Commercial Aviation Alternative Fuels Initiative

Environmental Assessments Status

Presented to:

ICAO Workshop: Aviation and Alternative Fuels

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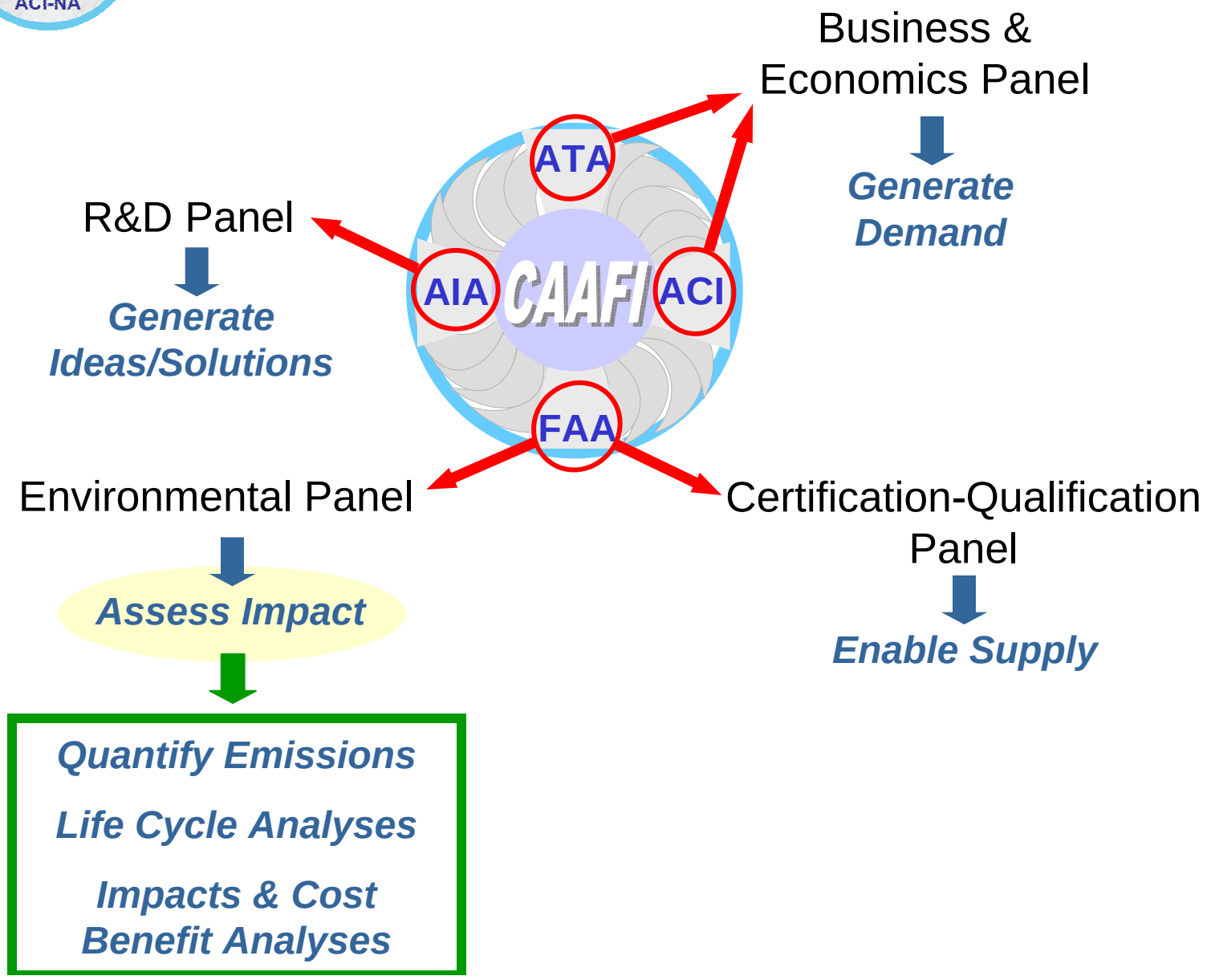
Context

- *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

CAAFI Environmental Panel Tasks



Aircraft Emissions & Climate Change

CO_2: 71%

Water: 28%

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

Emissions

Atmospheric Chemistry & Physics

Primary $PM_{2.5}$

SO_x

NO_x

O_3

CH_4

H_2O

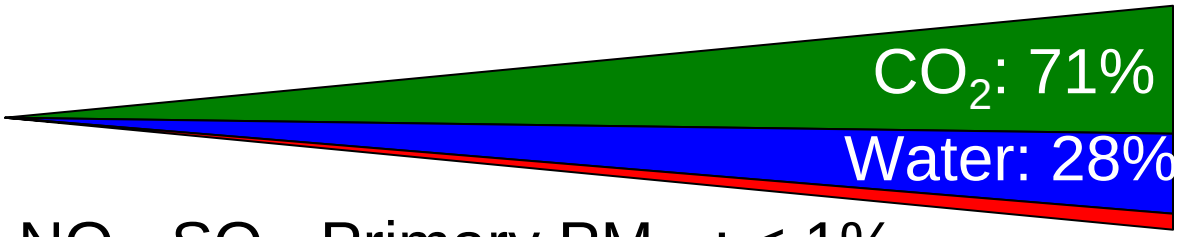
CO_2

Global Climate Change

(an extraordinarily simplified view)

Adapted by J. Hileman from: Sequeira, Christopher J., *An Assessment of the Health Implications of Aviation Emissions Regulations*, S.M. thesis, Massachusetts Institute of Technology, Department of Aeronautics and Astronautics, 2008.

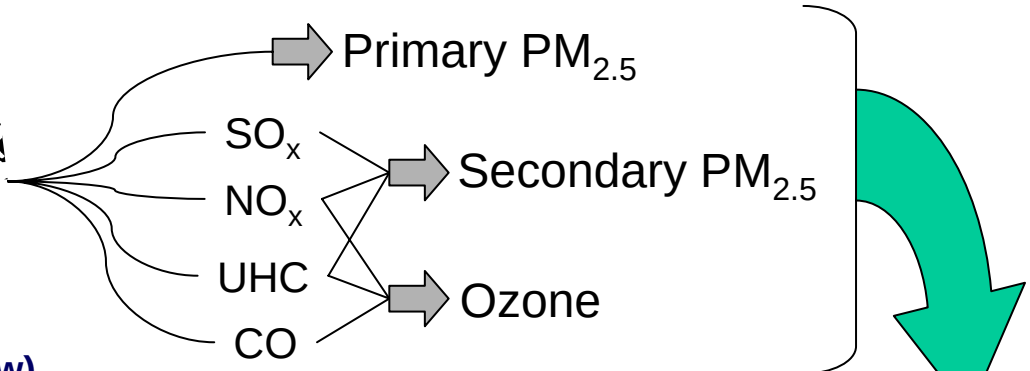
Aircraft Emissions & Air Quality



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

Atmospheric Chemistry & Physics

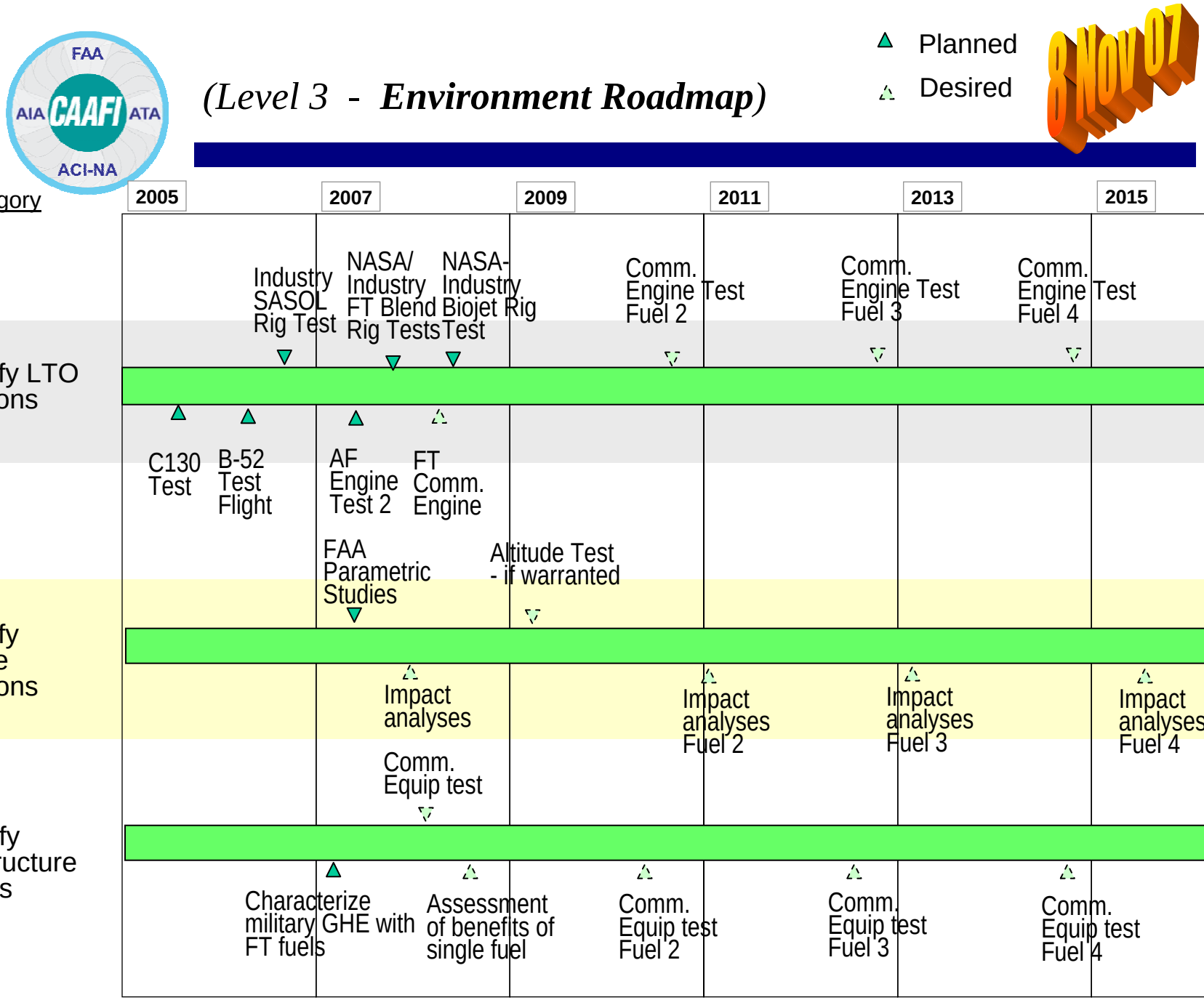
Emissions



(an extraordinarily simplified view)

Population Exposure and Health Impacts

Adapted by J. Hileman from: Sequeira, Christopher J., *An Assessment of the Health Implications of Aviation Emissions Regulations*, S.M. thesis, Massachusetts Institute of Technology, Department of Aeronautics and Astronautics, 2008.

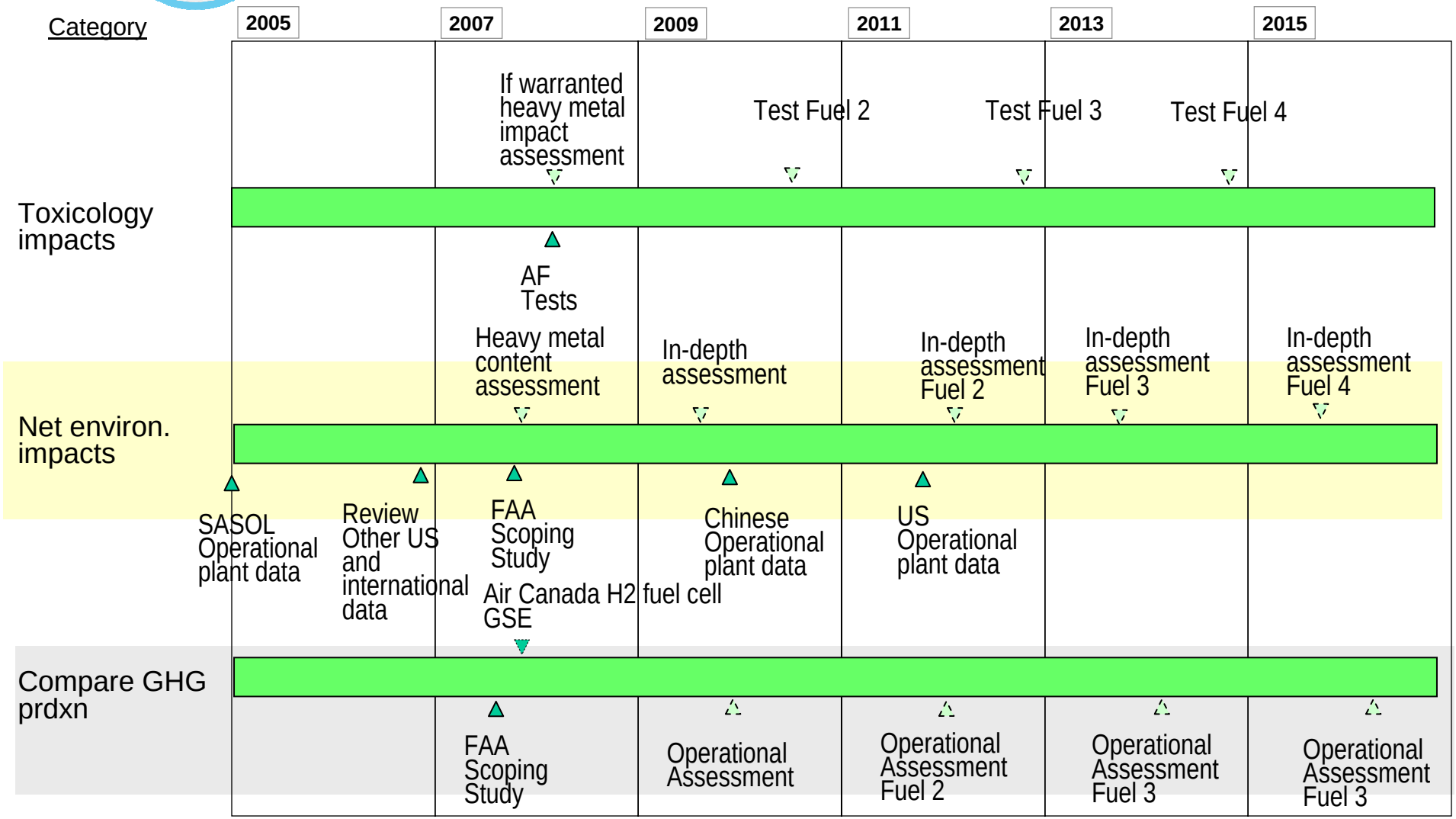


Fuels 2, 3, 4 etc. could be CTL, GTL, BTL via FT, other bio, etc. as defined by what fuel producers are likely to drive to

*(Level 3 - **Environment Roadmap**)*

Planned
Desired

8 Nov 07



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

Sample Contributors to Activities

- CAAFI Environmental Panel

FAA

Supporting Legislation for US Gov't Funding

Sponsor Life Cycle Emissions Studies

Emissions Measurements

Partnering with X-Prize on incentives

ICAO/CAEP

Engine Emissions Certification

USAF

B-52 FT Fuel Emissions Qualification

High-Bypass Engine FT Fuel Emissions

Sponsor Life Cycle Emissions Studies

PARTNER-RAND

Feasibility Studies

Alternative Fuel Emissions Life Cycle Study

Cost-benefit analyses

NASA/PW

FT fuel Emissions Engine Ground Test

Boeing/GE

Bio-fuel Emissions Engine Ground Test

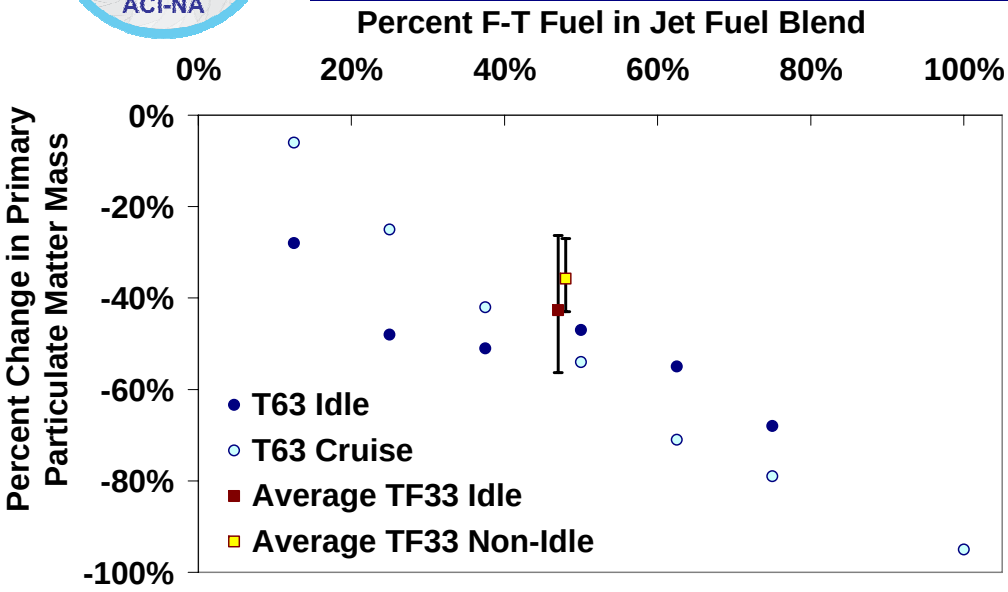
Flight Demo

Dept of Energy

CO_2 Sequestration Studies

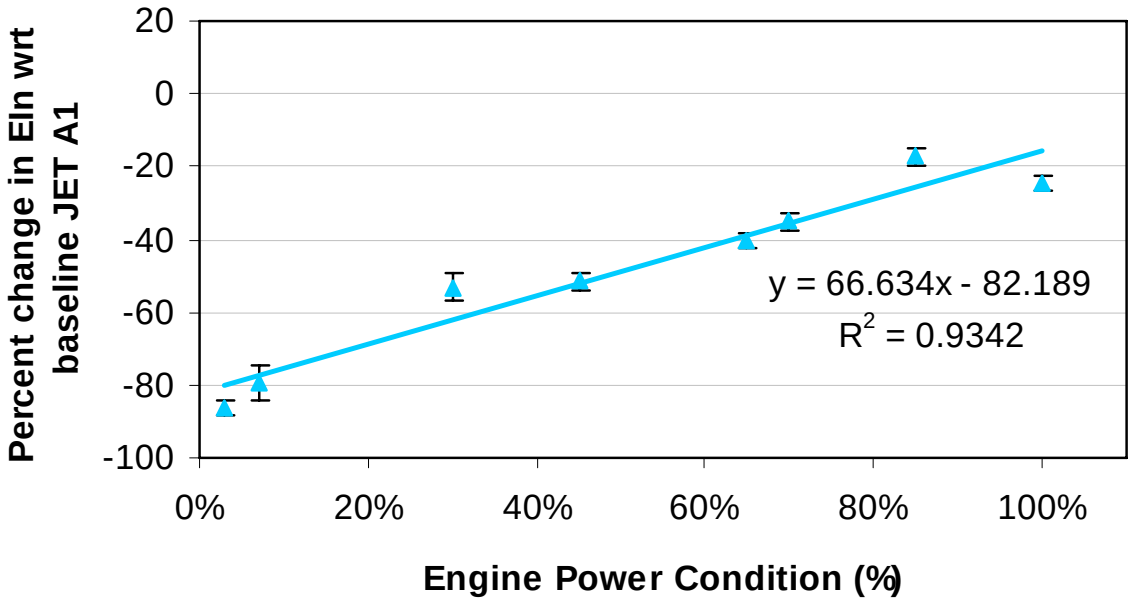
Co-fired CTL/BTL Studies (NOBLIS/Princeton)

Quantifying LTO Emissions

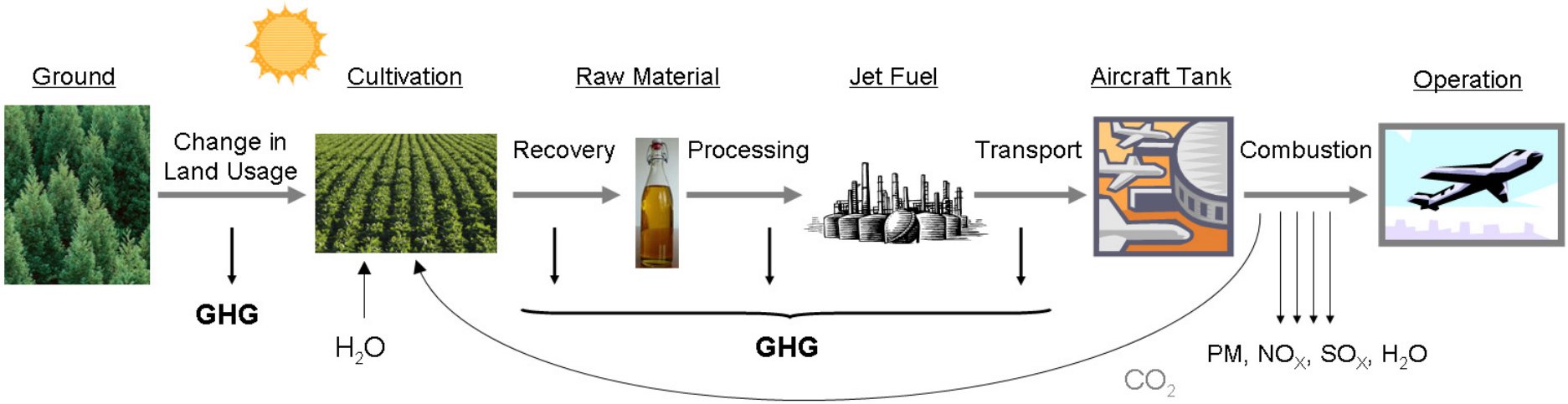


Measured reductions in primary PM in military gas turbine engines burning various alternative fuel blends (USAF)

Results showing observed reductions in primary PM in a CFM56-7B engine burning a mixture of 50% F-T fuel and 50% Jet A-1 (PARTNER COE)



Emissions Life Cycle Analyses



Assessing uncertainties critical:

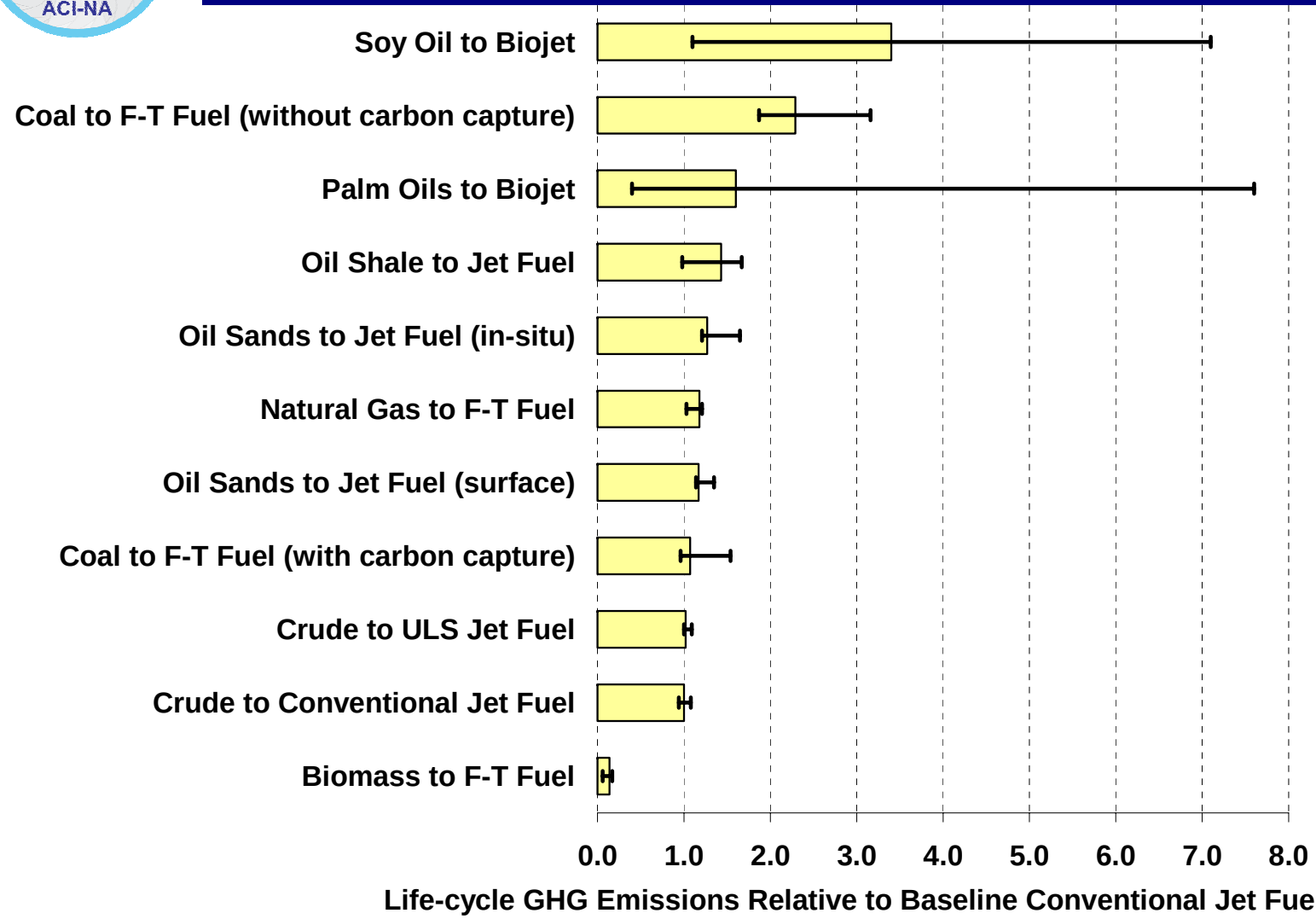
– Key sources of uncertainties include feedstock properties, N_2O emissions from nitrogen fertilizer use, land use change emissions, process efficiencies, allocation of co-product credits

– Should use sensitivity analysis to address uncertainties

– Should provide range of GHG emissions rather than a single value

Results from H.M. Wong S.M. Thesis (2008)

Sample Life Cycle Analyses (LCA)

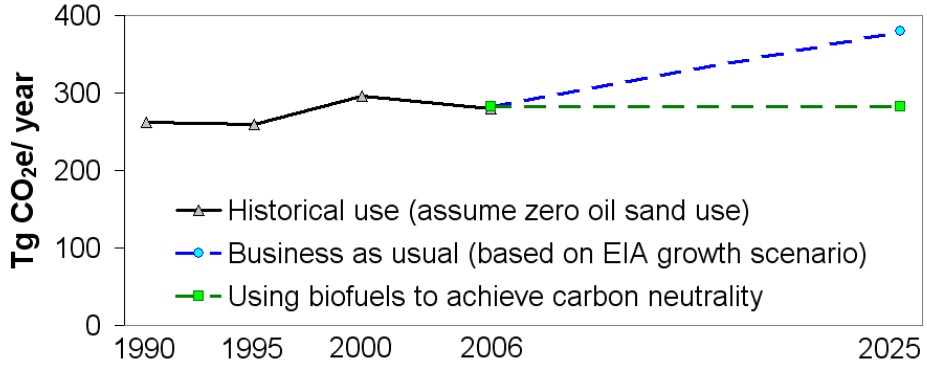


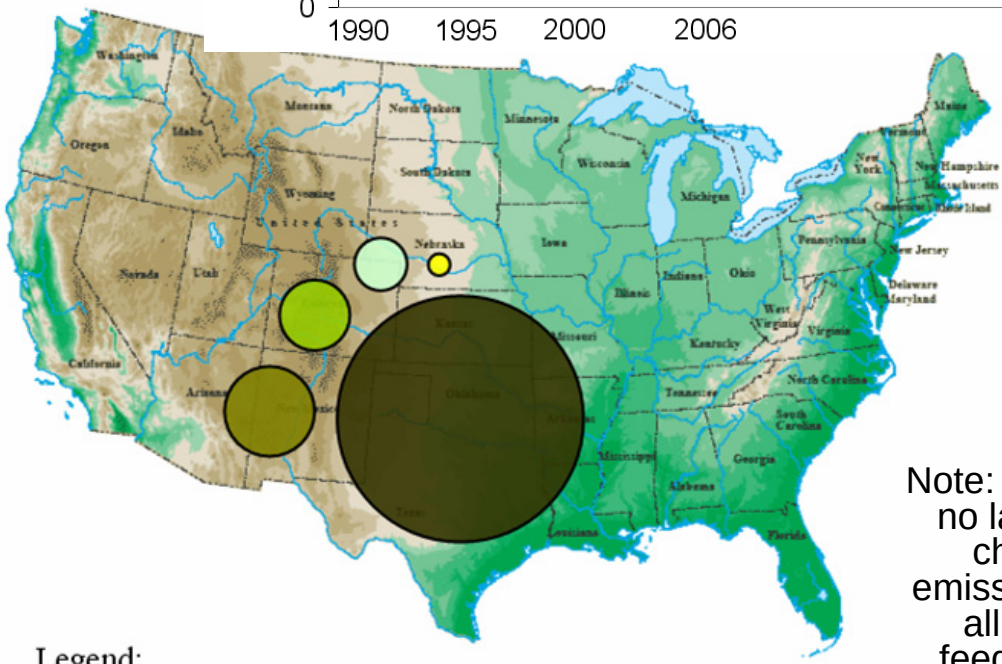
In general, life-cycle emissions are not deterministic, "Point Values." Instead, they are better defined as scenario-dependent ranges.

Potential for Biojet and BTL - Results from H.M. Wong S.M. Thesis (2008)

Enabling Carbon Neutral U.S. Aviation Growth

- Assessed potential for carbon neutral growth from 2006 to 2025.
- Analysis used biofuel life-cycle GHG emissions and yield per hectare.
- Circles show land area requirements for three existing and two hypothetical feedstocks.
- Soybean and palm requirements both exceed current production levels.
- Analysis looked at single feedstock solutions – practical approach is to consider multiple feedstock solutions.
- ***Need feedstocks with high yield and low life-cycle emissions that do not require arable land.***





Note: Assumed no land use change emissions with all of the feedstocks.

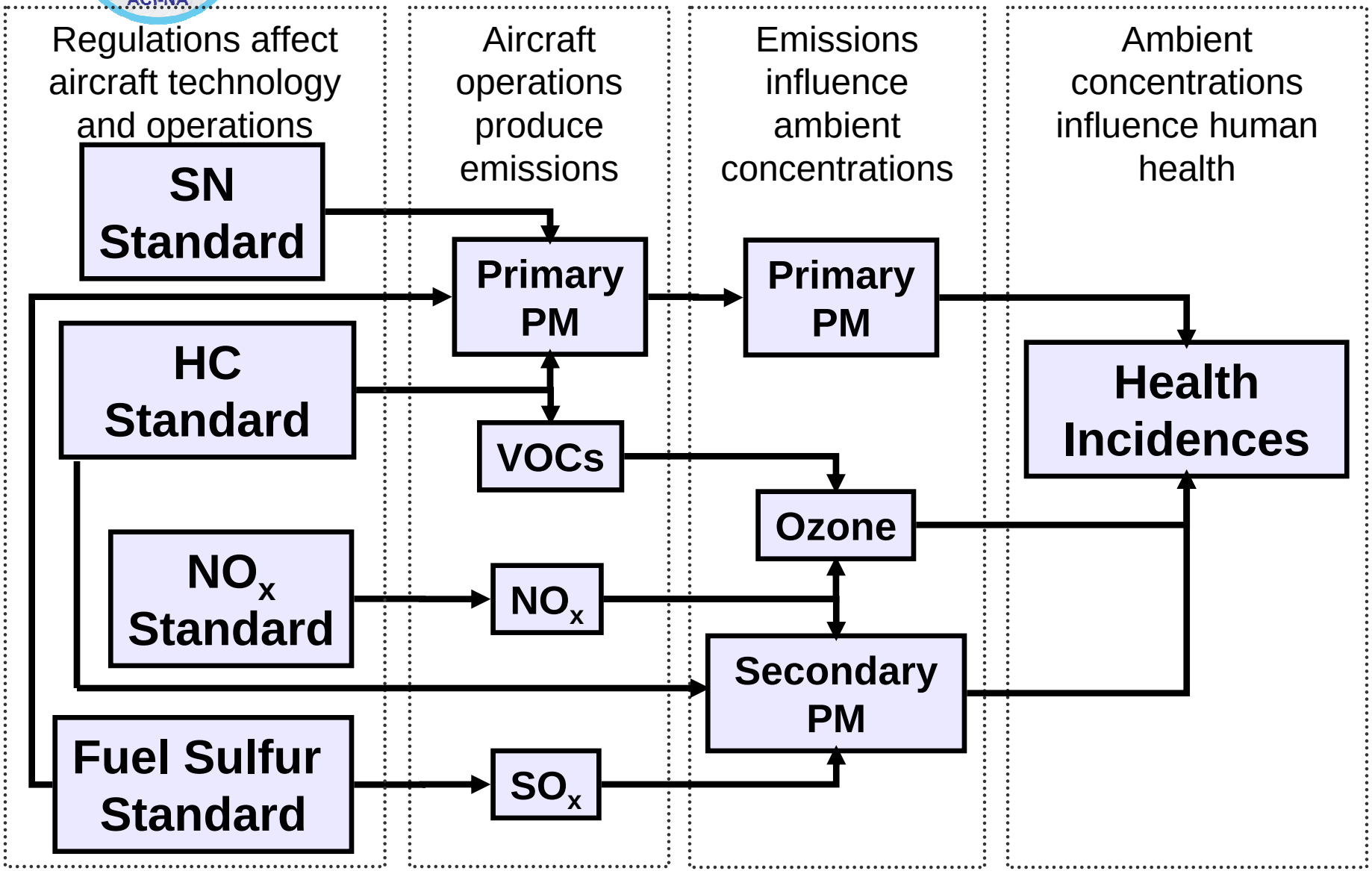
Life Cycle Analyses (LCA) Conclusions

- Alternative aviation fuels from biomass offer substantial life-cycle GHG emissions reductions relative to conventional jet fuels
- Land use change impacts from the use of biomass feedstocks (particularly food crops) could potentially increase life-cycle GHG emissions
- Use of waste products and dedicated energy crops in the large-scale production of bio-jet fuel more feasible than food-based crops in terms of feedstock requirements
- Next generation biomass feedstocks with high oil yields offer promise

Next Steps for LCA

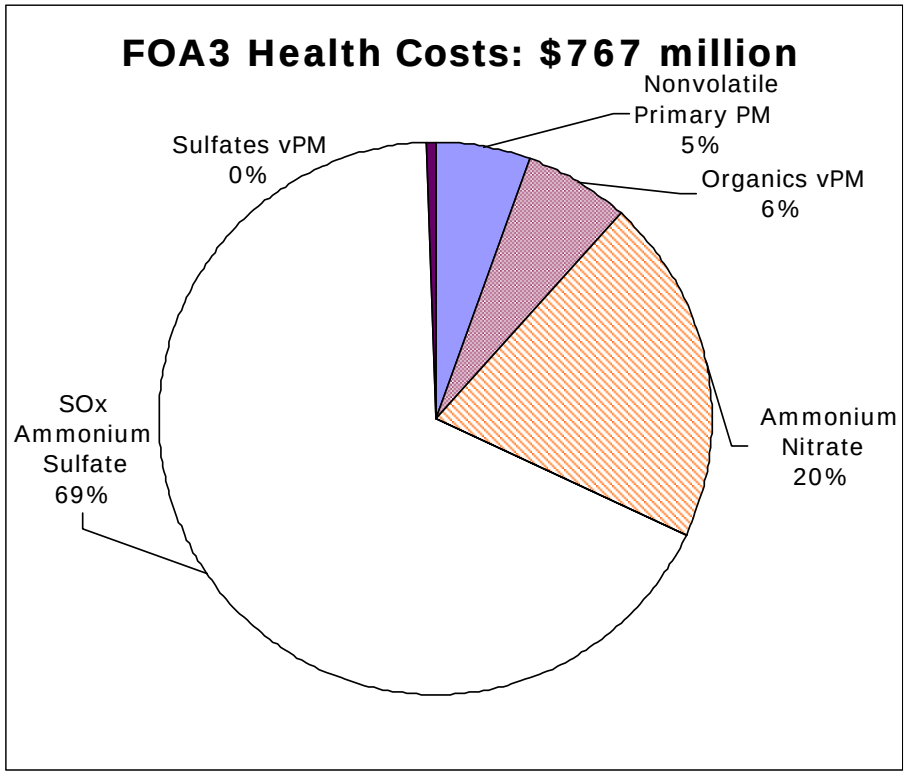
- Explore the use of *any* additional feedstocks that could reduce GHG emissions
- Examine overall sustainability of potential alternative jet fuel pathways to assess viability for large-scale production
- Conduct detailed, specific analysis of land use change impacts in the use of biomass feedstocks for alternative jet fuel production
- Develop an aviation-specific life-cycle analysis framework (including aircraft operation emissions analysis)
- Conduct multiple but coordinated analyses, engage stakeholders, peer review results

Impacts & Cost-Benefit Analyses (CBA)

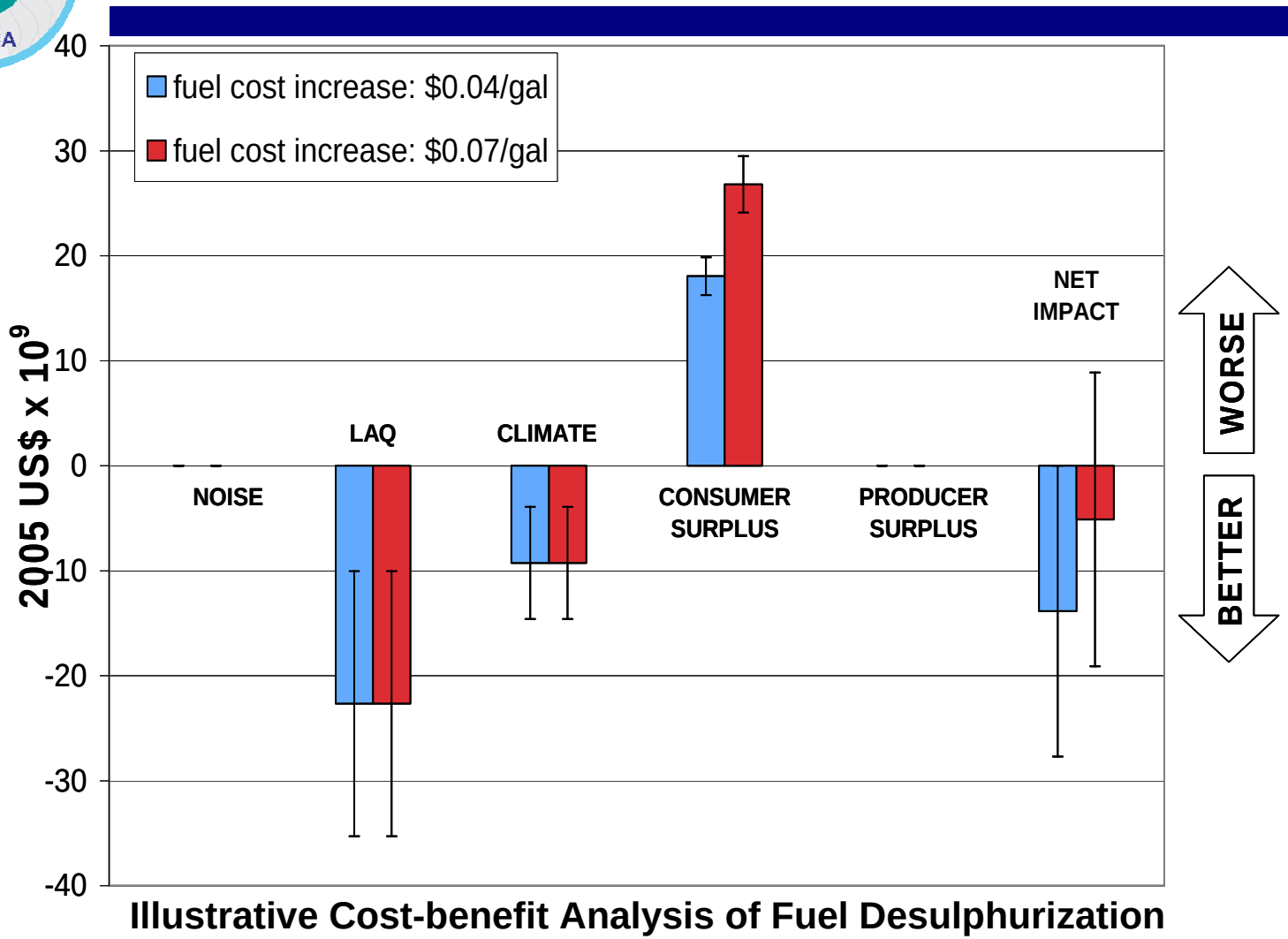


Aviation PM Impacts

- Yearly health costs from aviation in the USA: ~ $0.8 billion, with ~90% due to Particulate Matter (PM) exposure
- PM related to fuel sulfur dominates the PM related health cost (46% - 73%)



Illustrative Analyses of Low Sulfur Impacts



Illustrative Cost-benefit Analysis of Fuel Desulphurization

COST DATA AFTER: Energy Information Administration, The Transition to Ultra-Low-Sulfur Diesel Fuel: Effects on Prices and Supply, Washington, D.C.: U.S. Government Printing Office, SR/OIAF/2001-01, May, 2001.

U.S. Environmental Protection Agency, Introduction of Cleaner-Burning Diesel Fuel Enables Advanced Pollution Control for Cars, Trucks and Buses, Washington, D.C.: U.S. Environmental Protection Agency, Office of Transportation and Air Quality, EPA420-F-06-064, October 2006. URL http://www.epa.gov/otaq/highway-diesel/regs/420f06064.htm

Next Steps for Low Sulfur CBA

- Illustrative analyses show that U.S.-wide switch to alternative lower sulfur jet fuel would reduce annual health costs by ~$200 million and possibly be cost-beneficial, with uncertain climate impacts
- CAAFI sponsors/stakeholders plan to pursue a more detailed study to assess the environmental, safety, maintenance and cost impacts of reduced sulfur jet fuel
- Collaborating with Coordinating Research Council (CRC) – expect preliminary results by summer 2009

Summary

- Alternative fuels exist that could both reduce lifecycle CO_2 and improve air quality
- Need to do life cycle GHG and costs and benefits very carefully – getting this right is critical to progress
- CAAFI environmental panel facilitating data collection and analyses to inform decisions
- CAAFI environmental panel is engaged in interagency LCA tools and rules team.

Questions?