Crediting Low-Carbon Aviation Fuels in CORSIA

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A STAR ALLIANCE MEMBER

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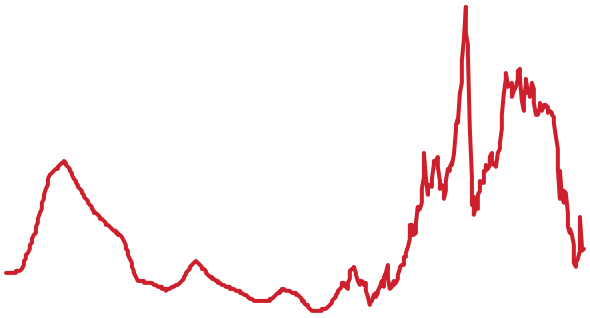
Reduced emissions has both commercial and environmental benefits…

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

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…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
- Power aircraft using electricity while at the gate

Regional partners

- Flying the right size aircraft for each route
- Nonstop service to smaller cities saves fuel and time

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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 CO_2 costs

Reputational

- Reputational advantage from reduced CO_2 footprint

Biofuels must be a drop-in solution to be cost-effective

Dollar coin
Re-introduced in 1971, 1979, 2000, 2007

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**

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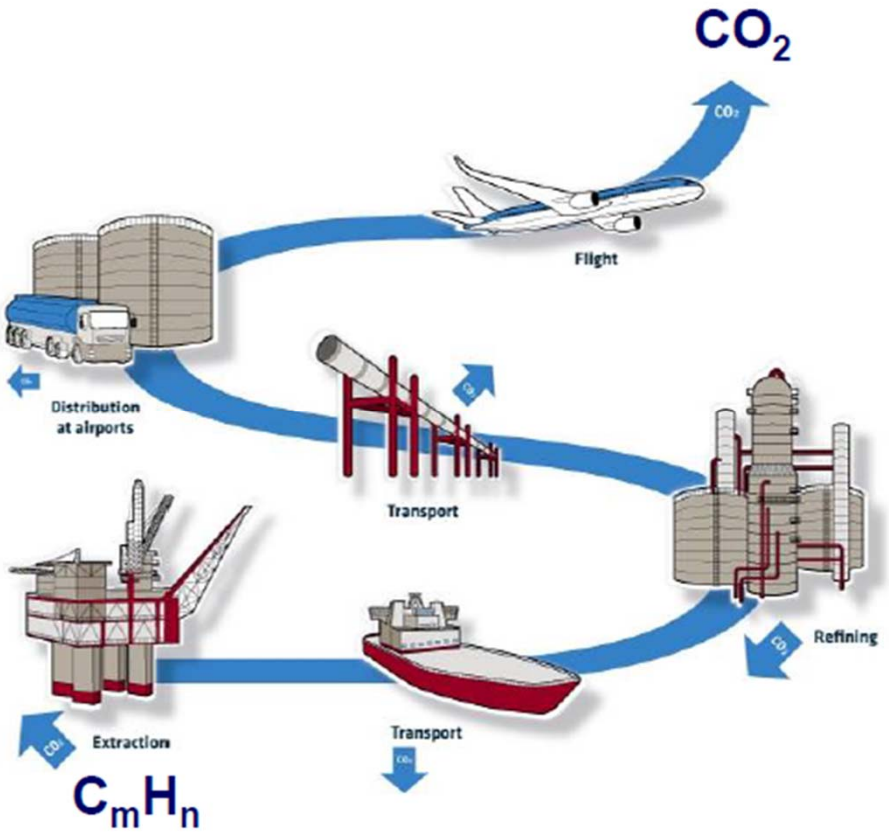
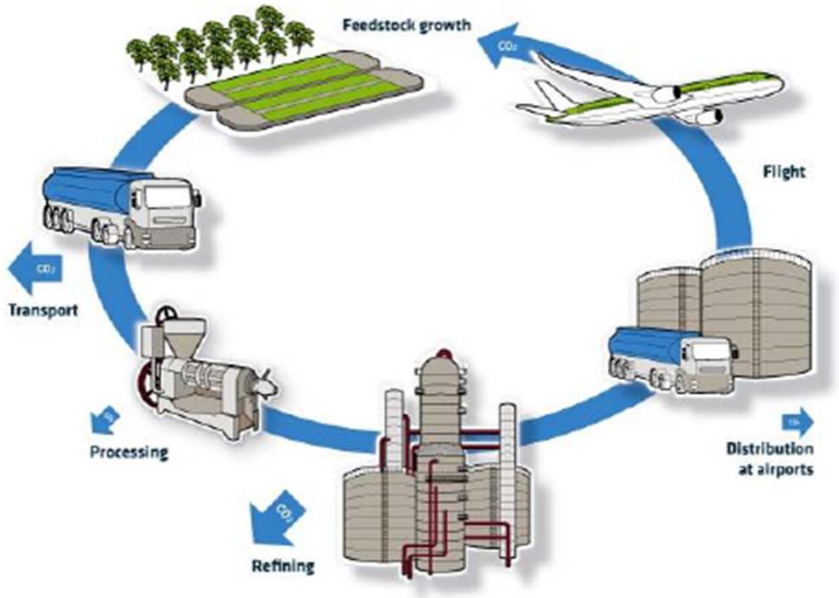
To be affordable and scalable, biofuels must go into hydrant systems—all airlines will use, but not all will pay

Petroleum-based fuel



Biofuel



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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 CO_2 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

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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 CO_2 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 CO_2 reductions
  - Biofuel accounting practices still being written
  - Biofuel use receives full credit instead of sharing CO_2 benefit

Chicago-London flights pass over four countries, but will only be regulated once

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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

$$Oblig_i = \left(Ind_i - Ind_{2020}\right) \times \frac{Airline_i - Biofuel_i}{Ind_i}$$

$$Oblig = \left(110 - 100\right) \times \frac{10 - 0.5}{110}$$

$$Oblig = 0.86$$

Emissions obligation
Individual biofuel credit

$$Oblig_i = \left(Ind_i - Ind_{2020}\right) \times \frac{Airline_i}{Ind_i} - Biofuel_i$$

$$Oblig = \left(110 - 100\right) \times \frac{10}{110} - 0.5$$

$$Oblig = 0.41$$

Note: figures are for demonstration purposes only; formula becomes more complicated starting in 2030

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CORSIA will help drive biofuel adoption but not be a major driver—at least in the near term

Relationship of CO_2 costs to fuel price

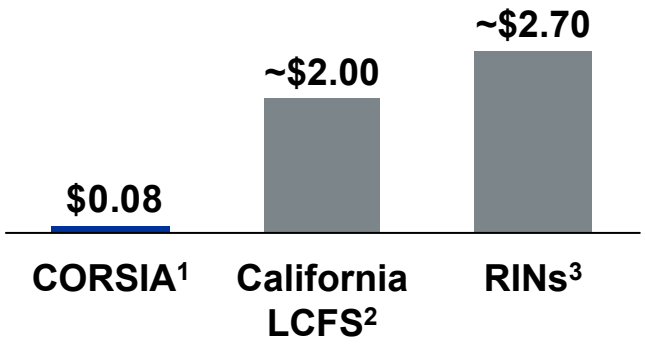
$$metric\ tons\ CO_2 = gallons\ \ fuel \times Fuel\ \ Density \times Combustion\ Factor$$

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

$$1\ metric\ ton\ CO_2 = 104\ \ gallons\ \ fuel$$

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

Current biofuel price supports
per gallon



[1] Assumes $10/metric ton CO_2, biofuel with 80% lifecycle CO_2 reduction
[2] Biofuel with 80% lifecycle CO_2 reduction, assuming aviation inclusion in LCFS
[3] D3 RIN for cellulosic biodiesel

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Most long-term biofuel commitments—even from foreign carriers—are for California delivery

Airline	Provider	Location	Quantity	Starts
UNITED	AltAir Fuels	**Los Angeles**	15M gals	Mar 2016-Mar 2019
KLM Royal Dutch Airlines	AltAir Fuels	**Los Angeles**		Sep 2016-Sep 2019
Lufthansa	gevo	Chicago	40M gal	Nov 2017-Nov 2022
FedEx Express	Red Rock Biofuels	**Oakland**	3M gal/yr	7-year agreement
Southwest	Red Rock Biofuels	**Bay Area**	3M gal/yr	
Alaska Airlines	Hawai'i BioEnergy	Hawaii		Fall 2018
Alaska Airlines	gevo			
jetBlue	SG Preston	New York	9.9M gal/yr	2019-29
Cathay Pacific	Fulcrum BioEnergy	**San Francisco**	375M gal	2019-29
Qantas	SG Preston	**Los Angeles**	4M gal/yr	2020-30
UNITED	Fulcrum BioEnergy	**United hubs**	90M gal/yr	10-year agreement
British Airways	Velocys	U.K.		2021

Key takeaways

- **CO_2 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**


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