Sustainable Aviation Fuels

An overview of potential and challenges for developing economies

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Outline

1. Aviation Decarbonization Challenge
2. Aviation Decarbonization Levers – with focus on SAF
3. Ongoing SAF Activities at the WGB – Africa

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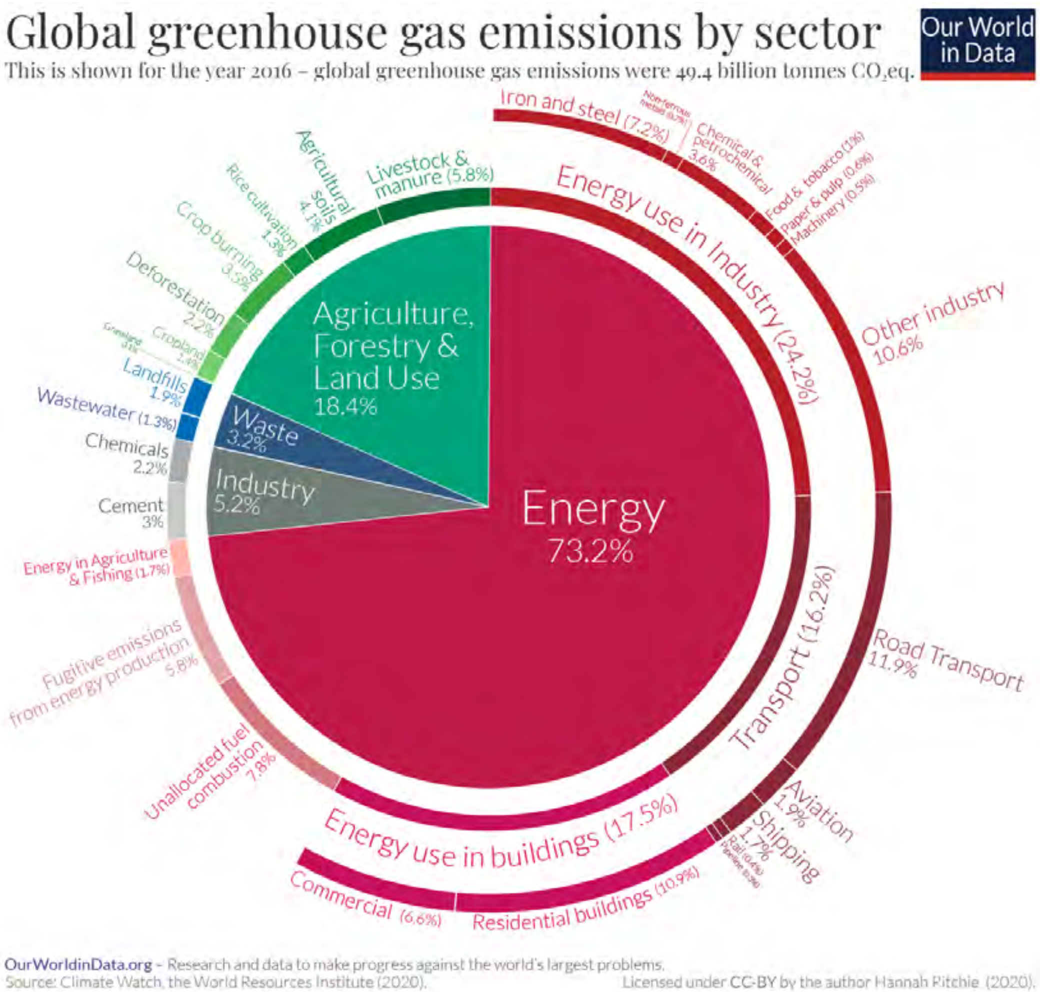
The Decarbonization Challenge in Aviation



- Aviation contributes roughly 2% to global greenhouse gas emissions.
- With regard to radiative forcing, when including contrail-cirrus, the share could be as high as 4%.

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The Decarbonization Challenge in Aviation

HARD TO ABATE

A GROWING SECTOR

BUSINESS AS USUAL (MORE EFFICIENT PLANES) NOT ENOUGH

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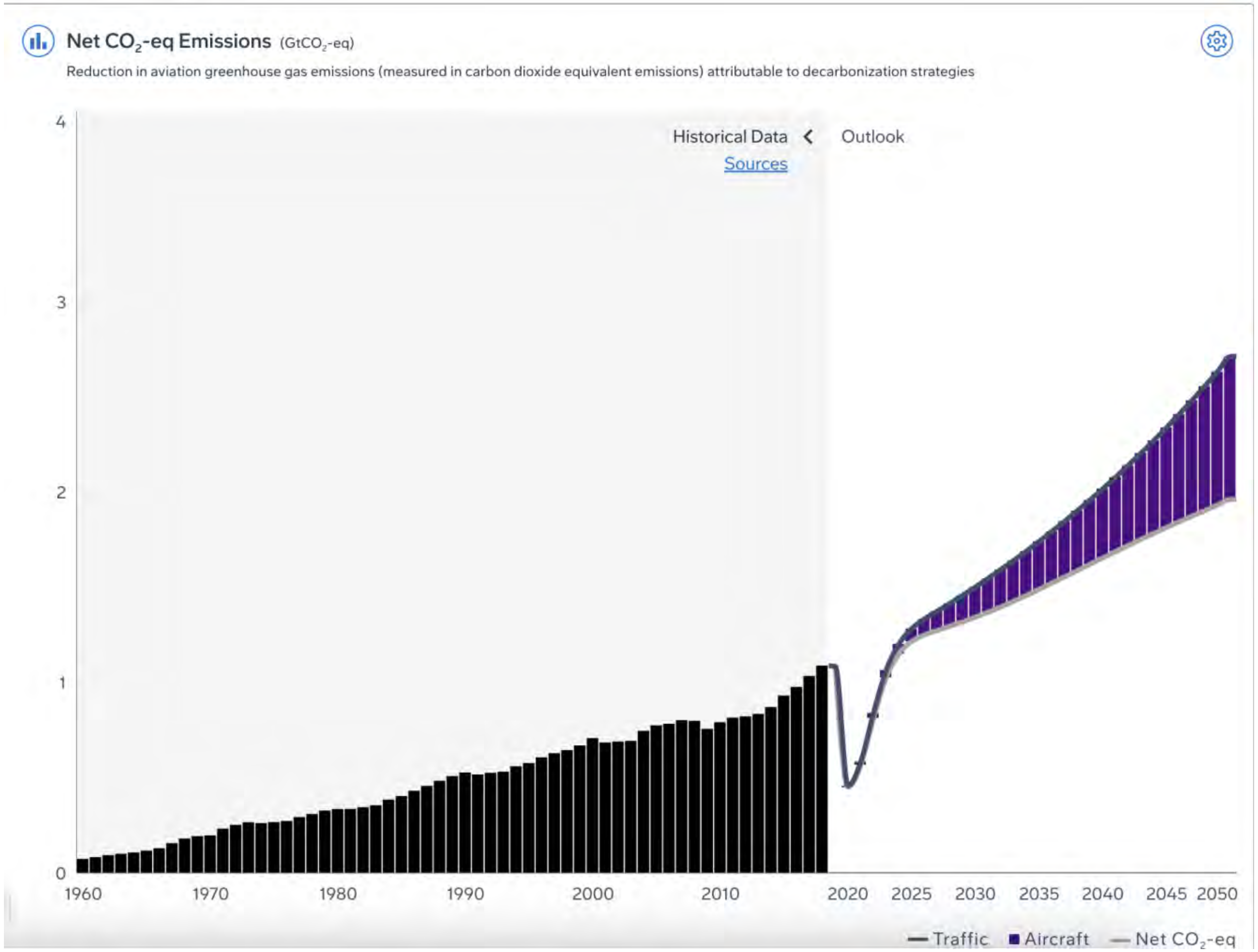
Emission Development with a business-as-usual approach



Visual created using Boeing's Cascade tool, Business As Usual Scenario, assuming no operational improvements, and no SAF usage and evolutionary new aircraft development. Traffic forecast: 3% p.a.

In a business-as-usual scenario, annual aviation emissions would largely double by 2050 compared to 2024, **to 2 million tons of CO_2 per annum**.

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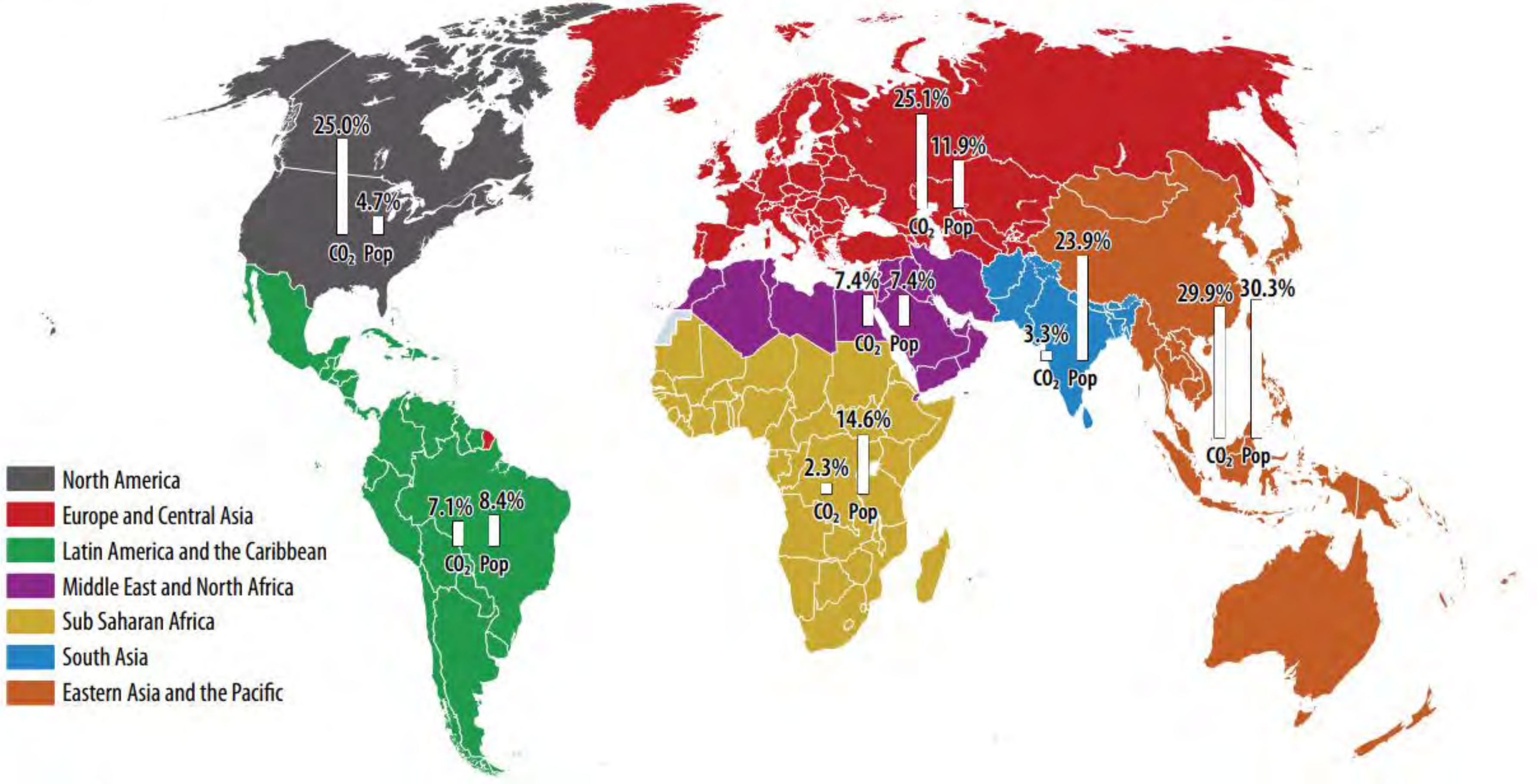
East Asia & Pacific's Aviation Emissions Align with Population

But High-Income Countries Still Dominate Emissions Despite Smaller Populations

Figure 1.1. CO_2 Combustion Emissions of Aviation and Population, by Region



Source: The Role of Sustainable Aviation Fuels in Decarbonizing Air Transport (World Bank 2022)

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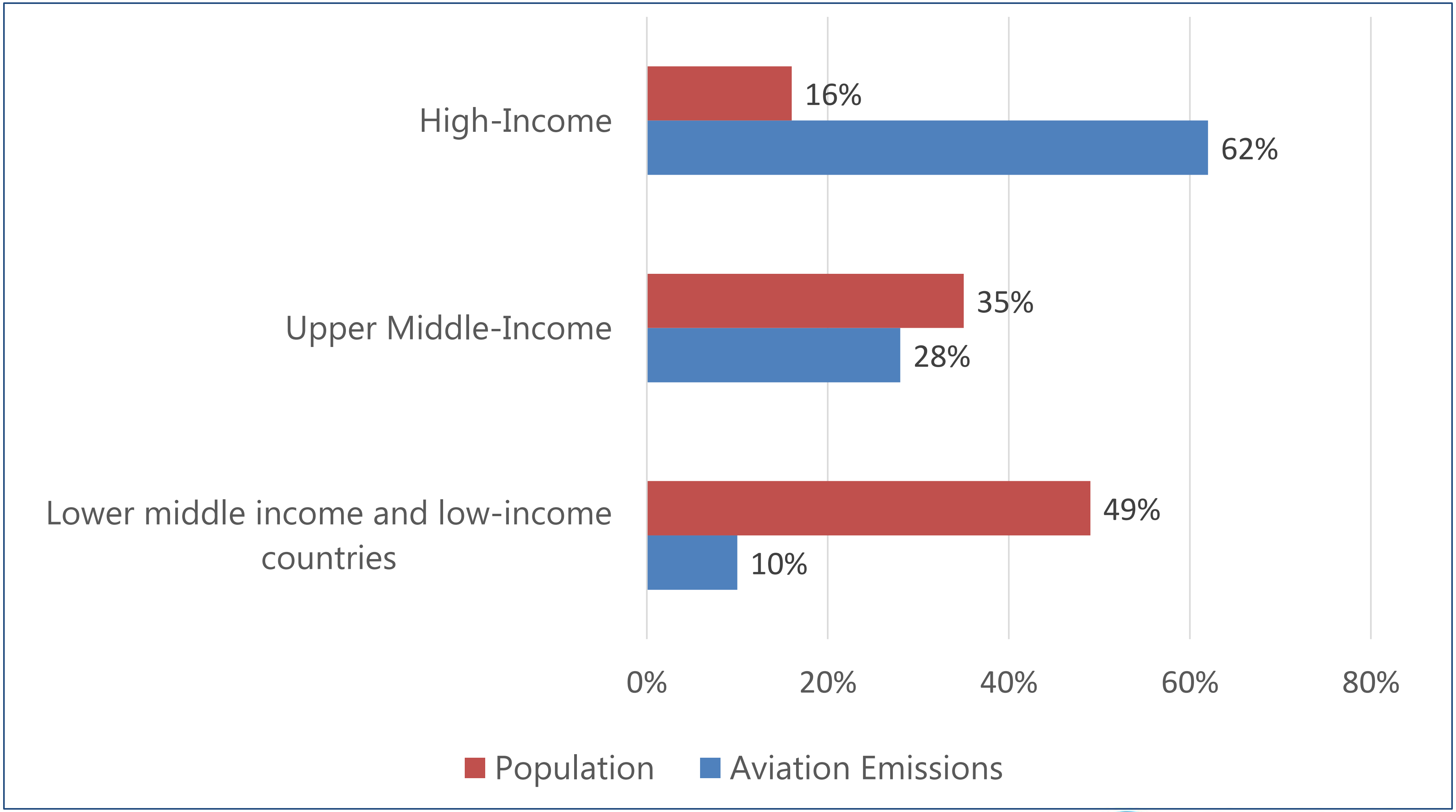
Most of the CO2 emissions from aviation operations have been caused by flights originating in high income countries



Source: Graver et al., 2019

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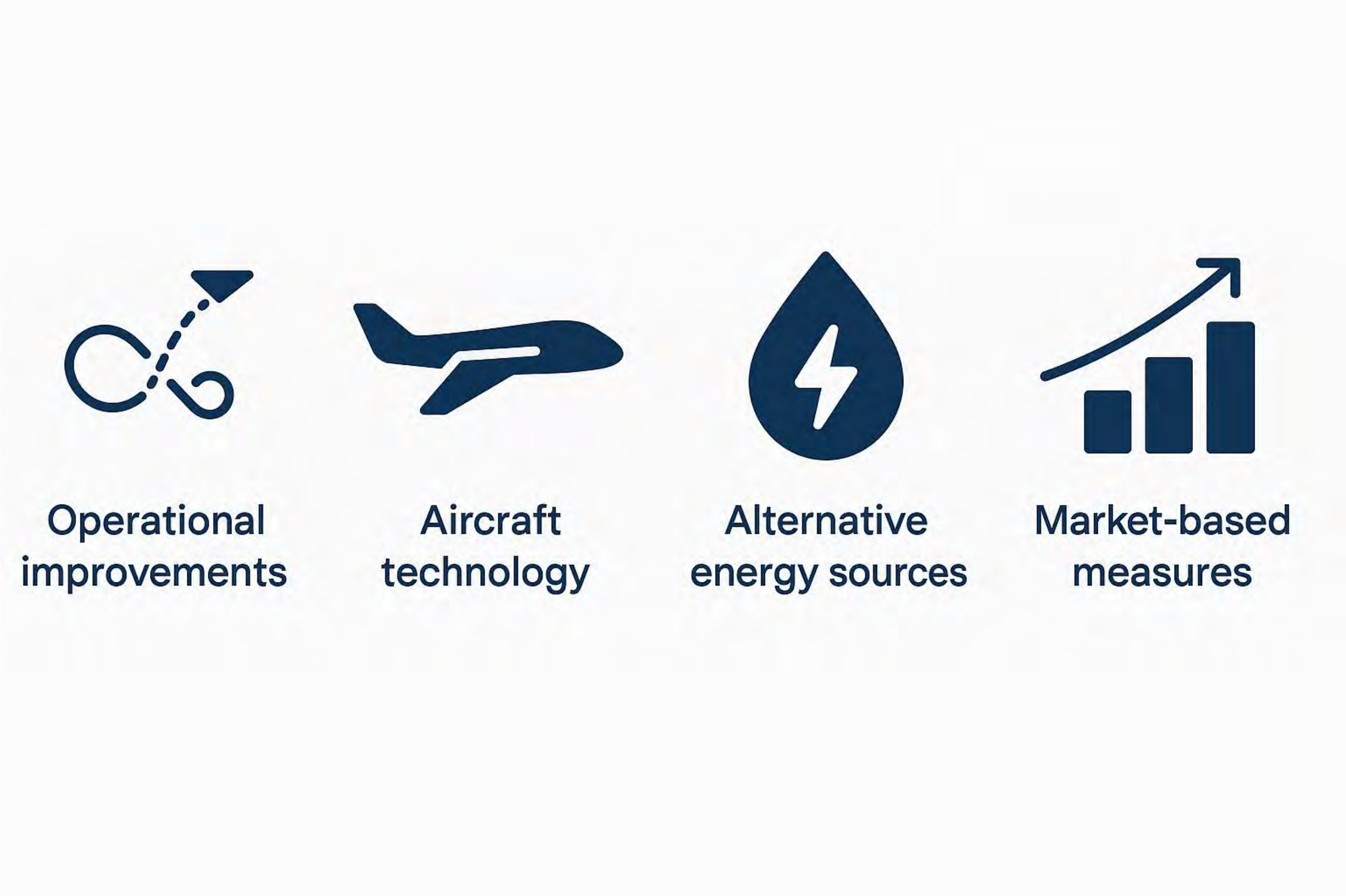
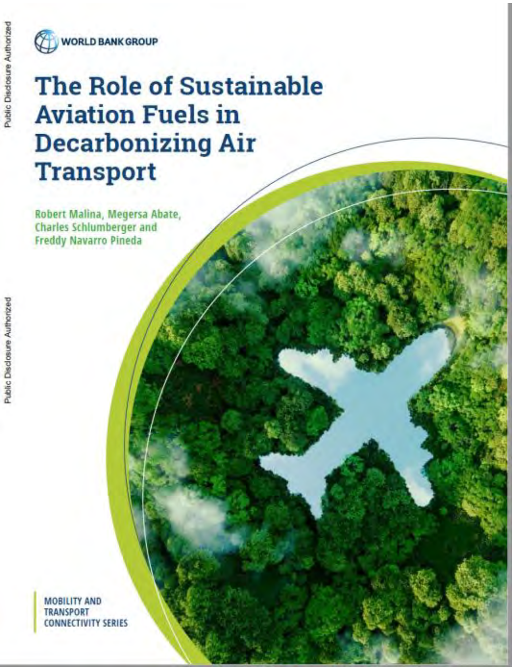
Decarbonization levers



World Bank Report: The Role of Sustainable Aviation Fuels



Key Findings

1. **By 2050, SAF production could reduce aviation GHG emissions by up to 58% compared to current levels**, but this requires strong policy support, especially in developing countries.

2. **Most SAF production efforts are focused in OECD areas,** which puts developing nations at a disadvantage and prevents them from reaping significant economic, environmental, and social benefits.

3. **Developing nations risk being "left behind" regarding SAF access.** There is currently no organized effort to explore and evaluate the SAF potential in these countries, despite the availability of sustainable biomass and renewable energy resources.

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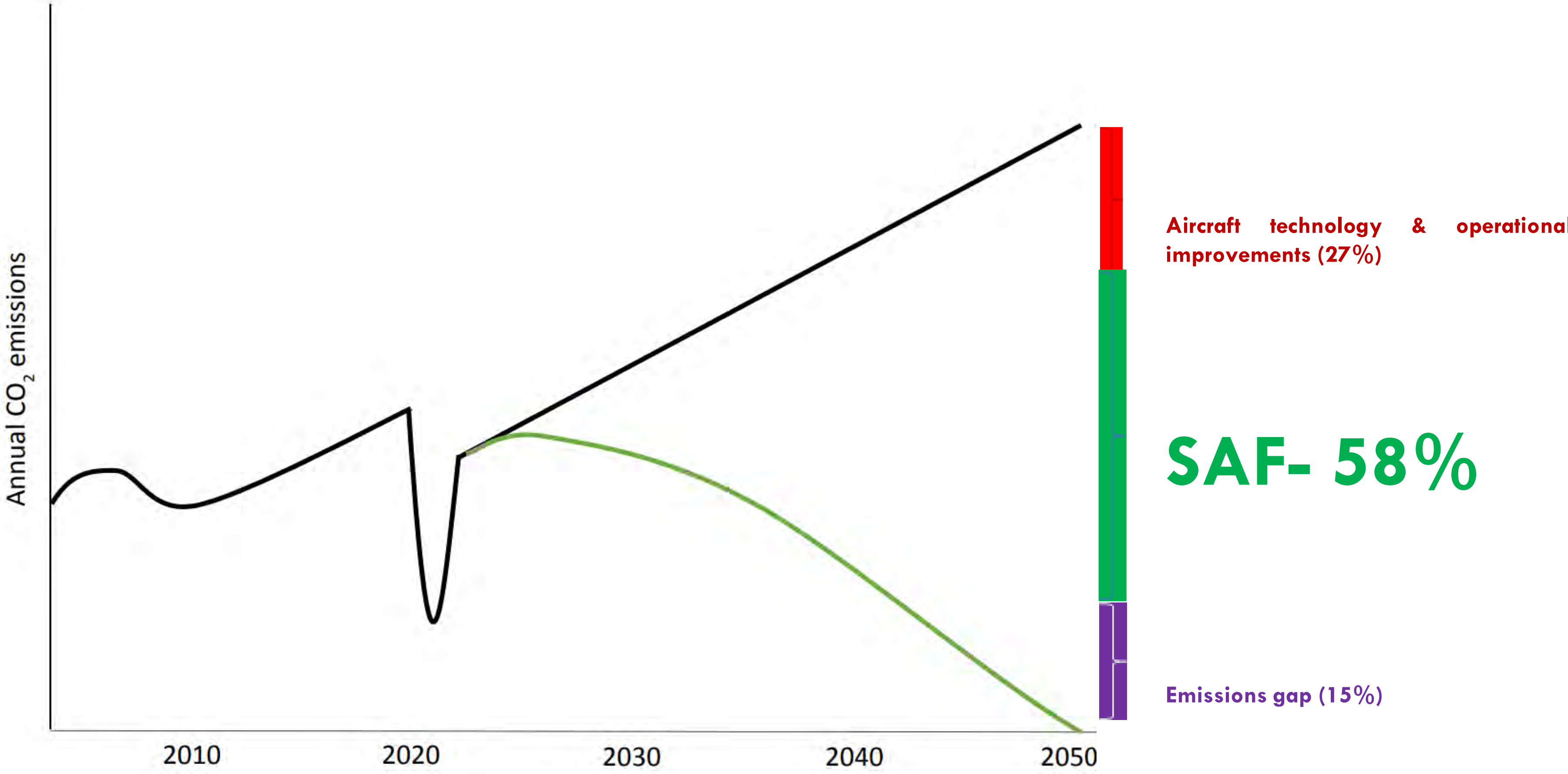
SAF Is Key Lever to Get Aviation to Net Zero

Tech and operational improvement will also play key roles

Levers for net-zero aviation



Source: The Role of Sustainable Aviation Fuels in Decarbonizing Air Transport (World Bank 2022)

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What is SAF?

SAF is a group of **liquid fuels** from non-petroleum sources that are **certified to be used in existing aircraft engines** and that **fulfil a set of sustainability criteria.**

SAF are drop-in fuels that can usually be used up to 50% blend, but there has been test flights with 100% SAF.

SAF is made by heterogenous set of technologies regarding feedstock & conversion technologies: **Biomass to Liquid, Waste to Liquid and Power to Liquid**.

SAF's CO_2 reduction can be as high as 100% (or more), on a lifecycle basis, compared to conventional jet fuel from petroleum, but it can also be lower.

*The term SAF applies to the blended fuel. The "neat" component is actually called "**Synthetic Blend Component**" (SBC). In practice the term SAF is often also used for the non-blended, neat product and that is how we refer to it, also in this presentation.*

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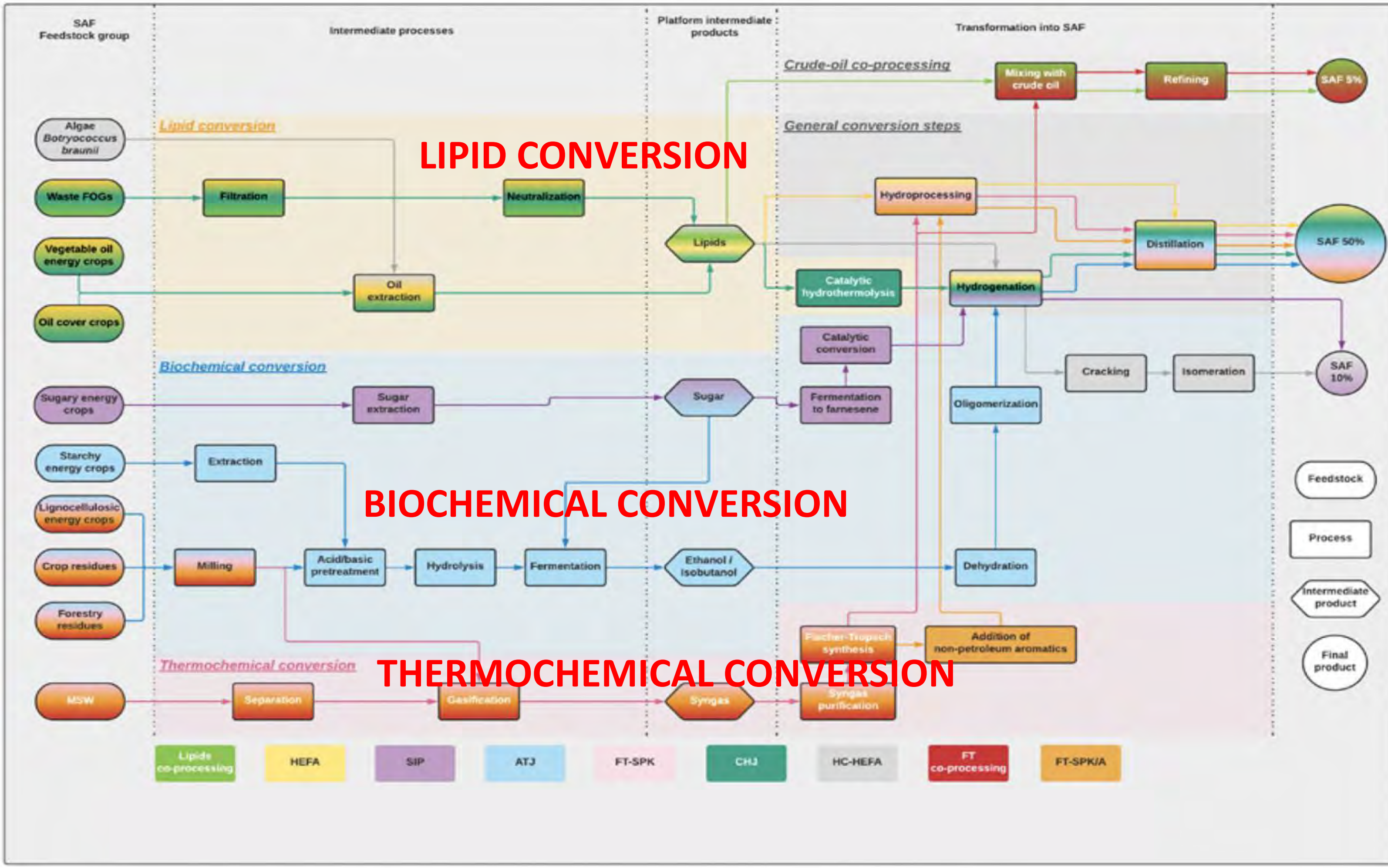
Approved SAF Pathways



Source: Original figure produced for this publication.

This flow diagram shows 9 SAF pathways that are ASTM-certified for use in jet engines. PtL via FT not explicitly shown.

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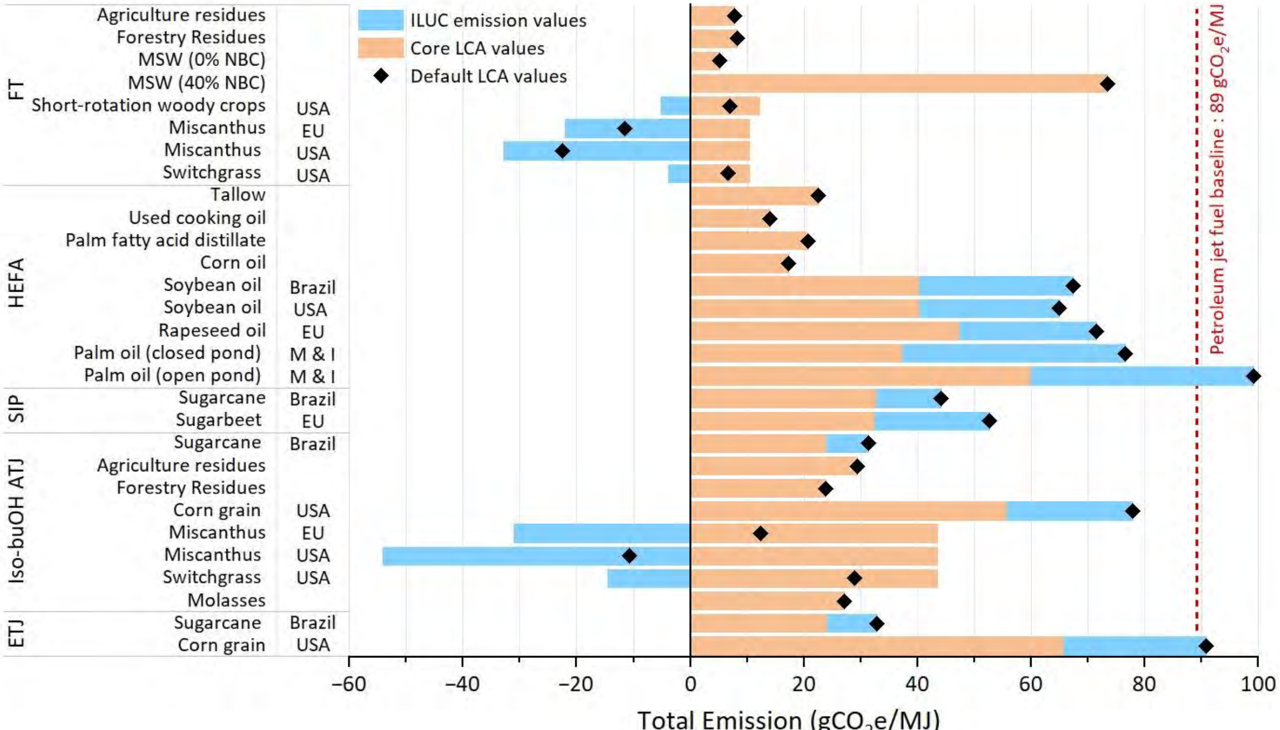
Lifecycle greenhouse gas emissions of SAF

- The **emission benefit of SAF** is **highly heterogeneous** and depends on many different factors, like, for example, the type of feedstock, type of farming (where needed), magnitude of land change (if relevant), conversion efficiency, type and amount of utilities required during feedstock production/extraction, and feedstock conversion).

- ICAO has established so-called "**default values**" for the lifecycle GHG emission intensity of SAF for use in its Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).

- Generally, SAF using **waste, residues**, or feedstock that can grow on **marginal lands** has the **highest emission benefit** within CORSIA.



Prussi et al., 2021

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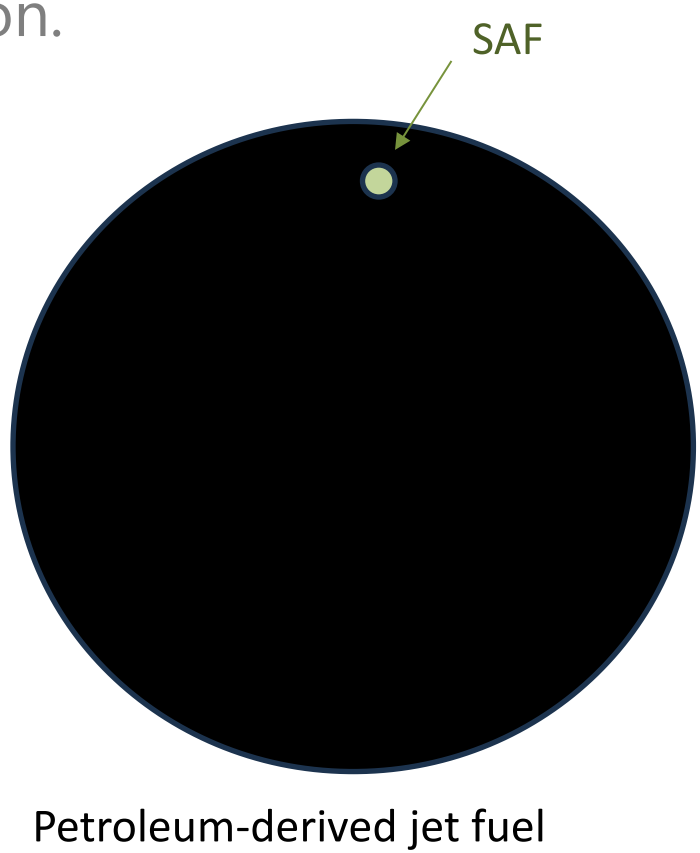
Current SAF production

In 2024, SAF production volumes reached 1 million tonnes (1.3 billion liters), double the 0.5 million tonnes (600 million liters) produced in 2023. In 2024, SAF accounted for 0.3% of global jet fuel production.

Source: IATA



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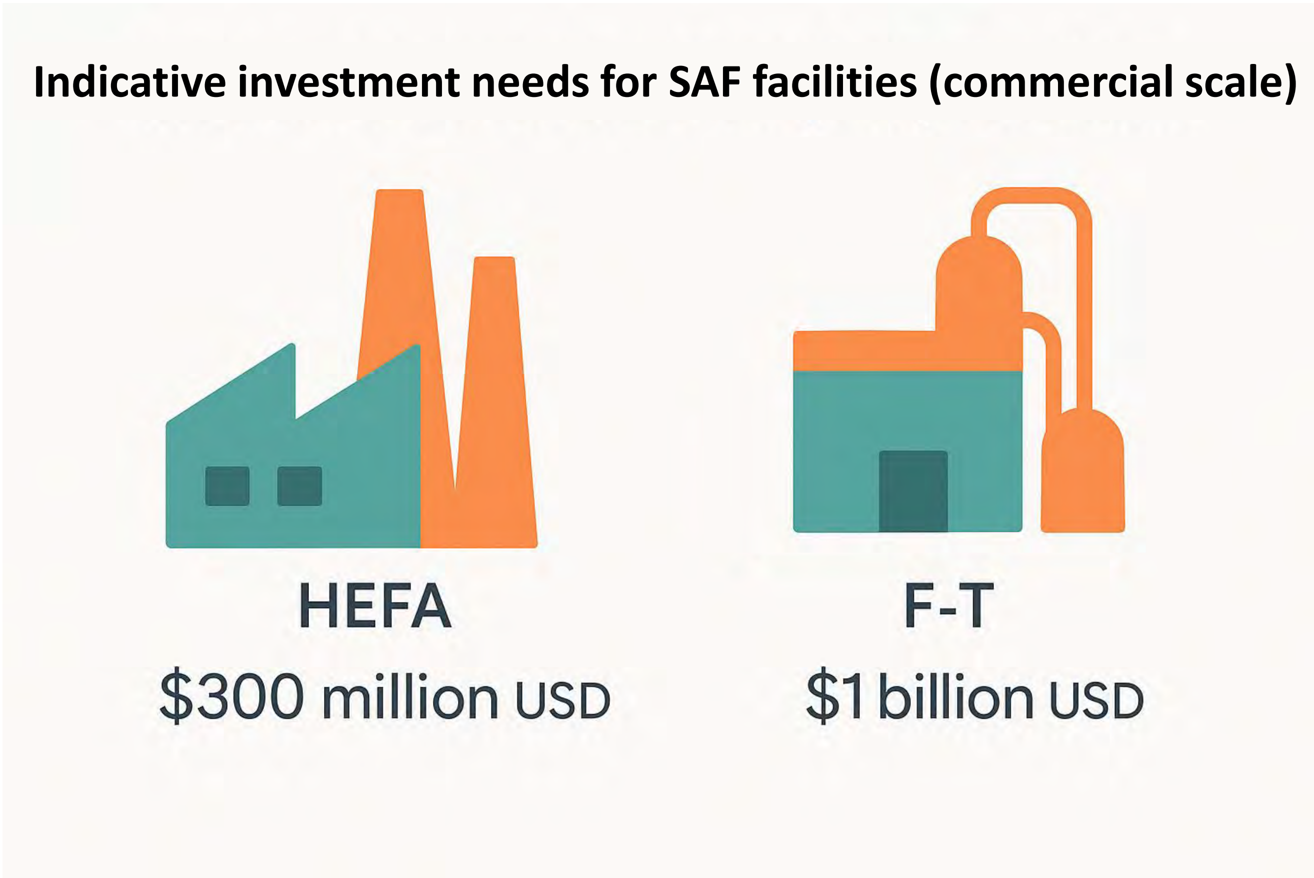
High construction costs of SAF facilities



Indicative numbers, only, based on typical commercial sizes.

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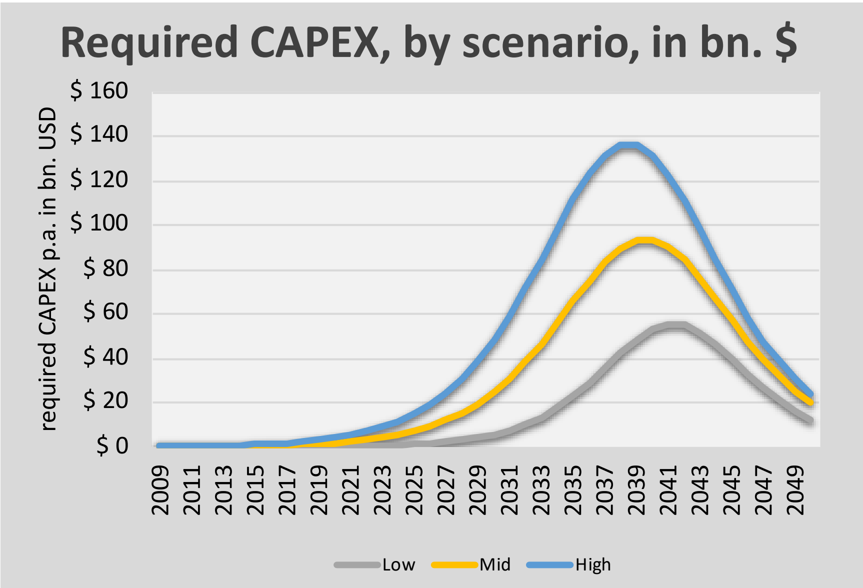
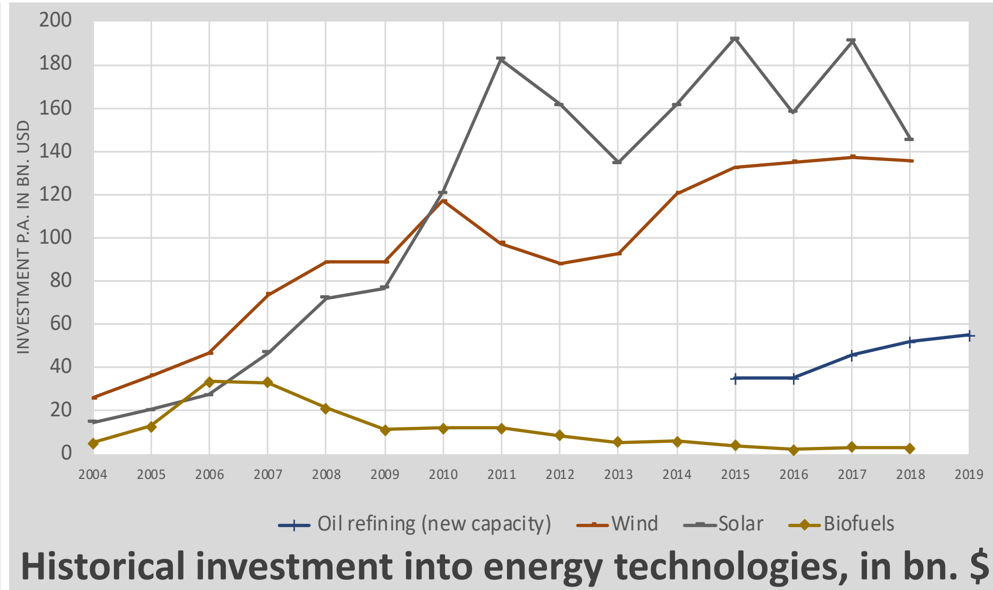
Required investment for the scale-up of SAF is high, but comparable to current and historical investments in energy





Required **investment** in the high scenario peaks at approximately **135 bn. $,** which is equivalent to more than **400 SAF producing facilities** coming online during the peak year. For comparison purposes, 2019 investment into new petroleum refining capacity was approximately 54 bn. $., peak solar energy investment was approx. 190 bn. $.

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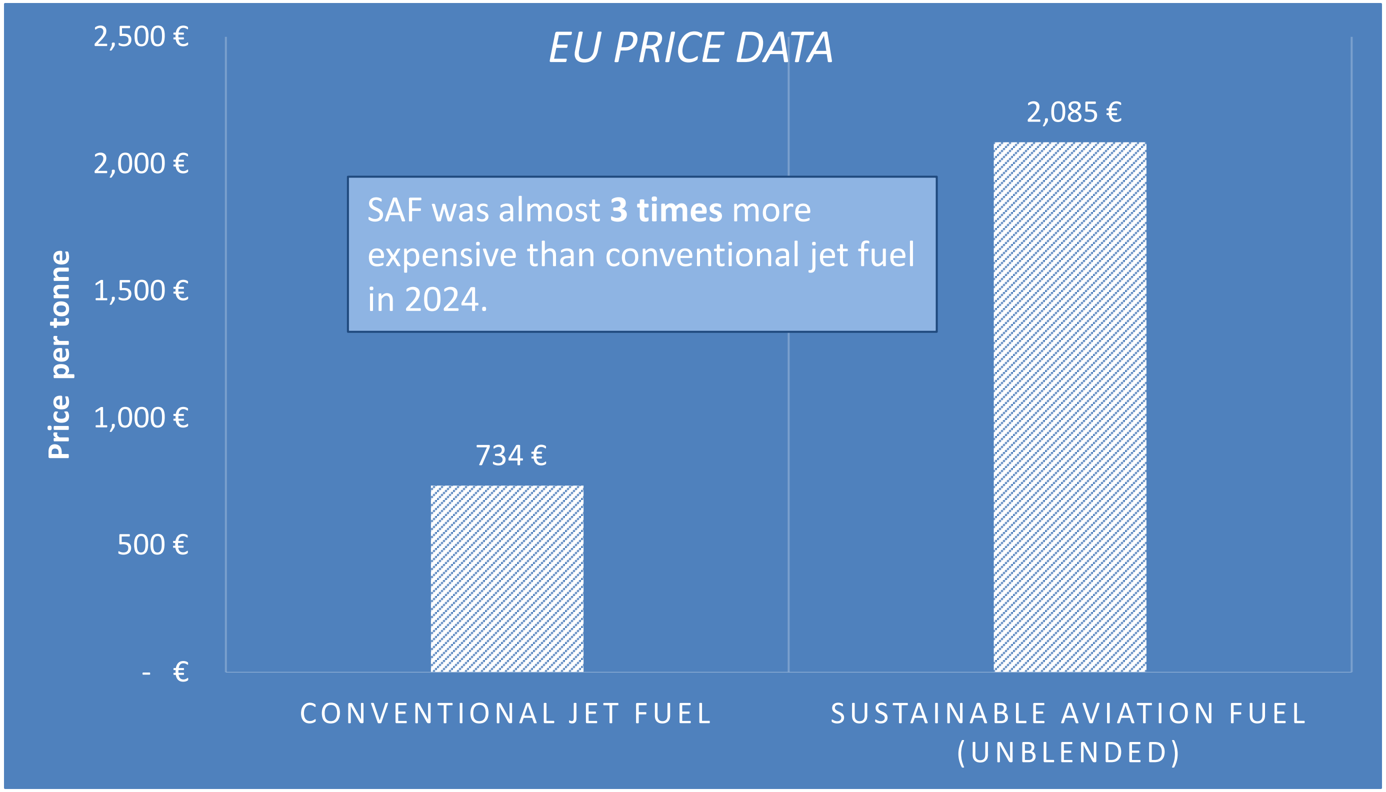
Current SAF prices



Source: EASA 2024 Aviation Fuels Reference Prices for ReFuelEU Aviation

For perspective: A 10% blend of SAF on a flight from Nairobi to Frankfurt would increase fuel costs per passenger by approx. 50 USD one way.

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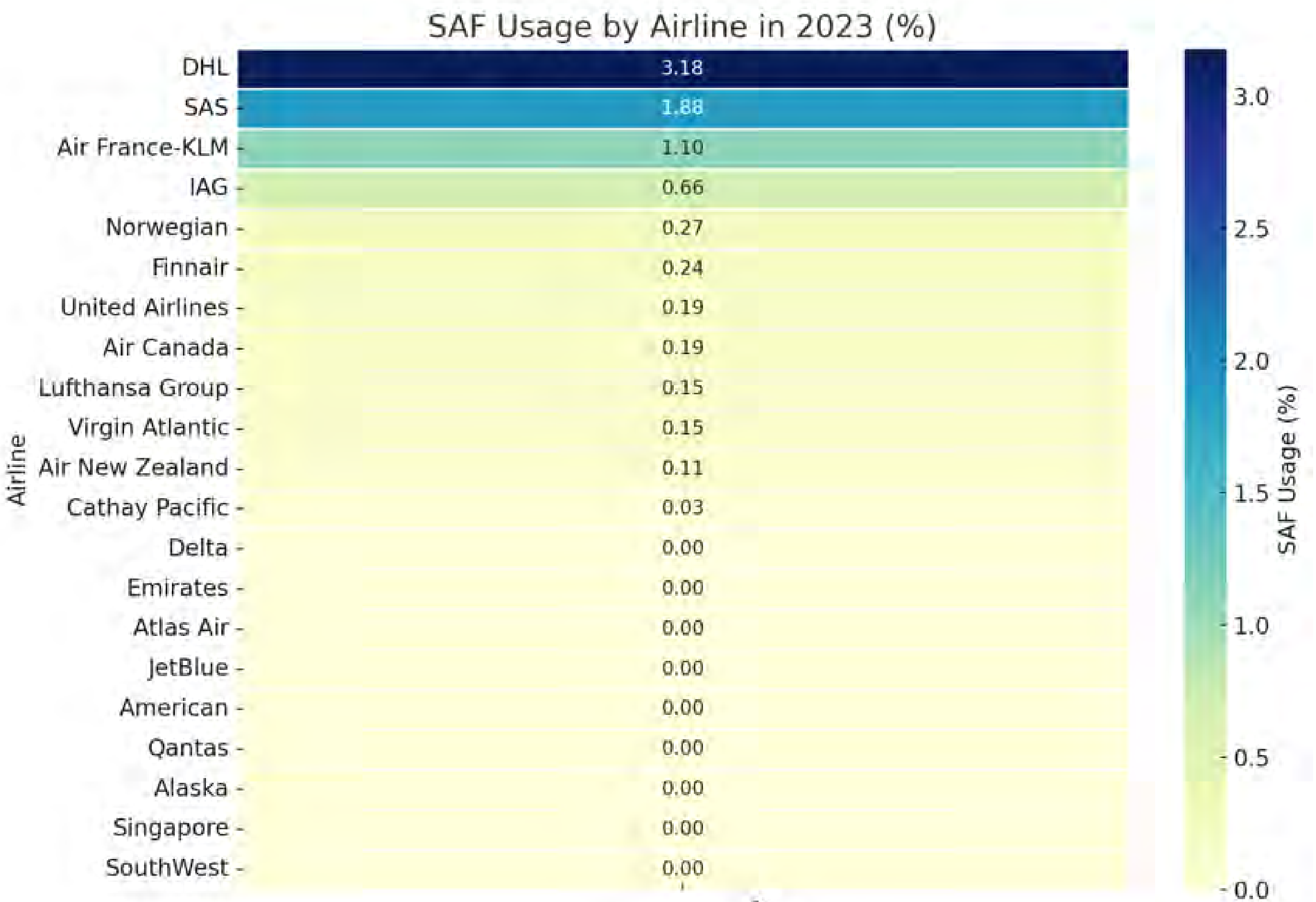
Current SAF Usage is localized in OECD Countries



- Current uptake is driven by customer demands, industry ambition
- Future uptake (not shown here), also driven by regulation, for example EU mandate.

Source: based on Ishka (2024)

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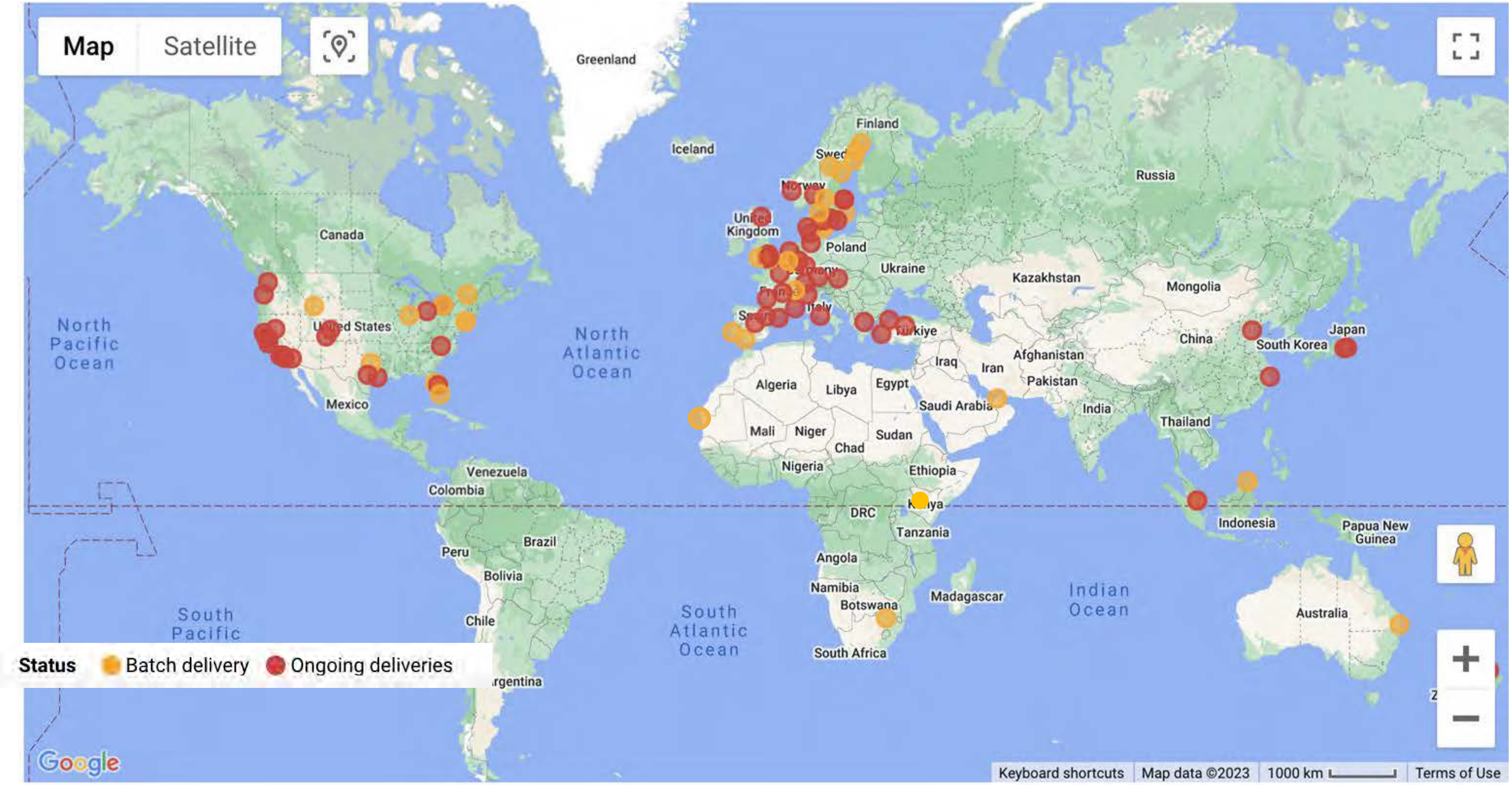
OECD countries dominate current & announced SAF production

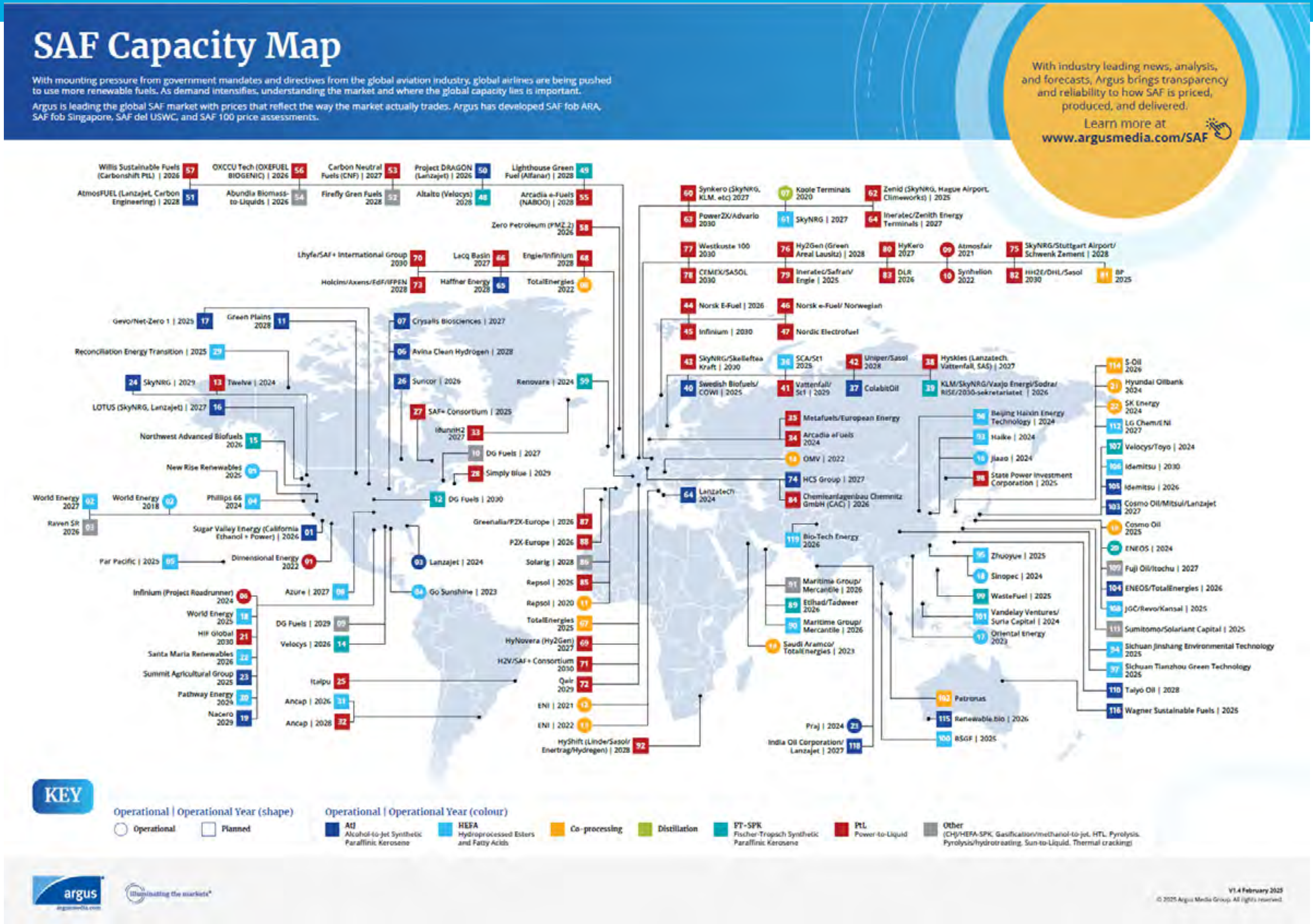
Very few airports in developing countries distribute SAF at the moment.



Source: ICAO

Current SAF Production Plans are Dominated by OECD

few in developing economies, only one plant in Africa



Source: Argus (2025)

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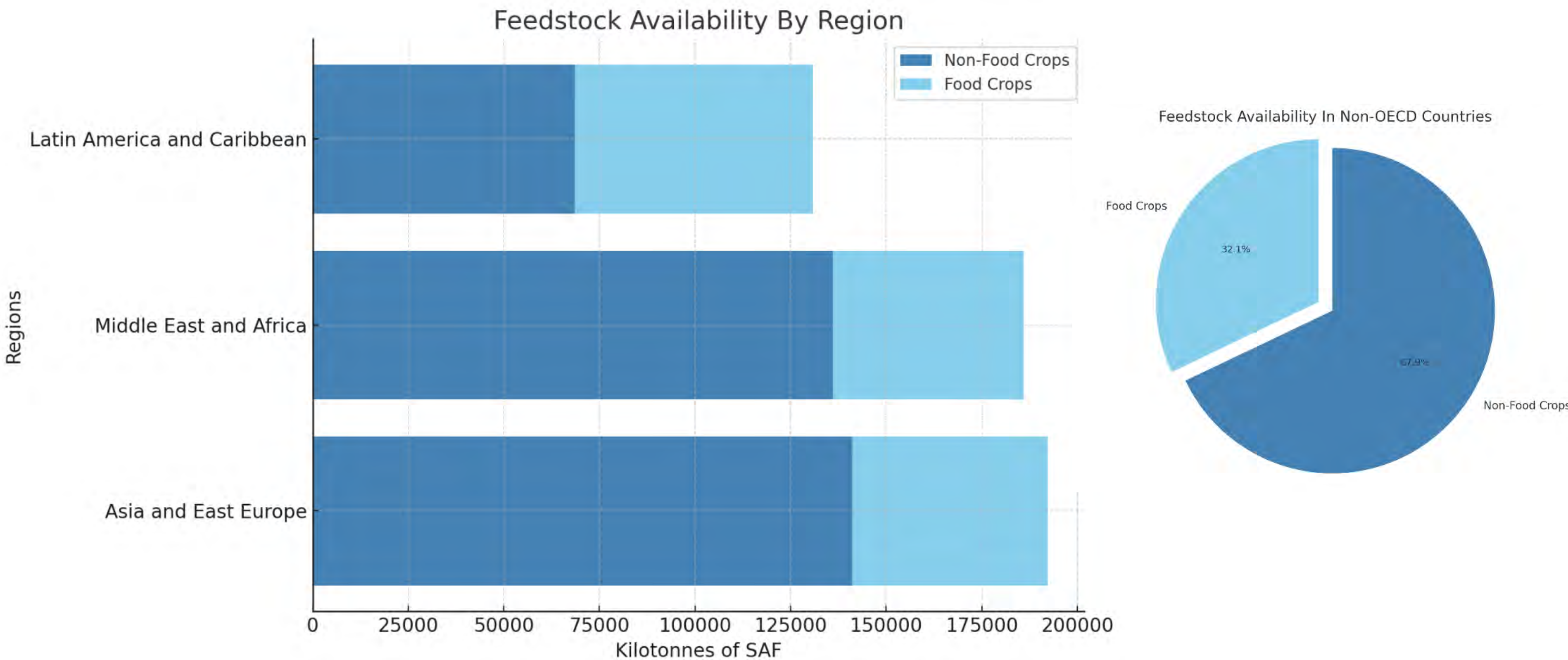
Significant potential for feedstock in non-OECD countries exists
2/3 of it doesn't compete with food sources



Source: The Role of Sustainable Aviation Fuels in Decarbonizing Air Transport (World Bank 2022)

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Ongoing SAF Related Activities

I. SAF Investment Decision-Making Framework
II. In-Depth Analyses of Four African Nations

SAF Investment Decision Making Framework

Composite Index to rank country's SAF production capacity

- **Pillar #1: Supply** - Assessed SAF supply potential across feedstock, refining, & infrastructure.
- **Pillar #2: Demand** - Analyzed factors driving air travel demand.
- **Pillar #3: Policy** - Reviewed SAF regulatory frameworks in African states.

World Bank (forthcoming)

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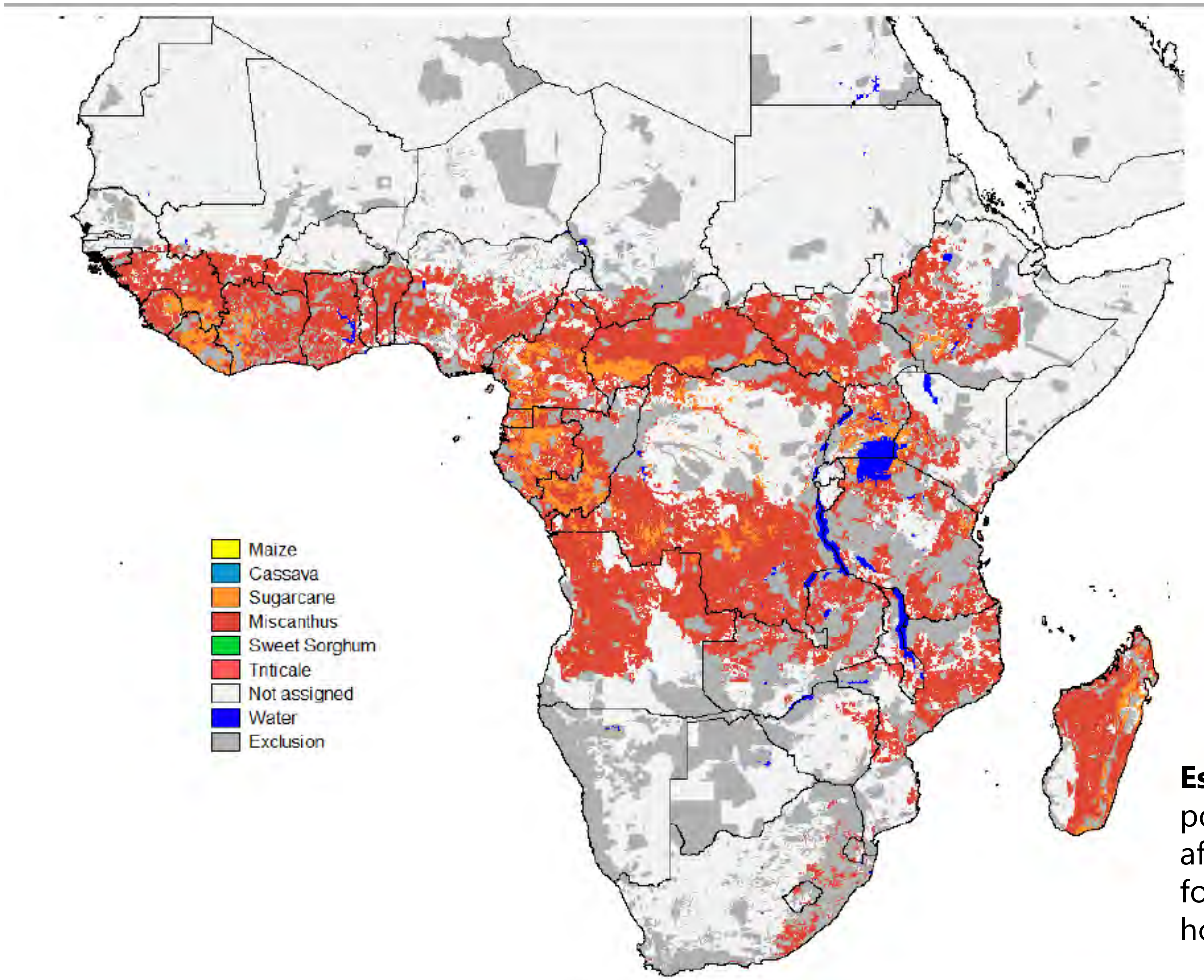
Sustainability Compliant Bioethanol Feedstocks *(current potential)*



Estimation from remain land - land potentially available for biofuel production after excluding land for food, grazing, forest, protected areas, biodiversity hotspots, built-up areas, water bodies etc.

Source: Worldwide Fund for Nature (WWF)

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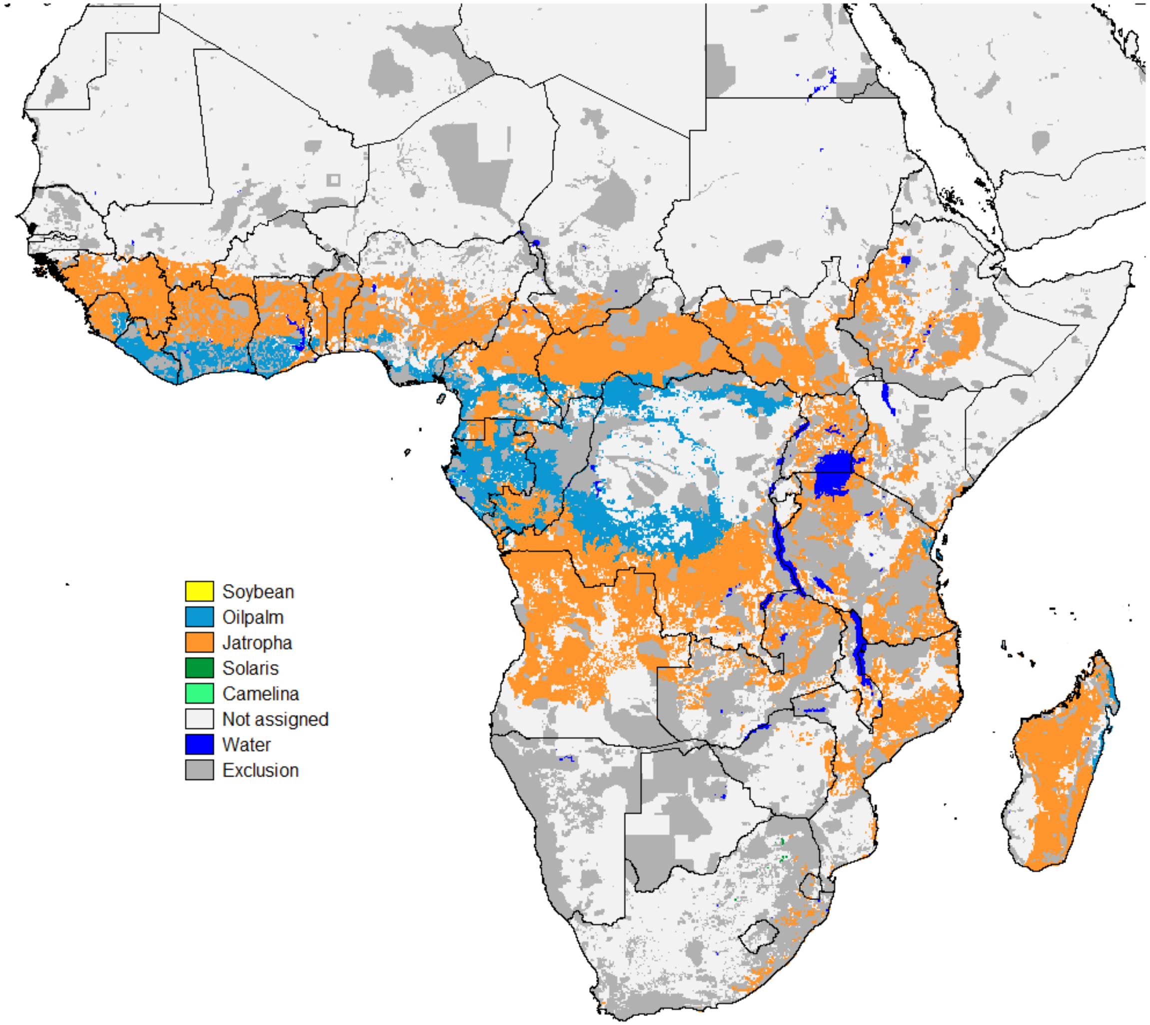
Sustainability Compliant Biodiesel Feedstocks *(current potential)*



Estimation from remain land - land potentially available for biofuel production after excluding land for food, grazing, forest, protected areas, biodiversity hotspots, built-up areas, water bodies etc.

Source: Worldwide Fund for Nature (WWF)

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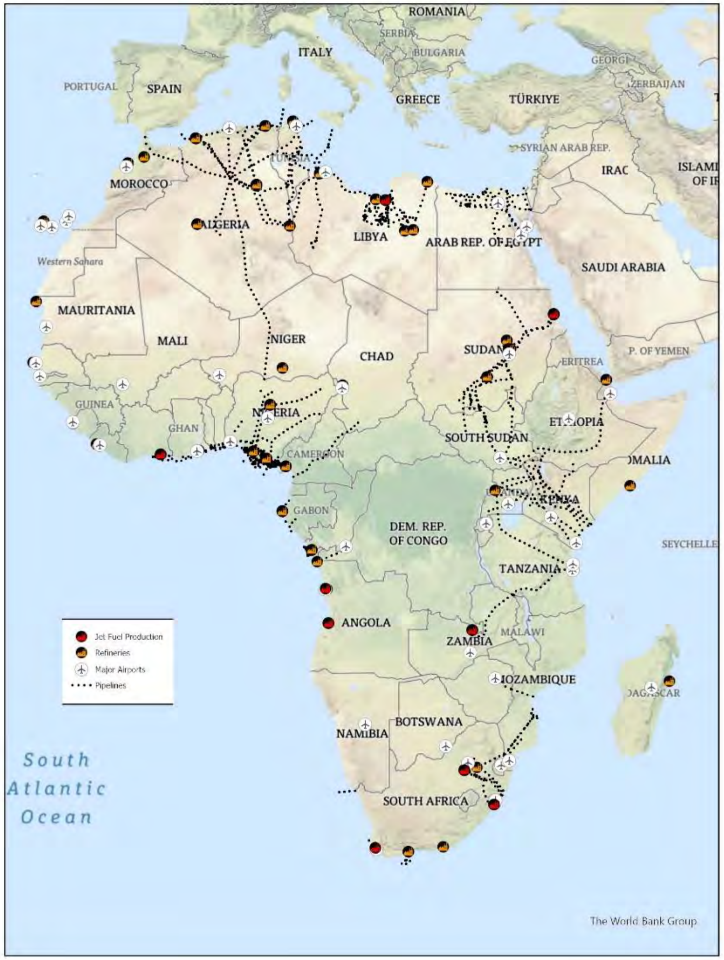
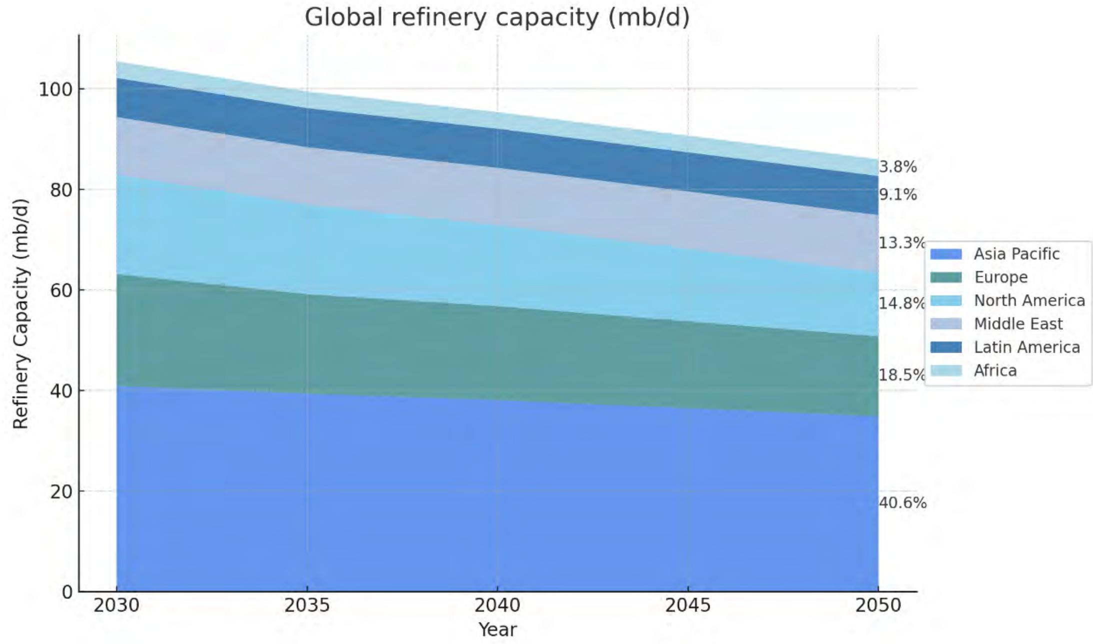
Africa has very limited Refinery and Fuel Logistics Capacity

Current stock is limited & is not expected to increase in the future

Refineries and supply logistics



World Bank (forthcoming)



Source: IATA (2024)

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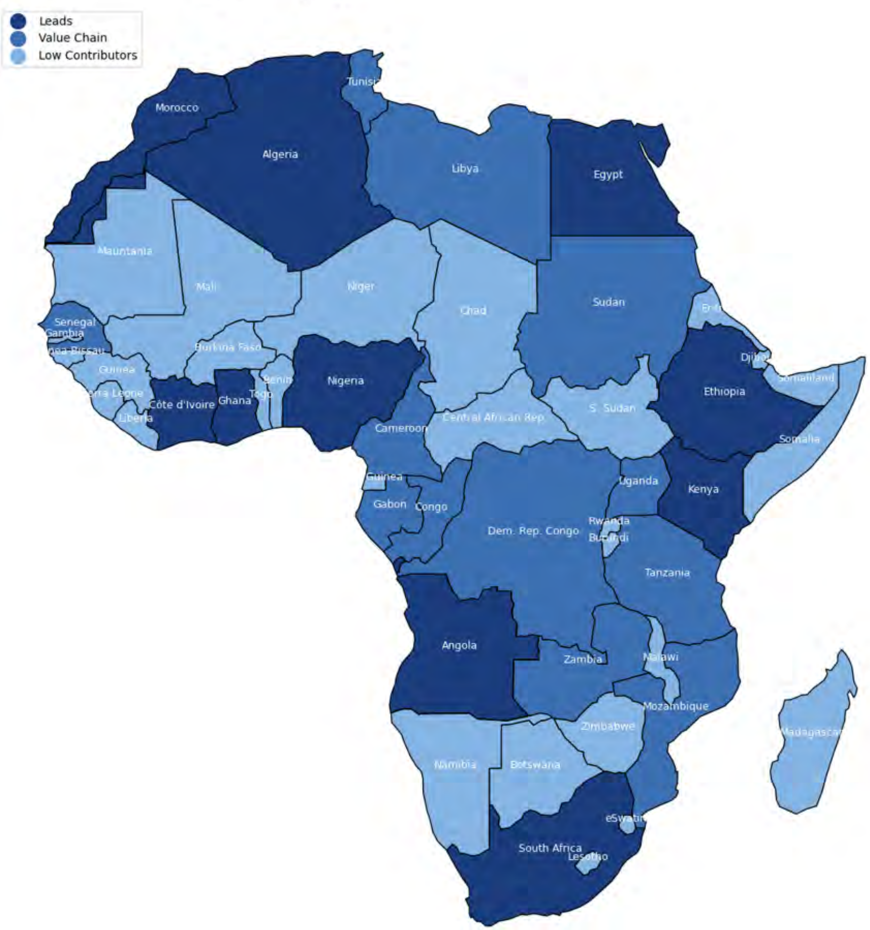
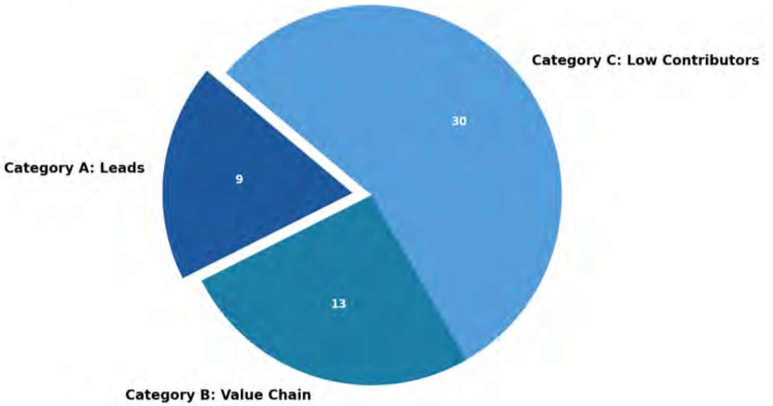
SAF Investment Decision Making Framework
Application to Africa



Summary of Initial Findings: SAF Decision Framework for Africa



Category	Description
C "Low Contributors"	• Countries with a **small GHG footprint** • Low Demand, Supply & Regulatory Framework • Scores below 15
B "Value Chain"	• Most countries, which are **able.** These have solid feedstock potential, but limited refining capabilities. • Scores between 17-20
A "Leads"	• Countries **"ready, willing and able"** • Countries with good scores R,S & D • Scores above 21

World Bank (forthcoming)

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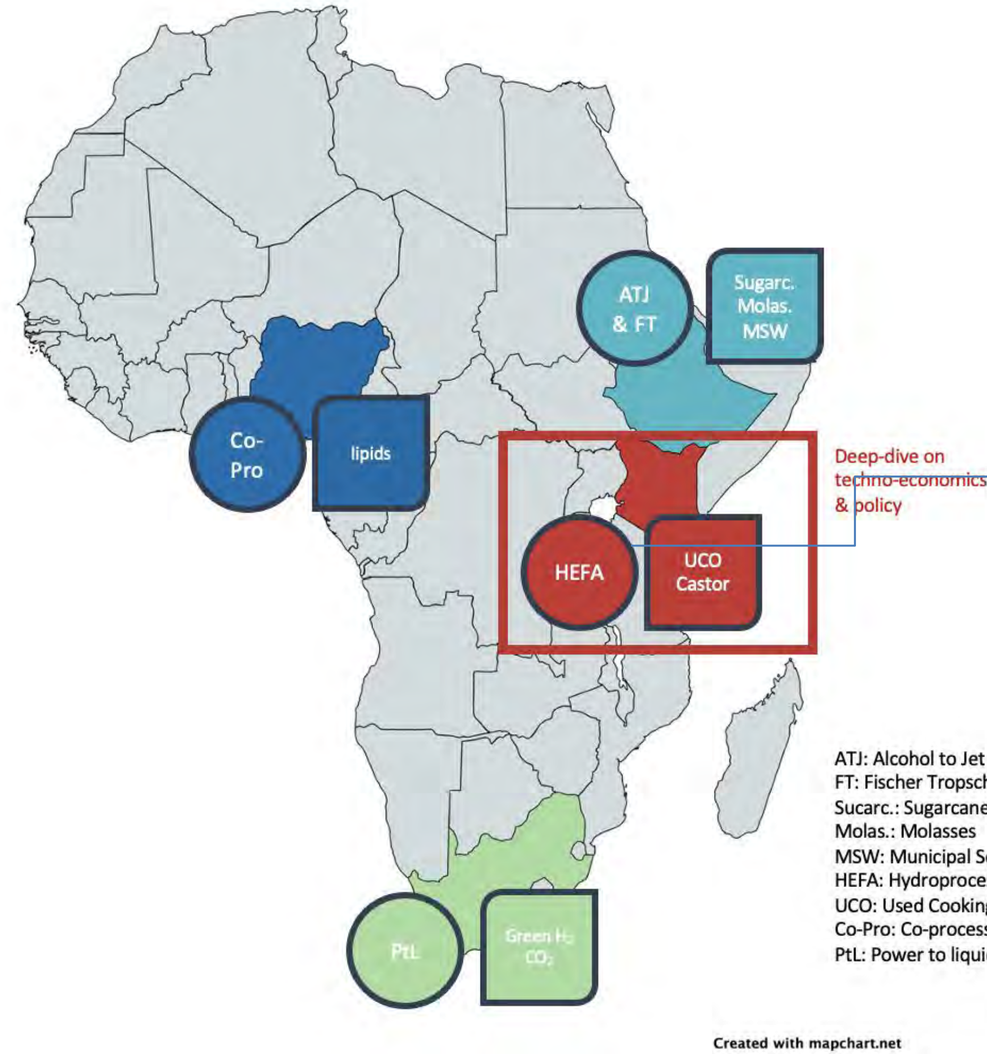
Techno-Economic Analyses in 4 African Countries

Various feedstocks and technology pathways



ESMAP
Energy Sector Management Assistance Program

ATJ: Alcohol to Jet
FT: Fischer Tropsch
Sucarc.: Sugarcane
Molas.: Molasses
MSW: Municipal Solid Waste
HEFA: Hydroprocessed Esters Fatty Acids
UCO: Used Cooking Oil
Co-Pro: Co-processing
PtL: Power to liquids

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Techno-Economic Analyses in 4 African Countries

Varying degree of investment needs

Country	Production Technology	Investment Needed (USD)	Jet Fuel Demand Met
Ethiopia	Alcohol-to-Jet (ATJ) Fischer-Tropsch (FT)	**$376M (ATJ)** **$547M (FT)**	**6% (ATJ)** **4% (FT)**
Kenya	Hydroprocessed Esters and Fatty Acids (HEFA)	**$235M**	**15%**
South Africa	Power-to-Liquid (PtL)	**$156M (excl. green hydrogen)**	**3%**
Nigeria	Co-processing	**Minimal investment needed (3,321–5,950 BPD, capacity)**	**25%-45%**

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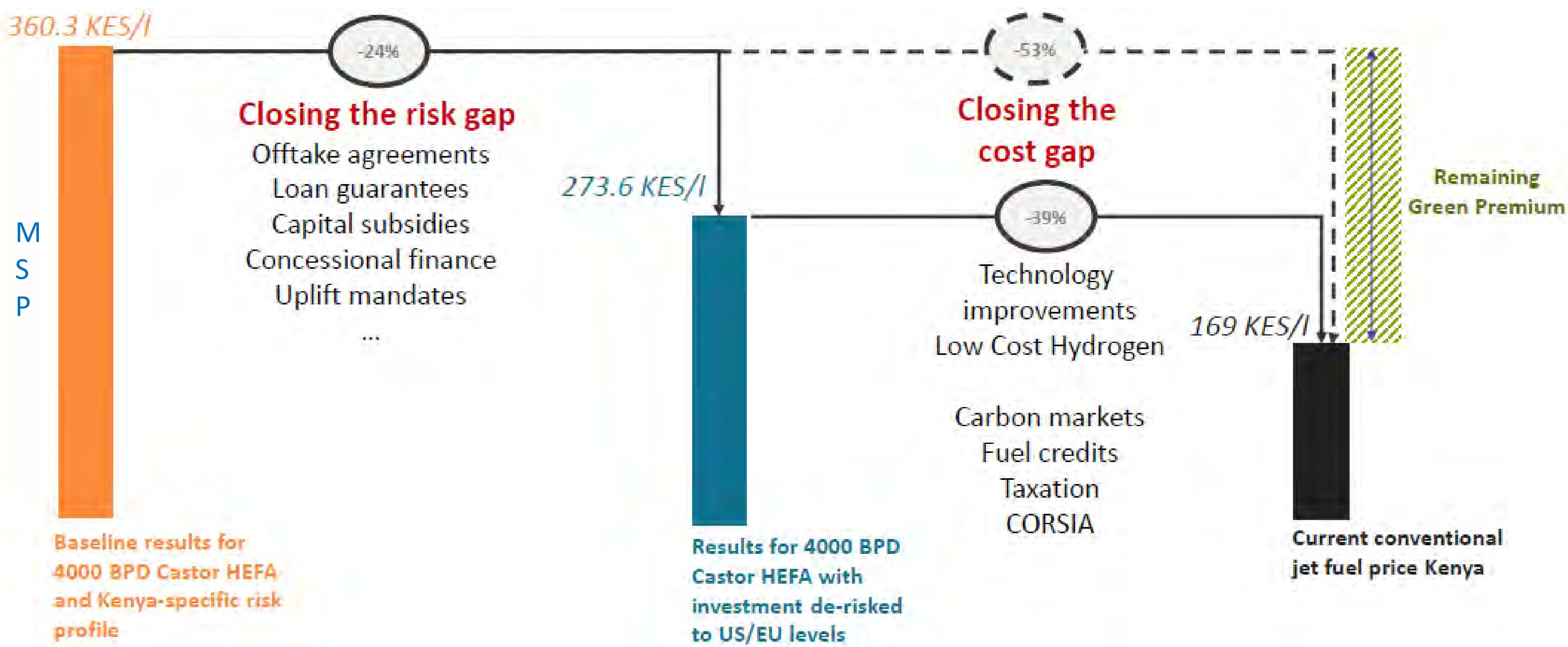
Key Message from the TEAs: We Need to Close the Risk and Cost Gap of SAF

A "Coalition" will be needed to drive down risk premiums



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Minimum Fuel Selling Price (MSP)

The MSP is the price that the SAF needs to be sold for an investor to meeting the expected rate of return. This is the SAF price at which the net present value of the refinery project equals zero.

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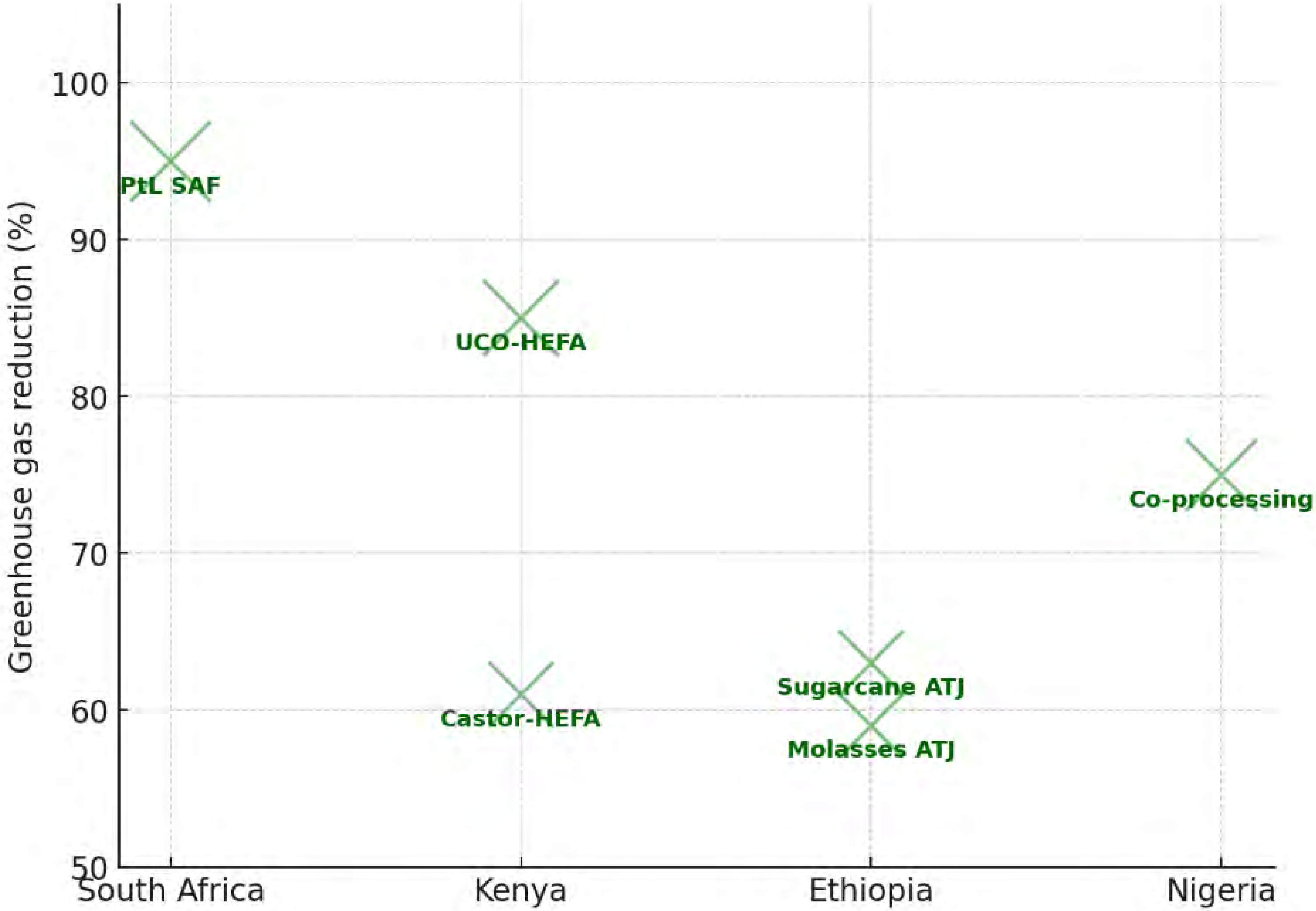
GHG Emission Analysis Highlights Environmental Benefits
Ranging from 59- 83% compared to Jet-A



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World Bank (forthcoming)

Our Analytical Studies are Informing Regional Engagements
With Both Internal And External Partners

Country	Technical Assistance	Partners
Kenya	Assessing **feasibility of Mombasa Refinery** for SAF through **TF from ESMAP**	**GIZ/FAA/EU/ ICAO**
African Union Commission	Informing **Continental SAF Strategy**	**EU/EASA**
Zambia	Feasibility Studies and Action Plan to produce SAF	ENV GP
Colombia	Feasibility study for SAF	AG GP

Investments		
Pakistan/Kenya	**Equity/Debt investment with private sector**	**ADB/Shell/Eni**

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