Aviation and Oil Depletion

Energy Institute
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The Aviation Industry

- Aviation is one of the fastest growing industry sectors in the world
- Aviation is growing at 2.4 times the rate of growth of average world GDP
- Aviation consumes 5 million barrels of oil per day

Source: Scientific American Aug 06
The UK Aviation Industry

- UK aviation is growing at 5% per year
- UK aviation fuel consumption is growing at 3% per year
- The difference is due to efficiency improvements in aircraft and engine design, Air Traffic Control and passenger load factor
Aviation Energy Issues

- There is currently no alternative to the use of kerosene in jet aircraft engines.
- Global Warming emissions from aviation are increasing in line with increasing fuel use.
- Fuel is one of the largest costs an airline faces (10 – 35%)
- The industry would like a cheaper, less damaging source of energy.
Aviation and Oil Depletion

The Ideal Aircraft Fuel

The Near Term Solution
Fuel Conservation

The Long Term Solution
Alternative Fuels
The Ideal Aircraft Fuel

• High Specific Energy
• Specific Safety Criteria
• Minimal Global Warming Emissions
  – Carbon Dioxide
  – Water Vapour
  – Contrails
The Ideal Aircraft Fuel
High Specific Energy

• MegaJoules of energy / Kilogram of fuel
• We also want a high energy density measured in MegaJoules / Cubic Metre
• Affects the total size & weight of the aircraft
• 1 Kg of extra aircraft structure mass results in a 3 Kg increase in maximum take-off mass
The Ideal Aircraft Fuel

Specific Safety Criteria

• High flash point to minimize flammability and explosion hazard within the fuel tank and in aircraft accidents.

• Low freezing point (-40° C). The outside air temperature at jet cruising levels is in the vicinity of –60 degrees Celsius. Water and ice crystals will clog up filters

• Lubrication, Cooling, Balance Trim
The Ideal Aircraft Fuel

Carbon Dioxide

• In 2000, aviation accounted for 5% of UK CO2 emissions. (Dept for Transport)
• In 2020, 10 – 12% and could rise to 40% by 2050 if not checked. (Environmental Audit Committee)
• If aviation CO2 emissions continue to grow unchecked, every other industry and home in the UK will need to become carbon neutral by 2050. (Tyndall Centre)
This is total CO₂ output of the UK in line with government reduction commitments.

This is the target non-aviation sources in the UK will need to achieve at the current rate of growth of aviation CO₂ output.

Source: Tyndall Centre

Source: UK NAP phase 1

The Ideal Aircraft Fuel
Carbon Dioxide
The Ideal Aircraft Fuel
Radiative Forcing

- A study produced by the Intergovernmental Panel on Climate Change (IPCC)
- United Nations Framework Convention on Climate Change (Kyoto Protocol)
- The first in-depth analysis of the climate change effects of aviation
The Ideal Aircraft Fuel

Radiative Forcing

Global Warming Potential & CO2e not suitable for aviation. Radiative Forcing is a better indicator.

RF takes into account CO2, Water Vapour, Particulates, Ozone and Contrails.

Aviation emissions are approximately 2.7 times as destructive as the effect of its CO2 alone.
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Contrails
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Alternative Fuels
Fuel Conservation
Options

- Minimum Fuel
- Air Traffic Control Efficiency
- Aircraft
- Ground Operations
- Shorter Sector Lengths
- Competition
Fuel Conservation

Minimum Fuel

• Carrying less fuel saves fuel.
• Fuel is required to lift the fuel required for the later stages of the flight.
• Modern computer generated Air Plans can be accurate to within one minute and several kilograms of total fuel requirements.
Fuel Conservation

ATC Efficiency

- 6-10% improvement by 2020 through more efficient air routes
- Future Air Navigation (FANS) allows aircraft to travel without using airways
Fuel Conservation

Step Descent vs. Continuous Descent

37,000’ (450 Kg/hour/Engine)

550 Kg/hour

3°- 5° profile at idle thrust (250 Kg/hour)

700 Kg/hour

900 Kg/hour

1,000 Kg/hour

3° profile
Fuel Conservation

Aircraft Considerations

• Aircraft become less efficient with age
  – (1% per year)
• Care and Maintenance
• Interior Layout
• Large high speed turboprops that can compete with jets on short range flights
• Early Retirement
Before

After
Fuel Conservation
Benefits of Early Retirement

- Increasing efficiency of new built aircraft @ 1% per year
- Increasing inefficiency of old aircraft @ 1% per year

Early Retirement

Year | 0 | 26 | 31 | 52
---|---|---|---|---
Fuel Consumption

- Scheduled Retirement
Fuel Conservation

Ground Operations

- Auxiliary power units
- Service vehicles
- Ground Delays

- Tow aircraft to the runway before starting engines
Fuel Conservation

Competition

- Fly less
- Increased Load Factor
- A return to a regulated industry with government restrictions on aircraft size and frequency on each route
Fuel Conservation

Shorter Sector Lengths

- Aircraft Efficiency versus Sector Lengths
- Hub & Spoke networks
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Fuel Conservation

The Long Term Solution
Alternative Fuels
Alternative Fuels

• Hydrogen
• Natural Gas
• Alcohols
• Biofuels
• Synthetics
Hydrogen

• Provides 2.5 times the energy per Kg than kerosene
• The volume of hydrogen would be 2.5 times that of an equivalent amount of kerosene
• No CO2 emissions
• Generates 2.6 times more water vapour
Alternative Fuels

Hydrogen

- Hydrogen is expensive to produce and difficult to store
- Requires cryogenic storage on the aircraft
- There is currently no infrastructure
- It will not be practical until it is available worldwide
Alternative Fuels

Dornier 328 Jet

Configured to use hydrogen
Alternative Fuels

Hydrogen

Airbus A300 with Cryogenic Storage
NASA Blended Wing Airliner

30% improvement in fuel consumption
Alternative Fuels

Alcohols

• Less energy by volume (50-75%)
• Very corrosive
• Increased Volatile Organic Compounds which destroy the ozone layer
• Carbon neutral (sort of)
Alternative Fuels

Biodiesel

• Unsuitable for jet engines due to
  – Very high flash point,
  – Low volatility,
  – Need for high pressure,
  – Thickens and crystallizes at the temperature found at jet aircraft operating altitudes

• Currently approved as a kerosene extender up to 10%

• Possibly up to 20% with enhanced filtration technology
Alternative Fuels

Synthetics (Synfuel)

- Produced from coal, natural gas or biomass
- Fischer-Tropsch method
- Coal is converted to gas then to liquid
- Cleaner than petroleum kerosene with lower sulphur
- Sulphur acts as a lubricant and would need to be replaced by additives
Alternative Fuels
Synthetics (Synfuel)

• Produced by Sasol of South Africa since 1999
• Current regulations permit a maximum of 50% synthetic fuel mixed with petroleum derived kerosene
• Already used on flights departing Johannesburg
• Aero Engine manufacturers expect to have a fully synthetic fuel approved in 2006
Historically engines have been designed around fuel. It’s time to design the fuel around the engine’s needs. Synthetic fuels can help us do that.

Fred Biddle, Fuels Technology Manager, Pratt & Whitney
Conclusions

• Fuel efficiency and fuel conservation strategies will continue to dominate airline fuel policy
• Kerosene will continue to be used in aircraft with a gradual shift to synthetic fuel driven by availability and price
• Hydrogen powered aircraft offer little benefit until there is a world wide supply
• Global Warming emissions will continue to be a serious problem
Thank You