CAAFI Environment Team: Developing Tools & Means to Address Environmental Issues

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COMMERCIAL AVIATION
ALTERNATIVE FUELS INITIATIVE

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Overview

* Refresher on the Environmental Imperative

* CAAFI Environment Team Focus & Achievements to Date
  * Greenhouse Gas (GHG) Emissions Life Cycle Analysis
  * Sustainability Impact Matrix & Guidance (Drafts)
  * Environmental Progression Tool

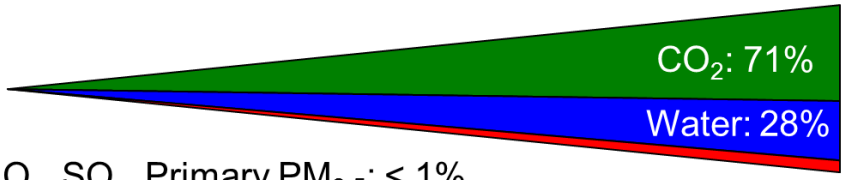
* Additional Work Ahead

Refresher on the Environmental Imperative

* Overall Objectives for Alternative Fuel Deployment
  * Energy Security/Supply Reliability
  * Commodity Competitor to Petroleum
  * **Environmental Benefit (our focus)**

* Environmental Benefit
  * Life Cycle Greenhouse Gas (GHG) Emissions Improvements
  * Potential to Reduce Emissions with Air Quality Impact
  * Sustainability More Broadly: Do Not Induce Other Environmental Problems
    * Water use, land use, food-basket competition, etc.

Environmental Impacts of Aviation



CO, HC, NO_x, SO_x, Primary $PM_{2.5}$: < 1%

Aircraft Noise

Atmospheric Chemistry and Physics

Primary $PM_{2.5}$

SO_x

NO_x

UHC

CO

Secondary $PM_{2.5}$

Ozone

Population Exposure and Health Impacts

Combustion Emissions

soot

SO_x

NO_x

O_3

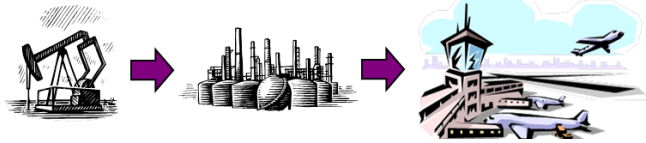
CH_4

H_2O

CO_2

Contrails & Cirrus Clouds

Impacts from Fuel Production



CH_4, N_2O, CO_2

Global Climate Change

Cooling Effects

Warming Effects

Alternative jet fuels could help to mitigate impacts

Environmental Impacts of Aviation

CO_2: 71%

Water: 28%

CO, HC, NO_x, SO_x, Primary $PM_{2.5}$: < 1%

Aircraft Noise

Atmospheric Chemistry and Physics

Primary $PM_{2.5}$

SO_x

NO_x

UHC

CO

Secondary $PM_{2.5}$

Ozone

Population Exposure and Health Impacts

Combustion Emissions

soot

SO_x

NO_x

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CH_4

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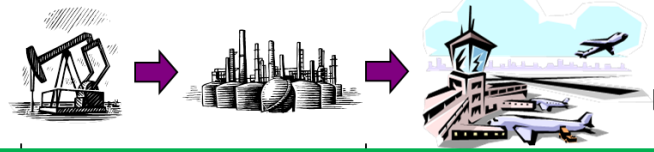
Contrails & Cirrus Clouds

Impacts from Fuel Production



CH_4, N_2O, CO_2

Life Cycle GHG Emissions

Global Climate Change

Cooling Effects

Warming Effects

Sustainability

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GHG Life Cycle Analysis: Focus & Achievements to Date

* Confirmed We Know the Steps and How to Apply Them to Aviation (building on "Framework & Guidance for Estimating Greenhouse Gas Footprints of Aviation Fuels")
  * Strong basis established for how the U.S. federal government can use existing tools and methodologies for confirming compliance with Section 526 of the Energy Independence & Security Act (EISA) and how commercial aviation stakeholders can demonstrate life cycle benefit
* Integrated Jet Fuel into the ANL GREET Model

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Aviation Fuel Options in GREET1_2012

Fuels and Feedstocks

- **Petroleum Jet Fuel**
  - Conventional Crude
  - Oil Sand
- **Pyrolysis Oil Jet Fuel**
  - Crop Residues
  - Forest Residues
  - Dedicated Energy Crops
- **Hydrotreated Renewable Jet Fuel**
  - Soybeans
  - Palm Oil
  - Rapeseeds
  - Jatropha
  - Camelina
  - Algae
- **Fischer-Tropsch Jet Fuel**
  - North American Natural Gas
  - Non-North American Natural Gas
  - Renewable Natural Gas
  - Shale Gas
  - Biomass via Gasification
  - Coal via Gasification
  - Coal/Biomass via Gasification

Aircraft Types

- **Passenger Aircraft**
  - Single Aisle
  - Small Twin Aisle
  - Large Twin Aisle
  - Large Quad
  - Regional Jet
  - Business Jet
- **Freight Aircraft**
  - Single Aisle
  - Small Twin Aisle
  - Large Twin Aisle
  - Large Quad

- **LCA Functional Units**
  - Per MJ of fuel
  - Per kg-km
  - Per passenger-km

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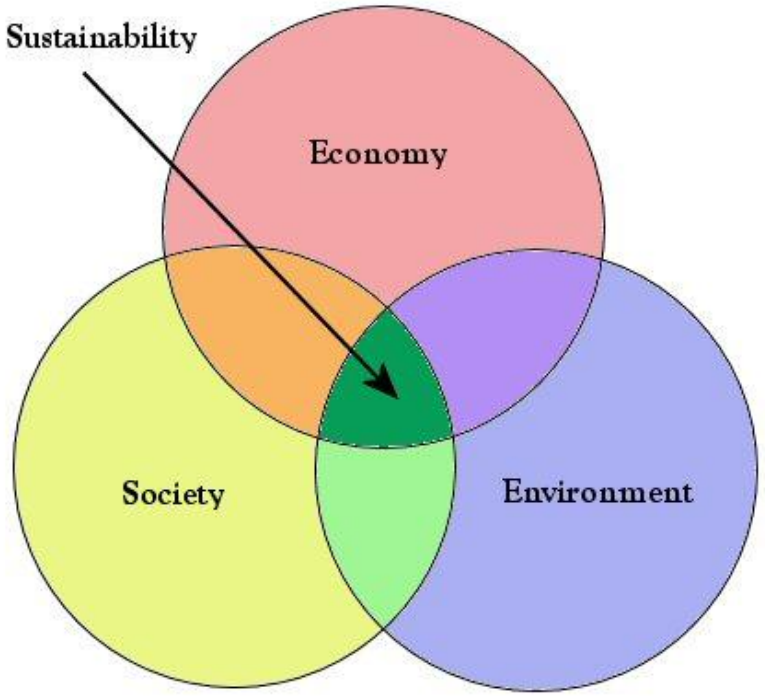
GHG LCA: Ongoing Work

* Continue to Use GREET to Examine Additional Pathways
* Project to Compare GHG LCA Results from Different Models/Tools
  * EPA- RFS2
  * EU Renewable Energy Directive – BioGrace
  * GREET

For now, accepted country-based tools are fine; but eventually will need mutual recognition for proper crediting of environmental benefit (alternative fuel for international flights)

Sustainability: Focus of Environment Team to Date



Environmental Aspects of Sustainability

- Reduce air emissions
- Ensure compliance with requirements
- Do not induce environmental harm

Note: The Team recognizes that there are other aspects of "sustainability" besides environment

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Sustainability: Focus & Achievements to Date

- Developed (Draft) Sustainability "Impact Matrix" and (Draft) Guidance
  - Identified areas of concern – key environmental indicators
  - Identified relevant metrics for reflecting potential impact
  - Overview of existing regulatory and voluntary sustainability regimes
  - Developed a draft "Impact Matrix" that defines the potential impact risk for various resources along the biofuel supply chain and metrics for evaluating impacts
- Developed Draft Environmental Progression
  - Puts "environmental readiness" on a scale with feedstock readiness and fuel readiness

DRAFT Sustainability Impact Matrix

POTENTIAL FOR DIRECT IMPACTS	Economic Operator				
	Feedstock Producer	Feedstock Processor	Fuel Producer	Fuel Blender/ Distributor	Fuel End User
Energy Use (Balance)	High	Medium	High	Low	High
Greenhouse Gases	High	Low	High	Low	High
Air quality	Medium	Low	High	Medium	High
Biodiversity	High	Medium	Medium	Low	Low
Land Use	High	Low	Medium	Low	Low
Water quality (Pollutants, Eutrophication)	High	Low	Medium	Low	Low
Freshwater use (Consumption)	High+	Low	High	Low	Low
Soil quality	High	Low	Low	Low	Low
+ most likely related to irrigation for first generation biofuels, less likely for advanced biofuels					
Potential Impact Severity (color) →		Low	Medium	High	

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Next Steps

* Putting Together Working Group to Further the Work on Comparing LCA GHG Methods and Tools
* Stakeholder Review of the Sustainability Impact Matrix and Guidance and Environmental Progression Tool
  * Plan to publish "living documents" this summer
* Will Work on Case Studies
* Will Work with Business Team on Economic Aspects of "Sustainability" and further Consideration of the Role of Social Aspects


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