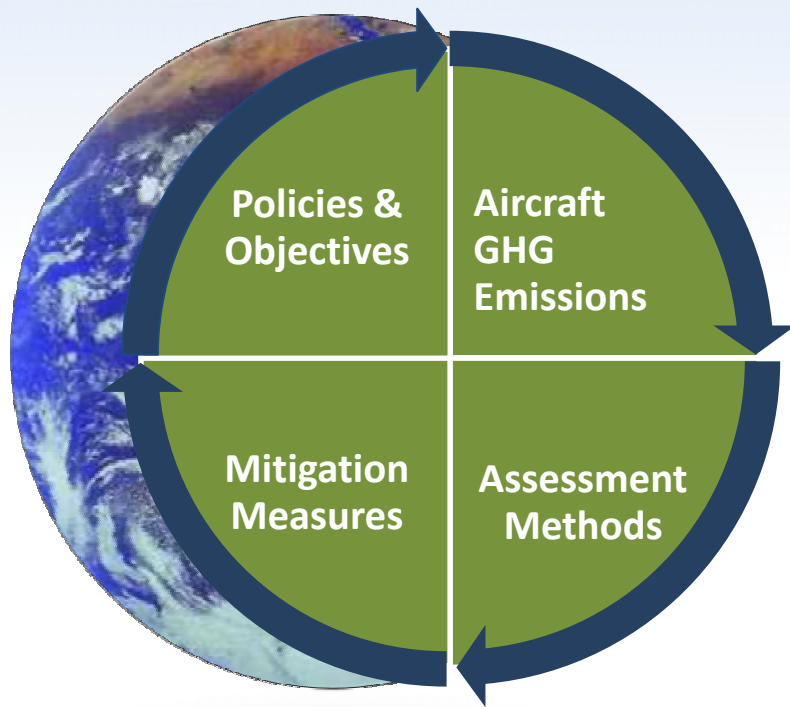




Pre-Colloquium Tutorial



Tuesday, 11 May 2010

9:00 – 17:00

**ICAO Headquarters
Montreal, Canada**



Purpose of the Pre-Colloquium Tutorial

- Provide a broad & basic overview of:
 - Global Climate Change
 - Enable a better understanding of the
 - Aviation-related greenhouse gases.
- Colloquium Sessions & Topics.**



Colloquium Topics



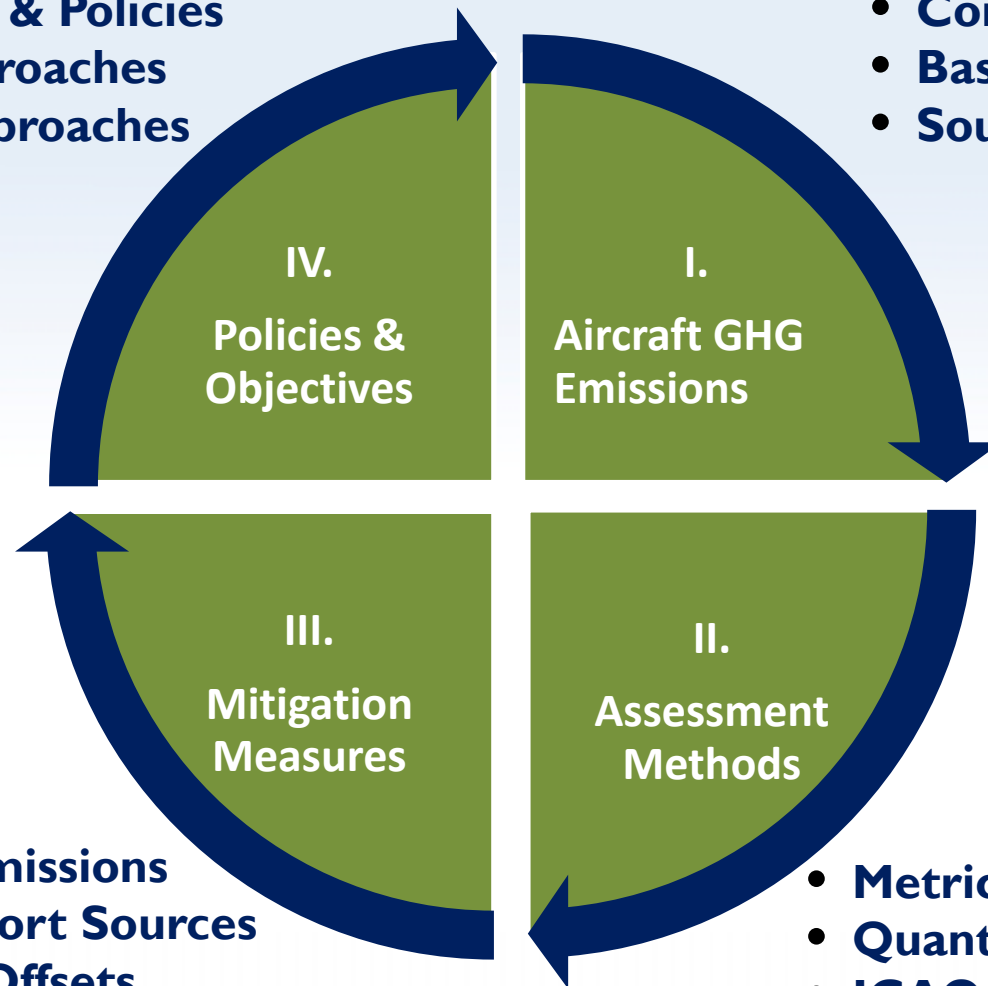
- ❑ Sustainable Aviation
- ❑ Aviation's contribution to global GHG's
- ❑ Advancements in Quantification Methods
- ❑ GHG Emission Mitigation
 - Technological Advancements
 - Operational Opportunities
 - Market-based Measures
 - Alternative Fuels
- ❑ Adaptation
- ❑ Action Plans



Tutorial Curriculum

- **Legislations & Policies**
- **Market Approaches**
- **Aviation Approaches**

- **Common Terms**
- **Basic Concepts**
- **Sources of GHGs**



- **Aircraft Emissions**
- **Other Airport Sources**
- **Credits & Offsets**

- **Metrics & Trends**
- **Quantification Methods**
- **ICAO Carbon Calculator**

Tutorial Applicability Test	Points
If you believe professional wrestling is real and the Apollo moon landing was fake.	+ 10
If you believe that Al Gore discovered global warming & the internet.	+ 10
If you believe that carbon foot-printing is a “CSI” crime scene investigation method.	+ 10
<i>Subtotal</i>	[0 to +30]
People address me by Dr...., Sir..., or Noble Prize-Winning...	-10
I have memorized the Global Warming Potential values for all six Kyoto Protocol greenhouse gases.	-10
People are not sitting near me because I road my bike 40 km to this Colloquium to minimize my climate impact.	-10
<i>Subtotal</i>	[0 to -30]
Total Points	[-30 to +30]

Tutorial Applicability Test Results

20 – 30 pts.

- I could possibly benefit by attending this tutorial.

0 – 20 pts.

- Heck, I am already here so I might as well stick around. Maybe they will give away some cool prizes.

> 0 pts.

- My time will be better spent watching the last episode of *American Idol*.

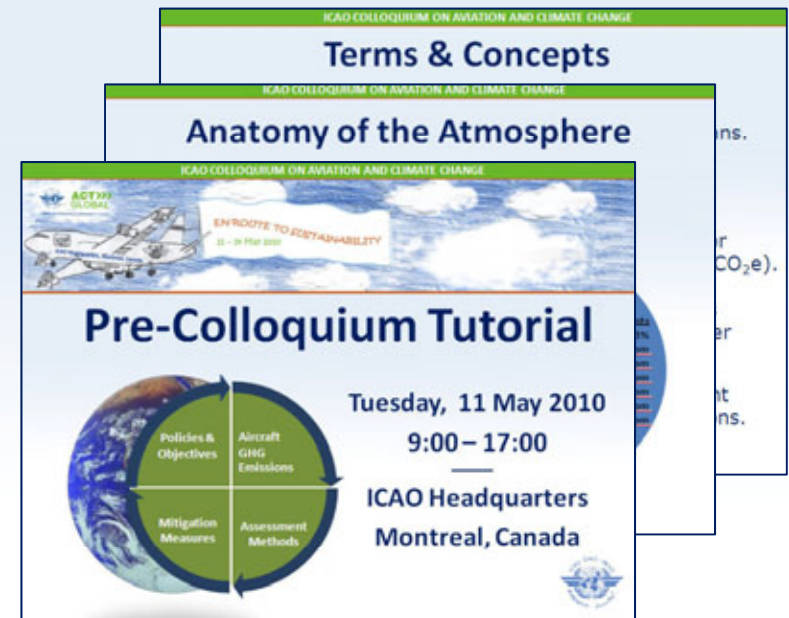
Tutorial Programme

- ➔ ○ 9:00 - 10:30 **Session 1: *Aircraft GHG Emissions***
- 10:30 - 11:00 **- *Coffee Break* -**
- ➔ ○ 11:00 - 13:00 **Session 2: *Assessment Methods***
- 13:00 - 14:00 **- *Lunch Break* -**
- ➔ ○ 14:00 - 15:30 **Session 3: *Mitigation Measures***
- 15:30 - 16:00 **- *Coffee Break* -**
- ➔ ○ 16:00 - 17:00 **Session 4: *Policies & Objectives***
- *Adjournment* -**

Tutorial Materials

Handouts

- ❑ Schedule & Roster
- ❑ Tutorial Viewgraphs
- ❑ Tutorial Evaluation Form



“Post-it” Note Board



Instructors

Michael Kenney, KB Environmental Sciences, Inc.

- **B.S./M.S. Environmental Sciences (Air Quality)**
- **25+ years experience**
- **Airport Air Quality Specialist**



Ted Thrasher, ICAO

- **B.S. Aviation Engineering**
- **15+ years experience**
- **Environmental Officer, Modeling & Analyses**

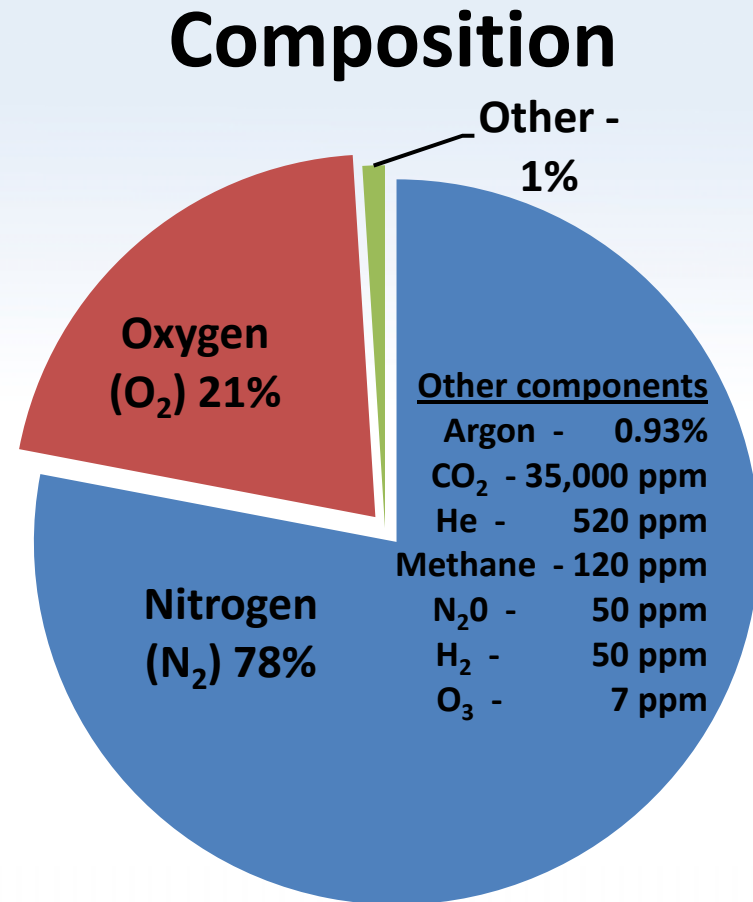
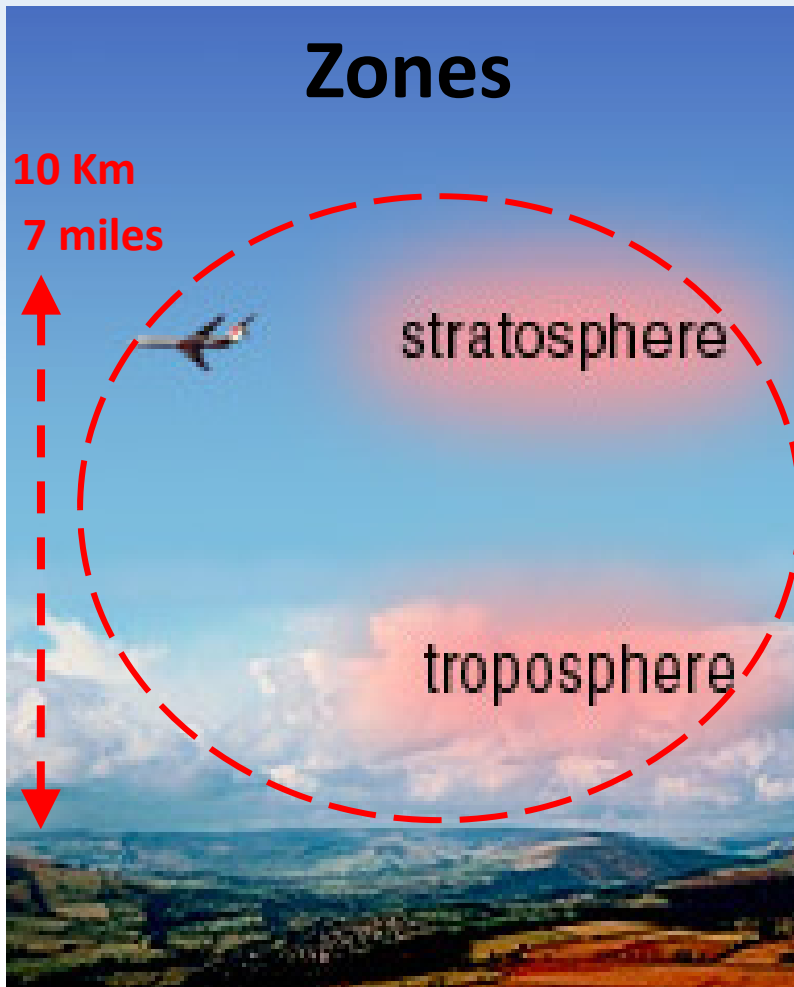


Session I: Aircraft GHG Emissions

- ❑ **Common Terms**
- ❑ **Basic Concepts**
- ❑ **Sources of GHGs**



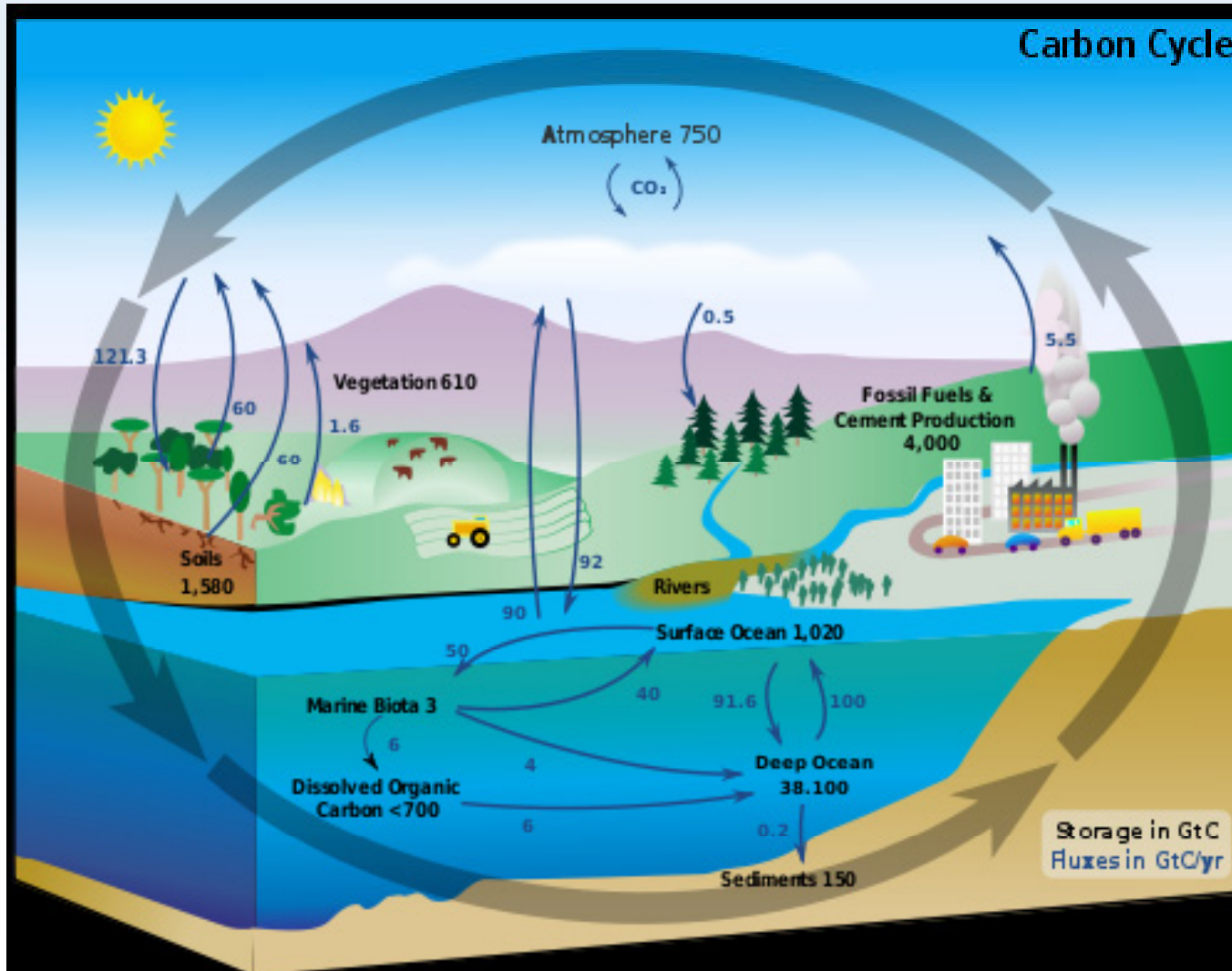
Anatomy of the Atmosphere



Terms & Concepts

- ❑ **Carbon Cycle** – Process by which carbon moves between the earth's atmosphere, land and the oceans.
- ❑ **Carbon Dioxide** – One of the most important and abundant of the Greenhouse Gases.
- ❑ **Carbon Dioxide Equivalents** – A unified metric for normalizing effects of different GHG's (CO₂e).*
- ❑ **Carbon Footprint** – The sum of all GHG emissions caused directly or indirectly by human activities over a given timeframe.
- ❑ **Carbon Neutral** – Having a net "0" carbon footprint by balancing the measured amount of GHG emissions.*

Carbon Cycle

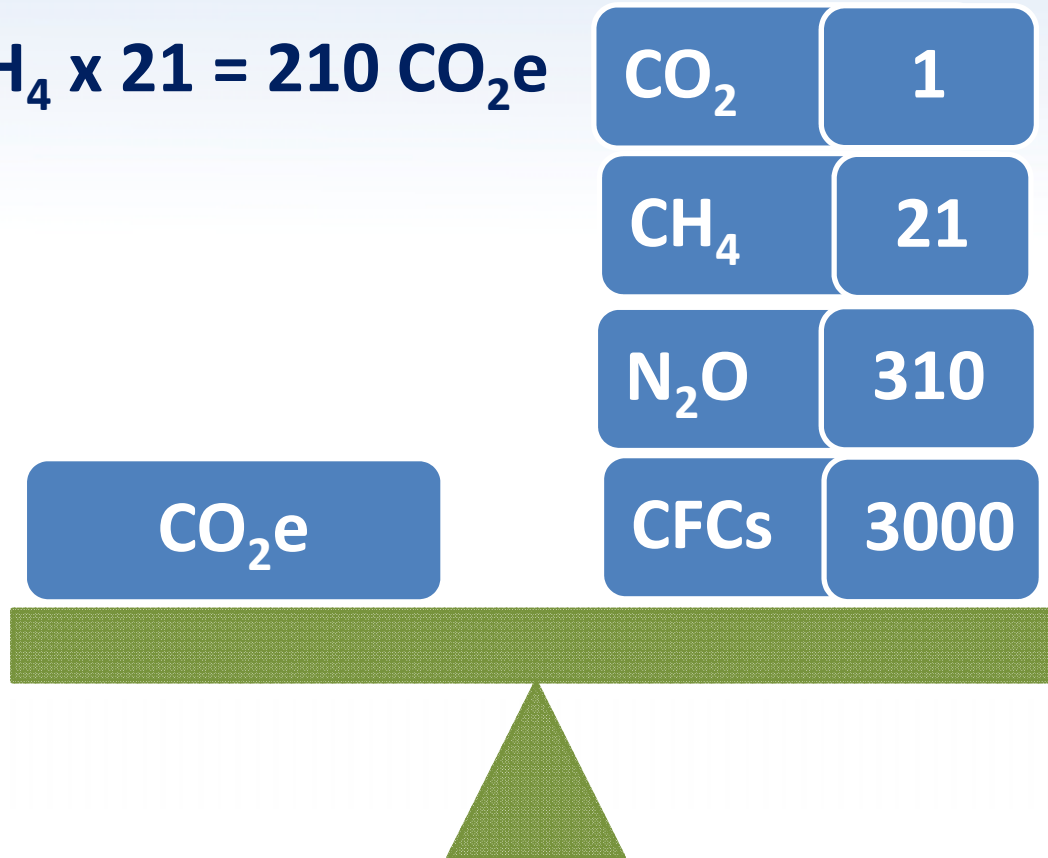


Carbon Dioxide Equivalents

Example

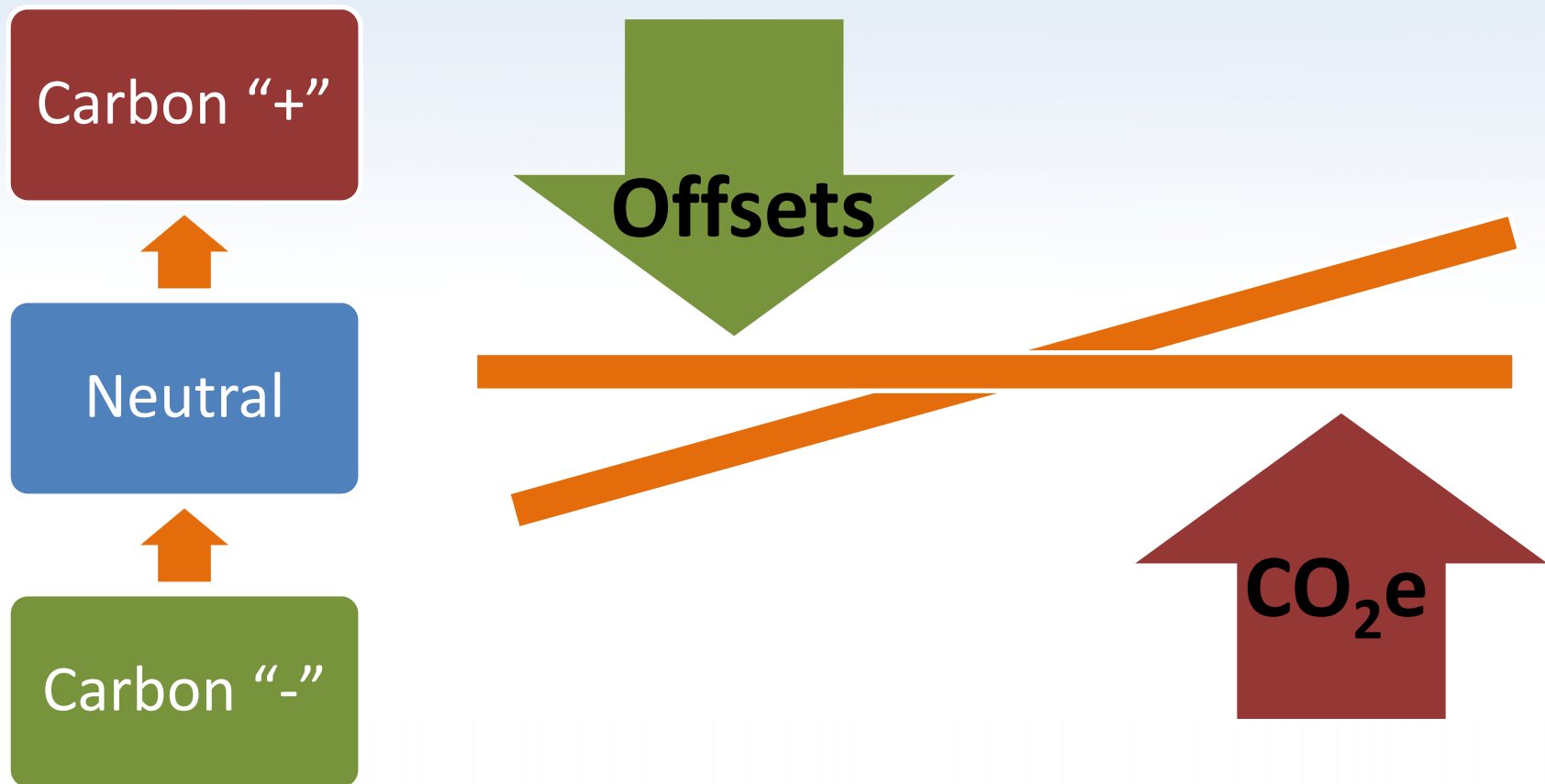
$$10 \text{ MT CH}_4 \times 21 = 210 \text{ CO}_2\text{e}$$

Global Warming Potentials



Carbon Neutral

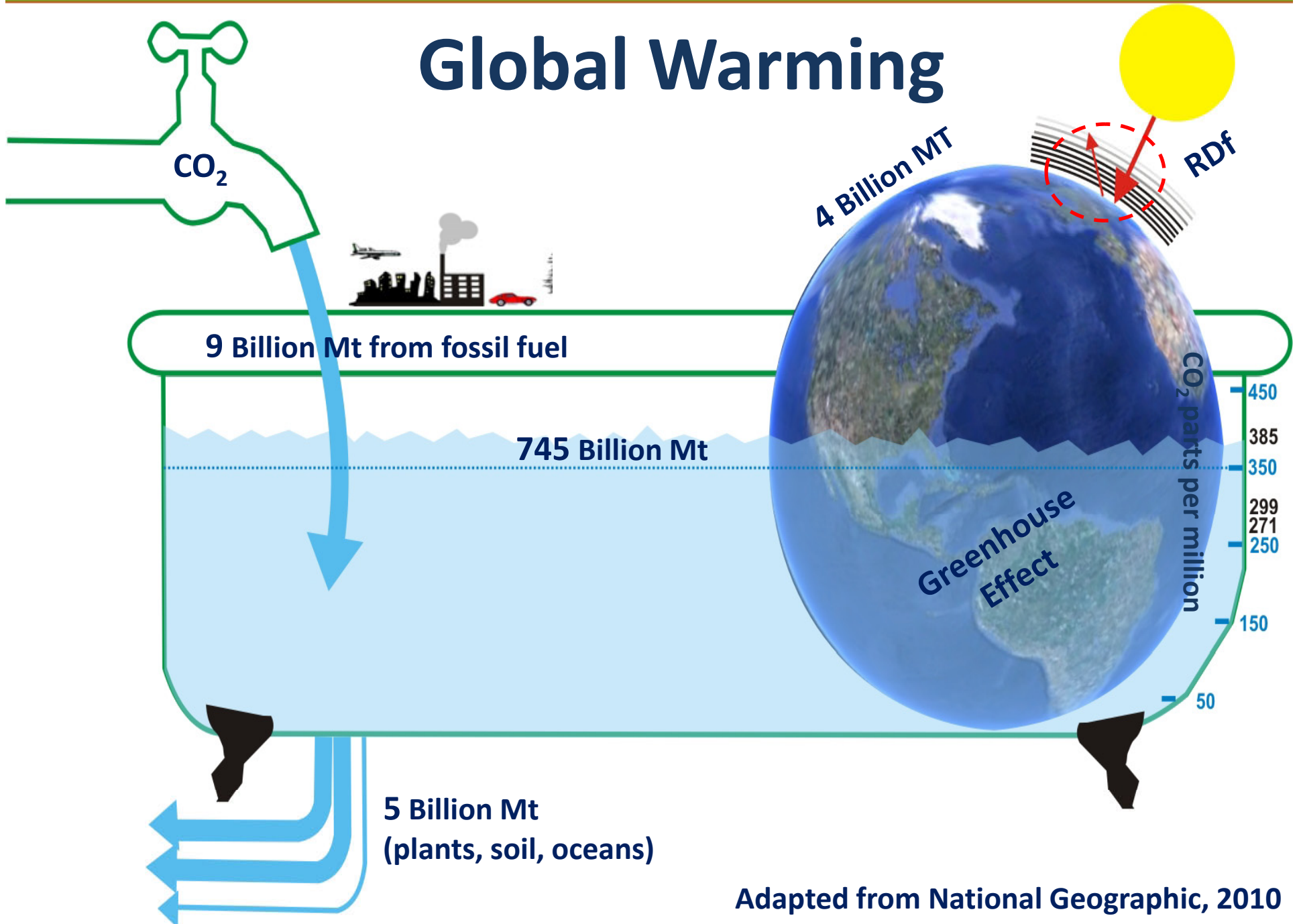
“Net” Balancing of Carbon Emissions



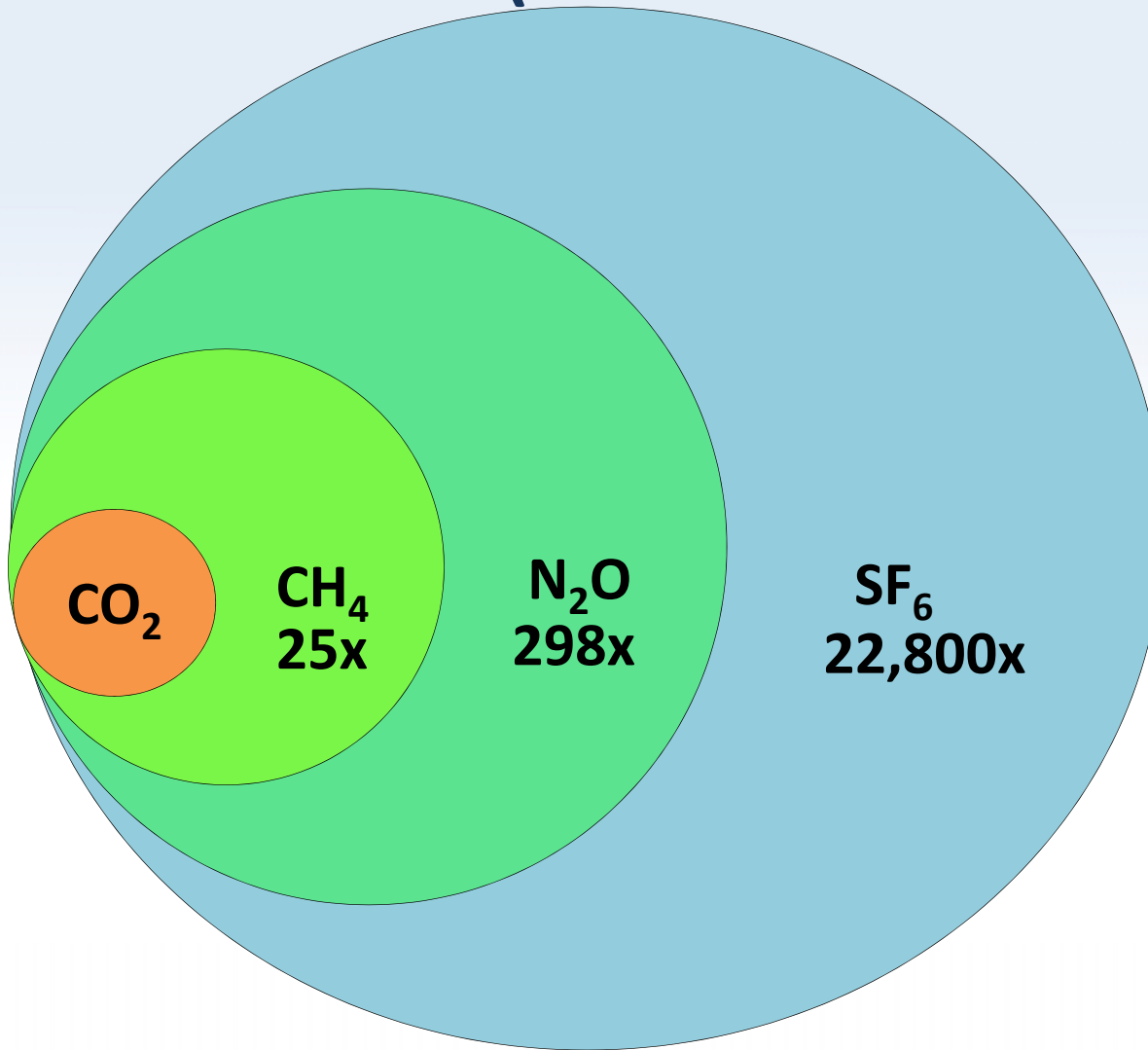
Terms & Concepts

- ❑ **Climate Change** – A change in climate due to a change in the global atmosphere and beyond natural variability.
- ❑ **Global Warming** – The persistent increase in the earth's mean temperature, relative to long-term trends.
- ❑ **Global Warming Potentials** – An index that compares the impact of a GHG relative to CO₂ (GWP).
- ❑ **Greenhouse Effect** – The process that maintains the earth's mean surface temperature.....
- ❑ **Greenhouse Gases** – Atmospheric gases that absorb earth's outgoing radiation and reemit it back to earth.

Global Warming



GHG Global Warming Potentials (100-Year Time Horizon)



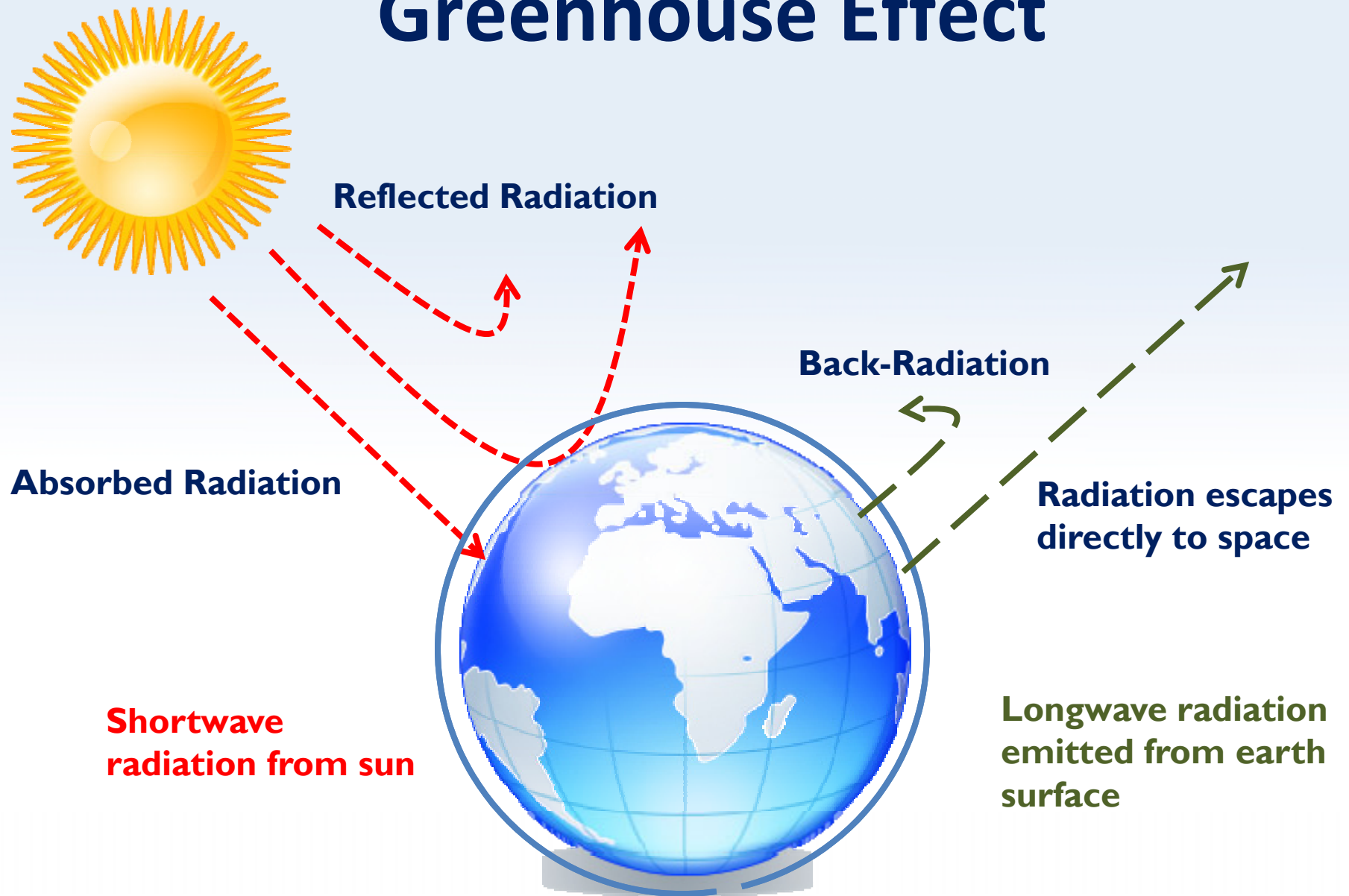
Based upon:

- Infrared absorbing ability
- Atmospheric decay rate

Compared to CO₂

Graphic not to scale.

Greenhouse Effect



Greenhouse Gases



- Carbon Dioxide
- Natural Respiration, Fuel Combustion, Cement Production



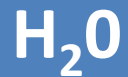
- Methane
- Waste refection, livestock, fossil fuels



- Nitrous Oxide
- Industrial processes

Session 1. *Aviation's Current and Future Contributions to GHG Global Emissions;*
by Lee, Schuman, Waitz, Sausen
11.00 – 12.30 Weds.

- Hydrofluoromethane, sulfur hexa-floride
- Chemicals



- Water vapor
- Natural Respiration, Fuel Combustion



- Ozone
- NOx and reactive volatile organic compounds

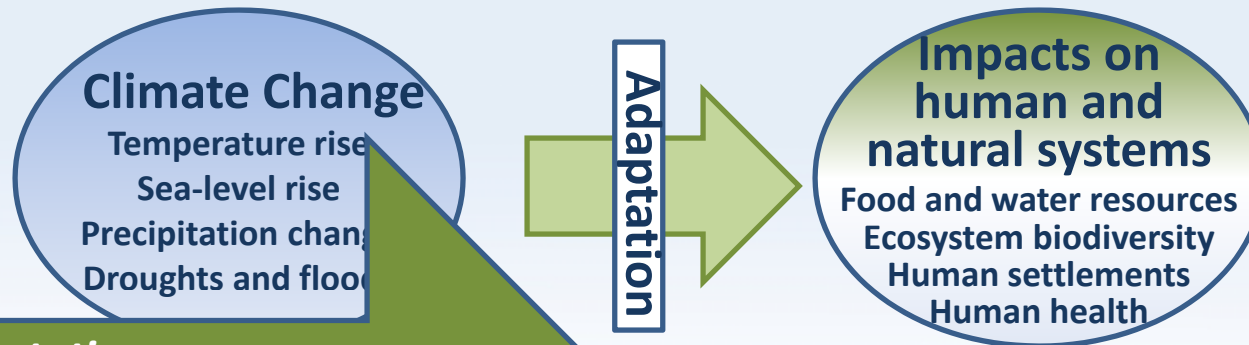


- Nitrogen Oxides
- Fuel combustion

Terms & Concepts

- ❑ **Adaptation** – Actions by humans and environmental systems to accommodate impacts of climate change.
- ❑ **Environmental Sustainability** – Conditions that meet the needs of the present generation without compromising the those in the future.
- ❑ **Lifecycle Assessment** – The assessment of the environmental footprint produced at every stage of a product's or action's lifecycle.
- ❑ **Mitigation Measures** – Methods to reduce, eliminate or compensate for adverse environmental effects.
- ❑ **Radiative Forcing** – the net imbalance of the lower atmosphere due to human activities over the past 2000 years.

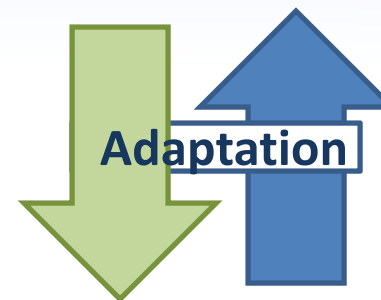
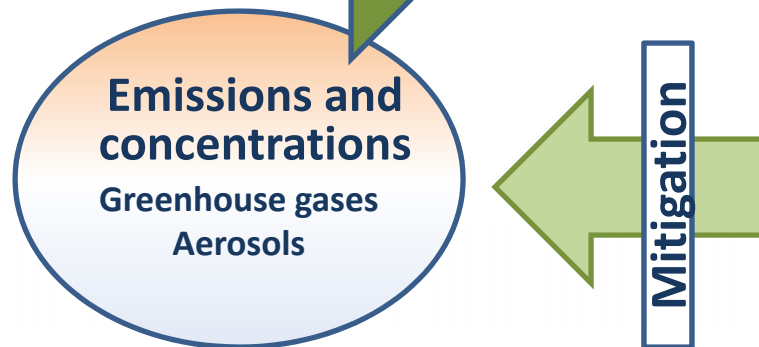
Adaptation



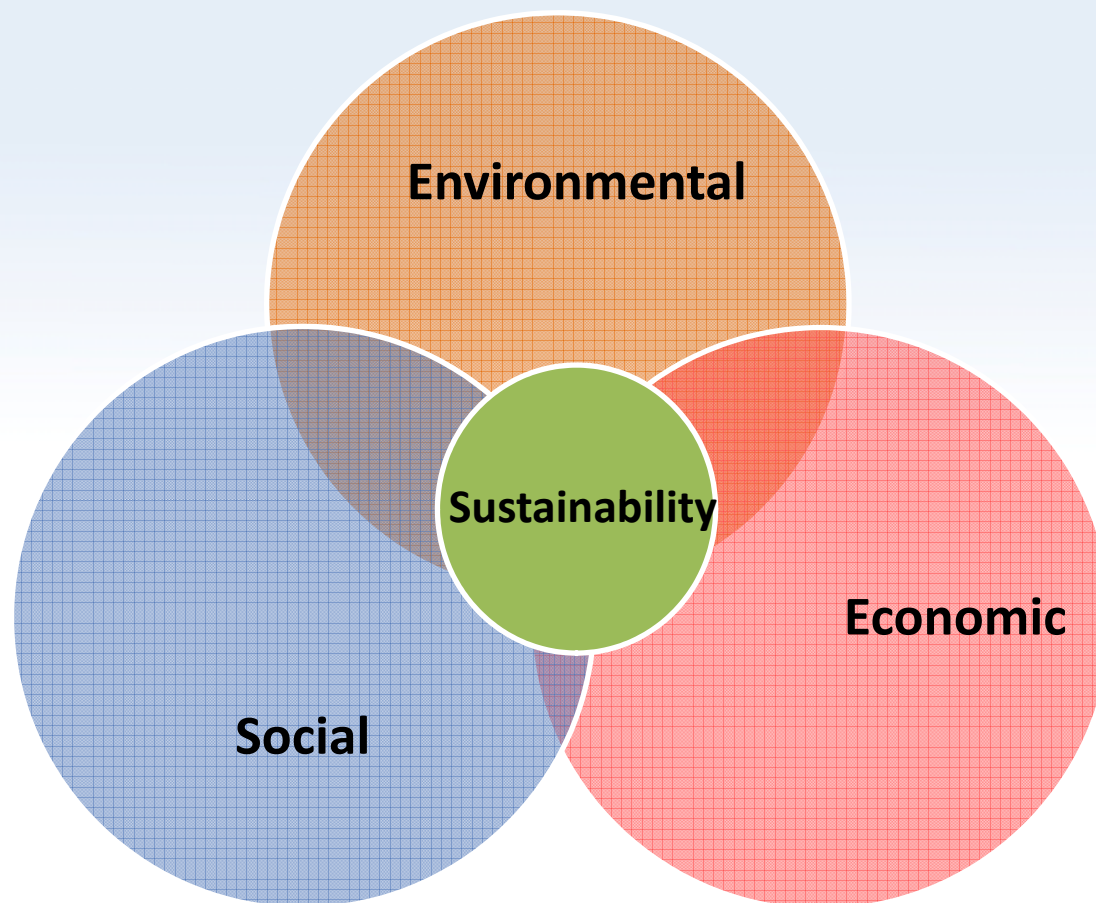
Session 6. Adaptation

By Mayora, Lyle, Puempel, Melrose, Larsen

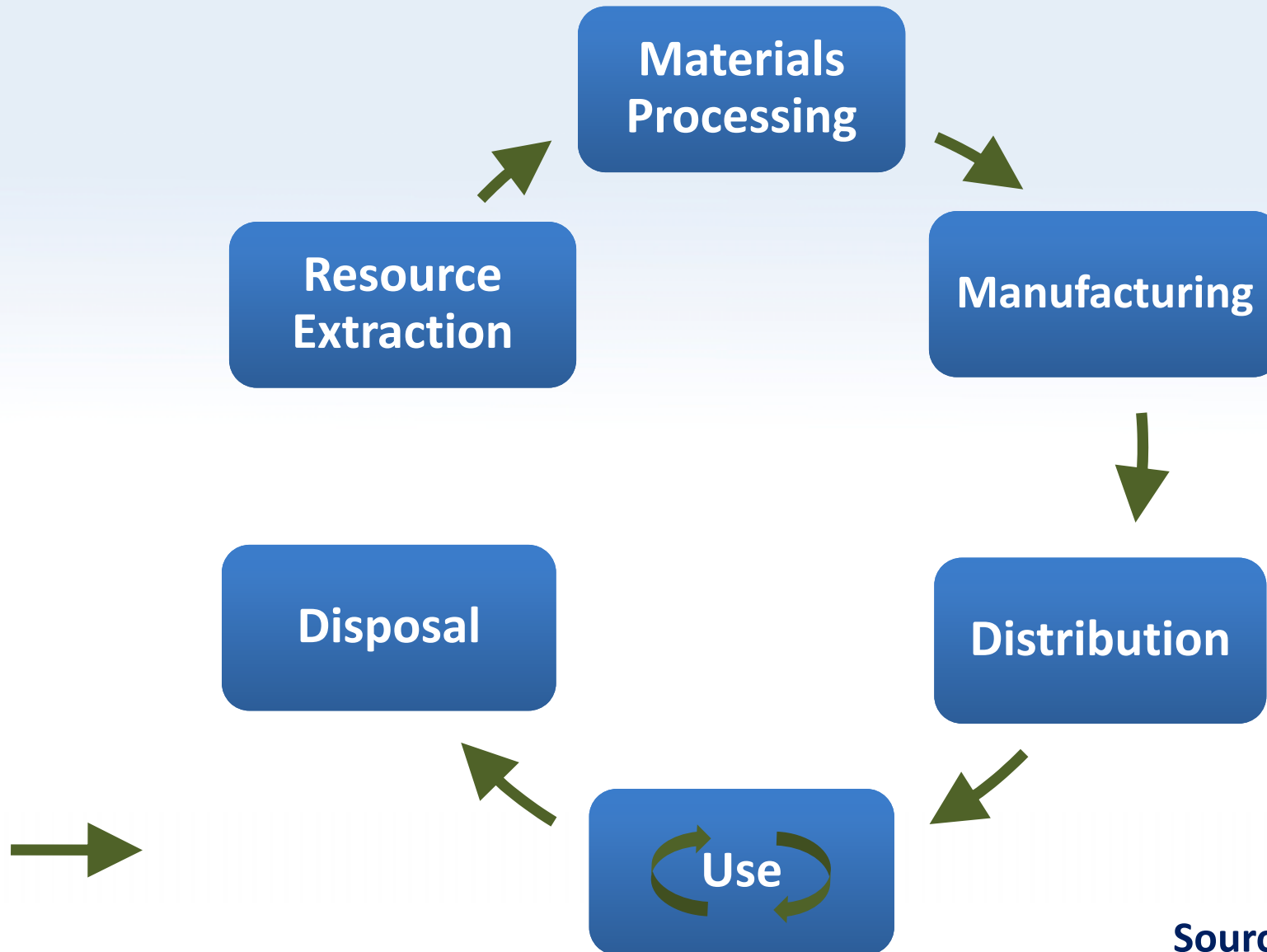
16.30 – 17.30 Thurs.



Environmental Sustainability



Life Cycle Emissions

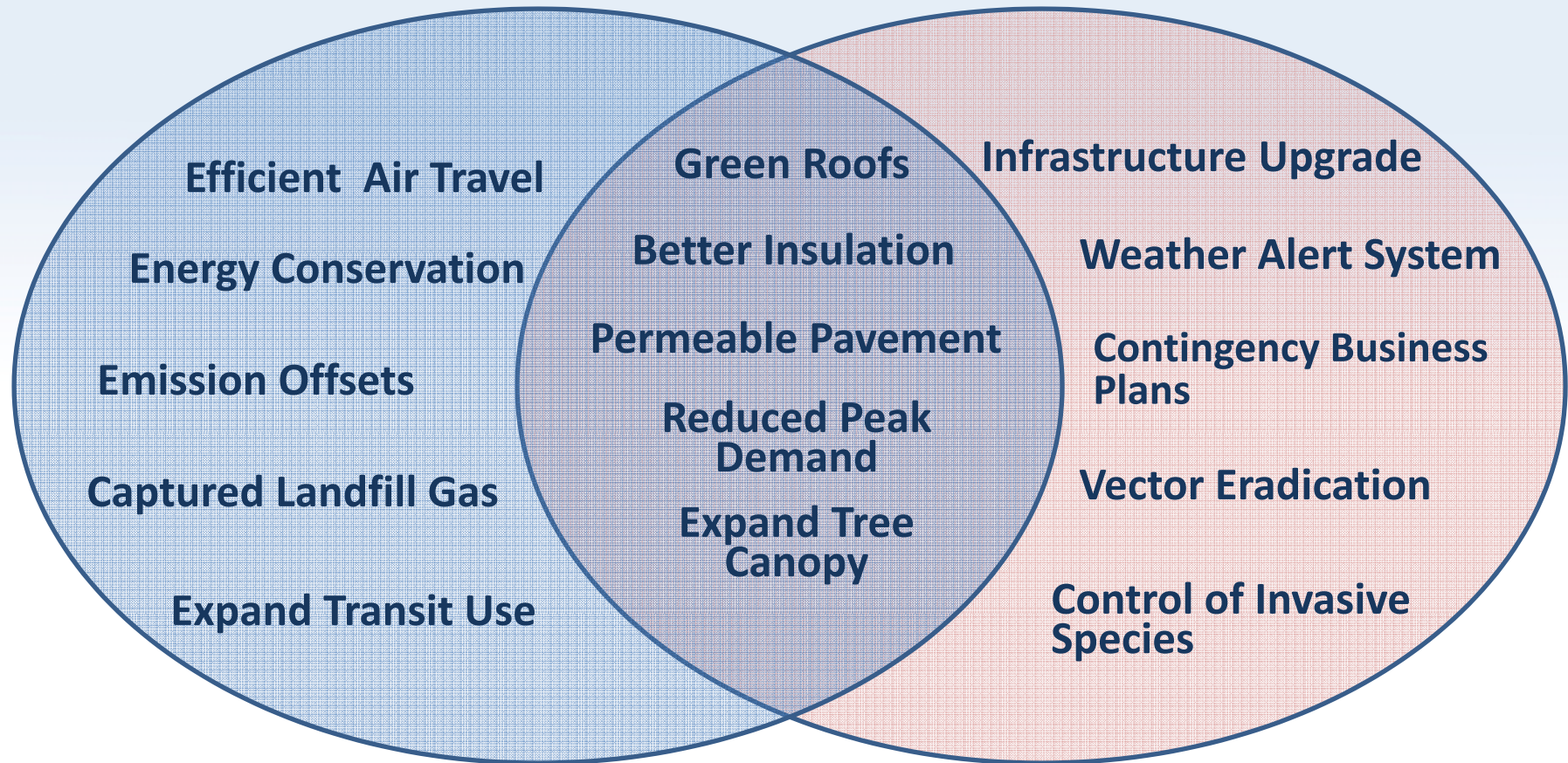


Source: KBE, 2010

Mitigation

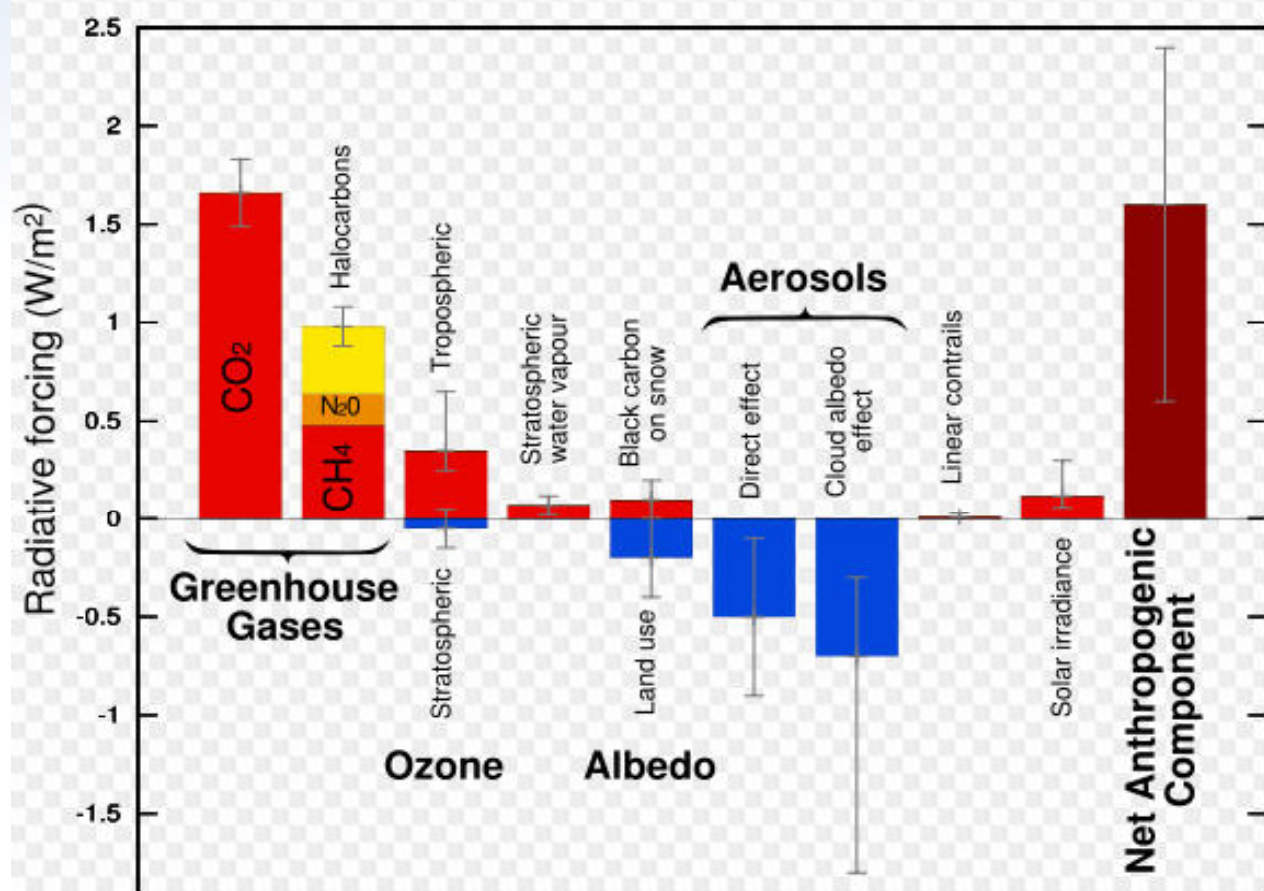
Mitigation

Adaptation



Source: Penney, J., 2008,
“Emerging Climate Change Adaption Strategies,” Clean Air Partnership

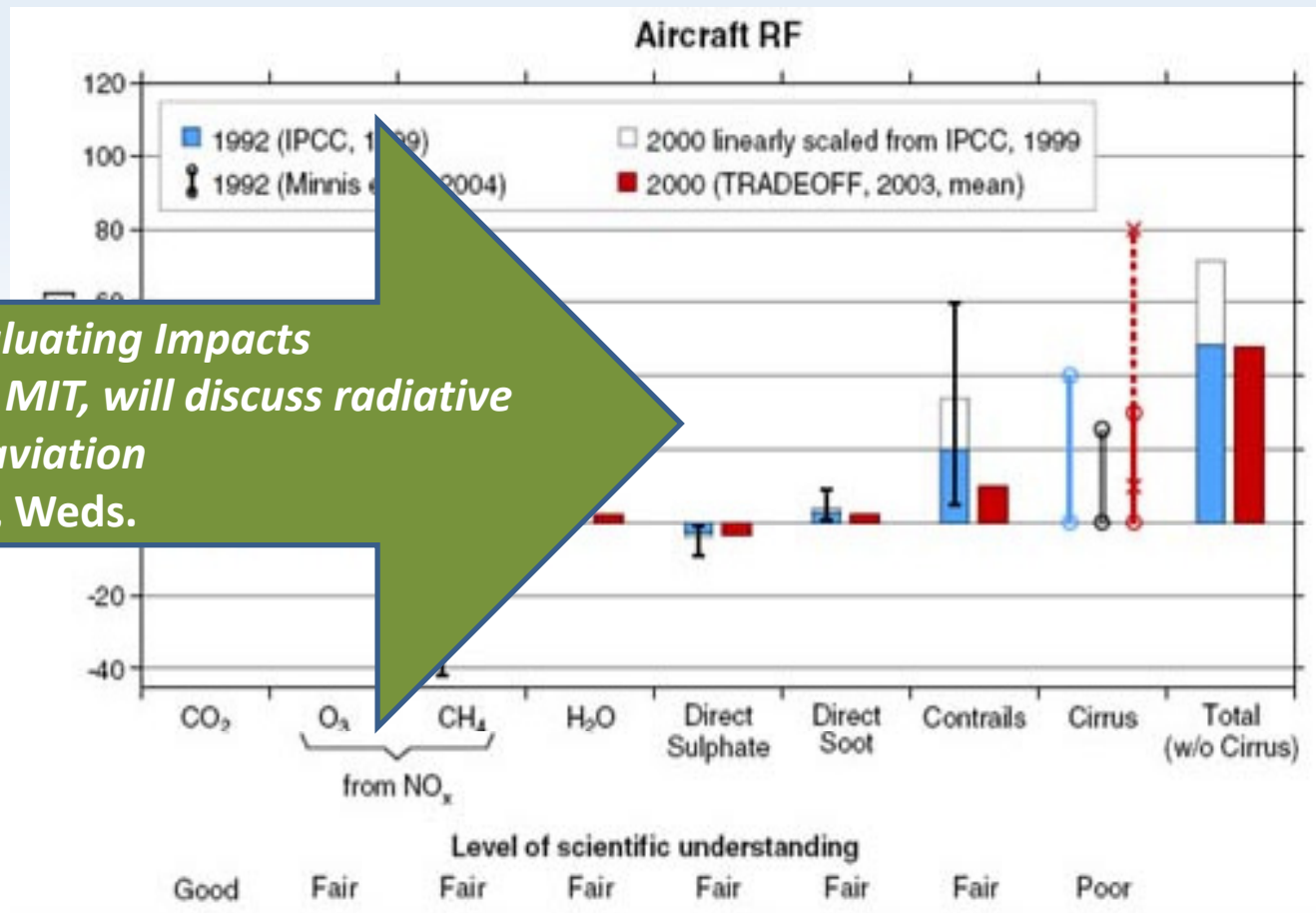
Man Made Radiative Forcing Measures



Source: IPCC

Radiative Forcing from Aviation

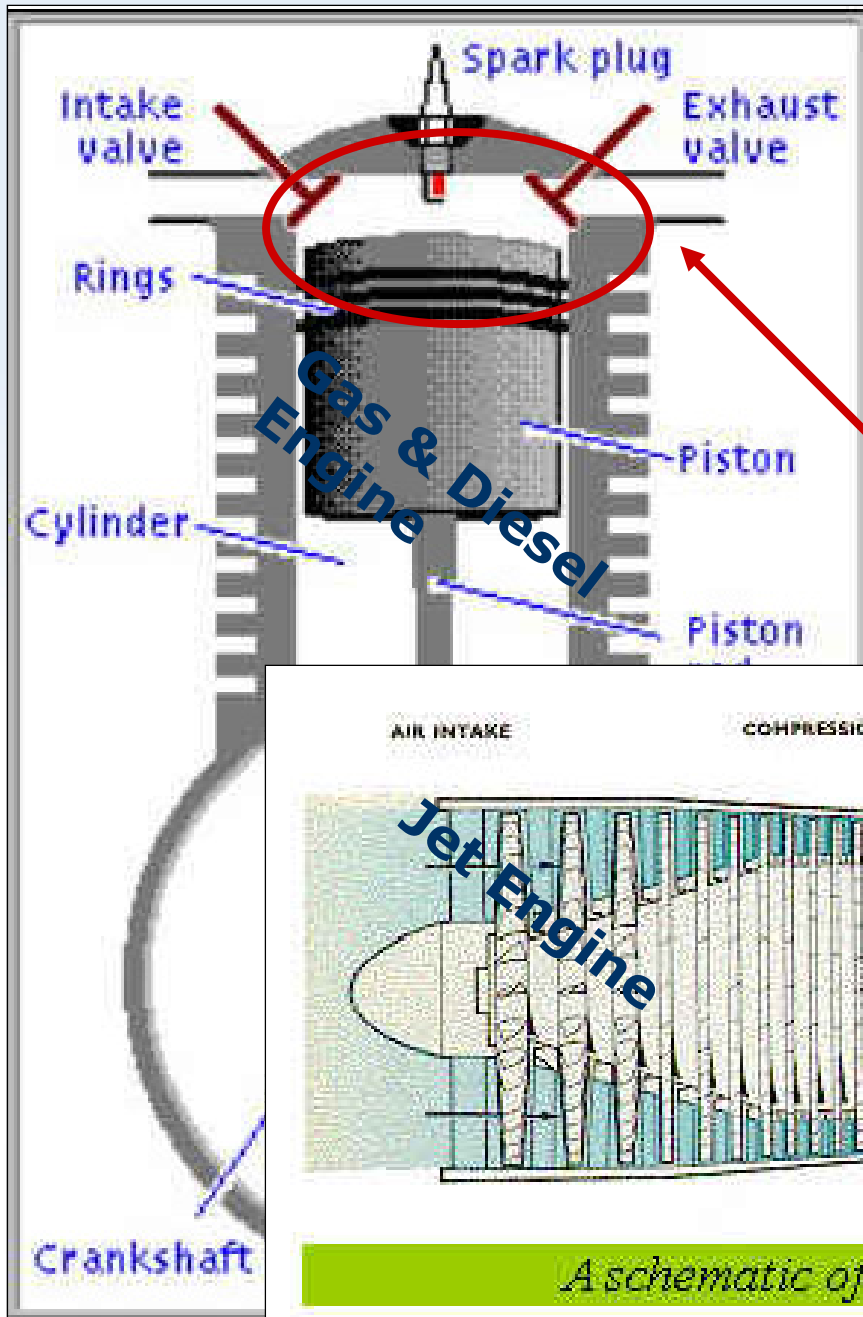
Session 1. Evaluating Impacts
 Dr. Ian Waitz, MIT, will discuss radiative forcing from aviation
 11.00 – 12.30, Weds.



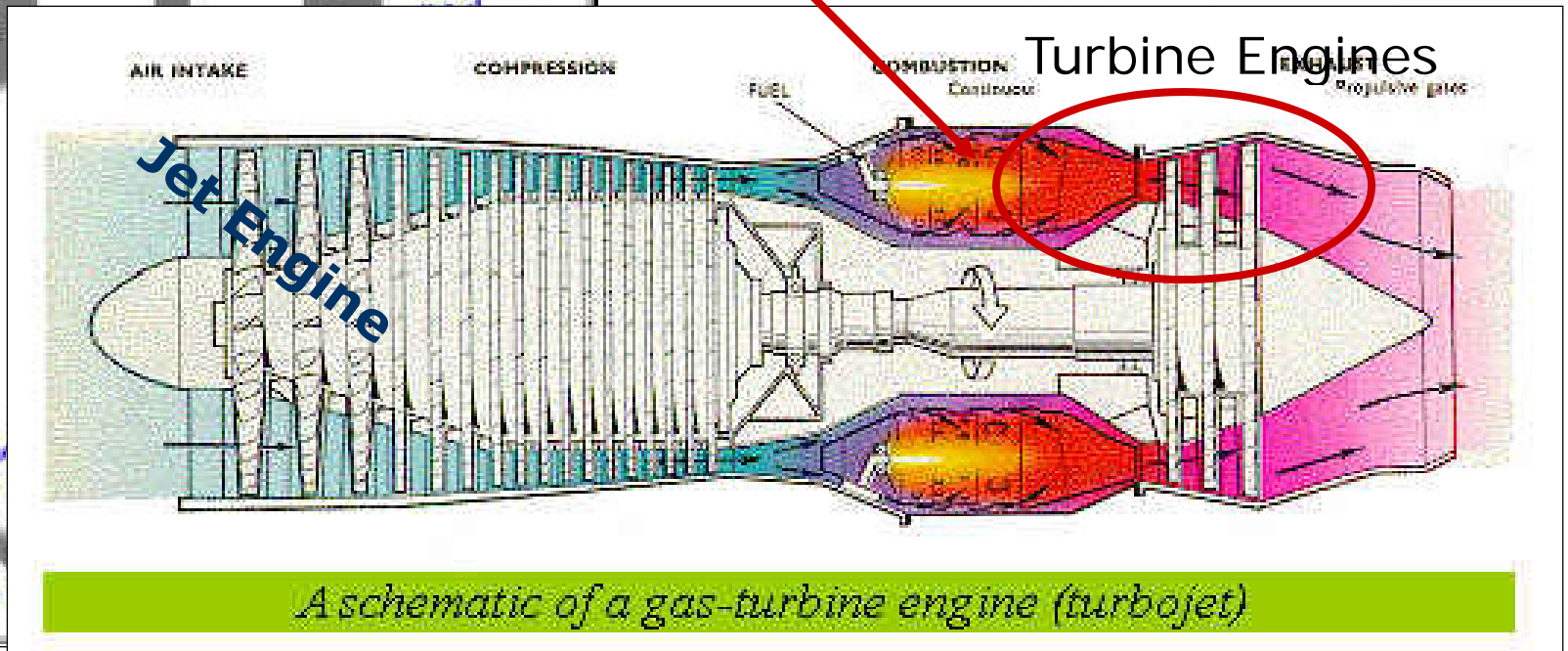
Acronyms

- **CAEP** – Committee on Aviation Environmental Protection
- **GHG** – Greenhouse Gases
- **GIACC** – Group on International Aviation & Climate Change
- **IATA** – International Air Transport Association
- **ICAO** – International Civil Aviation Organization
- **IPCC** – Intergovernmental Panel on Climate Change
- **UNFCCC** – United Nations Framework Convention on Climate Change

Mechanics of Combustion



Combustion Zone



A schematic of a gas-turbine engine (turbojet)

Fundamentals of Combustion

1. “Ideal” World Conditions



2. “Real” World Conditions



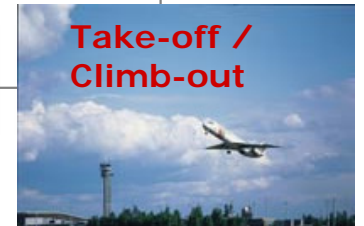
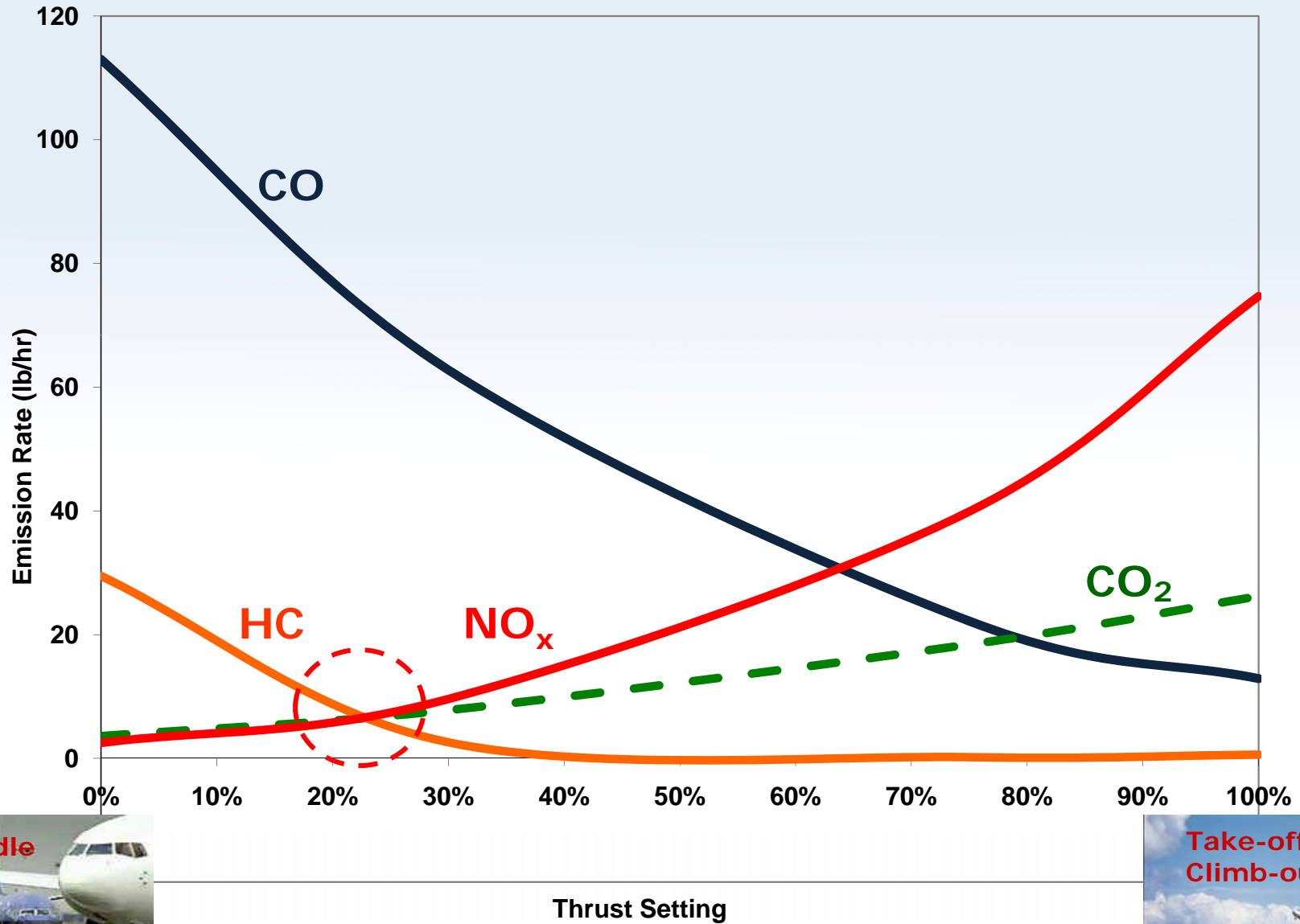
HC

HAPs - Hazardous Air Pollutants
 VOCs - Benzene, toluene
 Carbonyls - Formaldehyde
 SVOCs - Naphthalene

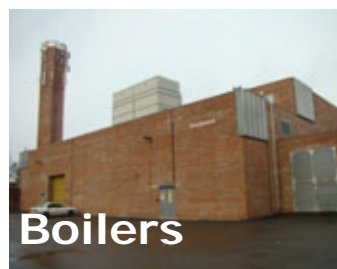
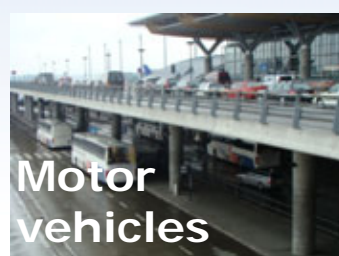
PM

PM₁₀ - Repairable (≤10 μ)
 PM_{2.5} - Fine (≤2.5 μ)
 PM_{0.1} - Ultrafine (≤0.1 μ)
 BC - Black (Elemental) Carbon
 Soot

Aircraft Engine Emissions vs. Thrust Settings



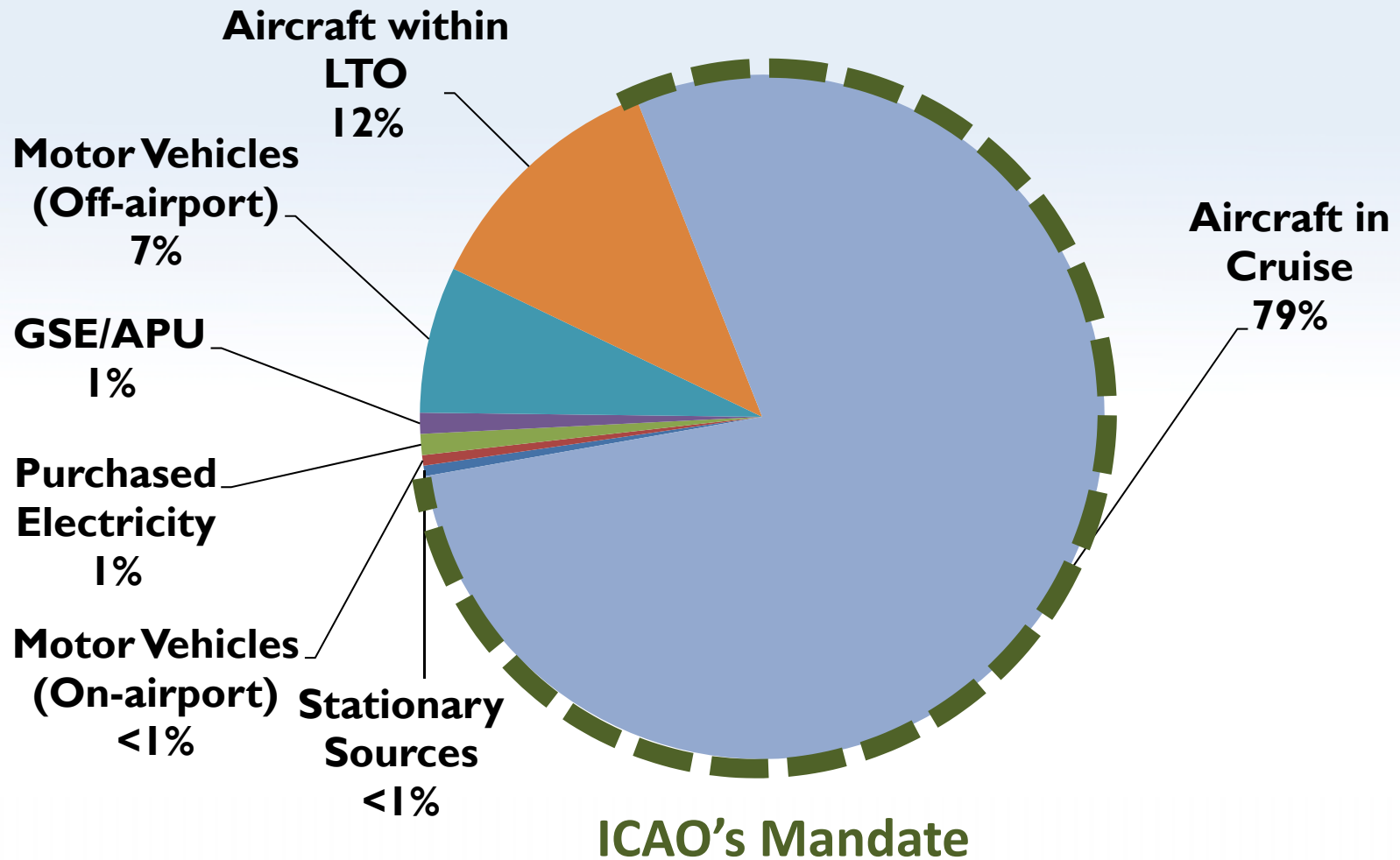
Aviation Sources of GHG Emissions



Airport GHG Emissions Sources

GHG	Source	General Characteristics
✓	Aircraft	Civil/Commercial/Passenger; Cargo; General Aviation; Military; Helicopter.
✓	Ground Support Equipment (GSE)	Baggage tug, push-back tractor, fuel truck, cabin service truck, deicing equipment.
✓	Auxiliary Power Units (APU)	On-airplane engines for gate power and electricity.
✓	Motor Vehicles	Patron, employee, cargo vehicles; rental cars; transit buses; shuttle vans;
✓	Stationary Sources	Boilers, heaters, incinerators, snow melters, emergency generators.
-	Fuel Facilities	Evaporative emissions of hydrocarbons.
✓	Fire Training Facility	Live-fire training facility using jet fuel or propane.
✓	Infrastructure & Buildings	Electricity produced by fossil fuels and CFCs for refrigeration and air conditioning.
✓	Construction Activities	Construction vehicles and heavy "off-road" equipment ; concrete/asphalt plants: material stockpiles; fugitive dust.

Airport-Related GHG Emissions Sources



Source: KBE, 2010

Session I Summary

Common Terms

- ✓ Carbon Cycle
- ✓ Lifecycle Assessment

Basic Concepts

- ✓ CO₂ and fuel combustion
- ✓ Radiative forcing

Connecting the
Dots



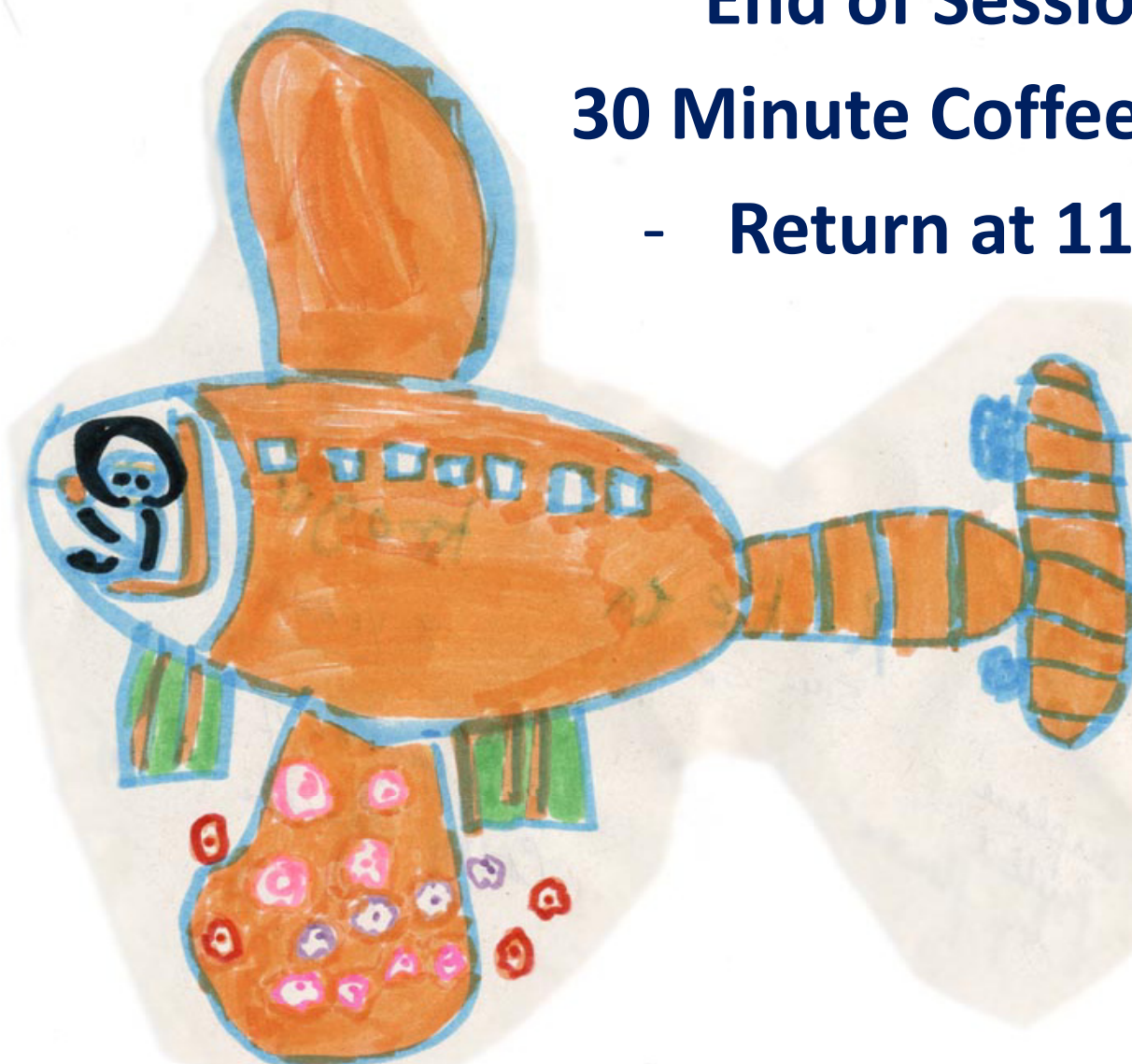
Emission Sources

- ✓ Aircraft largest source associated with airports
- ✓ Aircraft emissions ICAO

Session I.
Aircraft GHG
Emissions

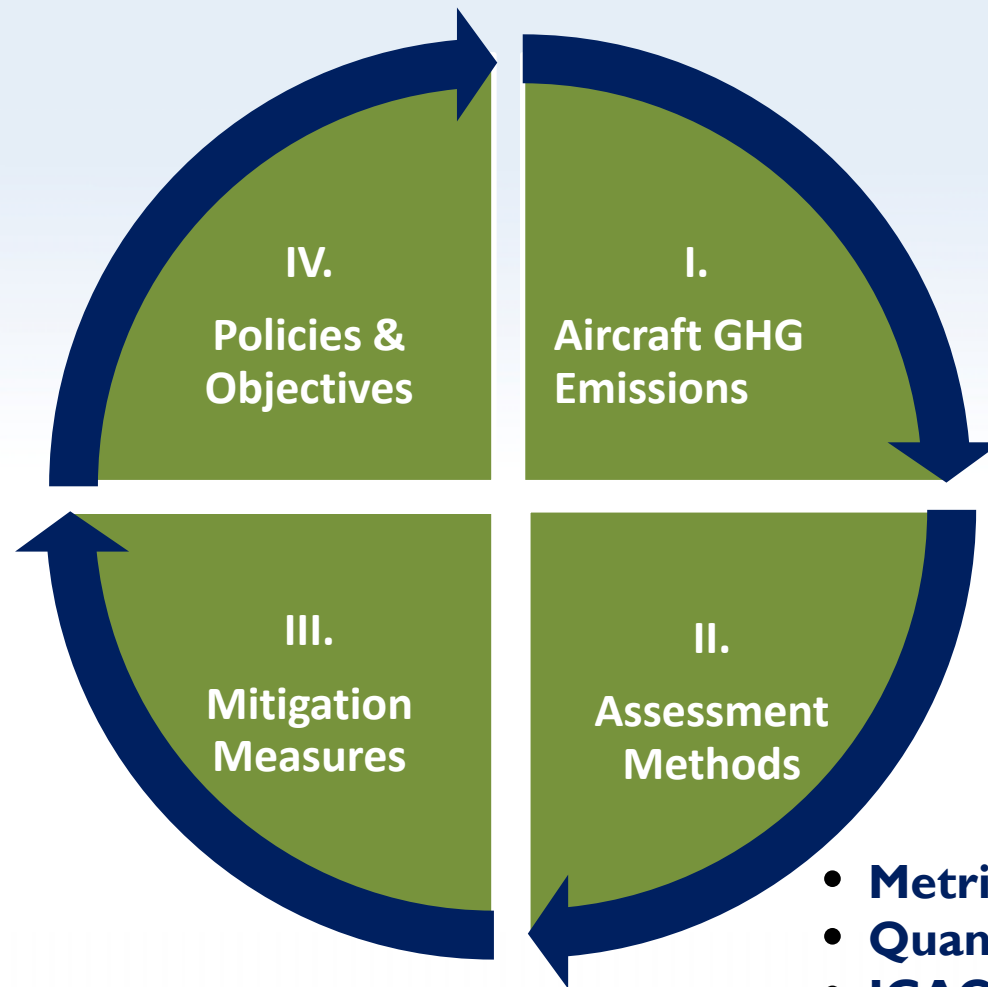


End of Session I
30 Minute Coffee Break
- Return at 11:00 -



*Artwork from ICAO's Aviation in a
Green Environment Contest*

Session II: Assessment Methods



- **Metrics & Trends**
- **Quantification Methods**
- **ICAO Carbon Calculator**

Common GHG Metrics

MT

- Metric ton (M), Million Metric Ton (MT), Giga Ton (Gt)
- Based on amount and molecular weights of GHG compounds

Session 2. Aviation Emissions Quantification
 By Fleming, Thrasher, Johnson. Howard,
 Burt, Oh, Pesmajogiou & EU
 14.00 – 15.30 Weds.

GWP

- Global Warming Potential
- Adjusts warming power of individual GHG to the equivalent warming effect of CO₂ (per unit of mass)

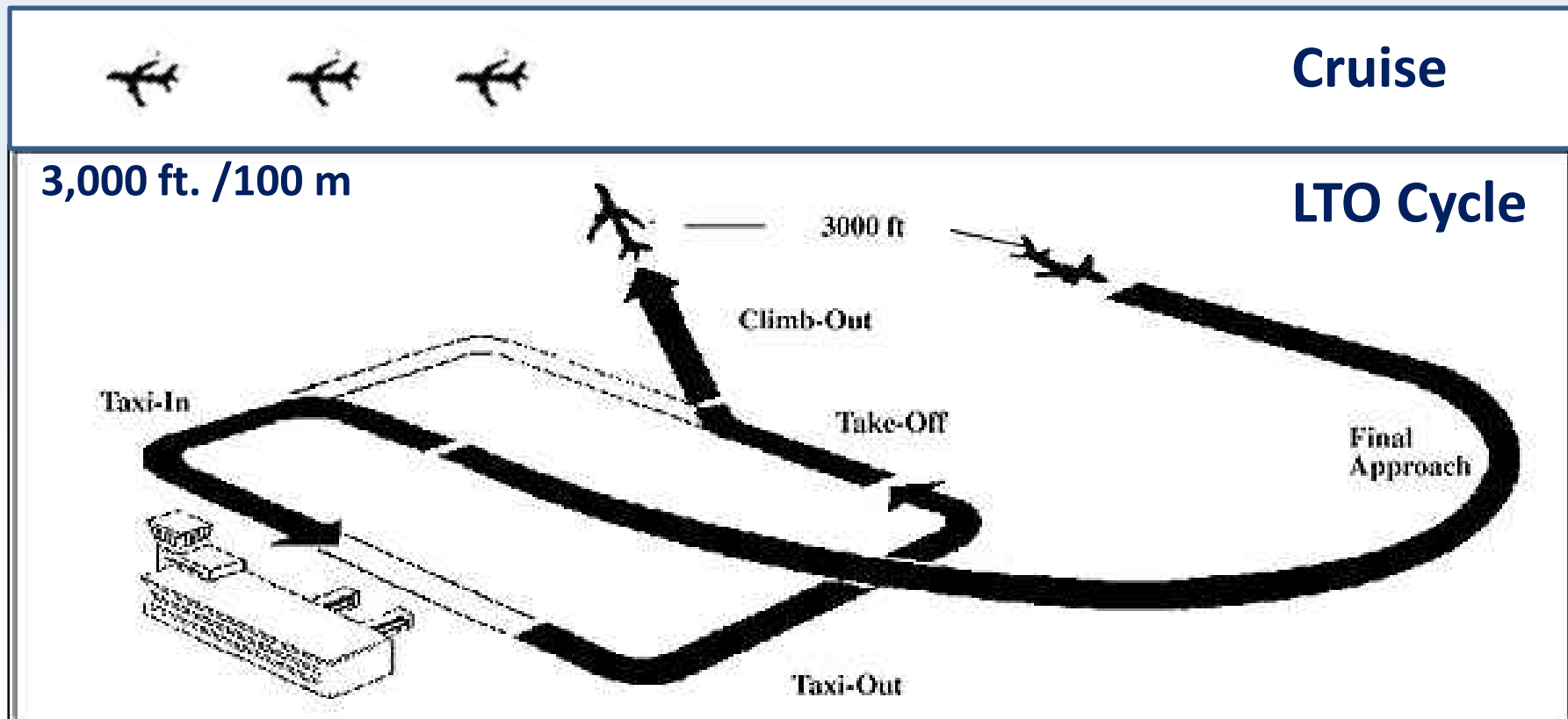
RD_f

- Radiative Forcing (watts/square meter – W/m₂)
- The rate of energy change per unit area of the globe as measured at the top of the atmosphere

CE

- Carbon Equivalency
- Ratio of the mass of carbon dioxide molecule to the mass of a carbon atom (44:12).

Aircraft LTOs & Modes



Landing & Take-off (LTO) Cycle

1 landing & 1 take-off

1 LTO = 2 Ops.

Operational Modes

- Approach
- Landing
- Taxi-in, taxi-out & delay
- Take-off
- Climb out
- Cruise

GHG Inventory Boundaries

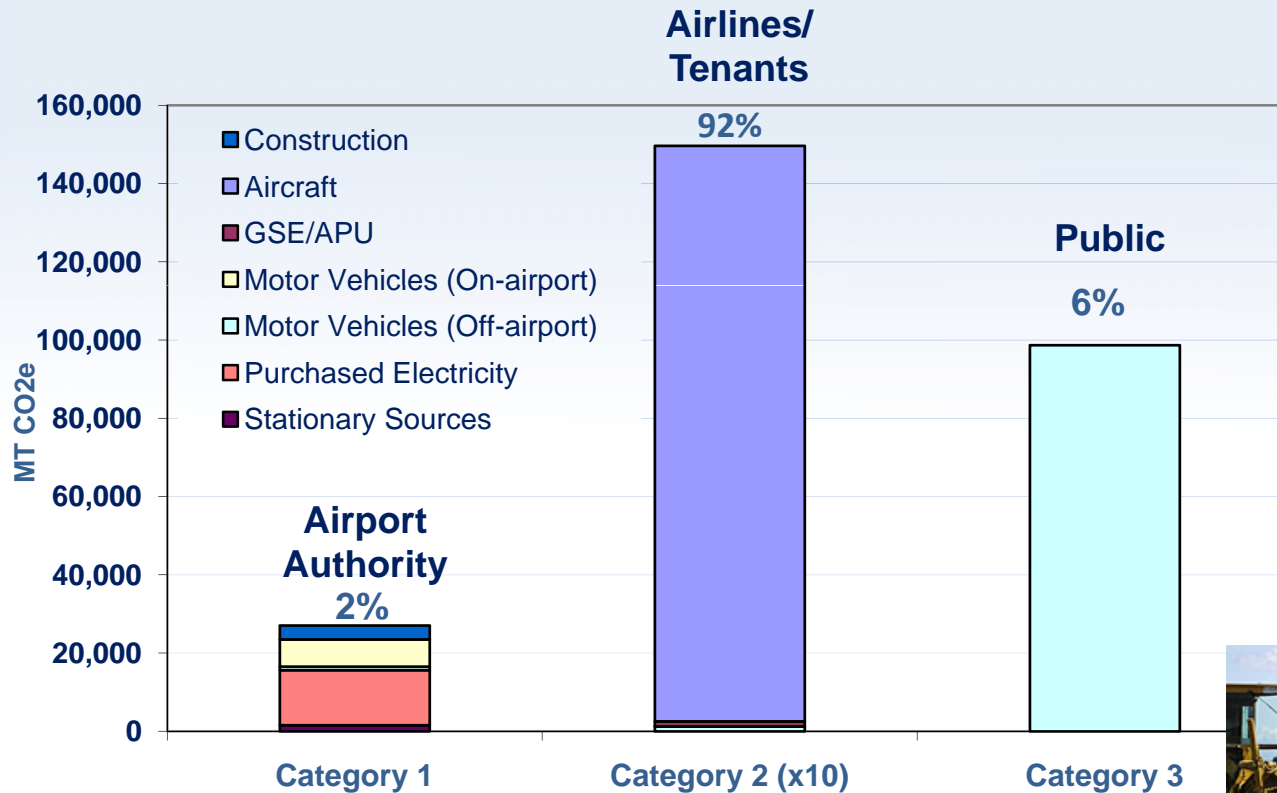


❑ Under Development

❑ Topics

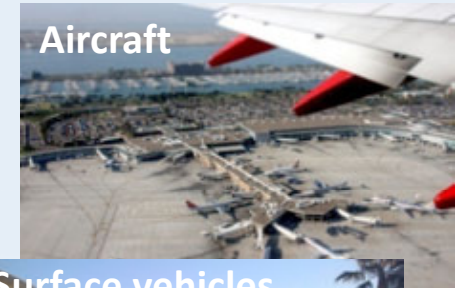
- Double-counting
- Ownership
- Mitigation
- Legislations
- Taxes/Quotas

Ownership



Ownership & Control Categories

San Diego International Airport



Scopes

Scope I

- Direct
- Owned & Controlled by the Reporting Entity

Scope II

- Indirect
- Electricity

Scope III

- Indirect
- Related to entity
- Owned & controlled by others

Weights & Volumes



Fuel

Oxygen



Products of combustion



Avogadro's Number

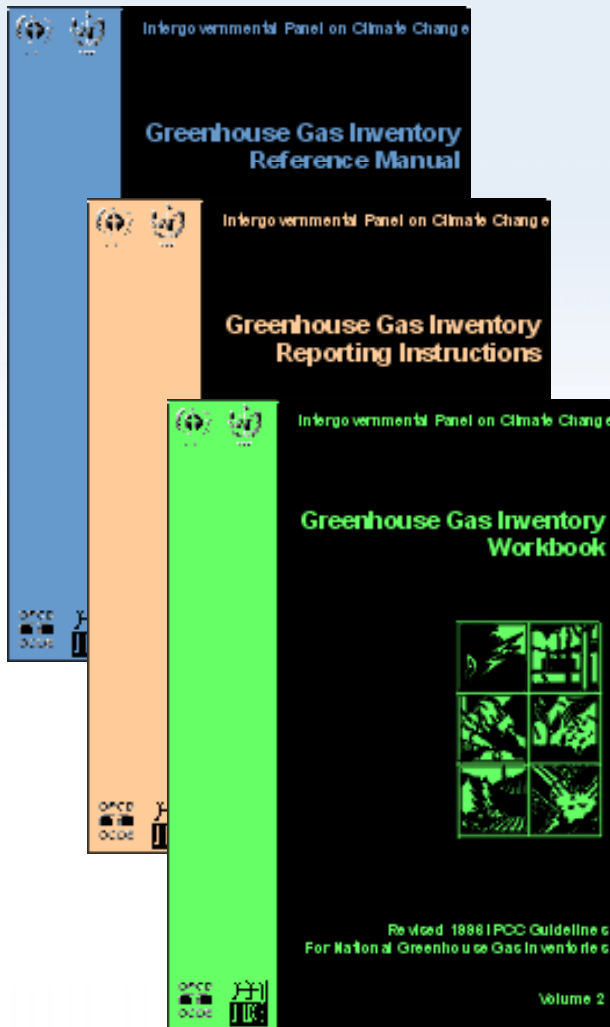


6×10^{26} molecules = 1 mole
 Mol. Wt. of C = 12 grams
 Mol. Wt. of O = 16 grams

12 C @ 12 g.	=	144 g
24 O @ 16 g.	=	384 g
Gram mole wt. of CO ₂	=	528 g

1 Kg jet fuel = 3,156 g CO₂
 1 gal. jet fuel = 21 lbs. CO₂

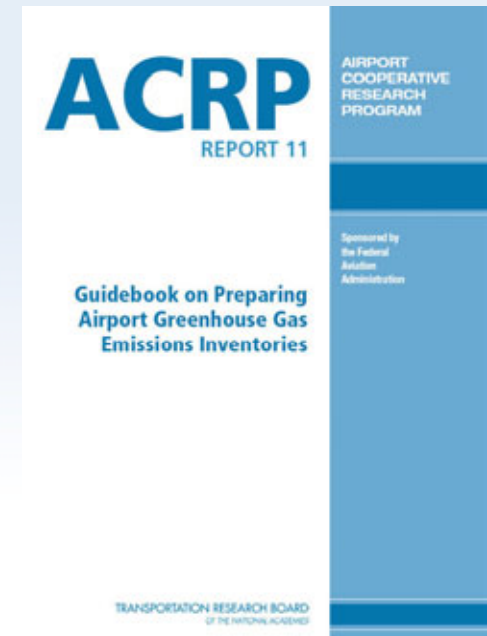
GHG Quantification Guidelines



IPCC Guidelines for National Greenhouse Gas Inventories



ICAO Aircraft Emissions Inventory Guidelines



ACRP Airport GHG Inventory Guidelines

GHG Emissions Inventory

Basic Formula

$$E_{\text{(GHG emissions)}} = A_{\text{(activity data)}} \times R_{\text{(rate)}} \times \text{GWP}$$



Where:

E = lbs., tons, Mt., Mg., Gg.

A = LTOs, operational minutes, kg or gal. of fuel

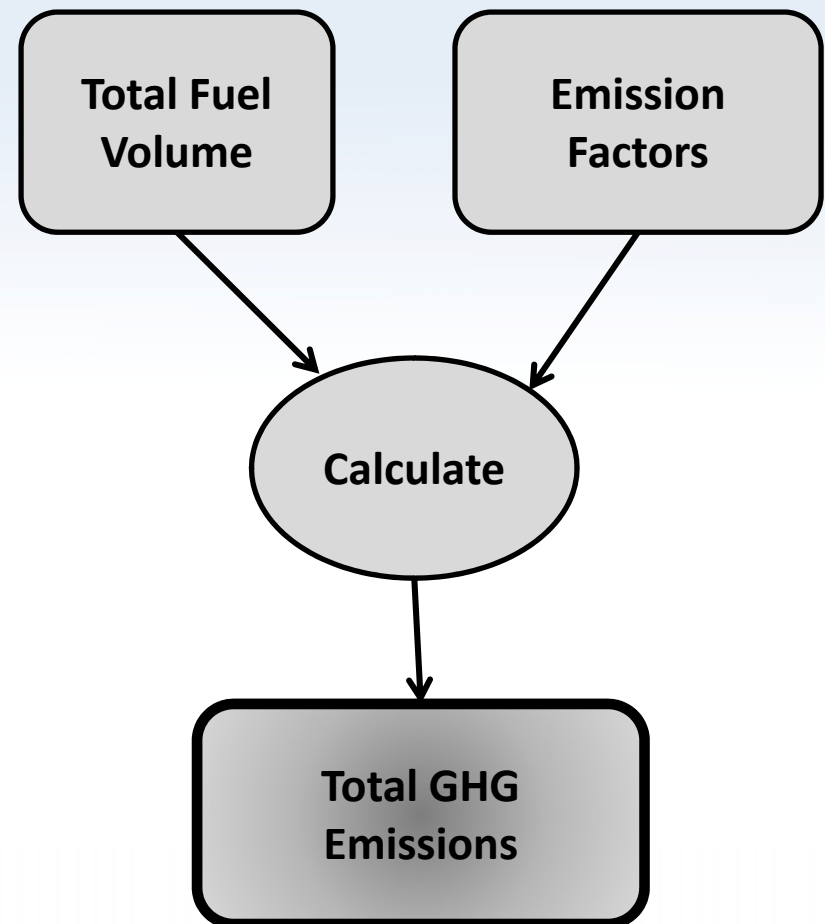
R = kg or lbs./operation – minute – gallon (EF)

GWP = Global warming potential (CO_{2e})

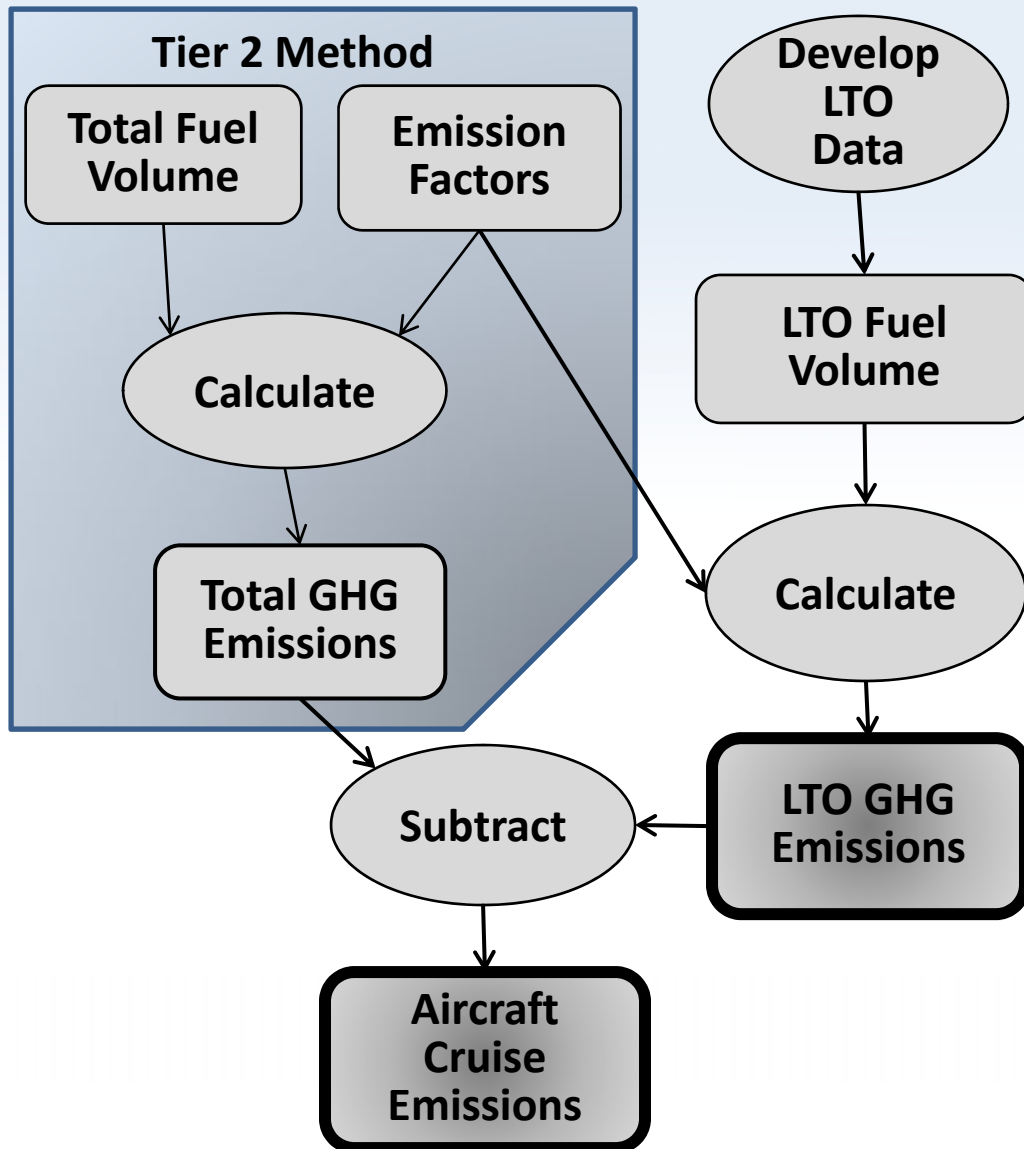
GHG Emissions Calculations

Tier 1/Method 1

- ❑ Suitable for gross estimates of CO₂
- ❑ Based upon:
 - Basic fuel use data
 - Average fleet emission factors
- ❑ Data needs
 - Fuel volumes, by type & destination



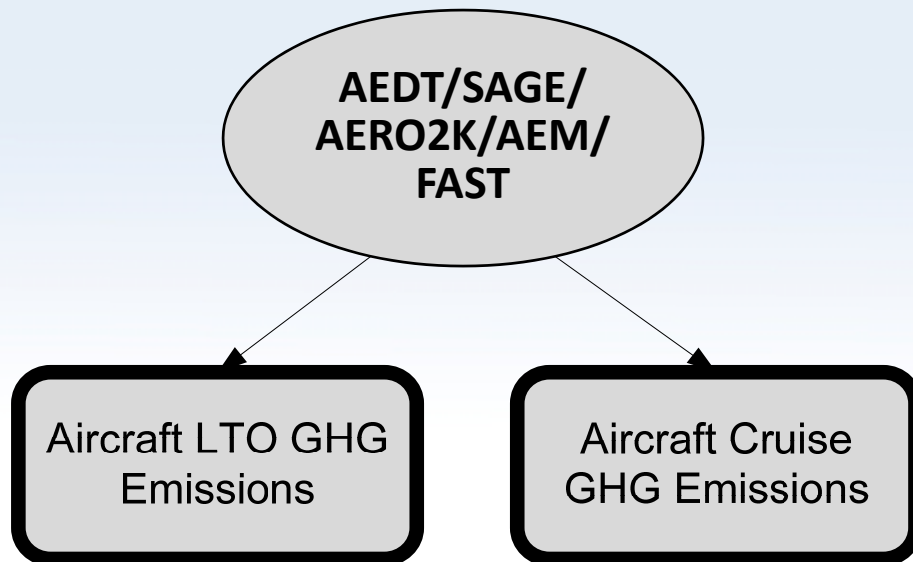
GHG Emission Calculations



Tier 2 Method

- ❑ More complex.
- ❑ Separates “cruise” from “LTO” CO₂ emissions.
- ❑ Based upon:
 - Tier 1 data
 - LTO data

GHG Emission Calculations



AEDT - Aviation Environmental Design Tool
AEDT/SAGE - System for Assessing Aviation's Global Emissions
AERO2K – EUROCONTROL 5th Framework Programme project

Tier 3 Method

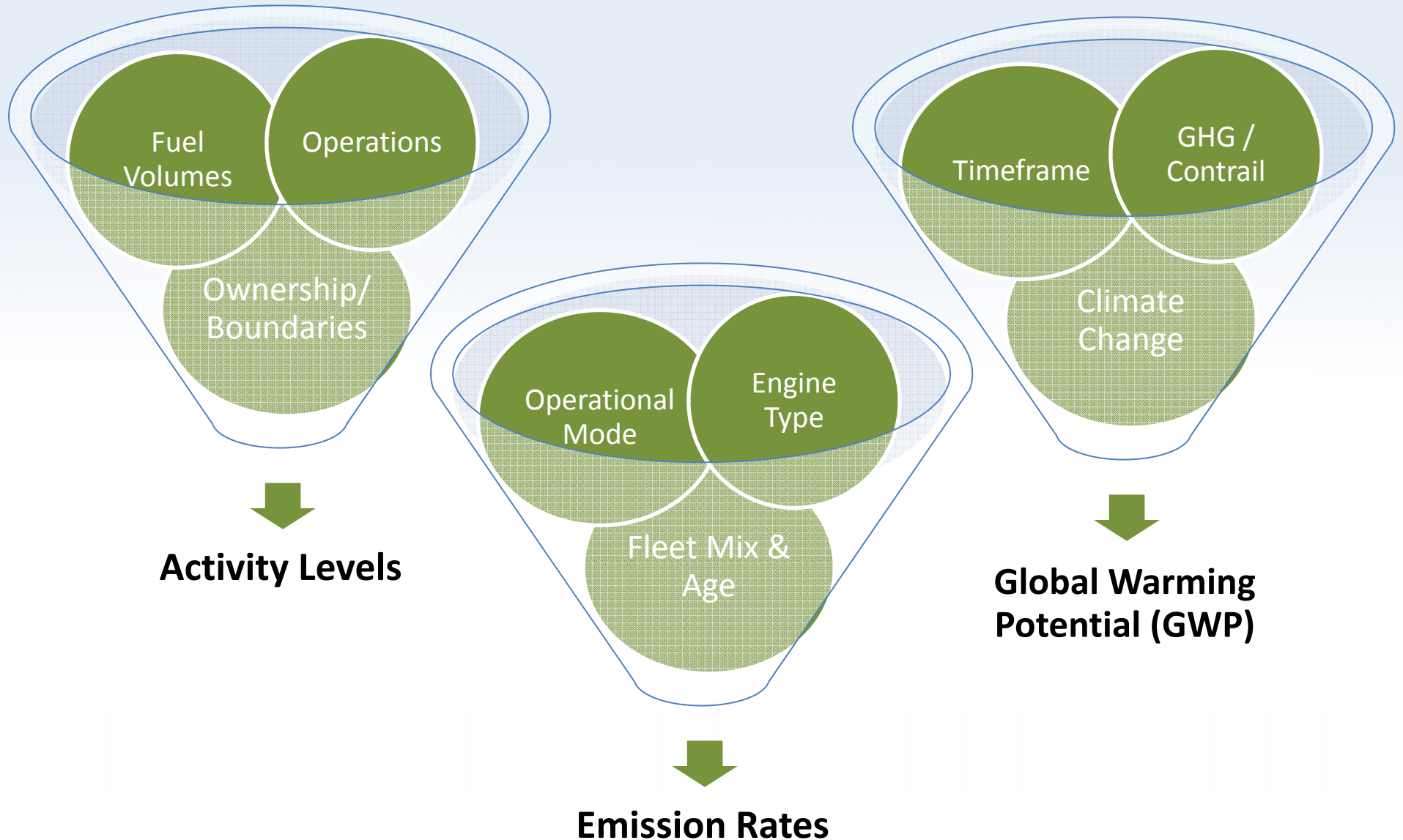
- ❑ **Most complex**
- ❑ **Produces CO₂ emissions by:**
 - **Fuel type**
 - **Aircraft type**
 - **LTO mode**
 - **Destination**

- POP QUIZ No. 6 -

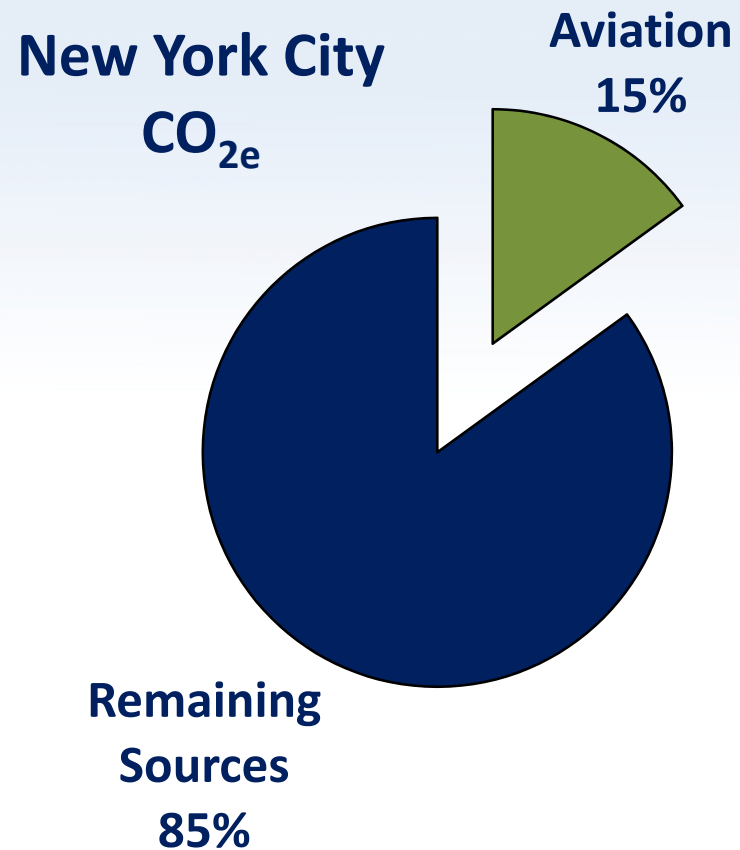
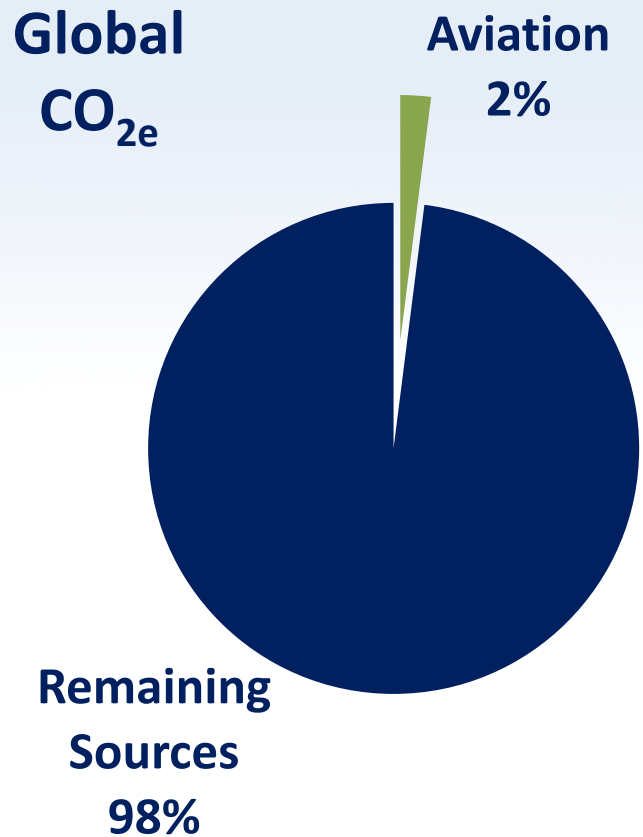
What is main advantage of a Tier II GHG emissions inventory?

- A. Separates “LTO” from “cruise” emissions**
- B. Requires less data than Tier I method**
- C. Corrects for the uncertainties of radiative forcing.**
- D. Results in a lower carbon footprint than Tiers I or III.**

Sources of Uncertainty



How Good Does the Data Need to Be?

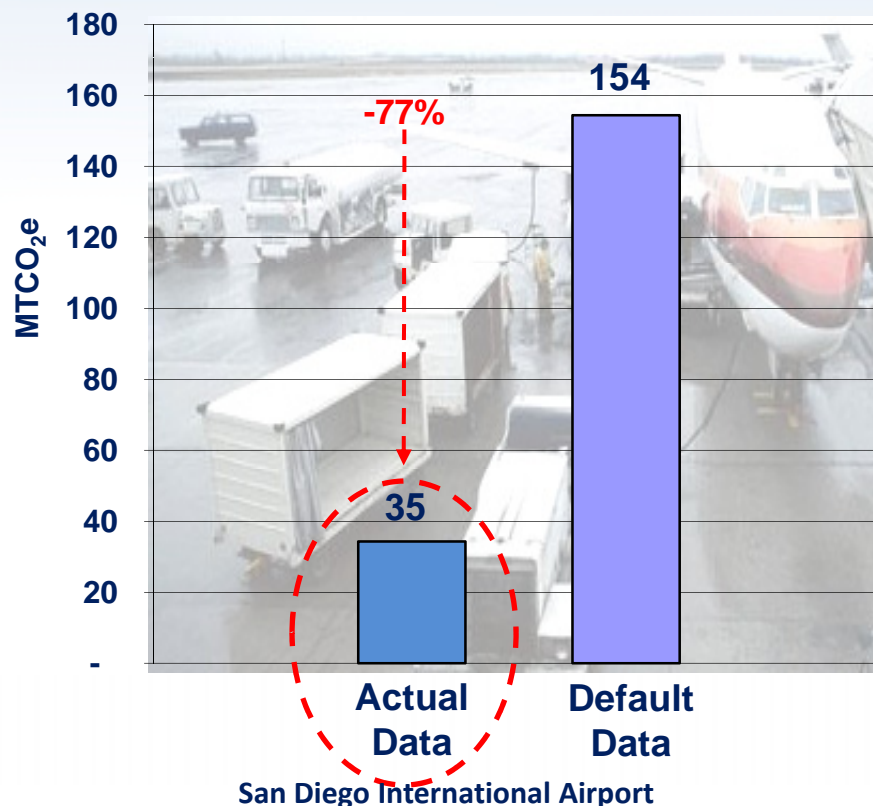


Actual vs. Default Data

Ground Support Equipment (GSE)

Greenhouse Gas Emissions

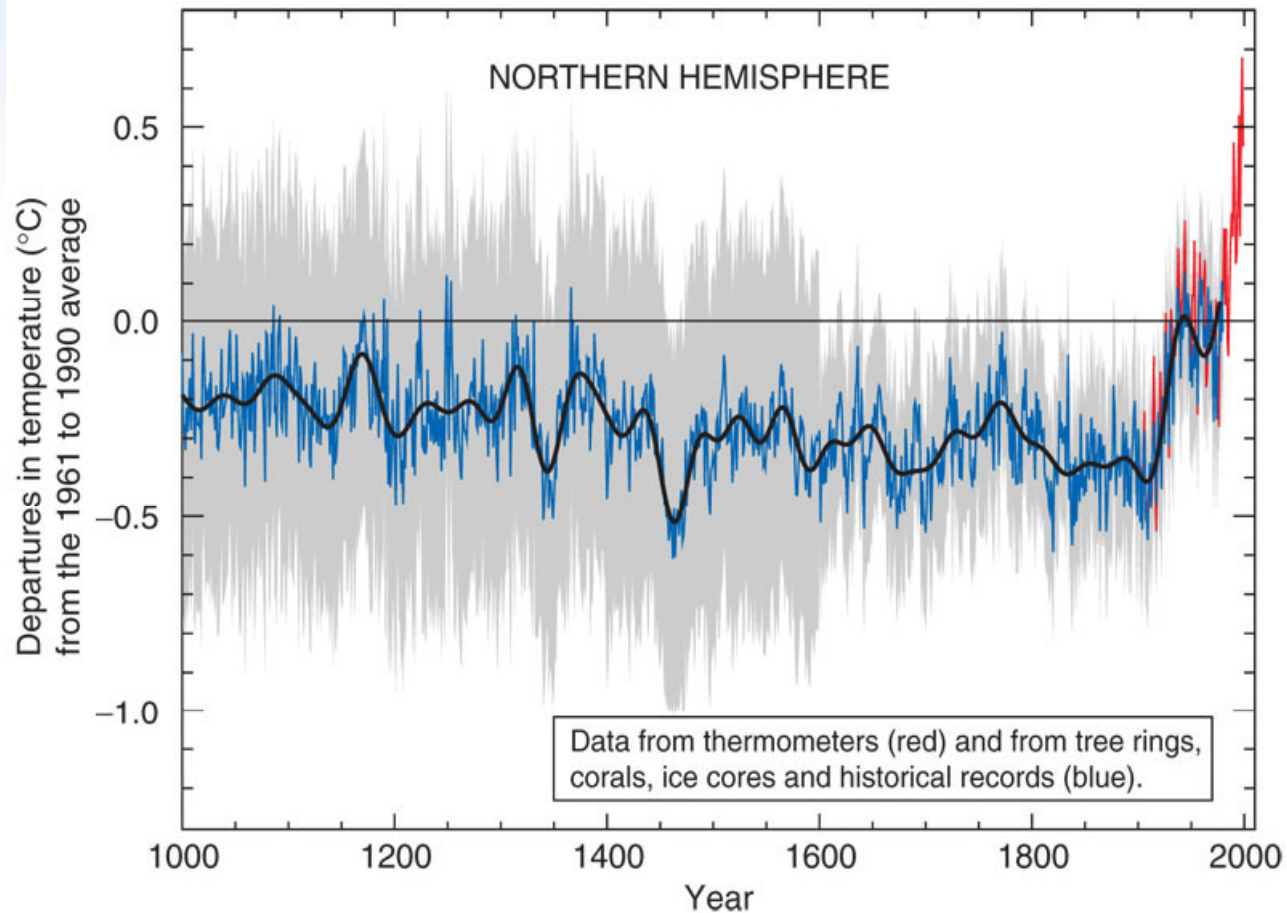
GSE Data



- Equipment type (tug, loader, on- versus off-road)
- Fuel type (diesel, gas, GNG, electric).
- Fuel use (gal.)
- Operational time (min.)
- Age
- Horsepower

Source: KBE, 2010

Global Warming Trends

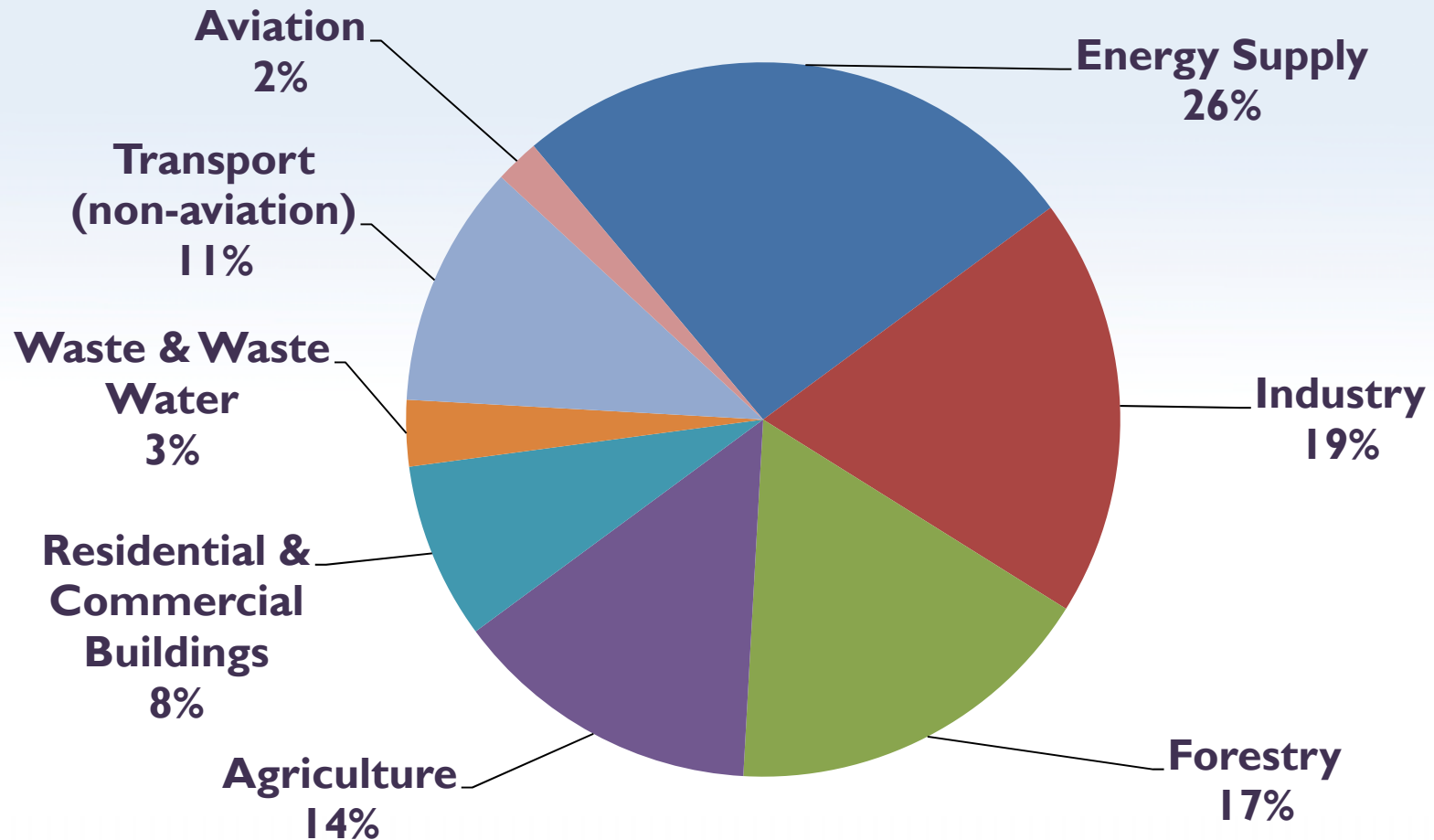


Source IPCC

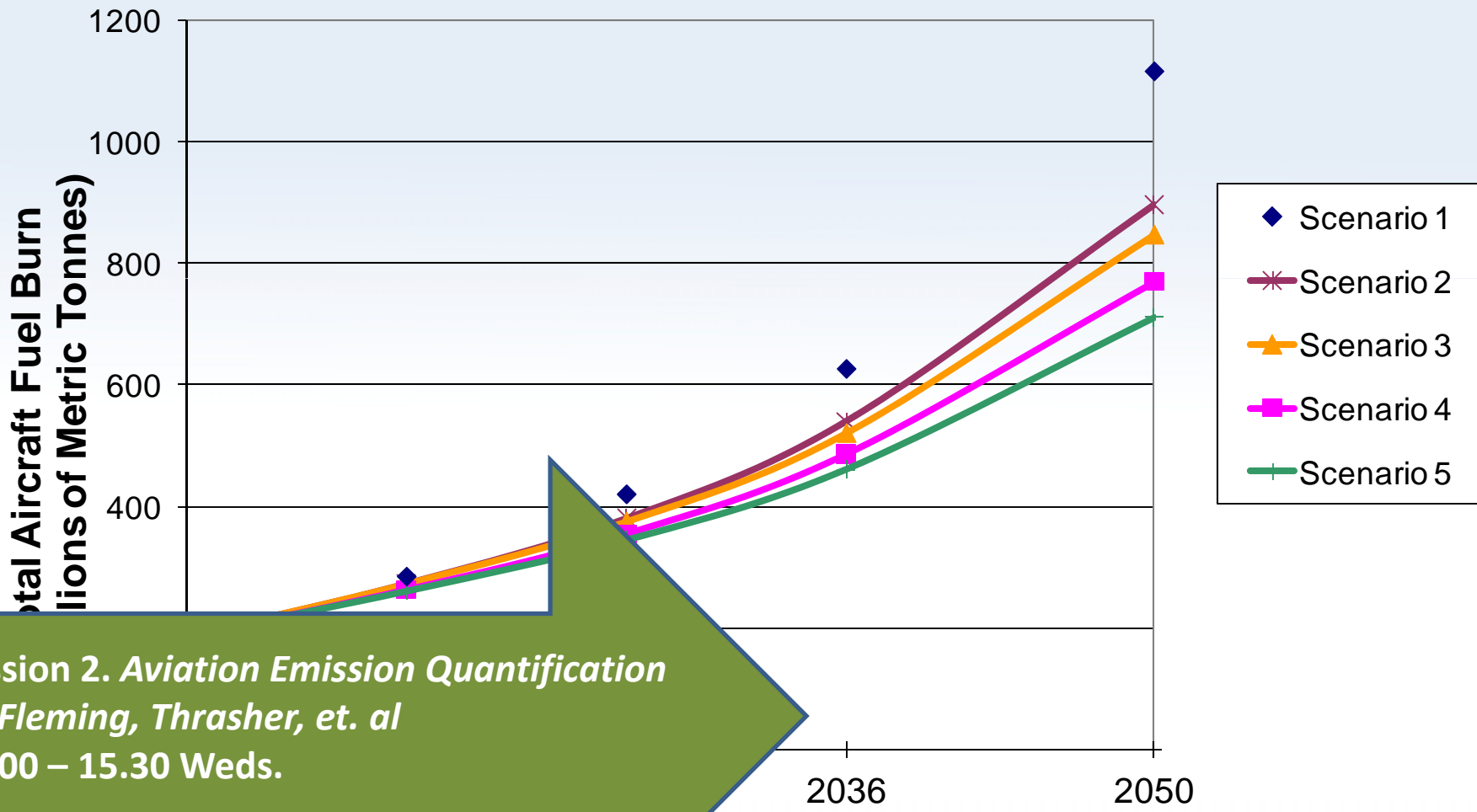
Aviation's Effects on Climate

Parameter	CO ₂	NOx		Particulates & Aerosols	Contrails & Cirrus Clouds
		O ₃ Increase	CH ₄ Decrease		
Temperature Response	Warming	Warming	Cooling	Soot: Warming Sulfates: Cooling	Net warming
<p>Session 1. <i>Aviation's Current and Future Contributions to GHG Global Emissions;</i> by Lee, Schuman, Waitz, Sausen 11.00 – 12.30 Weds.</p>					
Spatial Distribution	Global	Cont. - Glob.	Cont. - Glob.	Soot: Loc. - Glob. Sulfates: Cont.	Local – Cont.
Scientific Understanding	Good	Fair	Fair	Fair	Poor

Global GHG by Sector, 2004



GHG: Fuel Burn Full-Flight Results



Session 2. Aviation Emission Quantification
 By Fleming, Thrasher, et. al
 14.00 – 15.30 Weds.

Note: Results were modelled for 2006, 2016, 2026, 2036, then extrapolated to 2050.

ICAO Carbon Emissions Calculator

Overview

Background

Methodology

UN Users

Next Steps

Background

- ❑ **Methodology Developed through CAEP**
- ❑ **23 Member States**
 - **Global representation**
- ❑ **13 Observers**
 - **Primary aviation stakeholder representation**
 - **Airlines, air navigation service providers, airports, manufacturers, UN (UNFCCC, WMO), international coalition of NGOs**



Methodology

Objectives

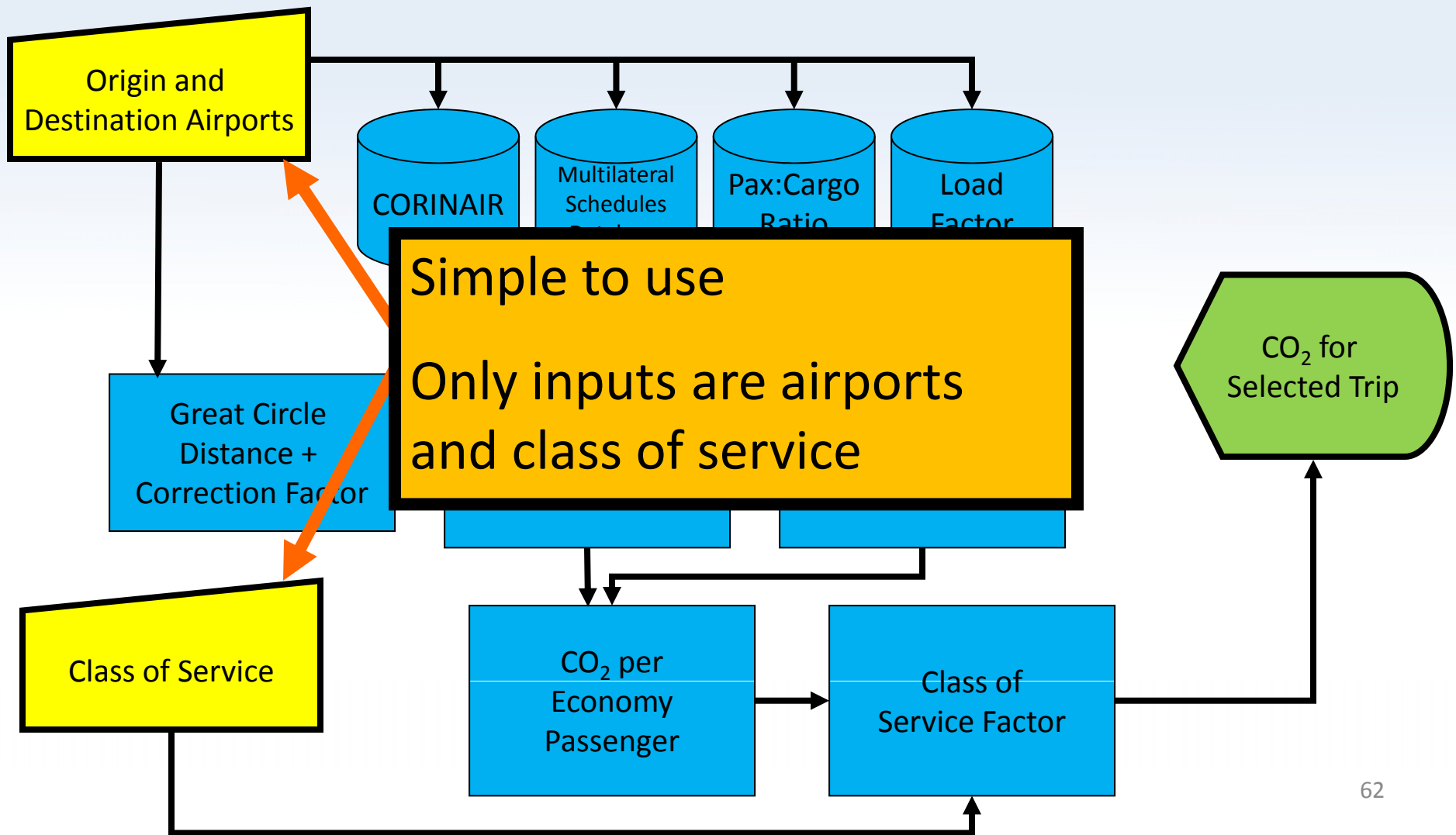
- **User-friendly, unbiased, tool to compute carbon emissions from air travel**
- **Suitable for use with offset programmes**
- **Best publicly available data**
- **Fully documented**

Methodology (cont.)

- ❑ **Developed by Experts from**
 - ICAO Secretariat
 - ICAO Member States
 - Universities
 - NGOs
 - International Air Transport Association – IATA (Airlines)
 - International Coordinating Council of Aerospace Industries Associations – ICCAIA (Manufacturers)

- ❑ **Methodology is internationally recognized and accepted**

Aviation Carbon Calculation Methodology



ICAO Carbon Emissions Calculator (Public Interface)

- Transparent
- Easy-to-use
- Publicly available
- Delivers consistent estimates of CO₂ – suitable for use with offset programs
- Available since June 2008



Climate Neutral UN Initiative

- **October 2007: “greening of the UN” launched**
- **Includes moving the UN system towards climate neutrality**
- **Supported by UNEP through the Environmental Management Group (EMG)**

Climate Neutrality

“Climate neutrality” is defined by the entire set of policies that an institution uses when it estimates its known GHG emissions, takes measures to reduce them, and purchases carbon offsets to “neutralize” those emissions that remain

- UNEMG (Environmental Management Group) EMG/AM.07/05/Rev.2

Approach to Climate Neutrality

- **Develop a Strategy / Action plan**
- **Identify criteria necessary to guarantee a credible climate neutral footprint**
- **Establish specific policies on waste management, paper use, recycling, sustainable procurement, building operation**

UN Interface

- **Excel-based**
- **Designed to facilitate inventory preparation**
- **Accepts data from travel reservation / approval systems or travel agencies directly**
- **Available since April 2009**

UN Interface (concl.)

The screenshot displays the ICAO Carbon Emissions Calculator (Version 1.1) within a Microsoft Excel spreadsheet. The interface includes a title bar, menu bar, and ribbon. The main spreadsheet area contains the calculator's input and output sections.

Calculator Settings:

- Database version: 2.3
- Schedules date: 31-Dec-2008
- Load factors date: 31-Dec-2007
- Class of Service Column: B
- Route Column: A

Results Summary:

Results	
Total CO ₂ (tonnes):	2235.718
Total km flown:	17,367,854
Total trips:	1,543
Remarks:	Run complete 24-Aug-2009 14:16

Flight Data Table:

Route	Class	CO ₂ (kg)	Trip Distance (km)	Messages	Sug. Class
SCL-LIM-PTY-SCL-PTY-SCL	C	3044.7		19305	C 5683
EZE-MAD-BKK-MNL-BKK-MAD-EZE	C	7899.9		44884	C 20800
EZE-MAD-BKK-MNL-BKK-MAD-EZE	C	7899.9		44884	C 20800
EZE-MAD-BKK-MNL-BKK-MAD-EZE	C	7899.9		44884	C 20800
EZE-MAD-BKK-MNL-BKK-MAD-EZE	C	7899.9		44884	C 20800
EZE-MAD-BKK-MNL-BKK-MAD-EZE	C	7899.9		44884	C 20800
YUL-YYZ-HKG-BKK-CNX-BKK-HKG-YYZ-YUL	C	4348.7		30658	C 5683
MAN-LHR-MIA-PTY-MIA-LHR-MAN	C	2468.3		18424	C 5683
BKK-KUL-BWN-BKK	Y	423.1		4575	Y 20800
YUL-CDG-SEZ-CDG-YUL	C	3916.6		26722	C 5683
FIH-NBO-BKO-ABJ-NBO	C	2533.5		13145	C 5683
YOW-YUL-JFK-CCS-MIA-ORD-YOW	Y	959.3		9259	? 5684
SCL-GRU-CCS-SCL	Y	1076.8		11906	? 5683
MAD-CDG-YUL-CDG-MAD	Y	977.1		13170	? 5684
YUL-CDG-DKR-CDG-YUL	C	2894.1		19496	C 5684

UNEMG Decision

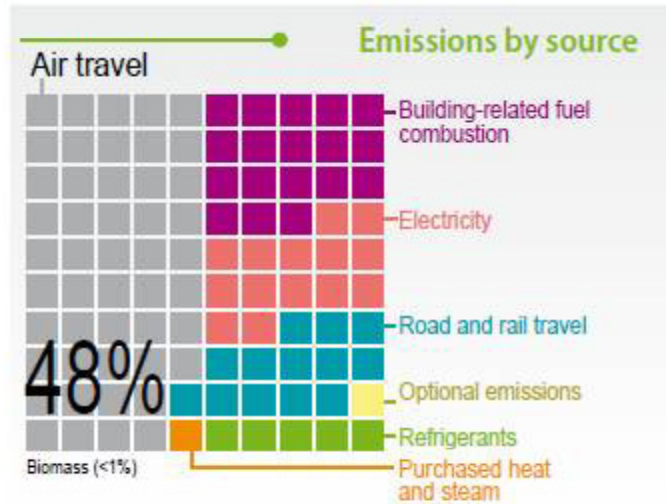
- *The UN Environment Management Group adopted the ICAO Carbon Emissions Calculator as the official tool for all UN bodies to quantify their air travel CO₂ footprint - April 2009*
- All 2008 UN air travel GHG inventories are being prepared using the ICAO Calculator

Initial Results

UN system facilities, travel and peackeeping operations

key figures 2008

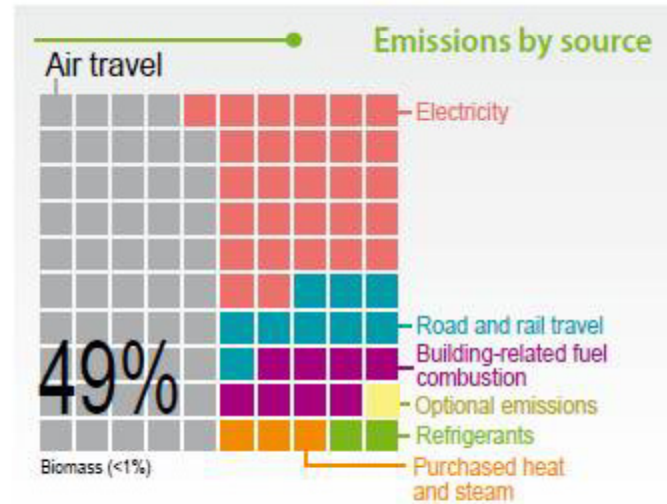
Total emissions	1'741'413 t CO ₂ eq
Emissions per staff member	8.4 t CO ₂ eq
Air travel per staff member	4.0 t CO ₂
Number of staff	206'954



UN system facilities and travel

key figures 2008

Total emissions	769'108 t CO ₂ eq
Emissions per staff member	8.3 t CO ₂ eq
Air travel per staff member	4.0 t CO ₂
Number of staff	92'748



Next Steps

- ❑ **Phased approach for updating methodology and data through CAEP**
- ❑ **Try it out for yourself!**

Session II.
Assessment
Methods

Session II Summary

Metrics & Trends

- ✓ Mt, CO₂e, GWP, Rf
- ✓ Aviation 2% of total man-made, but growing

Quantification Methods

- ✓ Boundaries & Ownership
- ✓ Tiers I, II, III

Connecting the
Dots

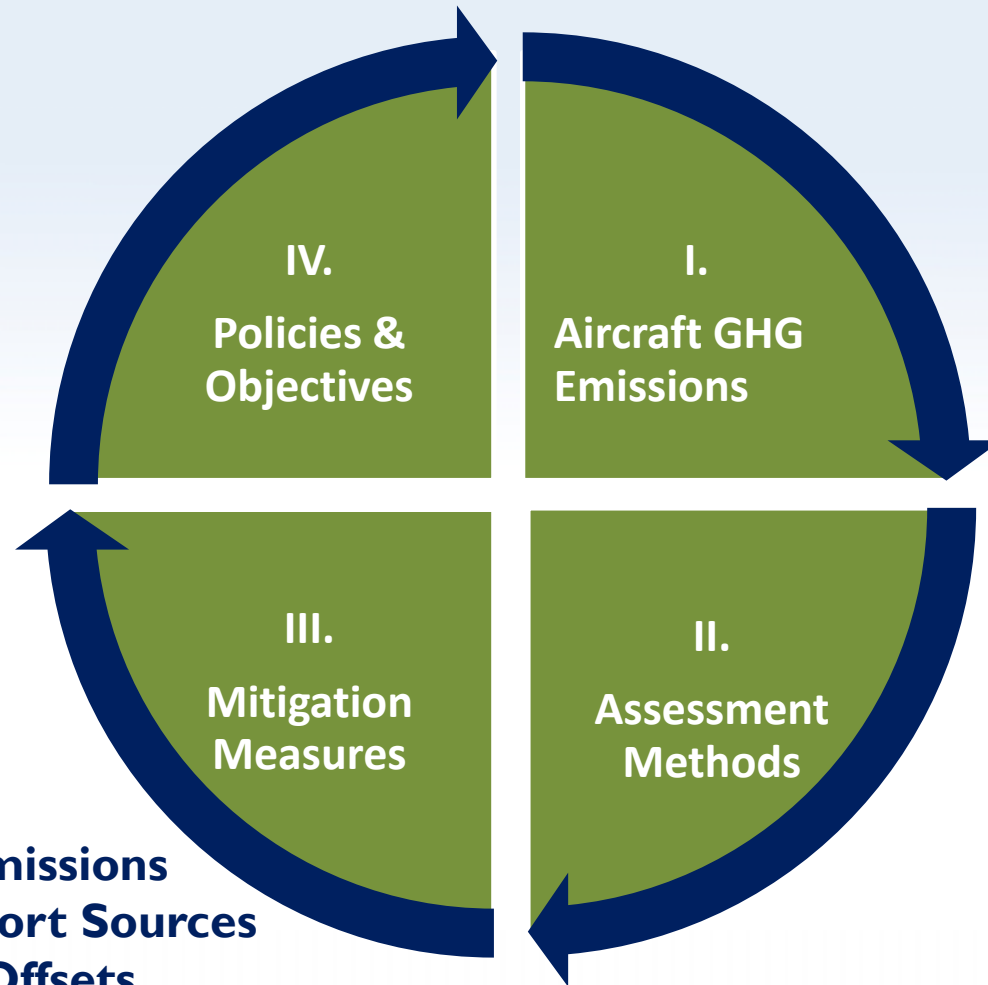
ICAO Carbon Calculator

End of Session II
1 Hour Lunch Break
Return at 14:00



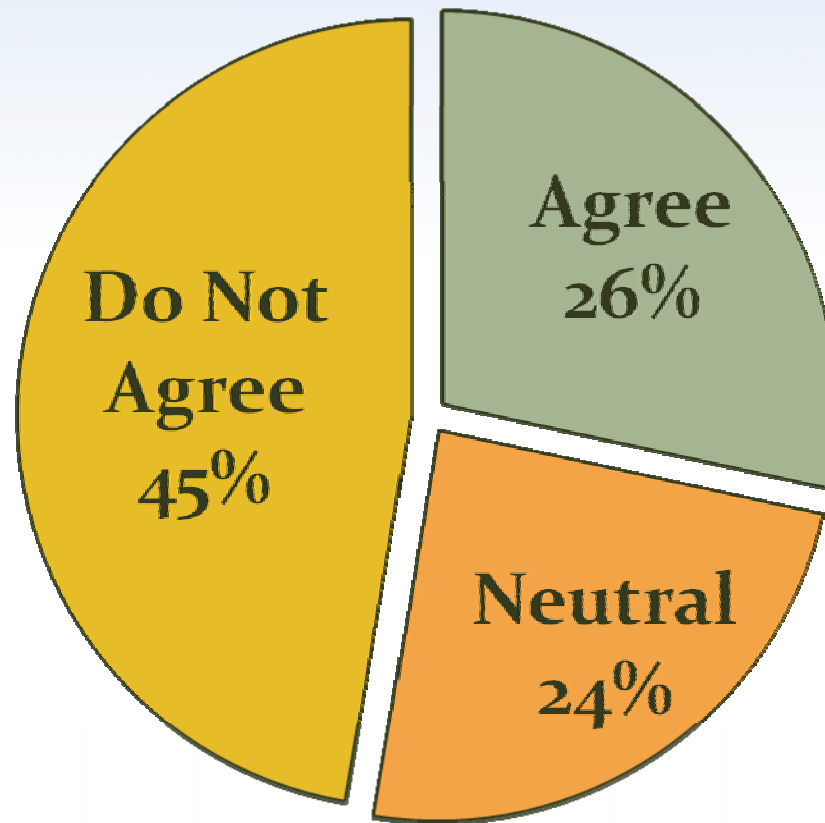
*Artwork from ICAO's Aviation in a
Green Environment Contest*

Session III: Mitigation Measures



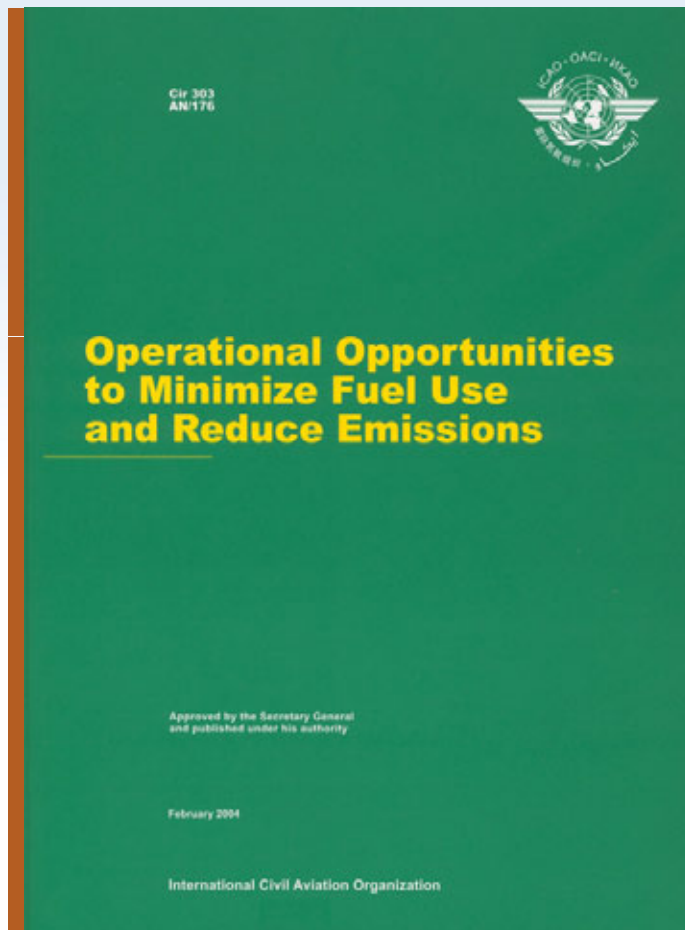
GHG Mitigation Measures

*The Aviation Sector Is Effectively Managing It's
Greenhouse Gases.**



**AAAE Airport Air Quality Conference, May 1, 2009*

ICAO Guidelines



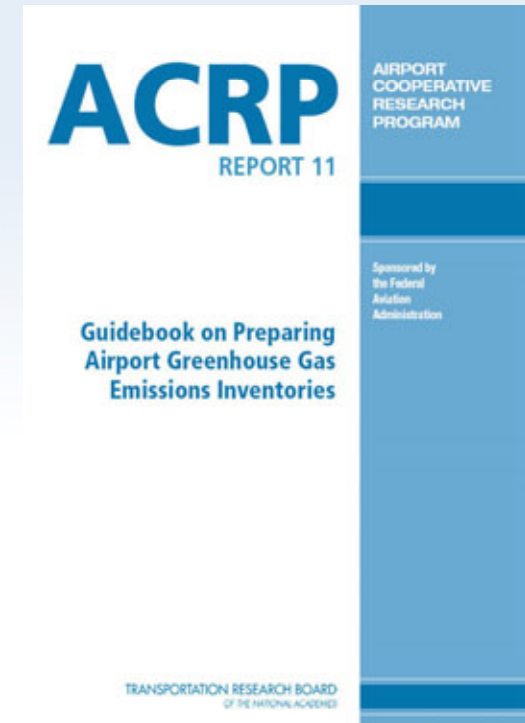
Topics

- Principles of Fuel Savings
- Aircraft Performance
- Maintenance Activities
- Weight Reduction
- Air Traffic Management
- Route Planning
- Take-off, cruise, landing

Practical GHG Emission Reduction Strategies for Airports

Reduction Strategies (124)

- Aircraft operations (19)
- Business planning (11)
- Carbon sequestration (4)
- Construction (5)
- Energy management (37)
- Ground transportation (17)
- Ground service equipment (1)
- Materials & embedded energy (4)
- Operations & maintenance (3)
- Performance measurement (5)
- Refrigerants (4)
- Renewable Energy (on-site) (14)

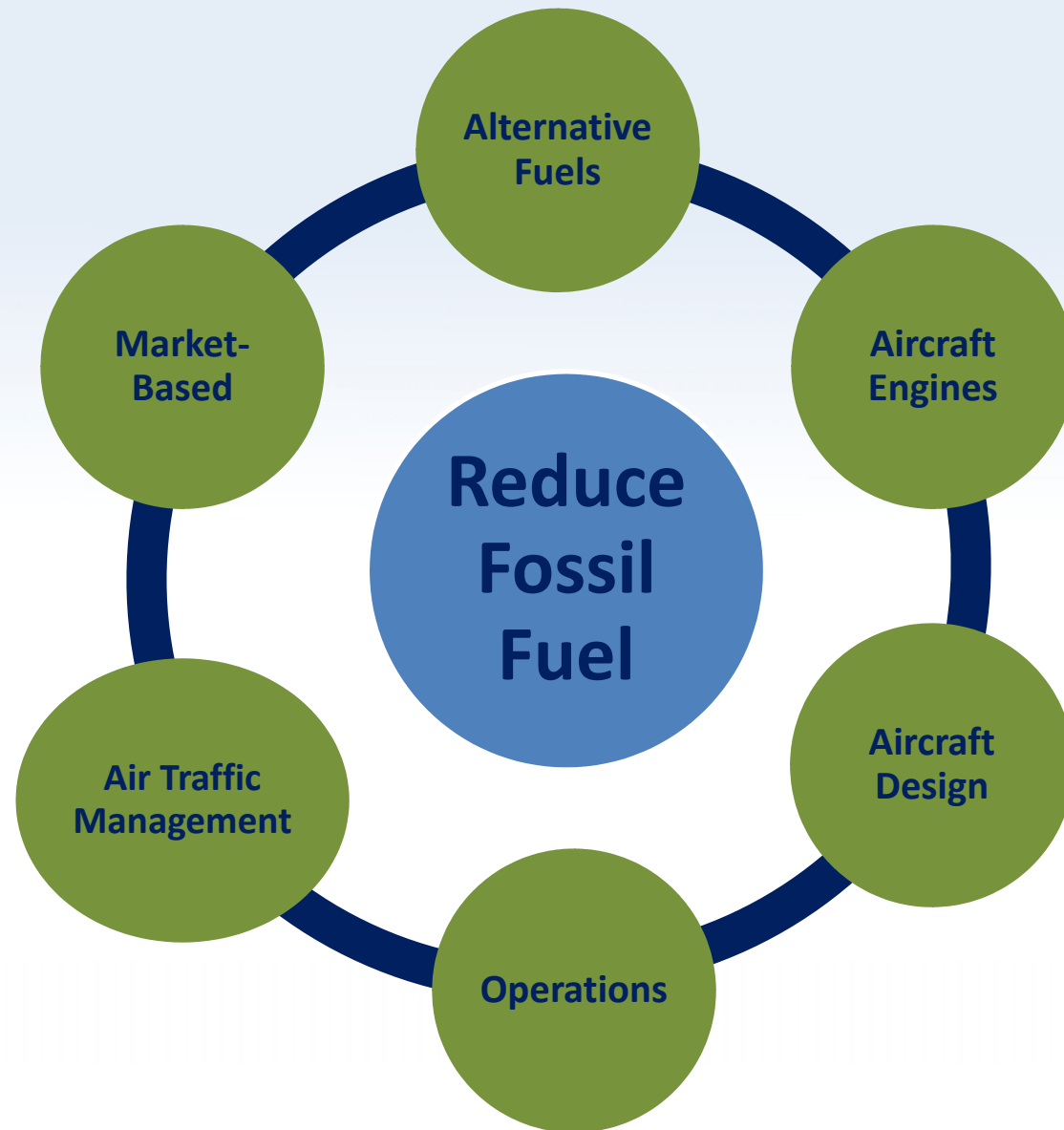


ACRP Report 02-10

Publication Date ~ May 2011



Mitigation Measures



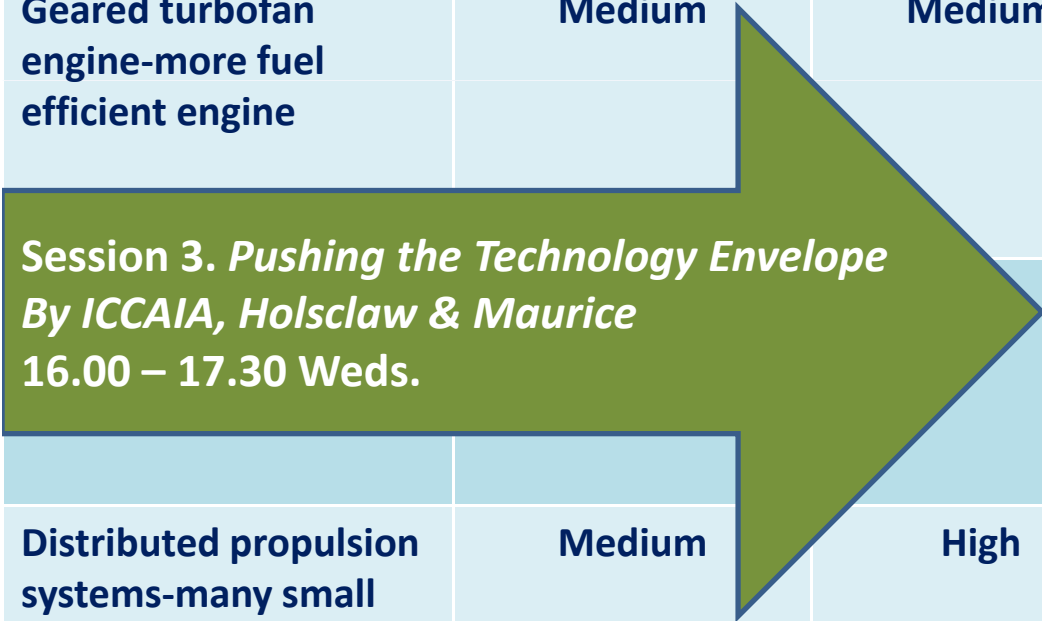
Alternative Fuels

Topics & Issues

- ❑ **Drop-In Fuels**
- ❑ **Synthetic Fuels**
- ❑ **Bio-Fuels**
- ❑ **Renewable Fuels**
- ❑ **Life-cycle Emissions**

Session 7. Alternative Fuels
By Hupe, Young, Maurice, et.al.
9.00 – 11.00 Thurs.

Selected Aircraft Engine Mitigation Measures

Measure	Potential Reduction in Carbon Dioxide Emissions	Potential Research and Development Costs	Estimated Time Frame for Commercial Use	Potential for Public Acceptance
Geared turbofan engine-more fuel efficient engine	Medium	Medium	Short-medium	High
				
Distributed propulsion systems-many small engines instead of few large ones	Medium	High	Long	High

Session 3. Pushing the Technology Envelope
 By ICCAIA, Holsclaw & Maurice
 16.00 – 17.30 Weds.

Source: GAO survey of experts.

Short = < 5 yrs, Medium = 5-15 yrs, Long = > 15 yrs

Selected Aircraft Improvements Mitigation Measures

Measure	Potential Reduction in Carbon Dioxide Emissions	Potential Research and Development Costs	Estimated Time Frame for Commercial Use	Potential for Public Acceptance
Blended wing-body— Fuselage and wings as part of one airframe	High	High	Long	Low-medium
Lightweight composite airframes— Lightweight materials	Medium	Medium	Medium	High
Winglets—Wing attachments to reduce drag	Low	Low	Short	High

Source: GAO survey of experts.

Short = < 5 yrs, Medium = 5-15 yrs, Long = > 15 yrs

Selected Operational Mitigation Measures

Measure	Potential Reduction in Carbon Dioxide Emissions	Potential Research and Development Costs	Estimated Time Frame for Commercial Use	Potential for Public Acceptance
Air-to-air refueling— Air tankers fueling aircraft in flight	Low	High	Long	Low
<i>Session 4. Flying Through Operational Opportunities</i> <i>By Galotti, Melrose, Clarke, Fagan et.al.</i> <i>9.00 – 11.00 Thurs.</i>		Low	Short	High
Multiple aircraft flying close together to reduce drag		Medium-high	Medium-long	Low
Multi-stage long distance flights—Use of fueling stops on long-distance flights	Low-medium	Low	Short	Low

Source: GAO survey of experts.

Short = < 5 yrs, Medium = 5-15 yrs, Long = > 15 yrs

Air Traffic Management Mitigation Measures

Measure	Potential Reduction in Carbon Dioxide Emissions	Potential Research and Development Costs	Estimated Time Frame for Commercial Use	Potential for Public Acceptance
Required navigation performance—More precise routes	Medium	Medium	Medium	High
Automatic Dependent Surveillance-Broadcast—Satellite navigation system	Medium	Medium	Short	High
Continuous Descent Arrival—More fuel efficient landings	Low-medium	Medium	Short	High
NetGen Network Enabled Weather—Advanced real-time weather data	Medium	Medium	Medium	High

Source: GAO survey of experts.

Short = < 5 yrs, Medium = 5-15 yrs, Long = > 15 yrs

Market Based Measures

Topics & Issues

- ❑ Carbon offsets
- ❑ Emissions Trading
- ❑ Carbon Markets
- ❑ Gold Standard
- ❑ Taxes & Levies

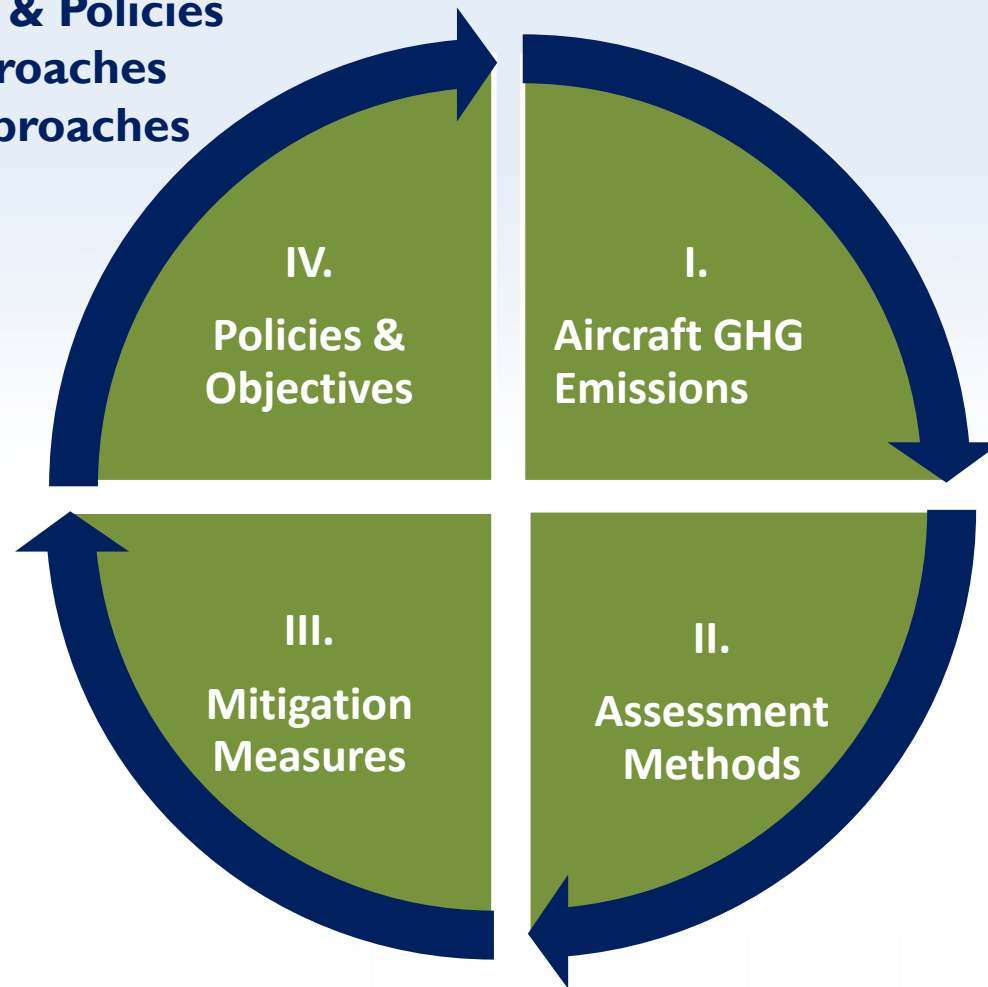
Session 5. Market Based Measures
By Howard, Hode, Fulton, Spencer, Burleson,
et. al..
11.30 – 16.00 Thurs.



Artwork from ICAO's *Aviation in a Green Environment Contest*

Session IV: Policies & Objectives

- **Legislations & Policies**
- **Market Approaches**
- **Aviation Approaches**



Overview

A. International Policy

- UNFCCC and Kyoto Protocol
- Main Challenges for ICAO

B. ICAO Programme of Action

- Global Goals
- Mitigation Measures
- Progress Monitoring

C. COP15 and beyond



UNFCCC – Kyoto Protocol

- Domestic aviation emissions - within States' territories - included as part of the national emissions totals and subject to reduction targets of developed countries (Annex I Parties) under UNFCCC Kyoto Protocol
- International aviation emissions (bunker fuels) – beyond States' boundaries – not included in national totals
- Article 2.2 of Kyoto-Protocol:

“ The Parties included in Annex I shall pursue limitation or reduction of emissions of greenhouse gases ... from aviation ... bunker fuels, working through the ICAO ... ”

Main Challenges for ICAO

- How to find an appropriate balance between future growth and climate impacts ?
- How to apply both ICAO's non-discrimination principle and UNFCCC's CBDR principle ?
- How to accommodate States' different views into a globally harmonized approach?



ICAO's Roadmap to COP15

- ICAO Assembly Resolution (A36-22) in September 2007:
- Leadership in limiting or reducing emissions from international aviation
- Formed Group on International Aviation and Climate Change (GIACC) to develop an Programme of Action on International Aviation and Climate Change
- Requested ICAO to convene a High-level Meeting to review the Programme of Action

ICAO's High-level Meeting in October 2009 adopted the Programme of Action – the first globally-harmonized agreement from a sector on a goal to address its CO₂ emissions

ICAO Programme of Action on International Aviation and Climate Change (1 of 2)

- ICAO and its Member States Agreed to:

Global Goals

- 1) achieve a global 2% annual fuel efficiency improvement until 2020 and aspirational goal of continuing 2% through 2050;
- 2) further explore the feasibility of more ambitious goals, including carbon-neutral growth and emissions reductions, for consideration by 37th ICAO Assembly in September 2010;

Mitigation Measures

- 3) develop a global CO₂ Standard for aircraft;
- 4) facilitate the development and deployment of sustainable alternative fuels for aviation;
- 5) facilitate the implementation of operational changes and the improvement of air traffic management and airport systems;

ICAO Programme of Action on International Aviation and Climate Change (2 of 2)

- ICAO and its Member States Agreed to:

Mitigation Measures (cont' d)

- 6) process to develop a framework for market-based measures in international aviation
- 7) elaboration on measures to assist developing States as well as facilitate access to financial resources, technology transfer and capacity building

Monitoring Progress

- 8) in order to monitor progress towards reaching the goals, States are encouraged to submit their action plans and annual reporting on international aviation CO₂ emissions to ICAO
- 9) ICAO will regularly report CO₂ emissions from international aviation to the UNFCCC, as part of its contribution to assessing progress made in the implementing actions in the sector

Alternative Fuels for Aviation

- **Mitigation strategy:**
 - Technological
 - Operational
 - Market-based measures
 - Alternative fuels
- **ICAO Conference on Aviation and Alternative Fuels in November 2009**
 - Facilitate the development and deployment
 - Endorsed drop-in fuels in the short and medium-term
 - Established a Global Framework for Aviation Alternative Fuels
- **Air transport is well positioned to become the first sector to use sustainable alternative fuels on a global basis**



UNFCCC COP15

- Intense negotiations of experts, Ministers and Heads of Governments
- Most debates were focused on CBDR under the UNFCCC and financing for adaptation activities not on mitigation actions
- Informal negotiations resulted in the “Copenhagen Accord”, which was “noted” by COP15 plenary
- NO specific decision on how to address GHG emissions from international aviation. Provides an opportunity for ICAO to make further progress

Next Steps

- **ICAO informal consultations to progress the Draft Assembly Resolution on international aviation and climate change**
 - 1) **explore the feasibility of more ambitious goals:**
 - Carbon-neutral growth
 - Emissions reductions
 - Moving beyond 2% fuel efficiency improvement
 - 2) **development of a framework on market-based measures in international aviation**
 - 3) **Elaboration of measures to assist States, to gain access to financial resources, technology transfer and capacity building**
- **37th Session of the ICAO Assembly in September 2010**
- **COP16 and COP/MOP6 in November 2010**

End of Session IV

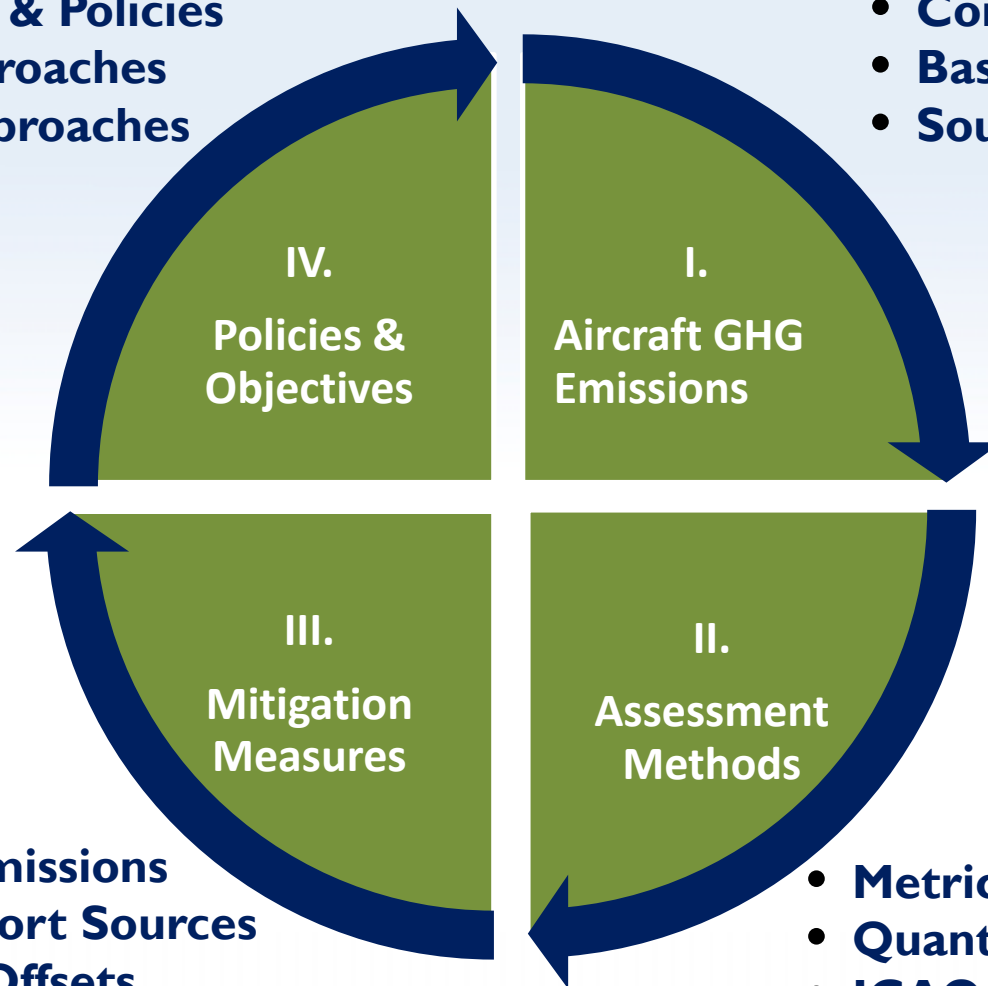


Artwork from ICAO

Tutorial Review Form

- **Legislations & Policies**
- **Market Approaches**
- **Aviation Approaches**

- **Common Terms**
- **Basic Concepts**
- **Sources of GHGs**



- **Aircraft Emissions**
- **Other Airport Sources**
- **Credits & Offsets**

- **Metrics & Trends**
- **Quantification Methods**
- **ICAO Carbon Calculator**

For more information on ICAO activities related to environmental protection visit the ICAO Web Page

www.ICAO.int/env/



Colloquium Topics & Schedule

- ❑ Sustainable Aviation
- ❑ Aviation's contribution to global GHG's
- ❑ Advancements in Quantification Methods
- ❑ GHG Emission Mitigation
 - Technological Advances
 - Operational Opportunities
 - Market-based Measures
 - Alternative Fuels
- ❑ Adaptation
- ❑ Action Plans



EN-ROUTE TO SUSTAINABILITY
11 – 14 May 2010



The End

A child's drawing on a white background. At the top, there are four blue, fluffy clouds and a large yellow sun with rays on the right. In the center, an orange airplane with green windows and a small figure in the tail is flying. A small flag with the letter 'M' is attached to the top of the fuselage. A stream of green dots falls from the bottom of the airplane towards the ground. On the ground, there are two green trees with brown trunks. The ground is represented by a green line with small green dots.