
GIACC/4

IP/1: Global Aviation CO₂ Emissions Projections to 2050

IP/2: CAEP Responses to requests from GIACC/3

IP/3: Recent developments in ICAO and other UN bodies

Environment Section

Air Transport Bureau

International Civil Aviation Organization



Tasks requested from GIACC/3 to CAEP

1. Information on its environmental trends/goals assessment for 2012, 2020 and 2025 based upon interpolation of existing data, and make an outline of possible scenarios based on broad brush assumptions for 2050 including what would happen under different alternative fuels uptake;

IP/1

2. Initial view on exploring a fuel efficiency metric that could take into account the net life cycle environmental benefits of alternative fuels;

3. Initial view on considering fuel conversion factors between existing fuels and potential alternative fuels;

4. Initial view on considering the development of an aviation CO₂ Standard;

5. Possible average weight for passengers; and

6. Status of developing new guidance replacing Circular 303 and of studies on market-based measures.

IP/2



Tasks requested from GIACC/3 to Secretariat

1. Further explore and report the status on communication and coordination between IMO and ICAO; } IP/3
2. Prepare material, building on the work of GIACC, and effectively present it to COP15; } (COP15)
3. In coordination with CAEP, explore ways of enhancing collection of data, formats, etc. necessary to measure emissions performance, taking into account existing guidance; } (IP/4)
4. Explore the technical assistance for States on data collection, monitoring and reporting; }
5. Support and report the progress in other fora; and } IP/3
6. Report on research on the ICAO's role in 1970s oil crisis } (IP/5)



Environmental Trends/Goals Assessment (IP/1, CAEP Task #1): Overview

- **Environmental trends/goals assessment for 2012, 2020 and 2025 based upon interpolation of existing data, and make an outline of possible scenarios based on broad brush assumptions for 2050**
- MODTF Approach
- Fuel burn projections to 2050 (MODTF Scenarios)
- CO₂ projections to 2050 (MODTF Scenarios)
- Commercial Aviation System Fuel Efficiency projections to 2050 (MODTF Scenarios)
- FESG Approach
- Fuel burn projections to 2050 (Additional Scenarios)
- Conclusions



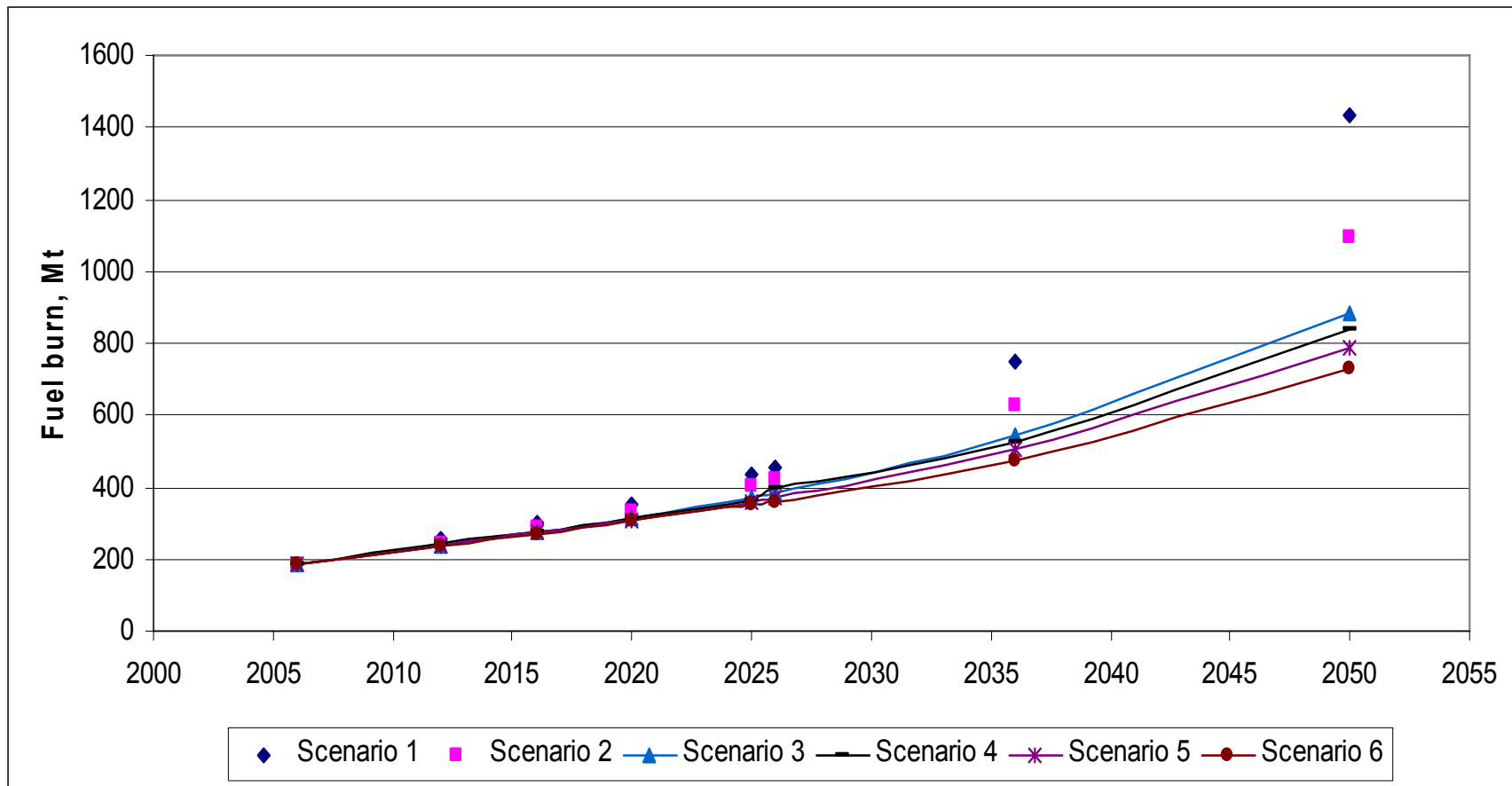
MODTF Approach

- Values for 2012, 2020, and 2025 were interpolated from previously-generated results (2006, 2016, 2026, 2036)
- Values for 2050 were extrapolated from previously-generated results
- **Results presented are illustrative. They demonstrate the order of magnitude of global aviation CO₂ emissions in 2050 under a range of assumptions. The uncertainties when looking out to 2050 must be acknowledged when interpreting the results presented.**

MODTF Scenarios

- **Scenario 1 (Do Nothing)**: This scenario assumes no improvements in aircraft technology beyond those available today and no improvements from communication, navigational and air traffic management (CNS/ATM) investment or from planned initiatives, e.g., those planned in NextGen and SESAR.
- **Scenario 2 (CAEP7 Baseline)**: This scenario includes the CNS/ATM improvements necessary to maintain current ATM efficiency levels, but does not include any technology improvements beyond those available today.
- **Scenario 3 (Low Aircraft Technology and Moderate Operational Improvement)**: In addition to including the improvements associated with the migration to the latest CNS/ATM initiatives, e.g., those planned in NextGen and SESAR (Scenario 2), this scenario includes fuel burn improvements of 0.95 percent per annum for all aircraft entering the fleet after 2006 and prior to 2015, and 0.57 percent per annum for all aircraft entering the fleet beginning in 2015 out to 2036. It also includes additional fleet-wide moderate operational improvements of 0.5, 1.4 and 2.3 percent in 2016, 2026 and 2036, respectively.
- **Scenario 4 (Moderate Aircraft Technology and Operational Improvement)**: In addition to including the improvements associated with the migration to the latest CNS/ATM initiatives, e.g., those planned in NextGen and SESAR (Scenario 2), this scenario includes fuel burn improvements of 0.96 percent per annum for all aircraft entering the fleet after 2006 out to 2036, and additional fleet-wide moderate operational improvements of 0.5, 1.4 and 2.3 percent by 2016, 2026 and 2036, respectively.
- **Scenario 5 (Advanced Technology and Operational Improvement)**: In addition to including the improvements associated with the migration to the latest CNS/ATM initiatives, e.g., those planned in NextGen and SESAR (Scenario 2), this scenario includes fuel burn improvements of 1.16 percent per annum for all aircraft entering the fleet after 2006 out to 2036, and additional fleet-wide advanced operational improvements of 1.0, 1.6 and 3.0 percent by 2016, 2026 and 2036, respectively.
- **Scenario 6 (Optimistic Technology and Operational Improvement)**: In addition to including the improvements associated with the migration to the latest CNS/ATM initiatives, e.g., those planned in NextGen and SESAR (Scenario 2), this sensitivity study includes an optimistic fuel burn improvement of 1.5 percent per annum for all aircraft entering the fleet after 2006 out to 2036, and additional fleet-wide optimistic operational improvements of 3.0, 6.0 and 6.0 percent by 2016, 2026 and 2036, respectively. This sensitivity study goes beyond the improvements based on industry-based recommendations.

MODTF Total Domestic + International Aviation Fuel Burn 2006 – 2050



- **Results are based on FESG “central” demand forecast, an analysis based on the “low” forecast is underway**
- Domestic and International aviation are combined. Based on the UNFCCC inventories of Annex I States, International Aviation accounts for ~60% of global aviation fuel consumption
- Scenario 1 is *Do Nothing* while Scenario 6 is *Optimistic Technology and Operational Improvement*



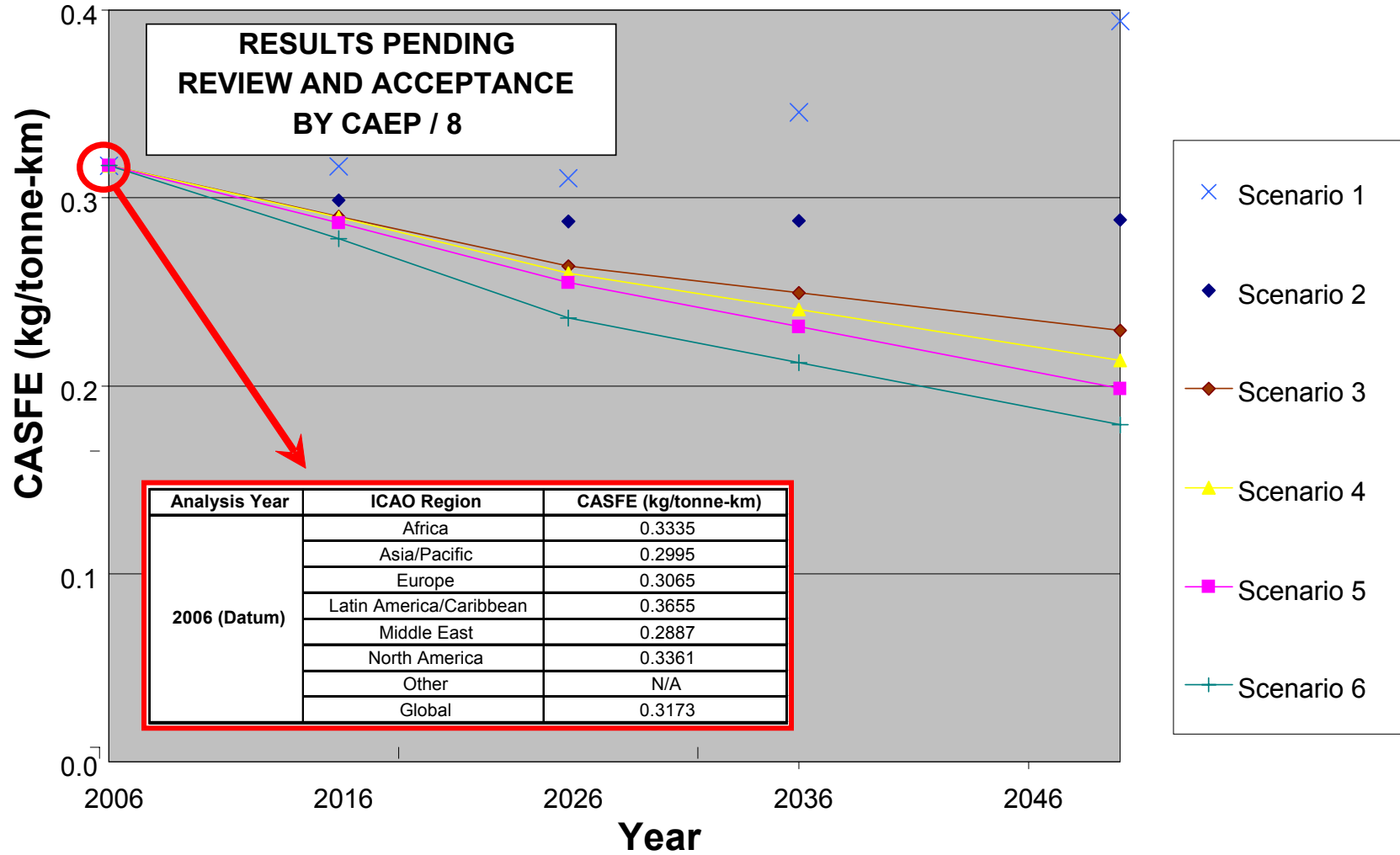
MODTF Total Domestic + International Aviation CO₂

Annual global aviation CO₂ emissions for the range of MODTF scenarios, in millions of tonnes of CO₂

MODTF Scenarios						
Results are in Millions of Tonnes of CO ₂						
Year	1	2	3	4	5	6
2006	591	591	591	591	591	591
2012	815	768	758	758	752	752
2016	954	901	872	872	863	856
2020	1,112	1,052	999	992	980	964
2025	1,371	1,277	1,176	1,163	1,141	1,109
2026	1,435	1,327	1,217	1,255	1,176	1,141
2036	2,373	1,978	1,713	1,653	1,589	1,507
2050	4,531	3,457	2,790	2,639	2,496	2,307

MODTF CAEP Fuel Efficiency Metric

Commercial Aircraft System Fuel Efficiency = $\frac{\text{fuel mass used}}{\text{payload} \times \text{distance}}$



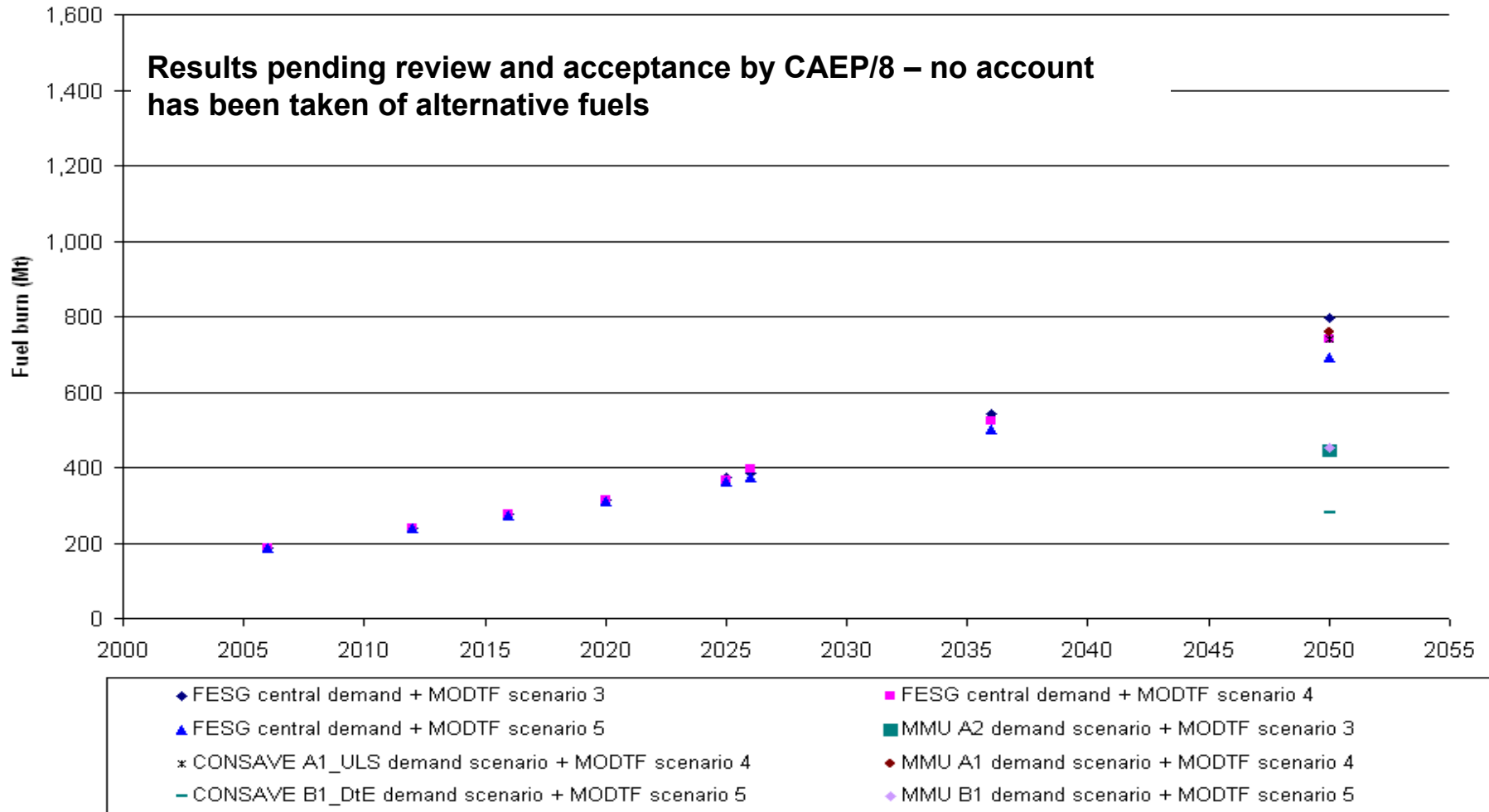
FESG Approach

- FESG investigated the effects of lower levels of demand, while leveraging the fuel burn estimates from MODTF Scenarios 3, 4, and 5

- FESG Demand Scenarios
 - FESG “central” (same as MODTF)
 - MMU A1, A2, B1 – based on the IPCC 1999 scenarios, they examine trends in technological change and economic developments such as increase/decrease in income gap between developed and developing countries.
 - CONSAVE Unlimited Skies (ULS) – vigorous technological innovation
 - CONSAVE Down to Earth (DtE) - air transport regarded very critically for the mainstream



FESG Total Domestic + International Aviation Fuel Burn 2006 – 2050



Conclusions

- Global aviation fuel burn is expected to grow from 190 Mt in 2006 to somewhere in the range 280-1430 Mt in 2050 (likely 730-880)
 - Not accounting for the impact of alternative fuels, CO₂ predicted to grow from 600 Mt in 2006 to lie in the range 890 – 4,520 Mt in 2050 (likely 2,300-2,800)

- On a per-flight basis, efficiency is expected to continue to improve through 2050

- But... even under the most aggressive technology forecast scenarios, **this anticipated gain in efficiency from technological and operational measures does not offset the expected growth in demand driven emissions**

- A growth in emissions relative to the 2006 (or earlier) levels will exist in the future

- A multi-faceted approach toward sustainability is possible from
 - Alternative fuels
 - Unforeseen technological advances
 - Market based measures



Exploring a Fuel Efficiency Metric that Takes Into Account Alternative Fuels (IP/2, CAEP Task #2)

- **Initial view on exploring a fuel efficiency metric that could take into account the net life cycle environmental benefits of alternative fuels**

- Initial view provided by CAEP WG3 (Emissions Technical Working Group) in April 2009:
 - *For kerosene-like “drop-in” fuels, the development of any fuel efficiency metric to include emissions from the life cycle of alternative fuels should be approached essentially as a two-part problem. These parts are an efficiency metric (based on fuel properties/aircraft technology/operational parameters), and a separate analysis taking account of life cycle emissions. CAEP has completed some preliminary work on a Commercial Aircraft System Fuel Efficiency Metric (CASFE).*

 - *Use of non-kerosene-like fuels (e.g. liquid methane and hydrogen) would seriously impact aircraft design and affect fleet mixes; the current CAEP work has not addressed this matter. (Potential CAEP/9 Work Item)*

- The last CAEP SG in September 2008 endorsed the use of the “Commercial Aircraft System Fuel Efficiency Metric (CASFE = Fuel Mass Consumed / Payload × Distance)” for environmental trends/goals assessment, and agreed on further refinement of CASFE metric.



Considering Fuel Conversion Factors between Existing Fuels and Potential Alternative Fuels (IP/2, CAEP Task #3)

- **Initial view on considering fuel conversion factors between existing fuels and potential alternative fuels**
- Initial view provided by CAEP WG3 meeting in April 2009:
 - Assuming this is purely an issue of the differences in the total life cycle emissions of different fuels, then this is substantially independent of the final user, i.e. it is not an aviation specific issue. A consistent methodology needs to be used for all energy uses and is best addressed from the energy supply side. Aviation needs reliable values for fuels that it might use, but does not need to be the developer of the information. We believe that these issues are being addressed by sources outside of CAEP such as US CAAFI (Commercial Aviation Alternative Fuels Initiative) and European SWAFEA (Sustainable Way for Alternative Fuel and Energy in Aviation).
 - Alternatively, if this question deals with CO2 emissions factors then this simply requires knowledge of the fuel composition that would need to be provided by the fuel supplier.
- The IPCC 28th session in April 2008 approved the development of a “Special Report on Renewable Energy Sources and Climate Change Mitigation”, in which one of the elements is the methodologies of life cycle assessment – CAEP and Secretariat will continue to interact with IPCC

Considering the Development of an Aviation CO₂ Standard (IP/2, CAEP Task #4)

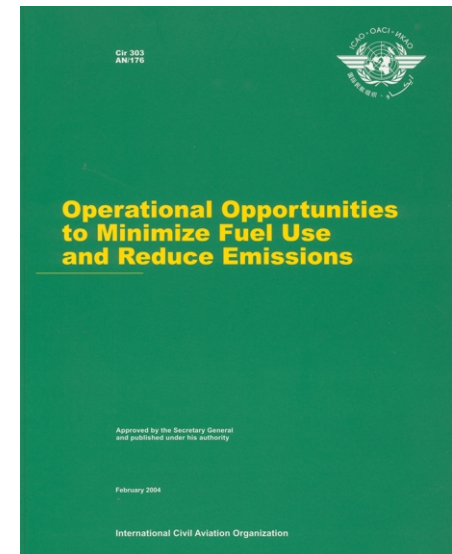
- **Initial view on the development of an aviation CO₂ Standard**
- Initial view provided by CAEP WG3 meeting in April 2009:
 - *CAEP has already devoted significant resources in attempting to develop aircraft efficiency parameters and continues work in related areas. Recognizing the importance of this matter, some major considerations to address the question of setting a CO₂ Standard are the following:*
 - The development of appropriate metric(s) is a key issue that must be addressed as a first step;
 - Any Standard should apply to aircraft, not just engines alone (because integration effect of engine with airframe must be considered, e.g. high bypass-ratio engine improves engine-level fuel efficiency, but may worsen aircraft-level efficiency by related weight and drag increase);
 - It may be easier to develop and implement an accurate methodology if it is based upon and solely applicable to new aircraft (due to complexity to identify methodology for great diversity of in-operation aircraft);
 - It is essential to avoid metrics and methodology that may contribute to perverse incentives and counterproductive influences on aircraft/engine development. Also there is a need to take into account operational considerations in order to avoid unintended consequences;
 - The implications for implementation by certification authorities and manufacturers; and
 - Defining the scope of work could be performed by WG3 to inform CAEP/8 discussion on this issue. (Potential CAEP/9 Work Item)

Considering the Average Weight for Passengers (IP/2, CAEP Task #5)

- **Possible average weight for passengers**
- ICAO and airline associations currently recommend that, if appropriate passenger mass values for their route structure are unknown, for statistical purposes, airlines can apply an average passenger mass value (including baggage) of 90 kg.
- ICAO 14th Statistical Panel in March 2009 agreed that IATA, with the support of ICAO, should inquire from its member airlines if an amendment of the average value for the passenger mass from 90 kg to 100 kg would be advisable – IATA's survey is expected to be presented to the Statistics Division meeting in November 2009 for a final decision.
- Environmental goals assessment being conducted by the CAEP modelling activities assumes an average passenger mass value of 91 kg.
- The ICAO Carbon Calculator assumes an average passenger mass value of 100 kg.

New Guidance Replacing ICAO Circular 303 (IP/2, CAEP Task #6)

- **Status of developing new guidance replacing Circular 303 and of studies on market-based measures**
- In 2004, ICAO published *Operational Opportunities to Minimize Fuel Use and Reduce Emissions (Circular 303)* – basis for Secretariat to provide inputs for the work of GIACC on the list of measures to reduce aviation emissions
- Work in progress in CAEP to develop new guidance replacing Circular 303 by
 - providing new and update information on current initiatives relating to fuel burn reduction
 - including initial information on
 - environmental impact assessment methodology;
 - guidance on computing, assessing and reporting on aviation emissions
 - environmental indicators
- Draft guidance is expected to be considered at CAEP SG in June 2009



Studies on Market-Based Measures (IP/2, CAEP Task #6)

- Work in progress in CAEP was reported to GIACC MBM WG
 - Scoping study on potential for carbon offset measures to mitigate impact of aviation on climate change
 - Identifies the offset measure as having a potential to implement in a short term due to its easy and practical implementation features
 - There is already an internationally accepted tool for the estimate of emissions per passenger (ICAO Carbon Emissions Calculator: www.icao.int) that could facilitate the development of a global offsetting scheme for aviation
 - Scoping study on issues related to linking open ETS including aviation
 - Implementation of different emissions trading schemes throughout the world, with harmonization of features and processes to the extent possible, will highly facilitate the linkage of such schemes enabling the creation of a global scheme.
- Draft reports are expected to be considered at CAEP SG in June 2009



Communication and Coordination with IMO

(Secretariat Task #1)

- **Explore and report the status on communication and coordination between IMO and ICAO**
- Regular conference calls amongst IMO, ICAO and UNFCCC
- Joint preparation of strategies
- Enhanced exchange of information on Environmental meetings between ICAO and IMO
- Tripartite meeting at IMO headquarters in London on 30 April 2009
- Coordination continues for the next Bonn Climate Talks in June



Recent IMO Progress (IP/3 Secretariat Task #1)

- IMO's intersessional meeting of the Greenhouse Gas Working Group 2 (GHG-WG 2) was held from 9 to 13 March 2009
 - Progress was made on technical and operational measures:
 - Energy Efficiency Design Index for new ships;
 - Energy Efficiency Operational Indicator for both new and existing ships; and
 - A Conceptualized Ship Energy Management Plan.
- With regard to market-based measures (MBM), a number of delegations opposed the development of any MBM in light of CBDR
- MECP 57 and 58 discussed the possibility of having a levy on maritime bunker fuels
- MEPC 59 in July 2009 is expected to adopt a package of technical and operational measures, with in-depth discussions on MBM



Developments in the UNFCCC (Bonn Climate Talks) (IP/3, Secretariat Task #5)

- **Support and report the progress in other fora**
- Bonn Climate Change Talks: AWG-LCA5 and AWG-KP7 from 29 March to 8 April 2009
- Focused on further elaborating elements for a draft negotiating text
- AWG-LCA5 relevant issues for aviation were:
 - discussions on emissions reduction goals and on how to consider sectoral goals
 - a proposal from least developed countries (LDCs) for a levy on int. aviation to raise additional funding for adaptation
 - the use of NAMAs (Nationally Appropriate Mitigation Actions) to facilitate the prioritization of technology transfer and financial support for developing countries
- AWG-KP7 discussed sectorals and the possible inclusion of targets for international aviation emissions in post-2012 agreement



AWG-LCA Negotiating Text - FCCC/AWGLCA/2009/8 Paragraphs – 135, 136

- 135. All sectors of the economy should contribute to limiting emissions, including international maritime shipping and aviation. Sectoral approaches could address emissions that cannot be attributed to any particular economy, and multilateral collaborative action would be the most appropriate means to address emissions from international aviation and the maritime transport sector.
- 136. Option 1
- The International Maritime Organization shall be encouraged to continue without delay its activities for the development of policies and measures to reduce GHG emissions, and specifically:
 - (a) To achieve, through the use of its policies and mechanisms, total GHG emission reductions which are at least as ambitious as the total GHG emission reductions under the Convention;
 - (b) To report regularly to the COP {and its subsidiary bodies as appropriate} on relevant activities, emission estimates and achievements in this respect;
 - (c) To report to the COP {at its seventeenth session} on policies, established measures, measures under development, and expected emission reductions resulting from these measures.

AWG-LCA Negotiating Text - FCCC/AWGLCA/2009/8 Paragraphs –137, 138

■ 137. Option 2

Parties shall take the necessary action to reduce emissions of GHGs not controlled by the Montreal Protocol from aviation and marine bunker fuels.

Global reduction targets for such emissions from aviation and marine bunker fuels shall be set as equal to, respectively, {X per cent} and {Y per cent} below {year XXXX} levels in the commitment period {20XX to 20XX}. Units from existing and potential new flexibility mechanisms may contribute towards achieving these targets.

Parties shall work through the International Civil Aviation Organization and the International Maritime Organization to enable effective international agreements to achieve these targets to be approved by 2011. Such agreements should not lead to competitive distortions or carbon leakage. Parties shall assess progress in the implementation of this work, and take action to advance it, as appropriate.

■ 138. Option 3

{Parties}{Annex I Parties} shall pursue limitation or reduction of emissions of GHGs not controlled by the Montreal Protocol from aviation and marine bunker fuels, working through the International Civil Aviation Organization and the International Maritime Organization, respectively.



AWG-LCA Negotiating Text - FCCC/AWGLCA/2009/8

Paragraphs –173 – Financial resources

- 173. New and additional financial resources {shall} be generated through a combination of various sources, including:

Option 1

...

Option 4

Levies on emissions from international aviation {and maritime transport}.

Option 5

An international air passenger adaptation levy/green levy on air fares {, except on journeys originating in and destined for LDCs}.

AWG-KP Negotiating Texts on Further Emission Reduction Commitments for Annex I Parties -FCCC/KP/AWG/2009/8

Paragraph – IV

■ Article 2

Proposal by the EU (emissions from international aviation and maritime bunker fuels)

Replace paragraph 2:

“Parties shall take the necessary action to achieve a reduction of emissions of greenhouse gases not controlled by the Montreal Protocol from international aviation and maritime transport”

Insert the following paragraphs after paragraph 2:

- .2 bis. Global reduction targets for the emissions from international aviation shall be set equal to [X per cent] below 2005 levels in the commitment period [20XX to 20XX].**
- 2 ter Supplemental to action on international aviation Parties may allow units from the mechanisms defined in Articles 6 and 12 [placeholder for new mechanisms] for the purposes of achieving the aforementioned targets.**
- 2 qua Global reduction targets for the emissions from international maritime transport shall be set equal to [Y per cent] below XXXX levels in the commitment period [20XX to 20XX].**
- 2 quin Supplemental to action on maritime transport Parties may allow units from the mechanisms defined in Articles 6, 12, and 17 [placeholder for new mechanisms] for the purposes of achieving the aforementioned targets.**
- 2 sex Parties shall work through the International Civil Aviation Organization and the International Maritime Organization, to enable an effective international agreement to achieve international targets that do not lead to competitive distortions or carbon leakage to be approved by 2011 [or after 2 years from the entry into force of this Protocol]5. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall assess progress of the implementation of this paragraph, and shall take action to advance the implementation, as appropriate”**



AWG-KP Negotiating Texts on Further Emission Reduction Commitments for Annex I Parties -FCCC/KP/AWG/2009/8

- Proposal by Japan

- Amend paragraph 2:

“The Parties shall pursue limitation or reduction of emissions of greenhouse gases not controlled by the Montreal Protocol from aviation and marine bunker fuels, working through the International Civil Aviation Organization and the International Maritime Organization, respectively”



Letter from Yvo de Boer

As I indicated at the meeting, I sincerely hope that the ICAO will agree upon a robust architecture to address emissions of greenhouse gases from international aviation as the culmination of the work that it has been undertaking during the past years in response to the provisions of the Climate Change Convention and Article 2.2 of the Kyoto Protocol. In this regard, I would like to stress again the importance of the ICAO work in various areas, including market-based measures, that could ensure cost-effective emission reductions.

Parties are looking forward to receiving the outcome of this work, including the results of the activities of the ICAO's Group on International Aviation and Climate Change (GIACC). By delivering concrete results to the COP in Copenhagen, including a robust architecture and an implementation programme to address these emissions, ICAO and its member states would be sending a positive signal to the UNFCCC process and to the international community at large. Such results could play an essential role in shaping the way in which emissions from international aviation will be addressed in the framework of the future regime.

ICAO's Work on Aviation and Alternative Fuels

- ICAO hosted a Workshop on Aviation and Alternative Fuels from 10 to 12 February 2009
- **Key outcome: options exist to narrow the “CO₂ emissions gap” that cannot be mitigated with operational and engine technological improvements alone**
- ICAO Conference on Aviation and Alternative Fuels is planned for November 2009 whose agenda includes:
 - Facilitating acceptance of standard methodologies for performing life-cycle (well-to-wake) assessments for alternative aviation fuels
 - Establishing a globally harmonized way of assessing the technology readiness level of aviation fuels
 - Developing a standardized vocabulary and definition of terms used in alternative fuels
 - Developing guidance to facilitate airport/airline/distributor/fuel supplier costs and benefits
 - Helping the stakeholders align, on an international level, roadmaps and programs to ensure bio-fuel supply development is coordinated between aviation, agriculture and renewable fuel interests
 - Promoting national and government-backed infrastructure investments in synthetic and bio-fuel pilot plants and possibly full-scale production facilities

