Use of Sustainable Biofuels for Aviation

Requirements of the Airline Industry
Biofuel for CO$_2$ Reduction
Environmental Impacts of the Airline Industry

- CO$_2$: 71%
- Water: 28%

CO, HC, NO$_x$, SO$_x$, Primary PM$_{2.5}$: < 1%

Aircraft Noise

Atmospheric Chemistry and Physics

- SO$_x$
- NO$_x$
- UHC
- CO
- Ozone
- Primary PM$_{2.5}$
- Secondary PM$_{2.5}$

Population Exposure and Health Impacts

Global Climate Change

- Cooling Effects
- Warming Effects

Combustion Emissions

- soot
- CO$_2$
- NO$_x$
- O$_3$
- CH$_4$
- H$_2$O

Emissions from Fuel Production

- CH$_4$, N$_2$O, CO$_2$

Land and Water Usage
IATA Goals for Climate Protection

2010
1.5% p.a. fuel efficiency working towards CO₂-neutral growth

2020
CO₂ neutral growth from 2020
Implementation of a global sectoral approach

2050
50% reduction in net CO₂ emissions over 2005 levels

Assuming constant air traffic growth until 2050, 1.8 billion tons of CO₂ have to be substituted.
Requirements For The Airline Industry
Year 2050:
Emission reduction 1.8 billion tons of CO2 per annum

- CO2 Reduction: 1.8 billion t.
- Fleet Rollover: 0.1 billion t.
- Infrastructure: 0.1 billion t.
- Engine/Airframe Research: 0.2 billion t.
- Biofuels: 1.4 billion t.

ISCC General Assembly 2012, Joachim Buse, Lufthansa Aviation Biofuel
Aviation Biofuels: Climate-Friendly Alternative to Jet A-1

- **Benefits**
  - Improved CO$_2$ - balance by CO$_2$ – retention of biomass through photosynthesis
  - Fuel is free of sulfur and carbons, lower soot formation
  - Various ressources and two processing routes to produce biofuel
  - Promotes local an regional solutions and economies

- **Disadvantages**
  - Availability
  - Price
  - Biodiversity
  - Indirect land use change
Sustainability and Greenhouse Gas Reduction

- Biofuels only make sense if they generate major net greenhouse gas savings and are sustainable.

- Competition with food crops to be avoided, both for ethical and economic reasons.

- Lufthansa is actively looking into possible biomass alternatives and supporting several biomass projects.

- Current focus is on jatropha and camelina, but other crops looked into as well.
Comparison of Complexity: Jet A-1 vs. Biofuels

Fossil Fuels
- **Ressource**
- **Refinery**
- **Consumer**

  - Upstream: crude-oil transport
  - Downstream: specialty transport

Biofuels
- **Plantation industry/harvesting**
- **Extraction/compression**
- **Conversion**
- **Two-step distillation**

- High complexity
- Multilevel production from the field to the consumer
- Various bottlenecks
- Seasonality
## Comparison: Aviation Biofuels – Jet A-1

<table>
<thead>
<tr>
<th>Properties</th>
<th>Jet A-1</th>
<th>BtL-FT</th>
<th>HVO</th>
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<tr>
<td>Standard</td>
<td>ASTM 1455</td>
<td>ASTM 7566</td>
<td>ASTM 7566 Annex 1</td>
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<td>Licence</td>
<td>1960</td>
<td>2009</td>
<td>2011</td>
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<td>Temperature stability</td>
<td>- 47°C</td>
<td>- 47°C – - 69°C</td>
<td>&gt; - 47°C</td>
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<tr>
<td>Density</td>
<td>0,78 – 0,82</td>
<td>0,72 – 0,75</td>
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<tr>
<td>Energy content</td>
<td>100%</td>
<td>104%</td>
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<tr>
<td>Blending with Jet A-1</td>
<td>-</td>
<td>≤ 50%</td>
<td>≤ 50%</td>
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The Technical Aspects

- Currently, only “drop-in” fuels are certified and approved for aviation
- Perfect fit to existing infrastructure and ready for use without modifications - neither in storage depots nor in aircraft engines
- New pathways for biokerosene are progressing (e.g. Alcohols-to-Jet)
- Quality key concern for biofuels
  - New market participants on producers’ side
  - Often technology based companies have limited background and understanding in aviation fuel management and handling
- There is an urgent need for sustainability certification along the value chain of biofuels “from farm to fly“
- „PureSky ® – Sky friendly energy“ is Lufthansa’s brand name for sustainable biofuels
Biomass
Biofuels - High Potential, Demonstrated Feasibility – But The Market Does Not Exist

From Laboratory to Industrial Scale Plant
Breeding, cultivation, harvesting, standards in the beginning
Large-scale production technology in the beginning

Feedstock Availability
Massive gap between demand and availability

Fluctuating Profitability
Production costs still high
Profitability depends on global crude-oil-price

Role of Oil Companies
No core business
Not on top-agenda
Lack of incentives to get over market barriers
Focus in 2012: Farming and Sustainability Certifications!

- Availability of sustainable biomass is a key requirement!
  - Current focus on
    - Jatropha
    - Camelina
    - Palm

- There is an urgent need for sustainability certification of farming projects!
Focus until 2020/2025

- Avoidance of desertification
- Avoidance of exodus
- Avoidance of slash and burn
- No competition with food production
- Local employment by local production
- Biodiversity and sustainable agriculture
Cultivated area to meet LH’s feedstock demand in 2025

- **Corn** 473.255 km²  
  (State of California 403.933 km²)

- **Rapeseed** 68.403 km²  
  (State of West Virginia 62.361 km²)

- **Jatropha**  
  (States of Massachusetts & Vermont 44.262 km²)

- **Palmoil**  
  (State of Connecticut 12.548 km²)

- **Algae 30%** 1.387 km²  
  (City of Los Angeles 1.291 km²)

- **Algae 70%** 625 km²  
  (New York City 780 km²)
Project burnFAIR: Facts

Duration: 15th July – 27th December 2011, 8 flights/day

Route: Hamburg – Frankfurt – Hamburg (1h flight time)

Aircraft: Airbus A321

Biofuel quantity: 800 tons

Biofuel ratio: 50% in one engine

Total cost: 8.4m USD

Emission savings: approx. – 1,500 tons CO₂
Use in the aircraft – The „Drop In“ Concept

- Research of engine performance: One engine to operate with 50% blend of HVO kerosene
- First truck supplies bioblend to the starboard wing tank
- Second truck supplies conventional JET A-1 to the backboard wing tank
- No major changes in normal cockpit procedures
- “Bio-Engine” shows expected data and operates normal
First Results of the Project Aviation Biofuel

Bottom line

On December 27th 2011, the aircraft D-AIDG completed its last flight with biofuel

Total number of flights: 1187
Biofuel blend [volume in tons]: 1557
Emission saving [CO$_2$ in t]: 1471
First Results of the Project Aviation Biofuel

Engine Condition Monitoring and Logistics

- Due to higher energy content of HRJ a reduction in fuel burn of the starboard engine was found (~1%)
- Biojet fuel burns “cleaner” - less particles and smaller size of particles
- No segregation of biofuel mix in the storage tank
Airlines` Requirements for Aviation Biofuels

Worldwide agreement on Certification Systems to guarantee sustainable biomass feedstock production, processing and transport

Airlines should actively contribute to

- Stop deforestation
- Stop rural exodus in poor regions
- Stop enlargement of deserts
- Stop poverty
- Improve social development
- Improve labour conditions
- Develop new industries
- Foster international co-operation and friendship
The beginning is half the way to success
(korean wisdom)