Aviation and Environment

Michael Lakeman, Environmental Strategy
Boeing Commercial Airplanes

November, 2016

Then and now…
Cleaner and quieter with each new model

707

787

Aviation's Impact: Economy & Environment Today

3.4%

of global economy is supported by aviation

21st

if aviation were a country, it would rank 21st in size by GDP

5.4%

average yearly growth of passenger air traffic since 1990

2%

of global CO_2 emissions attributable to aviation

8th

If aviation were a country, it would rank 8th in the world for its carbon emissions

1.6%

average yearly growth of aviation CO_2 emissions since 1990

Source: Air Transport Action Group Benefits Beyond Borders, Boeing CMO

Industry leaders have committed to action

CO2 Emission Reduction Goals

2010
1.5% per year fuel efficiency

↓

Working towards carbon-neutral growth

2020
Carbon-neutral growth

↓

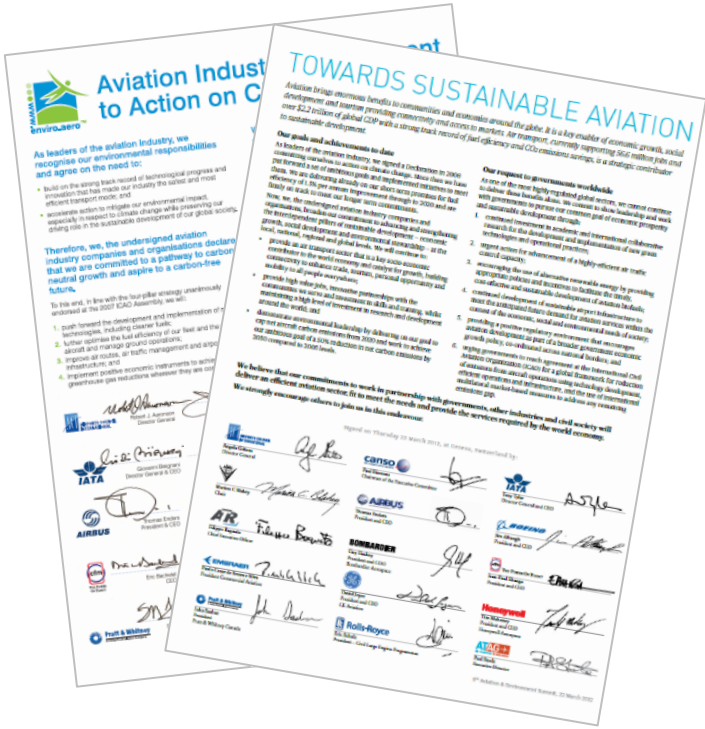
Implementation of global sector approach

2050
-50% CO_2

↓

Half the net aviation CO_2 of 2005

Industry Leader Commitments



Carbon emissions policies in 2016: Three new major agreements

- **United Nations Climate Agreement:** global deal in Paris Dec. 2015, ratified Oct. 2016 - impacts countries at national level

- **ICAO Airplane CO2 emissions standard:** agreed at ICAO Feb. 2016 - impacts OEMs

- **ICAO Carbon Offseting Scheme:** adopted by ICAO Oct. 2016 agreement - impacts airlines

ICAO Carbon Offsetting Scheme Moving Forward for Implementation

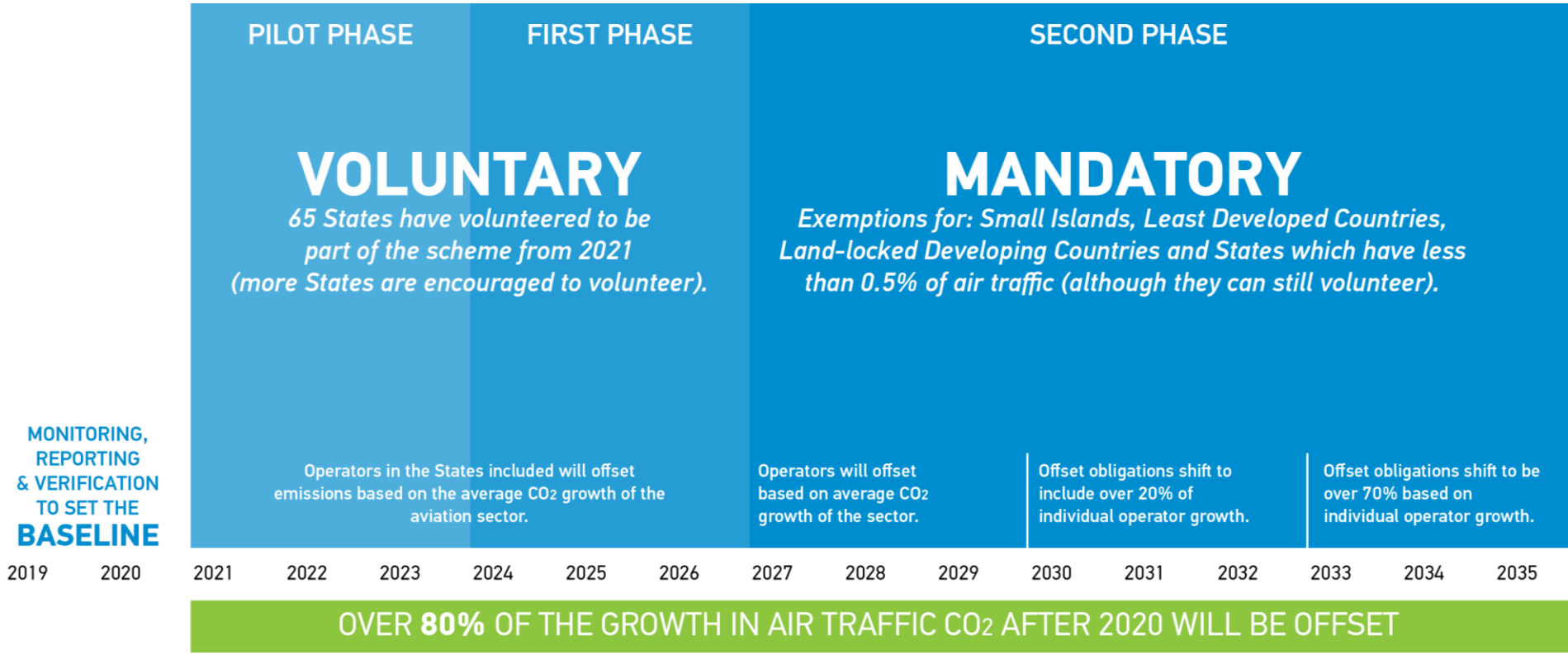
- What: Carbon offset program for international commercial flights, covers CO2 emissions
- Framework: Aligned to carbon neutral growth, route-based, strong environmental criteria
- Timeframe: 2020's in phased implementation

Infographic from EU Mobility & Transport

66 participating states from start
80+% of CO2 emissions growth

CORSIA
CARBON OFFSETTING AND REDUCTION SCHEME FOR INTERNATIONAL AVIATION

CORSIA Deployment Timeline



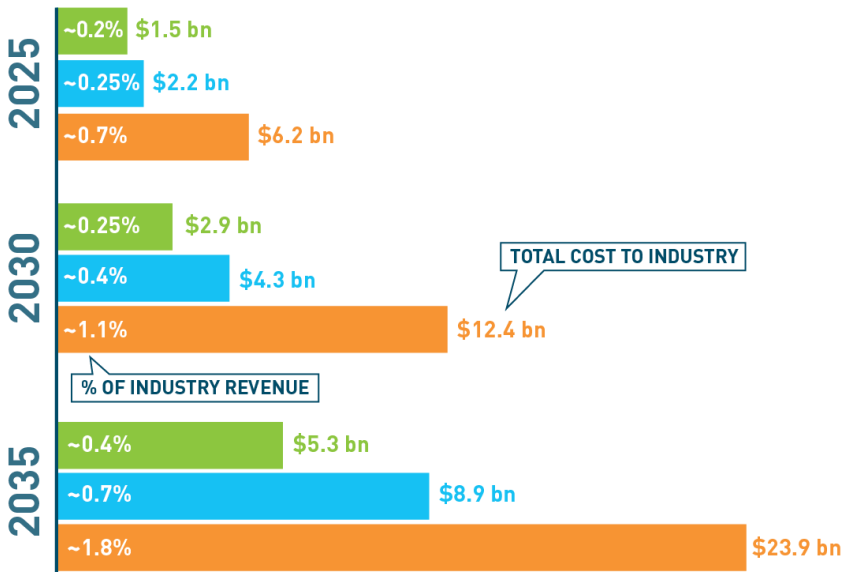
How much will the CORSIA cost?

CORSIA
CARBON OFFSETTING AND REDUCTION SCHEME FOR INTERNATIONAL AVIATION

HOW MUCH WILL CORSIA COST PER FLIGHT?

Sample flights (2030, operator growing at average industry growth rate)	Offsets *Low estimate*	Offsets *High estimate*	Fuel *Cost, summer 2016 price*	Fuel **fluctuation** *(Cost of $10/barrel increase)*
Casablanca → Madrid *737-800*	$51	$131	$1,656	$278
Frankfurt → Addis Ababa *787-800*	$578	$1,497	$18,920	$3,172
Mexico → Buenos Aires *A350-900*	$910	$2,357	$29,799	$4,996
Dubai → Sydney *A380*	$2,542	$6,585	$83,248	$13,957

ICAO projections of the cost of the global offsetting scheme to industry and percentage of industry revenues



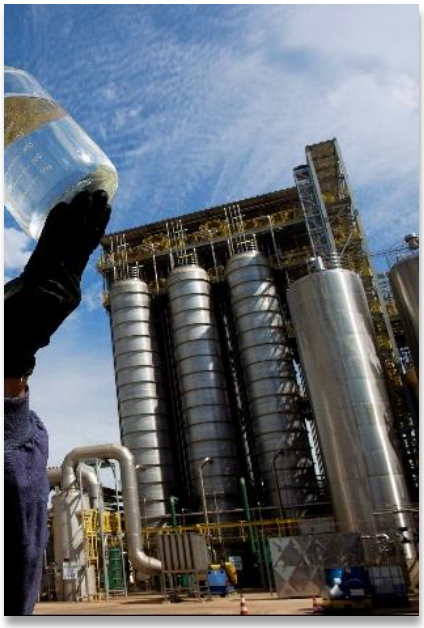
3% to 8%
of Fuel Cost per Flight

0.2% to 1.8%
of Industry Revenue

Aviation Needs “Drop-In” Biofuel

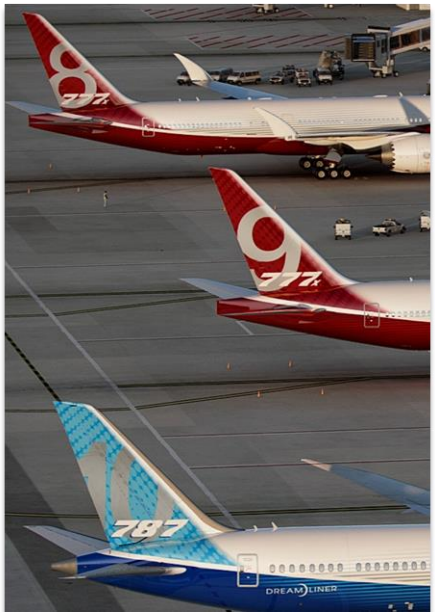
Meets strict sustainability criteria, reduces lifecycle CO_2 by 50 – 80%

New ways to make the same fuel



Blend directly with conventional jet fuel

Meets or exceeds performance of petroleum

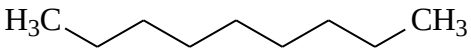


No change to airplanes, engines or fueling infrastructure

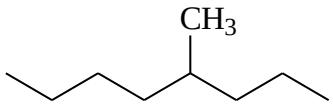
Typical jet fuel chemistry

Paraffins (75-95%)

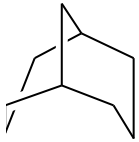
Ideal Carbon Length C8-C16



Normal Paraffins

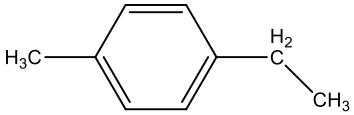


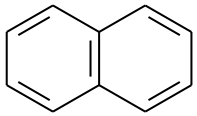
Iso-paraffins



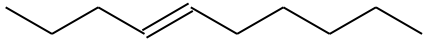
Cyclic Paraffins

Aromatics (<25%)

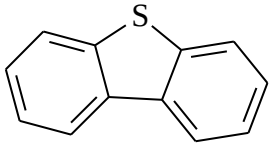


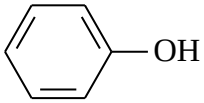


Olefins (<5%)



Sulfur, Nitrogen, Oxygen Containing Compounds





Acids, phenols, etc

Aviation biofuel state of play

Technically viable

ASTM and Def Stan approved

High quality standard, drop-in fuels

Four pathways approved since 2011

In demand

Airlines support - 2,500+ commercial flights

Airports support

Continued military interest

Sufficient supply

Limited but growing refinery capacity

Shrinking premium for approved fuels

Level playing field with ground transport needed

First Commercial Aviation Biofuel Refinery AltAir Fuels in Paramount, CA

- First dedicated US production facility for HEFA-SPK and Green Diesel fuels with ongoing production
- Repurposing of mothballed refinery
- Waste FOG feedstocks

- 40MGY nameplate capacity in “Phase 1”
- HEFA blends being delivered to LAX
- Military diesel (F76) being delivered to Navy under DLA FY’16 contract
- Ownership evaluating 5-7X expansion in next 2-3 years

Offtake agreements
Beyond demonstration

neat quantities

AltAir Fuels	+ UNITED	=	5 M gpy from 2016
	+ World Fuel Services, Gulfstream	=	3 yr agreement 30/70 blend
	+ Sky NRG, KLM	=	3 yr agreement Enabling LAX flts
Fulcrum Bioenergy	+ Cathay Pacific	=	375M usg
	+ UNITED	=	90-180 M gpy Over 10 yrs
Red Rock Biofuels	+ Southwest	=	3 M gpy
	+ FedEx	=	3 M gpy

Offtake agreements

Beyond demonstration

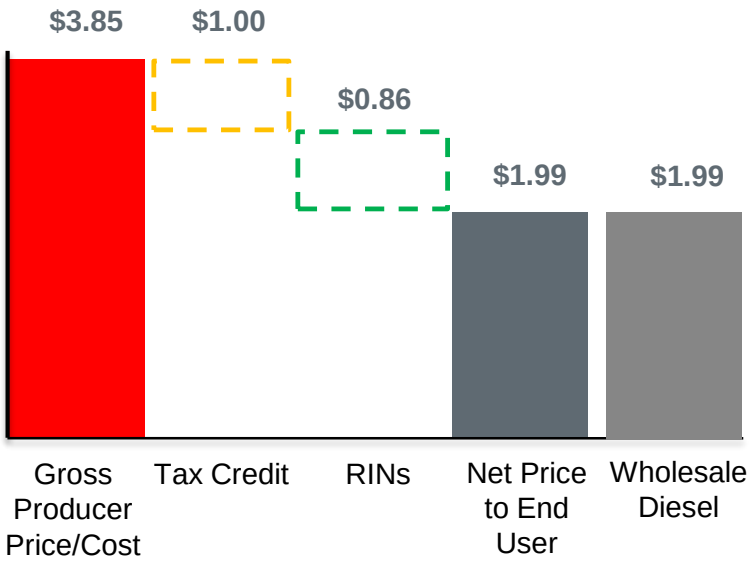
neat quantities

TOTAL | AMYRIS	+	CATHAY PACIFIC	=	Delivery flts 10% blend
HAWAI'I BioEnergy	+	Alaska Airlines	=	Supply from 2018
SG Preston	+	jetBlue	=	10M gpy, 10 yrs
gevo	+	Lufthansa	=	Up to 40M gal Over 5 yrs (MOU)
NESTE	+	SkyNRG NORDIC, OSLO AIRPORT, Lufthansa Group, KLM, SAS	=	(Bioport on demand)
~~SOLENA GROUP~~	+	BRITISH AIRWAYS	=	180M usg over 11 years

Green Diesel is Game Changer for Aviation Biofuel

2015 Green Diesel & Diesel Cost

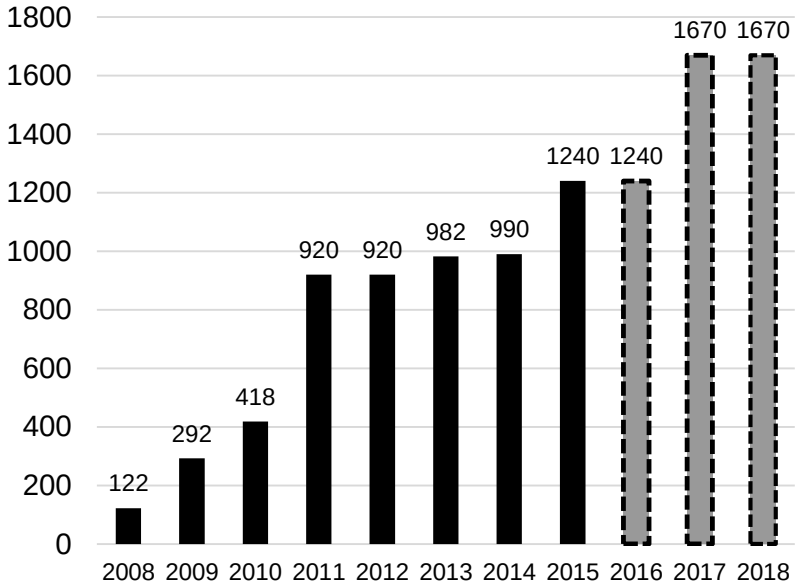
Net of incentives, green diesel is at parity with fossil (USD $ / gallon)



Source: EIA Gulf Coast Diesel and Jet Spot prices, BNEF RINs data, conversations with producers

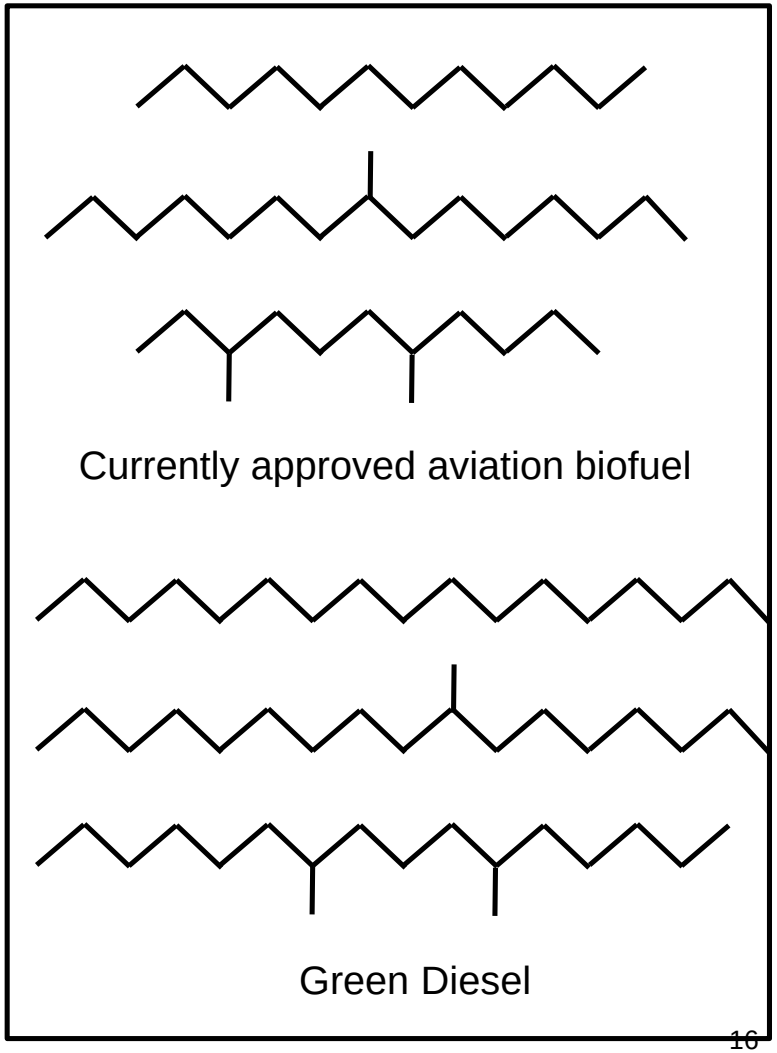
Production Volumes Large and Growing

Annual Global Production Capacity (Millions of gallons)

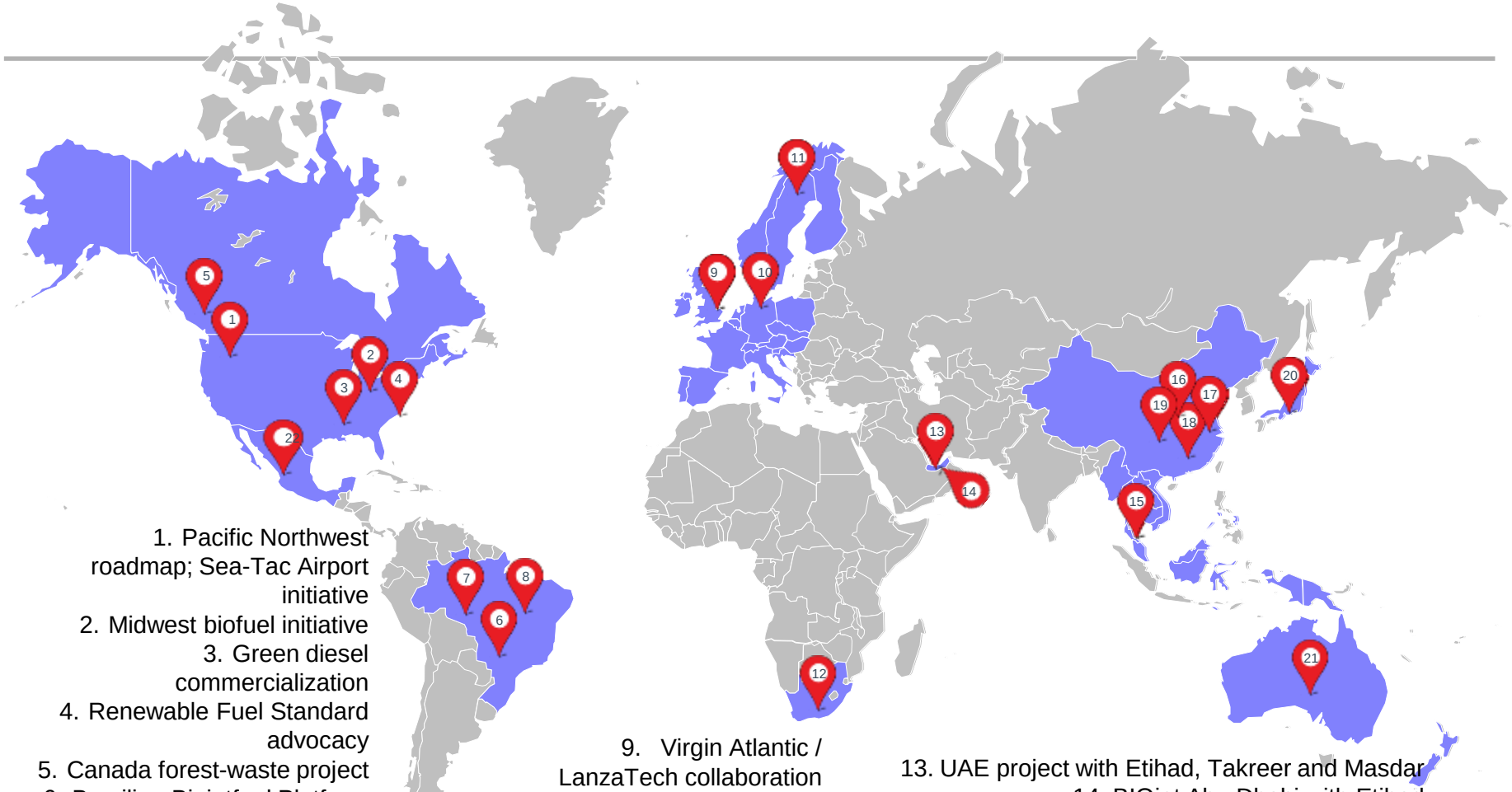


HEFA jet fuel and Green Diesel produced from same process

- Diesel fuel produced from oils & fats via hydroprocessing – same process as HEFA
- Contains no petroleum products
- Produced globally at scale
- Represents a 60 – 80 percent emissions savings over traditional petroleum diesel



Boeing Global Biofuel Engagements



1. Pacific Northwest roadmap; Sea-Tac Airport initiative
2. Midwest biofuel initiative
3. Green diesel commercialization
4. Renewable Fuel Standard advocacy
5. Canada forest-waste project
6. Brazilian Biojetfuel Platform
7. Joint research with Embraer
8. GOL biofuel flights
9. Virgin Atlantic / LanzaTech collaboration
10. AIREG Membership
11. Nordic Initiative for Sustainable Aviation
12. South African Airways national roadmap
13. UAE project with Etihad, Takreer and Masdar
14. BIOjet Abu Dhabi with Etihad
15. Southeast Asia smallhold farm initiative
16. Biofuel R&D in China
17. “Gutter oil” facility with COMAC
18. Hainan Airlines commercial flight
19. Agricultural waste project in China
20. Japan biofuel roadmap
21. Australia biofuel roadmap
22. Mexico biofuel center of excellence

Things to remember

Aviation is a vital part modern life - but is under growing social and political pressure to reduce its environmental footprint

Our industry has developed a comprehensive environmental strategy and set aggressive, credible emissions reduction targets

Boeing is a committed industry leader to the goal of increasing the environmental performance of commercial aviation