BOEING

CASCADE / SUSTAINABLE AEROSPACE TOGETHER

SAF Market Outlook

MARTIN GORRICHO

December 2025

CASCADE | Decarbonizing Aerospace

SUSTAINABLE AEROSPACE TOGETHER

FLEET RENEWAL

OPERATIONAL EFFICIENCY

RENEWABLE ENERGY

ADVANCED TECHNOLOGY

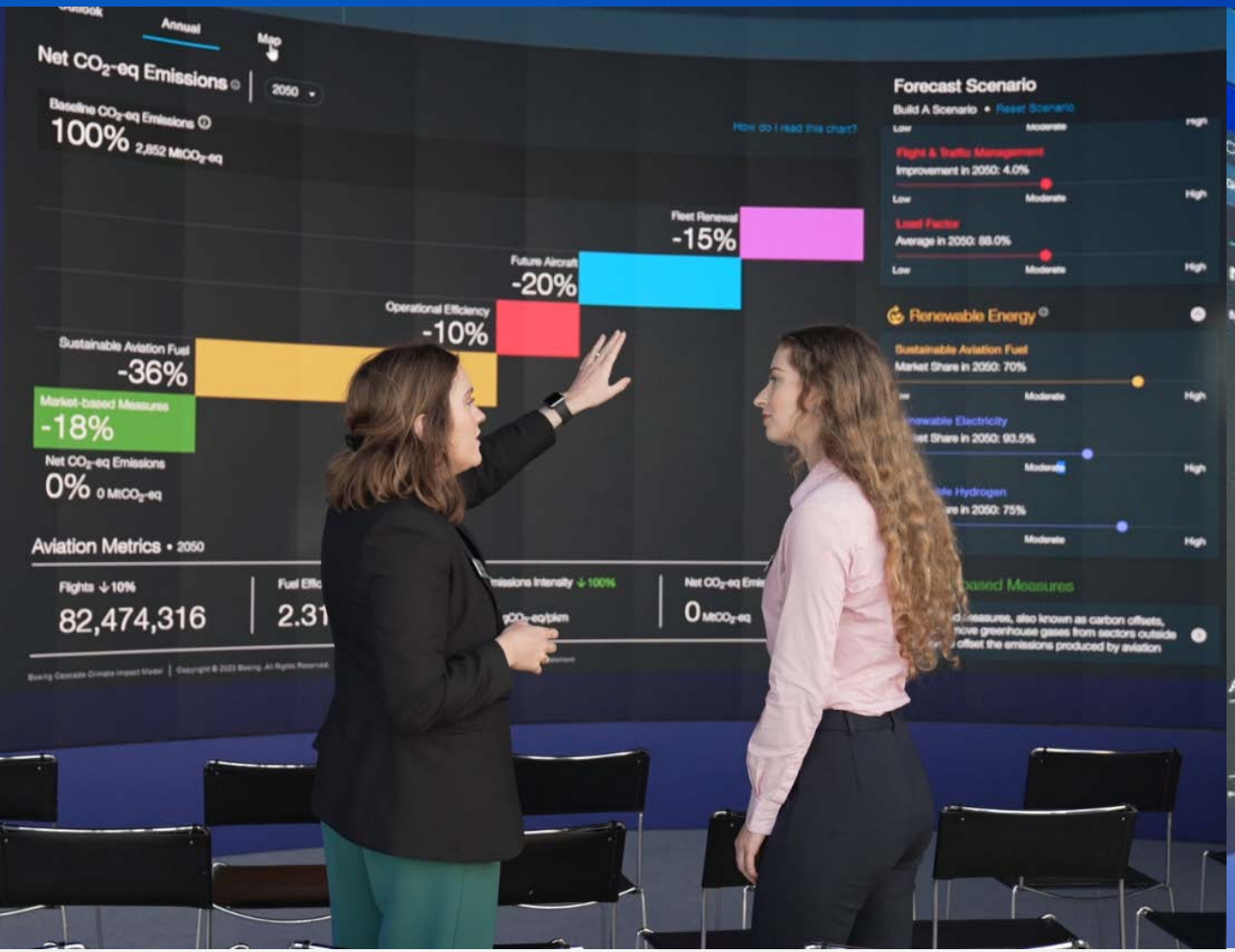
MARKET-BASED MEASURES

CORSIA

CASCADE

BOEING CASCADE CLIMATE IMPACT MODEL

Cascade.Boeing.com



MIT LABORATORY FOR AVIATION AND THE ENVIRONMENT

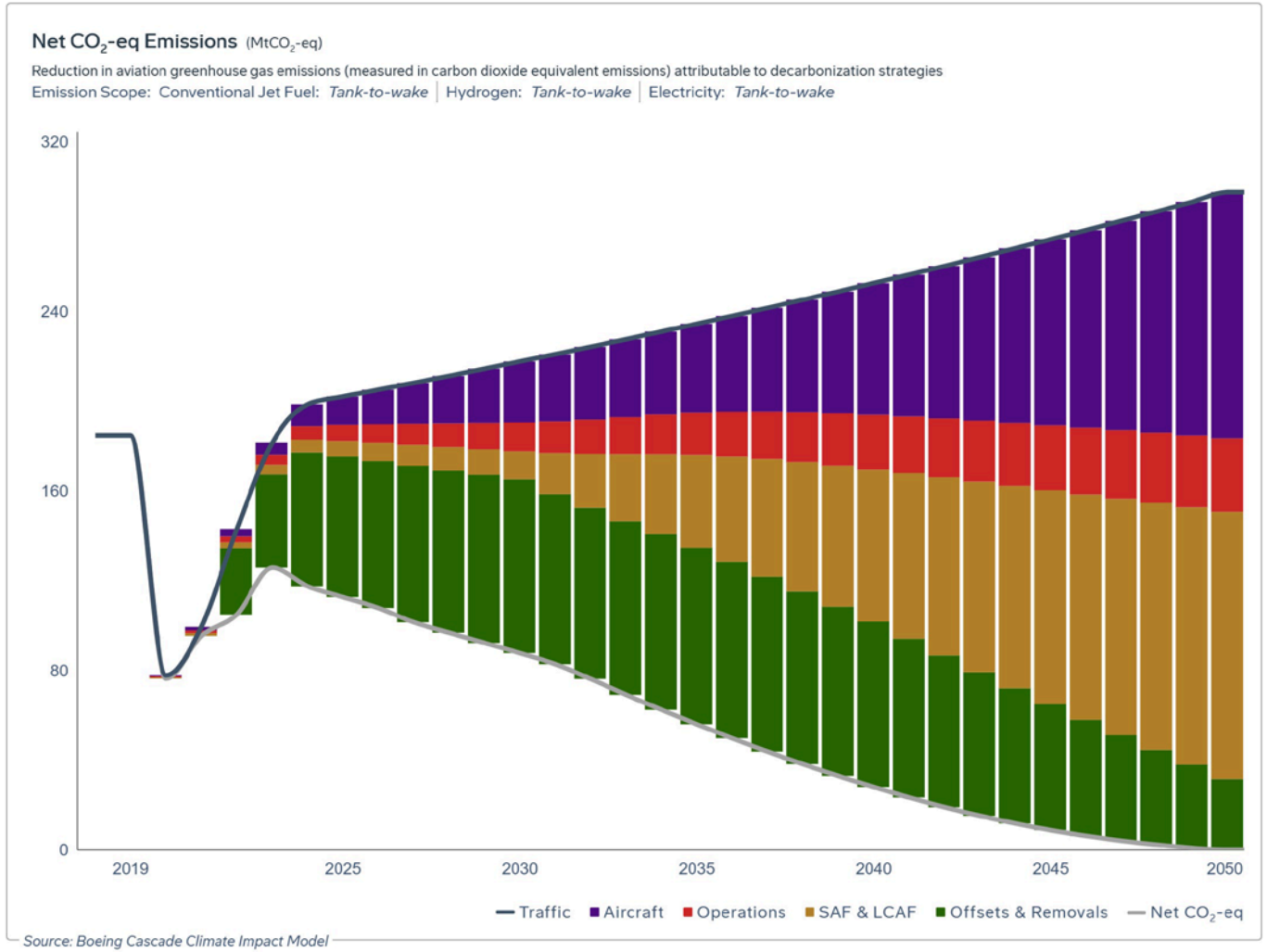
IATA

UNIVERSITY OF CAMBRIDGE

Aviation Impact Accelerator

NASA

A European Outlook- Destination 2050



Emissions
in 2050 ‹ 1/3 ›
0 Mt

Aircraft
in 2050 ‹ 1/3 ›
37%

Operations
in 2050
11%

Energy
in 2050 ‹ 1/5 ›
41%

Offsets & Removals
in 2050 ‹ 1/2 ›
11%

Policy progressions

Climate legislation affecting aviation has escalated significantly since 2023

Fuel Mandates

SAF Mandates

Many countries have enacted sustainable aviation fuel (SAF) mandates which specify the share of jet uplift in a country that must be SAF. Penalties occur for non-compliance.

Abatement Policies & Mandates

Emissions Trading Schemes (ETS)

Market measures which cap emissions and require companies to trade allowances to remain below cap.

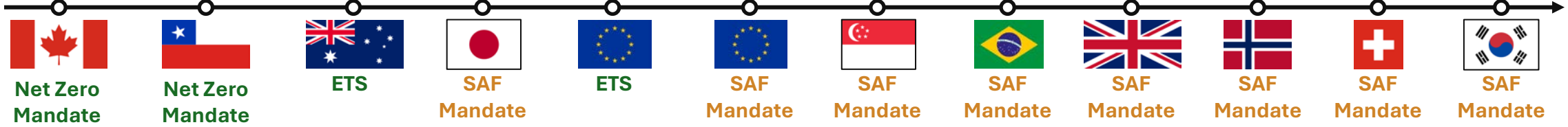
CORSIA

The Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) is an ICAO program to offset emissions from international aviation.

Net Zero Mandates

Many countries have mandated net zero, typically via mandatory Nationally Determined Contributions (NDCs) in support of the Paris Climate Agreement.

Recent Climate Policies Impacting Aviation

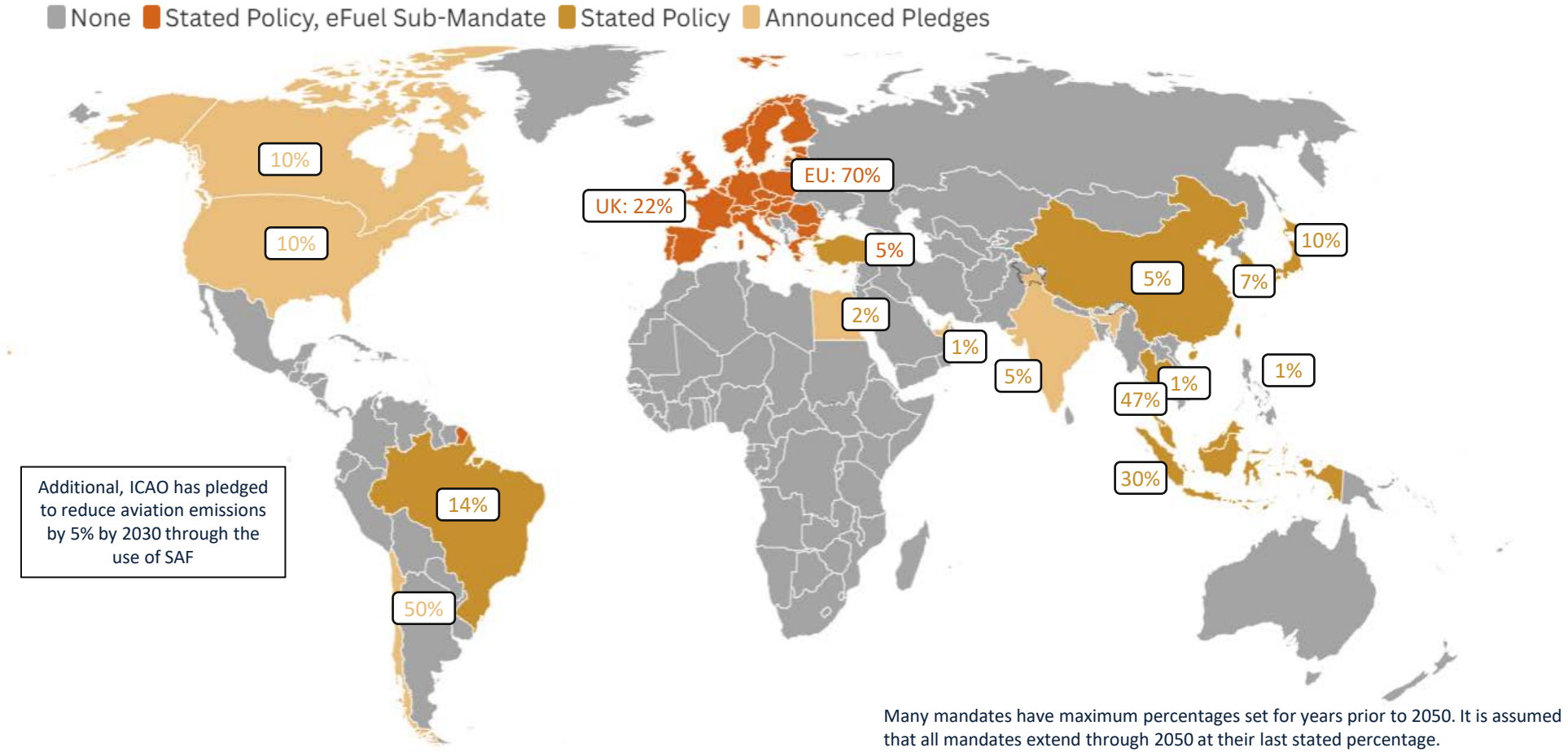


Shown by date enacted and/or date aviation brought into an existing policy. All SAF mandates and a sample ETS & net zero mandates shown.

CASCADE | SAF Policies

Ready for up-lift

SAF mandates are in place or in-development in 38 countries



Additional, ICAO has pledged to reduce aviation emissions by 5% by 2030 through the use of SAF

Many mandates have maximum percentages set for years prior to 2050. It is assumed that all mandates extend through 2050 at their last stated percentage.

CASCADE | SAF Policies

Flavors of Mandates

Only the UK and EU mandate a share of SAF that must be made from electricity and hydrogen (eFuels)

General Mandates

Most SAF mandates specify a share of total fuel uplift that must be SAF. They differ in their application and required emissions reduction relative to fossil jet A.

Example SAF Mandate Approaches

Brazil's mandate only applies to domestic flights

Japan's mandate only applies to international departures

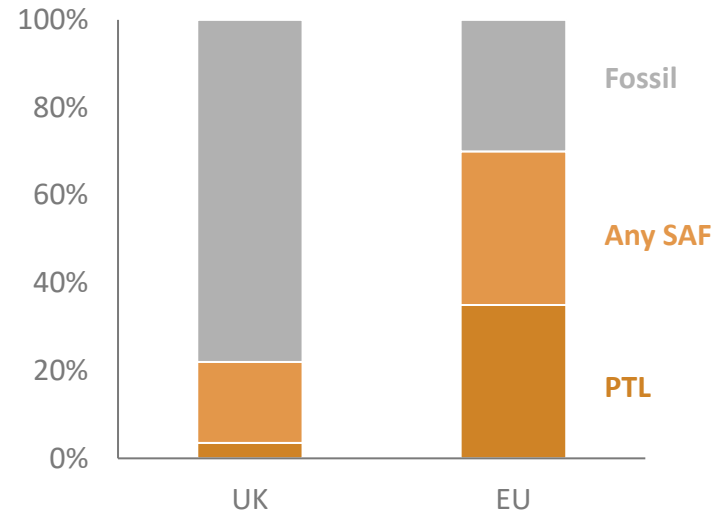
Europe's mandate requires that SAF must achieve at least 70% emissions reduction relative to fossil jet fuel

The UK's mandate is CO_2 –based not volume based; forecasted volumes assume 70% reduction in emissions

Mandates with PTL sub-mandate

Some countries additionally specify a share of the total SAF that must be produced from electricity and hydrogen, which is called Power-to-Liquid SAF.

2050 SAF Mandates with PTL Sub-Mandate

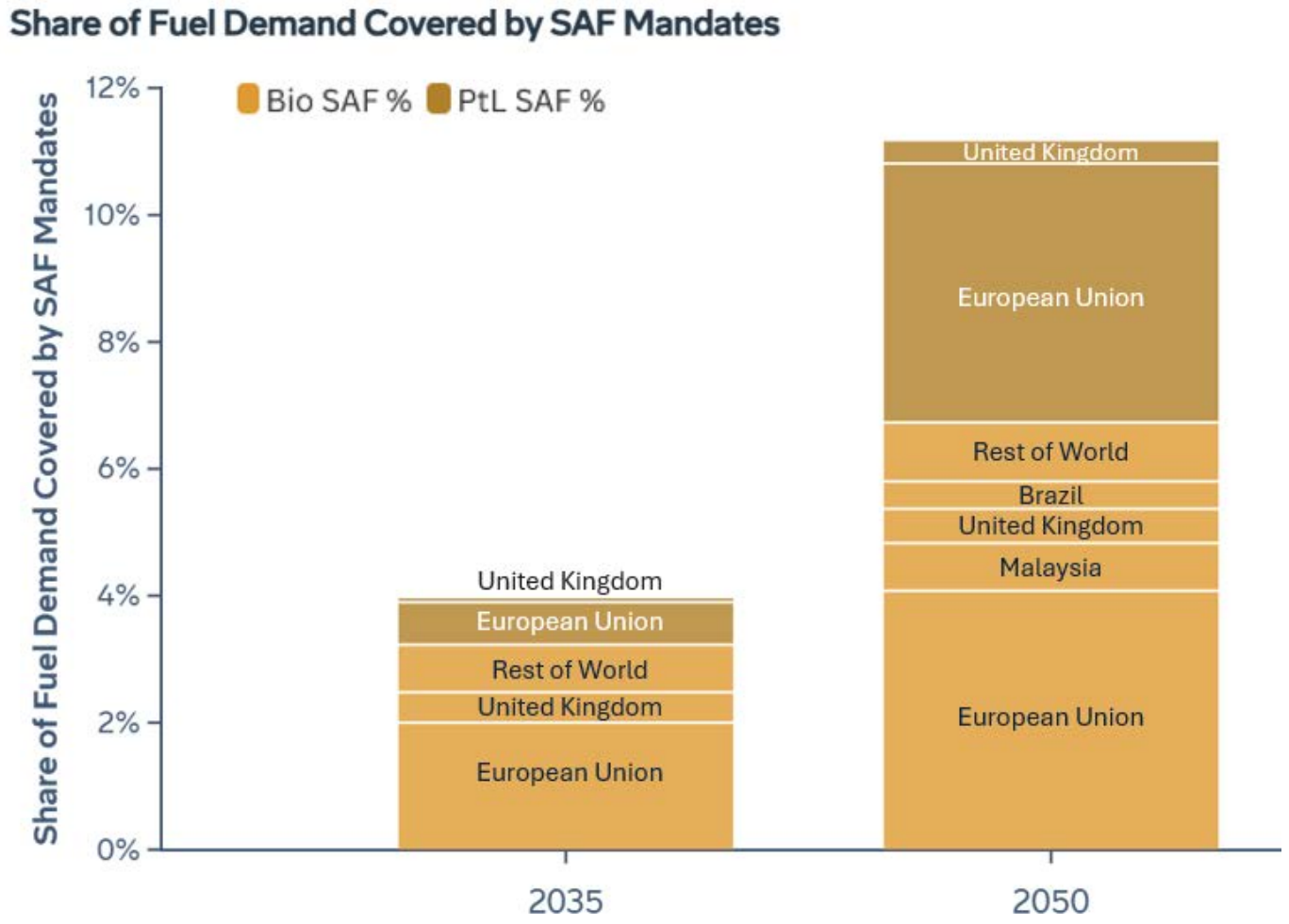


It is assumed that renewable electricity and green hydrogen supply is sufficient for PTL fuel production

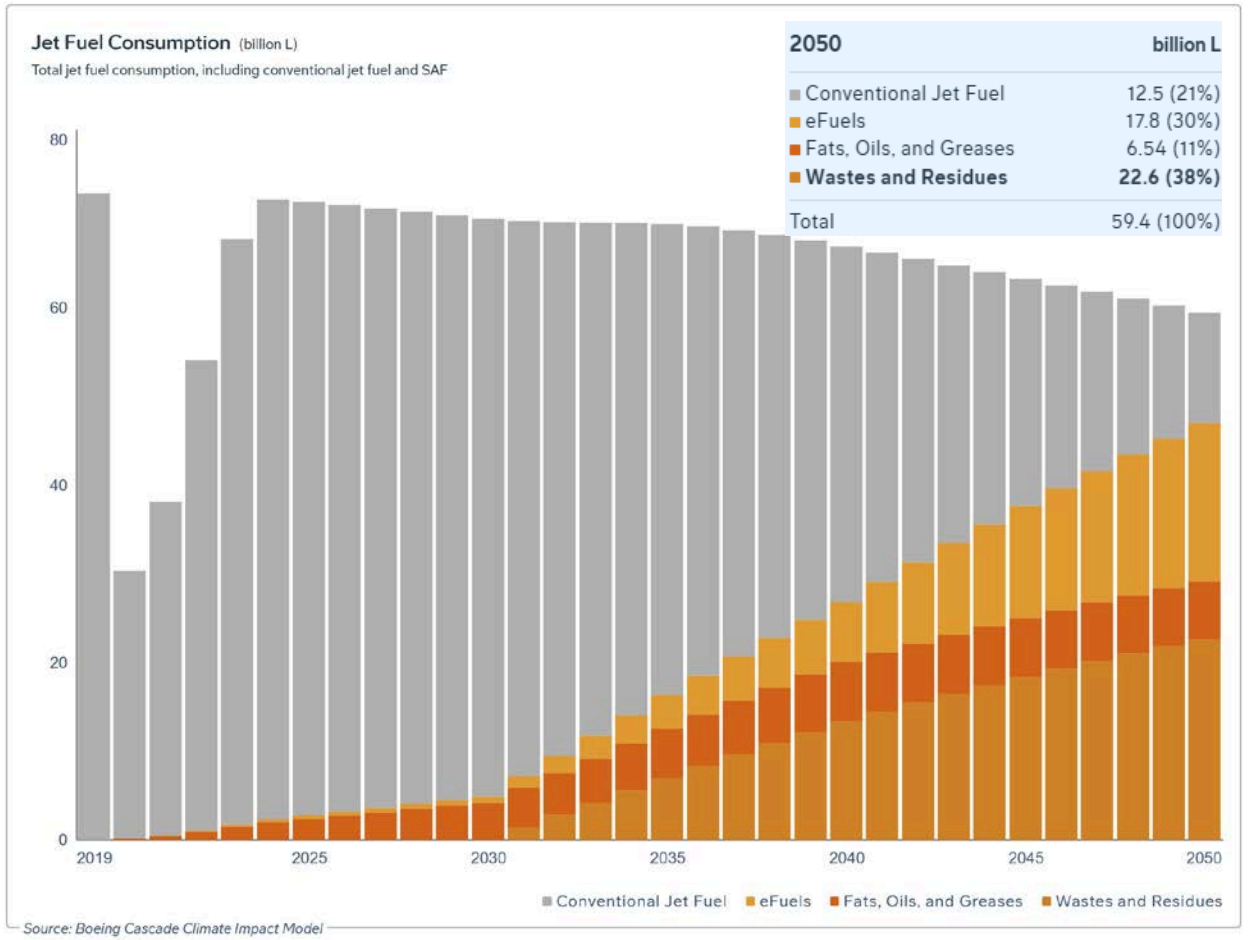
CASCADE | SAF Policies

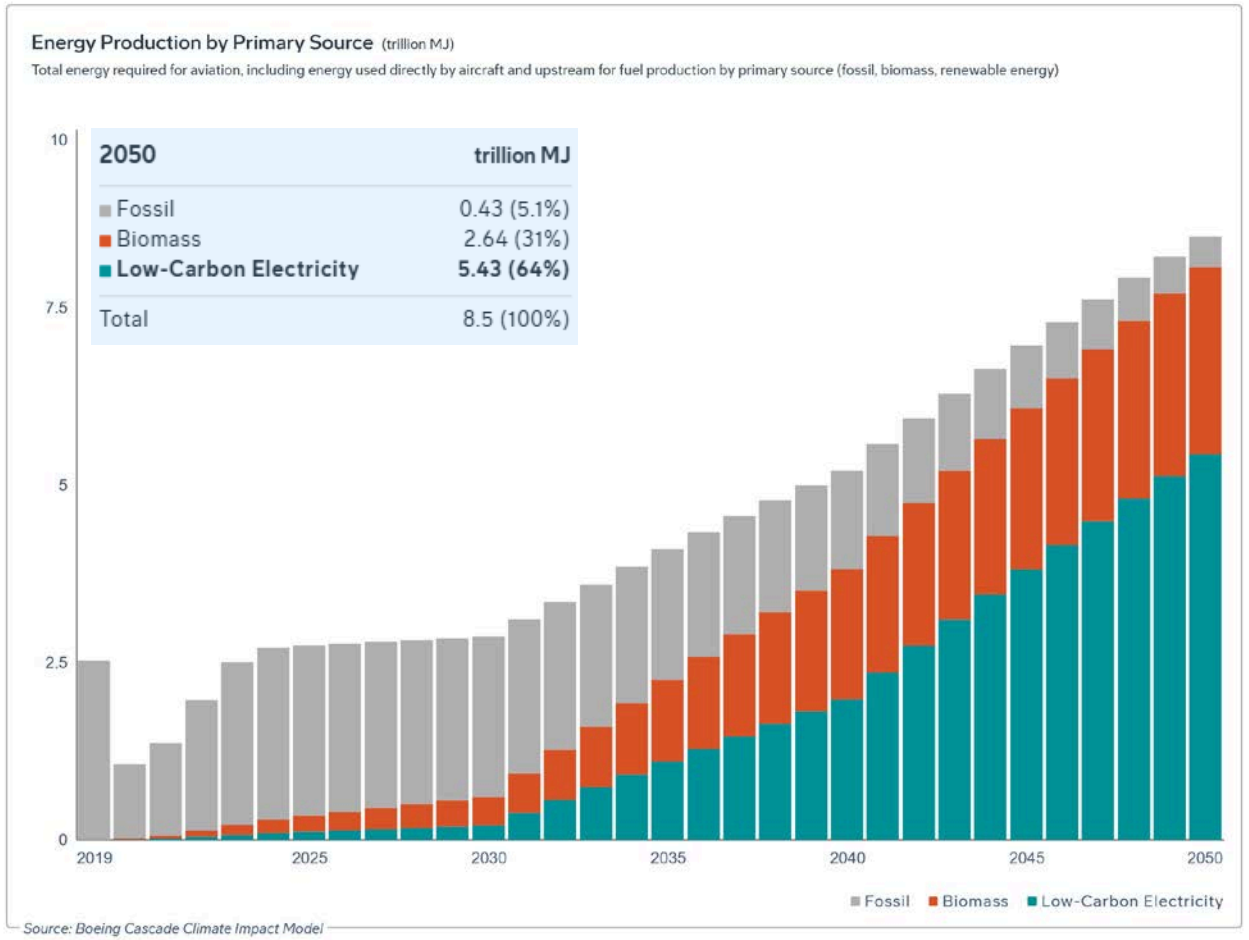
Fueled by SAF

Under stated policies, around 10-12% of jet fuel use in 2050-2065 will be covered by SAF mandates



A European Outlook- Destination 2050





Global SAF supply and demand gap – SkyNRG/ICF

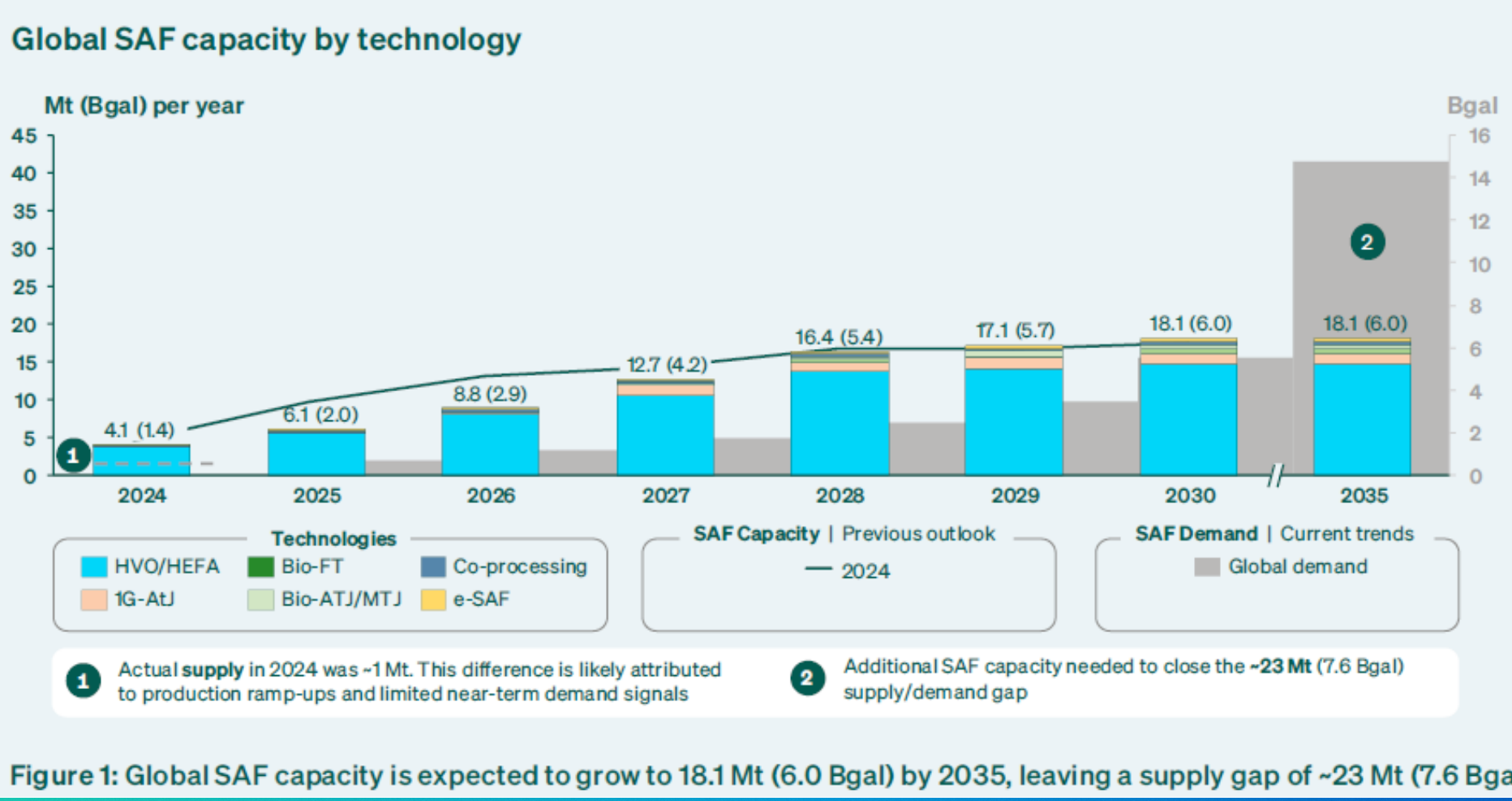
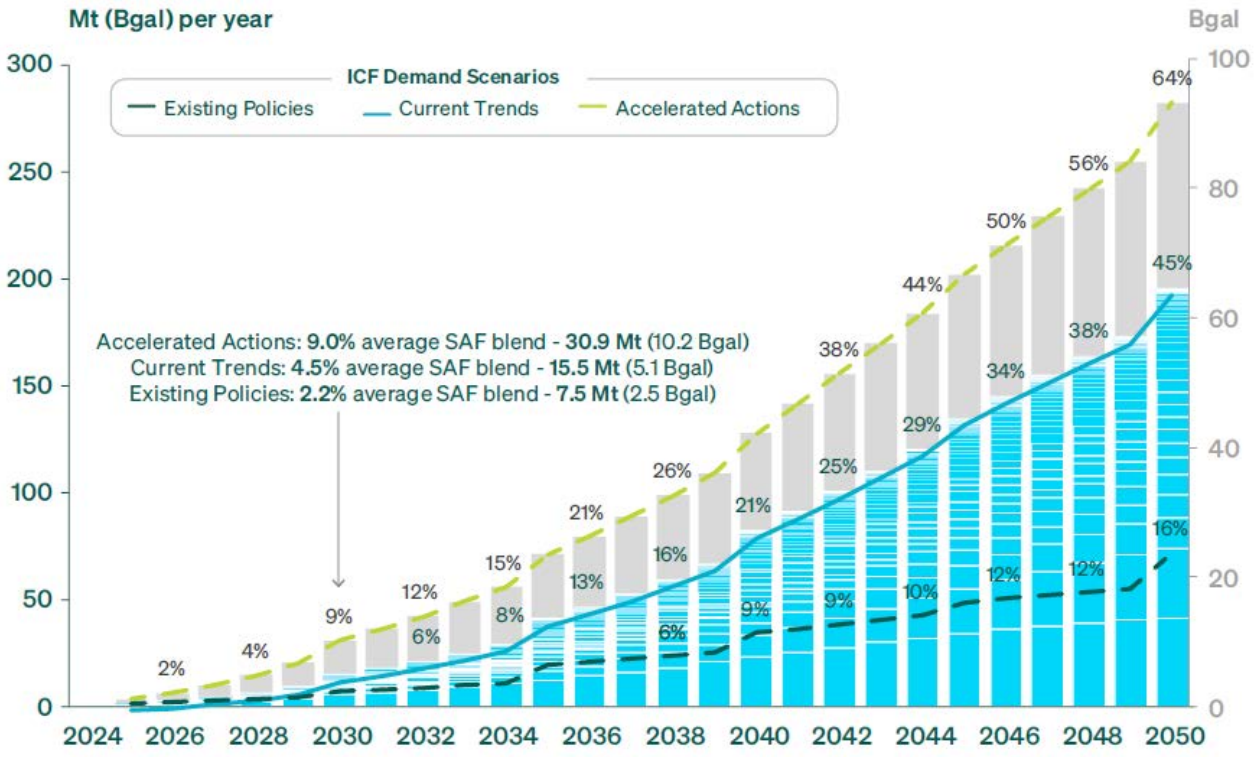


Figure 1: Global SAF capacity is expected to grow to 18.1 Mt (6.0 Bgal) by 2035, leaving a supply gap of ~23 Mt (7.6 Bgal)

- Global SAF **production capacity is projected to reach 18.1 Mt** by 2030. This figure exceeds the expected demand of 15.5 Mt.
- Based on current announcements, there is a projected **supply gap of approximately 24 Mt** by 2035
- **Co-processing** of renewable feedstocks in conventional refineries could yield up to 2 Mt. **Renewable Diesel** could add 4Mt

SAF Global demand 2050 – SkyNRG/ICF

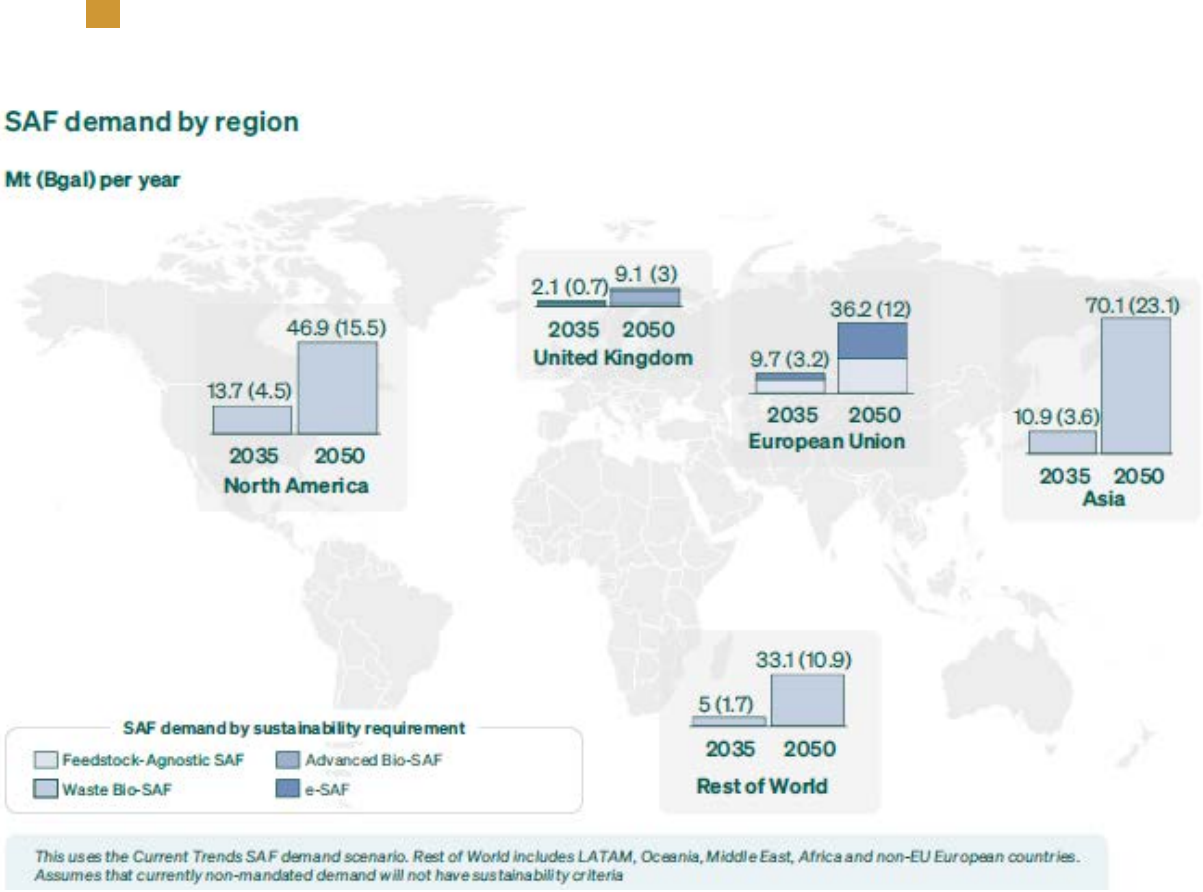
Global SAF demand

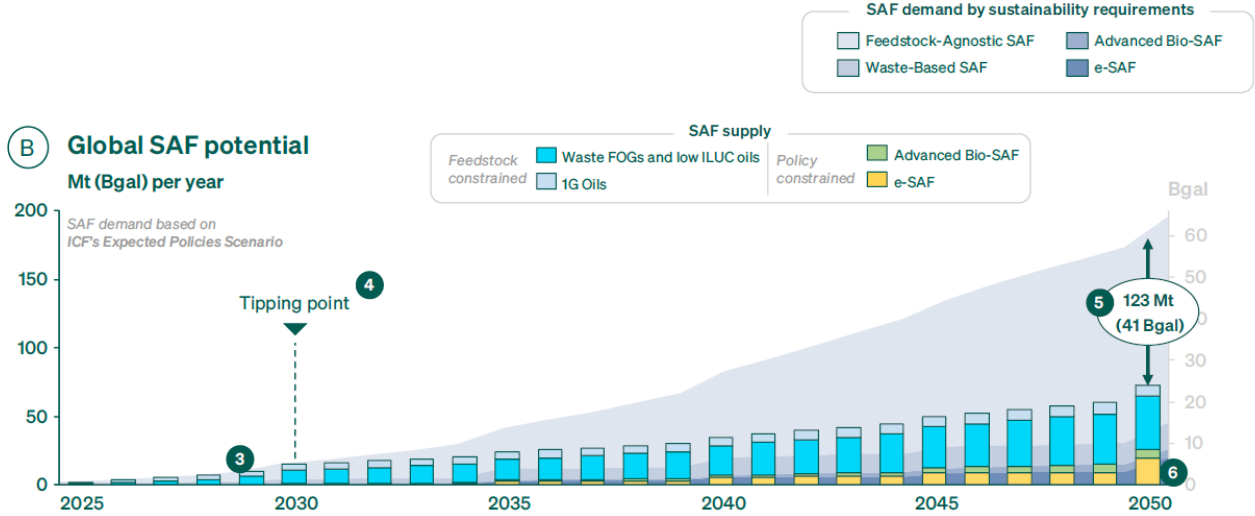


Existing policies assumes that SAF demand only scales to meet policies that are currently in place. Current Trends assumes that all announced pledges and national targets are met, including those that do not currently have implementation plans. Accelerated Actions assumes additional policies coming in place to encourage net-zero and meeting of global targets, such as CAAF/3.

SAF demand and capacity by region[C]

SAF demand by region and feedstock – SkyNRG/ICF



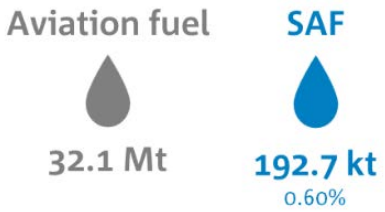


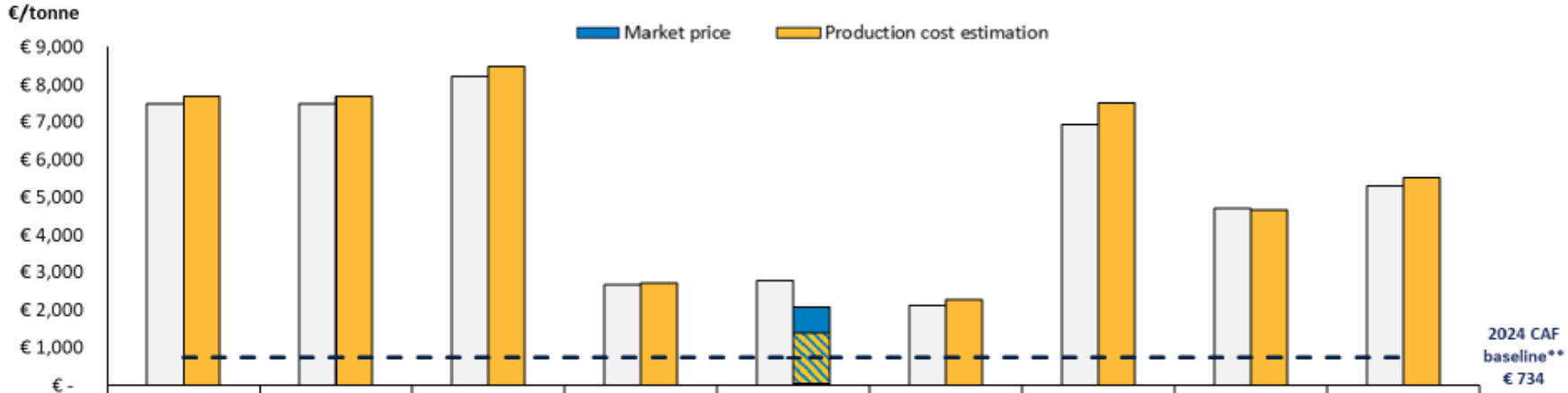
- The majority of global demand currently falls in the feedstock-agnostic category—accounting for approximately 75%
- Regional SAF demand and capacity show undersupply in most regions by 2035, except for LATAM
- HEFA technology accounts for 82% of projected global SAF production capacity by 2030. Long-term scalability is constrained by the limited availability of sustainable oils and fats.

CASCADE | EU SAF PRICES 2024

Mind the gap

2024 average prices per RFEUA aviation fuels category





	Synthetic aviation fuels from industrial CO_2	Synthetic aviation fuels from biogenic CO_2	Synthetic aviation fuels from atmospheric CO_2	Advanced aviation biofuels	Aviation biofuels *	Recycled carbon aviation fuels	Renewable H_2 aviation fuels	Low-carbon H_2 aviation fuels	Synthetic low-carbon aviation fuels
2023	€ 7,500	€ 7,500	€ 8,225	€ 2,675	€ 2,768	€ 2,125	€ 6,925	€ 4,700	€ 5,300
2024	€ 7,695	€ 7,695	€ 8,470	€ 2,715	€ 2,085	€ 2,280	€ 7,520	€ 4,655	€ 5,525

**The bar with blue and yellow stripes represents the 2024 production cost estimation for aviation biofuels (provided for informational purposes).*

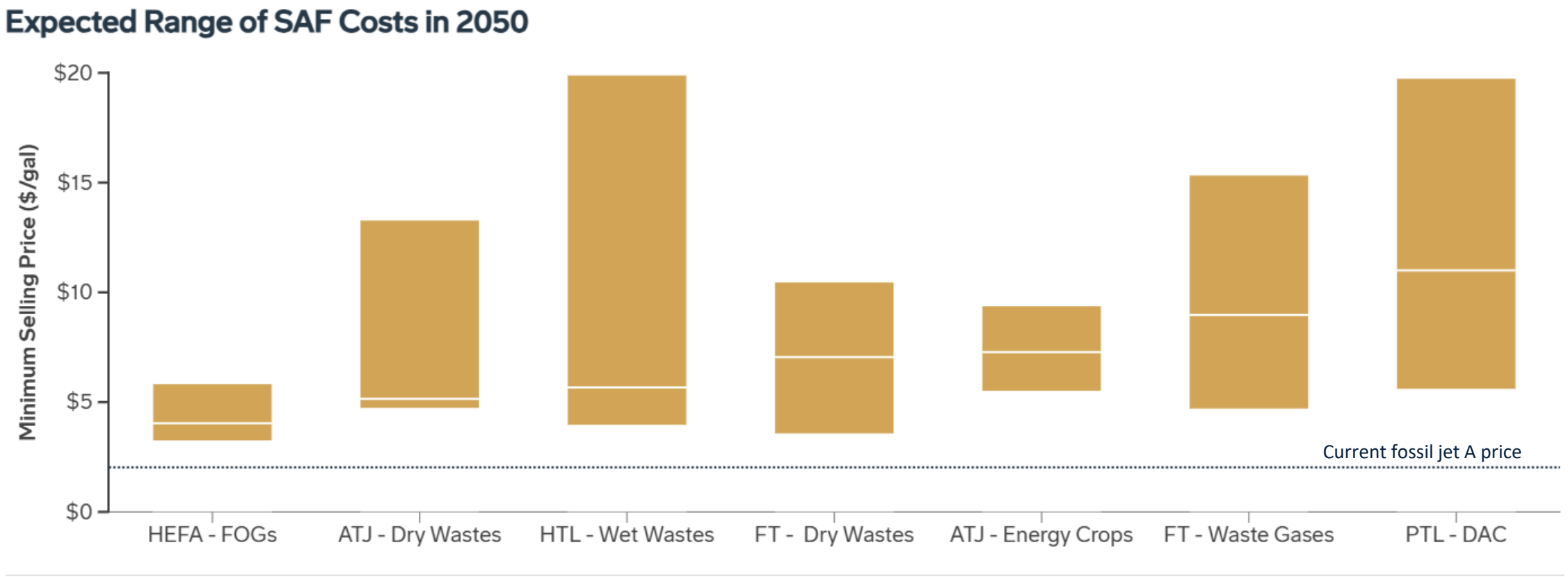
*** For reference: The 2023 CAF price was 816 €/tonne.*

Other issues:

- 98% biofuels (used cooking oil, 81%).
- 69% originated from non-EU countries – China (38%)
- Fewer than ten aviation fuel suppliers accounted for 80% of supply
- Five Member States accounted for 99% of the total amount supplied

CASCADE | Cost Assumptions

Mind the gap



Minimum selling price, which excludes profit margin, taxes, distribution, and blending costs; assumes average carbon intensity of each feedstock-pathway combination based on literature; jet A price provided by Sales & Marketing Airline Financial & Economic Analysis; 2025 $
HEFA = Hydroprocessed Esters and Fatty Acids Synthesis; FOGs = fats, oils and greases; ATJ = Alcohol-to-Jet synthesis; HTL = Hydrothermal Liquefaction; FT = Fischer-Tropsch synthesis; PTL = Power-to-Liquid synthesis; DAC = direct air capture

CASCADE | SCALING UP SAF

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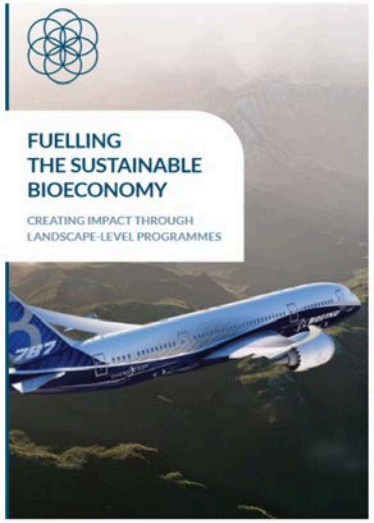
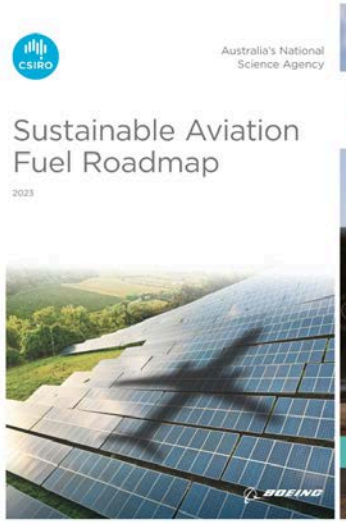
SAF ROADMAPS





TÜRKİYE SUSTAINABLE AVIATION ALLIANCE

RSB

ACT CORSIA

Investment in SAF Production

FIREFLY

SKYNRG

WAGNER SUSTAINABLE FUELS

norsk e-fuel

Technical research & symposiums

CSATS
CASCADE SUSTAINABLE AVIATION TECHNOLOGY SYMPOSIUM

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

NASA

UNIVERSITY OF CAMBRIDGE

BOEING

Ensuring 100% SAF Capability

PATH FORWARD

- The **conversion of solid biomass to fluid intermediates** has been a large obstacle to previous commercialization attempts (e.g. cellulosic ethanol). Develop standardized intermediates + conduct R&D on processes to creating these. This will derisk investments in processing infrastructure, facilitate access to logistics networks, consolidate number of certifiable pathways needed.

- **Feedstock supplies** are limited + **existing product slates** do not favor SAF. Develop new feedstock types that are tailored towards SAF (e.g. new oilseed varieties) + conduct research on improvements (to the HEFA process e.g.) that improve yields.

- SAF projects are **struggling to reach FID**. Assess and develop fundable business cases for SAF production, including a framework for quantifying the total economic value of a project (including co-benefits), assessment of the voluntary market size, and analyze actions that have enabled willingness to pay. Policy support and financial incentives seem to be a driving factor (i.e. Revenue Certainty Mechanism)

Conclusions

- By 2030, the HEFA feedstock potential will be outpaced by the global SAF demand, resulting in a growing supply gap after 2030. Long-term biomass supply uncertainty is less important than current inability to mobilize biomass
- The potential for advanced bio-SAF is high, mainly due to relative low cost and feedstock abundance.
- Lack of market signals to incentivize potential producers throughout the value chain (farmers, refiners, etc.)
- Asia might turn from net exporter to importer as new policies foster internal SAF consumption
- Europe will continue as net-importer with vulnerabilities and dependencies from external feedstock and price fluctuations
- FID: High cost premium makes investment risky (esp. without a supportive incentive or policy structure)

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- Commercial Market Outlook https://www.boeing.com/commercial/market/commercial-market-outlook#overview