

# Taking Flight: The Future of Sustainable Aviation Fuels



**Kristin Marshall**

Associate Research Director

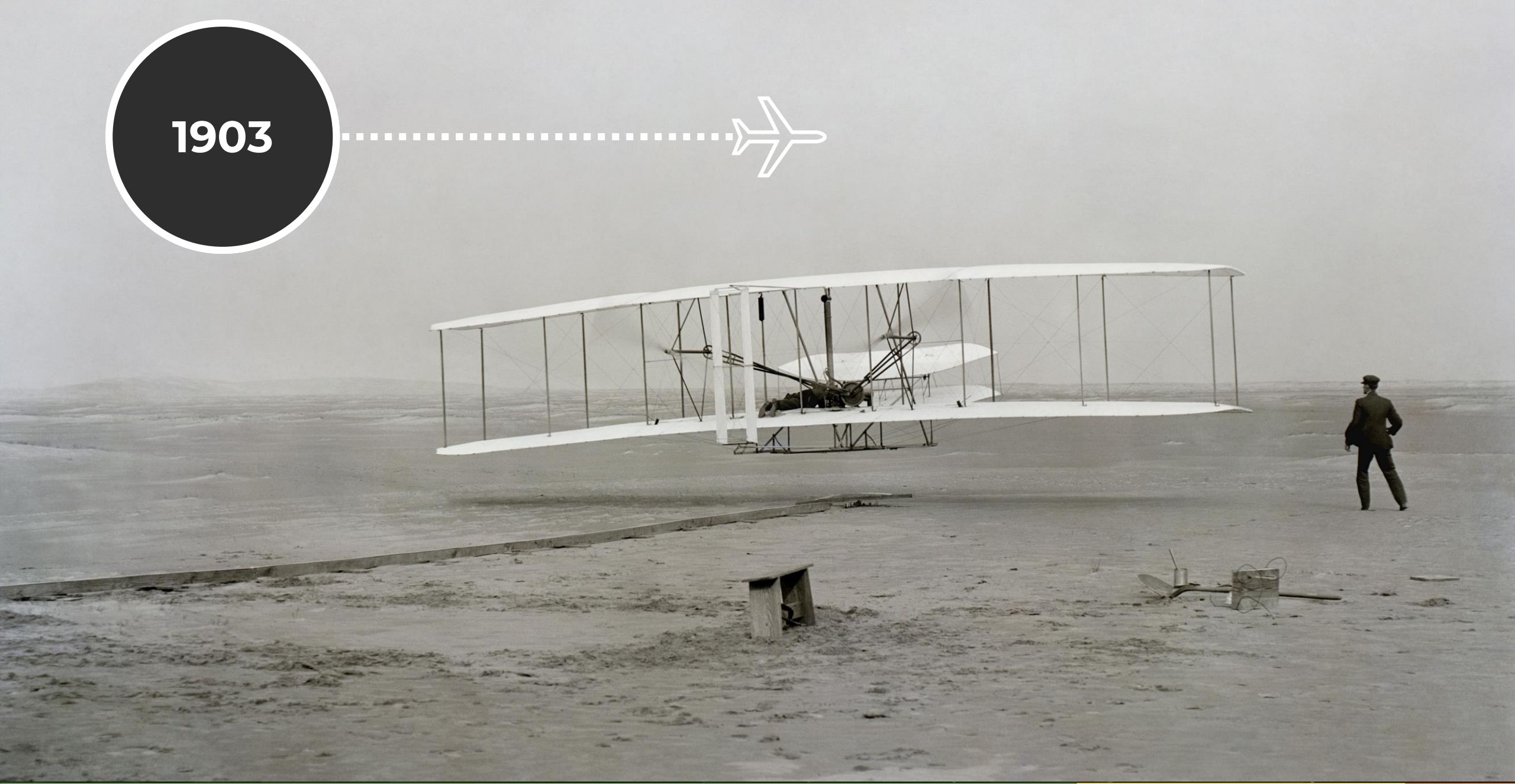


**Mukunda Kaushik**

Analyst



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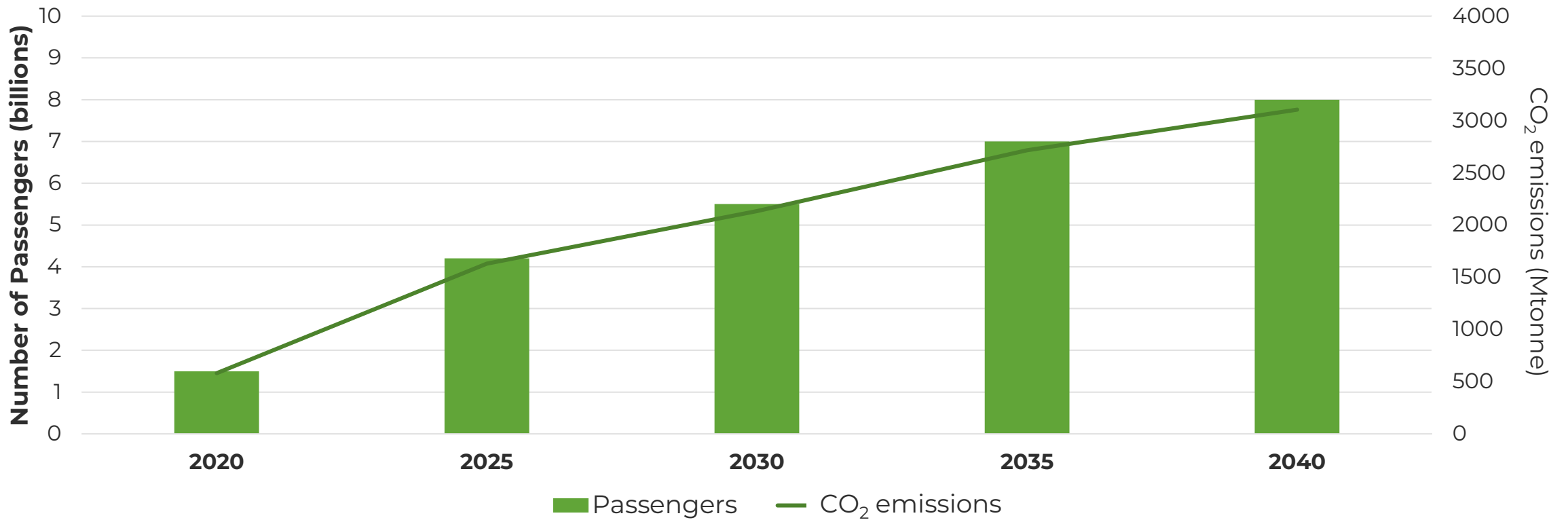


Today



# 3 GTONNE CO<sub>2</sub> EMISSIONS BY 2040

## Global Air Passengers



# COMBATTING EMISSIONS

## IATA approved Fly Net Zero by 2050

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- The International Air Transport Association (IATA) is a trade association of 317 airlines from 120 countries.
- At the 77th IATA Annual General Meeting, the IATA approved Fly Net Zero by 2050 to achieve net-zero carbon emissions from its operations by 2050.



# > 300 AIRLINES, ONE CHALLENGE

Innovative aviation technology to achieve net-zero operations by 2050



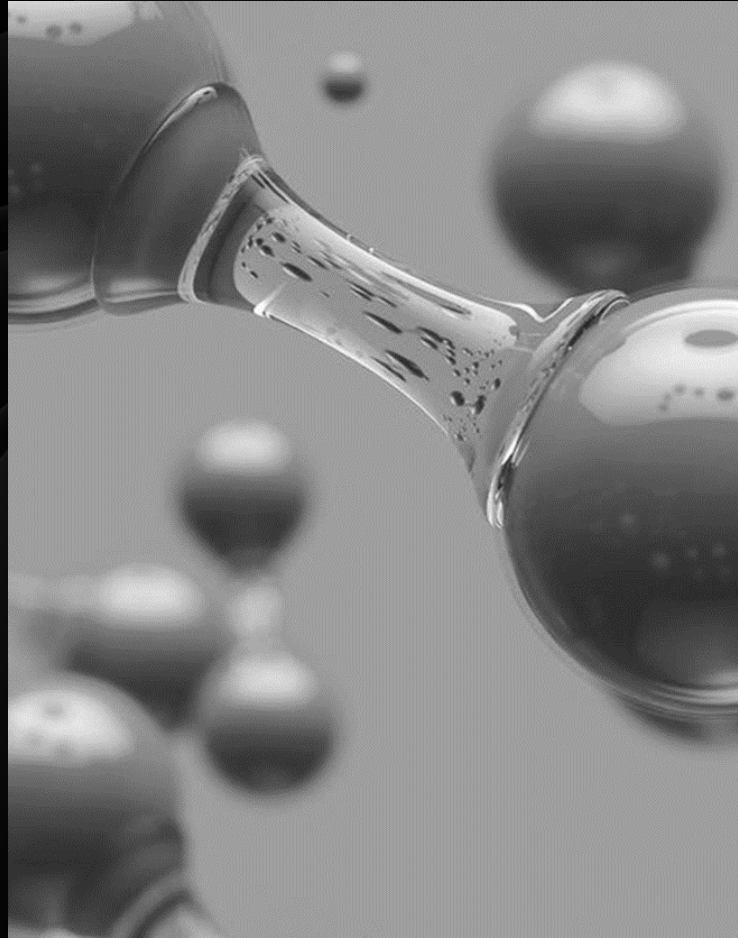
# ELECTRIC AVIATION

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# HYDROGEN AVIATION

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# SUSTAINABLE AVIATION FUEL

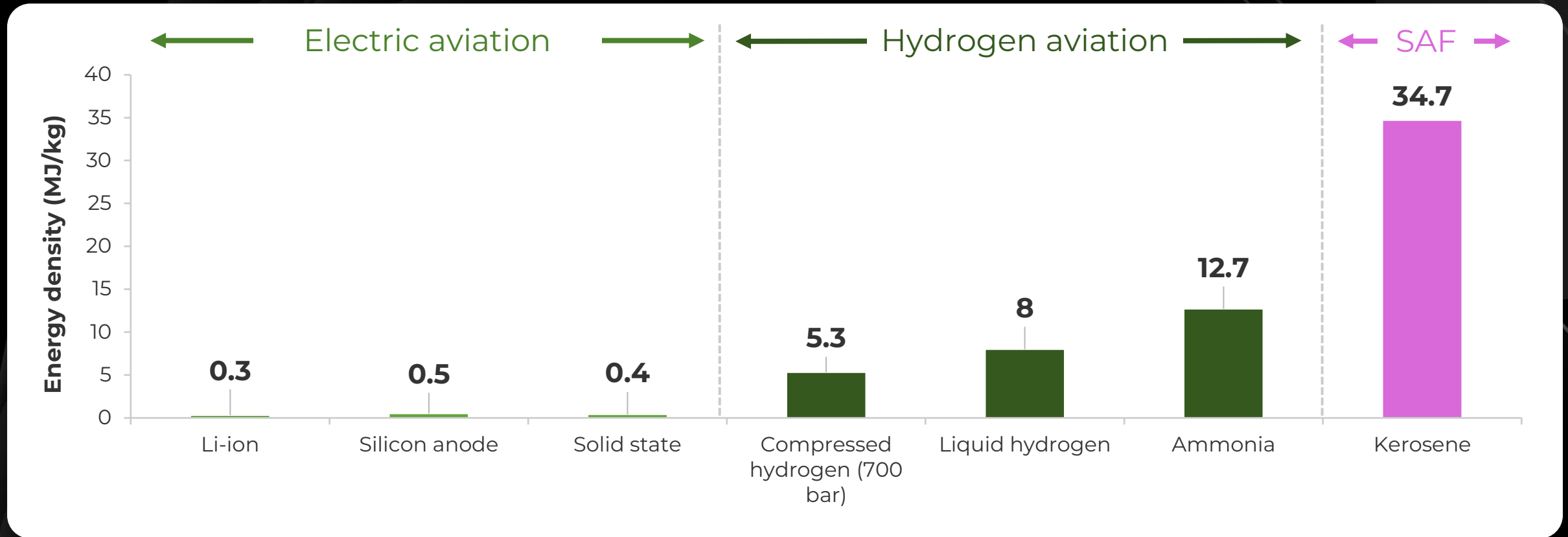
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# SAF: THE WINNING OPTION FOR AVIATION

Electric and hydrogen aviation fall short of required energy density



# WHERE CAN UNITED FLY?



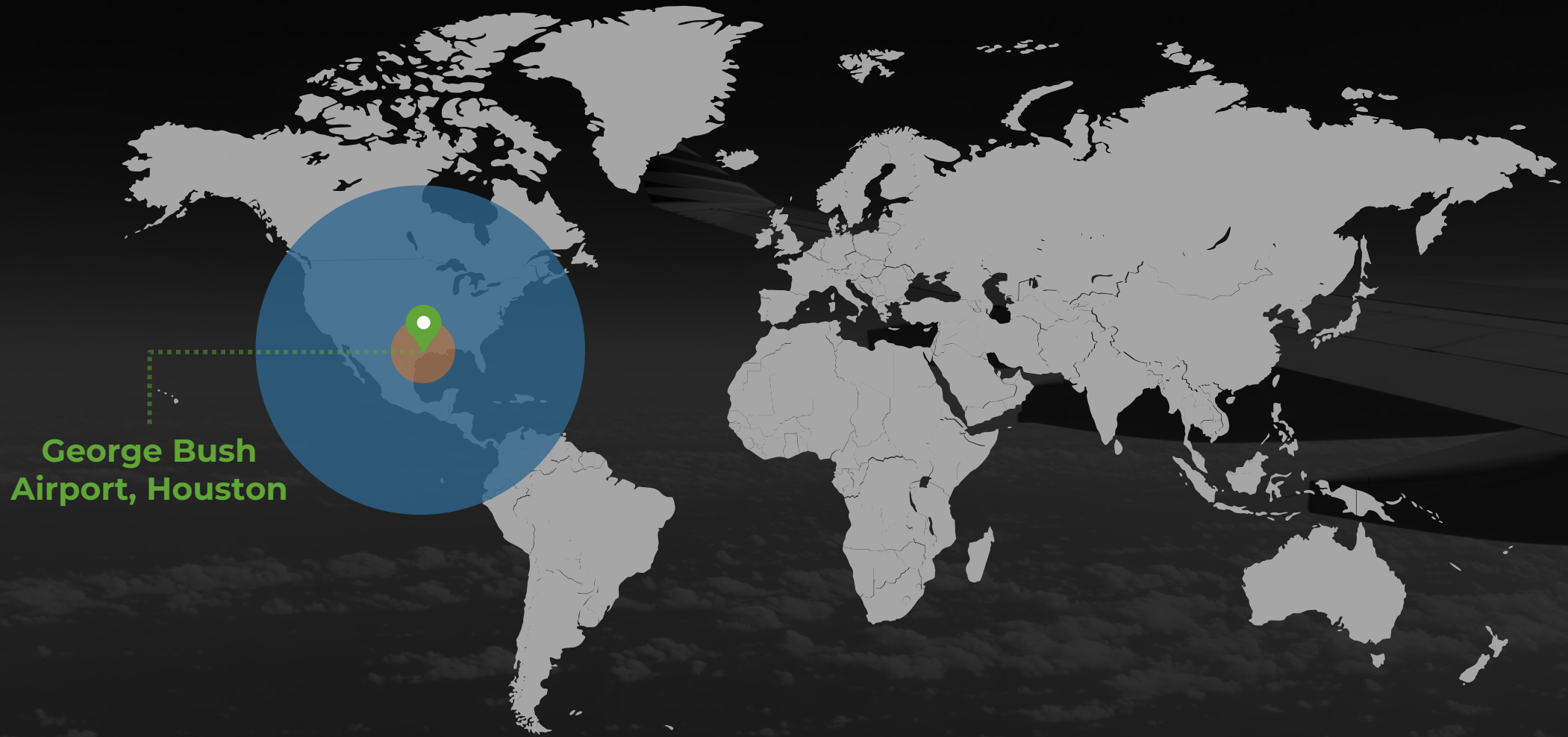
George Bush  
Airport, Houston

# TO AUSTIN WITH ELECTRIC



George Bush  
Airport, Houston

# TO CANADA AND MEXICO WITH H<sub>2</sub>



George Bush  
Airport, Houston

# AROUND THE WORLD WITH SAF



George Bush  
Airport, Houston

# UNITED'S PORTFOLIO FAVORS SAF

## 1 ELECTRIC AVIATION



ARCHER

ep<sup>®</sup>  
SYSTEMS

EVE  
MOBILITY REIMAGINED

Natron Energy

Heart  
Aerospace

## 2 HYDROGEN



ZEROAVIA

## 3 SAF



ALDER  
FUELS

Dimensional  
Energy

CEMVITA

NXTCLEAN  
FUELS

viridos

Fulcrum<sup>™</sup>  
BIOENERGY

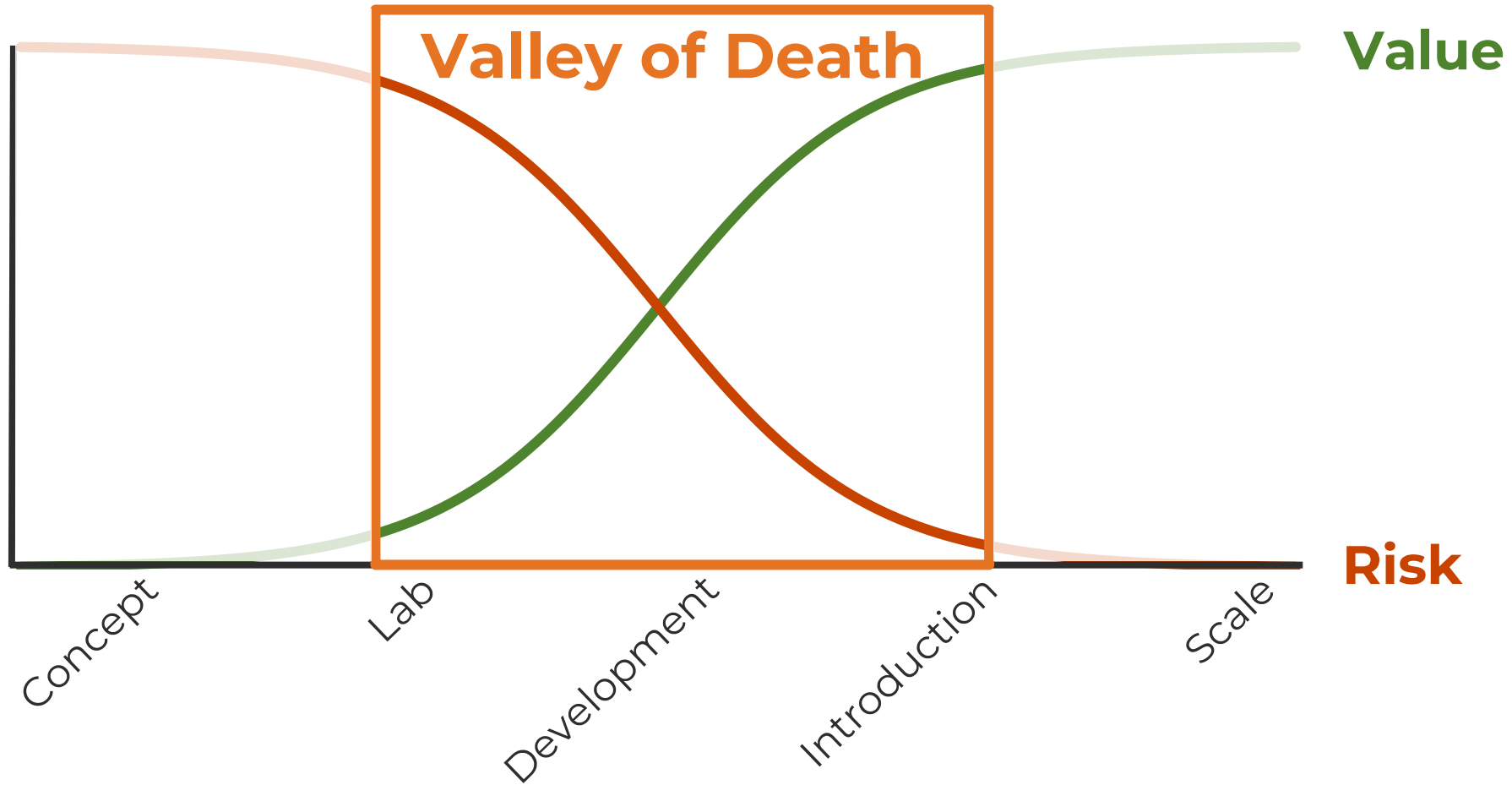
OXCCU

Svante



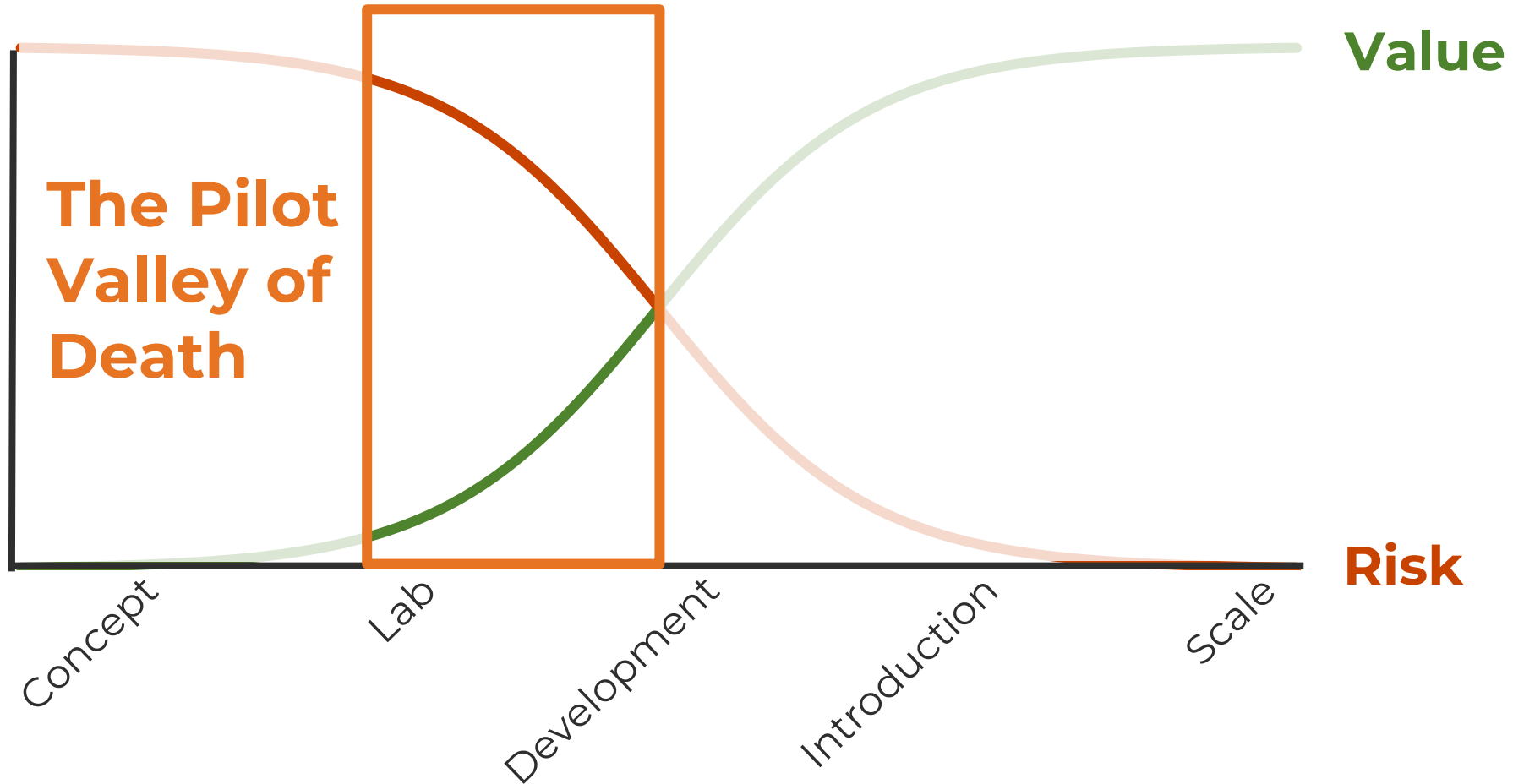
# **Decarbonizing aviation, still in its Wright Brothers moment, is hinged to scaling SAF**

# TURNING TECH INNOVATION INTO A BUSINESS

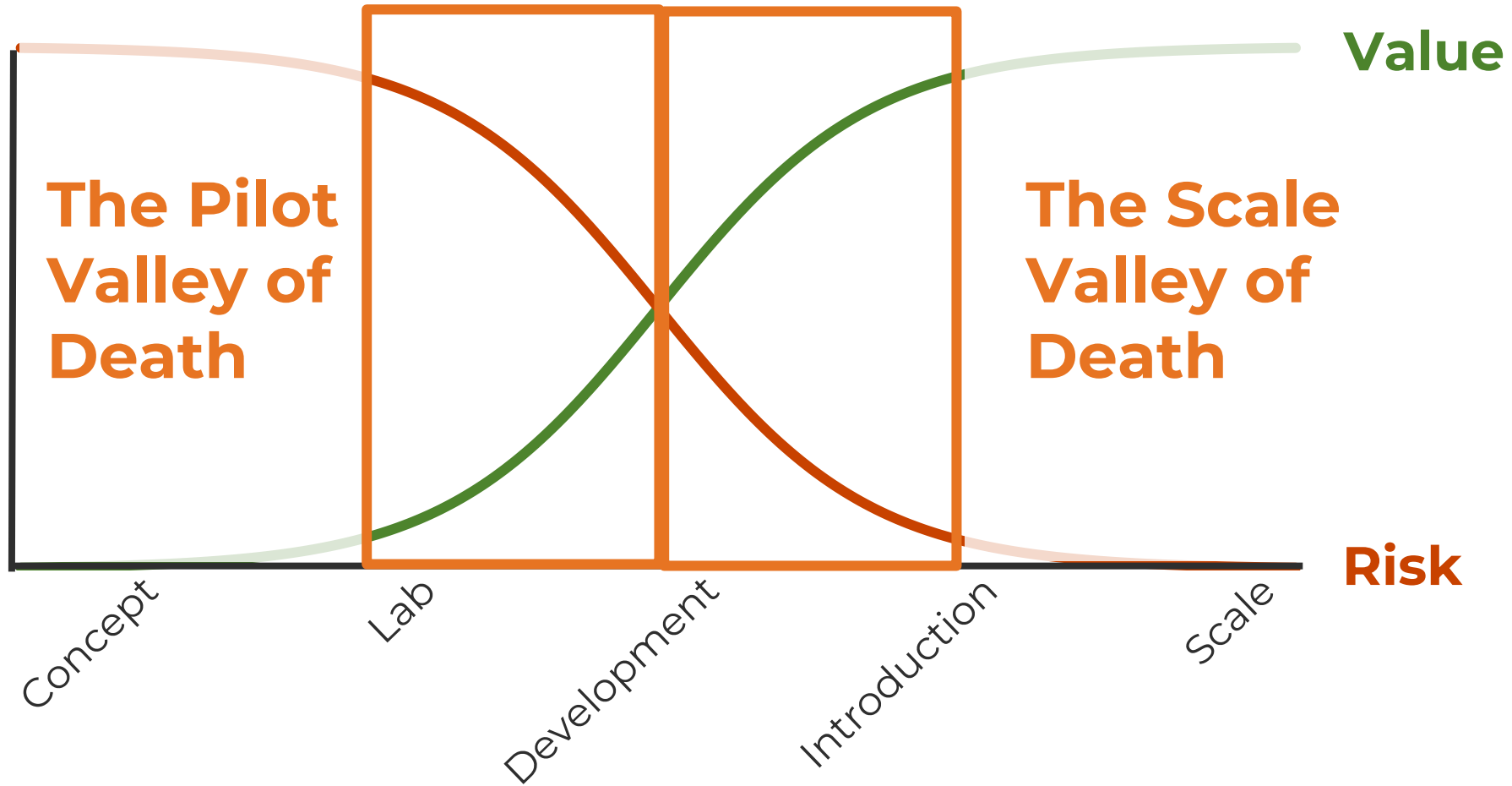




# THE FIRST VALLEY OF DEATH



# THE SECOND VALLEY OF DEATH



# THE LEVERS OF SCALING SAF

- + Scalable technology
- + Abundant feedstock
- + Sustainable feedstock
- + Low cost
- + Robust developers

## Main SAF pathways

1. Hydrotreated esters and fatty acids (HEFA)
2. Fischer-Tropsch (FT)
3. Alcohol-to-jet (ATJ)

**Neste** develops NEXBTL for the hydrotreatment of bio-oil to renewable fuels.

It is at scale, with two biorefineries in the Netherlands and Singapore with a combined capacity of 3 Mtonne/y of renewable fuels.

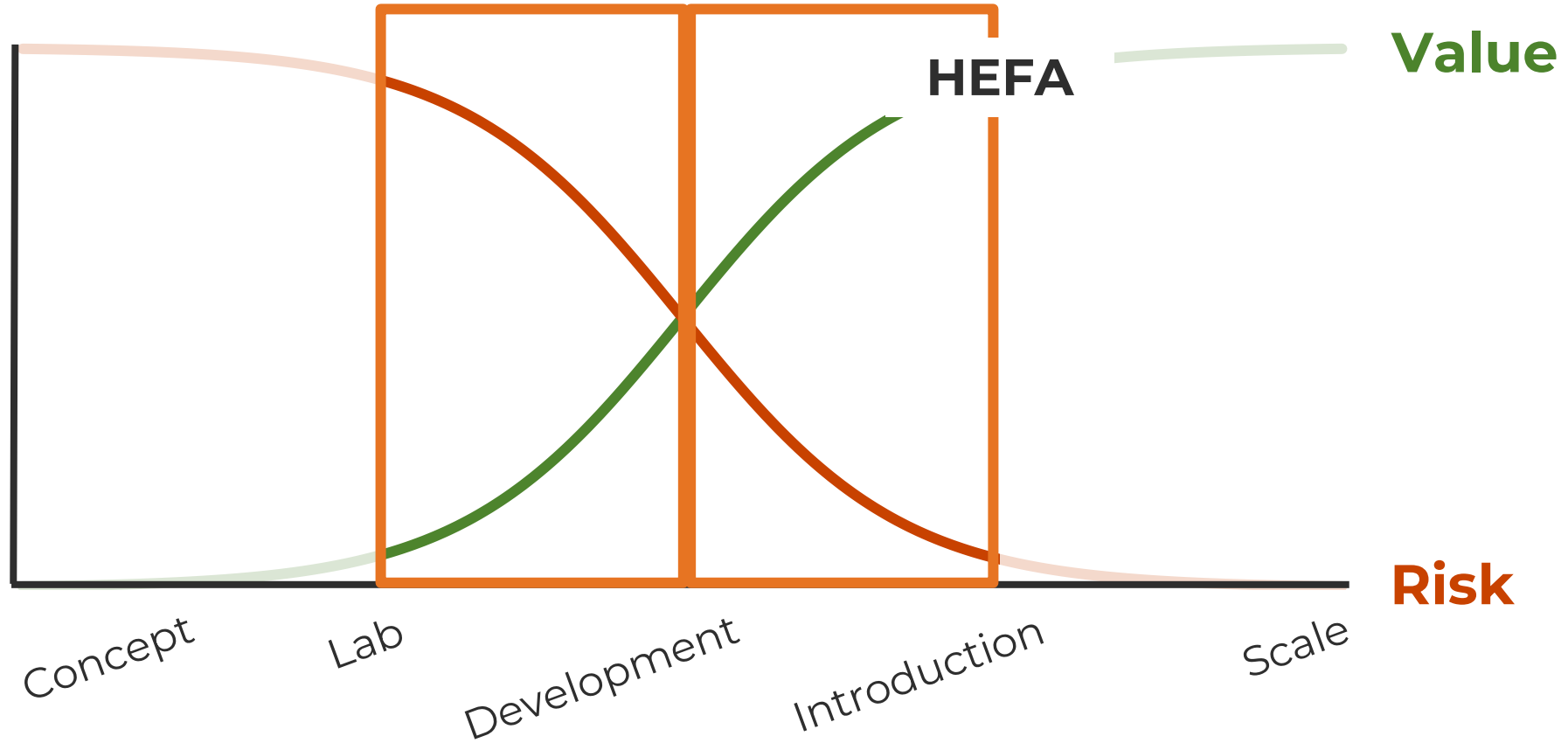
SAF PATHWAY

# HEFA

- + Commercial
- + Low cost
- + Robust developers
- Unsustainable
- Lack of feedstock

**NESTE**

# THE SECOND VALLEY OF DEATH



**Fulcrum Bioenergy** launched the first demonstration facility for SAF from municipal solid waste (MSW). The facility has a capacity of 10 million gallons per year.

The company uses Johnson Matthey's FT technology.

## SAF PATHWAY

# FT

- + Sustainable feedstock
- + Abundant feedstock
- + Robust developers
- Complex integration
- Expensive



**Arcadia eFuels** will produce 55,000 tonne/y of eFuel in Denmark from biogenic CO<sub>2</sub> and green hydrogen.

The company uses Topsoe's reverse water-gas shift (RWGS) reaction and Sasol's FT technology and has off-take agreements from Shell Aviation.

## SAF PATHWAY

# FT

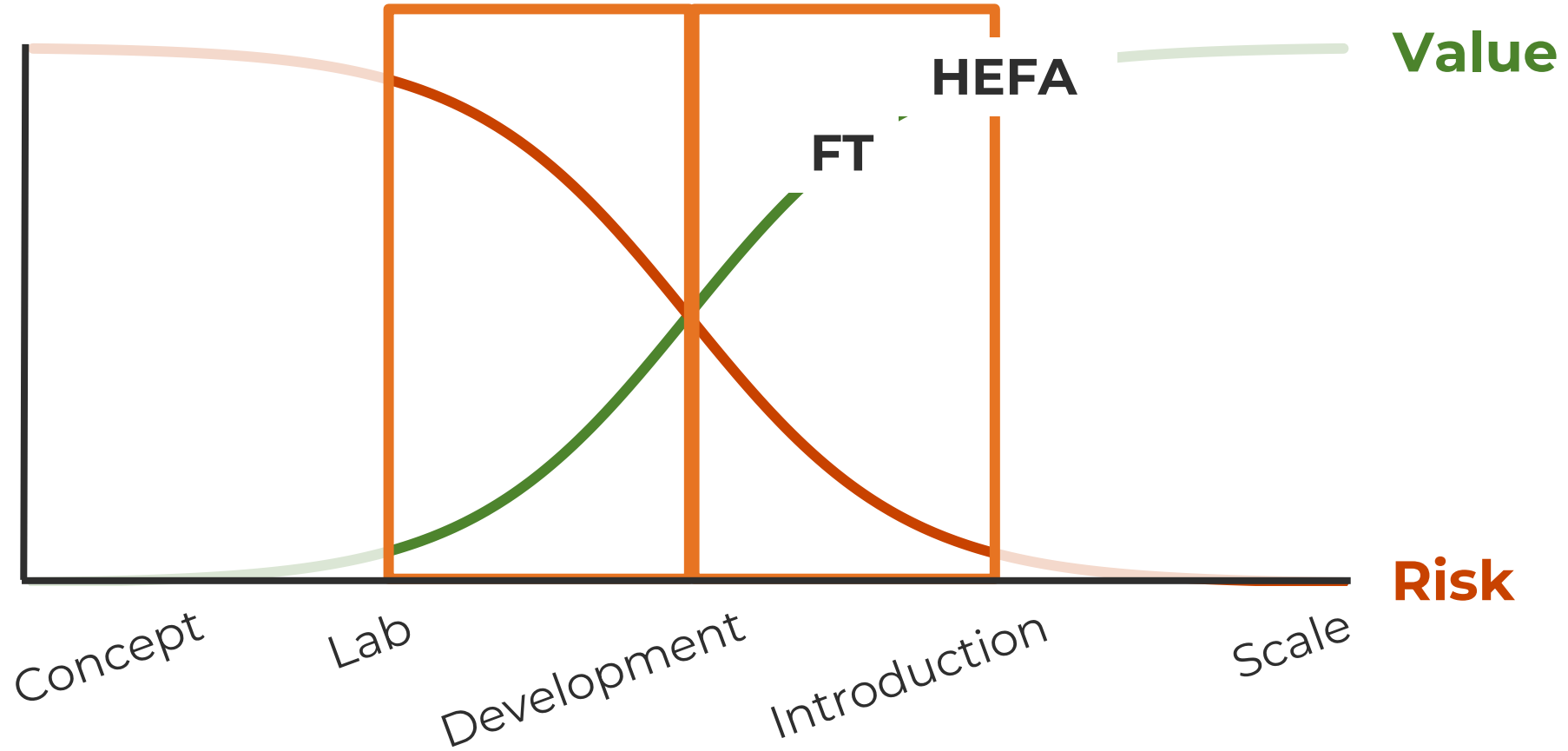
- + Sustainable feedstock
- + Abundant feedstock
- + Robust developers
- Complex integration
- Expensive

**Arcadia**<sup>TM</sup>  
eFuels

**TOPSOE**

  
**SASOL**

# FT: MORE FEEDSTOCK, BUT EXPENSIVE





**LanzaJet** launched the first demonstration for SAF from ethanol in January 2024. The facility's capacity is 10 million gallons per year.

The company uses first-generation ethanol.

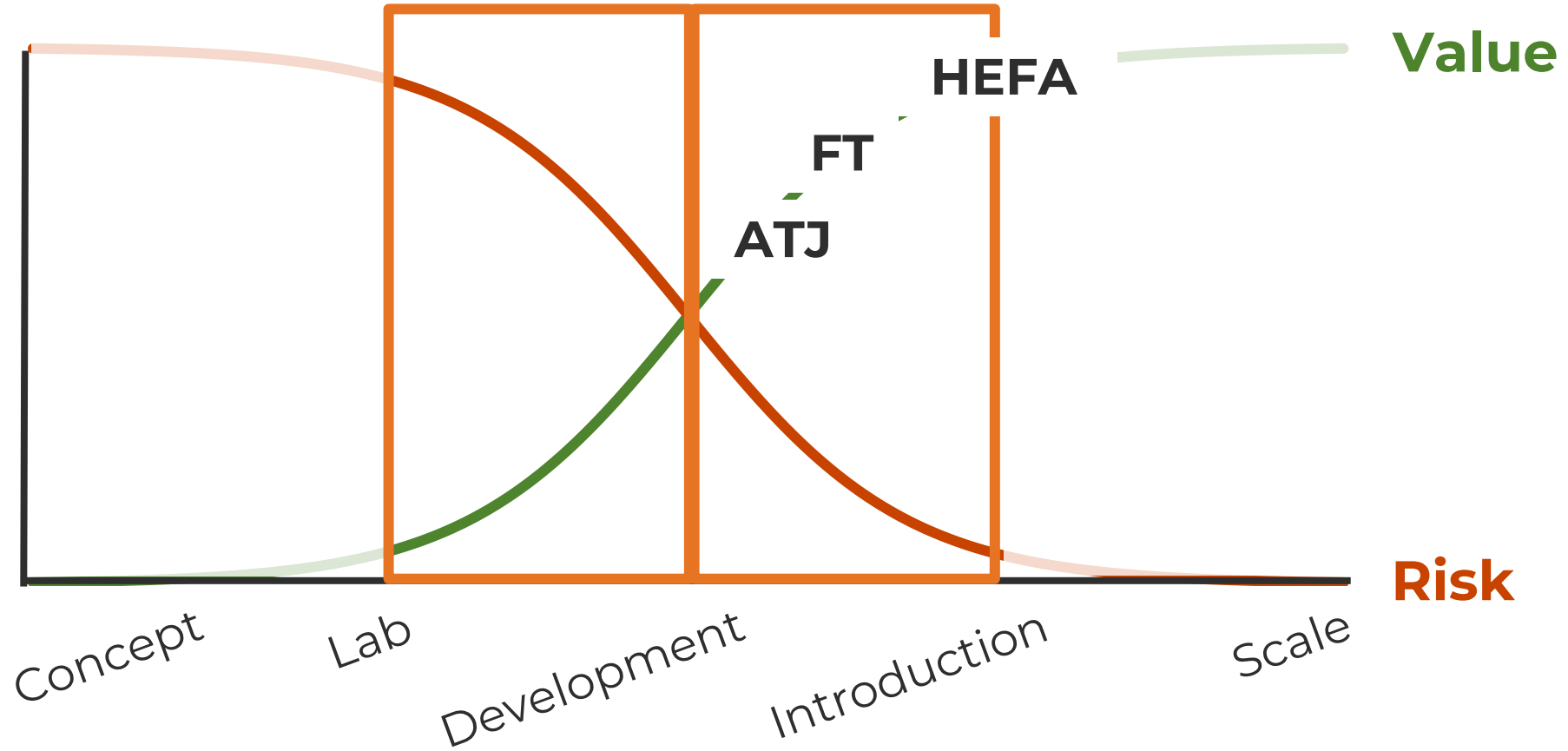
## SAF PATHWAY

# ATJ

- + Abundant feedstock
- + Low cost
- Unsustainable feedstock
- Lack of developers

**LanzaJet** 

# ATJ: LESS EXPENSIVE, BUT LESS MATURE



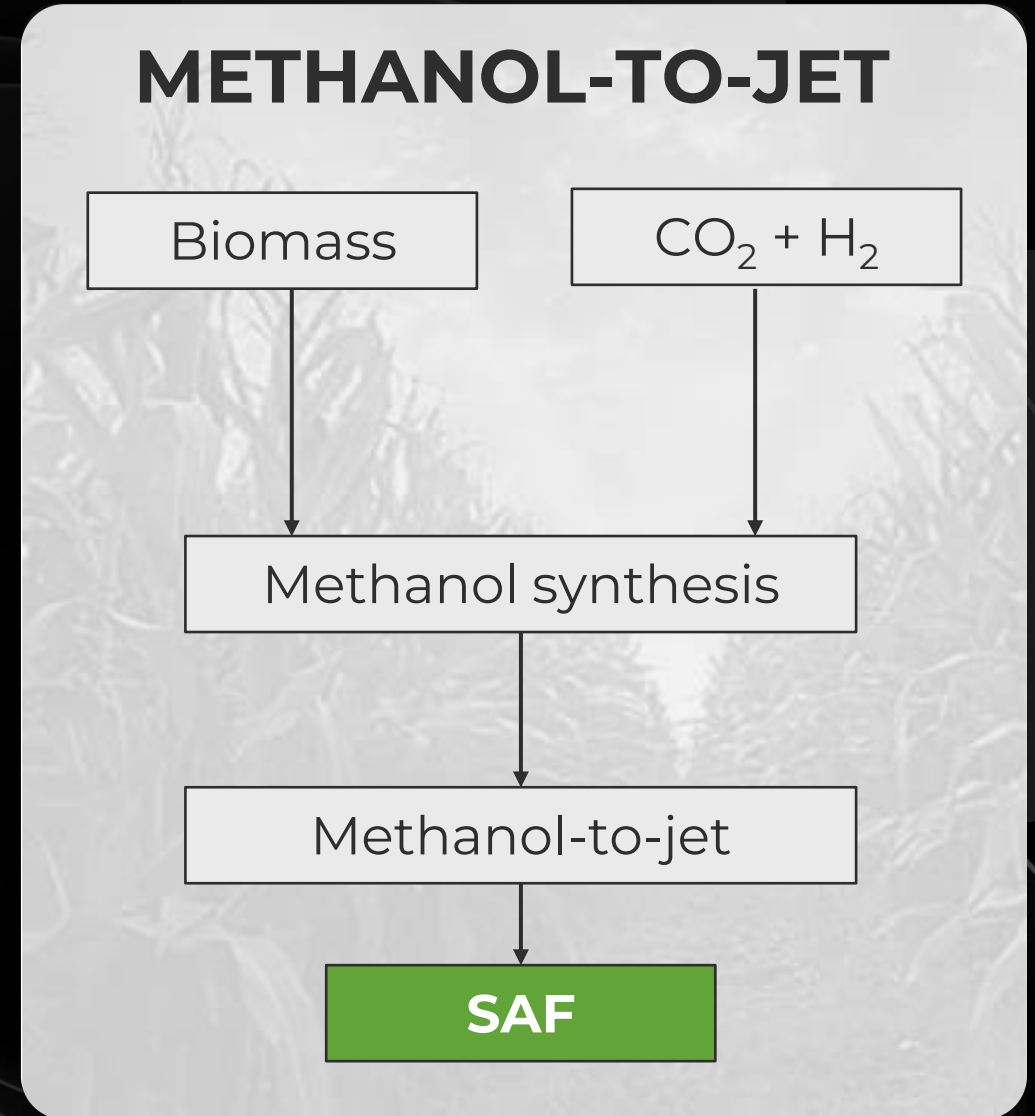
# THE LEVERS OF SCALING SAF

- + Scalable technology
- + Abundant feedstock
- + Sustainable feedstock
- + Low cost
- + Robust developers



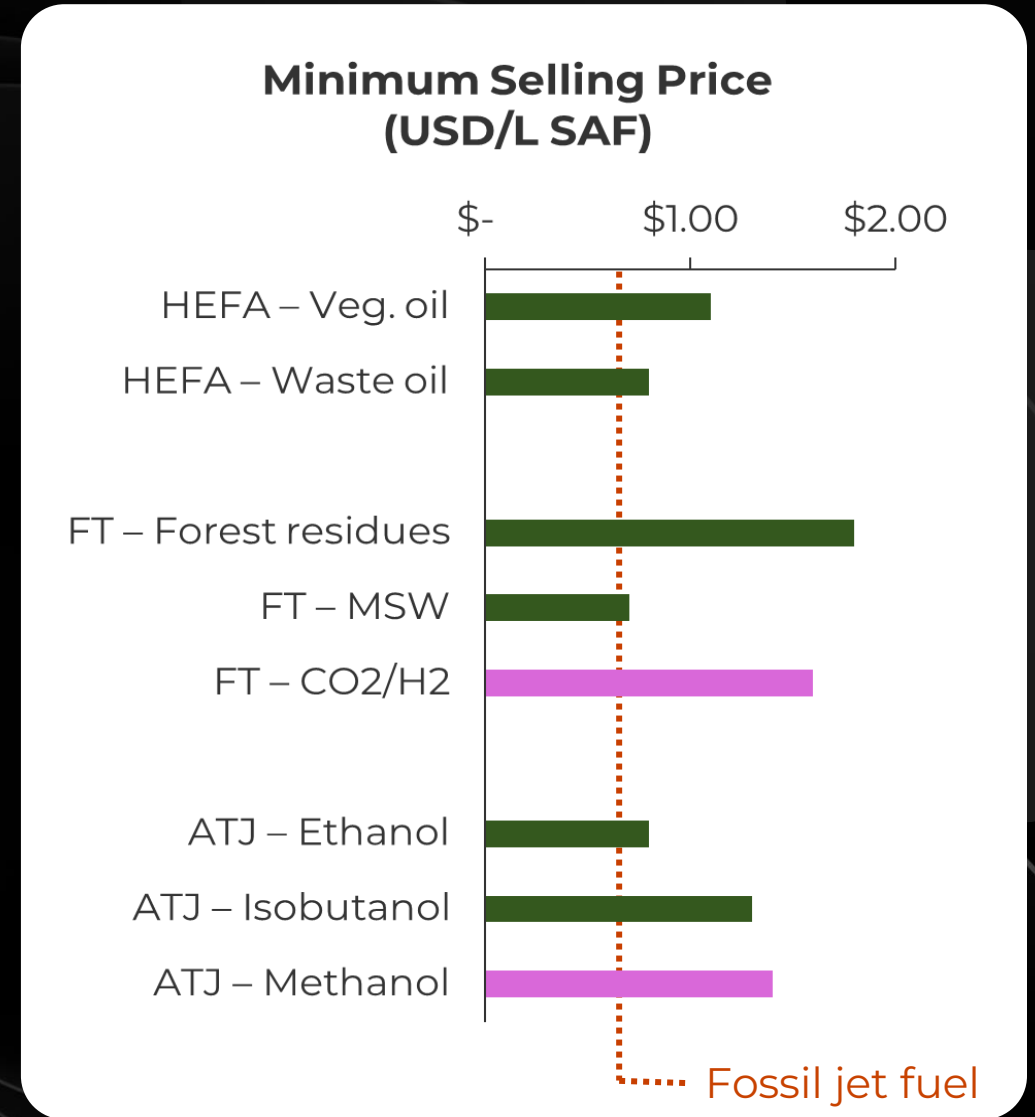
# THE LEVERS OF SCALING SAF

- + Scalable technology
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# THE LEVERS OF SCALING SAF

- + Scalable technology
- + Abundant feedstock
- + Sustainable feedstock
- + “Low cost”
- + Robust developers



Cost of SAF production

# THE LEVERS OF SCALING SAF

- + Scalable technology
- + Abundant feedstock
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- + “Low cost”
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**ExxonMobil**

**TOPSOE**

**Uop**

A Honeywell Company

**Axens**  
SOLUTIONS



**TotalEnergies**

MTJ Technology Developers

The U.S. “SAF Grand Challenge” aims to expand domestic SAF production to:  
**3 BGY by 2030**  
**35 BGY by 2050**



U.S. DEPARTMENT OF  
**ENERGY**



Approved and Accepted for U.S. Department of Energy

A handwritten signature in black ink, positioned above a horizontal line.

Date: September 8, 2021

Approved and Accepted for U.S. Department of Transportation

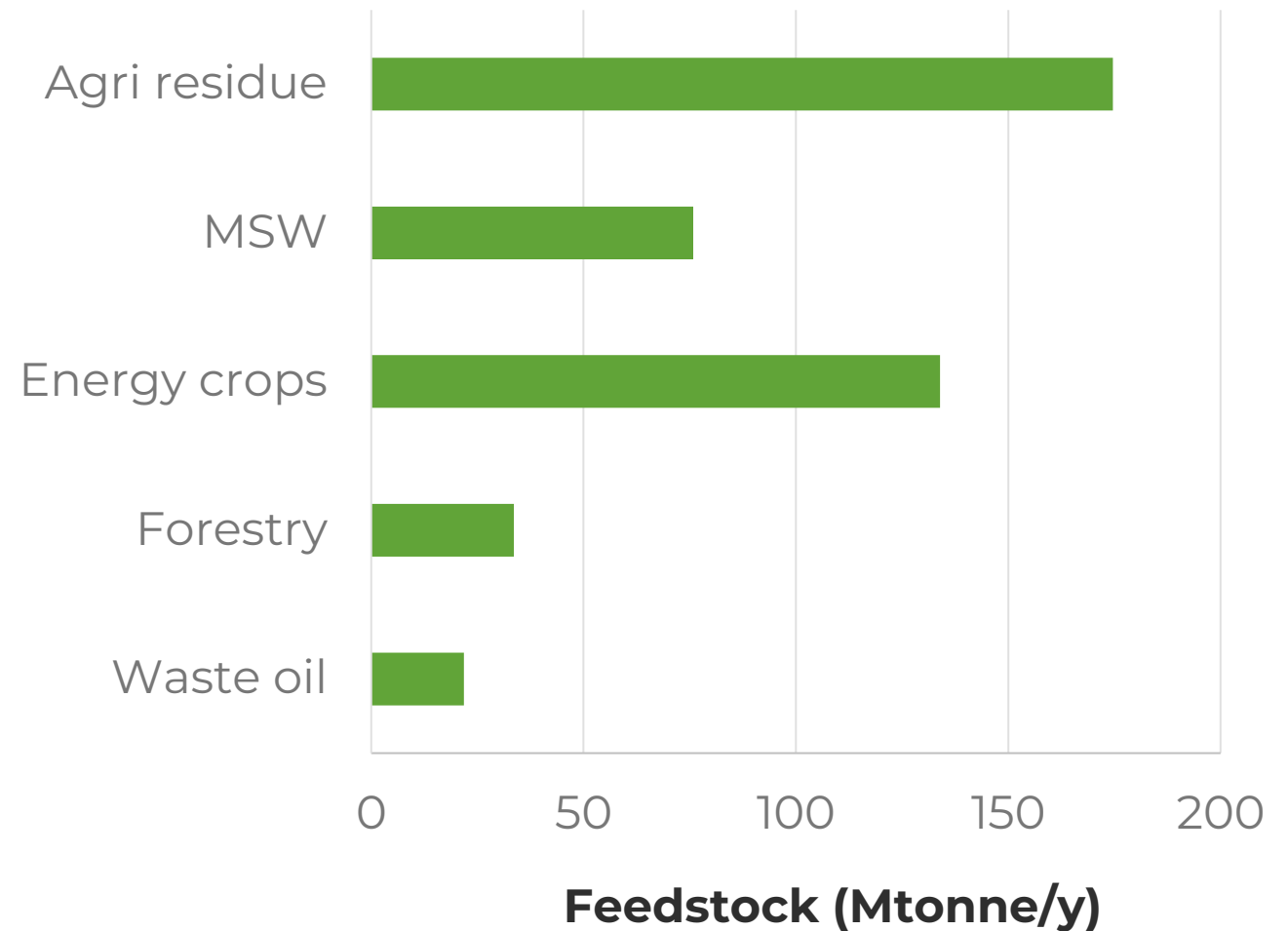
A handwritten signature in blue ink, positioned above a horizontal line.

Date: September 8, 2021

# U.S. BIOMASS AVAILABILITY

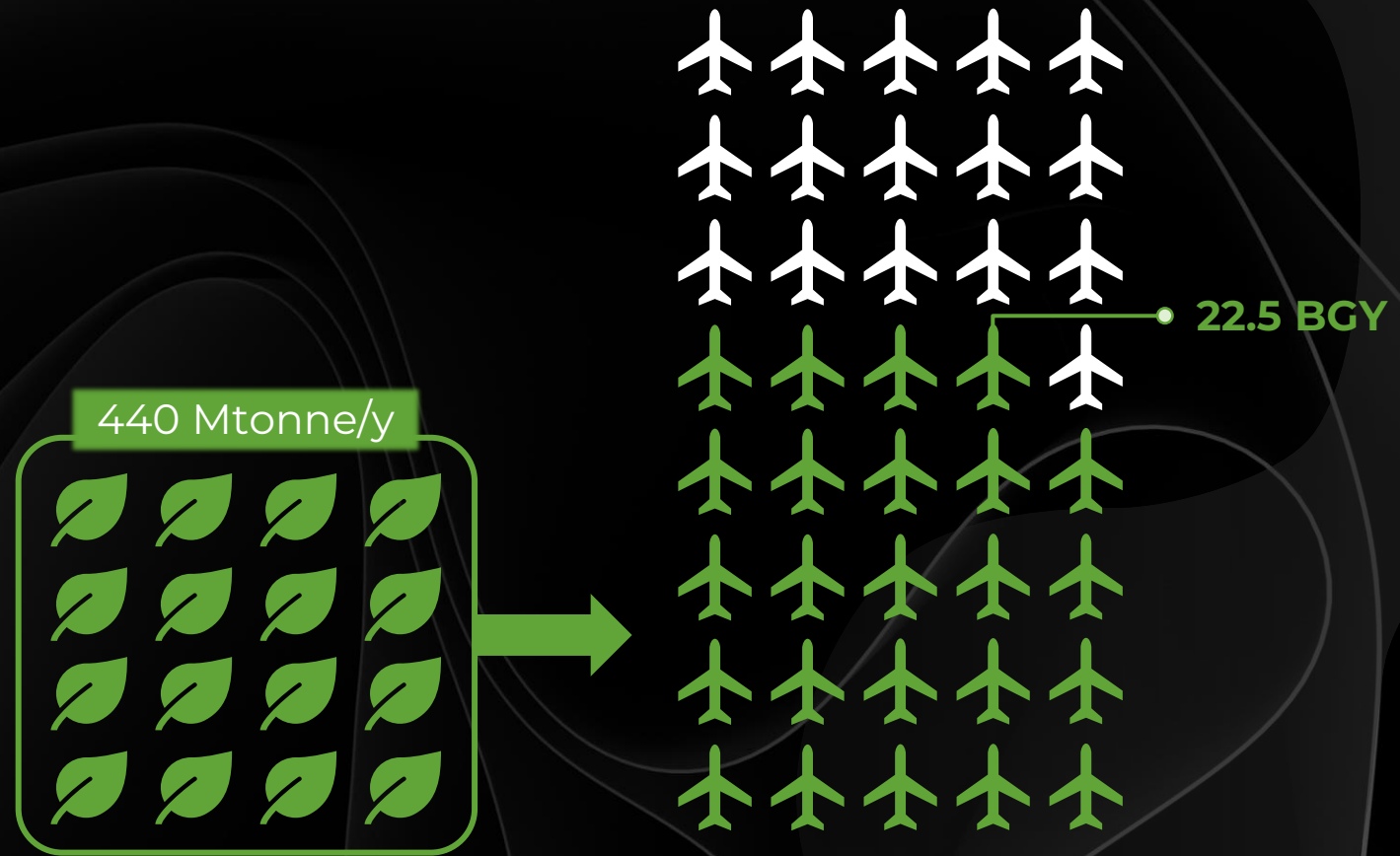
Feedstock availability is the greatest barrier to scaling up the SAF industry

## U.S. Biomass Feedstock Availability

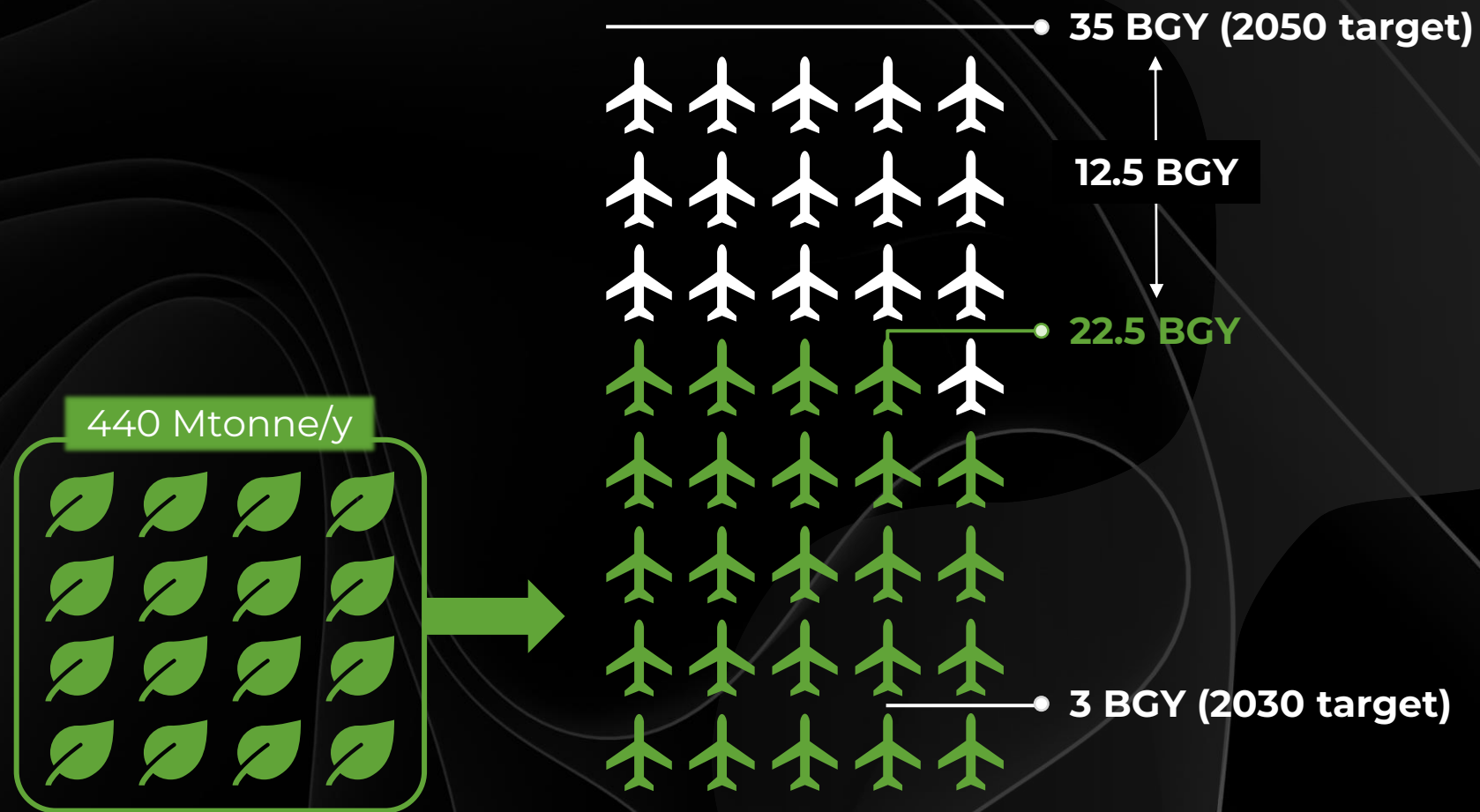




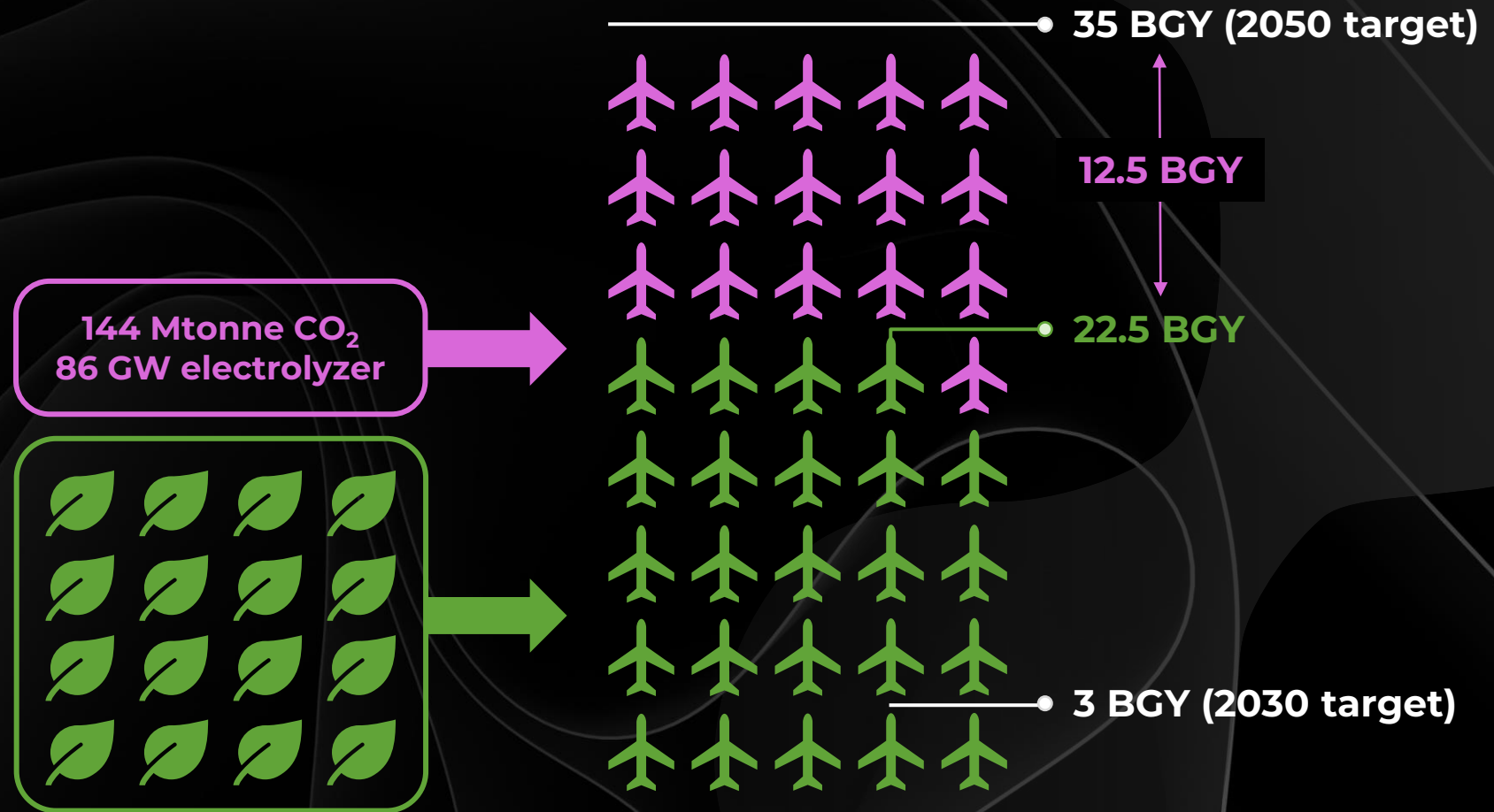
# THE U.S. CAN MEET ITS 2030 TARGETS...



# ...BUT WILL HAVE A DEFICIT FOR 2050

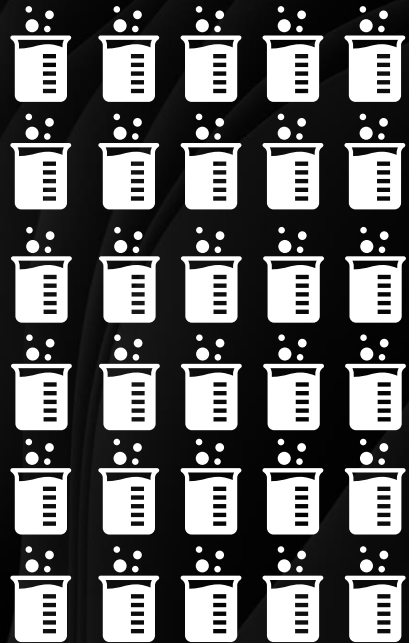


# THE DEFICIT WILL NEED E-FUELS

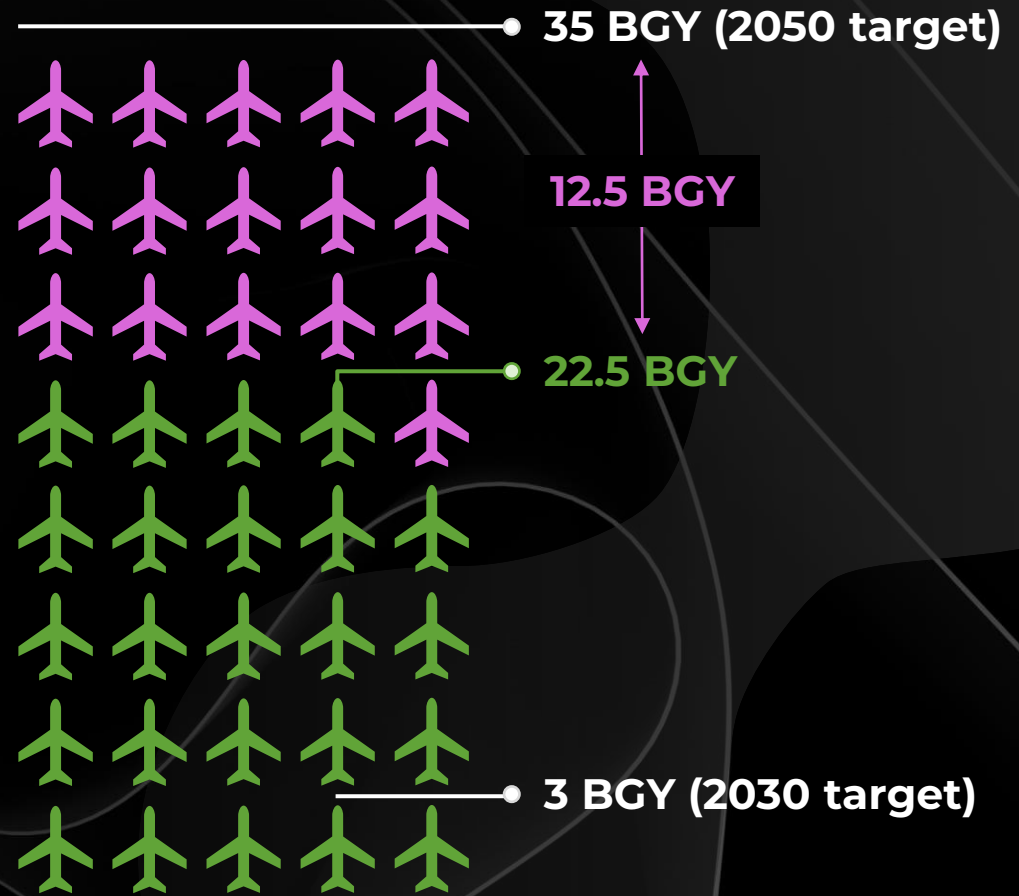


# BUT OTHER INDUSTRIES NEED BIOMASS

White House's Bold Goals look to displace more than 90% of today's plastics



144 Mtonne CO<sub>2</sub>  
86 GW electrolyzer



# U.S. BIOBASED ACTIVITY GROWING FOR NON-FUELS

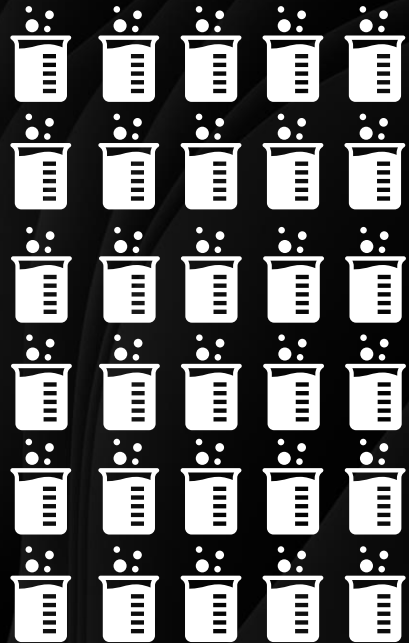
Several projects underway or announced in the past few years

- Citroniq to construct a 400-ktonne polypropylene plant in Nebraska by 2026
- New Energy Blue to process 275 ktonne/y corn stover to produce 2G ethanol that will go toward ethylene for Dow's polyethylene
- And more to come made possible by DOD-backed BioMADE — not only funding projects, but building a network of 12 to 15 bioindustrial manufacturing pilot facilities across the U.S.

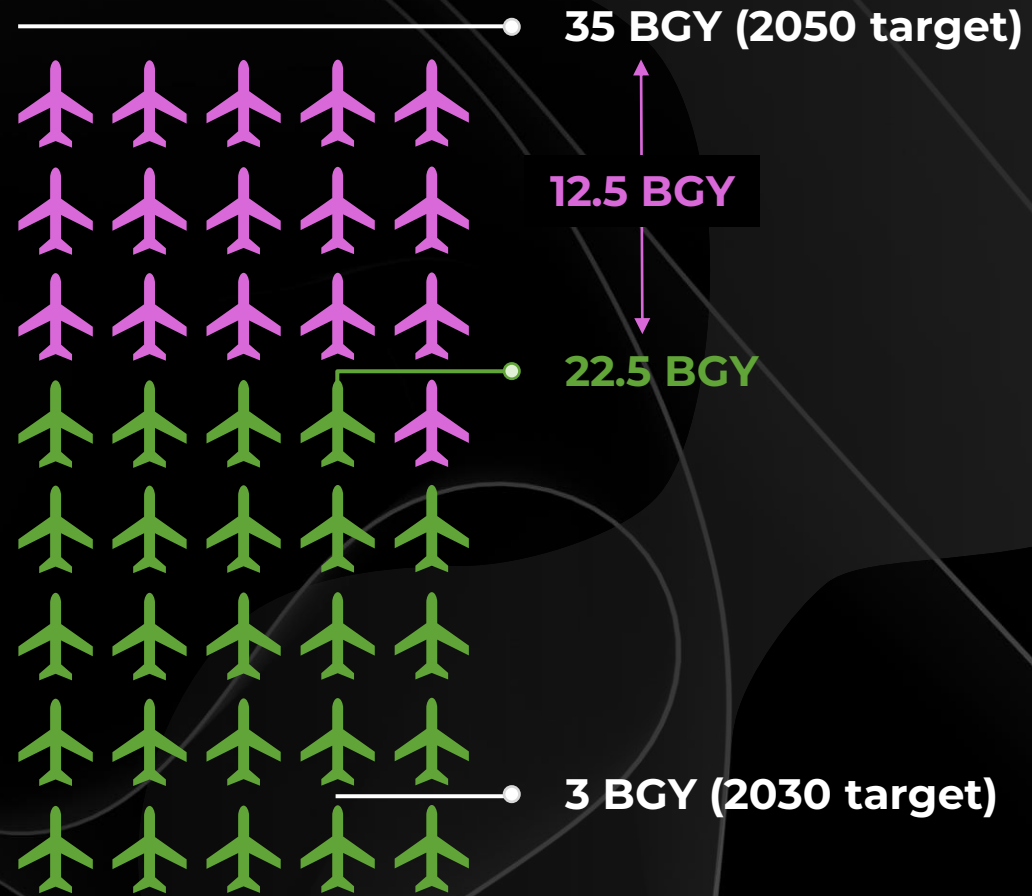


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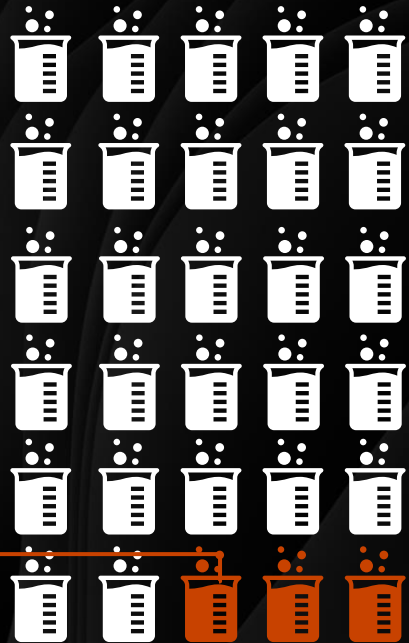


144 Mtonne CO<sub>2</sub>  
86 GW electrolyzer

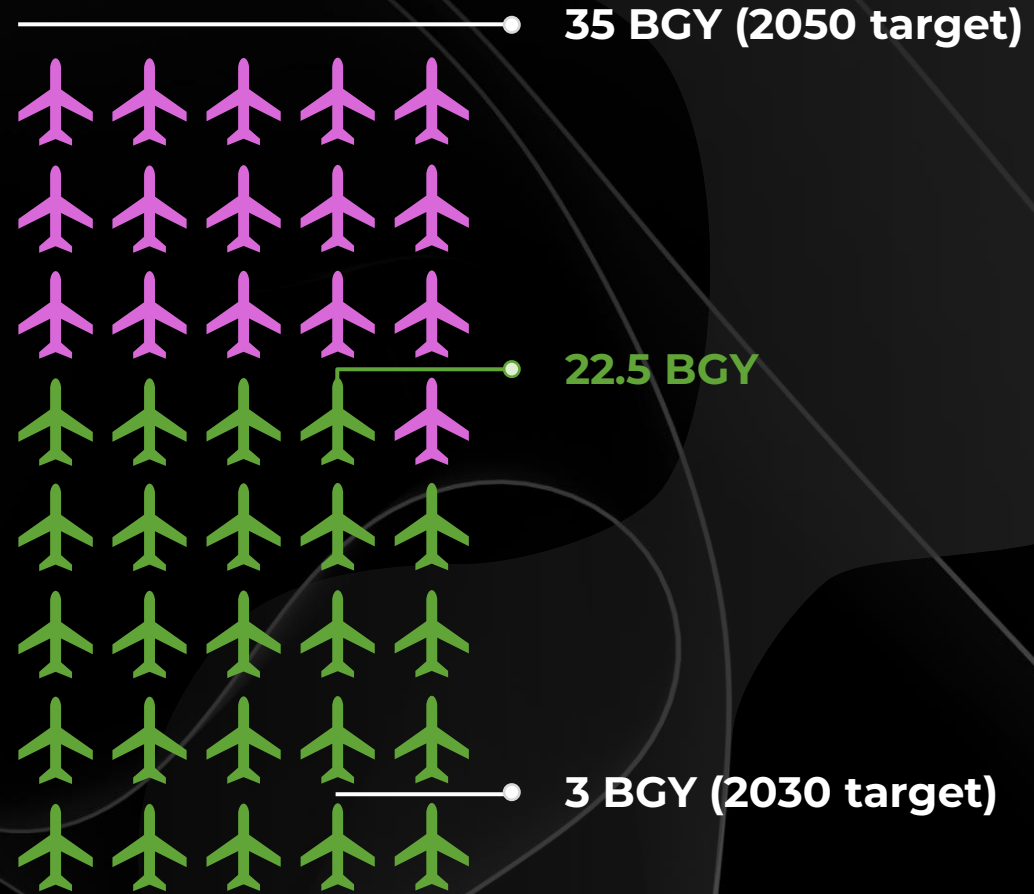


# A 10% SWITCH TO BIOPOLYETHYLENE

Displace more than 90% of today's plastics



144 Mtonne CO<sub>2</sub>  
86 GW electrolyzer

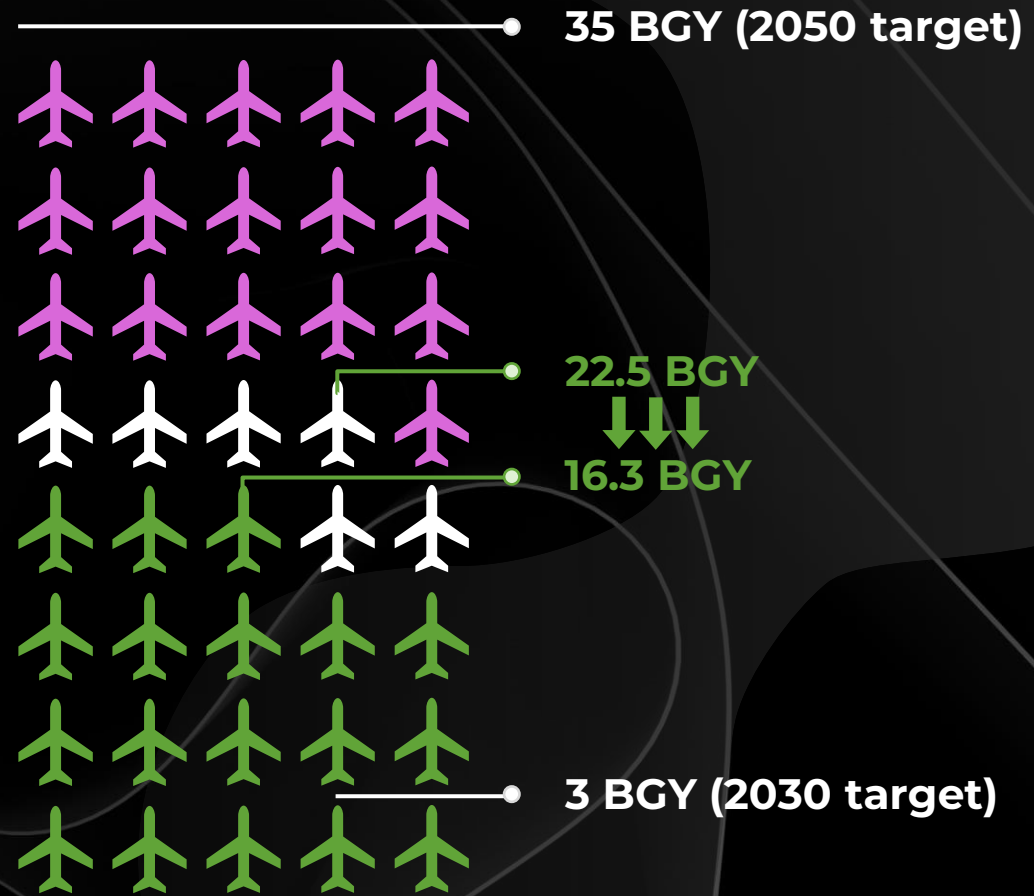


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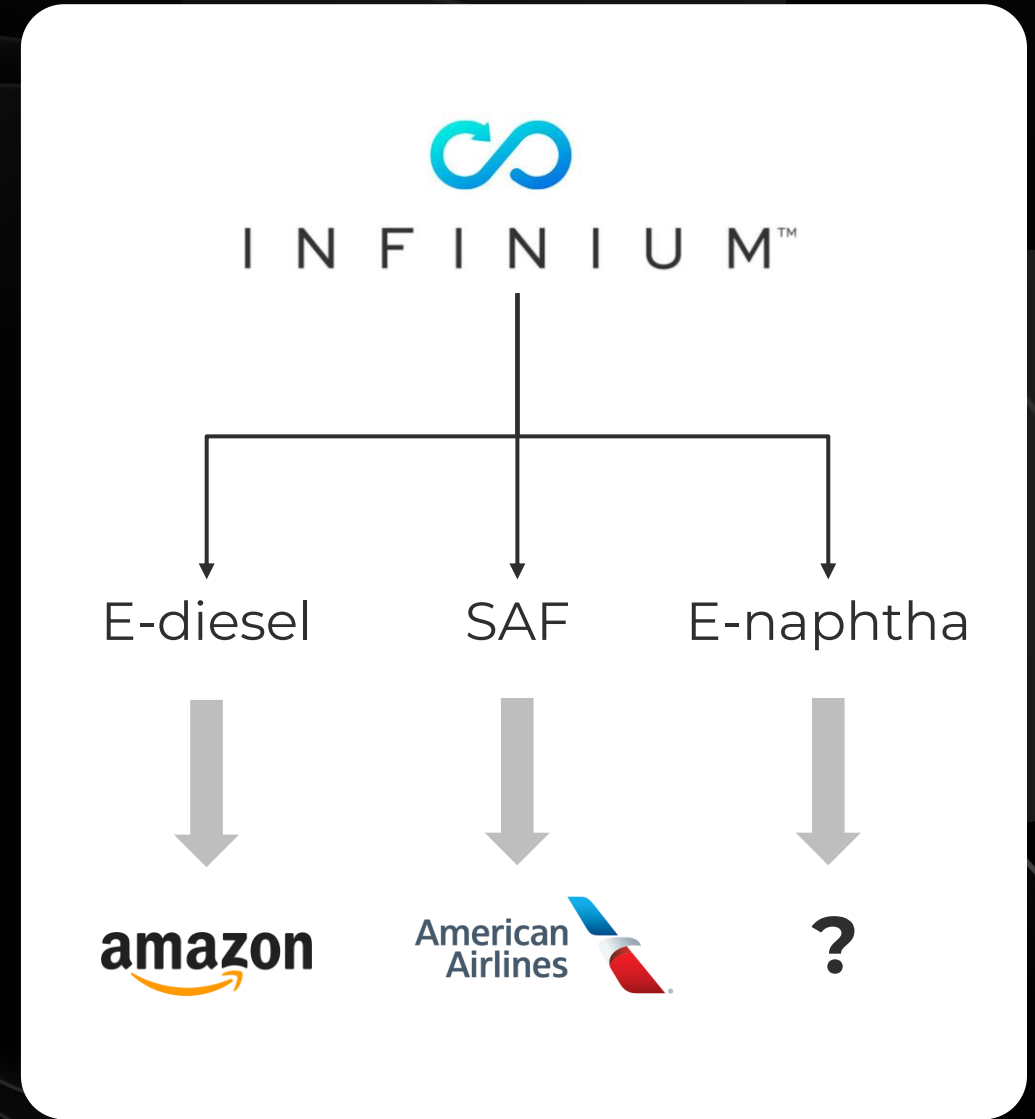




# SAF OR NAPHTHA?

**Infinium's Project Roadrunner is expected to begin operations in 2026.**

**In addition to SAF, the facility will also produce e-naphtha for plastics.**



MTJ Technology Developers

**TRULY DISRUPTIVE**

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# THE U.S. ALLOWS CORN ETHANOL AND SOYBEAN OIL AS SAF FEEDSTOCK

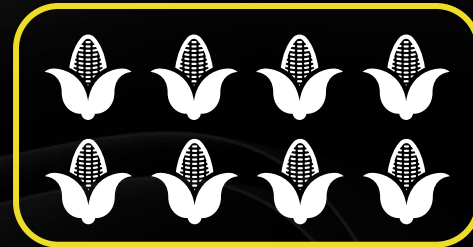
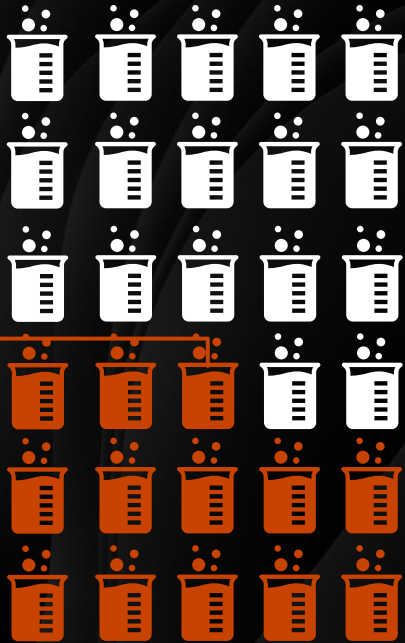
ELIGIBLE FOR IRA TAX CREDIT  
OF USD 1.75/GALLON



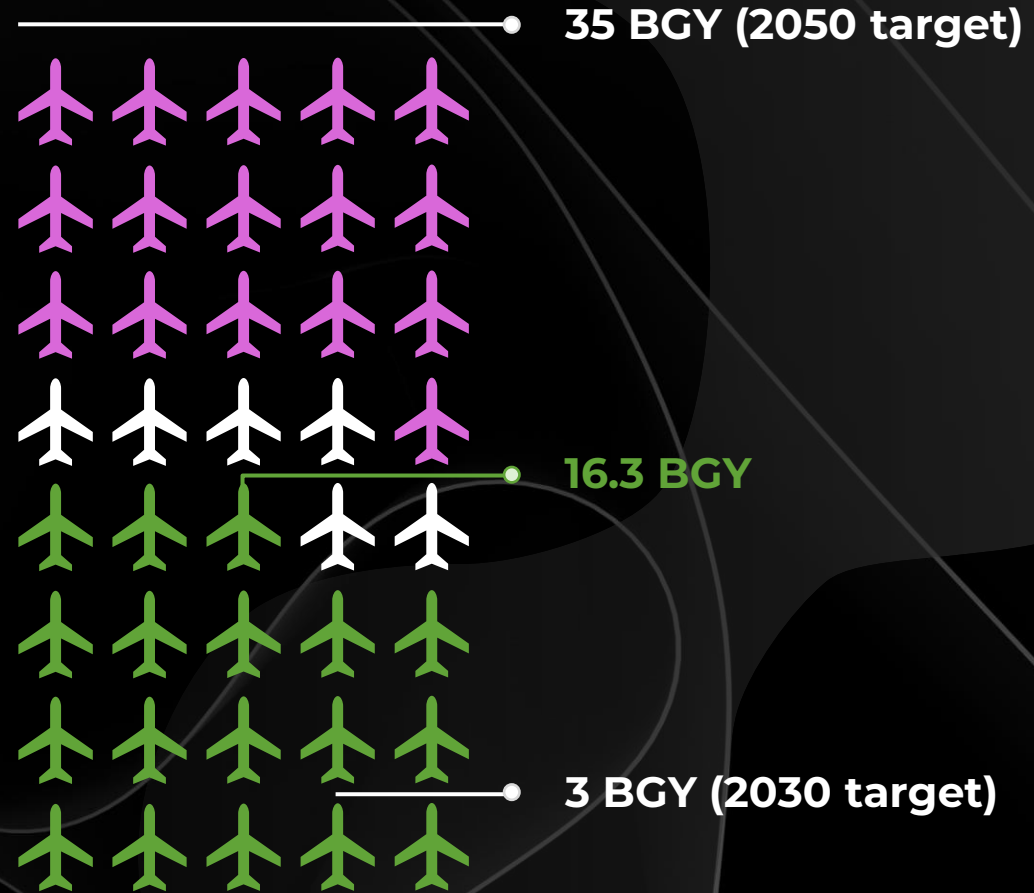
# TAPPING INTO NEW CORN FEEDSTOCK

Displace more than 90% of today's plastics

20 Mtonne ethylene

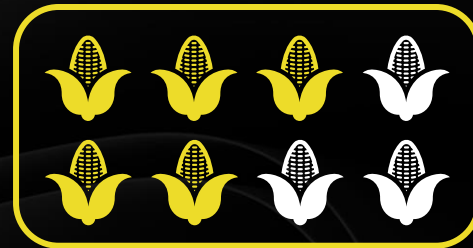
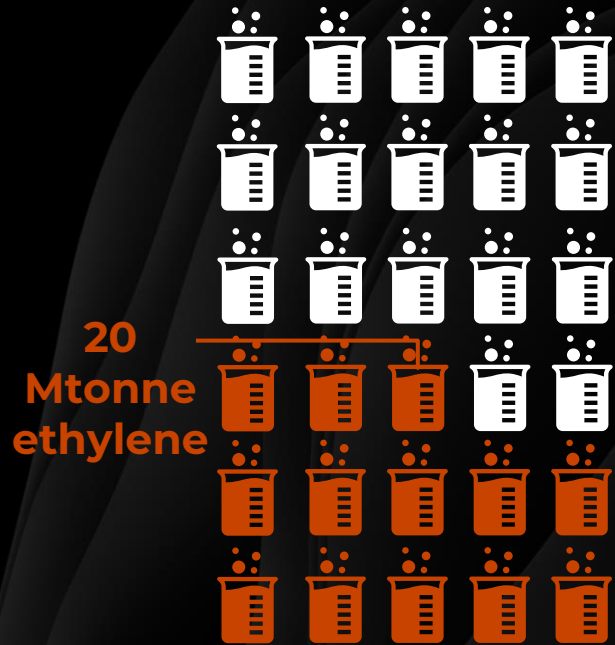


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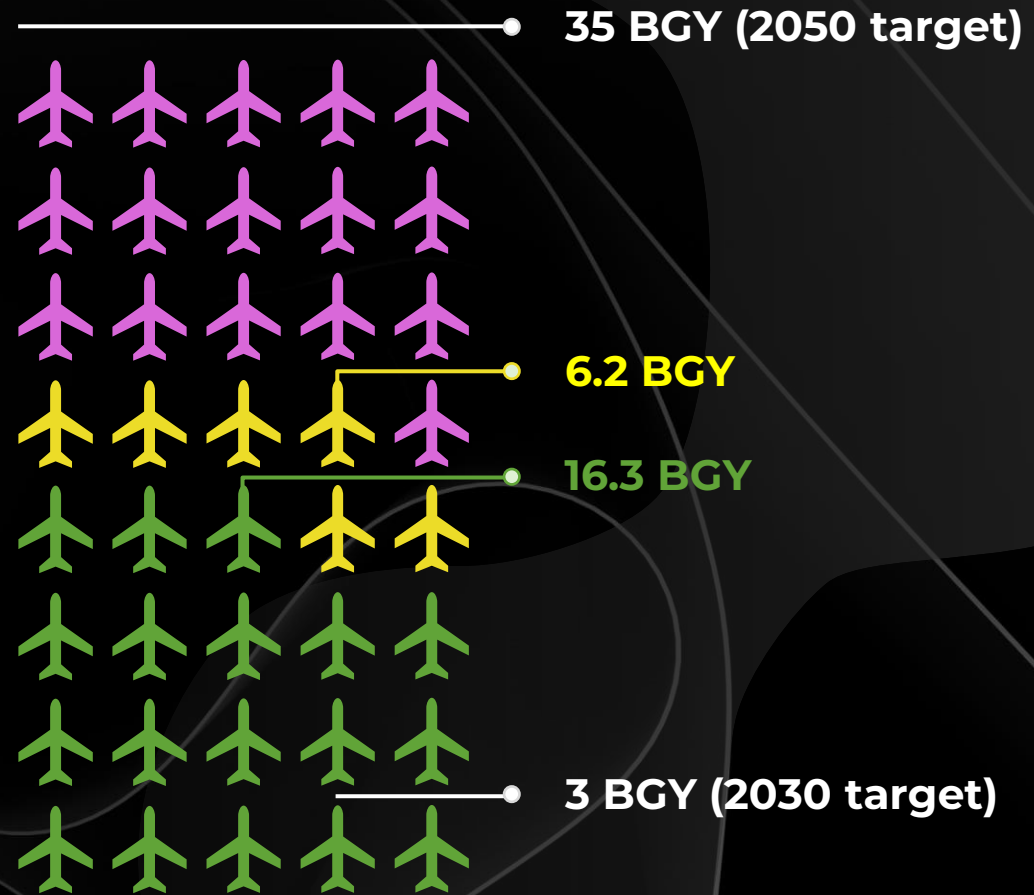


# TO NOT JUST FILL THE GAPS...

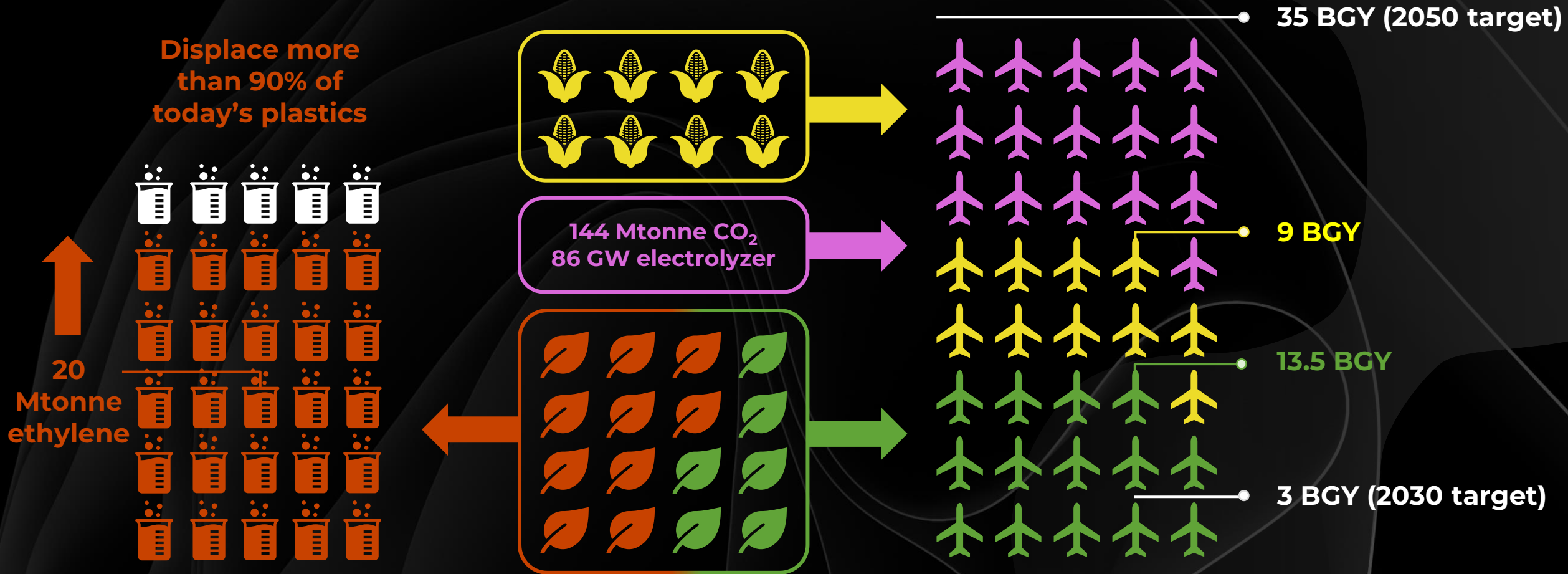
Displace more than 90% of today's plastics



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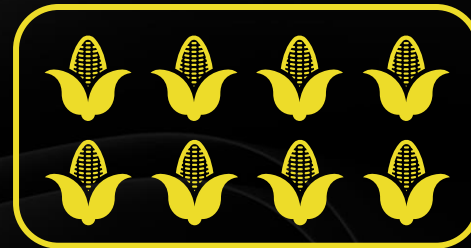
# ...BUT FREE BIOMASS FOR BIOCHEMICALS



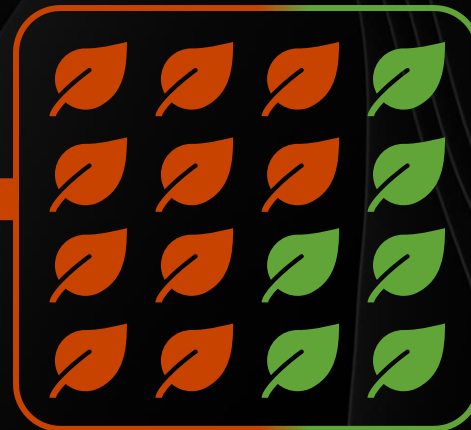
# THE U.S. SAF MIX OF 2050

35 BGY (2050 target)

Displace more than 90% of today's plastics



144 Mtonne CO<sub>2</sub>  
86 GW electrolyzer





# Key Takeaways

## 1 **SAF needs a balance of feedstock supply and carbon intensity with a scalable technology**

The U.S. will need to diversify its production mix to meet long-term SAF targets. CO<sub>2</sub> and H<sub>2</sub> can go through both FT and ATJ pathways.

## 2 **Methanol-to-jet is the most promising opportunity to scale SAF production**

With a strong group of corporate developers, the technology shows potential to turn CO<sub>2</sub> and H<sub>2</sub> into SAF at a lower cost than FT.

## 3 **Current lack of competition from biochemicals today can present opportunities**

Flexibility in facility outputs can leave companies nimble to future mobilization of the U.S. biochemical industry.



# Thank you

A link of the webinar recording will be emailed within 24–48 hours.

## UPCOMING WEBINARS

APRIL 18

[The Future of Agile Research:  
Using AI-Enabled Tools for  
Consumer-Centric Innovation](#)

APRIL 25

[Breaking Through the Sustainable  
Packaging Dilemma: Carbon  
Footprint vs. Waste Management](#)



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Factor