# Aviation Alternative Fuel Environmental Assessments

Presented to: CAAFI Annual General Meeting
Washington, D.C.

By: Lourdes Maurice
FAA Chief Scientist for Environment
CAAFI Environmental Panel Lead

Date: 30 September 2009

FAA
AIA
CAAFI
ATA
ACI-NA

www.caafi.org

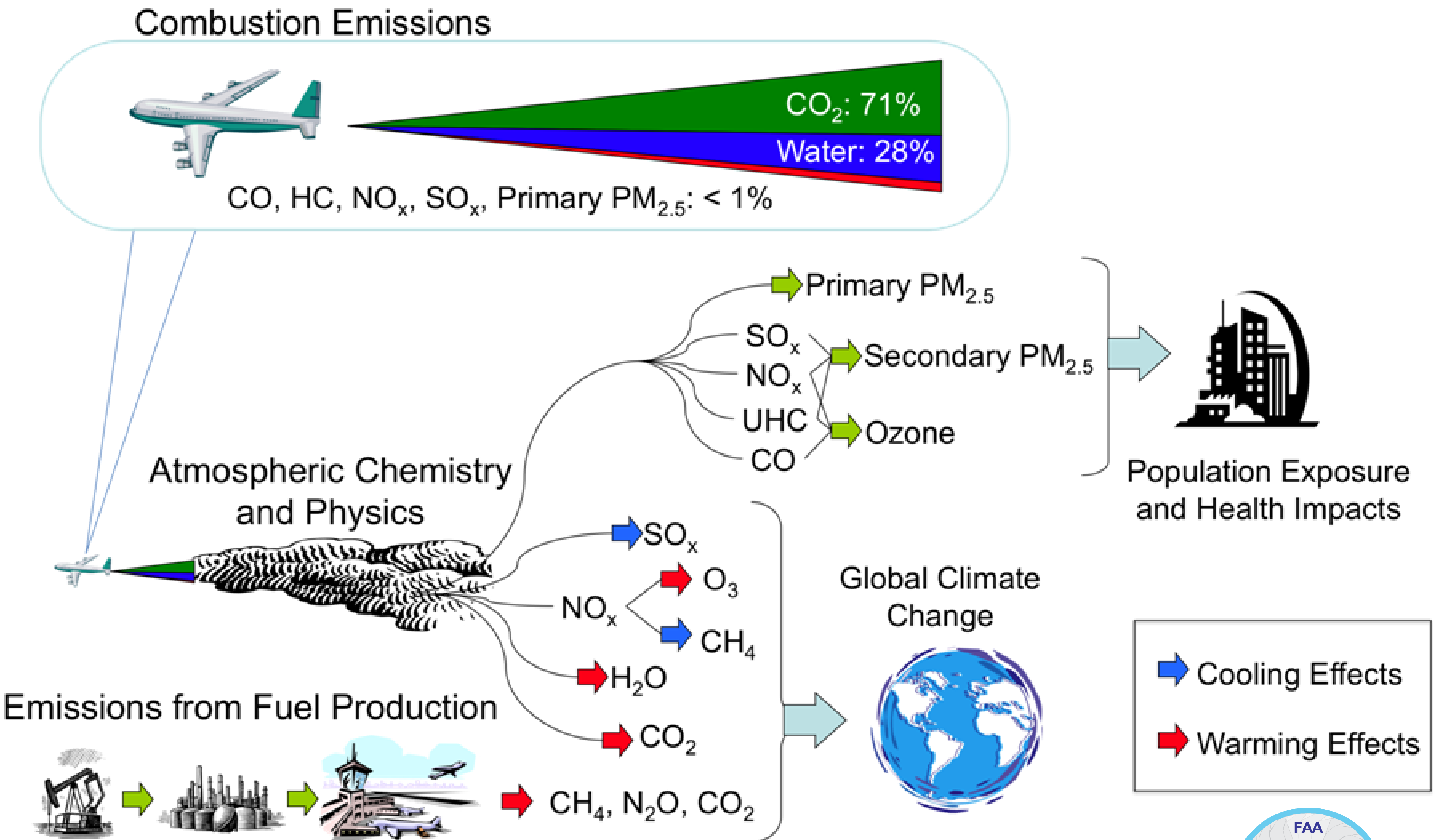
# Presentation Overview

- **Context**
- **CAAFI Environmental Tasks**
- **Progress**
- **Workshop Plans**

# Context

- *CAAFI Seeks to Facilitate Introduction of Alternative Aviation Fuels to:*
  - Secure a stable fuel supply
  - Reduce environmental impacts
  - Improve aircraft operations
  - Further research and analysis

# Simplified View of Aviation Emissions Impacts



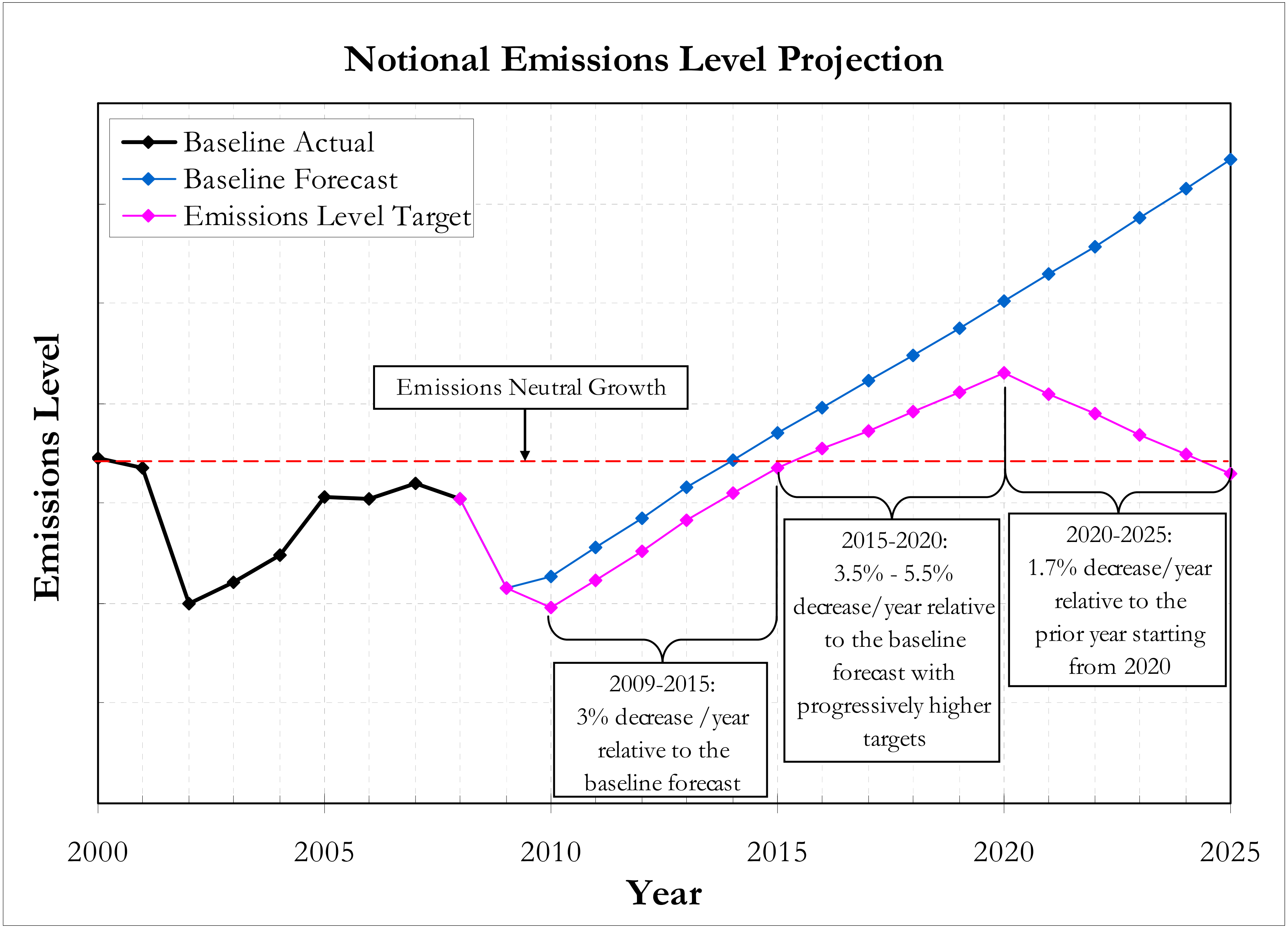

FAA AIA CAAFI ATA ACI-NA

# Glossary

Csoot – “soot” particles
$CH_4$ - methane
CO - carbon monoxide
$CO_2$ - carbon dioxide
$H_2O$ - water vapor
HAPs - hazardous air pollutants
NOx - oxides of nitrogen
$N_2$ - nitrogen
$N_2O$ - nitrous oxide
$O_2$ - oxygen
$O_3$ - ozone
PM - volatile and nonvolatile particulate matter
S - sulfur
$SO_2$ - sulfur dioxide
SOx - oxides of sulfur
UHCs - unburned hydrocarbons

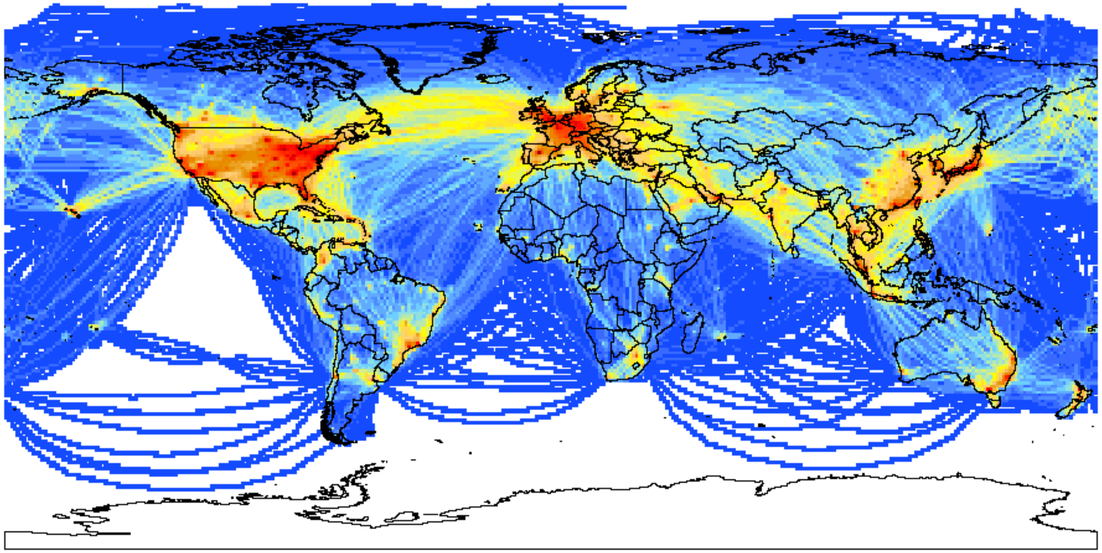
# U.S. Aviation Air Quality Goal

**Reduce the *significant* impact of aviation on air quality compared to today, notwithstanding aviation growth**



Notional Emissions Level Projection
Baseline Actual
Baseline Forecast
Emissions Level Target
Emissions Neutral Growth
2009-2015:
3% decrease / year relative to the baseline forecast
2015-2020:
3.5% - 5.5% decrease/year relative to the baseline forecast with progressively higher targets
2020-2025:
1.7% decrease/year relative to the prior year starting from 2020
Emissions Level
2000
2005
2010
2015
2020
2025
Year

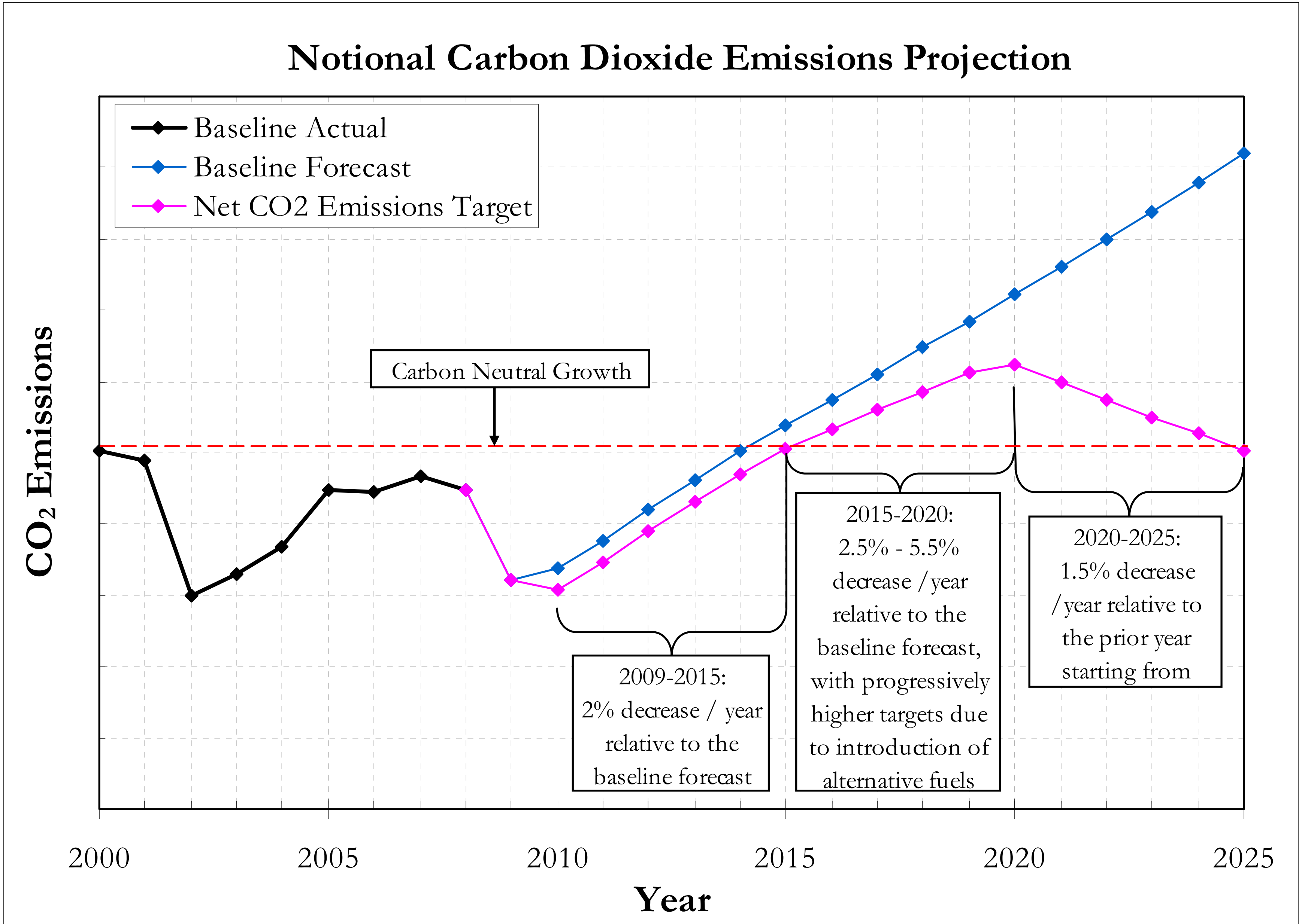
# U.S. Aviation Climate Goal



**Limit or reduce the impact of aviation greenhouse gas emissions on the global climate**

*Carbon neutral growth by 2020 compared to 2005*

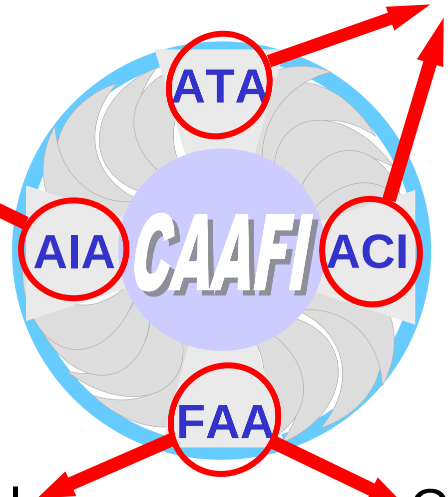
FAA AIA CAAFI ATA ACI-NA


Notional Carbon Dioxide Emissions Projection
Baseline Actual
Baseline Forecast
Net CO2 Emissions Target
Carbon Neutral Growth
$CO_2$ Emissions
2009-2015:
2% decrease / year relative to the baseline forecast
2015-2020:
2.5% - 5.5% decrease / year relative to the baseline forecast, with progressively higher targets due to introduction of alternative fuels
2020-2025:
1.5% decrease / year relative to the prior year starting from
2000
2005
2010
2015
2020
2025
Year

# Presentation Overview

- **Context**
- **CAAFI Environmental Tasks**
- **Progress**
- **Workshop Plans**

# CAAFI Environmental Panel Tasks




Business & Economics Panel

***Generate Demand***

R&D Panel

***Generate Ideas/Solutions***

Environmental Panel

***Assess Impact***

***Quantify Emissions***

***Life Cycle Analyses***

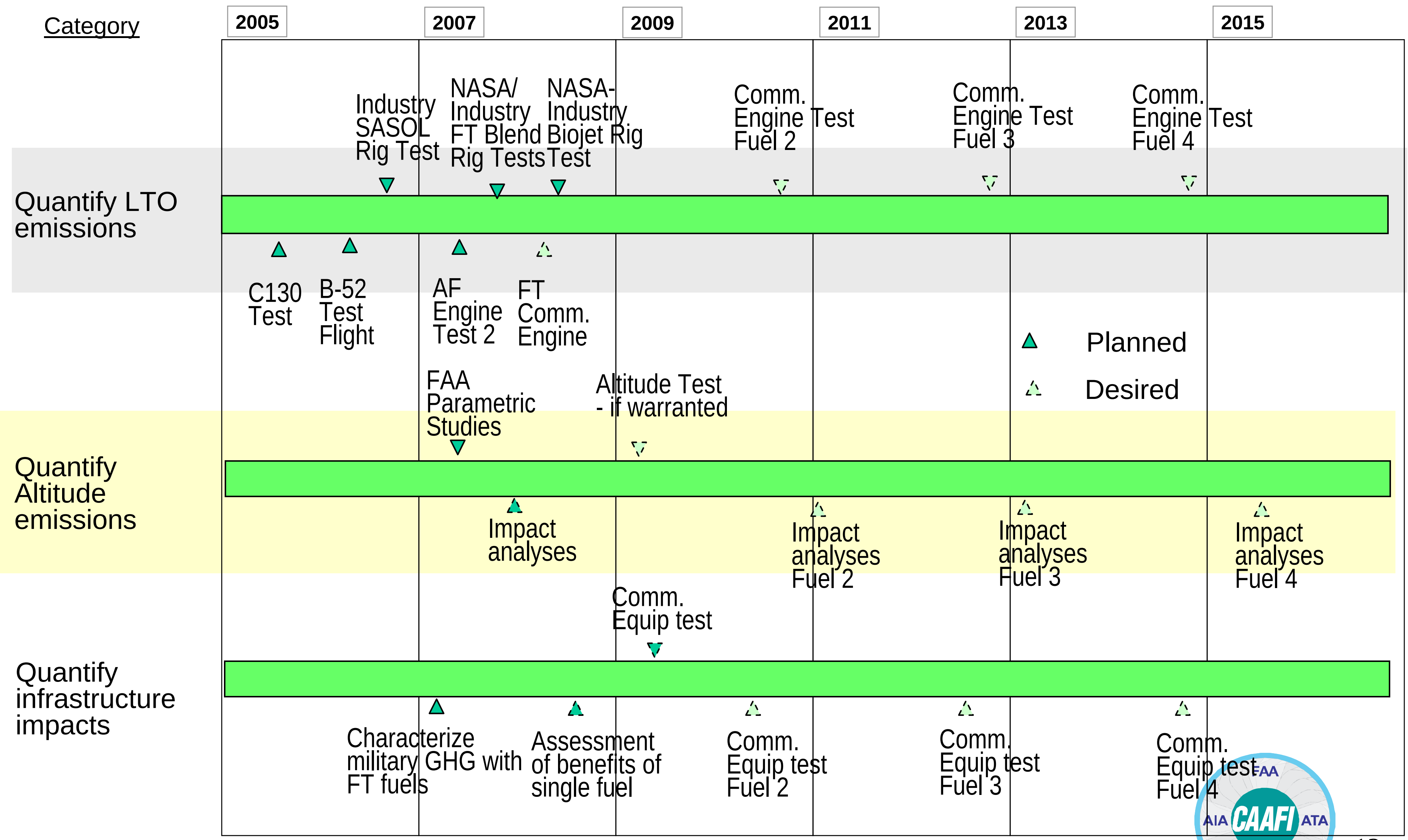
***Impacts & Cost Benefit Analyses***

***Foster solutions***

Certification-Qualification Panel

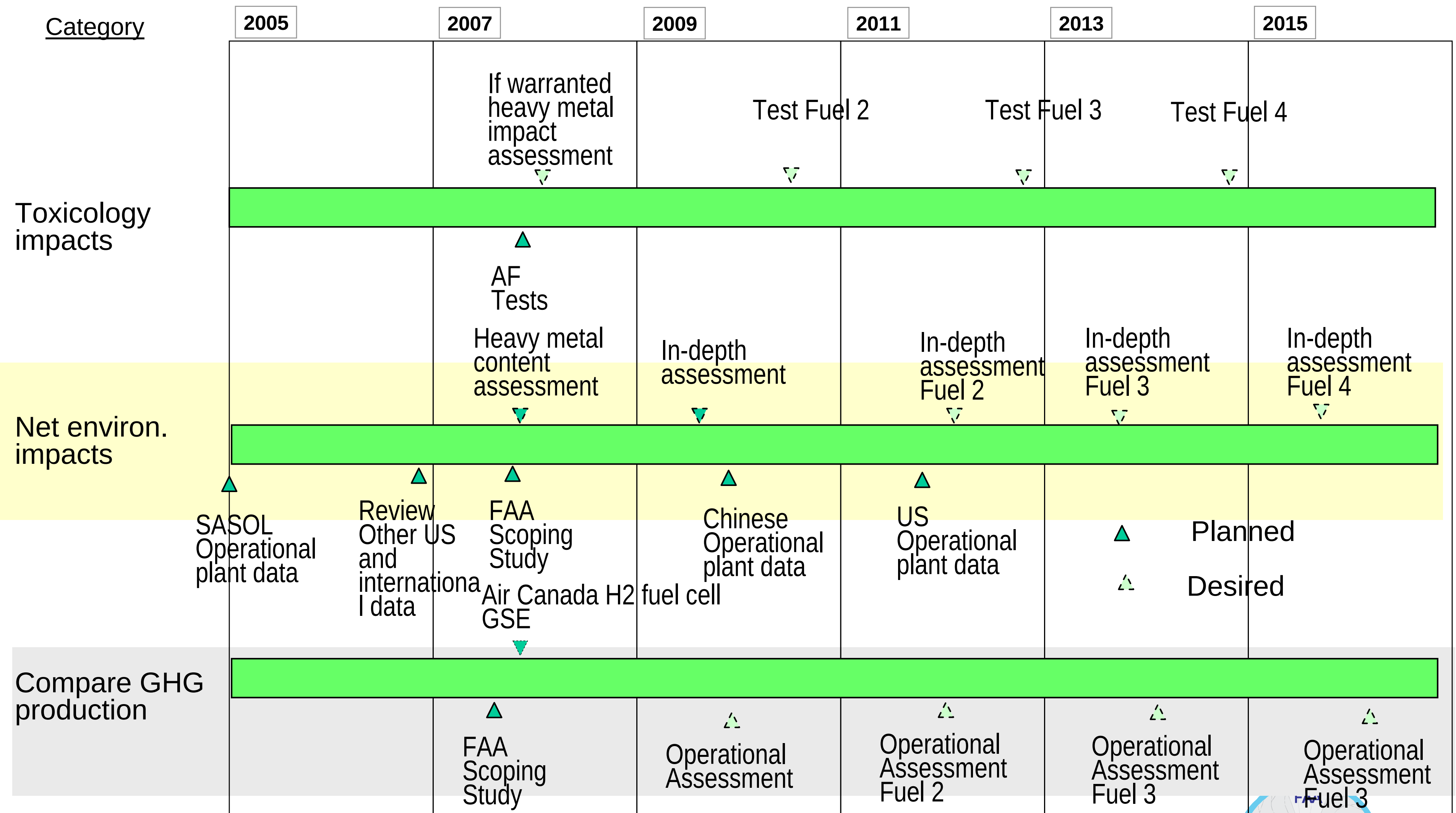
***Enable Supply***

# Aviation Alternate Fuels: Environment Roadmap




Fuels 2, 3, 4 etc. could be CTL, GTL, BTL via FT, other bio, etc. as defined by what fuel producers are likely to drive to

# Aviation Alternate Fuels: Environment Roadmap

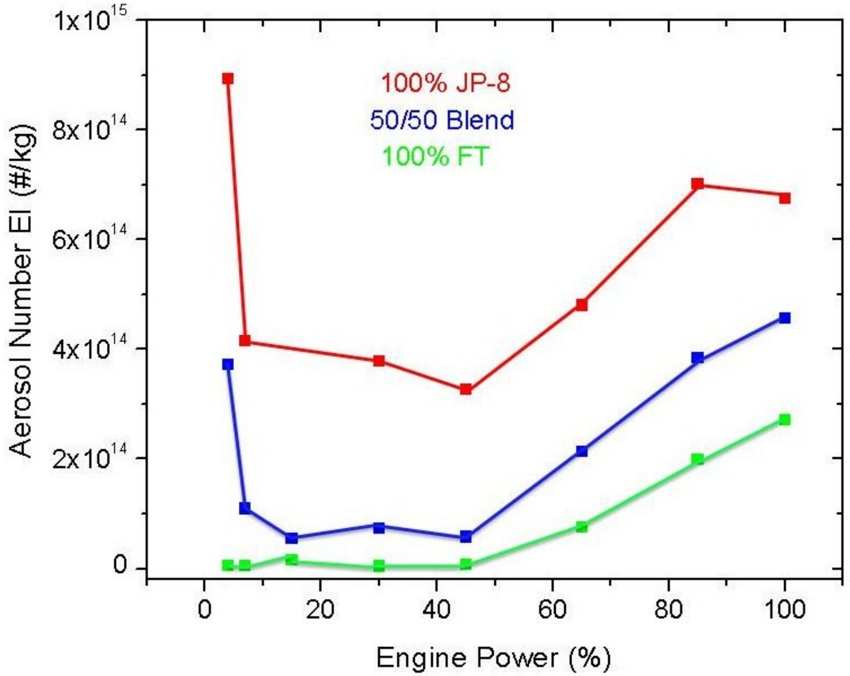



Fuels 2, 3, 4 etc. could be CTL, GTL, BTL via FT, other bio, etc. as defined by what fuel producers are likely to drive to

# Presentation Overview

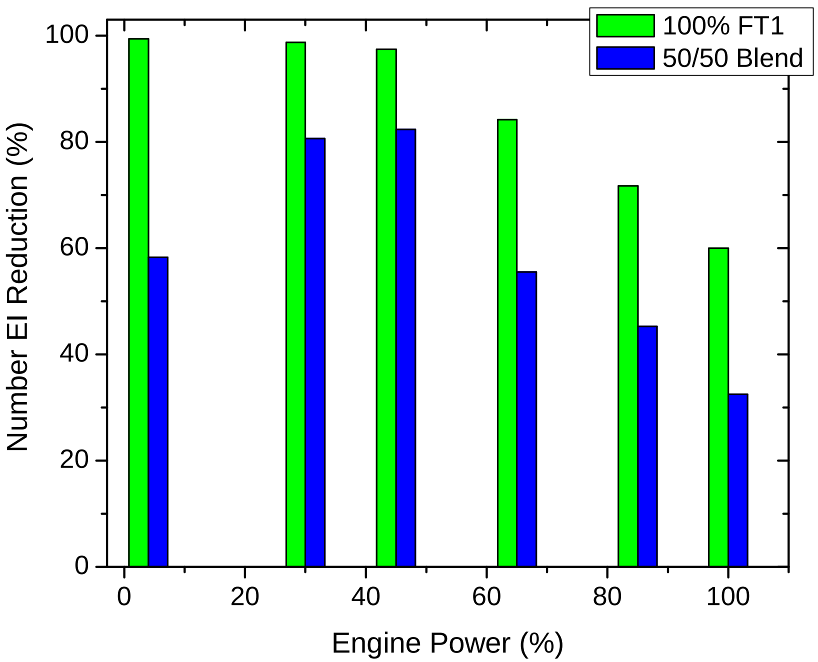
- **Context**
- **CAAFI Environmental Tasks**
- **Progress**
- **Workshop Plans**

# Recent Air Quality Results: Effects on Particle Number



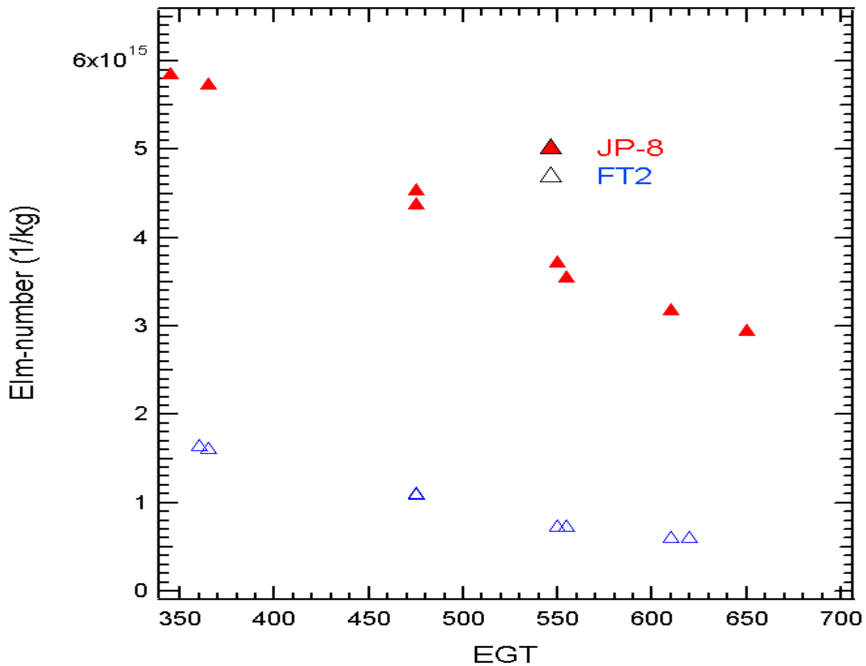

**Differences in emissions greatest at idle, less at higher engine powers**

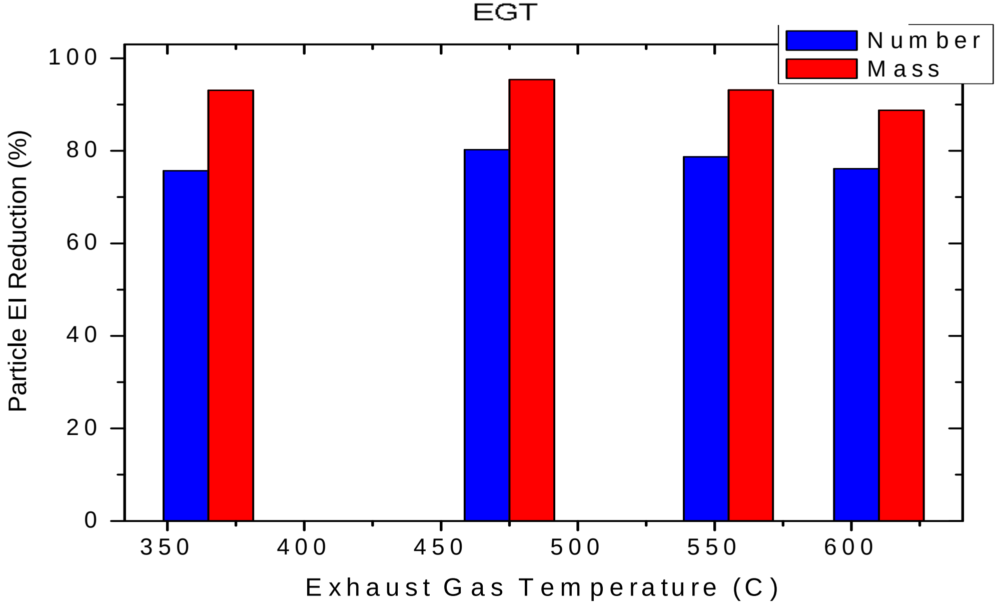
**Number emissions 98% lower at idle, 40% at takeoff power Emission reduction**




**FT (FT1) = Shell (natural gas) 50:50 blend Shell:JP8**

# Recent Air Quality Results: APU Emissions

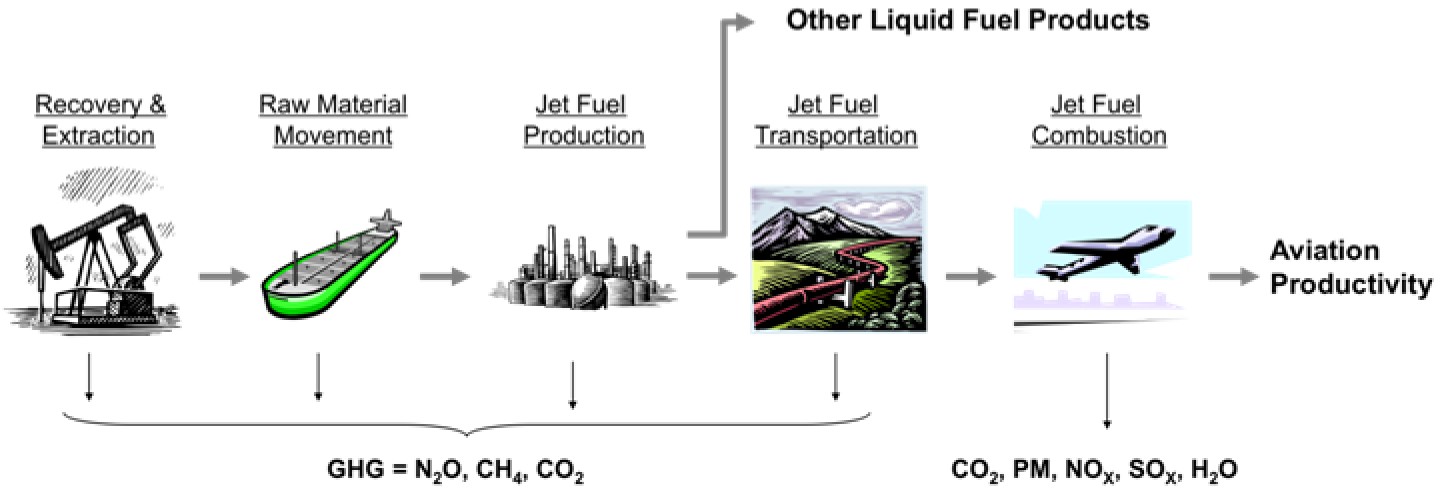



- **Mass emissions 90% lower when burning FT fuel**
- **Number emissions ~70% lower when burning FT fuel**

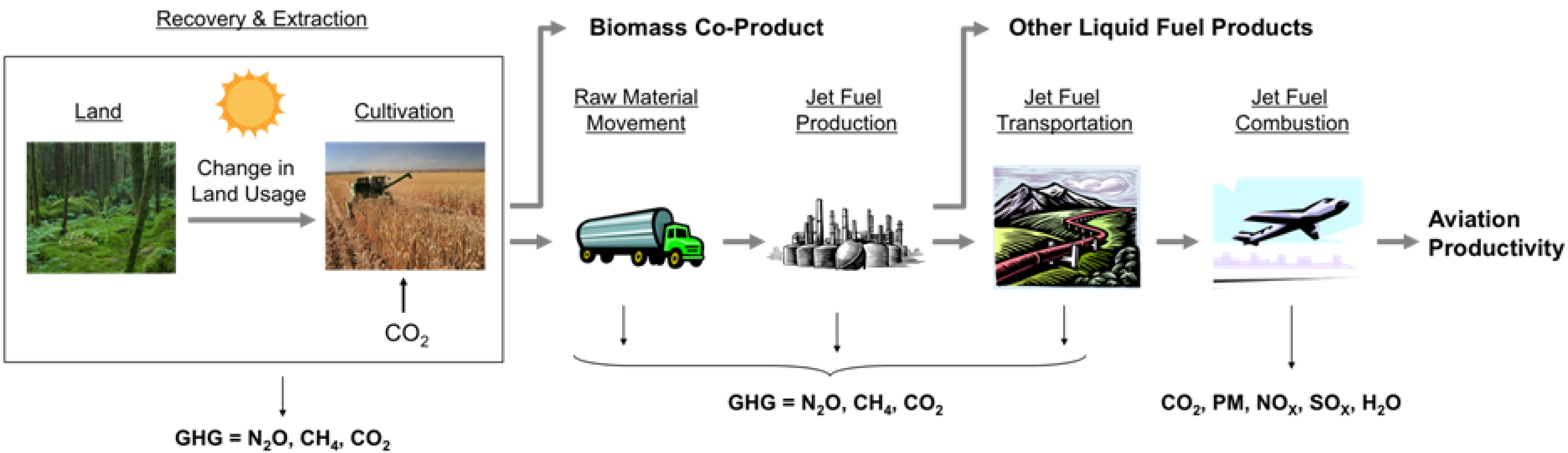
**** FT2 = Sasol (coal)**

# Well-to-Wake GHG Emissions Fossil-based Fuels




- Well-to-Tank GHG analysis via GREET (2008) framework with modifications to reflect alternative jet fuels of interest.
- Currently focusing on well-to-tank GHG emissions and $CO_2$ combustion emissions (future work will incorporate non-$CO_2$ combustion emissions).

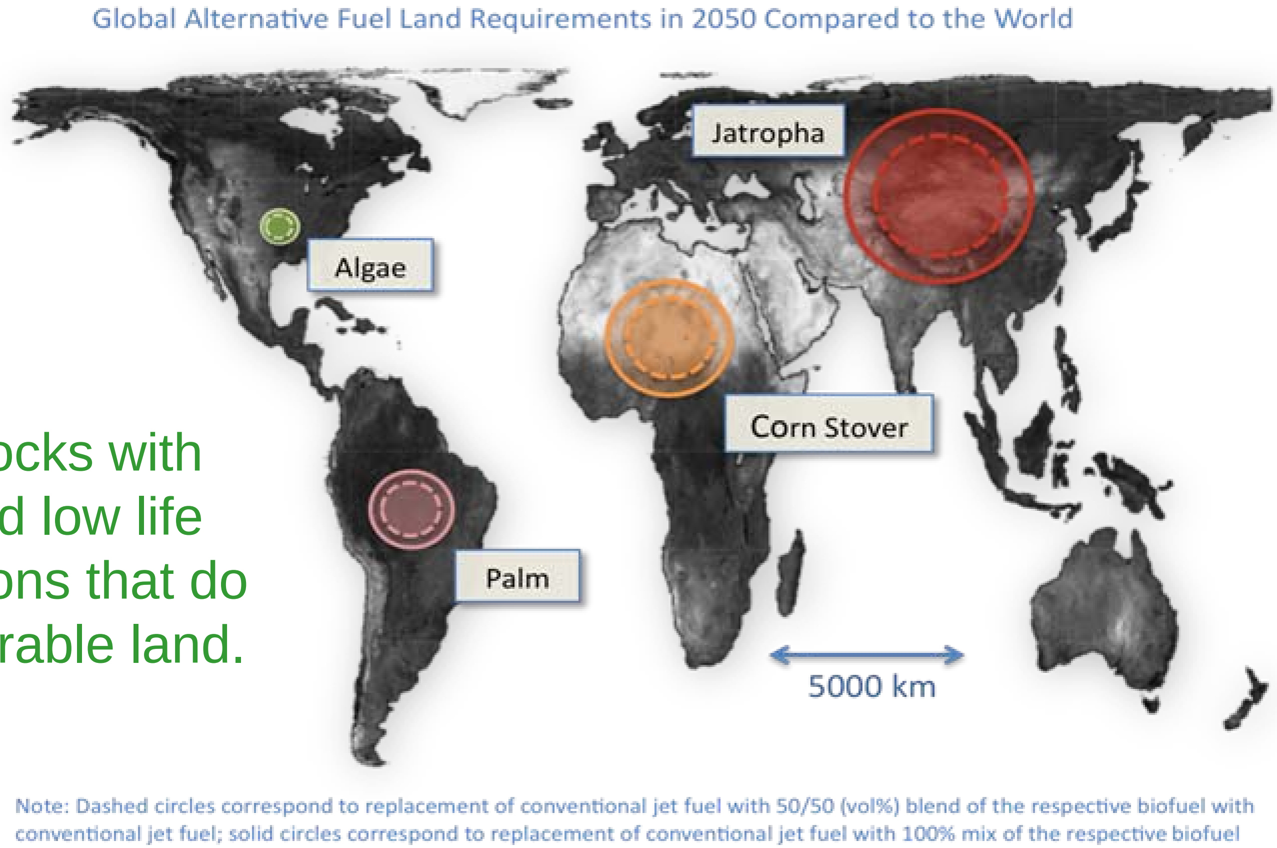
# Well-to-Wake GHG Emissions Bio-based Fuels




- Biofuels require modifications to analysis:
  - Farming energy and fertilizers
  - Water utilization
  - Land use changes
  - $CO_2$ extracted from atmosphere to grow biomass feedstock

# Sample Results

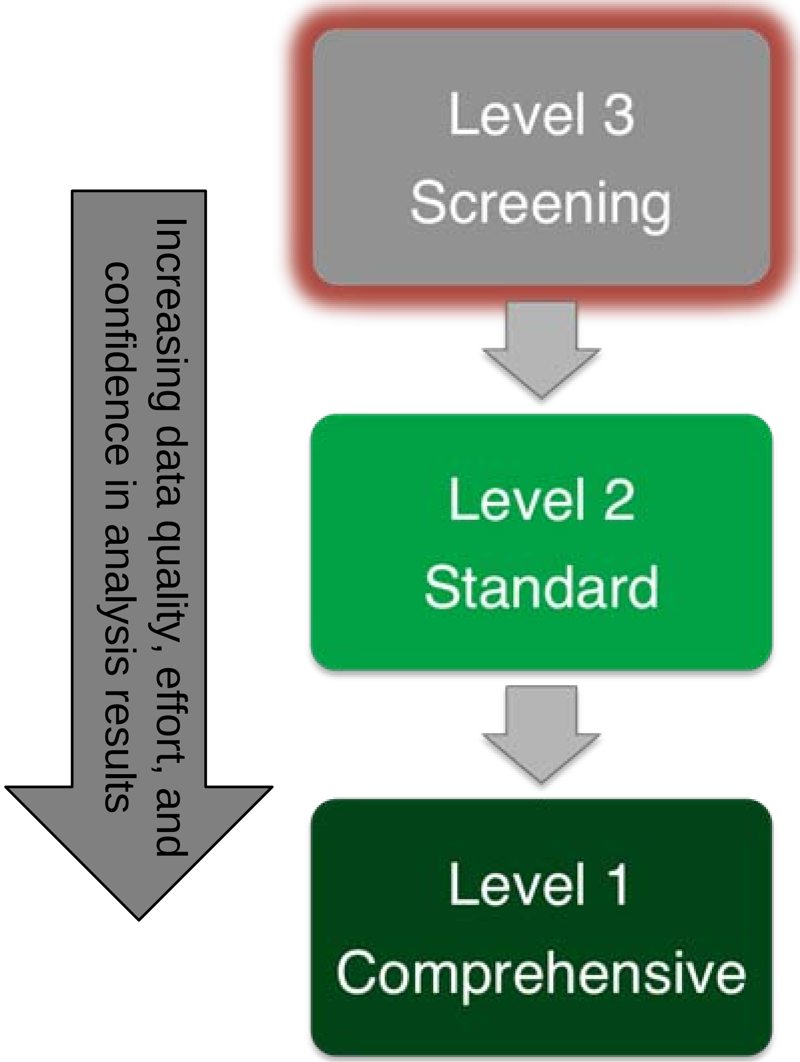
- **Analysis on Carbon Neutral Aviation Growth**




Need feedstocks with high yield and low life cycle emissions that do not require arable land.

Land area requirements for different biofuels to replace global conventional jet fuel use in 2050

# Life-Cycle Analysis Resolution Levels




Conducted in support of a preliminary assessment of a technology alternative, to inform policy makers about research funding.

All major operations examined, but with a lower degree of completeness and data quality than comprehensive LCA.

Conducted to meet regulation, such as Section 526 of EISA 2007.

Concepts developed as part of IAWG "Rules and Tools" Workshop (Feb 9-13, 2009).

# Ongoing Life Cycle Analysis Efforts

**Multiple research efforts are ongoing within the U.S. and Europe. Some examples:**

- **USAF:** The Aviation Fuel Life Cycle Assessment Working Group convened to develop guidance for estimating life cycle GHG emissions inventories for jet fuel.
- **NETL:** In the U.S., researchers in the National Energy Technology Laboratory examined the GHG emissions from U.S. transportation fuels, including jet fuel, derived from conventional petroleum.
- **PARTNER:** Partnership for AiR Transportation Noise and Emissions Research have examined a wide range of alternative jet fuel pathways (MIT has conducted much of this)
- **BOEING:** Boeing sponsoring research on jatropha based jet fuels at Yale University and algae based jet fuels at University of Washington and Washington State University.
- **OMEGA and SWAFEA:** Cambridge University in the U.K. examined algal jet fuels as part of OMEGA consortium; ONERA in France are currently leading an evaluation of a wide range of fuel options as part of SWAFEA (Sustainable Way for Alternative Fuel and Energy in Aviation).
- **Michigan Technical University:** Have conducted assessments of jatropha and camelina in cooperation with Honeywell UOP. Algae assessments in progress.

# Impacts and Costs/Benefits: Lower Sulfur

Approach

- Working with aviation fuel industry stakeholders to develop estimates of existing sulfur levels/refinery costs
- Preliminary cost-benefit analysis using the current air quality and climate impact representation in the FAA Aviation Portfolio Management Tool
- Conduct a refined cost-benefit analysis using a range of air quality and atmospheric/climate models


PARTNER

FAA AIA CAAFI ATA ACI-NA

# Outcomes of Sulfur Analysis

– Understand potential of ULS as one of the options to reduce aviation environmental impacts

– Understand interplay between $SO_2$ emissions and resultant effects on climate through sulfur aerosols, soot aerosols, contrail/cirrus formation and ozone (and methane changes)

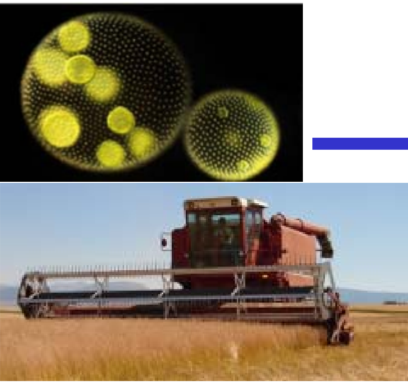
– Understand impacts of cruise altitude aircraft emissions on surface air quality

**More to come – Study just initiated!**

# Fostering Solutions: CLEEN

- Continuous Low Energy Emissions and Noise (CLEEN) Program
  - Advance the development and introduction of alternative “drop in” fuels for aviation, with particular focus on renewable options, including blends.
  - Demonstration and assessment of alternative fuels, including assessment of the testing required to support fuel qualification and specification development and production potential.
  - Potential FAA Reauthorization Targets: alternative fuels available to meet 20% of commercial and cargo airlines needs
  - Possible $13M augmentation in FY2010

# Potential CLEEN Fuels Efforts Focus



Evaluate & select feedstocks

Identify & pilot processing methods


Specification Properties

Fit-For-Purpose Properties

Component/Rig/APU Testing

Engine/Flight Testing

ASTM Research Report

# Presentation Overview

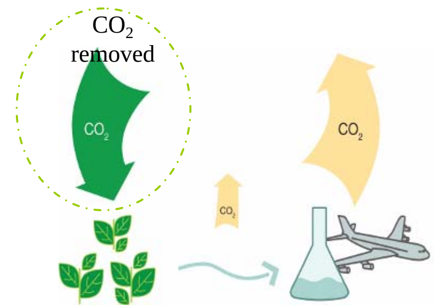
- Context
- CAAFI Environmental Tasks
- Progress
- Workshop Plans

# Workshop Agenda

Roadmap Discussion

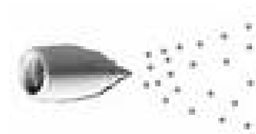

Program Updates


Life Cycle Analyses Reviews




Cost/Benefit Analyses

Particulate Matter Implications



Next Steps

# Thank You

**Lourdes Maurice**

**FAA Chief Scientist for Environment**

**CAAFI Steering Committee**


**Tel:** 202-493-4293
**Fax:** 202-267-5594
**Email:** Lourdes.Maurice@faa.gov

**Federal Aviation Administration**
**800 Independence Avenue, SW**
**Washington DC20591**