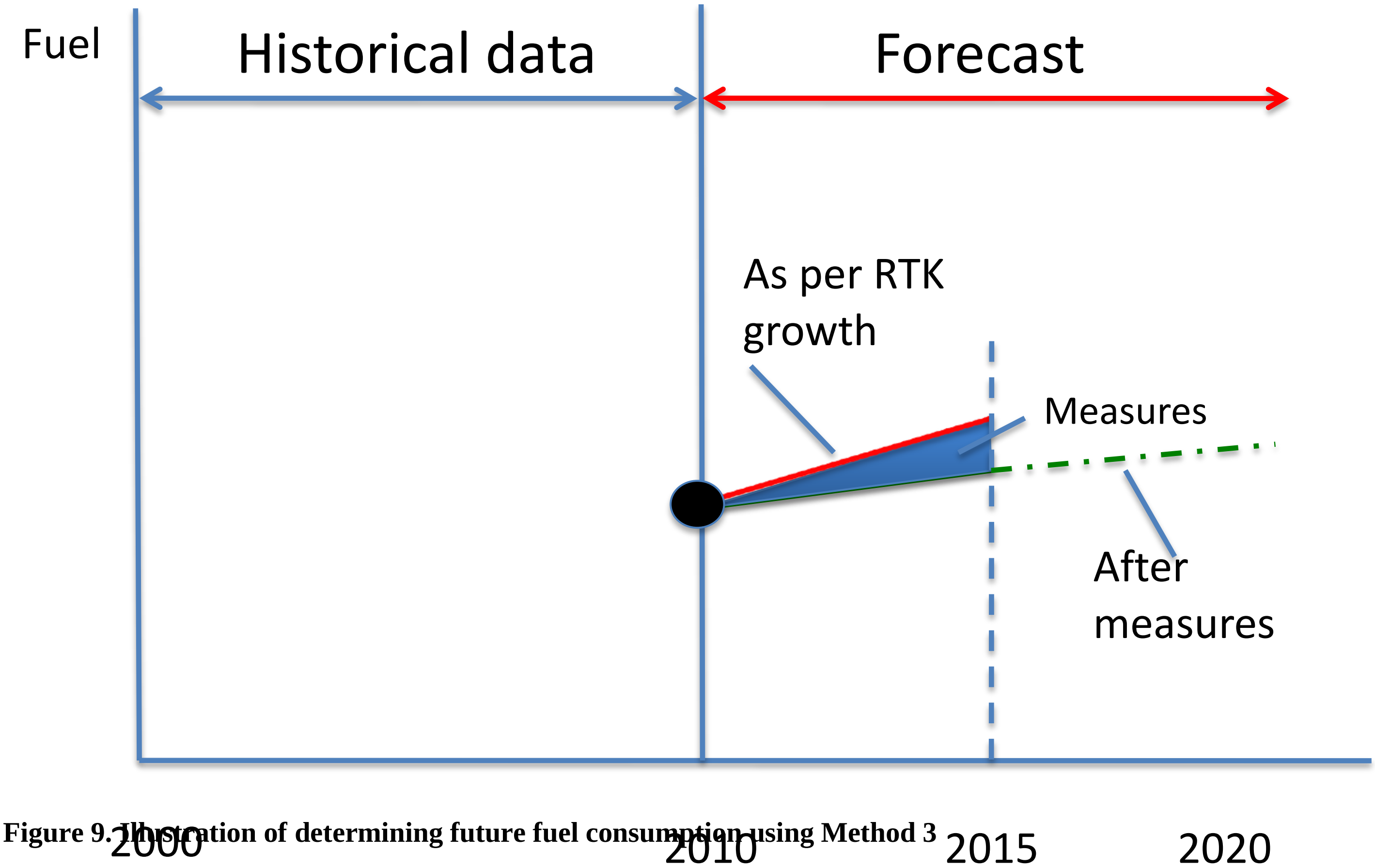


Figure 9. Illustration of determining future fuel consumption using Method 3

Examples

The examples presented below is for a fictional island State (ABC) where aviation plays a major role in its economy

Key assumptions:

- The State accounts for around 3 per cent of global international air traffic.
- The State has one international air carrier.
- Traffic expressed in terms of RTK is expected to average an annual growth of 3.5 per cent over 2010.
- The State expects to achieve an annual reduction of 2 per cent in Fuel Burn over RTK by 2020 and CNG from 2020.

Method 1

State ABC has access to fuel consumption and activity data for: 2000-2010 (see Table 4 below)

Table 4. Fuel consumption, RTK and fuel efficiency metric for the period 2000-2010

Year	Fuel Burn (Gl)	RTK (000)	FB/RTK
2000	3.69	12,879,797	0.286

2001	3.82	13,214,018	0.289
2002	3.87	13,988,573	0.276
2003	3.73	13,680,341	0.272
2004	4.14	15,461,181	0.268
2005	4.42	16,542,568	0.267
2006	4.54	17,315,792	0.262
2007	4.55	17,432,164	0.261
2008	4.53	17,525,512	0.258
2009	4.50	17,518,752	0.257
2010	4.60	18,067,089	0.256

The fuel efficiency metric exhibits a declining linear trend (see Figure 10). The model has a best fit with 91 per cent of the efficiency changes, explained by the capacity inductions and improvement measures implemented over the 2000 – 2010 period.

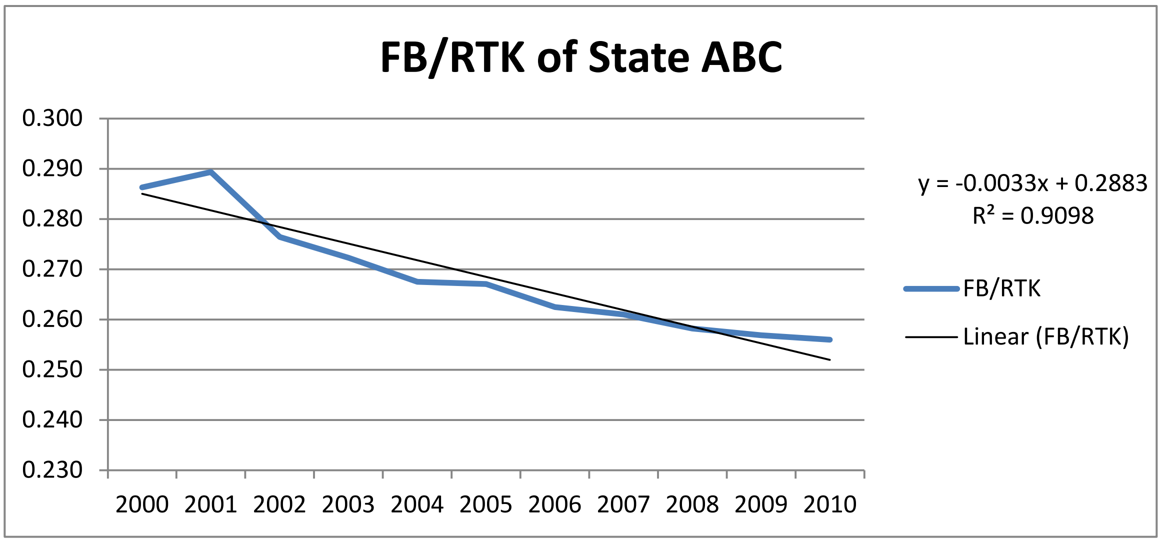


Figure 10. Fuel efficiency trends for Method 1

Although a linear fit is assumed for the example provided in Figure 10, other techniques and statistical methods with a higher level of complexity may be used by a State depending on the availability of resources.

Using State ABC's forecasts of 3.5 per cent RTK growth to 2025, the annual future RTK values are calculated as per Table 5 below.

Table 5. RTK forecast for 2011-2025

Year	Forecast RTK (000)
2010	18,067,089
2011	18,699,437
2012	19,353,917
2013	20,031,304
2014	20,732,400
2015	21,458,034
2016	22,290,065
2017	22,986,383

2018	23,790,906
2019	24,623,588
2020	25,485,413
2021	26,377,403
2022	27,300,612
2023	28,256,133
2024	29,245,098
2025	30,268,676

Using the past trend of fuel efficiency metric, the State can obtain future values by applying (for example) a linear extrapolation up to 2025. Using the projected data for the fuel efficiency metric and the RTK, fuel consumption can be estimated by using equation (2) above. Figure 11 illustrates the projected values for the baseline fuel consumption and fuel efficiency metric for the period 2010-2025.

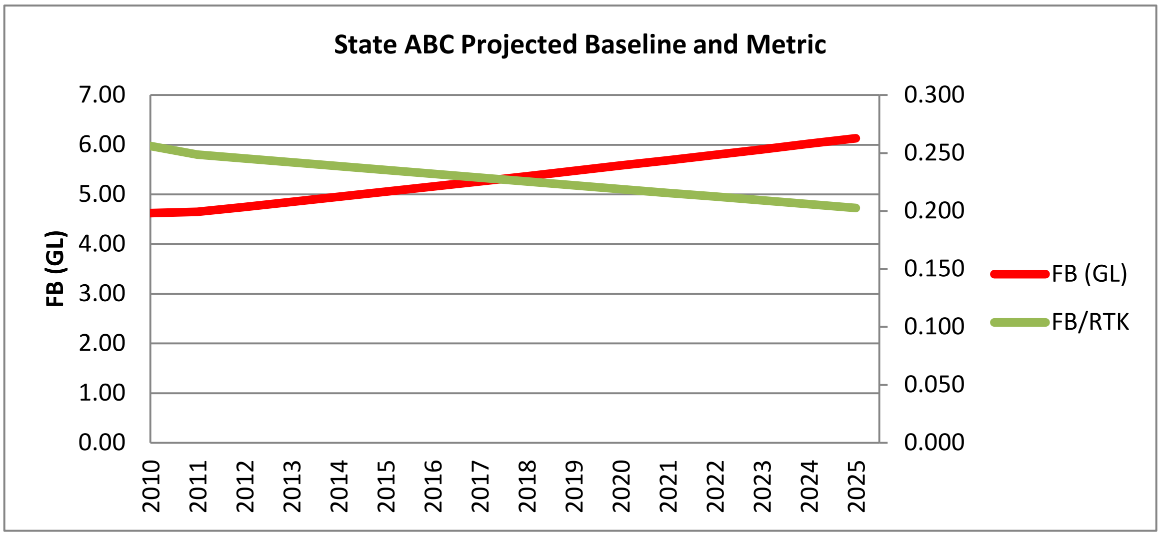


Figure 11. Projected fuel efficiency metric and fuel consumption

The expected results for Method 1 (see Table 6) are calculated as follows:

Expected Results = Baseline fuel consumption – Fuel gains due to additional measures

Table 6. Expected results using Method 1

Year	**Baseline**	**Fuel gains due to additional measures (Gl)**		**Expected results**
	Fuel (Gl)	**Accelerated Fleet Renewal**	**Efficient Operations**	**Fuel (Gl)**
	A	B	C	D=A-(B+C)
2011	4.65	0.03	0.01	4.61
2012	4.75	0.03	0.03	4.70
2013	4.85	0.05	0.04	4.76
2014	4.95	0.06	0.05	4.84
2015	5.05	0.20	0.06	4.79
2016	5.16	0.24	0.08	4.84
2017	5.26	0.24	0.09	4.94
2018	5.37	0.24	0.10	5.03

2019	5.47	0.24	0.11	5.12
2020	5.58	0.24	0.13	5.22
2025	6.13	0.24	0.14	5.75
2030	6.69	0.26	0.15	6.27

Method 2

The State arrives at the growth rate in the fuel efficiency metric (fuel consumption/RTK) using data for two years (2000 and 2010), as shown in the first two columns of Table 7.

Table 7. Fuel consumption, RTK and fuel efficiency metric for the years 2000, 2010, 2020 and 2025

Indicator	2000	2010	2020	2025
FB/RTK	0.286	0.256	0.229	0.216
RTK (000)	12,879,797	18,067,089	25,485,413	30,268,676
Fuel consumption (Gl)	3.68	4.63	5.83	6.55

Based on the values for 2000 and 2010, the growth rate of the fuel efficiency metric is: -1.112 per cent per year. Using this growth rate, fuel efficiency can be extrapolated to the future (e.g., 2020 and 2025). Similar to Method 1, RTK for future years is estimated by applying the annual growth rate of 3.5 per cent. Therefore, fuel consumption for 2020 and 2025 can be estimated by multiplying the efficiency metric with the forecasted RTK data (using equation (2) above). The results for 2020 and 2025 are given in the last two columns of Table 7.

The expected results for Method 2 (see Table 8) are calculated as follows:

Expected results = Baseline fuel consumption – Fuel gains due to additional measures

Table 8. Expected results using Method 2 for selected years

Year	Baseline	Fuel gains due to additional measures (Gl)		Expected results
	Fuel (Gl)	Accelerated Fleet Renewal	Efficient Operations	Fuel (Gl)
	A	B	C	D=A-(B+C)
2011	4.65	0.03	0.01	4.61
…				
2020	5.83	0.24	0.13	5.46
2025	6.55	0.24	0.14	6.17

Method 3

State ABC has access to fuel consumption and activity data only for year 2010. Specifically, fuel consumption in 2010 was 4.63 GL. The first step is to estimate the expected fuel consumption for the years 2011 to 2015 using the growth rate for RTK (3.5 per cent annually). The same methodology can be used to project fuel consumption to a longer time horizon (e.g., 2020, 2030). The results are shown in Table 9.

Table 9. Projected fuel consumption for the period 2011-2015, 2020 and 2030

Year	Projected Fuel consumption (GL)
2010	4.63
2011	4.79
2012	4.95
2013	5.13
2014	5.31
2015	5.49
…	…
2020	6.52
2030	9.20

The next step involves the estimation of the impacts of additional measures for the period 2011-2015. After consulting with relevant stakeholders, the fuel gains due to additional measures (GL) are determined and the expected results (see Table 10) are calculated as follows:

Expected results = Projected fuel consumption – Fuel gains due to additional measures

Table 10. Expected results using Method 3

Year	Projected fuel consumption (GL)	Fuel gains due to additional measures (GL)	Expected results (GL)
	A	B	C=A-B
2011	4.79	0.16	4.63
2012	4.95	0.17	4.78
2013	5.13	0.21	4.92
2014	5.31	0.24	5.07
2015	5.49	0.39	5.10

Finally, the expected results for a longer time horizon (e.g., 2020 or 2030) can be estimated by calculating the trend of the fuel efficiency metric, in this example, for the period 2010-2015 and using this trend to extrapolate the expected results for the future. Indicatively, using the numbers in Table 10, the expected results for 2020 and 2030 would be 5.63 and 6.86 GL, respectively.

Appendix I

Reference material for the implementation of mitigation measures

Reference material that may be relevant to the implementation of most mitigation measures is available from various sources. This appendix presents some of this material that States may use in the identification and selection of measures.

1) Aircraft-related technology development

In 2009, IATA produced, with a number of industry experts, the *IATA Technology Roadmap*[14], which provides a summary and assessment of technological opportunities for future aircraft. This document looks at technologies that will reduce, neutralize and eventually eliminate the carbon footprint of aviation.

In November 2010, ATAG published the *Beginners Guide to Aviation Efficiency*[15] explaining, in simple words, the various measures to reduce aircraft engine emissions including aircraft design, engine design, aircraft operations in the air and on the ground.

ATAG also published in May 2009, the *Beginner's Guide to Aviation Biofuels*[16], which looks at the opportunities and challenges in developing sustainable biofuels for aviation.

The UK Committee on climate change published, in December 2009, a policy document entitled *Meeting the UK aviation target – Options for reducing emissions to 2050*[17]. The document explores various options including improvement in fleet fuel efficiency through technology innovation and the use of bio-fuels and hydrogen in aviation.

2) Improved air traffic management and infrastructure use

ICAO has emphasized to States that early implementation of new communications, navigation, surveillance and air traffic management (CNS/ATM) systems would be an effective means of reducing fuel burn and emissions. The results of a preliminary study of the environmental benefits associated with CNS/ATM and the methodology for their assessment have been incorporated into the *Global Air Navigation Plan* (Doc 9750). ICAO's *Global Air Navigation Plan* sets the scene for the implementation of performance-based air navigation system at the global and regional levels.

Operational measures are one of the instruments available to States to improve fuel efficiency and reduce CO_2 emissions. Experts from CAEP developed rules of thumb to assist States with estimating the potential environmental benefits from the implementation of new operational improvements. In addition, the ICAO Fuel Savings Estimation Tool (IFSET) has been developed by the Secretariat with support from States and international organizations to assist the States to estimate fuel savings in a manner consistent with the models approved by CAEP and aligned with the Global Air Navigation Plan.

IFSET is not intended to replace the use of detailed measurement or modeling of fuel savings, where those capabilities exist. Rather, it is provided to assist those States without such facilities to estimate the

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14 http://www.iata.org/ps/publications/Pages/technology-roadmap.aspx
15 http://www.enviro.aero/Content/Upload/File/ATAG_BeginnersGuidetoAviationEfficiency_MIDRESO(1).pdf
16 http://www.enviro.aero/Content/Upload/File/BeginnersGuide_Biofuels_WebRes.pdf
17 http://www.theccc.org.uk/reports/aviation-report

benefits from operational improvements in a harmonized way. IFSET is freely available in the ICAO public website[18].

In February 2008, a guidance document on *Environmental Impact Reduction Measures for ANSPs*[19] was published by the Civil Air Navigation Services Organization (CANSO). This document presents and discusses various initiatives air navigation service providers (ANSPS) can take to address noise, local air quality and climate change impacts. Arrival and departure, as well as en route procedures are discussed. CANSO has also prepared an *Introduction to Environmental Management Systems*[20] for ANSPs.

ICAO efforts to continually improve the global Air Traffic Management (ATM) system are focused on the Global ATM Operational Concept. The vision of the operational concept is to achieve an interoperable global air traffic management system, for all users during the all phases of flight that meets agreed levels of safety, provides for optimum economic operations, is environmentally sustainable, and meets national security requirements. The Concept was endorsed by the 11th Air Navigation Conference in 2003 and is now an important part of all major ATM development programmes including NextGen[21] of the United States and SESAR[22] of Europe, two important programmes to upgrade and modernise the provision of air navigation services and improve efficiency .

States may wish to gather more information and monitor the progress in the implementation of these programmes since they encompass a variety of projects and activities that they may select to include in their own action plans.

ACI also published a *Guidance Manual on Airport Greenhouse Gas Emissions Management*[23] in November 2009. While airport emissions are part of States' national inventories, their reduction may be a co-benefit of action plans to reduce GHG emissions.

3) More efficient operations

ICAO has published guidance material on operational opportunities to minimize fuel use and reduce emissions, in the form of the ICAO Circular 303-AN/176, published in February 2004. The Circular includes information on aircraft ground level and in-flight operations, as well as ground service equipment and auxiliary power units.

A similar publication, *Guidance Material and Best Practices for Fuel and Environmental Management* was released by IATA in 2004. The fourth edition[24] of this document was published in 2009.

Airbus published in October 2004 a document entitled *Getting to Grips with Fuel Economy*, the purpose of which is "to examine the influence of flight operations on fuel conservation with a view towards providing recommendations to enhance fuel economy." It applies to Airbus aircraft and provides guidelines for pre-flight procedures, take-off and initial climb, climb, cruise descent, holding and approach.

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18 http://www.icao.int/environmental-protection/Pages/Tools.aspx
19 http://www.canso.org/xu/document/cms/streambin.asp?requestid=68B029BD-C8D1-4552-B40F-89EA8FF378F8
20 http://www.canso.org/cms/streambin.aspx?requestid=07FFFD71-A8A6-43B2-8CC7-B1B0B6F31EEA
21 http://www.faa.gov/nextgen/
22 http://www.eurocontrol.int/content/sesar-and-research
23 http://www.aci.aero/aci/aci/file/Publications/2009/ACI_Guidance_Manual_Airport_Greenhouse_Gas_Emissions_Management.pdf
24 http://www.iata.org/whatwedo/aircraft_operations/fuel/Pages/fuel_conservation.aspx

In a series of four articles, published in 2007 and 2008, Boeing outlines fuel conservation strategies applying to Boeing aircraft which cover the appropriate use of the cost index, an improved understanding of cruise flight, efficient take-off and climb and improved approach and descent.

Sustainable Aviation (SA), an initiative from a coalition of industry partners in the United Kingdom, published in December 2008, is a CO_2 roadmap for UK civil aviation, covering various measures. SA also published *Aircraft on the Ground CO_2 Reduction Programme*, for the UK. Other reference SA material includes an industry code of practice for taxi operations and the use of fixed electrical power.

4) Economic / market-based measures

Related ICAO guidance documents and resources include:

- *ICAO Guidance on the Use of Emissions Trading for Aviation* (Doc 9885)
- *Report on Voluntary Emissions Trading for Aviation* (VETS Report) (Doc 9950);
- Market based measures webpage[25];
- *ICAO's Policies on Charges for Airports and Air Navigation Services* (Doc 9082); and
- *ICAO's Policies on Taxation in the Field of International Air Transport* (Doc 8632).

[25] http://www.icao.int/icao/en/Env2010/MarketBasedMeasures.htm

Appendix J

List of examples of measures implemented or planned (extracts taken from ATAG, *Committed to Making Your Flight Greener*)

Category	Measure	Description	Projected benefit
Aircraft-related Technology Development	Purchase of new aircraft	**Finnair to buy first Airbus 321's with "sharklet" wingtip devices**	Reduce fuel use and CO_2 emissions by 4 per cent
	Retrofitting and upgrade improvements on existing aircraft	**Air New Zealand 767-300ERs fitted with winglets**	The blended winglets save more than 6 million litres of fuel and 16,000 tonnes of carbon emissions annually.
		Korean Air Aerospace to manufacture sharklets for the Airbus A320	The devices are expected to result in around 3.5 per cent reduced fuel burn over longer sectors, corresponding to an annual CO_2 reduction of around 700 tonnes per aircraft.
		Aviation Partners Boeing blended winglets	As of March 2010 blended winglet technology will have saved 2 billion gallons of jet fuel.
		CFM International Tech lnsertion engine upgrade	1 per cent better specific fuel consumption over the life of the engine, which translates to better fuel burn and between 5 and 15 per cent lower maintenance costs.
		Ukraine International Airlines install winglets on planes	Reduce fuel burn by up to 5 per cent and, consequently, reduce CO_2 emissions.
		Copa Airlines leading the use of winglet technology in Latin America	Copa was the first airline in Latin America to operate the Boeing 737-700 and -800 aircraft with winglet technology, improving aircraft performance and reducing fuel consumption by 3.5 per cent.
		KLM installs winglets on its 737 aircraft	Winglets are expected to reduce fuel consumption by around 3 per cent, reducing CO_2 emissions by an equivalent amount.
		Swiss International Airlines installs new seating	Installation of ultra-light carbon-fibre seats in its short-haul fleet eliminated over 800 metric tonnes of CO_2 emissions each year. New seats installed on the long-haul fleet will reduce CO_2 emissions by another 2,000 metric tonnes per year.
		Lufthansa Cargo and Jettainer trial lightweight containers	New lighter containers reduce their weight by 20% reducing fuel use and CO_2 emissions.

Category	Measure	Description	Projected benefit
		Japan Airlines instrumental in developing new airline coolant	The new refrigerant, MethaCool, can replace costly dry ice which also releases carbon dioxide as it evaporates. JAL expect to reduce CO_2 emissions by 2000 tonnes each year when introduced across the fleet.
		Air France reduces emissions with lighter seats	These allow the plane to burn less fuel and therefore produce less GHG emissions.
		Southwest Airlines "Green Plane"	New seats, new cabin equipment and new carpets save more than US $10 million a year in fuel costs and reduce emissions. New materials will save about five pounds per seat, or roughly 472 pounds per plane.
		KLM uses environmentally friendly paint	Thinner paint layers mean the aircraft consumes less fuel and produces fewer CO_2 emissions.
		Continental Airlines' comprehensive emissions reduction programme	Reduce emissions and fuel use by 38 per cent through a number of initiatives including winglet retrofitting on Boeing 737 and 757 aircraft.
	Adoption of revolutionary new designs in aircraft/engines	**Boeing fuel cell experimental aircraft**	Use of existing technologies to develop an experimental single-person airplane that can sustain level flight powered only by a fuel cell.
		Airbus A380	Aircraft produces less noise and has a fuel burn of less than 3 litres per passenger per 100 kilometres.
		Rolls-Royce two-shaft engine research programme	Reduce fuel burn and CO_2 emissions by 15 per cent, compared to similar engines currently in service. Will also reduce NOx emissions.
		Rolls-Royce launches Trent XWB engine	28 per cent better fuel efficiency in the engine compared to existing equivalent engines.
		MIT leads team in NASA low-carbon aircraft research	Design team proposes new aircraft designs that could reduce fuel consumption by 70 per cent over current designs.
		Green taxiing means aircraft can avoid on-ground engine use	R&D project by Messier-Bugati, a leading supplier of aircraft landing gears, has identified a technology to allow aircraft to taxi without the use of engines – generating a 4-5 per cent reduction in on-ground fuel burn.
		Boeing 787 testing programme	The new Boeing 787 Dreamliner will reduce fuel use and emissions by 20 per cent over current model aircraft.
		Bombardier teams design environmentally-efficient CSeries	New aircraft is built of 70 per cent advanced structural materials, delivering significant weight savings, which contributes to the CSeries' 20 per cent fuel burn advantage.

Category	Measure	Description	Projected benefit
		Pratt & Whitney PurePower PW1000G engine	Double-digit reductions in fuel consumption, CO_2 and NOx emissions, engine noise and operating costs with this new-generation aircraft engine.
		Rolls-Royce undertakes environmentally-friendly engine research	A major contribution towards achieving the European ACARE targets of 50 per cent lower CO_2 emissions, 80 per cent lower NOx emissions and 50 per cent less noise by 2020, all from a 2000 baseline.
	Alternative Fuels	**Virgin Atlantic, GE and Boeing with biofuel, 23 February 2008**	
		Air China, Boeing, PetroChina and CFM with biofuel	
		United Airlines, Airbus and Rentech with gas to liquid, 30 April 2010	
		Embraer, Amyrus, Azul Airlines flight using biofuel	
		Sky Airline signs biofuel deal	Chilean low-cost carrier Sky Airline has signed a deal with PetroAlgae of Florida for the supply of renewable, second-generation biofuel from algae sources.
		Qatar National Entities and Airbus join for biofuels project	Development of sustainable bio-jet fuel that will also look into ways for production and supply.
		British Airways and Solena Group to build sustainable jet-fuel plant	Will convert 500,000 tonnes of household waste per year into16 million gallons of green jet fuel offering lifecycle carbon savings of up to 95 per cent compared to current fuel.
		Boeing, Etihad Airways, Honeywell and Masdar Institute bioenergy research	Using integrated saltwater agricultural systems to support the development and commercialisation of sustainable biofuel sources for aviation.
		Boeing, PetroChina, Honeywell UOP and Air China team up for Chinese biofuel project	Takes a comprehensive look at the environmental and socio-economic benefits of developing sustainable alternatives to fossil-based jet fuels in China.
		Air New Zealand, Boeing and Rolls-Royce with biofuel, 30 December 2008	Continental Airlines, Boeing, GE, CFM International and Honeywell with biofuel, 7 January 2009.

Category	Measure	Description	Projected benefit
		Continental Airlines, Boeing, GE, CFM International and Honeywell with biofuel, 7 January 2009	Japan Airlines, Boeing, Pratt & Whitney and Honeywell with biofuel, 30 January 2009.
		Japan Airlines, Boeing, Pratt & Whitney and Honeywell with biofuel, 30 January 2009	Qatar Airways, Airbus, Shell with gas to liquid fuel, 12 October 2009.
		Qatar Airways, Airbus, Shell with gas to liquid fuel, 12 October 2009	KLM, GE, Honeywell with biofuel, 23 November 2009.
		KLM, GE, Honeywell with biofuel, 23 November 2009	Interjet, Airbus, CFM and Honeywell with biofuel.
		Interjet, Airbus, CFM and Honeywell with biofuel	Qatar Government, Qatar Airways and Airbus announce biotuel initiative.
		Qatar Government, Qatar Airways and Airbus announce biotuel initiative	The project will aim to produce biofuels for aviation from local, sustainable, supplies of biomass.
		TAM to undertake Latin American demo flight using biofuel	Cathay Pacific joins Sustainable Aviation Fuel Users Group.
		Cathay Pacific joins Sustainable Aviation Fuel Users Group	SAFUG is developing global sustainability criteria and best practices for aviation biofuels. Cathay Pacific joined Alaska Airlines, British Airways, TUlfly, Virgin Blue, Air France, Air New Zealand, ANA, Cargolux, Gulf Air, Japan Airlines, KLM, SAS and Virgin Atlantic Airways. Aircraft manufacturer Boeing and Honeywell UOP are associate members.
		Porter airlines, Bombardier will test biofuel with a Q400, 2012	CANSO, IATA and EUROCONTROL flight efficiency plan.
Improved Air Traffic Management and Infrastructure Use	More efficient ATM planning, ground operations, terminal operations (departure and arrivals), en-route operations, airspace design and usage, aircraft air	**CANSO, IATA and EUROCONTROL flight efficiency plan**	The implementation is expected to bring benefits amounting to a reduction of around 500,000 tonnes of CO, per year.
		NavCanada environmental management project	Improved efficiencies achieved through new technologies and procedures will save 8.4 million metric tonnes of aviation related greenhouse gas emissions in the period 2009 to 2016.
		Air New Zealand, Qantas and Airways New Zealand practice optimum arrivals	Trial designed to better define future air navigation planning, and will achieve better industry environmental outcomes.

Category	Measure	Description	Projected benefit
	navigation capabilities.	**Japan Airlines' user preferred routes**	If UPR were used on all of its flights operating between Japan and Hawaii Japan Airlines could reduce its CO_2 emissions by 4,700 tonnes.
		Air France in trans-Atlantic AIRE test flight	This flight, from Miami to Paris, demonstrated that a reduction of up to 9 metric tonnes of CO_2 is available, if the flight is operated perfectly.
		American Airlines eco-friendly test flight	This perfect trans-Atlantic flight demonstration was part of AA's Fuel Smart programme which will save 120 million gallons of fuel in 2010.
		Fuel-efficient flight operations optimization by Air Berlin	CO_2 emissions were reduced throughout the fleet by reducing the flying speed without a noticeable increase in flying time, but saving 5,734 tonnes of CO_2.
		NavCanada awarded for ADS-B implementation	The air navigation service provider has installed an ADS-B system in the Hudson Bay area allowing aircraft to fly shorter routes and reduce emissions by around 547,000 metric tonnes.
		Emirates Airlines works with AirServices Australia on flexible routing	The measure, which allows pilots and flight dispatchers to plot the best route according to metrological conditions, has saved 10 million litres of fuel over 5 years.
		Air Traffic and Navigation Services wins award for airspace programme	The advanced Air Traffic Flow Management system deployed by South Africa's air navigation provider utilizes end-to-end Collaborative Decision Making to efficiently manage around 10 per cent of the world's airspace while also enhancing safety.
		IATA iFlex to deliver CO2 savings on ultra-long haul routes	The iFlex initiative will be implemented with airlines flying exceptionally long haul routes over uncongested airspace and could reduce emissions by up to 3 tonnes per flight according to early modelling
		Greener Skies project with Alaska Airlines, Boeing and Port of Seattle	Test flight over the Puget Sound reduced emissions by 35 per cent. The Greener Skies project uses satellite technology to fly more efficient landing procedures, which could ultimately be used by all properly equipped carriers at Seattle Airport.
		SAS Airlines uses 'curved approaches' to land	Flight path can be shortened and the fuel consumption and emissions can be further reduced.
		LFV introduces new rules to allow en route traffic over 9000m to fly most direct route possible	Decrease in fuel consumption of 10 tonnes, (and over 30 tonnes of CO_2) over a 24 hour period.

Category	Measure	Description	Projected benefit
		Delta Airlines uses automated flight tracking and management system	The Attila system provides for real-time efficiency measures to be implemented on flights landing at Delta's Atlanta Airport hub, saving more than 50,000 tonnes of CO_2 annually.
		United Airlines 'Green Corridor' demonstration flight	Saved 6,400 pounds of fuel and reduced CO_2 emissions by 20,000 pounds.
		lrish Aviation Authority's 'ENSURE' project	Saving 2.2 million kilometres flown; 14,800 tonnes of fuel; 46,800 tonnes of CO_2; and 195,500 minutes of flight time.
		Civil Aviation Authority of Singapore green flight	Demonstration flight from Singapore to Los Angeles reduced flight time by 30 minutes, saving 33 tonnes of carbon emissions.
		Heathrow, NATS, Singapore Airlines and Airbus introduce improved departure procedure for the Airbus 380	Savings of 300 kg of fuel per take-off, equating to one metric tonne of CO_2 emissions on a flight to Singapore.
		SESAR project Atlantic interoperability initiative to reduce emissions (AIRE)	Over 1000 flight tests performed suggest that around 400 tonnes of CO_2 could be saved annually across the Atlantic.
		lrish Aviation Authority and NATS implement functional airspace block	Flexible route block of upper airspace allows pilots to find their optimum flight paths, saving 46,800 tonnes of CO_2; and night-time fuel saving routes, saving18,100 tonnes of CO_2 per year.
		Smarter flying at Birmingham Airport brings CO2 reductions	NATS, working with Birmingham Airport and airlines, has saved 13,000 tonnes of CO_2 in the last 12 months with continuous descent approach techniques.
		lberia Airlines, AENA and Ineco test green approaches at Madrid-Barajas Airport	The new landing technique saves an average 25 per cent in emissions and fuel as well as significant noise reduction.
		British Airways and NATS 'perfect flight'	Proving flight between Heathrow and Edinburgh found that 1 tonne of CO_2 could be saved per flight if implemented on regular operations.
		Efficient take-offs at Copenhagen Airport	New departure techniques save around 10,000 tonnes of fuel and 32,000 tonnes of CO_2 per year.
		Airways New Zealand's strategic vision of air traffic programme	Managing future airport capacity and agreeing on priority flights and rescheduling services in the most efficient configuration, saving significant amounts of fuel and other operating costs.

Category	Measure	Description	Projected benefit
		The MINT Project	Swedish Air Navigation Service Provider (LFV), Stockholm Arlanda Airport, Novair and Airbus work on an advanced arrivals process that saves on average 518 kg of CO_2 per arrival.
		IATA route shortening projects	IATA saved 3.8 million tonnes of CO_2 in 2007 and 6 million tonnes of CO_2 in 2006 by shortening routes.
		Iberia takes part in SESAR trails	With enhanced efficiency on routes and the reduction of flight times, fuel savings of between 6 and 12 per cent are expected.
		Airbus-led 'AIRE2' trials to spearhead green trajectories with A380	Airbus is leading the AIRE2 flight trial programme with their A380 aircraft. Overall it is estimated that each A380 AIRE flight can reduce CO_2 emissions by around 3 tonnes, compared with existing procedures.
		Tailored arrivals at Miami	The Miami tailored arrivals operations have shown considerable fuel savings compared with normal arrivals into the airport. For 747- 400 aircraft arriving from Europe, the fuel savings are in the order of 700-800 lb per flight. the FAA has moved tailored arrivals operations from a demonstration phase to an implementation phase.
		Traffic Management Advisor at Newark	Traffic Management Advisor (TMA) is a system that implements potential delays further from the airport than standard traffic management normally would. An analysis of the narrow-body aircraft fleet operating into Newark shows an average of a six percent fuel saving for the arrival portion of the flight (within 250 nautical miles of the airport) when TMA is in use.
	More efficient use and planning of airport capacities	**Echo 4 taxiway at Paris Charles de Gaulle Airport**	Reduced taxi time by 90,000 minutes and saved nearly 1.1 million litres of fuel during one year.
		Air France / KLM hub operations streamlining	Coordinate arrival and departure periods that link small flows of feeder traffic with intercontinental traffic, establishing the most efficient operations on the largest possible network.
	Conversion of airport infrastructure and ground support equipment to cleaner fuels	**Aéroports de Paris taps into geothermal energy**	Paris Orly Airport has recently drilled a bore hole to gather naturally heated water to warm its terminal and save 9,000 tonnes of CO_2 annually.
		East Midlands Airport willow fuel farm	Produces fuel for a biomass boiler to heat the terminal, saving 350 tonnes of CO_2.
		Alice Springs Airport solar power station	Supplies about 28 per cent of the airport’s energy needs while reducing annual carbon emissions from the airport by 470 tonnes.
		Oakland International Airport	All aircraft gates are equipped with a 400 Hz power supply, reducing fuel

Category	Measure	Description	Projected benefit
		fixed electrical ground power	use and emissions.
		Geneva International Airport improving air quality	Fixed electrical ground power systems have been progressively installed since 2004 and have resulted in an annual emissions saving of more than 20,000 tonnes of CO_2.
	Enhanced terminal support facilities	**Malaysia Airports aims to meet, if not beat, global aviation targets**	As part of its aim for carbon neutral growth, Kuala Lumpur Airport has introduced energy-saving devices resulting in a reduction in energy use by 39 per cent, with more to come.
		Alaska Airlines turn to pre-conditioned air at the airport gate	Through the use of pre-conditioned air units at its five West Coast US airports alone, Alaska Airlines will reduce CO_2 emissions by 75 million pounds per year.
		Green buildings and sustainable designs at Hong Kong International Airport	Terminals are thermally efficient, using modern glass and building envelopes to reflect heat. Innovative systems cool only the bottom 3 metres of large open spaces, leaving the air above at ambient temperatures.
		New construction techniques and materials at Suvarnabhumi Airport	In this tropical environment, cooling of the building is undertaken through the construction materials. The three layer membrane stretched over the structure maximizes natural light, while reducing air conditioning power consumption by 50 per cent.
		Oakland International Airport building certification	Energy efficiency measures in the new terminal exceed California standards by 25 per cent, reduce carbon emissions by 211 tonnes per year and yield 24 per cent less water use.
		Heathrow Airport use of fixed electrical ground power and pre-conditioned air	Allowing pilots to turn off the auxiliary power unit is saving an estimated 100,000 tonnes of CO_2 per year at the world's busiest international airport.
		Fixed power units at Delhi Airport cut fuel, emissions, costs	The new terminal at Delhi International Airport has been built with fixed electrical ground power units to reduce APU use in each gate.
		Stockholm-Arlanda Airport aquifer cooling and heating the airport	This natural air conditioning system for the terminal will reduce the airport's annual electricity consumption by 4 GWh and its district heating consumption by around 15G Wh.
		Vancouver Airport's solar panels	A decrease of nearly 30 per cent in natural gas use in the airport's domestic terminal since 2001.
		Zurich Airport reduces CO_2 through fixed ground power	Over 30,000 tonnes of CO_2 is saved per year through installation of fixed electrical ground power units at its 50 gates.

Category	Measure	Description	Projected benefit
		San Francisco International Airport solar power project	Solar array will contribute 628,000 kilowatt-hours of electricity annually, reducing 2200 tonnes of CO_2 emissions over its 30 year life.
		Orly Airport solar water heating at staff restaurant	Part of the airport staff restaurant's annual needs are met by the solar cells saving 4 tonnes of CO_2 a year.
		McCarran International Airport and Ecostart escalalors	Ecostart is a motor efficiency controller that soft starts an escalator motor, bringing it from rest to full speed.
		Melbourne Airport's "Skycool" roof	Over an 18-month period the Skycool paint has helped to save more than 40,000 tonnes of CO_2 through a reduction in air conditioning use.
		Hamburg Airport's new Terminal 1	Heating and lighting energy requirements were reduced by 15-20 per cent through a combination of lowering the heating circulation temperature of the under floor heating and reassessing illumination needs.
		Boston Logan Airport LEED	Using Leadership in Energy and Environmental Design (LEED) principles, the airport has realized 12 per cent energy savings and 36 per cent water savings.
		Charles De Gaulle Airport electric transit	The airport transit rail line will cut bus traffic by half saving 750 tonnes of fuel per year.
		Heathrow Airport intermodality	An increase in the number of passengers using public transport to reach Heathrow has removed around 3,000 cars a day from London's roads.
		Incheon Airport looks towards carbon-neutral airport status	By 2013, Incheon Airport will obtain carbon-neutral status through several impressive initiatives including renewable energy initiatives that will save 83 tonnes of carbon emissions.
		Growth in airports signed up to ACI Europe's Airport Carbon Accreditation	Participating airports have reduced CO_2 emissions by 550,000 tonnes.
		Decades of change ahead for Gatwick Airport	Newly-independent airport to target 50 per cent reduction in greenhouse gas emissions from company operations within decade.
		Auckland Airport 'lifts' staff travel options	Scheme to improve car pooling and public transport to the airport to reduce the proportion of journeys up to 18 per cent.
		Athens International Airport energy savings	Savings of approximately 6,000 MWh between 2005 and 2007, corresponding to a decrease in energy consumption of approximately 10 per cent.

Category	Measure	Description	Projected benefit
		Continental Airlines recycling programme	Continental ensures that more than 87 per cent of its catering suppliers worldwide have extensive recycling programmes.
		Turkish Airlines Technic and Pratt & Whitney inaugurate new LEED engine centre	Designed to meet the gold standard of the US Green Building Council's LEED rating system, the centre is built with recycled material and uses renewable energy sources for a portion of its energy load. In addition the site is anticipated to reduce its overall water usage by 40 per cent compared with conventional facility designs.
		The new Quito Airport is being built with the environment in mind	Construction is being undertaken in such a way as to minimize impacts on communities, while the airport also employs sophisticated storm water management, fuel management and wildlife protection procedures.
		Los Angeles Airport terminal renovation gains LEED silver certification	The renovation achieved 20 per cent energy savings and 24 per cent water conservation over the old terminal building. More than 75 per cent of construction and demolition waste was recycled or salvaged.
		Gol Airlines' Passando Limpo project	An intelligent method for washing aircraft uses only 10 per cent of the water previously used to wash an aircraft.
		Phoenix SkyHarbor Airport energy conservation initiatives	An increased focus on energy conservation resulted in a 7 per cent decrease in energy use in one year, an 11.2 million pound reduction in greenhouse gases, savings of more than 7 million kilowatt hours and more than $200,000.
		Sri Lankan Airlines receives ISO 14001 environmental certification for catering facility	Airline's catering facility reduced electricity consumption by 10 per cent and fuel usage by 40 per cent, among a series of planned conservation efforts. The company has an Environmental Excellence Committee which is headed by the CEO.
		Stockholm-Arlanda Airport carbon neutrality	Independent assessment and recognition of airports efforts to manage and reduce CO_2 emissions. First carbon neutral airport operator in the world.
		Schiphol Airport's research projects	Aims to become carbon-neutral by 2012 and generate 20 per cent of all its energy requirements sustainably by 2020.
		JFK Airport and JetBlue recycling programme	Approximately 1,500 gallons of spent jet fuel and oil and some 600 pounds of steel are recycled each month.
		Christchurch International Airport carbon neutrality	First airport in the Southern Hemisphere to be certified carbon neutral.
		Dallas Forth Worth Airport's air	Reduced NOx and CO_2 emissions from 120 tonnes to 15 tonnes.

Category	Measure	Description	Projected benefit
		quality improvement project	
		Brussels Airport reaches new level in Airport Carbon Accreditation scheme	Brussels Airport has reached the 'reduction' level, thanks to its achievement in reducing its own CO_2 emissions by over 10,000 tonnes in the past year.
More efficient operations	Best practices in operations	**Asiana Eco Flight demonstration**	Emission reduction procedures resulted in a total reduction of 500 kg of carbon.
		IATA projects reduce airline CO_2 emissions by 12 million tonnes	Through the IATA Green Teams programme, airlines are identifying significant savings in fuel and emissions, as well as shortening 266 routes in 2009 alone.
		AeroMexico operates 'green flight' trial, saves 555 kg CO_2	The airline also launched several eco-initiatives on the flight, including using new lightweight carts, separating organic and inorganic waste, reducing the amount of onboard printed materials and using biodegradable bags and hand soap. The flight also saved 300 kg of CO_2 on the ground at Mexico City and 180 kg at San Jose, Costa Rica.
		American Airlines introduces single-engine taxiing	The airline estimates it reduces fuel burn by around 15 million litres a year by taxiing on one engine only.
		Volaris Airlines' "Por un cielo azul" programme	This programme, called For Blue Skies, looks at all parts of the airline's operations to reduce emissions through fuel efficiency analysis, cutting water on board by 40 per cent to reduce weight, recycling and IS0 14001 certification.
		Thai Airways holds ISO 14001 environmental certification for its catering services	Thai was also the first Asia-Pacific airline to sign up to the IATA Carbon Offset programme.
		Avianca educates staff on environmental responsibility with Beyond Flying programme	With the goal of reducing fuel consumption, the airline designed and implemented new operating techniques, reduced weight on board and optimised its routes and flight speeds resulting in an annual saving of US $13 million worth of fuel in 2009.
		FedEx opens solar-powered European hub at Cologne Airport	FedEx now operates five global hubs powered by solar panels which reduce annual CO_2 emissions across the network by nearly 4 tonnes.
		Qantas introduces energy efficient tri-generation power plant	Provides power to Qantas jet base, catering facility and domestic terminal, with the savings in emissions equivalent to 6,000 fewer cars on the roads per year and efficiency of 80 per cent.

Category	Measure	Description	Projected benefit
		Royal Jordanian introduces its first environment management plan	Projects to reduce pollutants, including aircraft emissions, ground support equipment emissions, fire extinguishers gas, aircraft air conditioning unit use, waste and hazard material.
		Singapore Airlines announces trial to go paperless	Move will reduce emissions and fuel use by reducing onboard weight.
		Spanair introduces single-engine taxiing	Implementation of single engine taxiing on arrival which leads to a 56 per cent reduction over dual engine taxiing.
		Stansted Airport aviation initiative to cut noise and emissions	Single-engine taxi technique will deliver significant improvements to local air quality at airports and reduce fuel burn as well as costs to airlines.
		Turkish Airlines undertakes fuel efficiency programme	With the assistance of IATA Green Teams, Turkish saved over 500,000 tonnes of CO_2 in 18 months.
	Optimized aircraft maintenance (including jet engine cleaning/washing)	**Air India to offer EcoPower engine wash solution to bring down emissions**	The Pratt & Whitney technique reduces fuel burn by an average of 1.2 per cent.
		Jetstar Airways to contract for EcoPower washes of its A320 and A321 engines	The EcoPower engine wash system reduces fuel burn by as much as 1.2 per cent.
		Air New Zealand's Christchurch Engine Centre to provide EcoPower washes	The Pratt & Whitney system will help Air New Zealand reduce fuel burn by 500,000 gallons per year by cleaning engines to operate more efficiently.
		Lufthansa clean engines	Airline cleans aircraft engines more frequently, which improves performance and life-span. Provides fuel savings across the entire fleet – translating to 74,000 tonnes less CO_2 per year
		Singapore Airlines Cargo signs up for EcoPower engine Wash	The airline is one of the world's largest operators of Boeing 747-400 freighters. The EcoPower engine wash system reduces fuel burn by as much as 1.2 per cent.
Economic / market-based measures	Accredited offset schemes	**Birmingham International Airport, Brazilian rainforest protection**	BIA's protection of 200 acres of rainforest will save 50,000 tonnes of CO_2.
		Kenya Airways joins IATA offset programme	The IATA offset programme uses real airline emissions data to offset flights using UN clean development mechanism projects. Kenya Airways will be the first African airline to join the programme.
		Ethiopian Airlines	Plans to plant two million trees throughout Ethiopia during the Ethiopian Millennium year.

Category	Measure	Description	Projected benefit
Other	Other	**Joint Boeing and Alenia composite recycling plant**	The composite recycling plant is expected to process an average of 1,102 tonnes of composite scrap annually.
		Boeing introduces better work practices at major US production facilities	Reduced CO_2 emissions by 31 per cent since 2002
		Bombardier CSeries factory being built to meet highest environmental standards	The production facility will be LEED certified with layout and design optimized for efficiency and to minimize environmental impact.
		AFRA announces 90 per cent recyclability target	The Aircraft Fleet Recycling Association sets a recyclability target of 90 per cent of the end of service fleet by 2016.
		Global aviation industry agrees to ambitious carbon reduction targets	Through the Air Transport Action Group, the aviations sector is the first in the world to agree to capping net carbon emissions from 2020 and reducing net carbon emissions by 50 per cent below 2005 levels by 2050.
		KLM and the World Wide Fund for Nature	KLM has signed a promise to the WWF saying it will reduce its CO_2 emissions by 3 per cent by 2012 and by 17 per cent by 2020.

Appendix K

Brief description of air carrier environmental programmes

(Refer to Learmount, David. "Lean, Mean Flying," *Flight International* (June 2010). pg. 39-40)

British Airways fuel saving programme: "flying smarter, shorter, lighter"

- The programme delivered 88,375 tonnes of CO2 savings during 2009 equivalent to the CO2 produced by burning 28,055 tonnes of fuel
- Initiatives include aircraft modifications, weight reductions on board and new operational practices
- Cargo: Lighter cargo nets;
- Engineering: Boeing 737 time on wing review; Boeing 777, smaller vortex generators; 777 high-speed aileron drop; 777 ram air modulators; whole-fleet weight saving initiatives; long-haul friction aircraft coating; Boeing 767 winglets; optimize engine washing programmes;
- Flight operations: Reduce fuel carriage; engine-off taxi-out times tactically; reduce long-haul statistical contingency fuel; improve accuracy of zero fuel weight calculation; review alternate airports to optimize fuel carriage; set flight management system cost index zero throughout all Airbus flights; carry out "perfect flight profile" trial; optimize performance advantages available from smart electronic flight bag use.
- Ground operations: increase the use of ground power and air conditioning supply so as to decrease auxiliary power unit use on the ground, both at base and at outstations; carry out loading so as to optimize the centre of gravity position; consider options for fuel saving when take-off is delayed; select closest runway for take-off.
- Cabin: Miniature wine bottles plastic instead of glass; lighter in-flight magazines; lighter cutlery in Club class; lighter serving trolleys.
- A new project to reduce emissions from auxiliary power unit use has the potential to deliver more than 40,000 tonnes of carbon savings a year across the airline
- The airline is working with air navigation service providers to enable flight trajectories to be optimized for fuel efficiency and low noise:
    - In the London terminal manoeuvring area's complex airspace, 95 per cent of BA's arrivals use a continuous descent approach profile.
    - Tailored arrivals and continuous climbs during departure are usually available and may save up to 20 per cent on conventional profiles
    - BA is working with NATS on "perfect flight" trials using the Edinburgh-London Heathrow route.
    - BA is working with NATS and the UK Civil Aviation Authority and a number of other UK-based operators that are working together to define a national code of best practice for ground operations.

Scandinavian Airlines' fuel saving programme

- SAS secured approval to conduct satellite-guided curved approaches to Stockholm Arlanda in regular operations with its B737s to Runway 01R.
- SAS is working with Oxford Aviation Academy, Stockholm to set global benchmarks for fuel-lean operational practices. SAS estimates that fuel savings of 12.5 per cent are possible using a range of hard and soft techniques
- SAS has worked with the Academy to develop a three day course in pilot skills that are specific to getting the most tonne-kilometres out of every kilogram of fuel

Appendix L

Examples of implemented measures in Australia

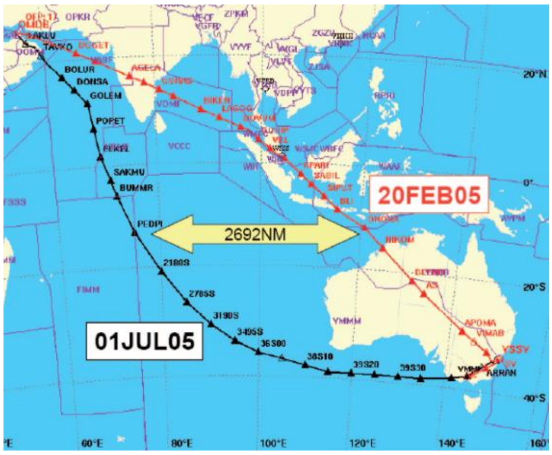
ANSP measures for improving fuel efficiency

Some examples of individual procedures that have been introduced by Airservices Australia to improve the efficiency of aircraft operations in Australia are discussed briefly in the following paragraphs. Details can be found on Airservices Australia's website.[26] While it is useful to know the emissions saved per flight, in order to understand the full benefits of any particular procedure an estimate is required of the potential savings over the entire network of operations. This will require a forecast of how widely and how quickly a given procedure is likely to be deployed.

Calculating potential gains over an entire system may also not be a simple matter of multiplying the gains for an individual flight by the total number of operations (at best this would provide an upper bound) since devising air traffic procedures to improve the fuel efficiency of an individual flight may lead to inefficiencies elsewhere in the system, especially if some aircraft are not given priority or are delayed in order to favour another flight.

Flextracks

Flextracks are non-fixed air traffic routes between airports that are designed to take advantage of favourable winds and avoid strong headwinds in order to allow aircraft to improve flight time and reduce fuel burn. Flextracks were first introduced between Australia and the US in 1995 and across the South Pacific in 1996 but a domestic network was not introduced until June 2005. Now Airservices Australia calculates and publishes flextrack information on a daily basis to provide airlines with flexible air traffic routes that are optimised for prevailing weather.[27] At present flextracks are being widely used between Australia and airports in Asia and the Middle East.



<u>Flextracks</u> — *Reported CO_2 savings:* — *3.4 tonnes CO_2 per flight from the Middle East to Australia*

Emirates has reported a reduction of 26, 644 tonnes of CO_2 over 5 years of flextrack operations on its Australian services.[28] For 592 flights from Dubai to Melbourne and Sydney in 2005–06, Emirates reported a total saving of 628 tonnes of fuel or an average reduction of approximately 3.35 tonnes of CO_2 per flight.[29] This saving is approximately 1 per cent of the total CO_2 emitted for a one way flight between Dubai-Melbourne or Dubai-Sydney.

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[26] Airservices Australia, Aviation & Environment (http://www.airservicesaustralia.com/aviationenvironment/environment/default.asp).

[27] Australian Organised Track Structure (AUSOTS) (http://www.airservicesaustralia.com/customer/ausots/ausots.asp).

[28] *Emirates cites five years of savings with Flex Tracks* (http://atwonline.com/eco-aviation/article/emirates-cites-five-years-savings-flex-tracks-0309).

[29] *New Customers, New Markets: Ultra-long-haul aircraft and ATM* (http://www.canso.org/cms/streambin.aspx?requestid=0D8A2B13-B989-47A5-96E5-89D928D003CA).

RNP approaches and departures

RNP (Required Navigation Performance) procedures are procedures which take advantage of the most advanced avionics and navigational equipment to deliver significantly more precise aircraft positioning than has previously been possible. Airservices Australia has announced it will continue to deploy RNP approaches and departures across Australia following a successful inaugural trial at Brisbane Airport from January 2007 to January 2008. RNP approaches and departures are now being trialled at 16 other Australian airports with Airservices Australia progressively implementing these procedures at 28 airports in the next 5 years making it the first national Performance Based Navigation (PBN) network in the world.

<u>*RNPs*</u> *Reported CO_2 savings: 400kg of CO_2 per approach*

The first stage of the Brisbane Green Project involving Qantas Airways' B737-800 fleet resulted in a reduction of more than 650 tonnes of CO_2 over a 12 month period for 1,612 instrument approaches involving 33 aircraft or approximately 403 kg of CO_2 per approach.[30] This is approximately 3 per cent of the total CO_2 emitted for a one way flight from Brisbane to Sydney. Initial estimates from the results of the Brisbane trial suggest RNP procedures can provide a fuel efficiency gain of approximately 1 per cent if implemented across the Australian network.

Improved gate-to-gate management of aircraft

Airservices Australia monitors all aviation traffic in Australia's delegated airspace and manages delays by advising pilots of required speed adjustments while en-route to their destination, up to 2000 kilometres from the airport. Managing delays while an aircraft is at cruising altitude results in 4 to 5 times less fuel used compared to holding aircraft at a lower altitude in the vicinity of an airport. By adjusting the cruising speed of the aircraft, Airservices Australia can ensure that aircraft arrive at the optimal time and avoid costly holding patterns. Airservices Australia is also working with airlines to hold aircraft on the ground before departure when there are, or could be, delays at their destination, thereby saving fuel.

<u>*Gate-to-gate management*</u> *Reported CO_2 savings: several hundred kg per flight*

A five minute holding on the ground can reduce CO_2 emissions on a typical Melbourne-Sydney flight by more than 600 kg or approximately 4 per cent of the total CO_2 emitted for a single flight between Melbourne and Sydney.[31]

[30] The Brisbane Green Project (http://www.airservicesaustralia.com/projectsservices/reports/RNP_Brisbane_Green_Project_Stage1_Report.pdf).

[31] *Airservices Australia develops air traffic management initiatives to reduce aviation's environmental footprint* (http://www.flightglobal.com/articles/2007/12/27/220360/airservices-australia-develops-air-traffic-management-initiatives-to-reduce-aviations.html).

International collaboration

Airservices Australia will continue to develop coordinated air traffic control procedures to improve operational efficiencies in the combined airspace of the Asia Pacific region through the *Asia and Pacific Initiative to Reduce Emissions* (ASPIRE) in partnership with air navigation service providers from the United States, New Zealand, Japan and Singapore. Thailand is expected to become a member in June 2011. Since it was established in February 2008, ASPIRE has undertaken 5 Trans-Pacific test flights with fuel savings ranging between 3-8 per cent per flight.

<u>*Aspire*</u>	*Reported CO_2 savings:*	*18 tonnes of CO_2 per flight across the Pacific*

In 2008 ASPIRE conducted three test flights which resulted in a total emissions reduction of 54.2 tonnes of CO_2. These flights were from Auckland to San Francisco by Air New Zealand (11.2 tonnes of CO_2 saved), Melbourne to Los Angeles by Qantas (28 tonnes of CO_2 saved) and Sydney to San Francisco by United Airlines (15 tonnes of CO_2 saved)[32]. According to the ICAO Carbon Calculator, the average CO_2 per flight one way for Auckland - San Francisco, Melbourne - Los Angeles and Sydney - San Francisco is 277 tonnes, 486 tonnes and 447 tonnes respectively. The three demonstration flights resulted in savings of between 3-6 per cent of the average carbon emissions per flight for the three routes.

Further test flights from Honolulu to Osaka by Japan Airlines in 2009 and from Los Angeles to Singapore via Tokyo in 2010 by Singapore Airlines resulted in a reduction of approximately 13.1 and 33.8 tonnes of CO_2 respectively or 6 per cent and 8 per cent respectively of the average carbon emissions per one way flight[33].

Airline measures for improving fuel efficiency

Fleet renewal and improvement

Australian airlines are implementing programmes to gradually renew their fleet with more fuel efficient Next Generation aircraft. For example, Qantas is continuing to build its fleet of A380, B737-800 and A330-200 aircraft, and in future will focus on the B787 Dreamliner[34] to provide fuel savings on further point-to-point destinations. Qantas has chosen the General Electric Next Generation (GEnx) turbofan engine to power its B787 fleet which is expected to reduce fuel consumption by up to 20 per cent compared to current turbofans.[35] Virgin Blue also operates a fleet of NextGen B737 and Embraer aircraft, and in future will operate A330-200 aircraft on domestic long haul services.[36]

Fleet renewal and changes in aircraft types are key determinants of changes in network fuel efficiency. The figure below shows changes in total carbon emissions by the top ten aircraft types in 2009-10 compared with 2008-09 for Australia’s international and domestic departures.

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[32] Airservices Australia media release 4 September 2009: *ASPIRE Annual Report: ‘Green’ flight tests results released* (http://www.aspire-green.com/mediapub/docs/0932.pdf).

[33] *JAL to conduct Asia’s first environmentally efficient ASPIRE flight* (http://www.aspire-green.com/mediapub/docs/091006_jal_aspire_flight.pdf); *Singapore Airlines completes first ASPIRE multi-sector green flight and saves over 33 tonnes of CO2 emissions* (http://www.greenaironline.com/news.php?viewStory=742).

[34] Qantas Fleet Developments (http://www.qantas.com.au/travel/airlines/fleet-developments/global/en).

[35] *Flying into the Future* (http://www.qantas.com.au/travel/airlines/aircraft-boeing-787/global/en).

[36] *The Virgin Blue Group of Airlines Takes Two New A330 Aircraft* (http://www.virginblue.com.au/AboutUs/Media/NewsandPressReleases/P_014188.htm).

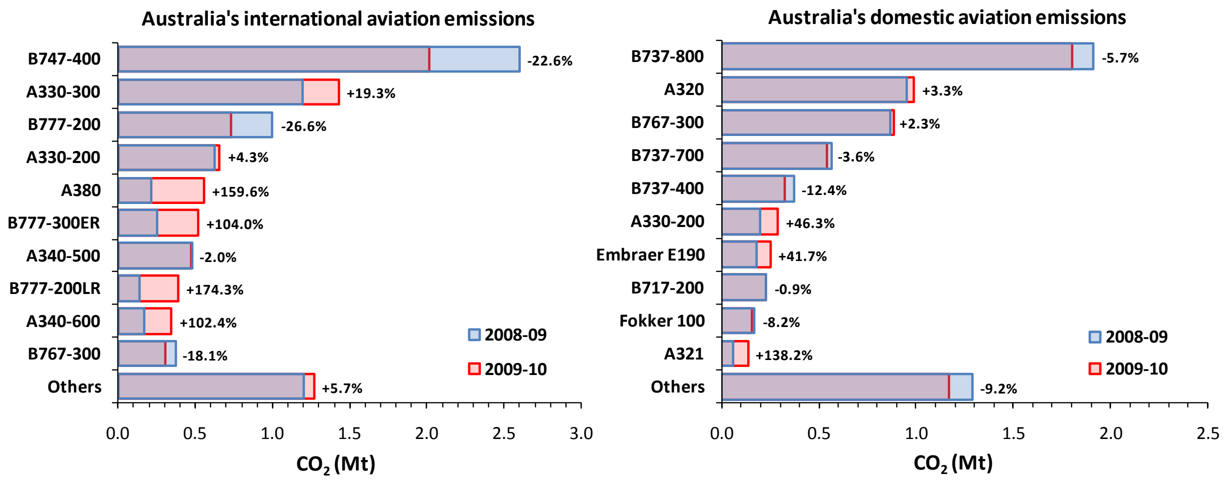


Figure 12. Contributions by aircraft types to Australia's aviation emissions, 2008-09 and 2009-10

Load factors

All other factors being equal, increasing the load factor increases the fuel efficiency metric on a per passenger-kilometre basis. This reduces the CO_2 per passenger and thereby the cost per passenger of offsetting the total emissions for a given flight. Airlines are also keen to improve their load factors in order to increase passenger revenues per available seat-kilometre. However, there is an optimum average load factor for an airline fleet which is less than 100 per cent. As the average fleet load factor increases above about 80 per cent, a greater proportion of flights actually operate full resulting in an increasing likelihood of the airline losing potential customers due to the non-availability of seats at the passengers' preferred flight times.

Australia's average annual load factors for international and domestic outbound traffic have increased in 2009-10 compared to 2008-09 by 2.9 per cent and 1.3 respectively (or 2.1 and 1.0 percentage points respectively) as shown in Table 11.

Table 11. Australia's average annual load factors for aircraft departures, 2008-09 & 2009-10

Sector	Average Annual Outbound Load Factors (%) 2008-09	2009-10	% Change
International	73.3	75.4	2.85
Domestic	76.8	77.8	1.26
Total	**75.9**	**77.1**	**1.57**

Source: Bureau of Infrastructure, Transport and Regional Economics (BITRE)

Measures offsetting emissions

Voluntary offsets by individual air passengers

Economic measures are a key tool in managing climate change emissions. In recent years there has been significant debate within Australia about the implementation of a regulated economy wide emissions trading scheme. At the present time, the Government of Australia is examining the introduction of some form of carbon tax. While there has yet to be implementation of these proposed mandatory measures, concerned individuals have been voluntarily purchasing carbon offsets to manage the climate change impacts of their flying.

In Australia, Qantas, Jetstar and Virgin Blue provide passengers with the opportunity to purchase offsets for their individual travel. Reports by Jetstar and Virgin Blue indicate that Australian domestic aviation passengers demonstrate a relatively high uptake of voluntary carbon offsets by international standards, with approximately 10 per cent of passengers electing to offset their flight[37]. Virgin Blue reported that the amount of carbon offsets in 2008-09 equated to about 4 per cent of its total emissions[38]. In 2008-09 Qantas and Jetstar customers paid to offset almost 250,000 tonnes of CO_2e which is just over 2 per cent of its total emissions[39].

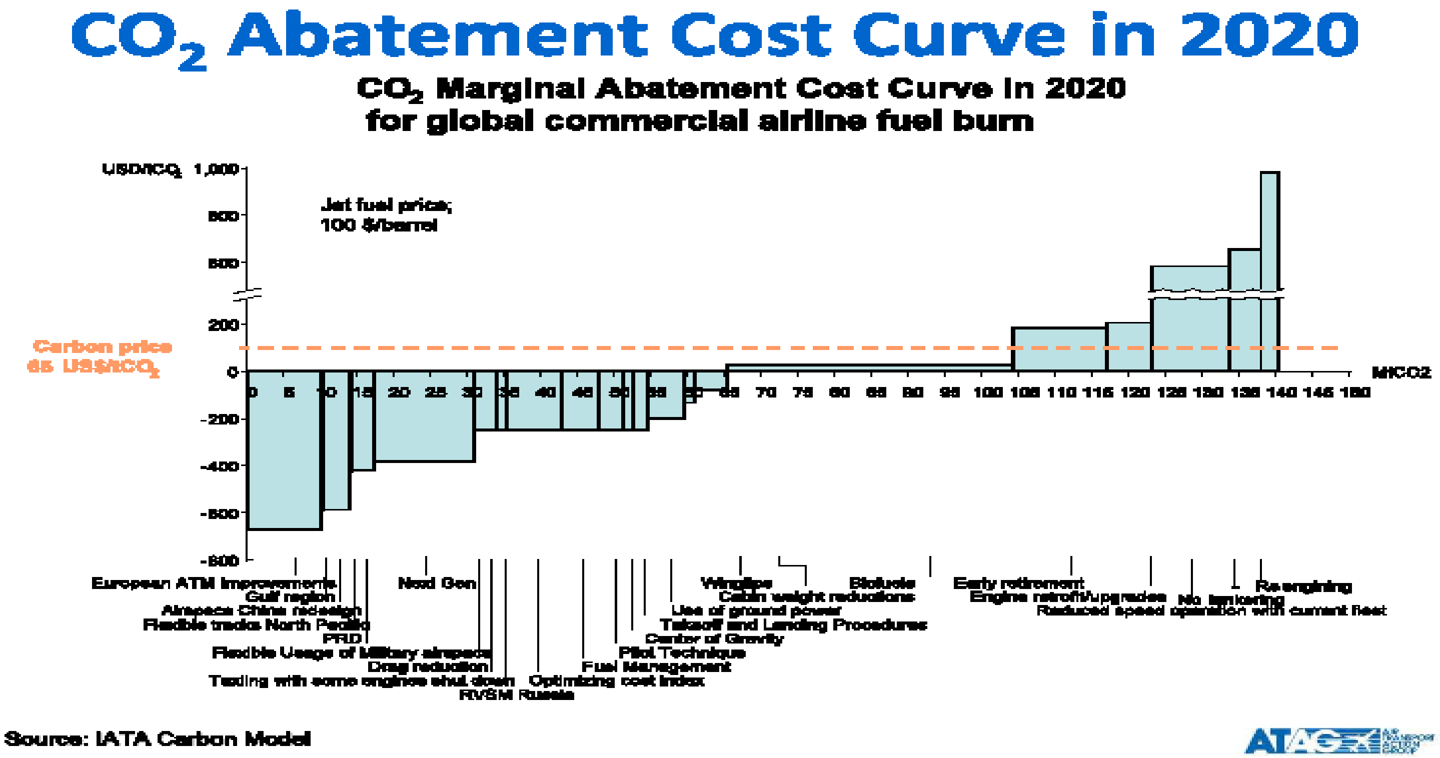
Voluntary offsets by airlines

Both Qantas and Virgin Blue purchase offsets to cover the emissions resulting from their ground vehicles and employee business travel. In 2008-09, Qantas reported that it offset more than 65,000 tonnes of CO_2e for its own work travel and ground vehicles.

[37] Carbon Offset Programs by Virgin Blue (http://www.greenaironline.com/news.php?viewStory=597) and Jetstar (http://www.environmentalleader.com/2007/10/05/jetstar-says-voluntary-carbon-offsets-big-success/).
[38] Virgin Blue (http://www.virginblue.com.au/AboutUs/CorporateResponsibility/Sustainability/Initiatives/index.htm)
[39] Qantas Annual Report 2009 (http://annualreport.qantas.com.au/environment-climate-change/)

Appendix M

CO_2 abatement cost curve in 2020



In considering which measures should be taken to reduce CO_2 emissions from commercial air transport, and in what order, one important criterion is the cost effectiveness of each measure. Marginal Abatement Cost (MAC) curves are a graphical means of showing the measures that can reduce CO_2 emissions in order of their cost effectiveness. In the chart shown, the most cost effective measures are on the left and the most expensive on the right. The vertical axis shows the net cost in US$ of the measure for each tonne of CO_2 reduced by it. The horizontal axis shows the quantity of CO_2 in millions of tonnes that can be saved by the measures. This MAC curve is not cumulative, as each measure has been considered in isolation and as such it may not be directly comparable with cumulative MAC curves in other sectors.

The chart is made up of individual abatement measures, a mixture of infrastructure, operations and technology options. The width of each bar shows the total CO_2 that has been estimated to be feasible to abate worldwide using this measure. The height of the bar shows its net cost in USD for each tonne of CO_2 abated (its relative cost-effectiveness).

This net cost includes the (amortized) capital cost and any operating costs of implementing the measure minus any resulting cost savings from reduced fuel use or operational savings. The bars on the left, mostly infrastructure efficiency improvements, show negative net costs. This means that the fuel and other savings resulting from the implementation of the measure exceed its (amortized) capital and operating costs. These are often called 'no regrets' measures i.e. they bring a financial as well as environmental benefit. Usually the barrier to implementation is political rather than economic. Sometimes the barrier is a lack of information or awareness. These are the measures that would be sensible to implement first to reduce CO_2 emissions from air transport. At the right end of the chart, measures such as re-engining existing aircraft have high net costs. Some of these measures can only be implemented at a cost of more than $1,000 for each tonne of CO_2 saved. These are very expensive ways of reducing CO_2.

The chart is a snapshot of what the analysis by McKinsey and ATAG (IATA) suggests is feasible in the year specified for each of the measures. The quantity of CO_2 abated by each measure is what could be saved in that year relative to a baseline of where emissions would be without such additional measures and in the absence of any concurrent measures. In this case the baseline was dependant on traffic growth and the 'normal' replacement of the fleet, based on the same survivor curves (a plot of the per cent of aircraft fleet remaining in service as a function of aircraft age. It usually takes the shape of an S curve reversed) used in CAEP analyses. Many of the measures depend on the size of the fleet or the flow of traffic. As a result, the size of CO_2 reductions from these measures will depend on the year in which the snapshot is taken.

The chart and the data portrayed shows that, beyond a certain point, it is not cost effective to abate CO_2 emissions from air transport within the industry. The MAC curve rises steeply towards the right of the chart, after a certain quantity of CO_2 has been abated by the measures specified. Comparing the MAC curve with the cost of reducing CO_2 in other industries (through, for example, carbon offsets or tradable emission allowances) shows the point at which it becomes cost ineffective to reduce CO_2 emissions from within the air transport industry.

Appendix N

Involvement of stakeholders

Category	Measure	Air carriers	Other stakeholders[40]	Airports	ANSPs	Manufacturers
Aircraft-related Technology Development	○ Aircraft minimum fuel efficiency standards	Yes				Yes
	○ Aggressive aircraft fuel efficiency standards, setting standards for the future	Yes				Yes
	○ Purchase of new aircraft	Yes	Yes	Yes		Yes
	○ Retrofitting and upgrade improvements on existing aircraft	Yes				Yes
	○ Optimizing improvements in aircraft produced in the near to mid-term	Yes				Yes
	○ Avionics	Yes	Yes		Yes	Yes
	○ Adoption of revolutionary new designs in aircraft/engines	Yes				Yes
Alternative Fuel	Development of biofuels or other fuels with lower carbon lifecycle content; and associated standards for alternative fuels	Yes	Yes	Yes		Yes
Improved Air Traffic Management and Infrastructure Use	○ More efficient ATM planning, ground operations, terminal operations (departure and arrivals), en-route	Yes	Yes	Yes	Yes	Yes

[40] Other stakeholders include passengers, governments and other airspace users.

Category	Measure	Air carriers	Other stakeholders[40]	Airports	ANSPs	Manufacturers
	operations, airspace design and usage, aircraft air navigation capabilities.					
	○ More efficient use and planning of airport capacities	Yes	Yes	Yes	Yes	
	○ Conversion of airport infrastructure and ground support equipment to cleaner fuels	Yes		Yes		
	○ Construction of additional runways to relieve congestion	Yes	Yes	Yes	Yes	
	○ Enhanced terminal support facilities	Yes		Yes		
	○ Improved public transportation access			Yes		
	○ Collaborative research endeavours	Yes	Yes	Yes	Yes	Yes
More efficient operations	○ Best practices in operations	Yes		Yes	Yes	Yes
	○ Optimized aircraft maintenance (including jet engine cleaning/washing)	Yes				Yes
	○ Selecting aircraft best suited to mission	Yes	Yes			
Economic / market-based measures	○ Voluntary inclusion of aviation sector in emissions trading scheme	Yes	Yes	Yes	Yes	Yes
	○ Incorporation of	Yes	Yes			

Category	Measure	Air carriers	Other stakeholders[40]	Airports	ANSPs	Manufacturers
	emissions from international aviation into regional or national emissions trading schemes, in accordance with relevant international instruments					
	○ Establishment of a multilateral emissions trading scheme for aviation which allows trading permits with other sectors, in accordance with relevant international instruments	Yes	Yes	Yes	Yes	Yes
	○ Establishment of a framework for linking existing emissions trading schemes and providing for their extension to international aviation, in accordance with relevant international instruments	Yes		Yes	Yes	Yes
	○ Emissions charges or modulation of LTO charges, in accordance with relevant international instruments	Yes	Yes	Yes	Yes	Yes
	○ Positive economic stimulation by regulator: research programs,	Yes	Yes	Yes	Yes	Yes

Category	Measure	Air carriers	Other stakeholders[40]	Airports	ANSPs	Manufacturers
	special consideration and government programs/legislation and accelerated depreciation of aircraft					
	○ Accredited offset schemes	Yes	Yes	Yes	Yes	Yes
	○ Explore extension of CDM	Yes	Yes	Yes	Yes	Yes
	○ Taxation of aviation fuel	Yes	Yes	Yes	Yes	Yes
Regulatory measures / Other	○ Airport movement caps/slot management	Yes		Yes	Yes	
	○ Enhancing weather forecasting services	Yes	Yes	Yes	Yes	
	○ Requiring transparent carbon reporting	Yes	Yes	Yes		
	○ Conferences and workshops	Yes	Yes	Yes	Yes	Yes

Appendix O

Costs and benefits related to the basket of measures adopted by ICAO to limit or reduce emissions from international civil aviation

Aircraft related costs will depend on the size of the fleet. Benefits will depend on the size of the fleet and on the number of operations.

1) Aircraft-related Technology Development

Measure	Benefit/cost	
Aircraft minimum fuel efficiency standards	Benefit:	Reduced CO_2 emissions
	Relative potential gains	Low to medium
	Co-benefits	Reduced fuel burn Possible offset carbon credits Reduced maintenance cost (new aircraft/engine)
	Cost:	Manufacturers: R&D, Retooling and new production processes costs Operators: - Purchase of new aircraft - Cost of additional training if required - Re-engining existing aircraft - Possible aircraft downtime cost - Loss of resale value of existing aircraft
	Cost range:	Low to medium
	Additional Metric(s):	Proportion of fleet compliant
Aggressive aircraft fuel efficiency standards, setting standards for the future	Benefit:	Reduced CO_2 emissions
	Relative potential gains	Medium to High
	Co-benefits	Reduced fuel burn Possible offset carbon credits Reduced maintenance cost (new aircraft/engine)
	Cost:	Manufacturers: R&D, Retooling and new production processes costs Operators: - Purchase of new aircraft - Cost of additional training if required - Re-engining existing aircraft - Possible aircraft downtime cost - Loss of resale value of existing aircraft
	Cost range:	Medium to high
	Additional Metric(s):	Proportion of fleet compliant

Measure	**Benefit/cost**	
Purchase of new aircraft	Benefit:	Reduced CO_2 emissions
	Relative potential gains	Very high
	Co-benefits	Reduced fuel burn Possible offset carbon credits Reduced maintenance cost (new aircraft/engine)
	Cost:	Cost of purchase of new aircraft Cost of additional training if required
	Cost range:	High
	Additional Metric(s):	Average age Proportion of fleet below a certain age
Retrofitting and upgrade improvements on existing aircraft	Benefit:	Reduced CO_2 emissions
	Relative potential gains	Low to high
	Co-benefits	Reduced fuel burn Possible offset carbon credits Possible reduced maintenance cost Possible gain in re-sale value
	Cost:	Cost of retro-fit and upgrade Possible aircraft downtime cost
	Cost range:	Low to medium
	Additional Metric(s):	Proportion of fleet retrofitted
Optimizing improvements in aircraft produced in the near to mid-term	Benefit:	Reduced CO_2 emissions
	Relative potential gains	Low to medium
	Co-benefits	Reduced fuel burn Possible offset carbon credits
	Cost:	Manufacturers: R&D, Retooling and new production processes costs Operators: - Purchase of new aircraft - Cost of additional training if required - Re-engining existing aircraft - Possible aircraft downtime cost - Loss of resale value of existing aircraft
	Cost range:	Medium
	Additional Metric(s):	
Avionics	Benefit:	Reduced CO_2 emissions
	Relative potential gains	Low to medium
	Co-benefits	Reduced fuel burn Possible offset carbon credits
	Cost:	Cost of avionics and installation Possible aircraft downtime cost
	Cost range:	Medium
	Additional	Proportion of fleet

Measure	Benefit/cost	
	Metric(s):	
Adoption of revolutionary new designs in aircraft/engines	Benefit:	Reduced CO_2 emissions
	Relative potential gains	High to very High
	Co-benefits	Reduced fuel burn Possible offset carbon credits
	Cost:	Manufacturers: R&D, Retooling and new production processes costs Operators: - Purchase of new aircraft - Cost of additional training if required - Re-engining existing aircraft - Possible aircraft downtime cost - Loss of resale value of existing aircraft
	Cost range:	High
	Additional Metric(s):	
Alternative Fuels	Benefit:	Reduced CO_2 emissions
	Relative potential gains	Medium to very high
	Co-benefits	Reduced fuel burn Possible offset carbon credits
	Cost:	Fuel producers: - Research & Development - Construction of production facilities - Logistics Operators: Depends on the type of fuel. For drop-in fuels, no substantial costs
	Cost range:	Medium to high
	Additional Metric(s):	

2) Improved Air Traffic Management and Infrastructure Use

Measure	Benefit/cost	
	Relative potential gains	Low to medium
	Co-benefits	Reduced fuel burn Possible offset carbon credits
	Cost:	
	Cost range:	Medium to high
	Additional Metric(s):	
More efficient use and planning of airport capacities	Benefit:	Reduced CO_2 emissions
	Relative potential gains	Low
	Co-benefits	Reduced fuel burn Possible offset carbon credits
	Cost:	

Measure	**Benefit/cost**	
	Cost range:	Medium to high
	Additional Metric(s):	
Conversion of airport infrastructure and ground support equipment to cleaner fuels	Benefit:	Reduced CO_2 emissions
	Relative potential gains	Low
	Co-benefits	Reduced fuel burn Possible offset carbon credits
	Cost:	
	Cost range:	Low
	Additional Metric(s):	
Construction of additional runways to relieve congestion	Benefit:	Reduced CO_2 emissions through reduced congestion/delays
	Relative potential gains	Low to high
	Co-benefits	Reduced fuel burn Possible offset carbon credits
	Cost:	
	Cost range:	High
	Additional Metric(s):	
Enhanced terminal support facilities	Benefit:	Reduced CO_2 emissions through reduced congestion/delays
	Relative potential gains	Low
	Co-benefits	Reduced fuel burn Possible offset carbon credits
	Cost:	
	Cost range:	Low to medium
	Additional Metric(s):	
Collaborative research endeavors	Benefit:	
	Relative potential gains	Low
	Co-benefits	
	Cost:	
	Cost range:	Low to medium
	Additional Metric(s):	

3) More efficient operations

Measure	**Benefit/cost**	
Best practices in operations	Benefit:	Reduced CO_2 emissions
	Relative potential gains	Low to medium
	Co-benefits	Reduced fuel burn Possible offset carbon credits
	Cost:	Procedures design and implementation Training costs
	Cost range:	Low

Measure	Benefit/cost	
	Additional Metric(s):	
Optimized aircraft maintenance (including jet engine cleaning/washing)	Benefit:	Reduced CO_2 emissions
	Relative potential gains	Low
	Co-benefits	Reduced fuel burn Possible offset carbon credits
	Cost:	Possible additional maintenance costs
	Cost range:	Low
	Additional Metric(s):	
Selecting aircraft best suited to mission	Benefit:	Reduced CO_2 emissions
	Relative potential gains	Low to medium
	Co-benefits	Reduced fuel burn Possible offset carbon credits Better aircraft utilization Better use of crews
	Cost:	
	Cost range:	Medium
	Additional Metric(s):	

Appendix P

List of climate funds – Climate Funds Update Website

www.climatefundsupdate.org*

Fund	Type	Administered by - Name and link	Areas of focus	Date operational
Adaptation Fund	Multilateral	Adaptation Fund Board	Adaptation	2009
Amazon Fund (Fundo Amazônia)	Multilateral	Brazilian Development Bank (BNDES)	Mitigation - general, Adaptation, Mitigation - REDD	2009
Clean Technology Fund	Multilateral	The World Bank	Mitigation - general	2008
Congo Basin Forest Fund	Multilateral	African Development Bank	Mitigation - REDD	2008
Environmental Transformation Fund - International Window	Bilateral	Government of the United Kingdom	Mitigation - general, Adaptation	2008
Forest Carbon Partnership Facility	Multilateral	The World Bank	Mitigation - REDD	2008
Forest Investment Program	Multilateral	The World bank	Mitigation - REDD	2009
GEF Trust Fund - Climate Change focal area (GEF 5)	Multilateral	The Global Environment Facility (GEF)	Mitigation - general, Adaptation	2010
Global Climate Change Alliance	Multilateral	The European Commission	Mitigation - general, Adaptation, Mitigation - REDD	2008
Global Energy Efficiency and Renewable Energy Fund	Multilateral	European Commission	Mitigation - general	2008
Hatoyama Initiative - private sources	Bilateral	Government of Japan	Mitigation - general, Adaptation	2008
Hatoyama Initiative - public sources	Bilateral	Government of Japan	Mitigation - general, Adaptation	2008
Indonesia Climate Change Trust Fund	Multilateral	Indonesia's National Development Planning Agency	Multiple foci	2010
International Climate Initiative	Bilateral	Government of Germany	Mitigation - general, Adaptation, Mitigation - REDD	2008

Fund	Type	Administered by - Name and link	Areas of focus	Date operational
International Forest Carbon Initiative	Bilateral	Government of Australia	Mitigation - REDD	2007
Least Developed Countries Fund	Multilateral	The Global Environment Facility (GEF)	Adaptation	2002
MDG Achievement Fund – Environment and Climate Change thematic window	Multilateral	UNDP	Mitigation - general, Adaptation	2007
Pilot Program for Climate Resilience	Multilateral	The World Bank	Adaptation	2008
Scaling-Up Renewable Energy Program for Low Income Countries	Multilateral	The World Bank	Mitigation - general	2009
Special Climate Change Fund	Multilateral	The Global Environment Facility (GEF)	Adaptation	2002
Strategic Climate Fund	Multilateral	The World Bank	Mitigation - general, Adaptation, Mitigation - REDD	2008
Strategic Priority on Adaptation	Multilateral	The Global Environment Facility (GEF)	Adaptation	2004
UN-REDD Programme	Multilateral	UNDP	Mitigation - REDD	2008

List of climate funds - World Bank website
www.climatefinanceoptions.org*

Fund	Type	Administered by - Name and link	Areas of focus	Date operational
Carbon Funds and Facilities	Multilateral	World Bank http://www.carbonfinance.org	Adaptation Mitigation – general Mitigation - REDD+	1999
Carbon Market Initiative (CMI)	Multilateral	Asian Development Bank (ADB) http://www.adb.org/Climate-Change/cc-mitigation-carbon-market.asp	Mitigation	2006
Catastrophic Risk Management	Multilateral	World Bank http://www.worldbank.org/catriskinsurance	Adaptation	2007
Clean Energy Financing Partnership Facility (CEFPF)	Multilateral	Asian Development Bank (ADB) http://www.adb.org/Clean-Energy/cefpf.asp	Mitigation	2007
Climate Change Fund (CCF)	Multilateral	Asian Development Bank (ADB) http://www.adb.org/Climate-Change/cc-fund.asp	Adaptation Mitigation – general, REDD+	2008
Climate Change Technical Assistance Facility	Multilateral	European Investment Bank http://www.eib.org/projects/topics/environment/climate-change/index.htm http://www.eib.org/attachments/strategies/cycle_en.pdf	Mitigation	
Climate Finance Innovation Facility (CFIF)	Multilateral	United Nations Environment Programme (UNEP) http://www.climate-finance.org/home/	Mitigation	
ClimDev-Africa Special Fund (CDSF)	Multilateral	African Development Bank (AfDB) http://www.climatefinanceoptions.org/cfo/node/174	Adaptation Mitigation	
DEG – Deutsche Investitions- und Entwicklungsgesellschaft mbH	Bilateral	DEG – Deutsche Investitions- und Entwicklungsgesellschaft www.deginvest.de	Mitigation	
Fund	**Type**	**Administered by - Name and link**	**Areas of focus**	**Date operational**

EIB-KfW Carbon Programme II	Multilateral	European Investment Bank (EIB) http://www.eib.org/attachments/thematic/eib_kfw_carbon_programme_ii_en.pdf	Mitigation	2009
Fund Solutions for Climate Finance (KfW & Partners)	Bilateral	KfW Entwicklungsbank http://www.kfw-entwicklungsbank.de/EN_Home/Sectors/Climate_change/index.jsp	Mitigation	
Global Facility for Disaster Reduction and Recovery (GFDRR)	Multilateral	World Bank http://www.gfdrr.org/gfdrr/		2006
Green Commodities Facility	Multilateral	United Nations Development Programme (UNDP) http://www.lowcarbonportal.org/show/59355F10-F203-1EE9-BD4D711D5A7FD1DF	Mitigation	
Infrastructure Fund (InfraFund)	Multilateral	Inter-American Development Bank (IDB) http://www.iadb.org/infrafund	Adaptation Mitigation – general	1959
International Development Association (IDA)	Multilateral	World Bank http://www.worldbank.org/ida/	Adaptation	1960
MDG Carbon Facility	Multilateral	United Nations Development Programme (UNDP) http://www.mdgcarbonfacility.org/	Mitigation	2007
Multilateral Carbon Credit Fund (MCCF)	Multilateral	European Investment Bank (EIB) http://www.eib.org/projects/publications/the-multilateral-carbon-credit-fund-mccf.htm	Mitigation	
Nordic Environment Finance Corporation (NEFCO) Carbon Finance and Funds	Multilateral	Nordic Environment Finance Corporation (NEFCO) http://www.nefco.org/financing/carbon_finance	Adaptation Mitigation	2008
Nordic Climate Facility	Multilateral	Nordic Environment Finance Corporation (NEFCO) http://www.nefco.org/financing/ncf	Adapatation	2009
Post-2012 Carbon Credit Fund	Multilateral	European Investment Bank http://www.eib.org/projects/topics/environment/climate-change/index.htm http://www.eib.org/projects/publications/post-2012-carbon-credit-fund.htm	Mitigation	

Fund	Type	Administered by - Name and link	Areas of focus	Date operational
Regional Fund of Agricultural Technology (FONTAGRO)	Multilateral	Inter-American Development Bank http://www.fontagro.org/	Adaptation - Agriculture	1998
Renewable Energy Enterprise Development	Multilateral	United Nations Environment Programme http://www.uneptie.org/energy/activities/reed/	Mitigation	
Seed Capital Assistance Facility (SCAF) http://www.climatefinanceoptions.org/cfo/node/45	Multilateral	United Nations Environment Programme http://scaf-energy.org/index.html	Mitigation	2010
Small Grants Programme	Multilateral	The Global Environment Facility http://sgp.undp.org/ http://www.thegef.org/gef/	Mitigation	
Sustainable Energy and Climate Change Initiative (SECCI)	Multilateral	Inter-American Development Bank (IDB) http://www.iadb.org/en/topics/climate-change/secci,1449.html	Adaptation Mitigation	
The Global Environment Facility (the GEF)	Multilateral	The Global Environment Facility http://www.thegef.org/gef/gef_projects_funding	Adaptation Mitigation - general	1991
The Multilateral Investment Fund (MIF)	Multilateral	Inter-American Development Bank (IDB) Group http://www5.iadb.org/mif/	Adaptation	1993

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References

PART 2

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