Alternative Jet Fuels - Environmental Benefits Analysis

Presented to: Public Meeting for Center of Excellence for Alternative Jet Fuels and Environment

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Date: November 15, 2012

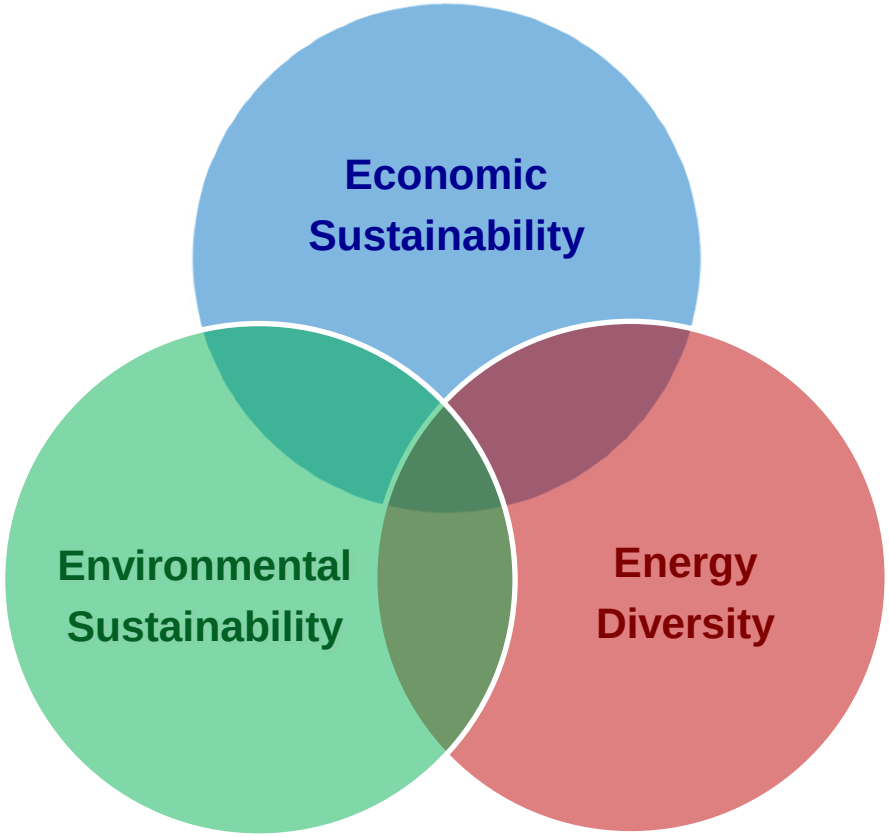
Sustainable Energy for Aviation

Uniqueness of Aviation in terms of Energy:

- Large existing infrastructure of vehicles designed for jet fuel.
- For safety and energy efficiency, aviation requires hydrocarbon-based fuels. Batteries, alcohols and biodiesel (FAME) will not work with current fleet.

Challenge:

- *Finding environmentally and economically sustainable feedstocks and methods to create hydrocarbon-based fuel that can…*
- Reduce global climate and air quality impacts.
- Be produced in large quantities without adverse impacts on our land and water resources.
- Expand and diversify energy supplies beyond petroleum.



Environmental Analyses

- Environmental Impacts
  - Global climate change
  - Surface air quality
  - Water quality and freshwater use
  - Land use
  - Biodiversity and soil quality
- Energy balance
- Emissions measurements
- Changing impact with large-scale production

Life Cycle Assessment (LCA)

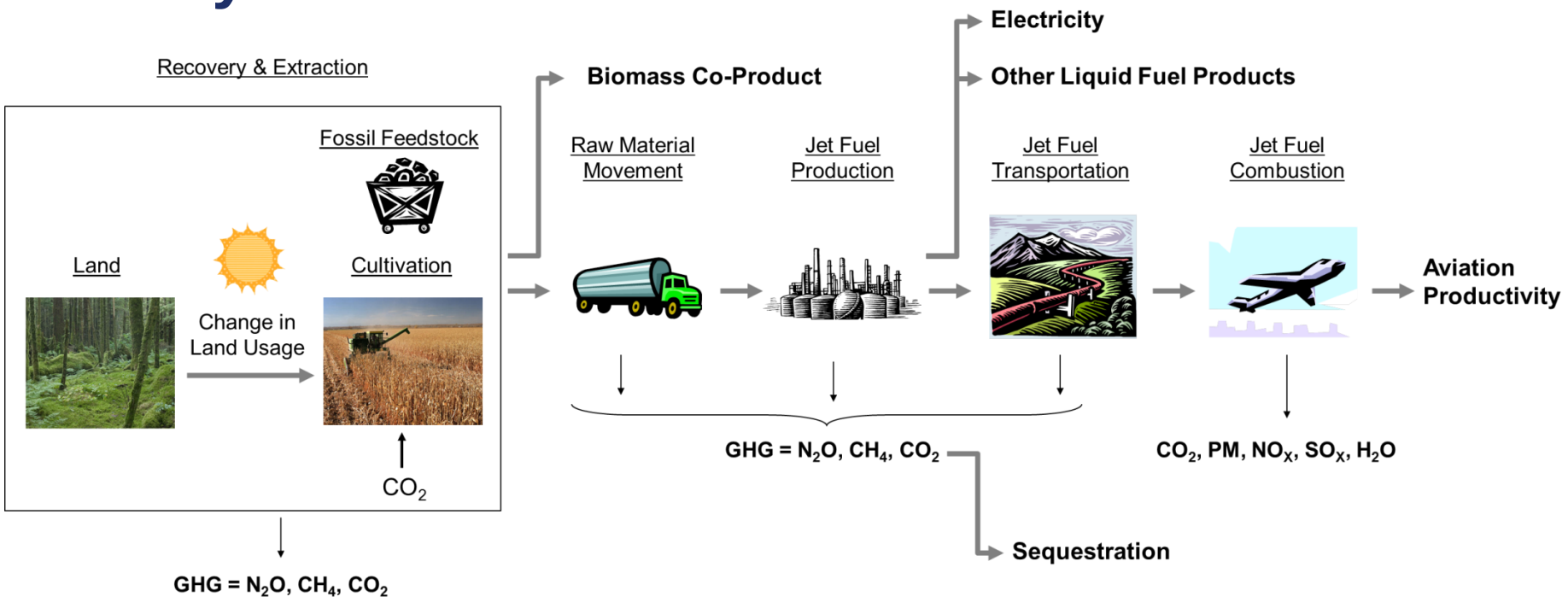
LCA is a technique to assess the environmental aspects and potential impacts associated with a product, process, or service, by:

- compiling an inventory of relevant energy and material inputs and environmental releases;
- evaluating the potential environmental impacts associated with identified inputs and releases;
- interpreting the results to help you make a more informed decision.

Appropriate for quantifying some, but not all, environmental impacts

Source: http://www.epa.gov/nrmrl/lcaccess/

Life Cycle GHG Emissions



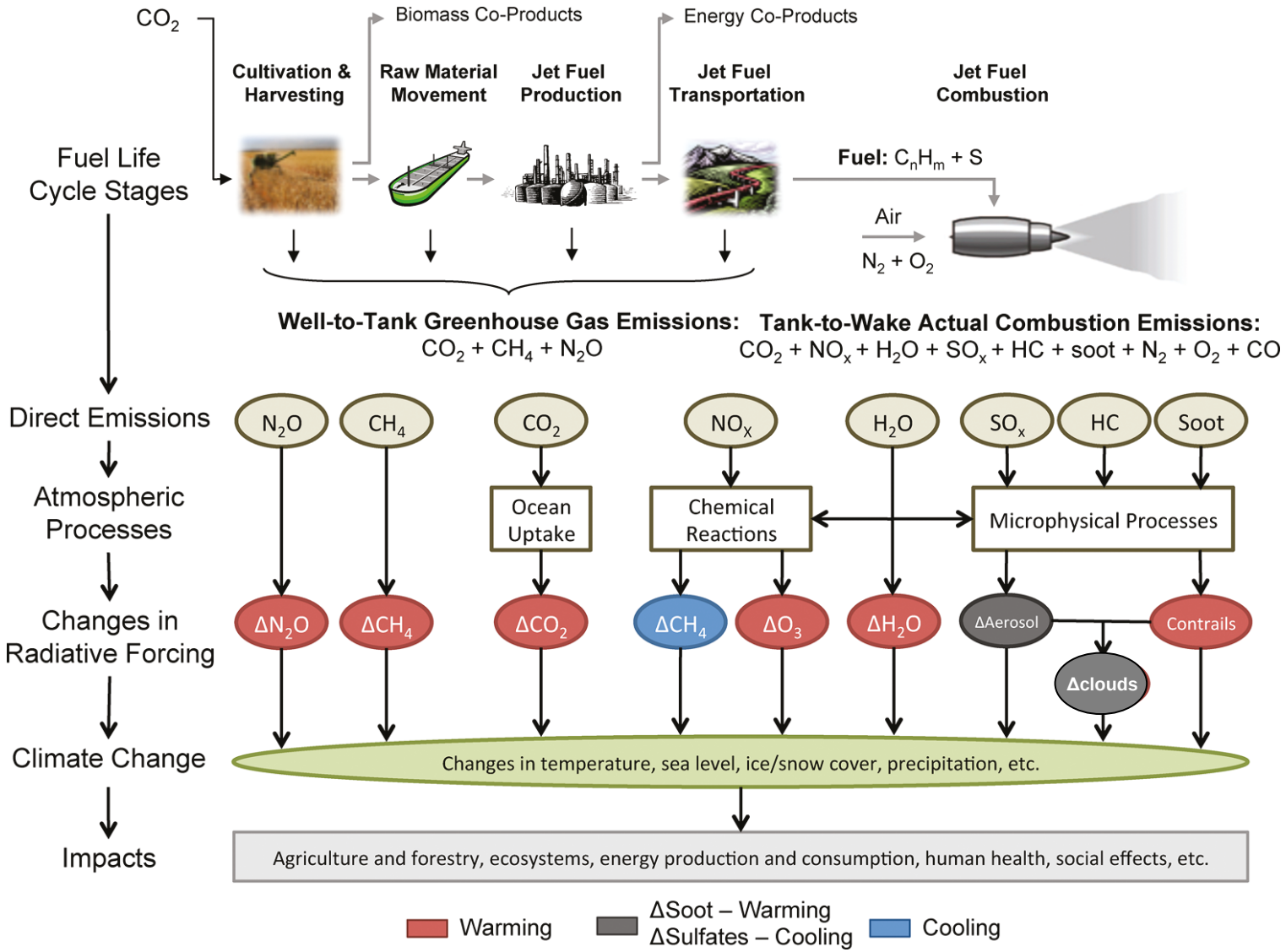
Key Issues in Life Cycle Analysis:

- System Boundary Definition (attritional versus consequential analysis)
- Allocating Emissions among co-products
- Data Quality and Uncertainty

Aviation fuels need to be considered alongside ground transportation fuels in tools such as GREET

* For more information on Argonne National Labs GREET tool: http://www.transportation.anl.gov/modeling_simulation/GREET/

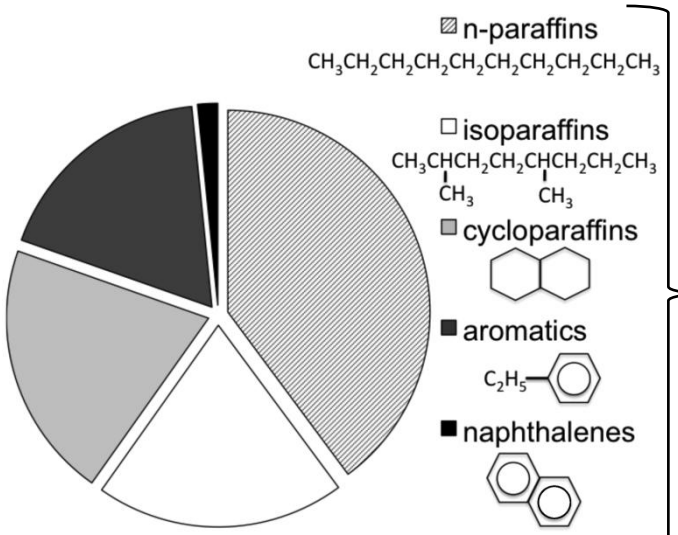
Well-to-Wake Climate Impact of Aircraft Emissions



Source: Stratton, Wolfe & Hileman (ES&T, 2011)

Federal Aviation Administration

Fuel Composition Impact on Aircraft Emissions

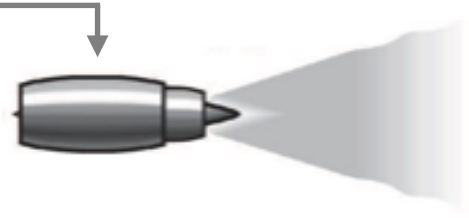


Weighted Mean Fuel Sulfur Content (PPM)		
	2006	2007
US East	446	321
US Gulf	858	800
US West	240	395
Nationwide	709	677

Fuel composition and engine design determine emissions

Fuel: $C_nH_m + S$

Air: $N_2 + O_2$



Tank-to-Wake Actual Combustion Emissions

$CO_2 + H_2O + NO_X + SO_X + soot + CO + HC + N_2 + O_2$

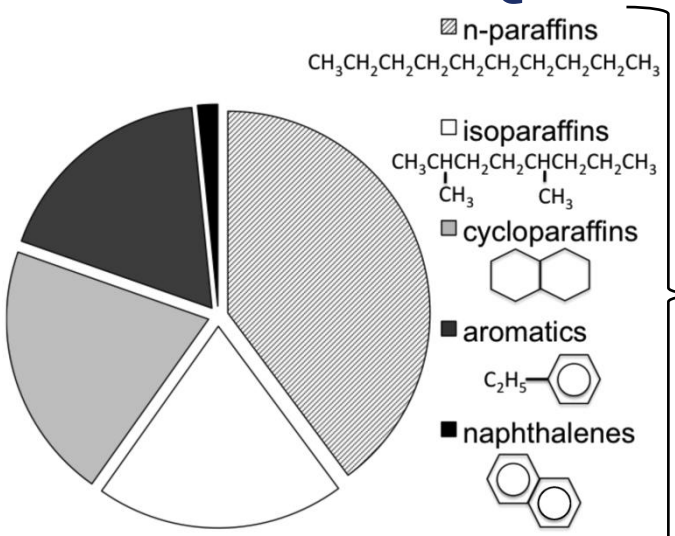
Alternative jet fuels have varied composition leading to changes in combustion emissions

Emissions Measurements

- Conduct measurements of gaseous (e.g., NOx, SOx, CO, HC) and particulate matter (i.e., black carbon or soot) emissions from conventional and alternative jet fuels

- Engine exhaust measurements:
  - Lab-scale gas turbine engines
  - Aircraft engine measurements (e.g., AAFEX-1 and AAFEX-2)
  - In-flight measurements (e.g., ACCESS)
  - Conducted in collaboration with other government agencies (e.g., NASA, EPA, DOD)

Surface Air Quality Impact of Aircraft Emissions



Weighted Mean Fuel Sulfur Content (PPM)		
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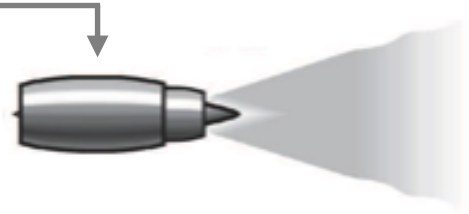
Alt jet fuel composition also affects surface air quality

Fuel: $C_nH_m + S$

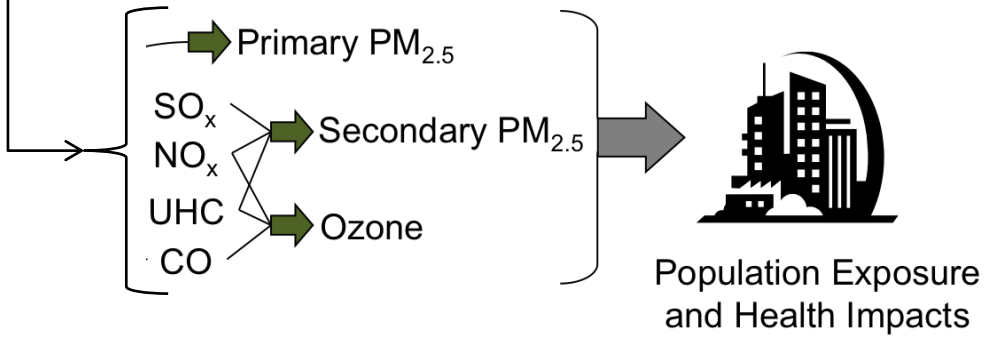
Air: $N_2 + O_2$



Tank-to-Wake Actual Combustion Emissions

$CO_2 + NO_X + H_2O + SO_X + HC + soot + N_2 + O_2 + CO$

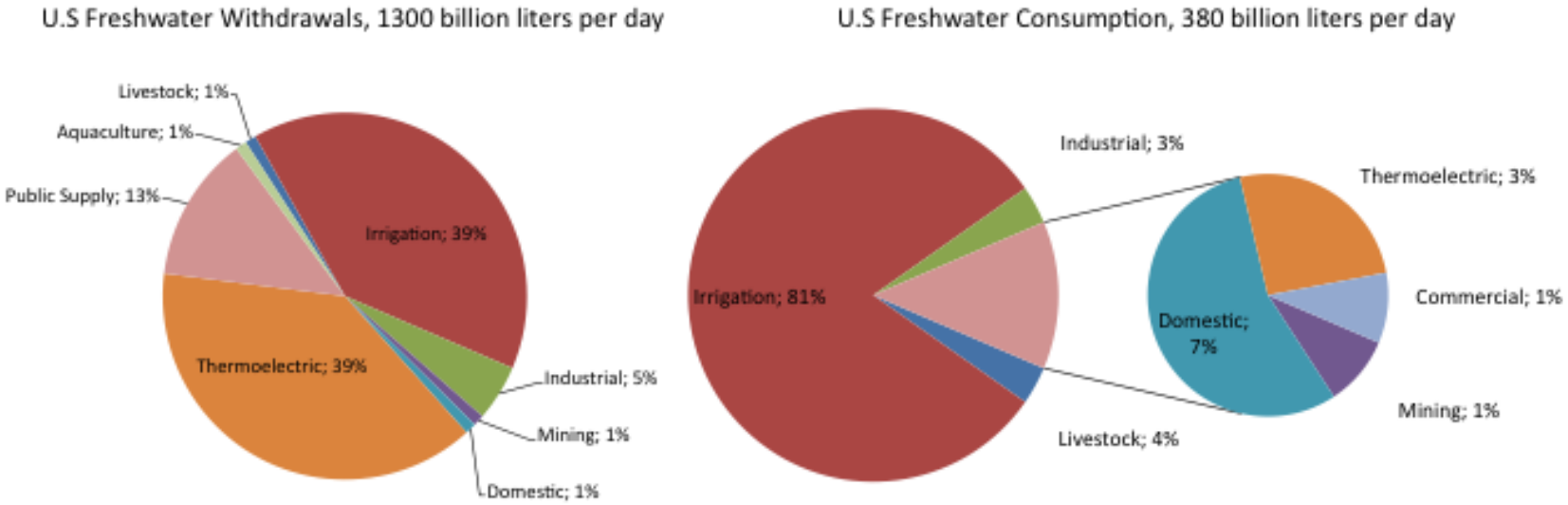
Atmospheric transformation and dispersion and removal determine pollutant concentration



Water Quality and Freshwater Use

- Runoff from agriculture activity can cause eutrophication and reduce water quality
- U.S. freshwater consumption dominated by irrigation
- Alternative jet fuel production could affect both water quality and water use

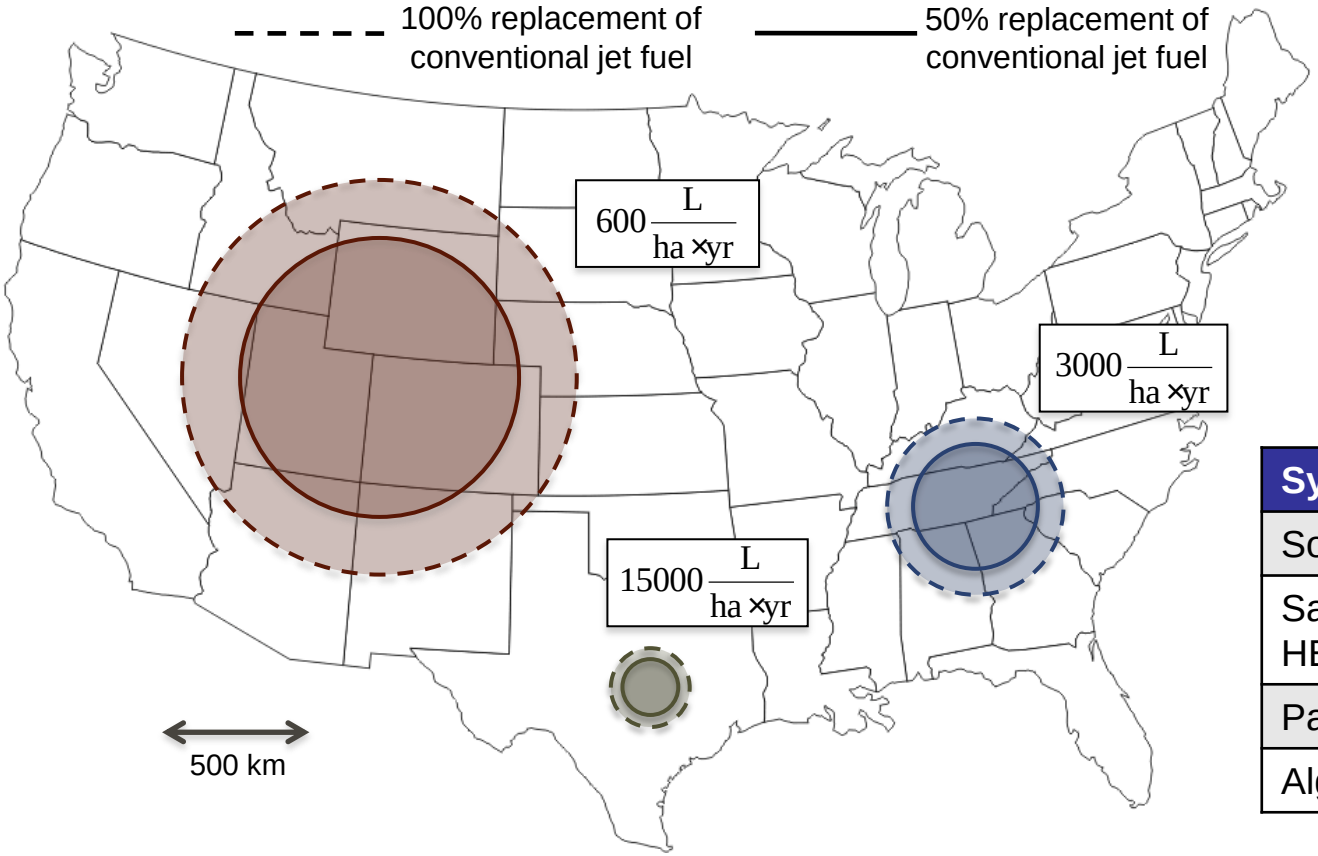
Water consumption and water withdrawals in the US by sector (data adapted from DOE, 2006)



DOE, *Energy Demands on Water Resources*, Report to Congress on the Interdependency of Energy and Water, Sandia National Labs, 2006.

Land Use Requirements

Considered U.S. domestic jet fuel usage of 1.4 million bpd (EIA, 2009).
Assessed land requirements to replace conventional jet fuel with 50/50 biofuel blend and 100% biofuel.



Synthetic Fuel	Yield (L/ha/yr)
Soy HEFA	400
Salicornia HEFA/Diesel	1200/1700
Palm HEFA	3300
Algae HEFA	17000

Using large land areas for alternative fuel production could have consequences on local, regional, and global environments (e.g., albedo)

Data from Stratton, Wong, & Hileman (2010)

Research Goals

- **Quantify sustainability of alternative jet fuels**
  - Conduct emissions measurements, characterization, and speciation
  - Use latest scientific knowledge to evaluate impact of full fuel life cycle, including changes to combustion emissions, on global climate change
  - Evaluate air quality impact of alternative fuel use
  - Evaluate other aspects of environmental sustainability (e.g., water use, water quality, biodiversity, soil quality, albedo)
  - Must be linked to emissions research technical area
- **Consider scale-up of alternative fuel production on environmental and economic sustainability**

Alternative Fuels - Environmental Benefits Analysis

- Develop effective measurement systems and conduct gaseous and particulate matter emissions measurements from alternative jet fuel use (see paragraph 3.1.6).
- Conduct analyses to quantify the environmental sustainability, including life cycle GHG emissions and land, air and water impacts, of candidate alternative jet fuel pathways.
- Develop a framework to evaluate the impacts of large scale alternative fuel production on both the environment and the economy (see paragraph 3.1.2) and use it to create alternative jet fuel deployment scenarios