Alternative Fuels, Aviation and the Environment

Presented to: ICAO / Transport Canada Workshop on Aviation Operational Measures for Fuel and Emissions Reductions

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Outline

- ***The Issues & Drivers***
- **The Basics of Alternative Fuels**
- **Causes for Caution & Optimism**
- **The Way Ahead**
- **Closing Observations**

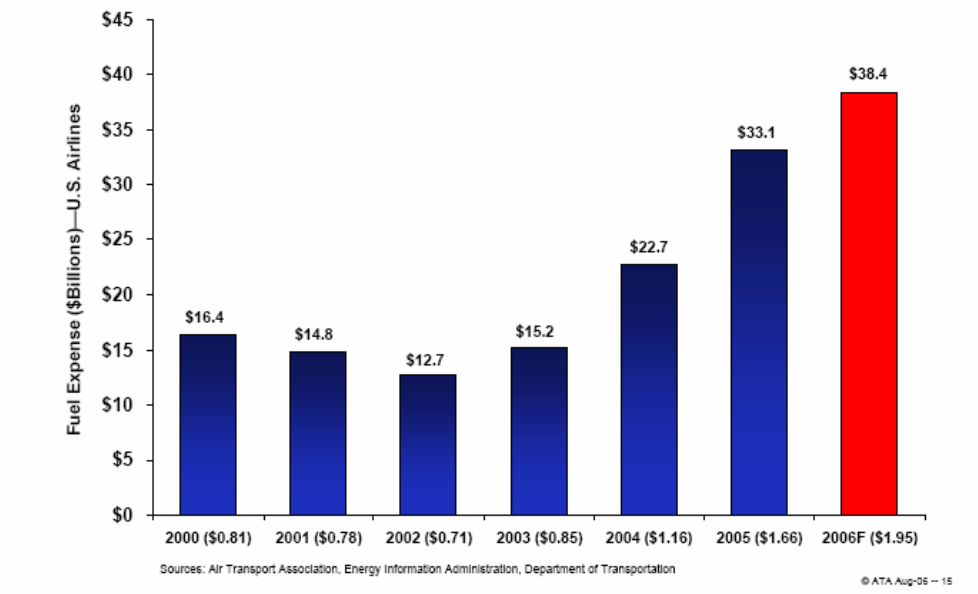
Environmental Issues

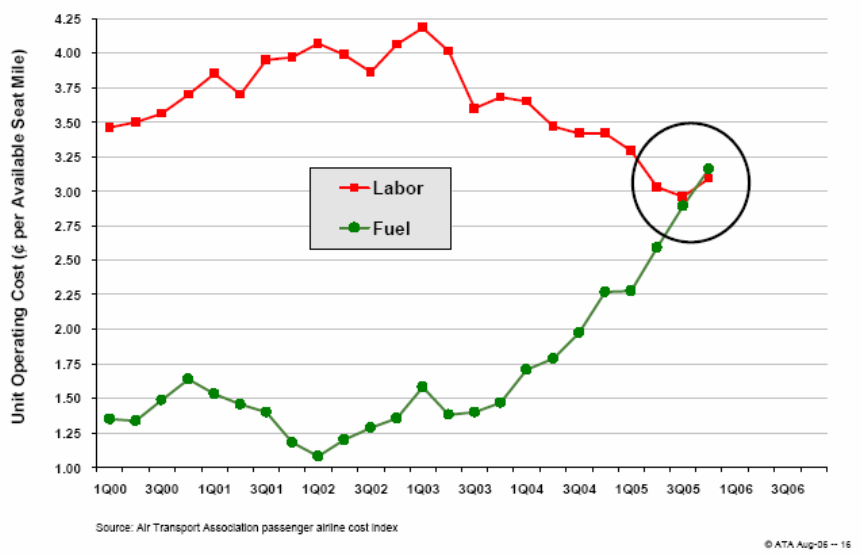
Energy Tops the List

- Increasing demand
- Supply interruptions
- Geopolitical instability
- Government regulation to increase “homegrown” fuels
- Environmental pressures
- Terrorism threats
- Financial hedging

Drivers: Rising Fuel Cost

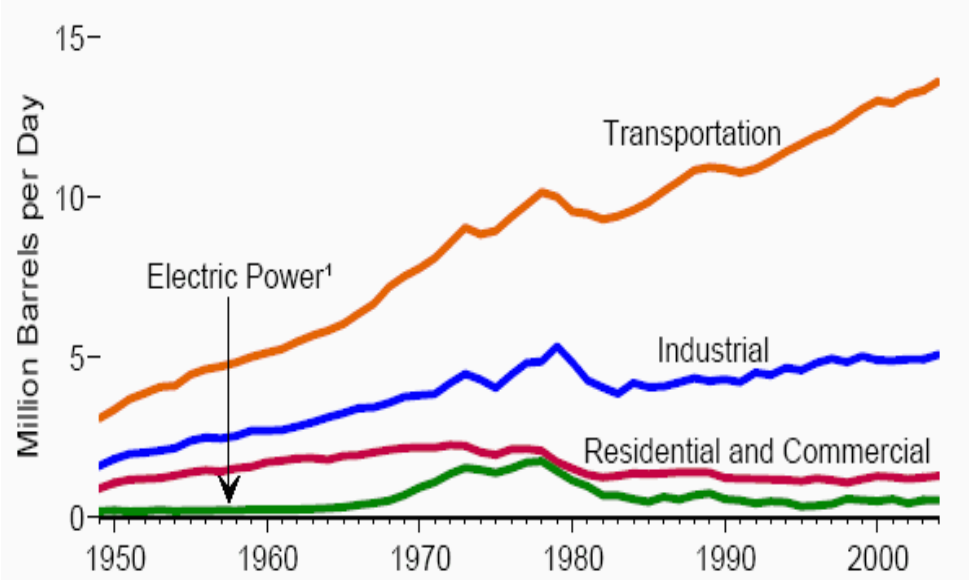
Civil Aviation Alternative Fuels Engagement Driven By Industry Economics Crisis …..





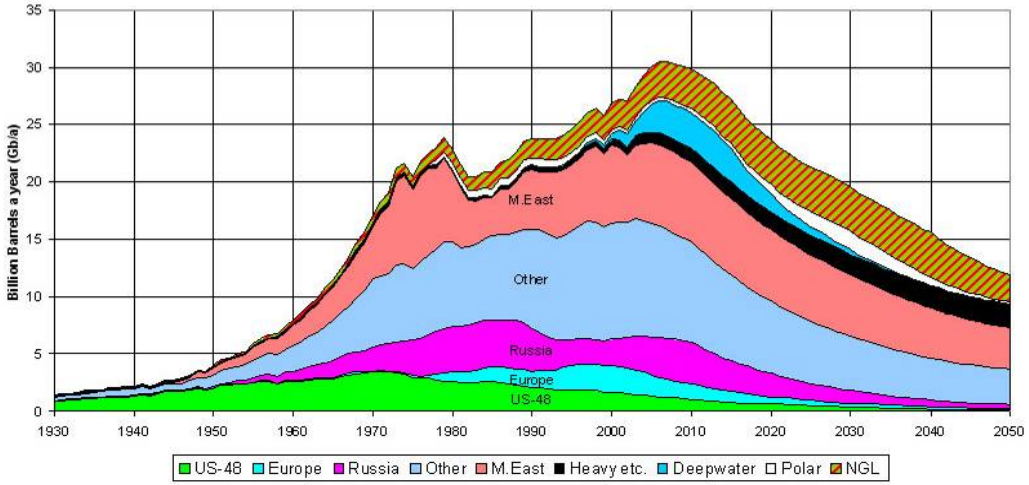
Surging Fuel Expense Offsetting Labor Restructuring

Drivers: Reliance of Transport on Oil

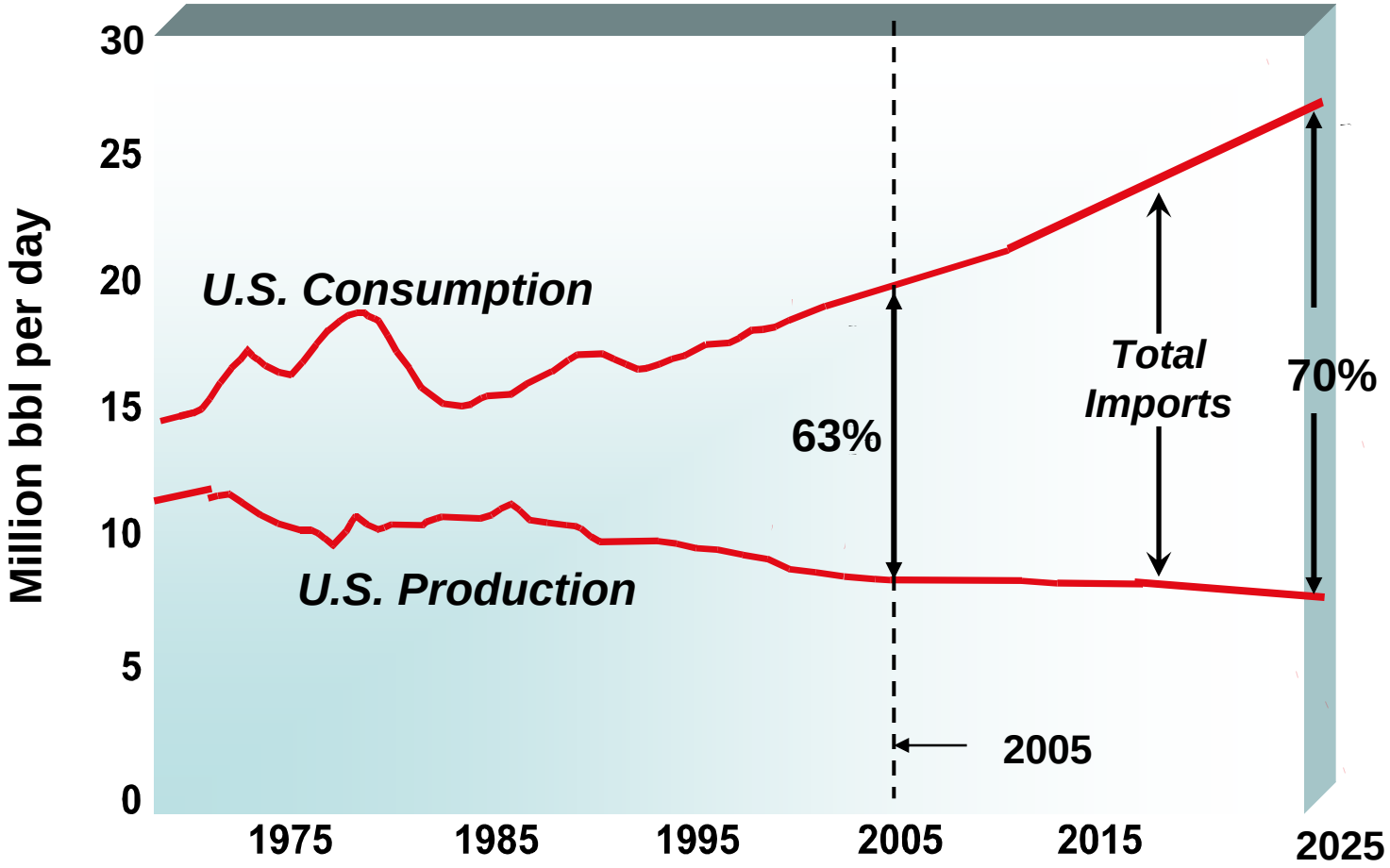


Transportation continues to have the largest reliance on oil…

…while some are predicting that we are nearing the peak of oil supply.



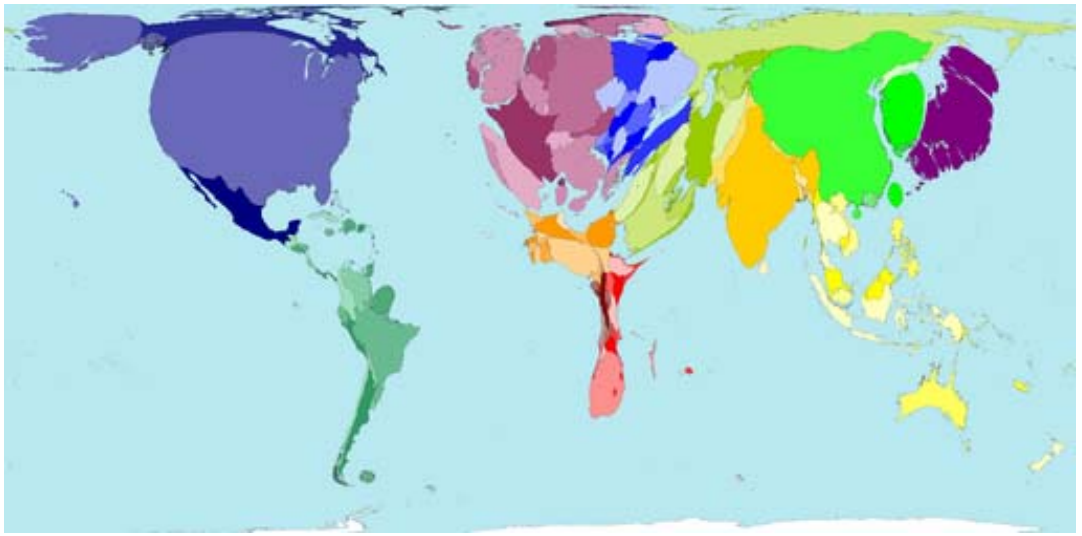
Drivers: Changing Crude Utilization



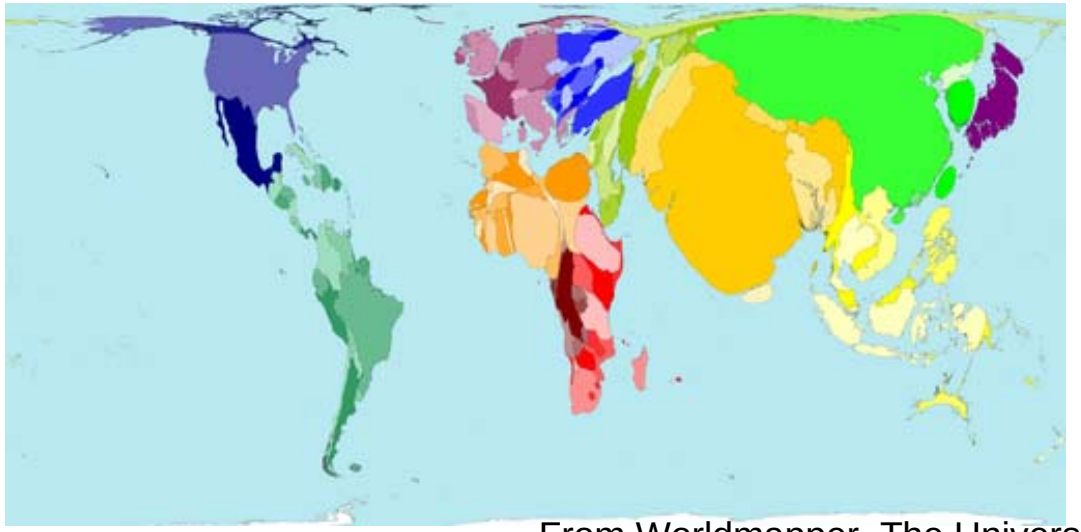
Source: EIA (AEO 2004); Reference Case Scenario [Courtesy John Winslow-DoE]

Drivers: Increasing Fuel Demand

Fuel Use

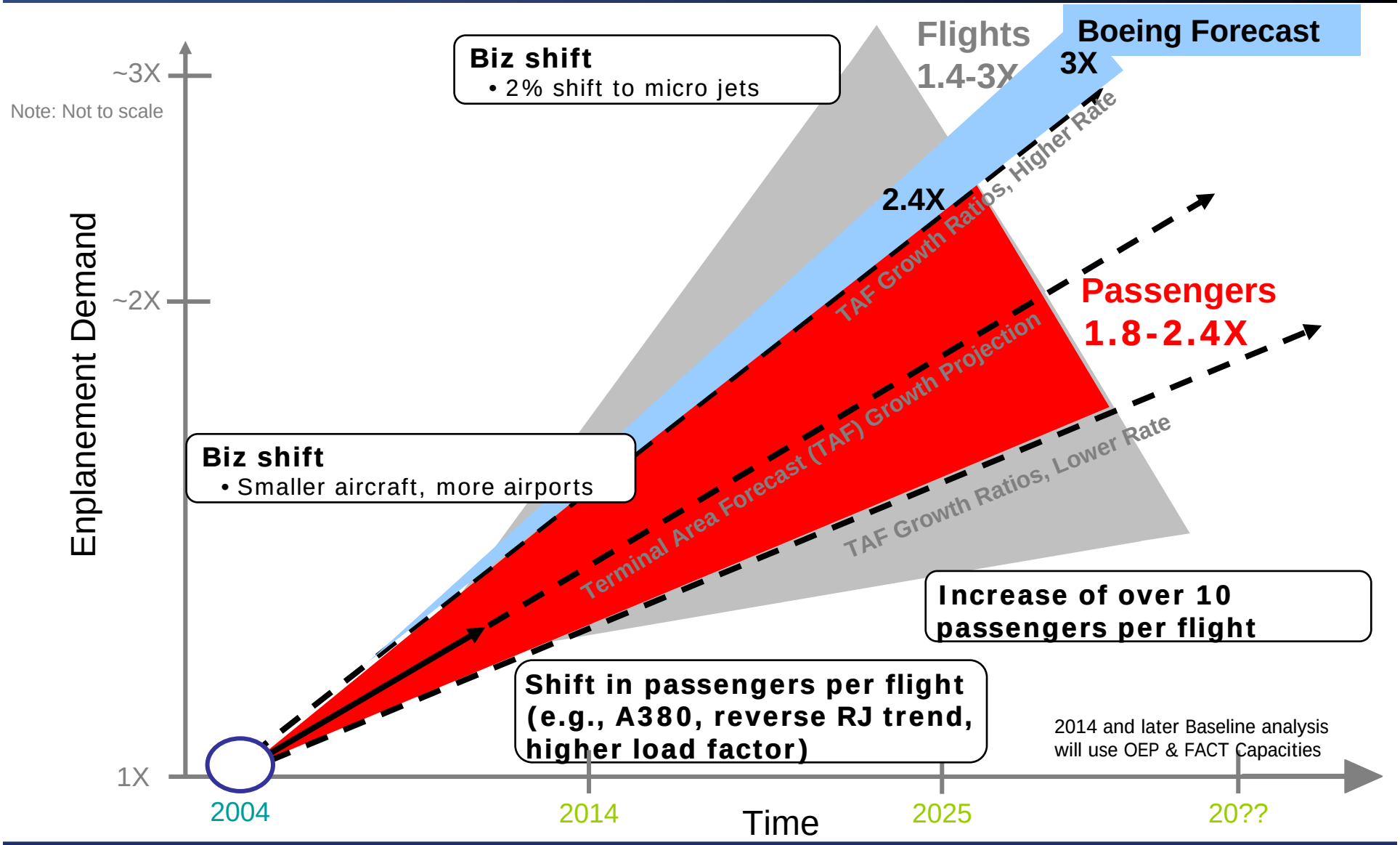


World's Population

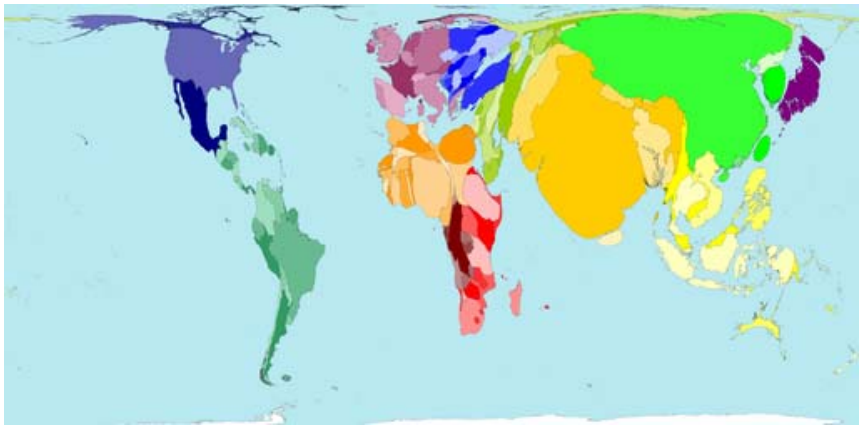


From Worldmapper, The University of Sheffield

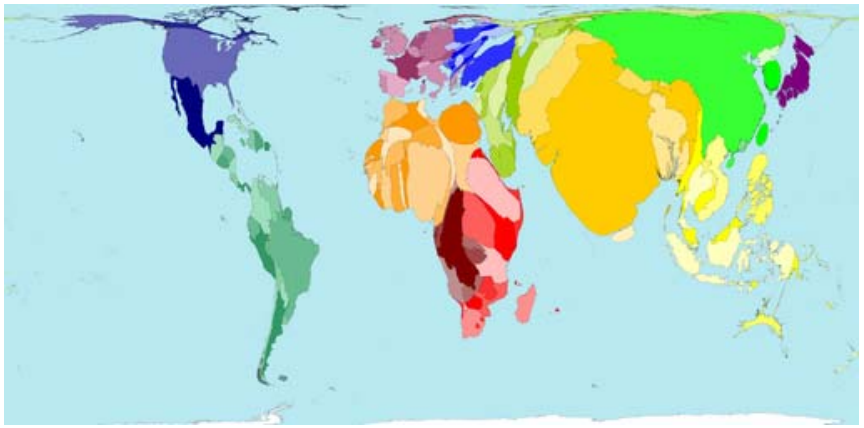
Drivers: Growing Demand for Aviation



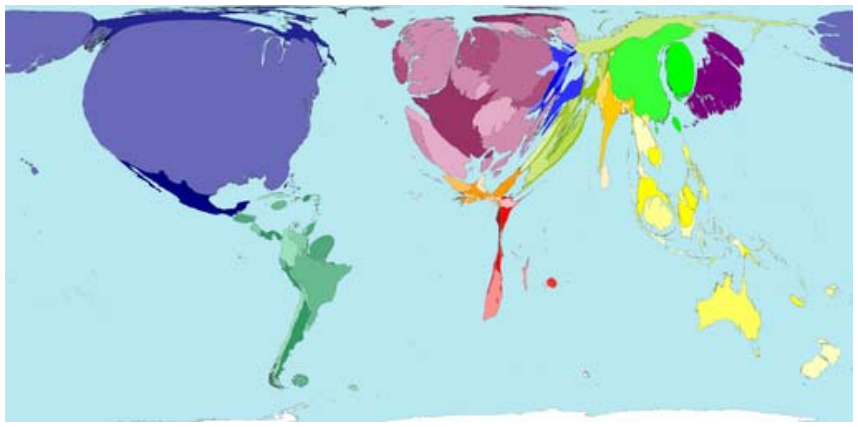
Drivers: Shifting Centers of Demand for Aviation



World's Population 2000



World's Population 2050



Kilometers Flown, today

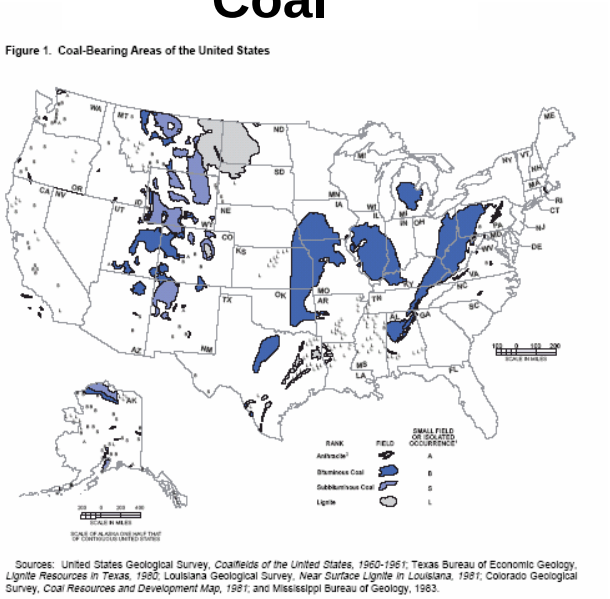
Kilometers flown 2050?

From Worldmapper, The University of Sheffield

Drivers: New Sources of Energy

- **Synthetic fuel from coal via gasification and Fischer-Tropsch (FT) processing**
  - **~ 900 B barrels of FT fuel from coal in US**
  - **vs. 685 B barrels of crude oil in Mideast**
  - **By-products: H_2, power generation from tail gas, ammonia, naphtha**

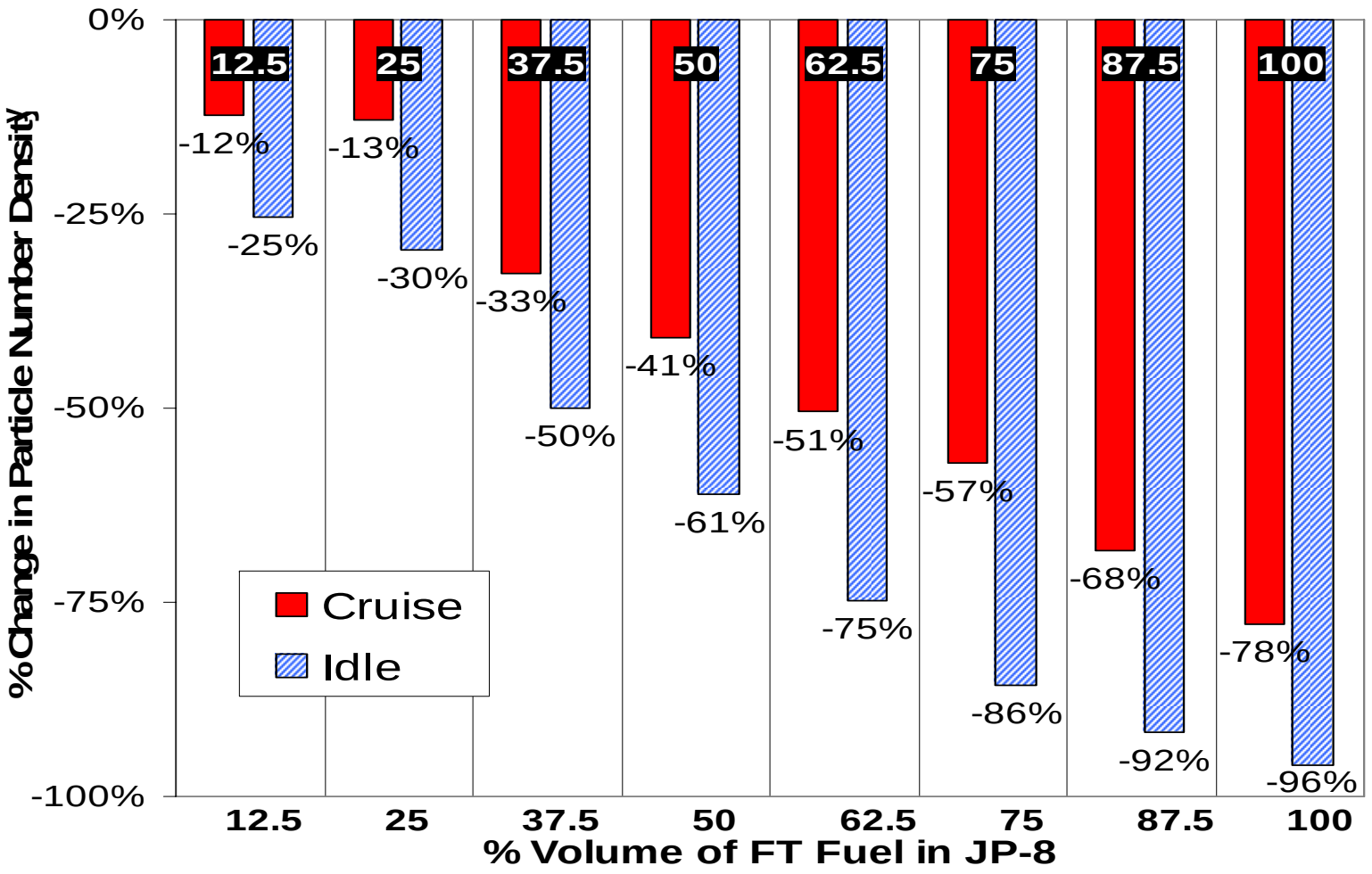
Coal



- **Some benefits of FT fuels:**
  - **Superior low temp properties, thermal stability, high heat sink**
  - **Fewer pollutants (reduced PM, no SOx)**
  - **Elastomer shrinkage issue may be resolved via blends**

After the US Air Force Scientific Advisory Board Assessment

Drivers: Potential for Environmental Improvements



Issues: Must Consider Environmental Trade-offs

Proposals to use coal to make liquid fuels for transportation need to be evaluated in the context of the compelling need to reduce global warming emissions …..

Because today's coal mining and use also continues to impose a heavy toll on America's land, water, and air, damaging human health and the environment, it is critical to examine the implications of a substantial coal-to-liquids program ……

Testimony of David G. Hawkins

Director, Climate Center, Natural Resources Defense Council

To the Committee on Energy and Natural Resources

United States Senate, April 24th, 2006

NRDC
THE EARTH'S BEST DEFENSE

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- ***The Basics of Alternative Fuels***
- **Causes for Caution & Optimism**
- **The Way Ahead**
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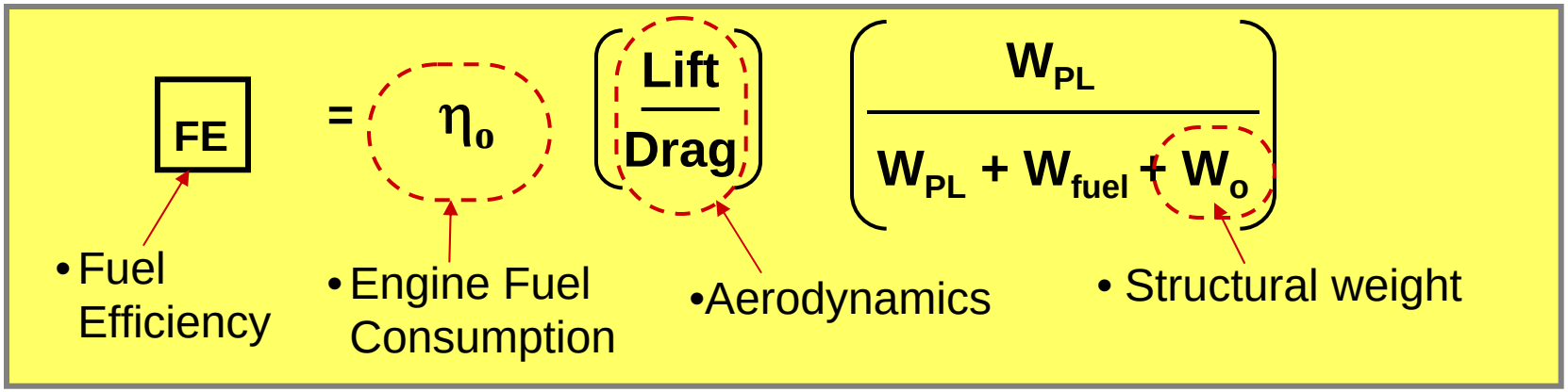
Comparing Alternatives



η_o = **Overall engine efficiency**
W_{PL} = **Payload Weight**
W_o = **Dry weight**

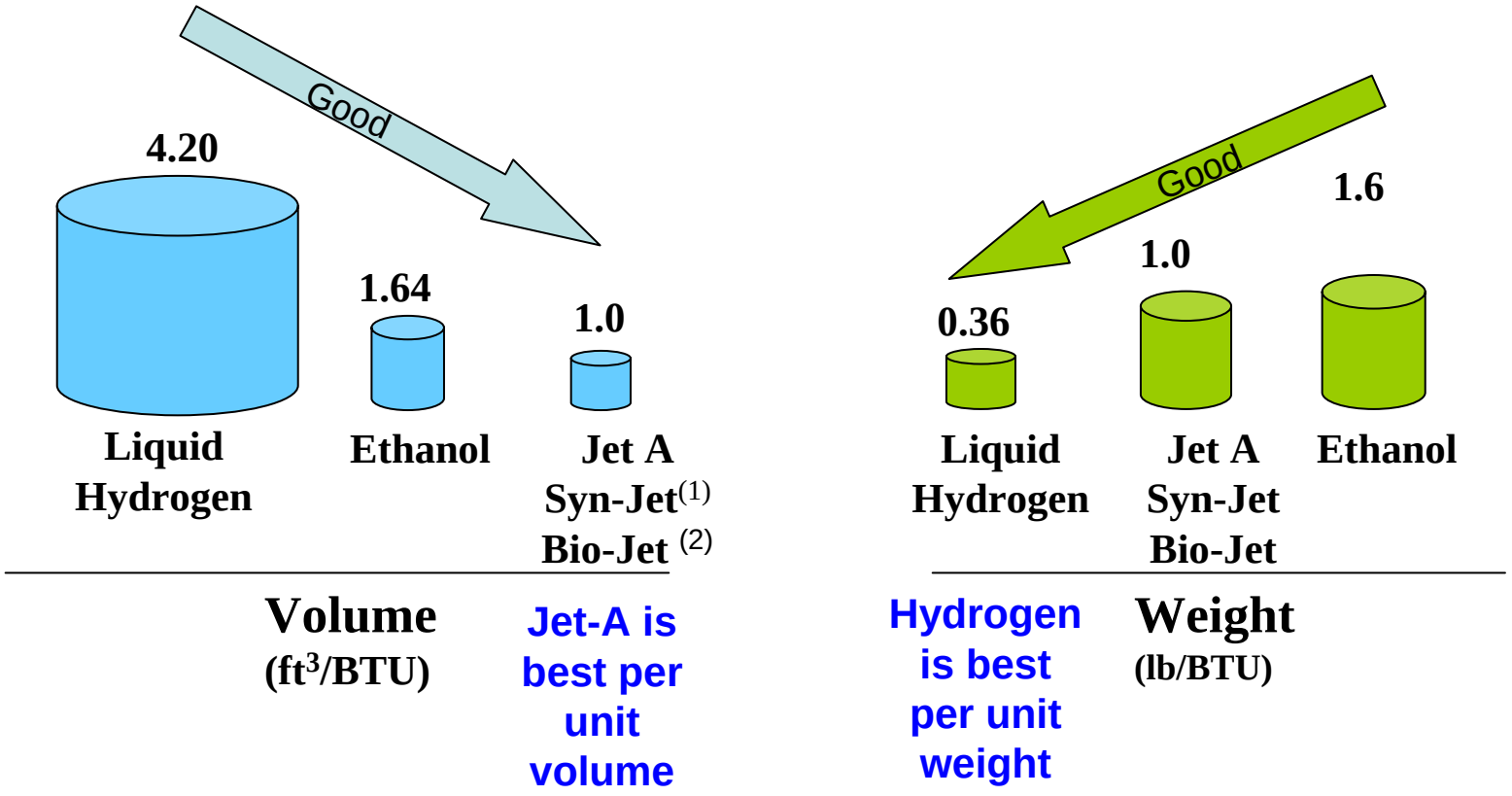
- **Define "fuel efficiency metric" FE to include direct contributions of:**
  - **Propulsion/engine system**
  - **Aerodynamics**
  - **Structural characteristics**

Courtesy of US Air Force Scientific Advisory Board

Alternative Fuels

- **Synthetic Fuels (Drop-in replacements)**
- **Bio (Renewable) Fuels**
- **Totally New Fuels**

Design Issues: Energy Content of Fuels

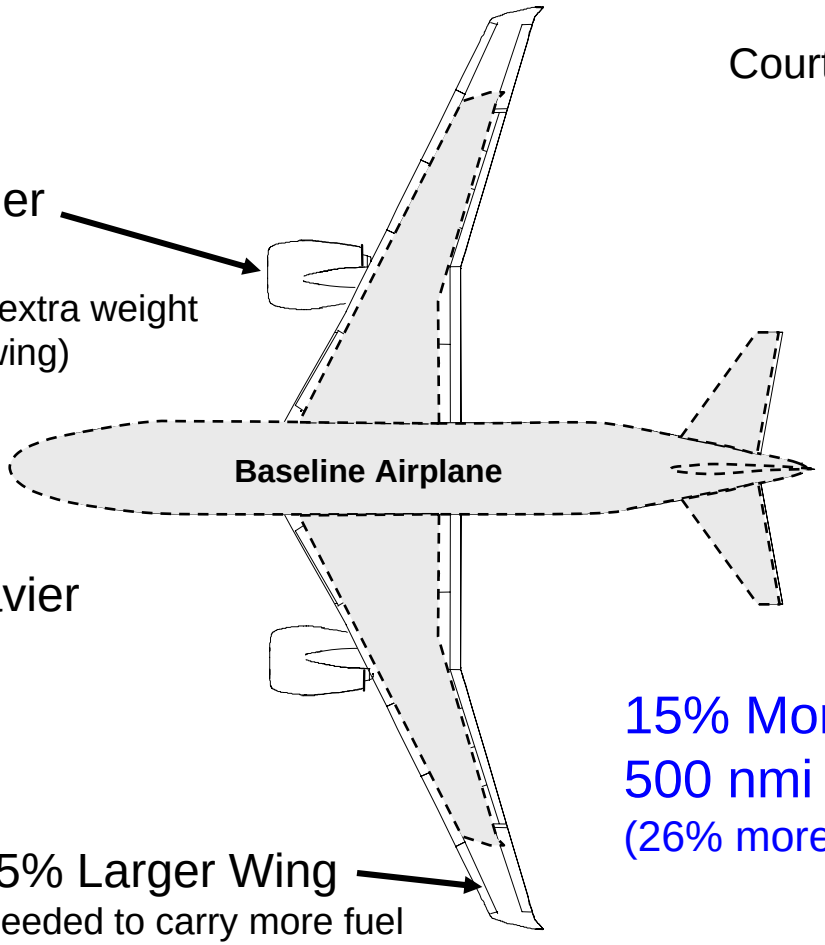


Courtesy of Dave Dagget, The Boeing Company

Design Issues: The Ethanol Airplane

Courtesy of Dave Dagget, The Boeing Company

50% Larger Engines
(needed for extra weight of fuel and wing)



35% Heavier Takeoff Weight
(20% OEW Increase)

25% Larger Wing
(needed to carry more fuel since it contains less energy*)

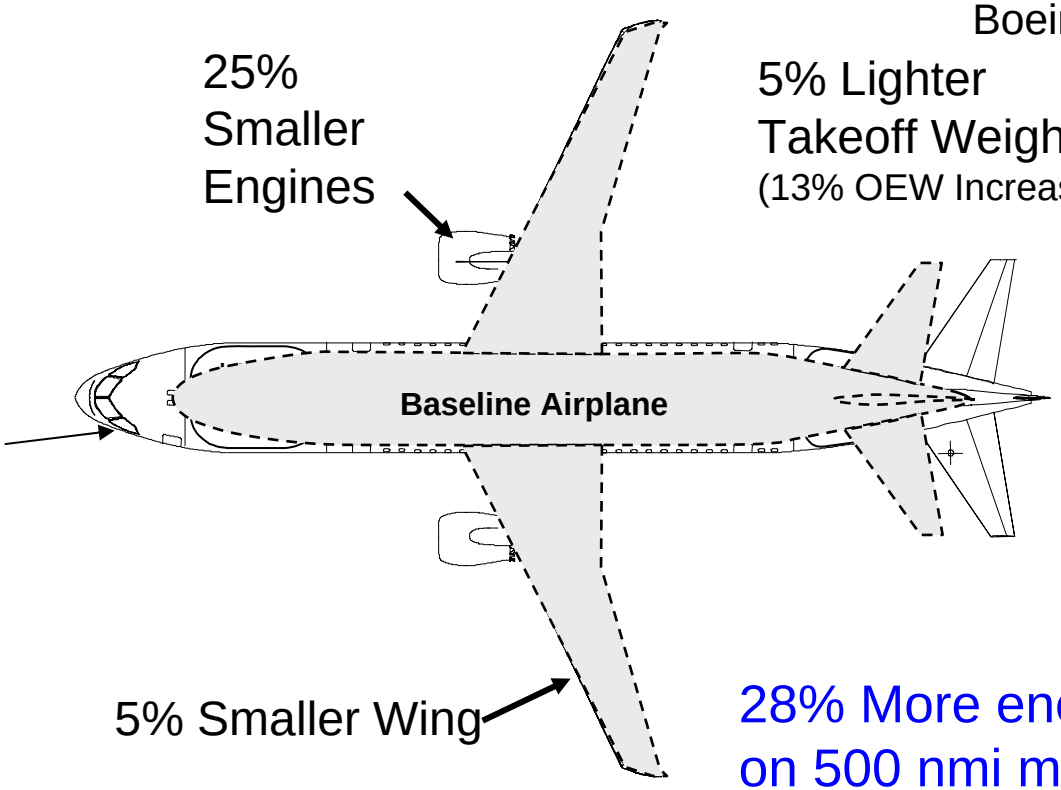
15% More energy use on 500 nmi mission
(26% more on 3K nmi mission)

*Ethanol only has 60% the energy content of Jet-A

Ethanol Airplane

Design Issues: The Hydrogen Airplane

Courtesy of Dave Dagget, The Boeing Company

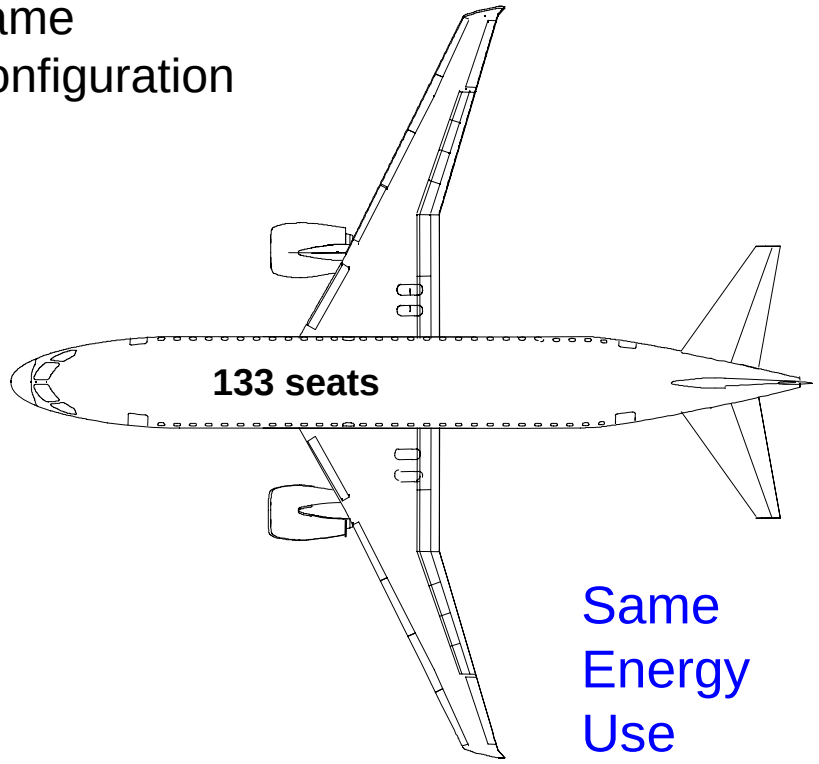


28% More energy on 500 nmi mission
(2% on 3k nmi mission)

Design Issues: The Synthetic or Bio-Fuel Airplane

Courtesy of Dave Dagget, The Boeing Company

Same Configuration



Same Energy Use

Alternative Fuels Benefits/Cost

	Δ Fuel Efficiency	Benefit / Cost
• **Near term (0-5 years):**		
• Fischer-Tropsch fuel from coal*	1%	High
• **Mid term (5-15 years):**		
• Oil shale*	1%	Medium
• Other HC: LNG, ethanol blends,* biodiesel*	1%	High
• Hydrogen for fuel cells in APUs	1%	Medium
• **Far term (15+ years):**		
• Biomass: black liquor fuels*	1%	High
• Hydrogen fuel for turbine engines	5%	Medium

*** As a means of providing a MORE ASSURED fuel source**

Assessment by the US Air Force Scientific Advisory Board

Supply Issues: Another Constraint

Courtesy of Dave Dagget, The Boeing Company

The US fleet might use a 15% bio-fuel blend which would require 2.04B gal. of bio-jet.

US Domestic Fleet in 2004

@

About same heat content as Jet fuel (i.e. 18,500 BTU/lb)

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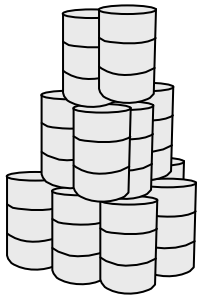
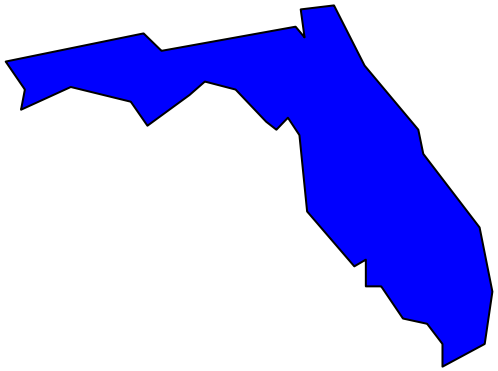


2.04B Gallons Bio-jet

Soybeans

This would require 34M acres (about land size of Florida) which would be about 10% of the total US cropland



US = 1.9B total acres, 349M of cropland

40 bu/acre soybeans @ 1.5 gal biofuel/bu = 60 gal/acres

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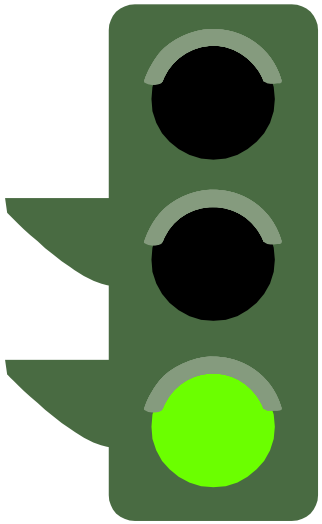
Alternative Fuels in Aviation- Reason for Optimism



- Synthetic Fuels may be Environmentally Friendly
- Helps Manage Interdependencies
- Enhances Energy Security
- Aviation's Potential as First Adapter
- Sustained High Costs Keep Synthetics Viable

Alternative Fuels for Aviation- Reasons for Caution

- Don’t Underestimate Technical Difficulty
- Cannot compromise safety
- Relative Ease of Transition on the Ground
- Difficulty of Predicting Energy Markets
- Production environmental drawbacks
- Alternative Fuels are Not a Panacea

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Alternative Fuels for Commercial Aviation - Vision

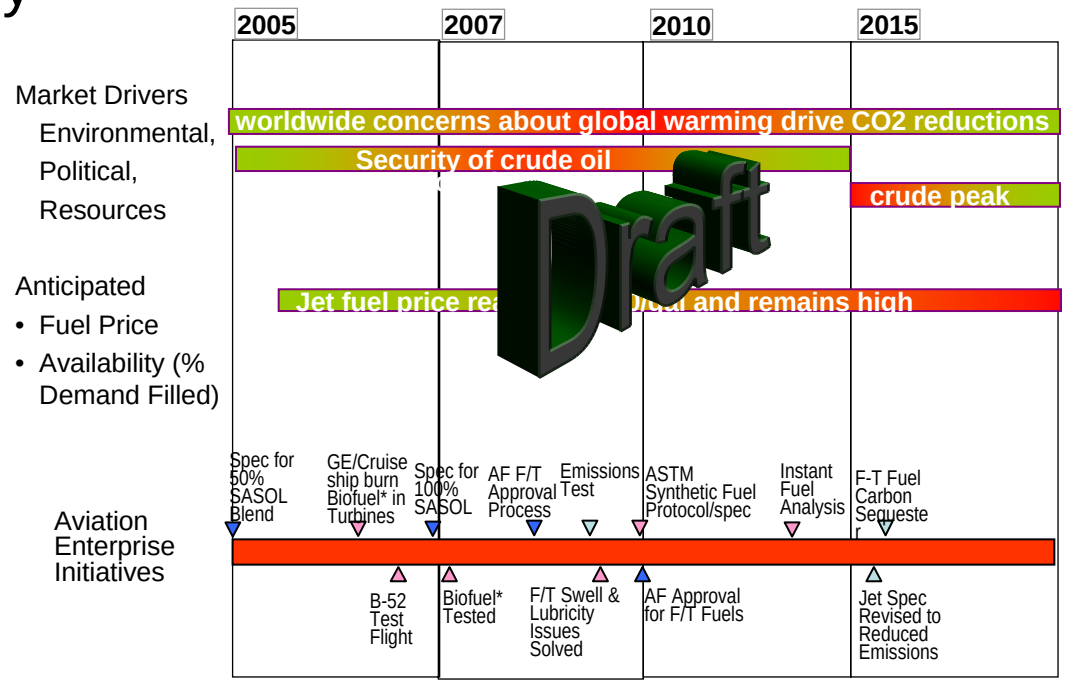
- **DoD and commercial sector must work together to promote/embrace alternative fuels to secure supply availability, to minimize price volatility, to improve operations and to *explore the potential to reduce environmental impacts***

….. Adopted 5/24/06 by AIA/ATA/FAA (and ACI) sponsored workshop with DOE, DoD and NASA stakeholders

Alternative Fuels for Aviation - Roadmap

AIA/ATA/FAA/ACI Sponsors Approach

- **Roadmap to be constructed and rolled up by process areas:**
  - R&D
  - Environmental
  - Business/economics/policy
  - Regulatory/Performance
- **October 23/24 2006 Stakeholders will gather in Atlanta, Georgia to draft Roadmap**
- **International participation welcome/encouraged**



Next Steps

- Establish whether we can and should stimulate production of a meaningful alternative aviation fuel effort for the US;
- Establish the net environmental benefits – taking into account potential environmental costs – that would arise from such fuels; and
- Identify the framework and policies required to facilitate adoption of alternative fuels.

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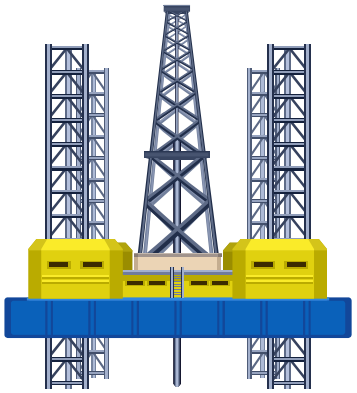
Alternative Fuels for Aviation - Observations



•There is a lot of “energy” re: alternative aviation fuels

•There is potential for real progress on alternative aviation fuels for aviation

- The use of alternative fuels is already occurring and our joint efforts--across countries, government organizations, industry, and academia, can make aviation a global leader
- However, we must also note that we have been down a similar road before in the late ‘70s and early ‘80s
- Progress is predicated on a long-term vision and the will of all stakeholders to see it through *but* realistically this may not occur in the absence of a favorable set of economic conditions (i.e., continued high prices)