Alternative Fuels for Aviation - Industry Options & Challenges

ICAO Workshop on Aviation & Alternative Fuels

Montreal, 10th – 12th February 2008

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Context - The ‘Three Hard Truths’

- **Surge in energy use**

  Energy use will increase due to increasing population and prosperity. This will mean greater demand for oil and gas, as well as other energy sources

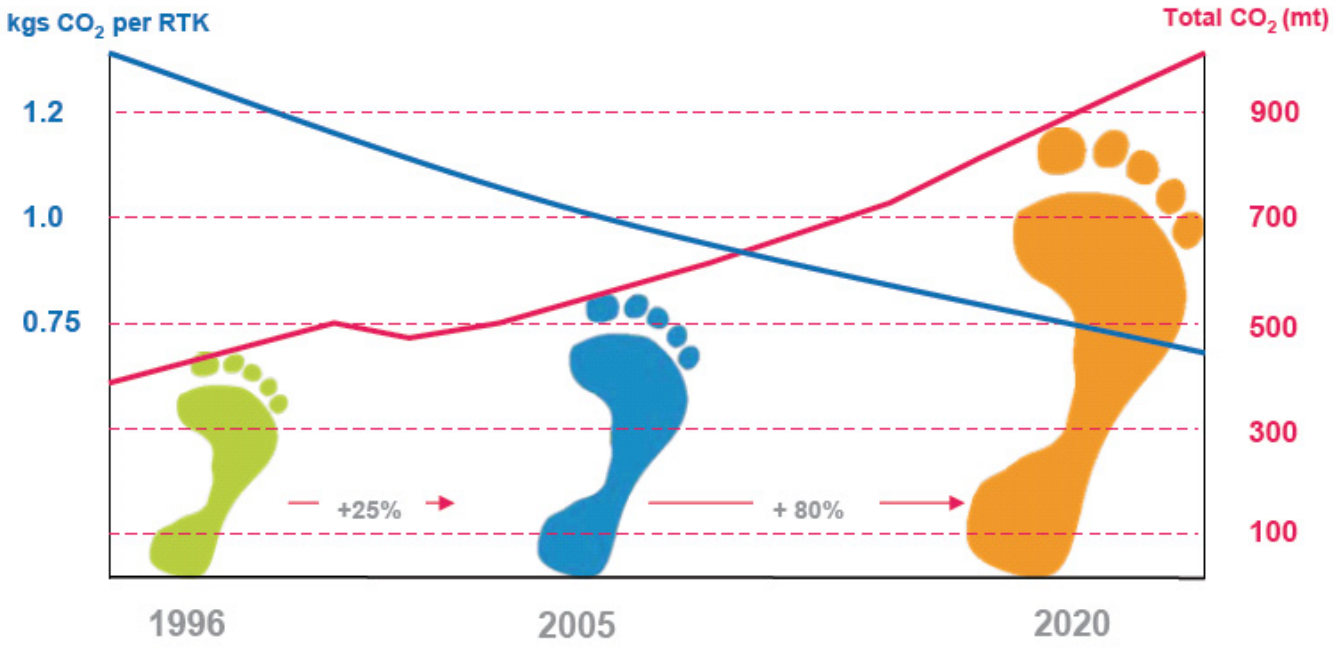
- **Supply will struggle to keep pace**

  Conventional oil and gas, and indeed all energy sources together, cannot meet this unconstrained demand

- **Environmental stresses are increasing**

  More energy means more CO_2 emitted at a time when climate change looms as a critical global issue.

Aviation remains in the climate change spotlight



- Aviation contributes ~2% of global CO2 emissions and ~15% of transport CO2 emissions
- However it is a more visible form of transport, often type-cast as a luxury.
- Projected growth in aviation and associated CO2 emissions will outpace incremental efficiency gains
- Non-CO2 greenhouse gas emissions take place in a sensitive layer of the atmosphere e.g. NOx, Soot, Contrails & Cirrus Cloud formation

Source:
IATA

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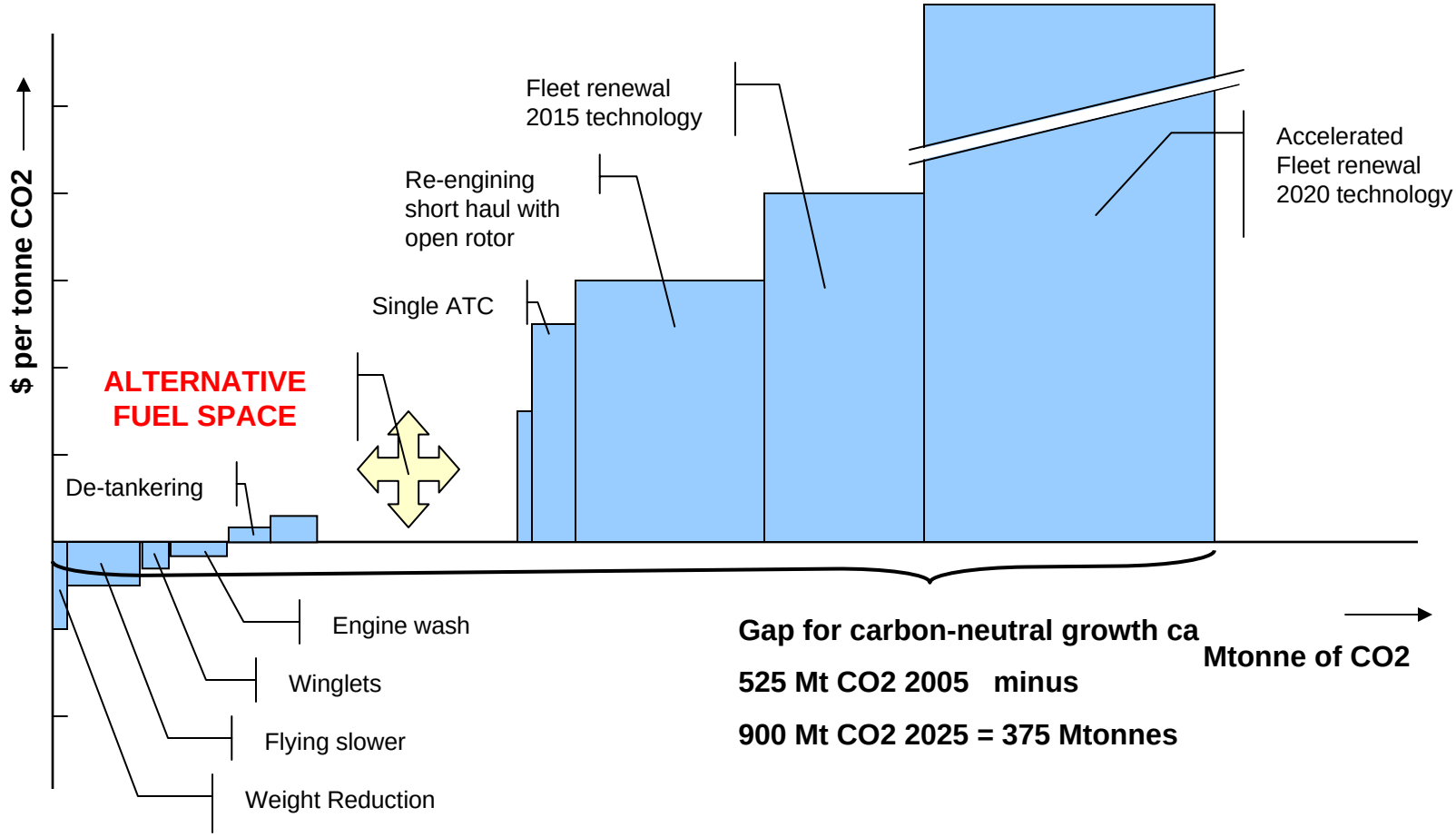
More analysis by the industry is required to determine alternative fuels' place on the CO2 abatement curve



Source: Shell Analysis

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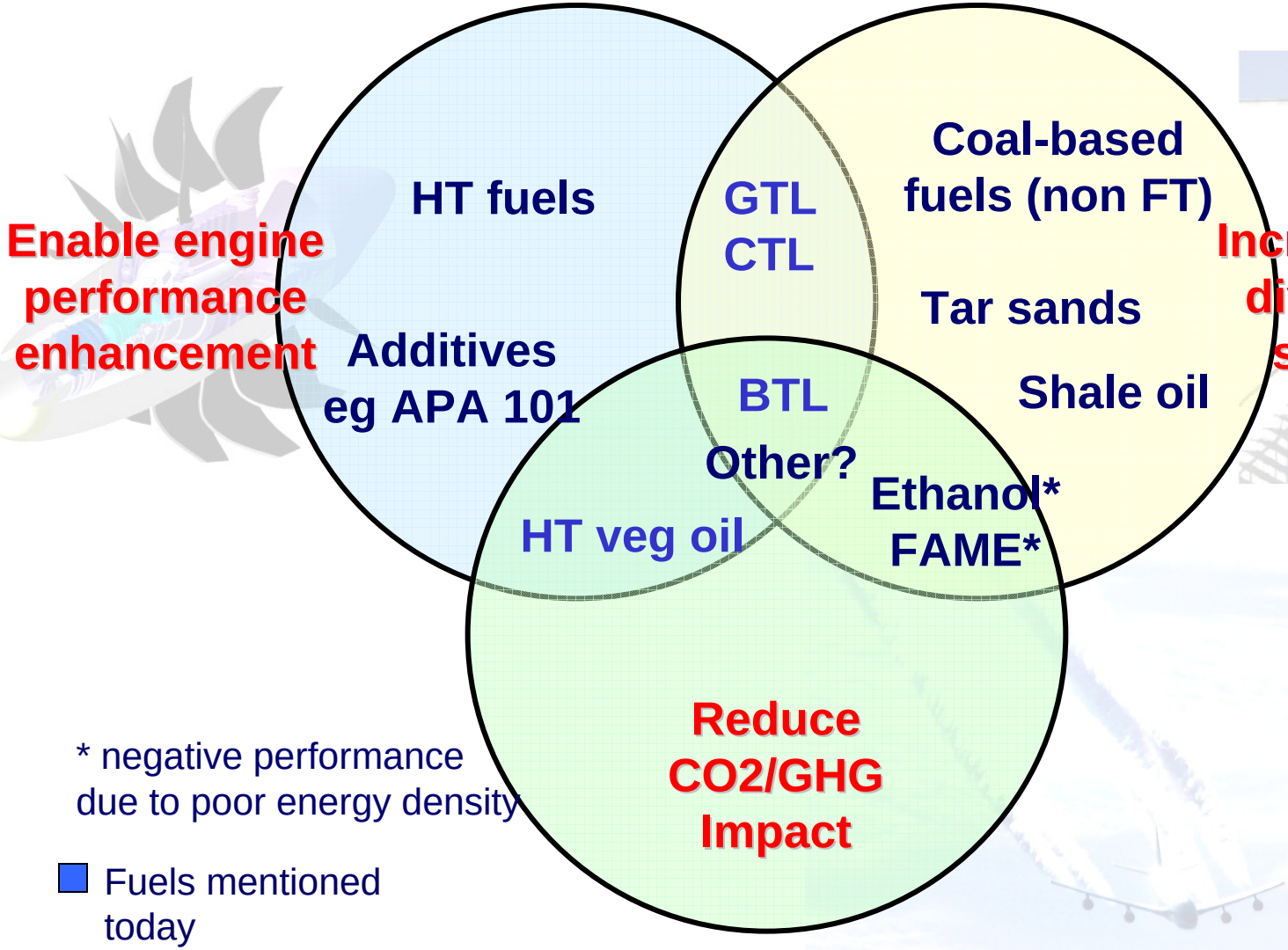
Alternative aviation fuel options are limited due to high specifications required.

- Long lifetime and high capital cost of aircraft – kerosene is preferred jet fuel for next 30 years
- Focus on safety means lead times for fuel or additive development are long (~10 years)
- Airlines don’t like aircraft that need different fuels
- Little incentive for OEMs to develop aircraft/engines running on a special high performance or alternative fuel
- Local alternative fuel solutions common in ground transportation fuels only applicable to general aviation
- Hydrogen would need completely new aircraft and infrastructure
- **Current wisdom says any new or alternative aviation fuel for the short to medium term must be a drop-in replacement**

Industry fuel options map



* negative performance due to poor energy density

■ Fuels mentioned today

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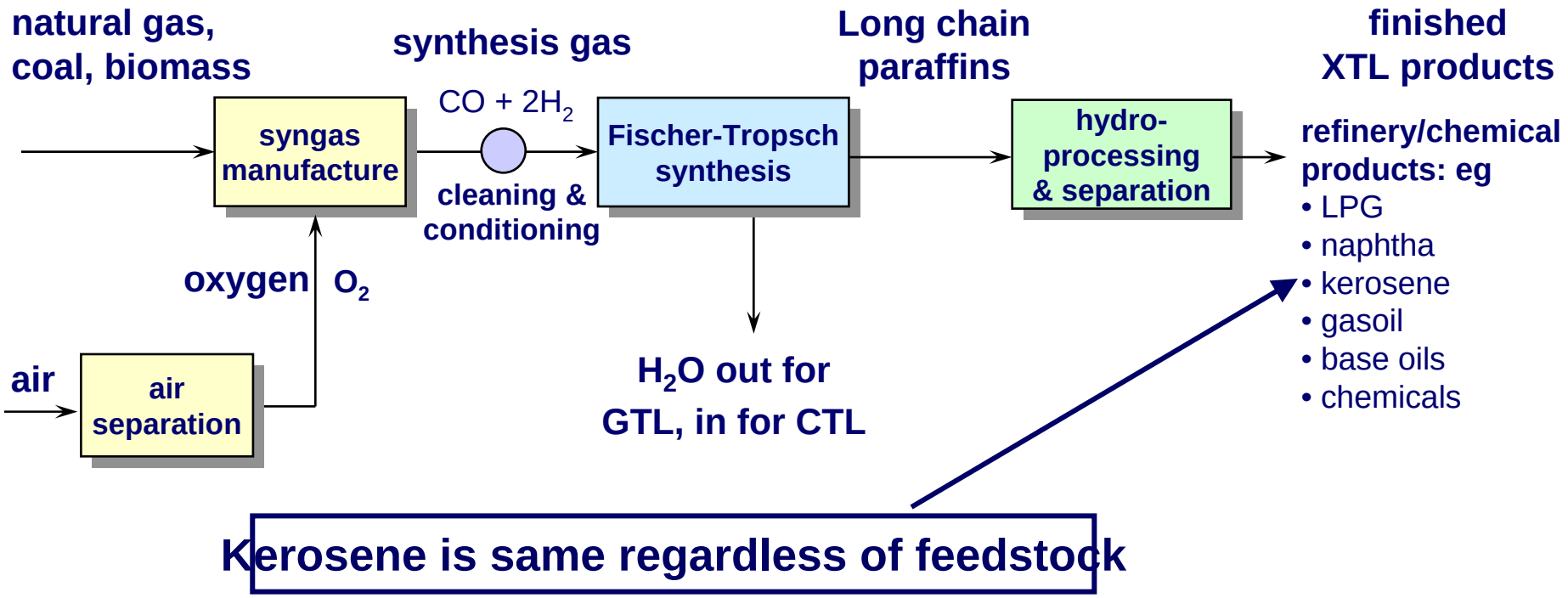
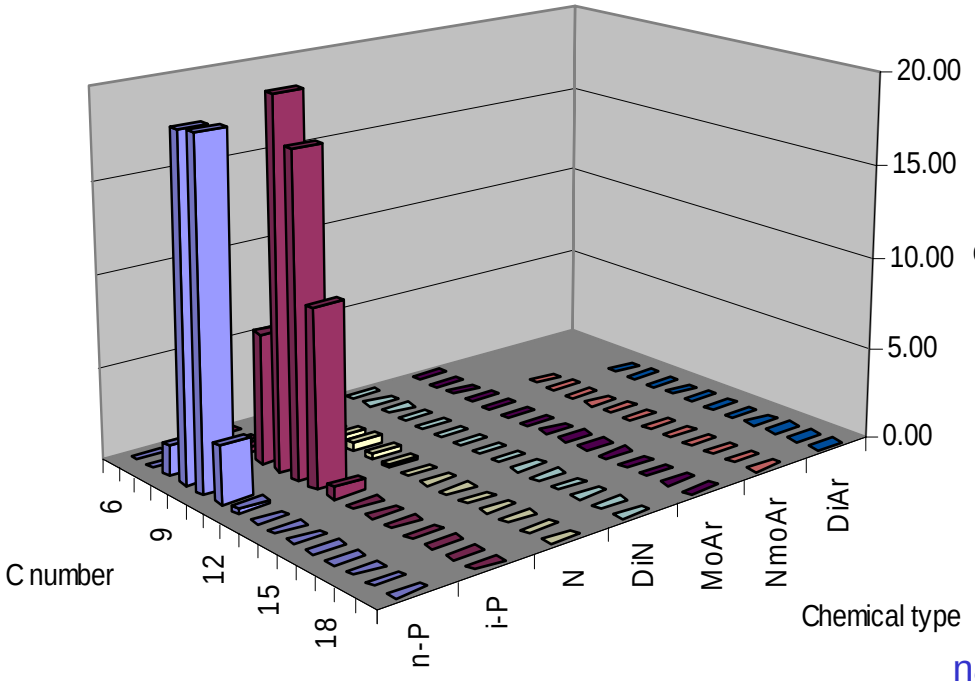
The Fisher-Tropsch (or XTL) process offers a versatile pathway to create synthetic fuels

Anything-to-Liquids (XTL) is a process that converts carbon & energy containing feedstock to high quality fuels & products via Fischer-Tropsch synthesis



Synthetic fuels have virtually no sulphur or aromatics - high energy content and combustion properties

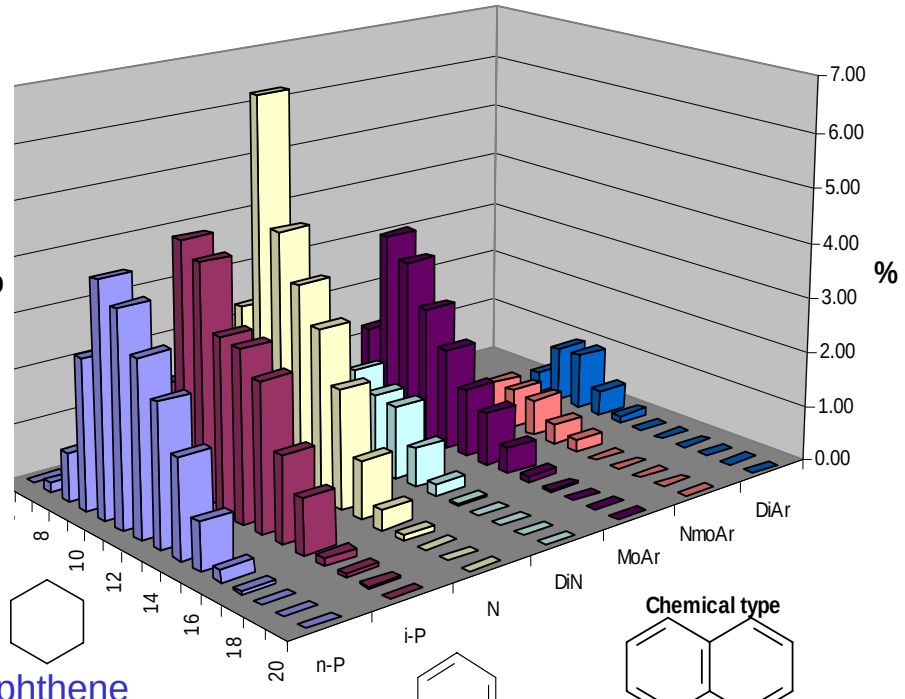
Gas-to-Liquids Jet



n-paraffinic

iso-paraffinic

Typical UK Jet A1



naphthene

aromatic

di-aromatic

naphthenic mono-aromatic

di-naphthene

di-aromatic

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Coal to Liquids (CTL) technology

- Reduces dependence on oil
- Relatively low coal prices can make economics work
- Attractive to governments with energy security concerns

BUT

- Very high capital cost for CTL plant
- Water availability (CTL requires input of fresh water)
- Significant process CO_2 footprint challenges

Shell: No current activity

Gas to Liquids- GTL Jet Fuel

- A jet fuel made from natural gas. Produces lower particulate emissions which affect air quality, no smell, easy to filter, clear.
- A lightweight source of energy – typically 2% more /kg compared to standard jet fuel
- Likely to be approved for use as a 50% blend with conventional kerosene

Shell:

- Small volumes available now (ex Bintulu, Malaysia).
- Larger volumes available from Pearl GTL plant in Qatar when on line around end of decade

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Case study: First Civil Aircraft Flight using GTL Jet Fuel - Feb. 1st, 2008

- Integral part of Synthetic Fuel Consortium efforts: GTL Jet Fuel supplied by Shell and blended with conventional kerosene.
- **Slightly less than 50% GTL for this first test to stay within conventional jet fuel properties (Defstan 91-91 except for density)**
- A380 MSN 004 Test Aircraft
  - Powered by RR Trent 900 engines
  - Engine 1 was test engine
  - Altitude relight at 45,000 ft
  - Accel/decel at various altitudes
  - Gravity feed

- **Data has proven that GTL is a viable fuel and has helped contribute to the specification limits for fuels**
- **Complete data analysis by partners; essentially the flight was perfectly normal**
- **Efforts to approve Generic 50/50 blend well underway and consortium moving on to investigate higher blend ratios up to 100%**

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Biomass to Liquids (BTL)

- Very low total CO_2 footprint possible (close to 90% reduction) without CCS
- Wide flexibility in biomass feed options

BUT

- Optimum plant size relatively small - Limited by biomass logistics costs
- Biomass is fundamentally carbon light, so conversion ratio relatively poor (tons-in to tons-out) compared to coal
- Biomass more difficult to clean up prior to processing than gas
- Large availability of biomass a challenge
- High capital costs compared to conventional oil

Shell: Involved in demonstration partnership with Choren in Germany

Hydro- treated vegetable oils

- To remove oxygen, hydrotreating or catalytic upgrading- conventional refinery processes

BUT

- Most Trigyceride-producing plants have carbon numbers ranging from C14 – C20, making them more of a diesel fraction
- Feed costs dominate the finished price (~80% of cost model). Common feedstocks are limited in availability and driven short very quickly
- Four Main Food Oil Crops (Palm, Rape, Soy, Sunflower). In some cases linked to sustainability issues.
- Jatropha and Algae could provide future non-food feedstocks.

Shell:

- Hydro-treating R&D program
- Involved in pilot project for algae as feedstock with Cellena in Hawaii

Summary

- Traditional Kerosene for aviation is hard to diversify away from due to stringent safety regulations
- Some options exist to create ‘drop in’ alternative fuels suitable for aviation – some ‘drop in’ fuels can create performance benefits
- There will continue to be competition for alternative molecules from other premium fuels sectors where incentives or penalties already exist
- Industry is working hard to find alternatives such as GTL, CTL, and biofuels options for aviation.

Questions?

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