

# Aviation's Market Pull for SAF (Sustainable Aviation Fuel)

**Steve Csonka**  
Executive Director, CAAFI



**First flight from continuous commercial production of SAF  
UAL 0708, 10 March 2016, LAX-SFO**

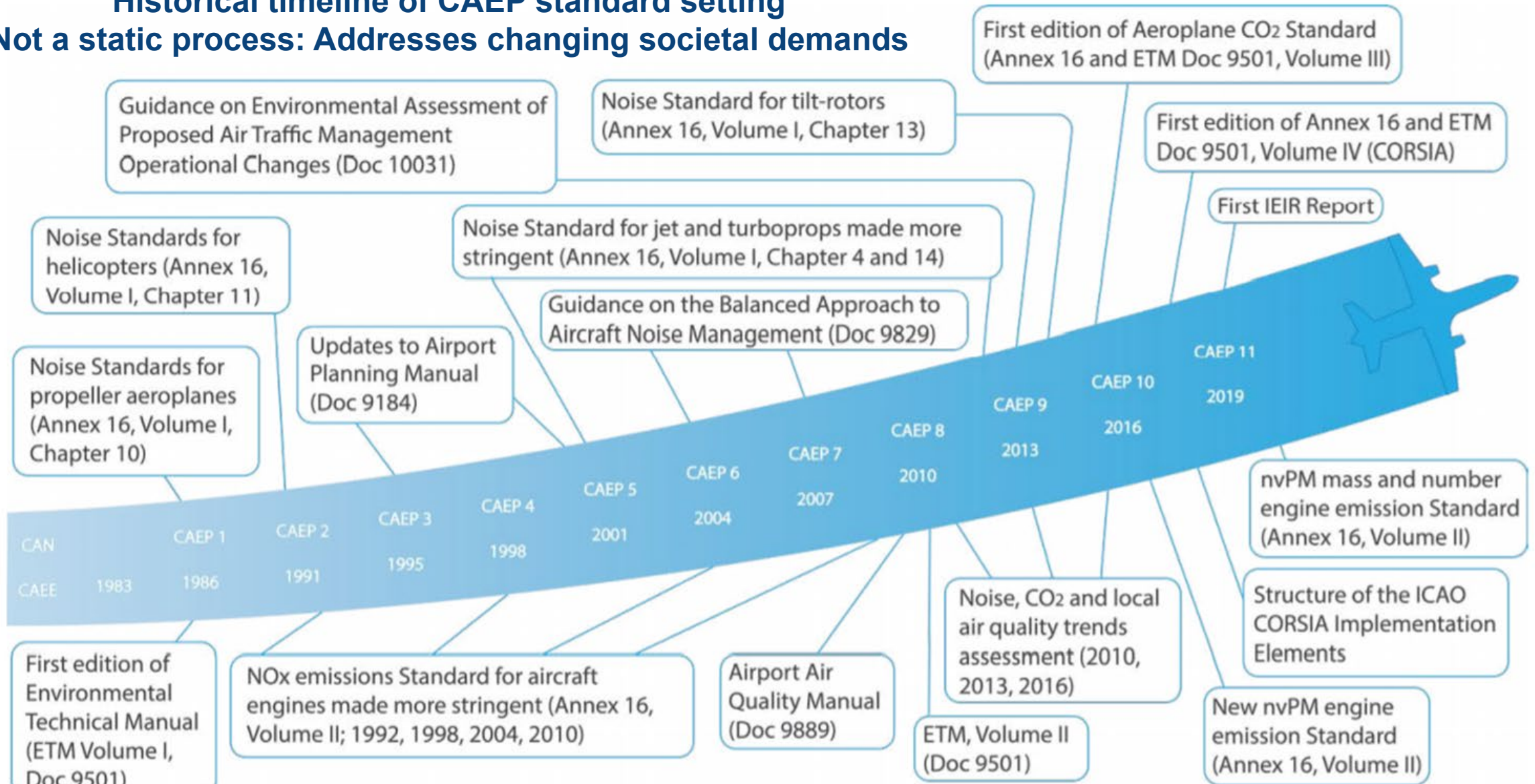
**Fuel from World Energy - Paramount (HEFA-SPK 30/70 Blend).**

**Only U.S. facility offering continuous production of SAF at present.  
Other batch production & tolling occurring due to extreme customer interest.**

# Aviation takes its environmental responsibility seriously

## Historical timeline of CAEP standard setting

Not a static process: Addresses changing societal demands



Source: ICAO

# Aviation takes its environmental responsibility seriously ... on GHGs too



Industry commitments in 2009, 2012, 2015, 2019

The business aviation community has long been committed to reducing the environmental impact of its products and operations. Indeed, we have improved the fuel efficiency of our products 40% over the past 40 years.

Our manufacturers and operators continually seek new ways of increasing an airplane's performance and range while reducing fuel consumption. Nonetheless, our community recognizes that we must do our part to reduce aviation emissions further even as we grow to meet rising demand for transportation.

PETER J. BUNICE  
PRESIDENT AND CEO  
GENERAL AVIATION  
MANUFACTURERS ASSOCIATION

DONALD SPERSTON  
DIRECTOR GENERAL  
INTERNATIONAL BUSINESS  
AVIATION COUNCIL

The General Aviation Manufacturers Association (GAMA) and the International Business Aviation Council (IBAC), on behalf of the manufacturers and operators of business aviation worldwide, have therefore developed an aggressive strategy for CO<sub>2</sub> emissions reductions to 2050. We also join with the commercial aviation sector in endorsing the International Civil Aviation Organization's (ICAO) proposal for a global sectoral approach for aviation emissions in a post-Kyoto Agreement on climate change.

Our commitments parallel those made by the commercial aviation sector and depend equally on efficiency improvements that are projected from infrastructure modernization, operations and alternative fuels. Our community pledges an average of 2% improvement in fuel efficiency per year from now until 2020 on a fleet-wide basis. We acknowledge the need for appropriately structured market-based measures, so long as any revenues collected should help business aviation achieve carbon neutral growth by 2020 and an absolute reduction of 50% of CO<sub>2</sub> emissions by 2050 relative to 2005.

Business aviation is a vital tool for businesses and economic development and is an integral part of the international transportation system. It facilitates commerce and investment, connects people and communities around the globe, helps relieve famine, and delivers vital relief to those in need or afflicted by natural or man-made disasters. Business aviation also represents a dynamic and critical engine for economic growth that brings jobs and prosperity to millions of people worldwide.

While business aviation manufacturers and operators are engaged in a sustained effort to meet these targets, a strong partnership between industry and government is also absolutely necessary to achieve these goals. We can only meet these targets if all stakeholders work together on comprehensive, ambitious and fair worldwide action to mitigate emissions.

In this document, we describe our strategy and ambitious goals to meet this critical global challenge of emissions reduction while continuing to deliver vital economic, business and social benefits.

## Aviation Industry Commitment to Action on Climate Change

As leaders of the aviation industry, we recognise our environmental responsibilities and agree on the need to:

- build on the strong track record of technological progress and innovation that has made our industry the safest and most efficient transport mode; and
- accelerate action to mitigate our environmental impact, especially in respect to climate change while preserving our driving role in the sustainable development of our global society.

Therefore, we, the undersigned aviation industry companies and organisations declare neutral growth and aspire to a carbon-free future.

To this end, in line with the four-pillar strategy unanimously endorsed at the 2007 ICAO Assembly, we will:

1. push forward the development and implementation of new technologies, including cleaner fuels;
2. further optimise the fuel efficiency of our fleet and the way we fly;
3. improve air routes, air traffic management and airport infrastructures; and
4. implement positive economic instruments to achieve greenhouse gas reductions wherever they are cost-effective.

We urge all governments to participate in these efforts by:

1. supporting and co-financing appropriate research and development in the pursuit of greener technological breakthroughs;
2. taking urgent measures to improve airspace design including civil-military allocation, air traffic management infrastructure and procedures for approving needed airport development; and
3. developing and implementing a global, equitable and stable emissions management framework for aviation through ICAO, in line with the United Nations roadmap agreed in Bali in December 2007.

Our efforts and commitment to work in partnership with governments, other industries and representatives of civil society will provide meaningful benefits on tackling climate change and other environmental challenges.

We strongly encourage others to join us in this endeavour.

Signatories include: IATA, Airbus, Boeing, Embraer, Pratt & Whitney, Rolls-Royce, GE Aviation, etc.

# Becoming the first industrial sector to commit to an agreed carbon reduction approach

# Aviation Industry Commitment to Climate Change Action: 3 Goal Approach

## GOAL 1

PRE-2020 AMBITION

1.5% ANNUAL  
AVERAGE FUEL  
EFFICIENCY  
IMPROVEMENT  
FROM 2009 TO  
2020.

T O I

## GOAL 2

IN LINE WITH THE NEXT  
UNFCCC COMMITMENT PERIOD

STABILISE NET  
AVIATION CO<sub>2</sub>  
EMISSIONS AT  
2020 LEVELS  
WITH CARBON-  
NEUTRAL  
GROWTH.

T O I + M

## GOAL 3

ON THE 2°C PATHWAY

REDUCE  
AVIATION'S NET  
CO<sub>2</sub> EMISSIONS  
TO 50% OF WHAT  
THEY WERE IN  
2005, BY 2050.

T O I

### Four Pillar Commitment:

#### Technology

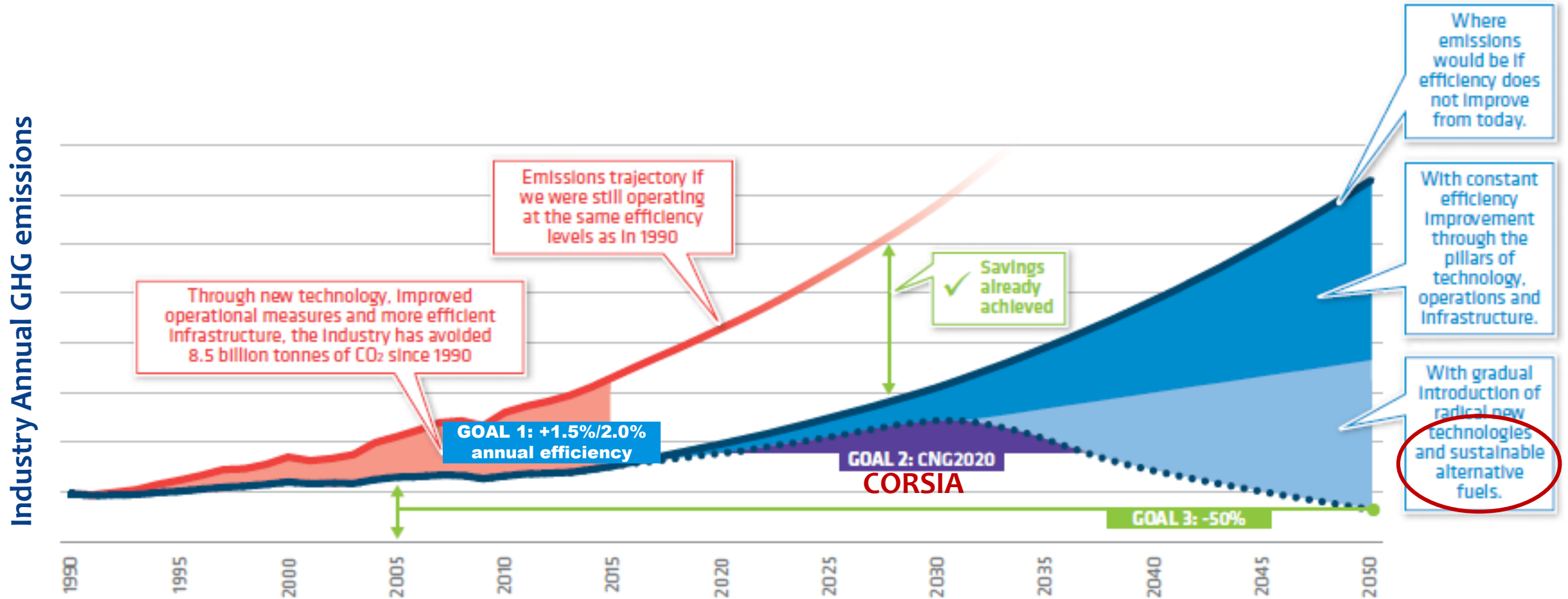
Includes the  
development and  
commercialization of  
Sustainable Aviation  
Fuels (SAF)

#### Operations

#### Infrastructure

#### Market-Based Measures

# SAF a key component of the Technology Pillar; enabler for GHG containment strategy



30 September 2020

Courtesy of ATAG: [www.atag.org/our-publications/latest-publications.html](http://www.atag.org/our-publications/latest-publications.html)  
 Beginner's Guide to Sustainable Aviation Fuel  
 Business Aviation made similar commitments

COMMERCIAL AVIATION  
 ALTERNATIVE FUELS INITIATIVE

# SAF (Sustainable Aviation Fuel)

a.k.a. aviation biofuel, biojet, alternative aviation fuel

**Aviation Fuel:** Maintains the certification basis of today's aircraft and jet (gas turbine) engines by delivering the properties of ASTM D1655 – Aviation Turbine Fuel – enables drop-in approach – no changes to infrastructure or equipment, obviating incremental billions of dollars of investment

**Sustainable:** Doing so while taking Social, Economic, and Environmental progress into account, especially addressing GHG reduction

**How:** Creating synthetic jet fuel with biochemical and thermochemical processes by starting with a different set of carbon molecules than petroleum ... a synthetic comprised of molecules essentially identical to petroleum-based jet (in whole or in part)

# SAF progress - Technical

- \* **SAF are becoming increasingly technically viable**
  - \* **Aviation now knows we can utilize numerous production pathways**  
(7 approved, 6 in-process, >15 in pipeline)
  - \* **Enabling use of all major sustainable feedstocks**  
(lipids, sugars, lignocellulose, hydrogen & carbon sources, circular-economy byproduct streams)
  - \* **Utilizing thermo-chemical and bio-chemical conversion processes to produce pure hydrocarbons, followed by standard refinery processes**
  - \* **Following blending with petro-jet, SAF is drop-in, indistinguishable from petro-jet**
  - \* **Some future pathways expected to produce SAF blending components that will need less, or zero, blending**
  - \* **Expanding exploration of renewable crude co-processing with refineries**
  - \* **Continuing streamlining of qualification – time, \$, methods**

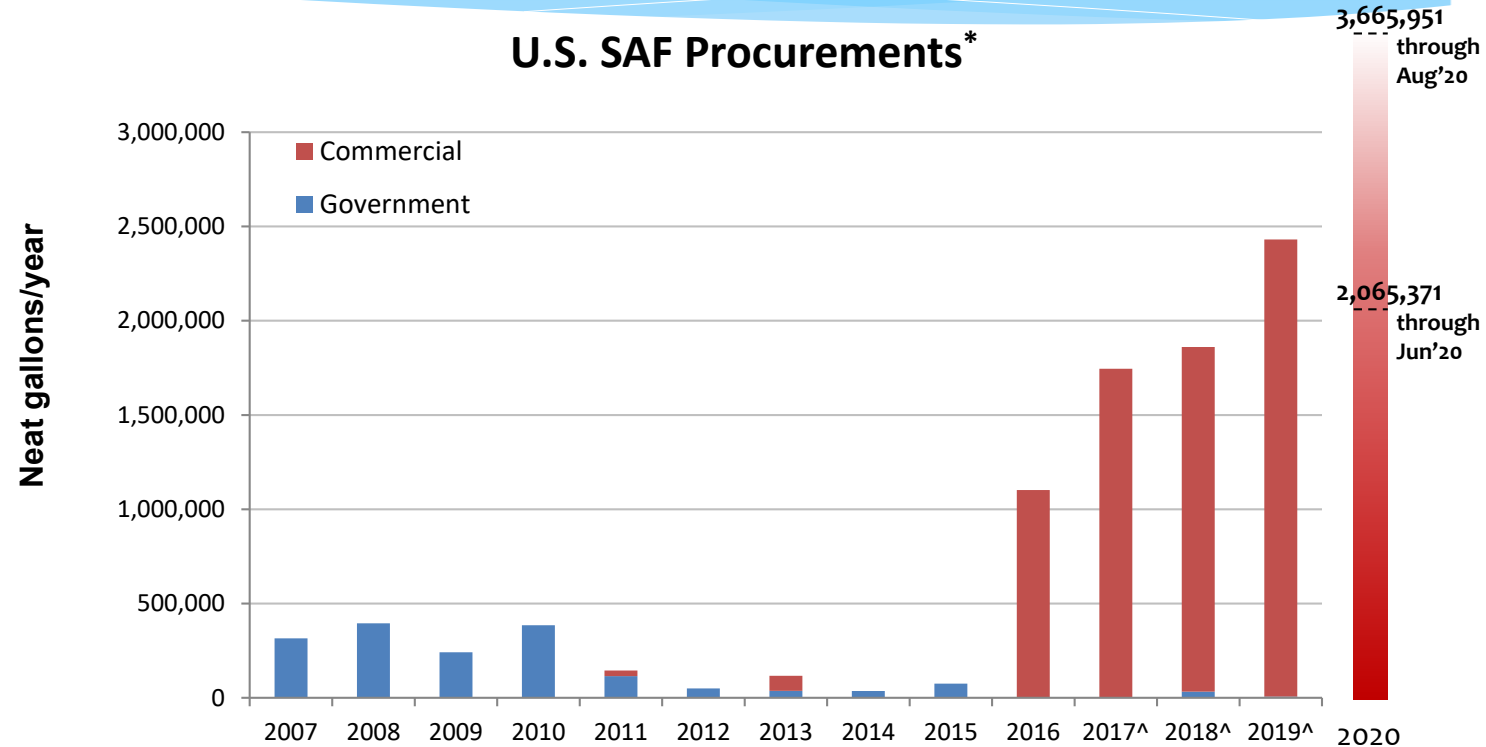
# Where we stand on U.S. SAF consumption

## Initiation under way, still early

- \* Four years of sustained commercial use
- \* Commercial & General Aviation engaged
- \* Two facilities in operation
- \* Two facilities under construction, others in development
- \* Cost delta still a challenge, with policies favoring renewable diesel
- \* In spite of that ... we still have \$6.5 B in airline offtake commitments for >350M gpy ... with more in development

30 September 2020

### U.S. SAF Procurements\*



Credit: FAA

\*Reflects voluntarily reported data on use by U.S. airlines, U.S. government, manufacturers, other fuel users, and foreign carriers uplifting at U.S. airports.

^2017-2019 calculation includes reported EPA RFS2 RINs for jet fuel.





# Worldwide SAF production capacity forecast

## Announced intentions\*

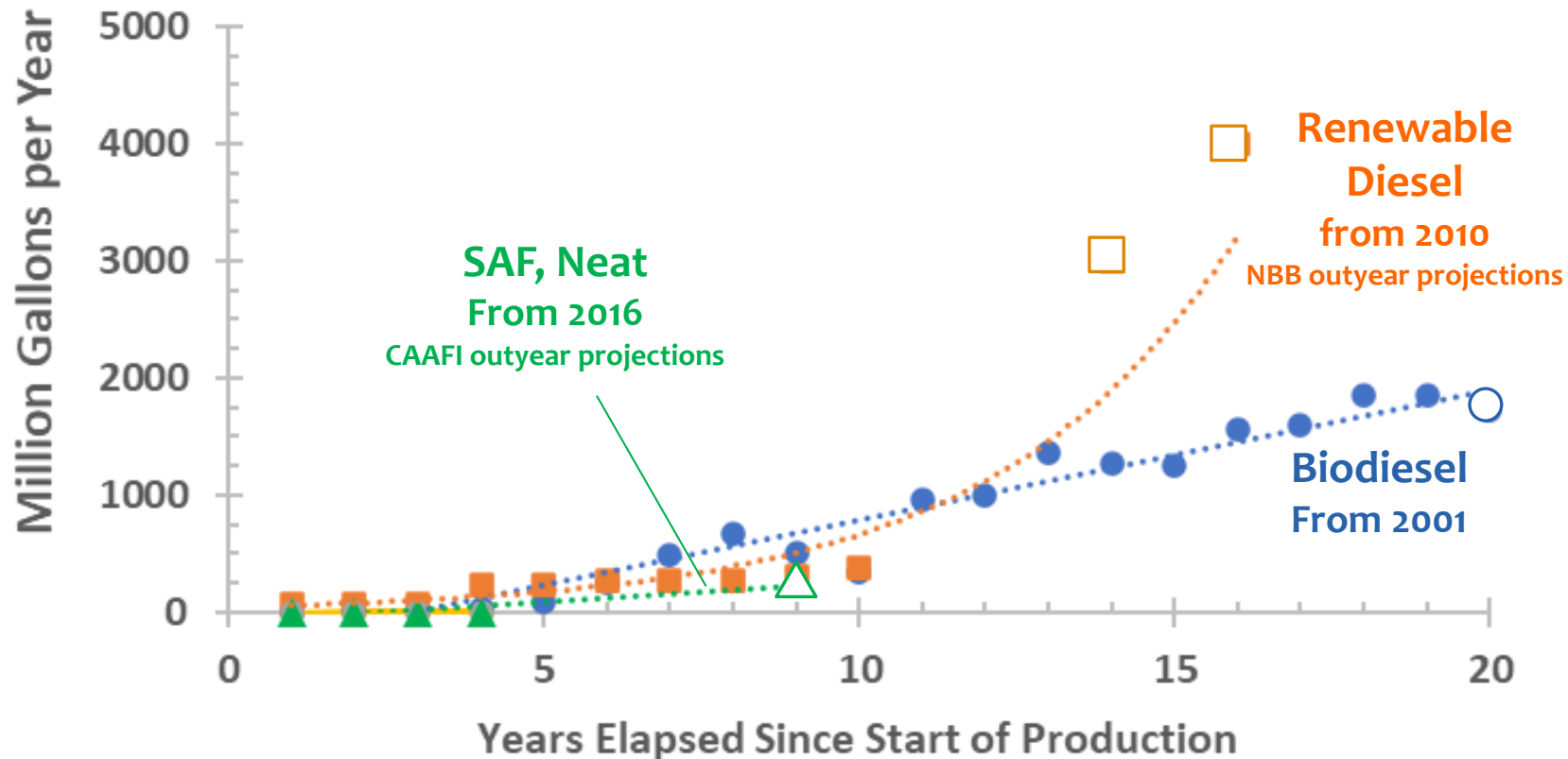
Year-end Production Levels (M gpy)

Year	2020	2021	2022	2023	2024	2025
World Energy	Paramount 25					
Neste	Porvoo 34		Singapore & Rotterdam 480	Luverne 10		
Gevo	Silsbee Demo quant's					
Total	La Mede ?					
Fulcrum Bioenergy		#1, Sierra 7				
SkyNRG			Delfzijl 33			
Go Sunshine				New Orleans 29		
Phillips 66					Rodeo 290?	
Red Rock Biofuels		Lakeview 6				
LanzaJet			Freedom Pines 10			
Fulcrum Bioenergy				#2, Gary, IN 21		
Preem					Gothenburg ~70	
World Energy			Paramount 150			
ReadiFuels				2 locations 24		
Velocys						Altalto Immingham, UK 16
LanzaJet					3 International locations 90	
Production Levels	~59+M	~72+M	~746+M	~830+M	~990 – 1336 M	1 B +

\* Not comprehensive; CAAFI estimates (based on technology used & public reports) where production slates are not specified

# Industry focus on enabling SAF affordability

## US Biofuel Production Trends



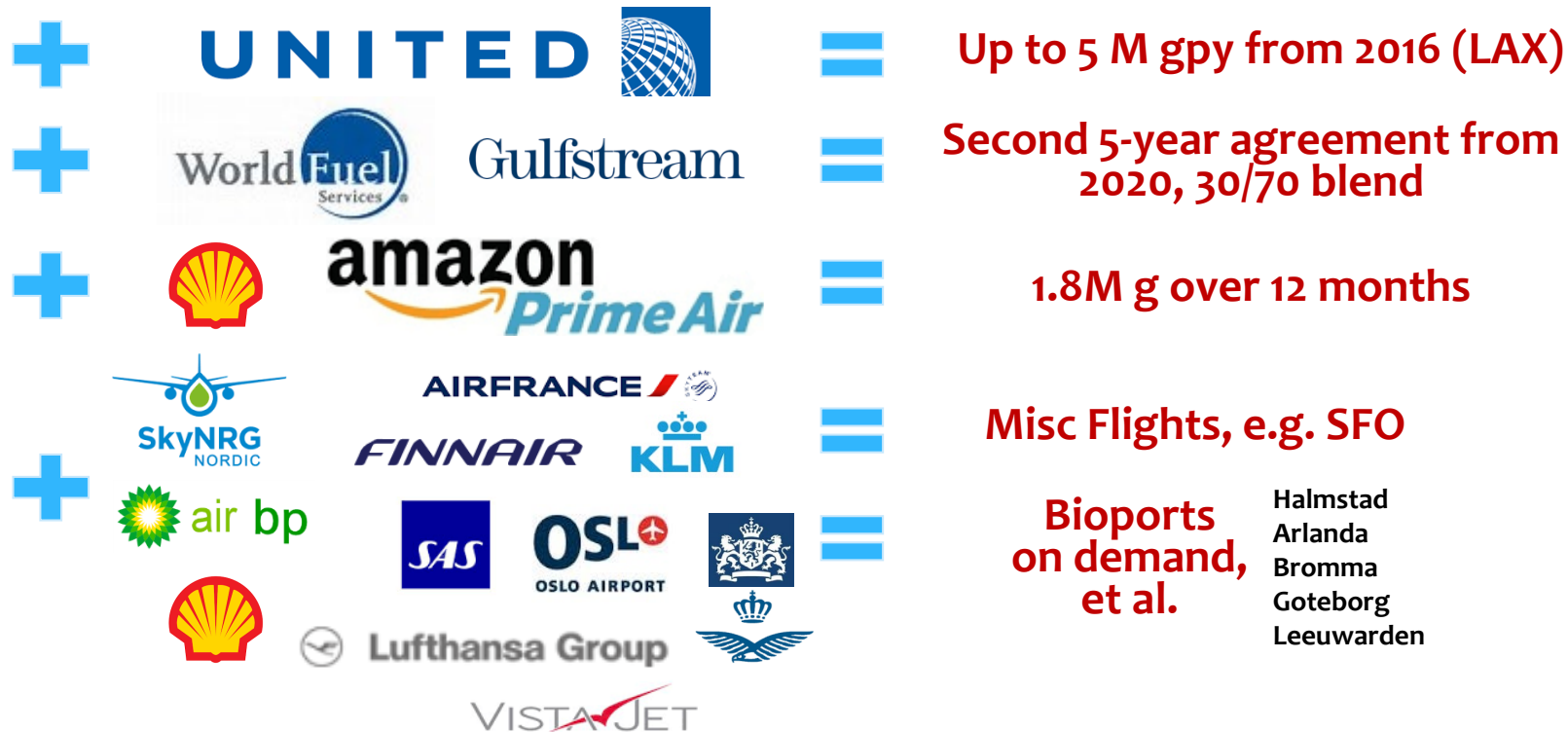
- \* We know what impact policy had on the ramp-up of ethanol and bio-diesel / renewable diesel – it can be replicated for SAF

# SAF offtake agreements

Beyond numerous demonstration programs



- Initial 40M gpy nameplate facility  
With 25M gpy SAF capacity



\* 24Oct'18: Moving forward with \$350M Paramount expansion to enable 306M gpy total capacity & jet capacity of 150M gpy; Fuel production expected by YE'22

# SAF offtake agreements – pg 2

Beyond numerous demonstration programs

**NESTE**

Porvoo\*

- Initial 34M gpy capacity



**SAS AIRBUS**



ZÜRICH AIRPORT

**FINNAIR**



*Alaska*



American Airlines



**NETJETS®**



neat quantities not announced

Porvoo SAF Q4'18 restart supplied to:

Swedish Airports - SAS;

Mobile, Hamburg – Airbus;

Frankfort – Lufthansa;

Amsterdam – KLM;

Zurich – WEF;

Helsinki – Finnair;

Stockholm – Emirates, Swedavia;

SFO - American, Alaska, and JetBlue

SFO, London – Signature FBO

\* Moving forward with significant expansion at Singapore and feasibility study at Rotterdam to enable ~480M gpy by 2023

# SAF offtake agreements – pg 3

## Beyond numerous demonstration programs



\* 3-4 facilities, utilizing ethanol conversion bolt-on approach



neat quantities

Up to 1M gpy, 5 yrs+ / France & EU supply;

Various Business Aviation airports FBOs

10M gpy, from 2022/2023 term/blend unspecified

Unspecified SAF distribution rights

# SAF offtake agreements – pg 4

## Beyond numerous demonstration programs



#1 Sierra \*

\* Initial 11M gpy nameplate facility, remainder at 2-3X in size



Marubeni



neat quantities

37.5M gpy

90-180 M gpy

50 M gpy

Project  
Development,  
License, and Offtake

10 yr  
agreements

\* Per statements made at ABLC 2020

#2 Gary, IN @ 3x capacity

Then replication in Houston, UK, WA state, CA state, Australia

Additional sites aligned with investor airlines' US focal cities previously discussed

# SAF offtake agreements – pg 5

Beyond numerous demonstration programs

 RED ROCK BIOFUELS	+	 Southwest	=	neat quantities
	+	 FedEx	=	3 M gpy each, 7 yrs (Bay Area, CA)
 SG Preston	+	 jetBlue	=	10M gpy, 10 yrs (JFK)
	+	 QANTAS	=	4M gpy, 10 yrs (LAX)
 SkyNRG NORDIC	+	 KLM	=	24M gpy, 10 yrs
	+		=	SAF Supply collaboration
 LanzaTech * capturing carbon fueling growth	+	 ANA	=	Freedom Pines, supply from 2022, 10M gpy nameplate
	+	 SUNCOR	=	
	+	 MITSUI & CO.	=	
 LANZAJET	+	 virgin atlantic	=	UK DfT F4C Funding: ATJ Development

\* 100M gpy by 2024 from 4 facilities

# SAF offtake agreements – pg 6

## Beyond numerous demonstration programs

neat quantities



Gothenburg Refinery



*SAS*



Long-term supply negotiation (from 2023).  
Fueling all domestic flights by 2030.



Detail tbd; Montreal East pilot facility approaching completion



# Other recent announcements

Multiple Producers, TBA +   = Full production slate offtakes **effort**

Multiple Producers, TBA +        = New aircraft deliveries from Airbus, Boeing, ...

Multiple Producers & Suppliers + Airports and Airline Tenants   = Exploration of greater ambition

 +  = Grays Harbor, WA feasibility study, and offtake agreement, tbd

# Other recent announcements

effort



MSW-based  
FT-SPK evaluations



In negotiation



BTL #1, Natchez, MS  
1,400 bpd



Carinata supply  
development

PROMETHEUS



To support flight test



MOU to explore production,  
support flight test, and  
enable 100% SAF flights

# Airline commitments of greater ambition



NZC'50

Obtain 30% of jet fuel from alternative sources by 2030; 06Nov'17

First U.S. Airline to Pledge to Reduce Own Emissions by 50% (vs. 2005) by 2050; 13Sep'18. \$40M SAF Investment Fund; 27Oct'19

Commits to flying 100 M passengers on SAF by 2030; 23Sep'19

Horizon 2030: offset 100% of domestic CO<sub>2</sub> from 2020; reduce 2030's CO<sub>2</sub>/pax-km by 50% from 2005; R&D for French SAF industry; 01Oct'19

Net-zero carbon by 2050, offsetting all domestic emissions by 2020; 10Oct'19

Net-zero carbon by 2050, CNG from 2020 on all emissions, \$33M investment in SAF by 2030, matching of customer offsets; 25Nov'19

Reduce its net emissions by 50% from 2019 by the end of 2025, and achieve carbon neutrality by 2045 at the latest; 09Mar'20

SAF corresponding to the total jet consumption used in all SAS domestic flights, by the year 2030; 14Nov'19

Net Zero by 2040, and 100% renewable operations by 2025

Improve carbon efficiency by 45% by 2030 (16-28% SAF usage, or up to 500M liters)

Multiple airlines now committing to net zero carbon by 2050 (NZC'50).  
Pressure to look at more progress by 2035.

# Commitments of Greater Ambition

## Airlines using passenger booking options to offset cost



Customer option to pay for incremental price of SAF of €29.50 on any flight



Customer option to pay for incremental price of SAF in 20-min blocks of flight time for €10 / block (up to 80% CO<sub>2</sub> reductions); fuel being allocated to future flights



**Lufthansa**



Compensaid – calculates specific cost of SAF for specific flights and enables customer to pay for incremental price  
On select flights, CHF80 to offset carbon, 5% of which goes to SAF via Compensaid



Customer option to pay for incremental price of SAF for 3 categories of flight: intra-Finland (€10), intra-EU (€20), International (€65); fuel being allocated to future flights

# Other commitments of greater ambition



Norway's government introduces 0.5 % blending mandate for advanced aviation biofuels from 2020; 04Oct'18



Netherlands committed to transition all military aircraft to 20/80 AJF blend by 2030 and 70% by 2050; 23Jan'19



France, in alignment with EU Green Deal goals, announces SAF targets: 2% of SAF from 2025, 5% in 2030 and 50% in 2050; 27Jan'20



DG Move have now put together a comprehensive "roadmap" as a potential way forward for an integrated approach for policy intending to foster SAF commercialization in the European Union - ReFuelEU



Sweden's government introduces GHG reduction mandate for jet fuel, from -0.8% in 2021 to -27% in 2030; Fossil free by 2045; 11Sep'20

# Paradigm changing announcements

Intent to help close price premiums



Resilient and Sustainable  
Aviation Fuel (RSAF) credit

Clean Skies for Tomorrow Program



**BOARD NOW**  
coalition for sustainable flying



Microsoft

AIRFRANCE KLM



Purchase of SAF for US-Netherlands flights  
(beyond offsetting employee travel)



Energy for Airlines

*SAF Now Consortium* launch, 15 Nov'19



# SAF progress – Significant commercial pull !

- \* First facilities on-line, producing SAF at various run-rates
- \* Commercial agreements being pursued, fostered by policy and other unique approaches
- \* Line of sight to first billion gallons, but reflecting only 1% of market need
- \* Making progress, but still significant challenges – only modest production: **focus on enabling commercial viability**
- \* Potential for acceleration a function of engagement, offtakes, first facilities' success replication, policy, ...
- \* ... and additional technologies that lower production cost, lower capital, enable byproduct revenue

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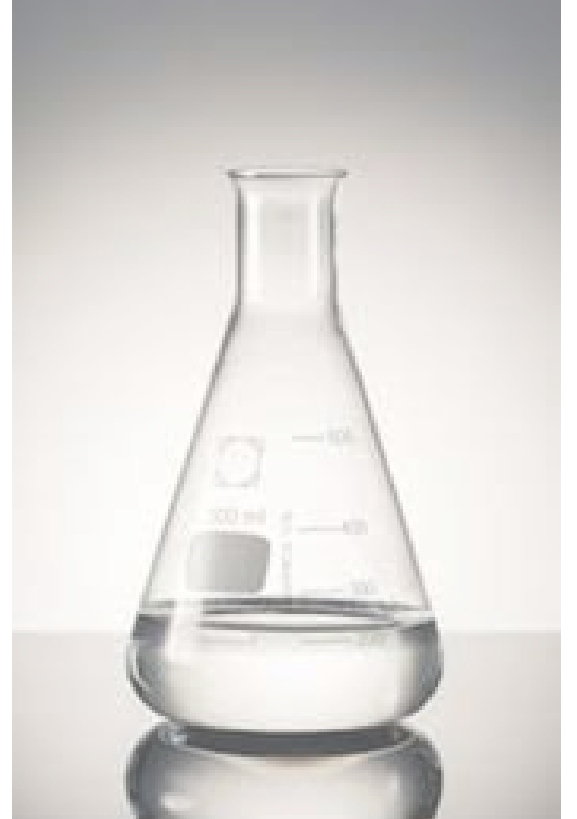
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# SAF: from a diverse set of world-wide feedstocks

## Wastes, residues, purpose grown, circular-economy byproducts

