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ICAO STOCKTAKING SEMINAR
TOWARD THE 2050 VISION FOR
SUSTAINABLE AVIATION FUELS



Challenges in SAF scale-up

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United is the only U.S. airline flying on SAF on a continuous basis



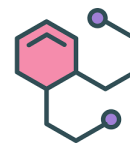
March
2016

United began flying World Energy's SAF from its Los Angeles hub in March 2016.



3 million
gallons

United has bought 3 million gallons of SAF from World Energy, more than any other airline in the world.



Tallow
feedstock

The SAF is made from tallow, an inedible substance made from beef fat.



2,700+
flights

Through the end of 2018, United has flown the equivalent of over 2,700 SAF flights.



60% CO₂
reduction

World Energy's SAF provides a greater than 60% reduction in CO₂ emissions on a lifecycle basis when compared to traditional jet fuel.



Dormant
refinery

This project created 65 new jobs at the previously idle refinery in Paramount, California.



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In 2015 United invested \$30 million in Fulcrum BioEnergy to convert municipal solid waste (MSW) into SAF

- Capture recyclables, generate renewable electricity credits, and produce fuel
- Greater than 80% reduction in CO₂ lifecycle emissions
- Co-develop up to five facilities (first SAF facility: Gary, Indiana)
- 900 million gallons over 10 years





Q: What about the price premium?

A: Airlines aren't willing to pay a premium



- Avoided costly startup expenses, so reduced need for cost recovery or to advance down the learning curve
- Cost/risk-sharing agreement



- Using MSW as feedstock at no cost; some studies show that feedstock is as much as 80% of the cost
- Bringing in investors from across the value chain who receive different benefit streams



Policy certainty has made California the focal point, but more incentives are needed to drive investment

	<u>LCA reduction</u>	<u>Key questions</u>
10 years ago	10%-20%	<p><i>Will it hurt the engines?</i></p> <p><i>Will it affect aircraft performance?</i></p> <p><i>How do we certify this?</i></p>
		Is it safe?
5 years ago	30%-40%	<p><i>What policies are needed?</i></p> <p><i>How can the business case work?</i></p> <p><i>Why should we be first?</i></p>



Today 60%-80%

How do we engage our customers?

Where is the money to scale up?



Patience and persistence are critical for SAF development

AltAir Fuels and 14 airlines sign biofuel MOU FlightGlobal

December 15, 2009

Fourteen airlines and alternative fuels producer AltAir Fuels have entered a memorandum of understanding to negotiate the purchase of roughly 50 million US gal of bio-derived jet fuel per year. **Participating airlines include** Air Canada, Alaska Airlines, American Airlines, Atlas Air, Delta Air Lines, FedEx, Hawaiian Airlines, JetBlue Airways, Lufthansa, Mexicana, Polar Air Cargo, **United Airlines**, UPS and US Airways.

AltAir **intends to produce at a new refinery in Anacortes, Washington**. The AltAir facility is **scheduled to begin production in 2012**.

United Airlines and AltAir Fuels to Bring Commercial-Scale, Cost-Competitive Biofuels to Aviation Industry

June 4, 2013

United Airlines today executed a definitive purchase agreement with AltAir Fuels.

AltAir Fuels will retrofit part of an existing petroleum refinery to become a 30 million gallon, advanced biofuel refinery **near Los Angeles, California**.

AltAir expects to begin delivering five million gallons of renewable jet fuel per year to United **starting in 2014**.

United Airlines is flying on biofuels. Here's why that's a really big deal.

The Washington Post

March 11, 2016

On Friday, United Airlines will launch a new initiative that uses biofuel to help power flights running between Los Angeles and San Francisco, with eventual plans to expand to all flights operating out of LAX. **The renewable fuel used to power United's planes will be coming from a Los Angeles refinery** operated by AltAir Fuels.



Airlines should seek multiple suppliers and avoid the ‘fear of failure’

United Airlines Flies First U.S. Commercial Advanced Biofuel Flight

November 7, 2011

United Airlines announced that it is operating the first U.S. commercial flight powered by advanced biofuels. Solazyme developed the algae oil that was refined into jet fuel to power today's commercial flight.

Also today, **United is announcing it has signed a letter of intent with Solazyme to negotiate the purchase of 20 million gallons of jet fuel per year,** derived exclusively from algae oil, for delivery as early as 2014.

Solazyme Ditches Biofuels (and Name) in a World of Cheap Oil

FORTUNE

March 16, 2016

A company that has been paving a path to make biofuels from algae oil over the past decade has **finally given up** on its biofuel ambitions **in a world of ultra cheap petroleum-based oil.**

Solazyme, now renamed as TerraVia, says **it will no longer focus on its fuels and its industrial businesses,** and instead will double down on selling its algae oil to the food and personal care industries, for use in products like cooking oil, protein powders and face lotion.



Communicating how SAF works is complicated

- **Naming:** SAF, SAJF, biofuel, biojet, renewable fuel, what should we call it?
- **Volume:** is 3 million gallons a lot or a little?
- **Blending and shared storage:** sharing too much detail can weaken the message



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We need to find ways to make SAF appeal to passengers

**Company offers fake
vacation photos for your
social media accounts**

abc NEWS



**The Prius as an Oddly-
Shaped Status Symbol**

The Atlantic



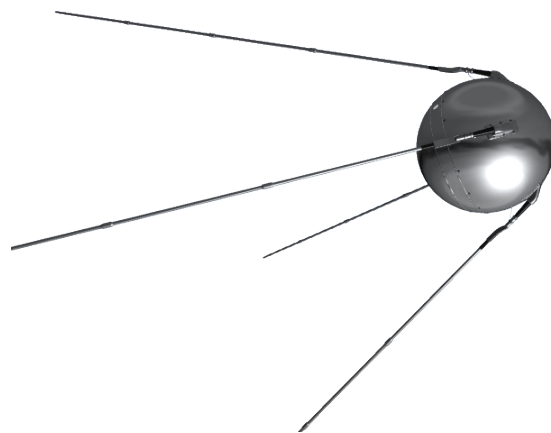
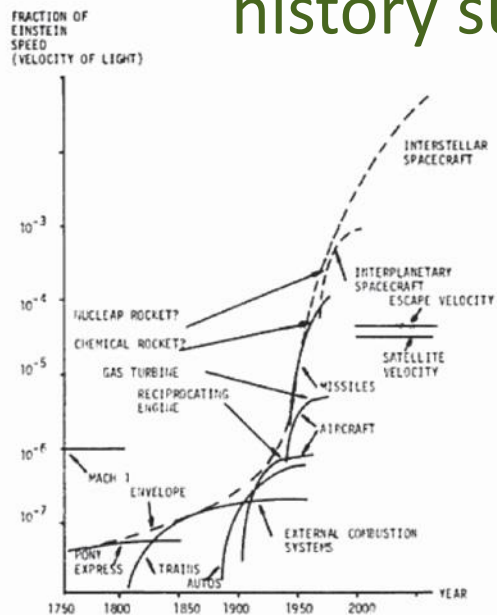
**Seven reasons to choose
a Dreamliner for your
next flight**

● **USA TODAY**

**It's just a very pretty plane.
The 787 is just a gorgeous craft
with its sweptback wings and
sleek lines. The forthcoming
787-10 promises to look even
more svelte.**



Although volumes are small today, history suggests technology can scale up



Orbiting the Earth
Projection: 1957
✓ 1957



Traveling to the moon
Projection: 1970
✗ 1969

Source: Kevin Kelly, *Was Moore's Law Inevitable?*



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THANK YOU