

IEA Bioenergy / UNIDO e-workshop “Opportunities of  
bioenergy and biofuels in developing economies”

23 MAY 2023

# SAF Production Challenges and Opportunities in Developing Countries

Robert Malina, Hasselt University, Belgium

Megersa Abate, The World Bank



**CMK**  
CENTRE FOR  
ENVIRONMENTAL SCIENCES

▶▶ **UHASSELT**

# The Role of Sustainable Aviation Fuels in Decarbonizing Air Transport

Robert Malina, Megersa Abate,  
Charles Schlumberger and  
Freddy Navarro Pineda



## Contents

Foreword.....	ix
Acknowledgments.....	x
About the Authors.....	xi
Abbreviations and Acronyms.....	xiii
Executive Summary.....	xv
<b>Chapter 1: Aviation and Climate Change.....</b>	<b>1</b>
<b>Chapter 2: Decarbonization Options for Aviation.....</b>	<b>9</b>
Commitments to Decarbonize Aviation.....	11
Demand-Side Measures: Avoid and Shift Strategies.....	12
Technology Measures.....	16
Operational Measures.....	20
Sustainable Aviation Fuels.....	22
<b>Chapter 3: Sustainable Aviation Fuels' Contribution to Decarbonizing Aviation in the Short Term, and Out to 2050.....</b>	<b>29</b>
SAF Production Announcements.....	31
Scenario Construction and SAF Projection Approach Out to 2050.....	33
SAF Production Out to 2050, and Associated GHG Emissions Reductions and CAPEX Requirements.....	36
SAF Production Challenges and Opportunities in Developing Countries.....	41
SAF Abatement Costs.....	45
Incentives for SAF Production and Use.....	48
<b>Chapter 4: Conclusions.....</b>	<b>57</b>
<b>Appendices.....</b>	<b>60</b>
Appendix A: Further Review of SAF-Related Studies.....	61
Appendix B: Feedstock Availability Modeling.....	65
Appendix C: SAF Abatement Costs Construction.....	68

<https://openknowledge.worldbank.org/handle/10986/38171>



# What is Sustainable Aviation Fuels (SAF)?



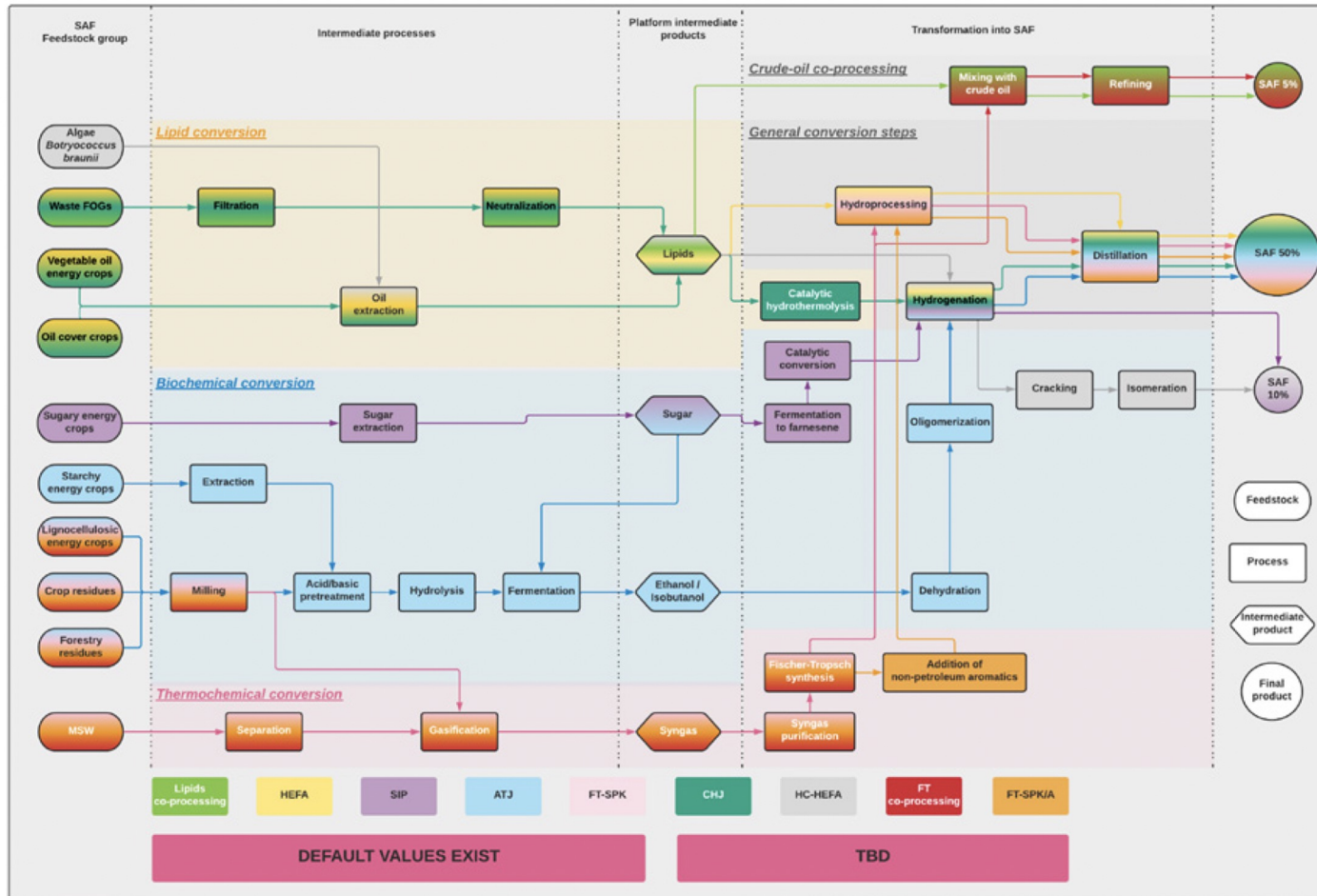
Photo taken at the ICAO Assembly, 2022.

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

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

SAF's CO<sub>2</sub> reduction can be as high as 100% (or more), on lifecycle basis compared to conventional jet fuel.

# “Approved” SAF pathways



This flow diagram shows current 9 SAF pathways that are ASTM-certified for use in jet engines.

Source: Original figure produced for this publication.

# World Bank Report: The Role of Sustainable Aviation Fuels



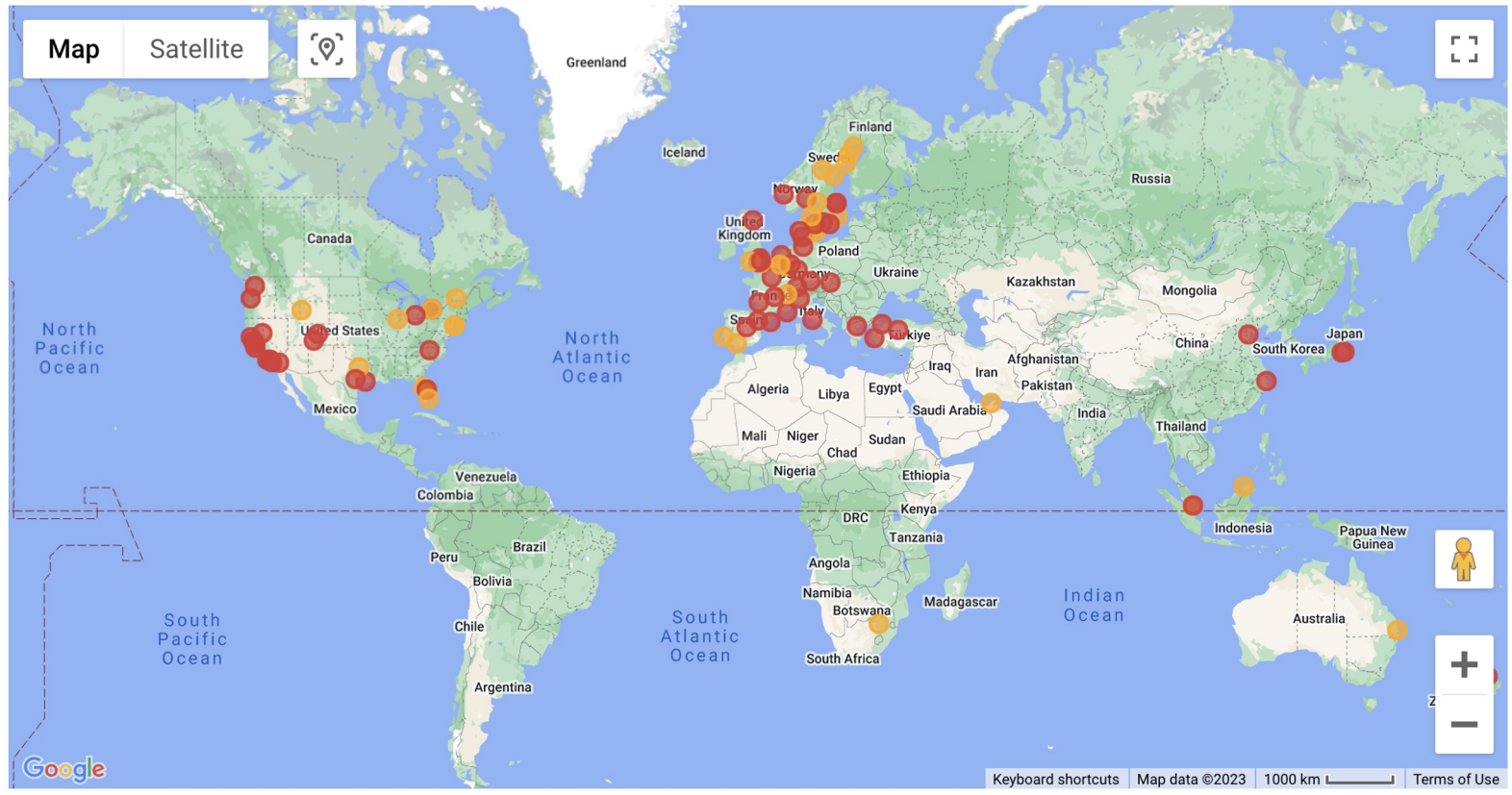
## Key Messages

1. **SAF will need to play a major role** in the decarbonization mix as it is the only option that can generate significant GHG emissions reduction in the medium-term already.
1. **Current SAF production plans are dominated by OECD locations**, developing countries are missing out on significant economic, environmental and social benefits of SAF production.
1. **SAF production can reduce up to 58% of aviation GHG emissions compared to business as usual in 2050** – this will require significant policy support, even more so in developing countries.
1. **Required investment for the scale-up of SAF is high, but comparable** to current and historical investments in other energy sectors.
1. **Abatement costs of SAF in 2030 can be below <math>\lt;100\text{ USD per t CO}\_{2e}</math>** for some highly mature and GHG-beneficial pathways. **By 2050**, and under the assumption of aggressive policies for mitigating climate change, large volumes of SAF could be provided **at below zero, or close to zero abatement costs**.



# OECD countries dominate current & announced SAF production

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



**Status**   ● Batch delivery   ● Ongoing deliveries

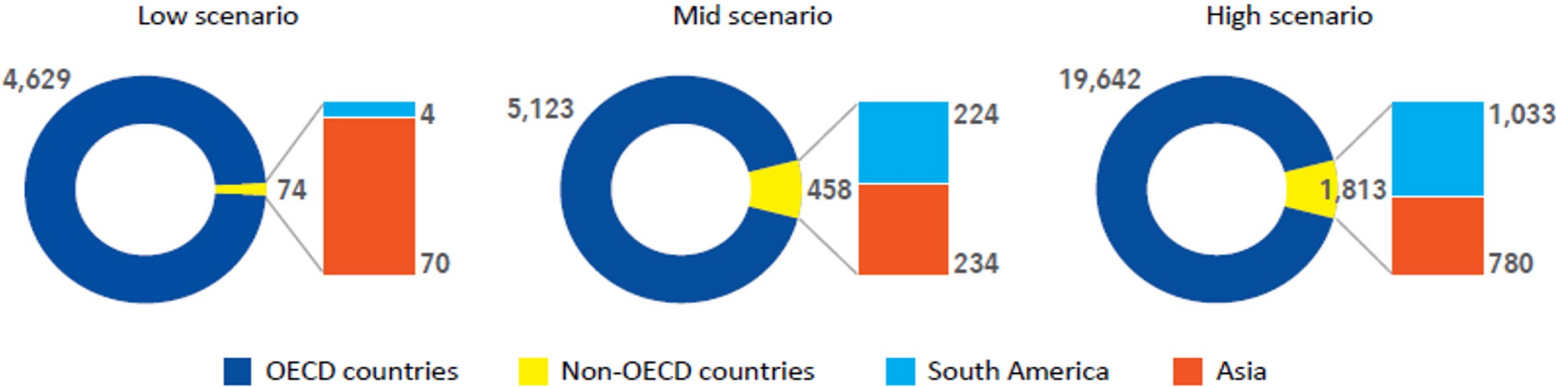
Source: ICAO (2023)

# OECD countries dominate current & announced SAF production

And developing countries remain underrepresented in short-term SAF production plans... only 10% by 2025

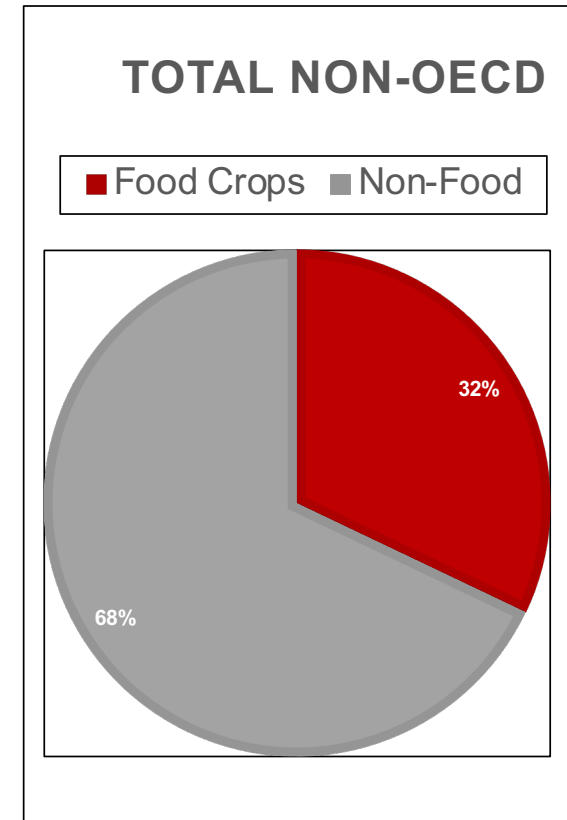
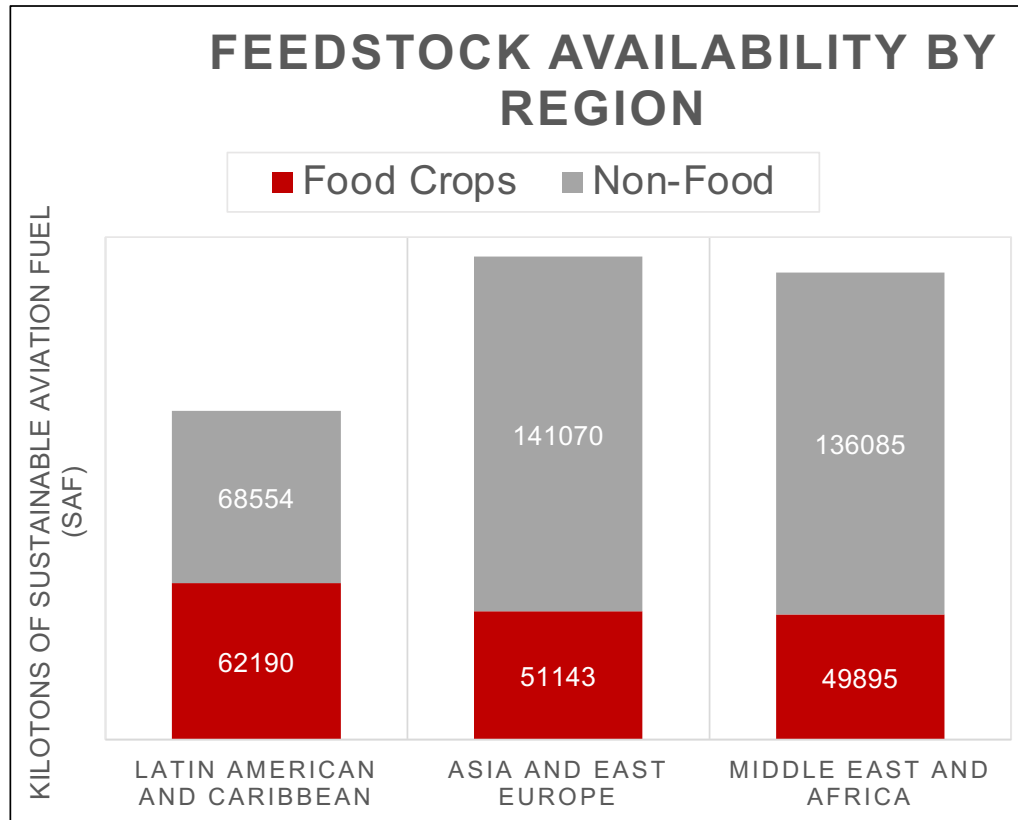
Figure 3.3. SAF Production in 2025, by Scenario, OECD and Non-OECD Countries

Kilotons



Source: World Bank (2022)

# Significant potential for feedstock in non-OECD countries exists



Source: World Bank (2022)

Note: Data derived from method published in Staples, Malina et al. Aviation CO<sub>2</sub> emissions reductions from the use of alternative jet fuels. Energy Policy. 2018 Mar 1;114:342-54.



# Barriers for SAF production in non OECD-countries

**Table 3.5.** Recent Studies on SAF Production in Non-OECD Countries and Major Hurdles Identified

Country	Publication year	Study partners (among others)	Main hurdles identified							References
			Poor or no research/technical expertise	Lack of a collection/refining infrastructure	Lack of access to funding	Lack of economic incentives	Incipient or non-existent biofuels policy	Sustainability issues	Unsuitable land to scale up cultivation	
Kenya	2018	ICAO	x	x	x	x	x		x	(White 2018)
Burkina Faso	2018	ICAO	x	x	x	x	x			(White 2018)
Brazil	2021	Stakeholders of the Brazilian Biojetfuel Program		x				x	x	(BBP 2013; Cortez et al. 2015; RSB and Agroicone 2021)
South Africa	2020	Stakeholders of Project Solaris			x			x	x	(RSB 2020)
Ethiopia	2021	Boeing	x	x	x	x	x	x	x	(RSB 2021)
India	2021	Stakeholders of the Clean Skies for Tomorrow India community		x	x			x		(WEF 2021)
Dominican Republic	2017	ICAO	x	x	x			x		(Gomez Jimenez 2017)
Trinidad and Tobago	2017	ICAO		x	x			x	x	(Serafini 2017)

Source: Original table produced for this publication.  
 Note: ICAO = International Civil Aviation Organization.

*“The challenge of the low-carbon transition starts with tackling the chronic lack of financing for productive investments that plagues most developing countries and the need to find new sources of financing and to leverage existing ones.”*

2015 World Bank Report

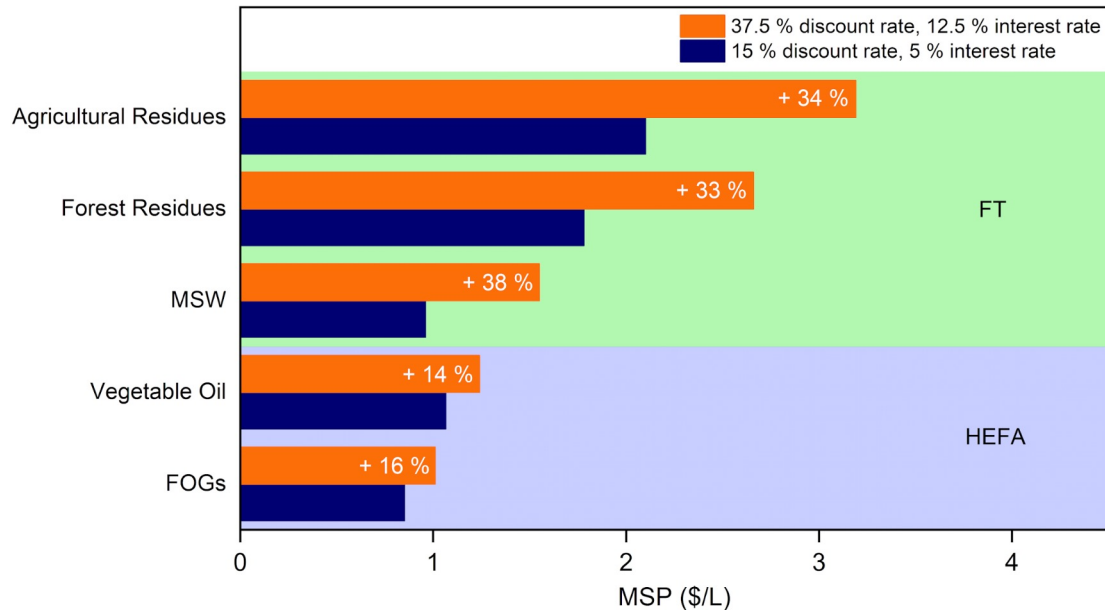
*One 2000 bpd MSW FT plant = 500 million USD = investment needs for Abidjan to Ouagadougou transport corridor, or the Ruzizi III Hydropower Project.*

*“The industry shares a broad agreement that the strong growth in announcements of SAF projects in OECD countries is largely driven by actual or expected policies implemented in those countries to speed up the decarbonization of the economy. However, very few non-OECD countries have introduced—or are actively pursuing the introduction of—SAF-incentivizing policies, and the lack of such incentives is regularly identified as a major barrier.”*

2022 World Bank Report

# The importance of de-risking SAF investment in developing countries

**Driving down risk premiums for SAF production would be a major factor in reducing the costs of producing SAF in these countries**



Source: Own calculations based on publicly available DCFROR models for SAF (Hydroprocessed esters and fatty acids TEA V2.2 developed by Kristin Brandt et al. 2022, Fischer Tropsch TEA V2.2 developed by Kristin Brandt et al. 2022)

Key Assumptions: Equity/loan split: 70/30, Duration 20 years, inflation: 2%. Discount rate and loan interest assumed as mentioned above. No monetary incentives included.

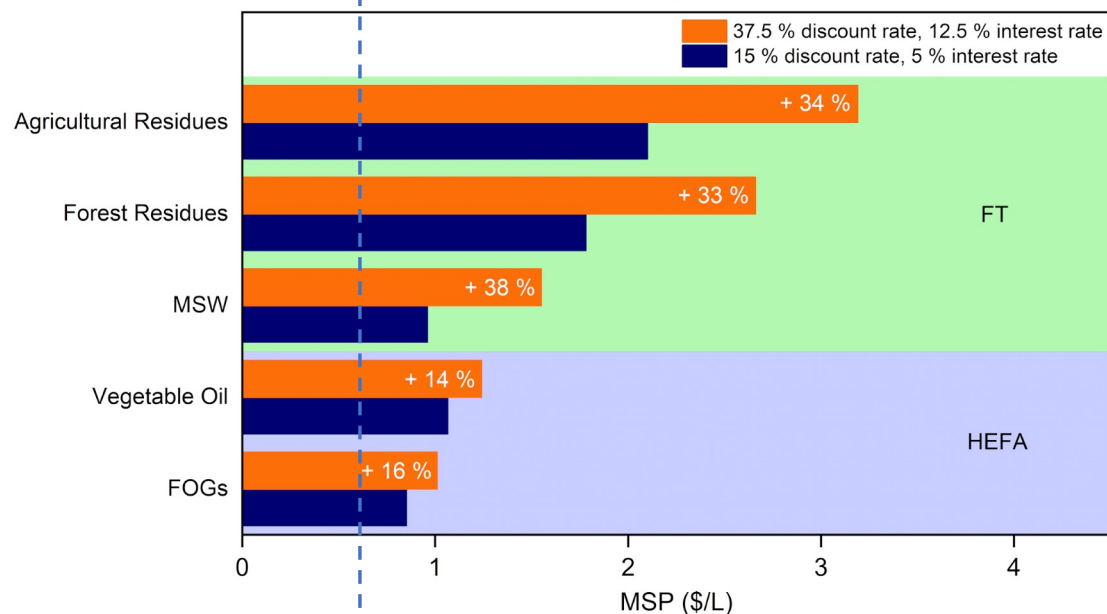
FOG: Fats, Waste Oils and Greases

MSW: Municipal solid waste

# The importance of de-risking SAF investment in developing countries (continued)

But even if risk premiums are down to OECD levels, there is still a **cost gap** with conventional jet fuel to make up for (“the green premium”).

conventional jet fuel price April 2023: \$0.6/litre



Source: Own calculations based on publicly available DCFROR models for SAF (Hydroprocessed esters and fatty acids TEA V2.2 developed by Kristin Brandt et al. 2022, Fischer Tropsch TEA V2.2 developed by Kristin Brandt et al. 2022)

Key Assumptions: Equity/loan split: 70/30, Duration 20 years, inflation: 2%. Discount rate and loan interest assumed as mentioned above. No monetary incentives included.

FOG: Fats, Waste Oils and Greases

MSW: Municipal solid waste

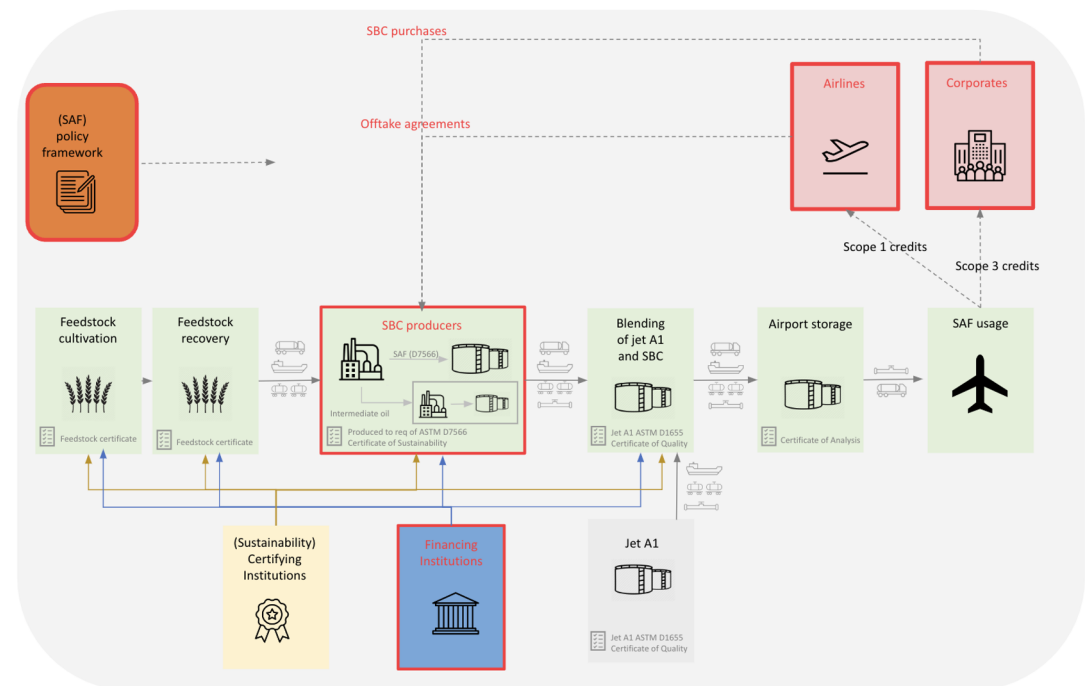
# The importance of de-risking SAF investment in developing countries (continued)

”**Coalitions**” will be needed to drive down risk premiums and distribute the green premium – for each specific SAF investment case.

- **Financing agreements** with international development banks;
- **Offtake agreements** from (international) airlines;
- **Scope 3 credit purchases** by corporates;
- **Government commitments** (expertise, regulation)

...

The World Bank Group is active in helping build such coalitions.





# Ongoing works on air transport decarbonization

## Knowledge Products



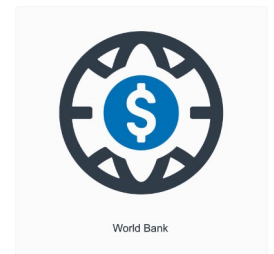
### 1. Decarbonizing Aviation Through the Scale-Up of SAF

- **Component 1: Country and Regional Deep-dives**
- **Component 2: Support to the International Civil Aviation Organization (ICAO)**
- **Component 3 : Outreach and Partnership Building**
- **Component 4: Bridging the gap in availability of financing sources for SAF development**

### 2. GHG accounting for Air Transport Sector Investments

## Investment

Together with IFC, the private arm of the WGB, we're pursuing opportunities



## developing countries face significant transport financing gap and the WB is

striving to fill it

- Developing countries face a **transport financing gap of up to \$944 billion** annually through 2030 (WRI 2016)
- The WB has set up the [Global Facility to Decarbonize Transport \(GFDT\)](#)
- The GFDT will support low carbon mobility and resilient transport solutions in three ways: **Project design and implementation, research and data, and capacity building.**
- **Ambition is to raise \$200 million over a 10-year period** to invest in low-carbon transport solutions.
- Together with our partners **we have raised \$9 million for this initiative.**
- We're yet to raise aviation specific funding, but efforts are underway.



THE GOVERNMENT  
OF THE GRAND DUCHY OF LUXEMBOURG



Ministry of Infrastructure  
and Water Management

**Thank you for your  
attention !**

**[robert.malina@uhasselt.be](mailto:robert.malina@uhasselt.be)**

**[mabate@worldbank.org](mailto:mabate@worldbank.org)**

