Why sustainable biofuels? Challenges and opportunities

**Challenge:**
Fuel price and availability

**Challenge:**
Greenhouse gas emissions

Source: 2008 average annual oil price forecasts as of Sept 2008 (Global Insight, EIA) and June 2008 (Moody’s, IATA)

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Pursuing alternative fuels initiatives

The industry is pursuing different alternative fuels initiatives to address these challenges…and that’s ok!

Sustainable Aviation Fuel Users Group

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Focus on Sustainability
Are all biofuels equal? What are the best and worst sources?
Sustainability considers: environmental, economic and social impacts

Lower CO₂ lifecycle

Does not compete with food or promote deforestation

Promotes local and regional solutions and economies
Commercial efforts underway via Sustainable Aviation Fuel User Group

GOAL: To help speed the creation of a viable market mechanism for sustainable biofuels.

Members are:

- Driving commercial viability requirements
  - Sustainability principle and monitoring in place
  - Technology/agronomy in place
  - Fuel processing technology in place
  - Viable feedstock and processing developers in place

- Using the power of their fuel spending dollars to ensure sustainability is a real requirement in the development of future aviation fuels
Ensuring a sustainable approach to aviation biofuels

The user’s group pledges to consider only renewable fuel sources that –

- require minimal land, water and energy to produce
- minimize biodiversity impacts
- don’t complete with food or fresh water resources
- provide socioeconomic value to local communities in cultivation and harvest of feedstocks

Group agrees to link with Roundtable on Sustainable Biofuels Process

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Sustainable Aviation Fuel Users Group
Our Commitment to Sustainable Options

As aviation leaders, we have a responsibility to help reduce, control greenhouse gas emissions, and improve operations across the industry. We also have an opportunity to deliver significant environmental and social benefits as we seek to lower the carbon intensity of our fuels overall by supporting the development, certification, and commercial use of lower carbon renewable fuels, derived from environmentally and socially sustainable sources.

Therefore, we, the undersigned airline operators and other aviation industry organizations, declare our commitment to advance sustainable aviation fuels, in line with the vision of the Roundtable on Sustainable Aviation Fuels. Collectively, we commit to the following:

1. Reduce greenhouse gas emissions from plant growth, harvesting, processing, and end use should be significantly reduced compared to those associated with jet fuels from fossil sources.
2. In developing countries, development projects should include provisions or outcomes that improve socio-economic conditions for local communities and respect human and labor rights. The Group agrees to link with the Roundtable on Sustainable Biofuels to develop a world-leading fuel base on sustainable aviation fuels, which will:
   - Provide a body of peer-reviewed research and best practices, including labライフサイクル emissions assessments, which will support the practical application of commercial aviation fuels to the development, certification, and commercial use of sustainable aviation fuels.
   - Work in conjunction with the Roundtable on Sustainable Biofuels as a basis for sustainability research and certification efforts. The Working Group will identify and research feedstock-specific sustainability indicators and metrics to contribute to the Roundtable.

We commit to working in partnership with governments, other industries and representatives of national security, aviation and aviation-related industries to develop a globally sustainable aviation fuels industry. We also encourage others in the aviation industry to join us in working together to help accelerate the development, certification, and commercial use of environmentally and socially sustainable aviation fuels.
Viable and sustainable feedstock alternatives

Viability is based on timing, technology and local resources
Commerically Viable
The business case for sustainable aviation fuel
Long term trajectory of cost is important

Fossil Fuels – mature technology chasing finite & diminishing supply.

Biofuels – emerging technology driving renewable & increasing supply.
New fuel supply models increase aviation fuel supplies

Fossil Fuel Model

Sustainable Fuel Model

Integrated Oil Production

Sustainable Biofuel Production

Individual Airline Fuel Demand

Individual Airline Fuel Demand

Scale of biofuel production allows for new opportunities for air carriers
Aviation is uniquely structured to maximize benefits of sustainable biofuels.
Technical and Fuel Requirements

Sustainable biofuels must provide near-term replacement solution
Sustainable biofuels work in existing aviation infrastructure

- Meets fuel performance requirements
- Requires NO change to airplanes or engines
- Requires NO change to infrastructure
- Can be mixed or alternated with Jet-A fuel
Sustainable biofuels can exceed current jet fuel specification

Fuel requirements:

- Freezing point
- High temperature thermal stability
- Energy density
- Storage stability

- Elastomeric compatibility
- Must be a replacement solution
- Meet ASTM fuel specs
- Have a low CO₂ footprint

**Synthetic Paraffinic Kerosene (SPK) from a bio-derived source**

<table>
<thead>
<tr>
<th>Property</th>
<th>Jet fuel specification</th>
<th>Bio-SPK performance</th>
<th>ASTM Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fluidity</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freezing point, degrees Celsius</td>
<td>max -40 Jet A</td>
<td>-63</td>
<td>D 5972, D 7153, D 7154, or D 2386</td>
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<tr>
<td></td>
<td>min -47 Jet A1</td>
<td>-69</td>
<td></td>
</tr>
<tr>
<td><strong>Combustion</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Net heat of combustion, MJ/kg</td>
<td>min 42.8</td>
<td>44.4</td>
<td>D 4529, D 3338, or D 4809</td>
</tr>
<tr>
<td></td>
<td></td>
<td>43.2</td>
<td></td>
</tr>
</tbody>
</table>

* Data provided by UOP

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- 23 degrees C lower freeze point
- Nearly 4% more energy content
Achieving the Goal
Driving a viable market for sustainable aviation biofuels
Sustainable biofuels can follow a similar adoption curve to wind energy. Technology matured; financial markets became comfortable with investing.

* Notional data
Accelerating fuel certification

Boeing is working to achieve certification of bio-spk fuels by 2010 by:

- Increasing airline participation in ASTM
- Coordinating flight demos, which generate performance data
- Writing the technical fuel certification report which supports near term certification
Successful flight test program demonstrated biofuel viability

- Demonstrated technical feasibility
- Identified sustainable biofuel sources
- Promoted development of viable commercial markets
- Demonstrated diverse engine / airframe combinations

<table>
<thead>
<tr>
<th>Boeing</th>
<th>Virgin Atlantic</th>
<th>Air New Zealand</th>
<th>Continental Airlines</th>
<th>JAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>20% Coconut &amp; Babassu</td>
<td>50% Jatropha</td>
<td>50% Algae &amp; Jatropha</td>
<td>50% Camelina, Jatropha &amp; Algae</td>
<td></td>
</tr>
</tbody>
</table>

Increasing level of test objectives
Focus areas in commercial scale production

Gaps in critical market drivers are being addressed by Sustainable Aviation Fuel Users Group

- Independent, transparent sustainability verification
- Investment
- Commercial scale production projects
- End-use by airlines
Driving development of viable feedstocks

- Sponsoring feedstock feasibility studies on jatropha, algae, halophytes
- Connecting feedstock projects with financial community
- Working with industry and NGOs to support sustainable feedstocks through public policy
- Co-founded
  - Algal Biomass Organization
  - Sustainable Aviation Fuel Users Group