Crediting Low-Carbon Aviation Fuels in CORSIA

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Reduced emissions has both commercial and environmental benefits…

- **Reduced cost**
  - Less fuel needs to be purchased
  - Less exposure to volatile markets

- **Additional payload**
  - Lower fuel weight → greater ability to carry passengers or cargo

- **Additional range**
  - Ability to serve more markets directly
...so we have been working on it since we started flying

- **Aircraft and engine manufacturers**
  - 80% reduction in fuel use vs. first-generation jets
  - Lighter materials
  - ETOPS: higher reliability for more direct routings on transoceanic flights

- **Maintenance providers and suppliers**
  - Aftermarket winglets provide up to 6% fuel reduction
  - Engine washing to remove unwanted materials

- **Airports and ATC providers**
  - Ensure optimal routings and altitudes
  - Reduce time in holding patterns
  - Engine washing to remove unwanted materials

- **Regional partners**
  - Power aircraft using electricity while at the gate
  - Nonstop service to smaller cities saves fuel and time
  - Flying the right size aircraft for each route
Airlines using half the industry’s fuel are taking tangible steps to develop biofuels, for a variety of reasons

**Strategic**
- Ensure stable fuel supply
- Reduce advantage of traditional fuel suppliers

**Financial**
- Potential to be market-competitive or even below traditional fuel pricing

**Regulatory**
- Increasing regulatory focus on climate change
- Provides protection against future CO₂ costs

**Reputational**
- Reputational advantage from reduced CO₂ footprint
Biofuels must be a drop-in solution to be cost-effective

Dollar coin

Dvorak keyboard
Patented in 1936

Double-decker bus
Less traffic congestion than articulated buses

New technology is great—as long as it fits the existing infrastructure
To be affordable and scalable, biofuels must go into hydrant systems—all airlines will use, but not all will pay.
United is deeply involved in regulatory and development work to encourage biofuel adoption

- **ICAO (International Civil Aviation Organization)** is the UN agency responsible for aviation standards
- ICAO’s CAEP (Committee on Aviation Environmental Protection) is responsible for policies regarding emissions
- United is part of CAEP’s Global Market-Based Measure Task Force, which is developing:
  - Reporting standards for an airline’s emissions
  - Reporting standards to receive regulatory credit for biofuel use
  - Methods to verify a biofuel’s sustainability
- **CARB’s LCFS (Low Carbon Fuel Standard)** is a per-gallon credit for producers of low-carbon fuels
  - Aviation fuel is currently excluded from generating credits
  - United and other stakeholders are working with CARB to provide the technical analyses to include aviation fuel in LCFS
EU ETS (European Union Emissions Trading Scheme) offered a cumbersome biofuel credit

- Aviation was added to EU ETS effective 2012 for all flights to/from/within (but not overflying) EU
- After ICAO agreed to develop a global system, EU agreed to limit EU ETS to intra-EU flights
- Airlines had to monitor CO₂ emissions from every single flight
- Biofuel was credited as zero emissions, but had to be accounted for individual flights—this doesn’t enable drop-in fuels

Chicago-London flights spend one hour in EU airspace, but are regulated for emissions over non-EU countries
ICAO’s CORSIA (Carbon Offsetting and Reduction Scheme for International Aviation) will credit biofuels

- **Goals**
  - Achieve carbon-neutral growth for international airline industry after 2020
  - Avoid conflicting patchwork of state measures regulating CO₂ emissions

- **Method**
  - Agreement covers 2021-2035
  - Countries “opt in” to start—current signatories over 86% of international aviation emissions
  - Developed countries cover 50% of developing countries’ growth, phased out over time

- **Biofuel accounting**
  - Biofuels receive lifecycle credit for CO₂ reductions
  - Biofuel accounting practices still being written
  - Biofuel use receives full credit instead of sharing CO₂ benefit

Chicago-London flights pass over four countries, but will only be regulated once.
While emissions growth is a shared obligation, biofuel credit goes solely to the purchasing airline

- To ensure international agreement, CORSIA was built with a shared obligation across developed and developing countries
- However, biofuel credit goes solely to the purchasing airline—otherwise the financial incentives would be too weak
- I.e., biofuel can be used instead of offsets to meet CORSIA obligations

**Emissions obligation**

**Shared biofuel credit**

\[
Oblig_i = (Ind_i - Ind_{2020}) \times \frac{Airline_i - Biofuel_i}{Ind_i}
\]

\[
Oblig = (110 - 100) \times \frac{10 - 0.5}{110}
\]

\[
Oblig = 0.86
\]

**Emissions obligation**

**Individual biofuel credit**

\[
Oblig_i = (Ind_i - Ind_{2020}) \times \frac{Airline_i}{Ind_i} - Biofuel_i
\]

\[
Oblig = (110 - 100) \times \frac{10}{110} - 0.5
\]

\[
Oblig = 0.41
\]

Note: figures are for demonstration purposes only; formula becomes more complicated starting in 2030
CORSIA will help drive biofuel adoption but not be a major driver—at least in the near term

Relationship of CO₂ costs to fuel price

\[
\text{metric tons } CO_2 = \text{gallons fuel} \times \text{Fuel Density} \times \text{Combustion Factor}
\]

\[
\text{metric tons } CO_2 = \text{gallons fuel} \times \frac{6.7 \text{ pounds}}{\text{gallon}} \times \frac{3.157 CO_2}{\text{fuel}} \times \frac{\text{metric ton}}{2,205 \text{ pounds}}
\]

1 metric ton CO₂ = 104 gallons fuel

\[
\Delta \frac{\$1.00}{\text{metric ton } CO_2} \approx \Delta \frac{\$0.01}{\text{gallon fuel}}
\]

Current biofuel price supports per gallon

<table>
<thead>
<tr>
<th></th>
<th>CORSIA¹</th>
<th>California LCFS²</th>
<th>RINs³</th>
</tr>
</thead>
<tbody>
<tr>
<td>~$0.08</td>
<td>~$2.00</td>
<td>~$2.70</td>
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</tbody>
</table>

¹ Assumes $10/metric ton CO₂, biofuel with 80% lifecycle CO₂ reduction
² Biofuel with 80% lifecycle CO₂ reduction, assuming aviation inclusion in LCFS
³ D3 RIN for cellulosic biodiesel
## Most long-term biofuel commitments—even from foreign carriers—are for California delivery

<table>
<thead>
<tr>
<th>Airline</th>
<th>Provider</th>
<th>Location</th>
<th>Quantity</th>
<th>Starts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>UNITED</strong></td>
<td>AltAir Fuels</td>
<td>Los Angeles</td>
<td>15M gals</td>
<td>Mar 2016-Mar 2019</td>
</tr>
<tr>
<td>KLM Royal Dutch Airlines</td>
<td>AltAir Fuels</td>
<td>Los Angeles</td>
<td></td>
<td>Sep 2016-Sep 2019</td>
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<tr>
<td><strong>Lufthansa</strong></td>
<td>gevo</td>
<td>Chicago</td>
<td>40M gal</td>
<td>Nov 2017-Nov 2022</td>
</tr>
<tr>
<td>FedEx Express</td>
<td>RED ROCK BIOFUELS</td>
<td>Oakland</td>
<td>3M gal/yr</td>
<td>7-year agreement</td>
</tr>
<tr>
<td>Southwest</td>
<td>RED ROCK BIOFUELS</td>
<td>Bay Area</td>
<td>3M gal/yr</td>
<td>Fall 2018</td>
</tr>
<tr>
<td>Alaska Airlines</td>
<td>HAWAII BioEnergy</td>
<td>Hawaii</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alaska Airlines</td>
<td>gevo</td>
<td>New York</td>
<td>9.9M gal/yr</td>
<td>2019-29</td>
</tr>
<tr>
<td>jetBlue</td>
<td>SG Preston</td>
<td>San Francisco</td>
<td>375M gal</td>
<td>2019-29</td>
</tr>
<tr>
<td>CATHAY PACIFIC</td>
<td>Fulcrum</td>
<td>Los Angeles</td>
<td>4M gal/yr</td>
<td>2020-30</td>
</tr>
<tr>
<td><strong>UNITED</strong></td>
<td>Fulcrum</td>
<td>United hubs</td>
<td>90M gal/yr</td>
<td>10-year agreement</td>
</tr>
<tr>
<td>BRITISH AIRWAYS</td>
<td>VELOCYS</td>
<td>U.K.</td>
<td></td>
<td>2021</td>
</tr>
</tbody>
</table>
Key takeaways

- CO₂ accounting for biofuels must align with industry practices

- CORSIA credit for biofuels will be a small but growing part of demand

- Incentives matter—the right policies will spur biofuel development
2017 Eco-Airline of the Year

fly the friendly skies