Decarbonizing aviation in Latin America in a sustainable way

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Overall Study: *Options for decarbonizing aviation in Latin America in a sustainable way: an assessment of carbon policies, carbon prices and fuel consumption in aviation up to 2050*

Overall objectives: a comprehensive analysis of scenarios for the deployment of Sustainable Aviation Fuels (SAF) up to 2050 in selected Latin American countries, exploration of pathways related to low carbon hydrogen, direct air capture and bioenergy with carbon capture and storage

Focus on countries: Brazil, Chile, Colombia, Ecuador, Mexico, Peru

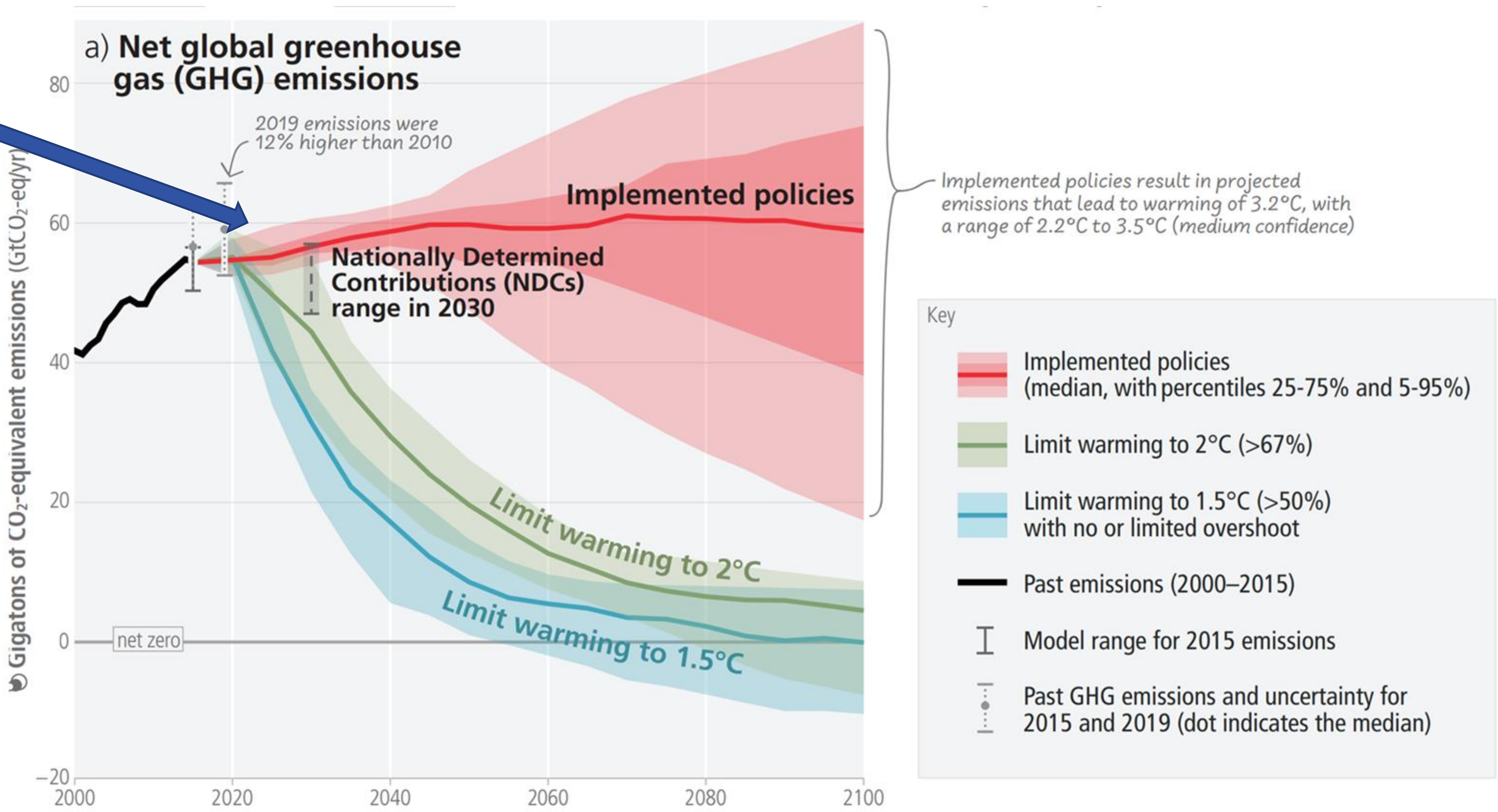
This presentation: Interim results for Brazil and Chile

Published report date: September 2024 with the results for all six countries (before the IATA World Sustainability Symposium)

https://globalchange.mit.edu/research/research-projects/options-decarbonizing-aviation-latin-america-sustainable-way-assessment

Aviation emissions reduction is a part of global energy transition driven by the *Paris Agreement:* need for scalable solutions to decarbonize

2022-2023 emissions are outside of the IPCC range



Source: IPCC (2023), Climate Action Tracker (2024)

SAF is a major, but not the only measure to reduce aviation emissions

IATA: Net-zero Carbon Emissions by 2050

2019 Emissions: 1 Gt

2050 Baseline Emissions: 1.8 Gt

ICAO: Long term global aspirational goal (LTAG) for international aviation

IATA <u>Approximate</u> Abatement Plan:

65%: Sustainable Aviation Fuels (SAF)

13% new propulsion technology

3% efficiency improvements

19% offsets and CCS

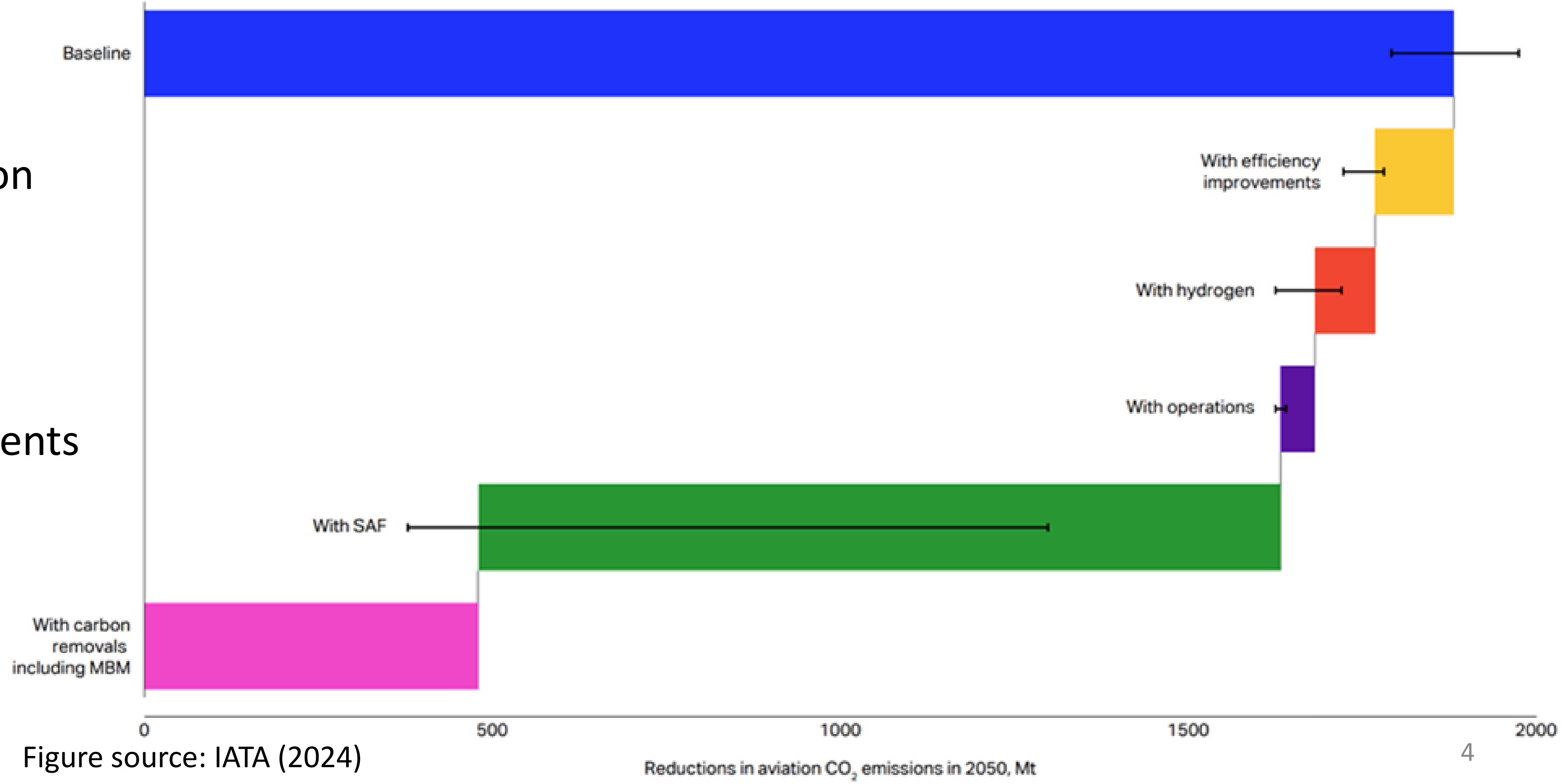


Figure source: IATA (2024)

SAF trades at a premium compared to conventional jet fuel

USA: IRA incentive up to $1.75 /gallon

Note: All prices in U.S. cents per gallon

Source: Argus Media | Graphic by Sourasis Bose

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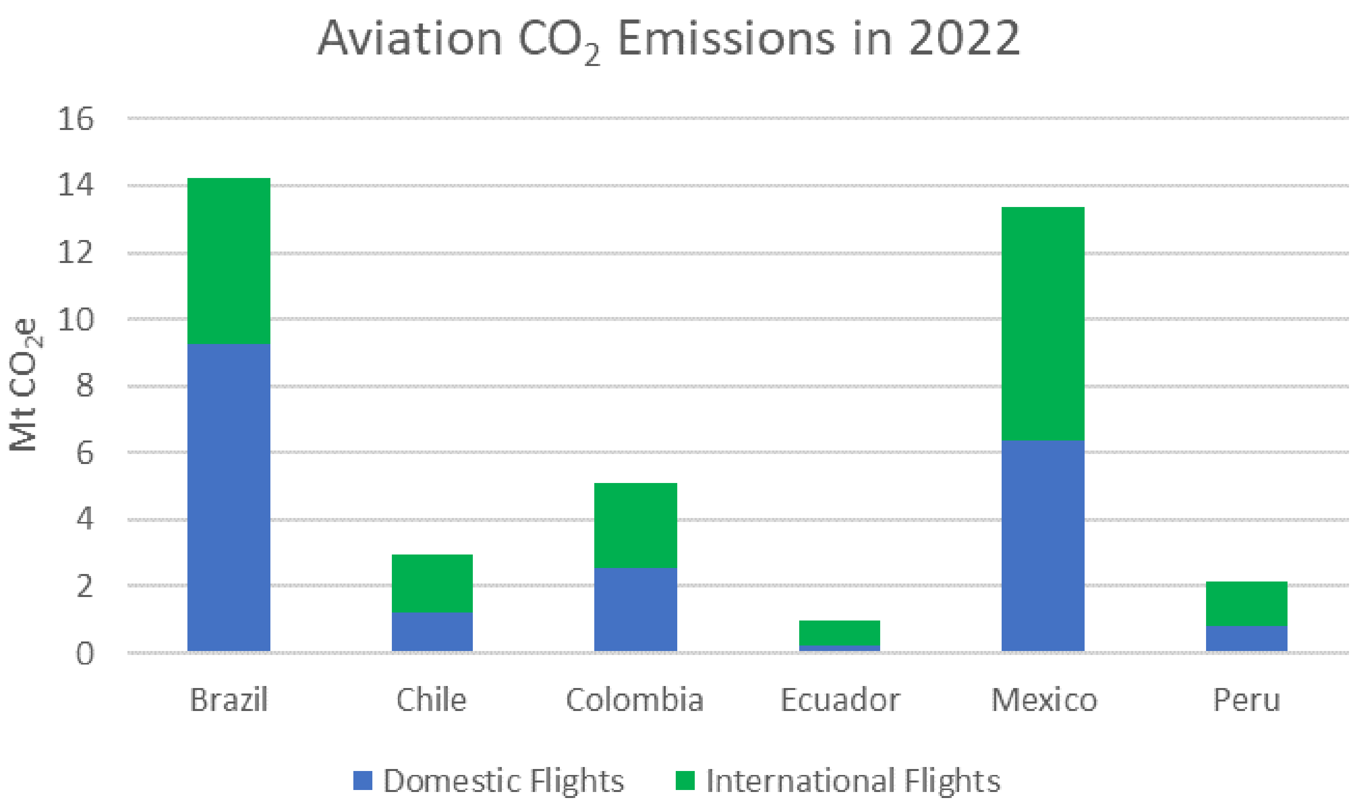
Need for Aviation Decarbonization Studies



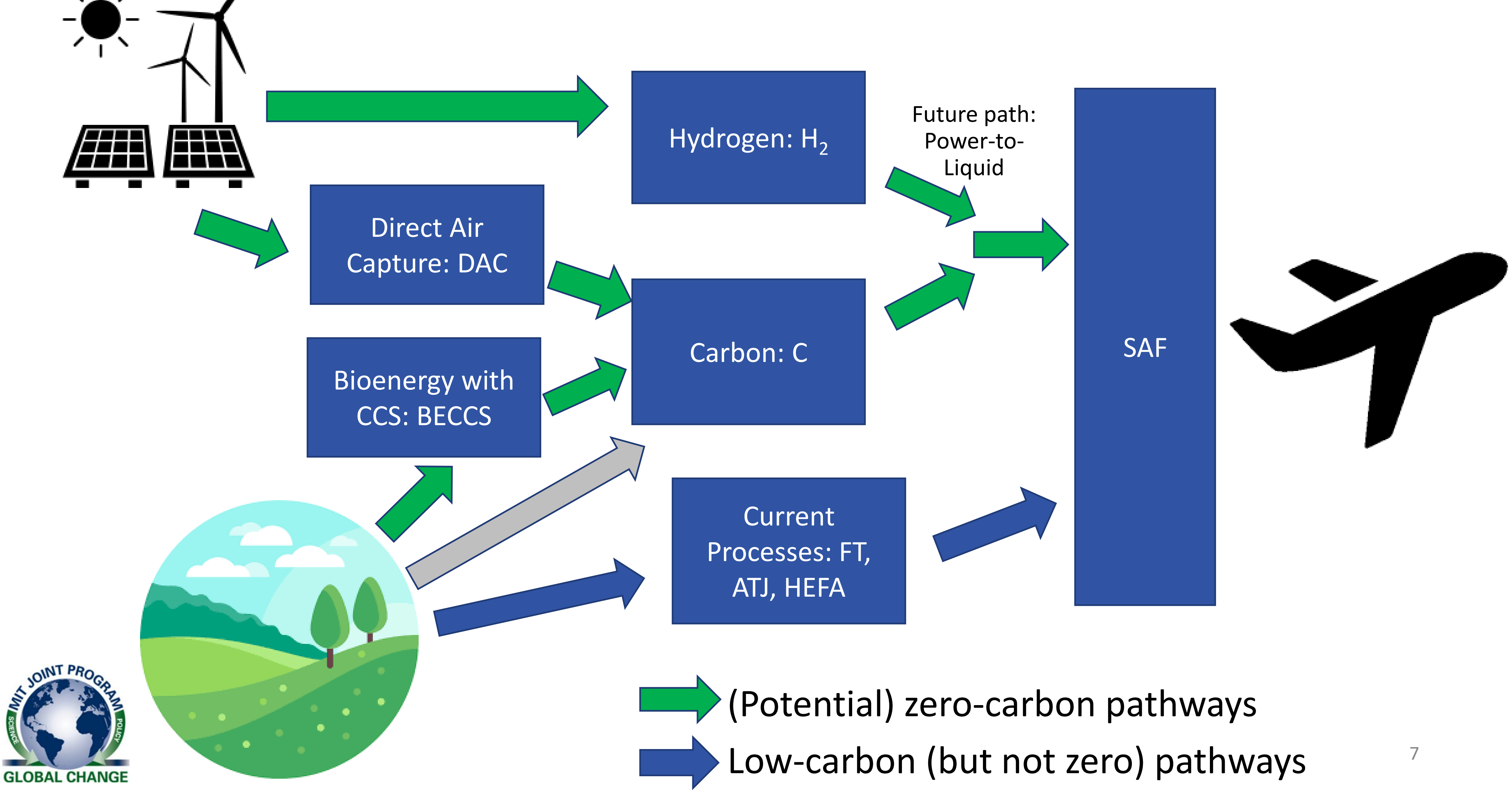
Data source: OECD (2024)

Decarbonization represents a **highly complex** task with **uncertainties** in policies and technology developments

There is a risk of **excessive** high-cost policies

Therefore, it is important to be **informed**, understand the current **policy proposals**, provide **independent** analysis to **influence** policies, and be prepared to **take actions** if exists the benefits for **early movers**

Sustainable aviation fuels (SAF) pathways



Biomass Pathways

Each pathway with different implications for technologies, costs and emissions

Feedstock

e.g., corn, sugar cane, soybean, switchgrass, landfill biogas

Production Process

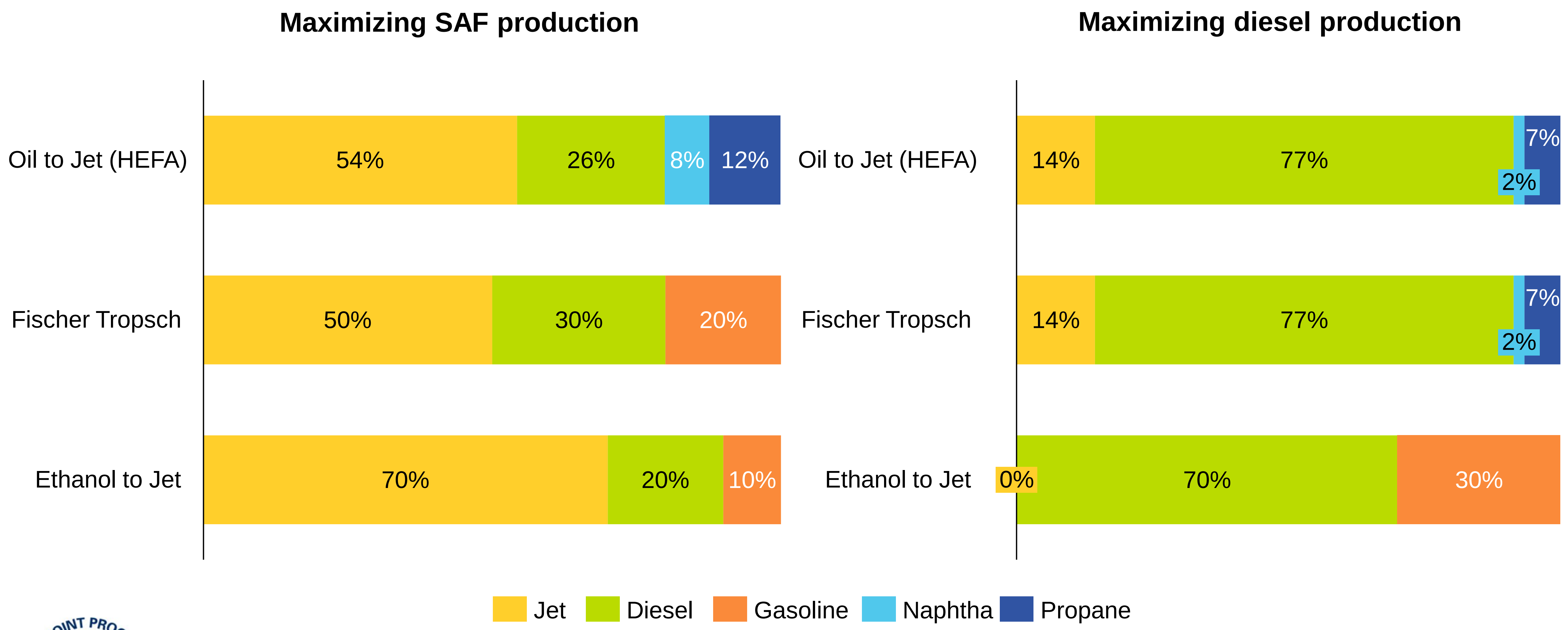
e.g., hydrotreating, gasification and upgrading, transesterification

Fuel Type

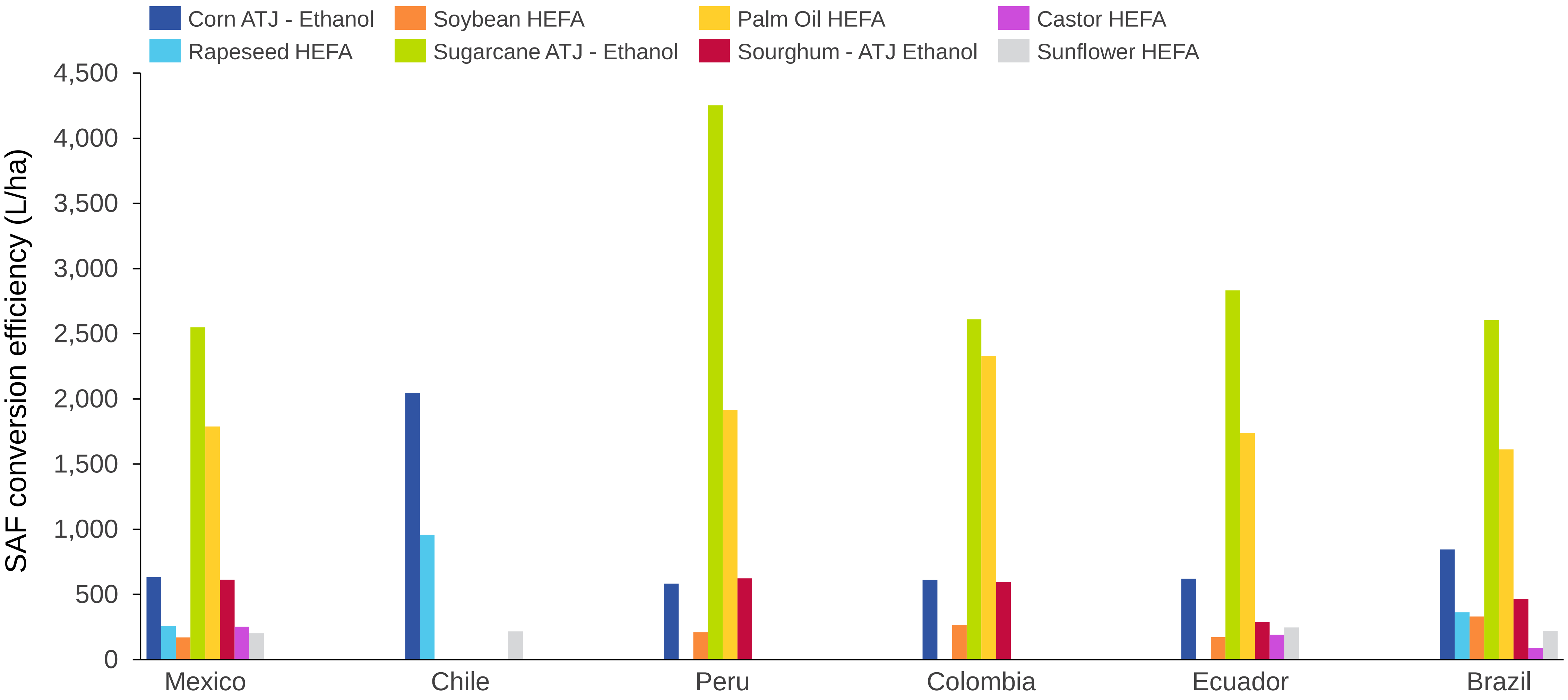
e.g., jet fuel, diesel, gasoline, naphtha, propane, ethanol, biodiesel, cellulosic fuels

Important consideration: Multiple products

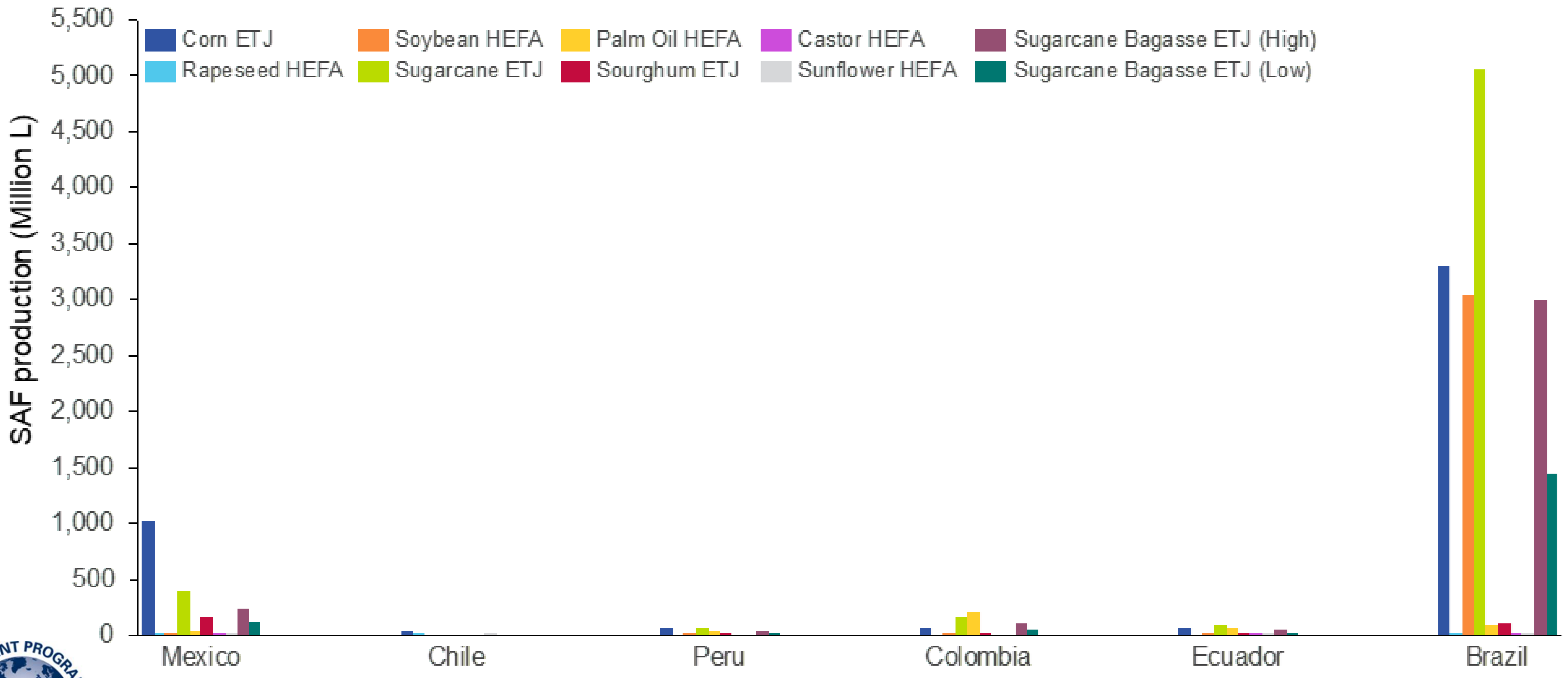
Jet fuel is ***not*** the only output: output slate depends on configuration



Conversion efficiency by area per country



SAF Potential if crop production was increased by 20%



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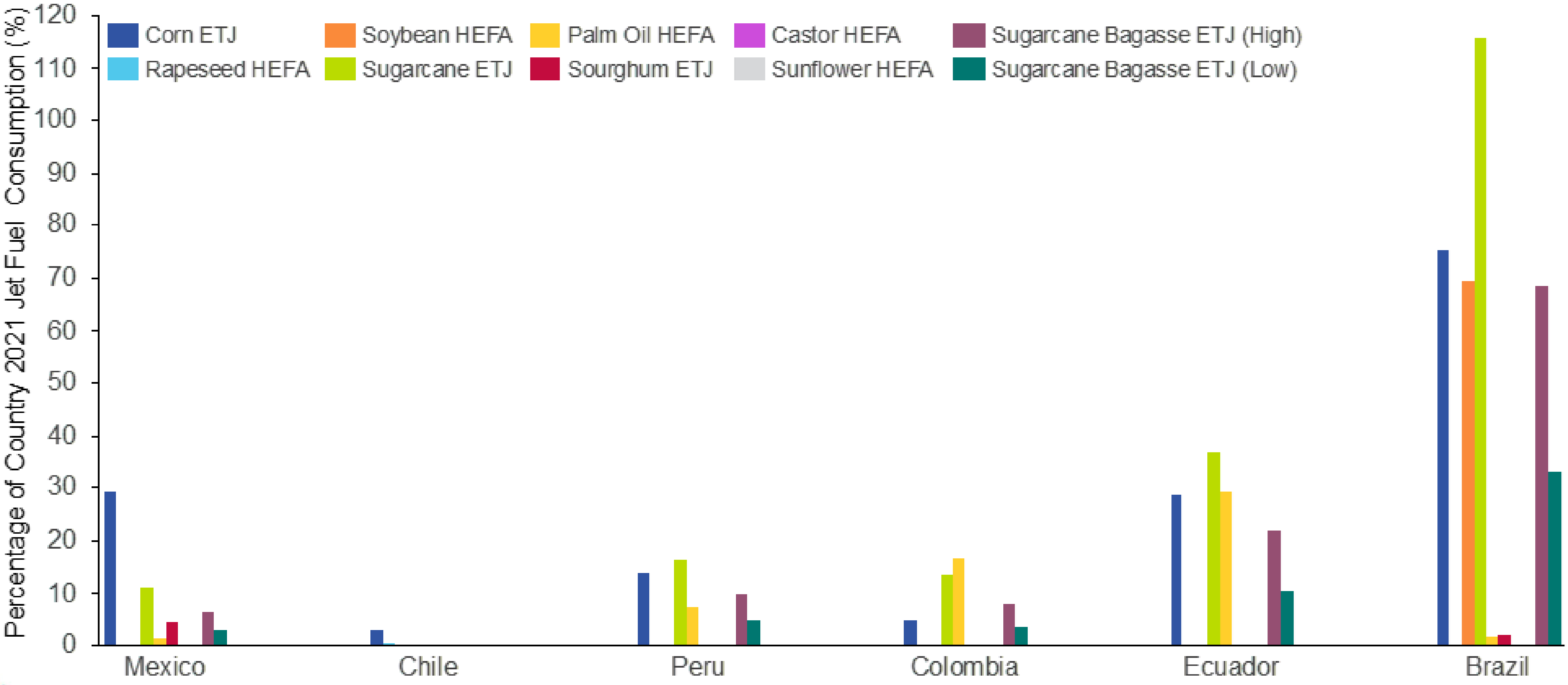
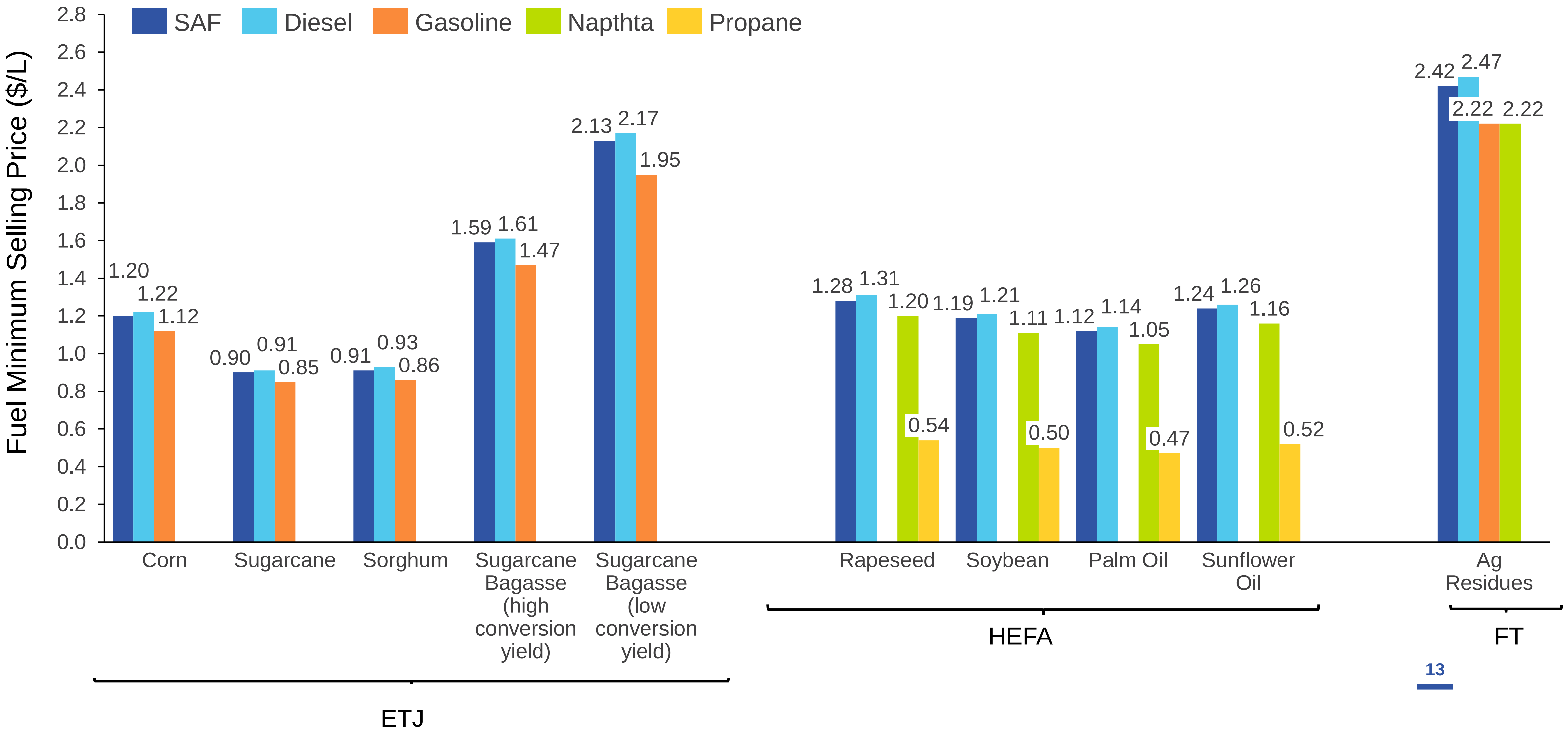
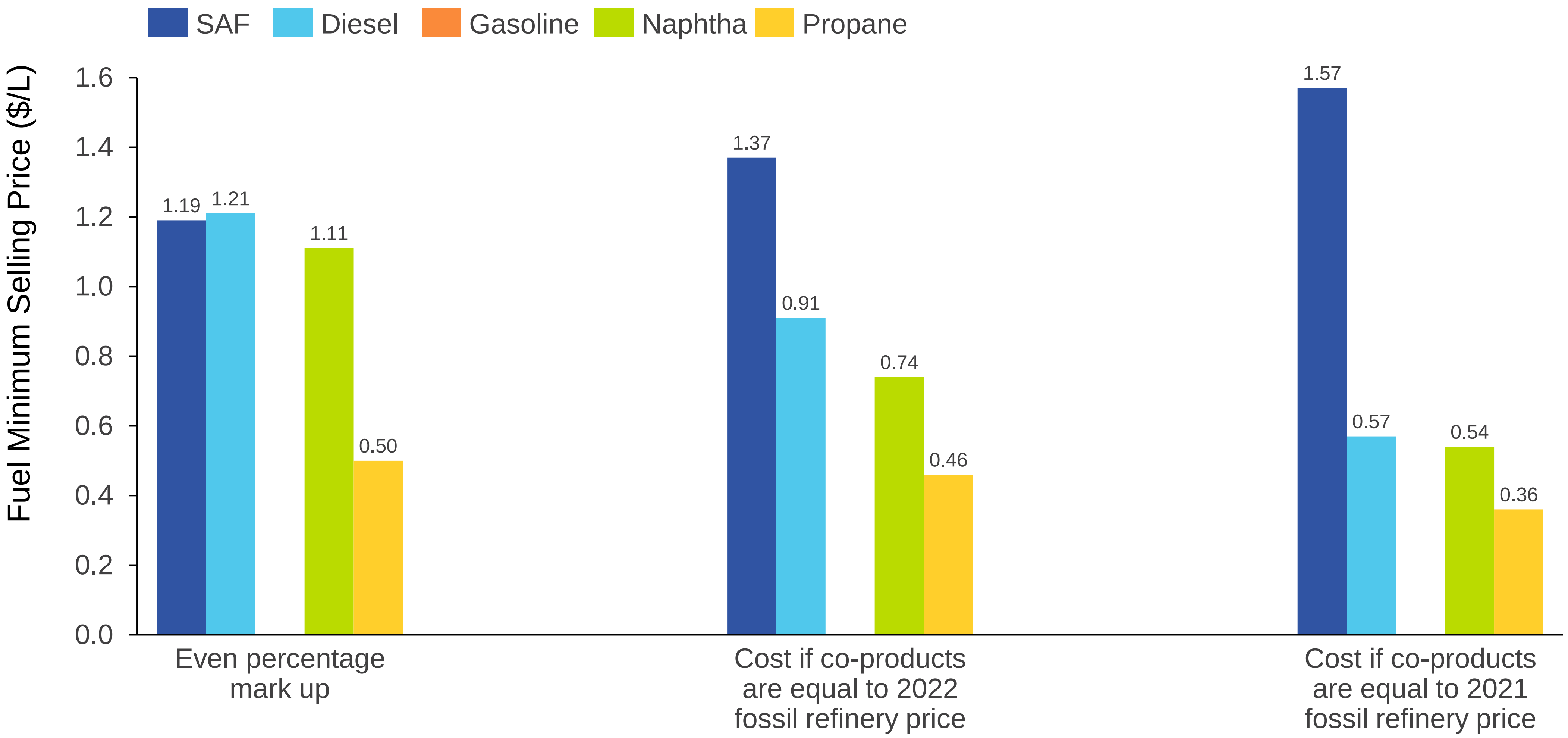


=> Opportunity for collaboration between the countries

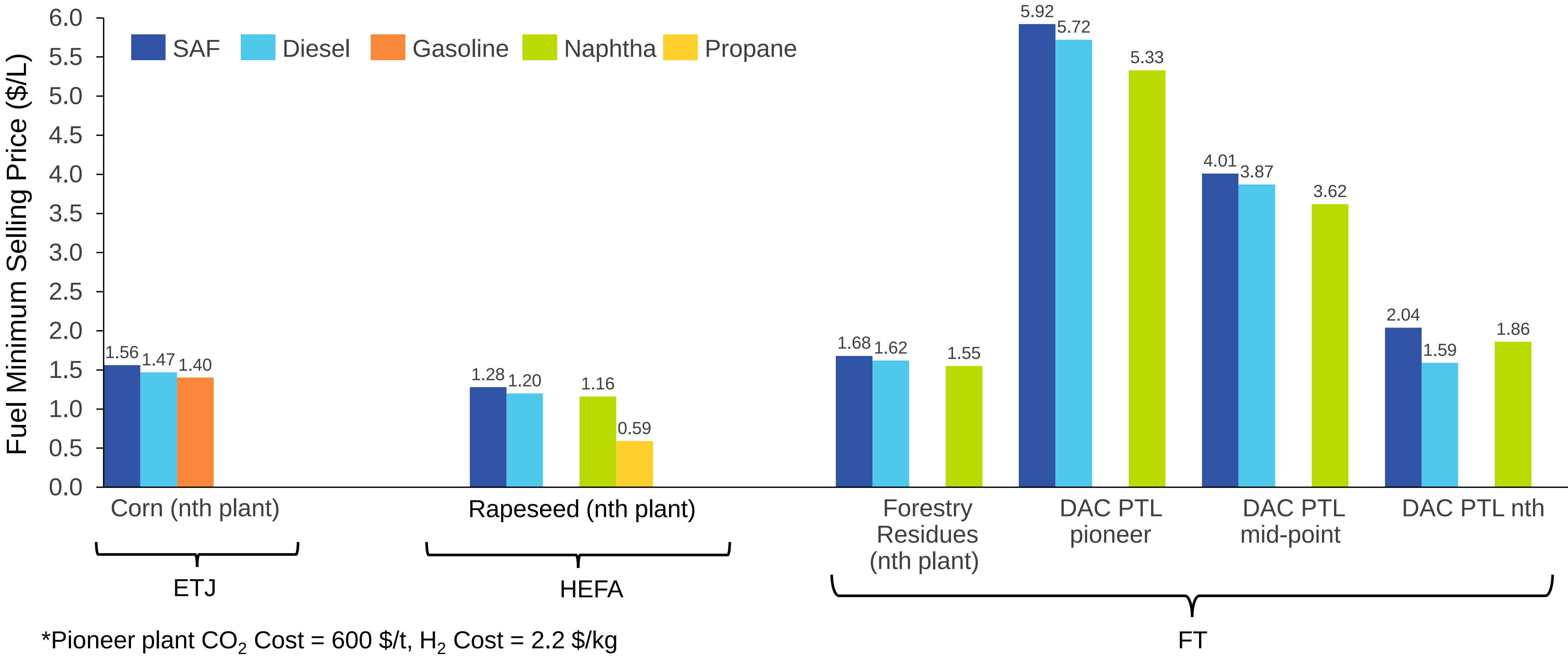
SAF Production Costs in Brazil (nth Plant)



Production Cost in Brazil if Green Premium is paid by SAF Only (Example for Soybean HEFA)



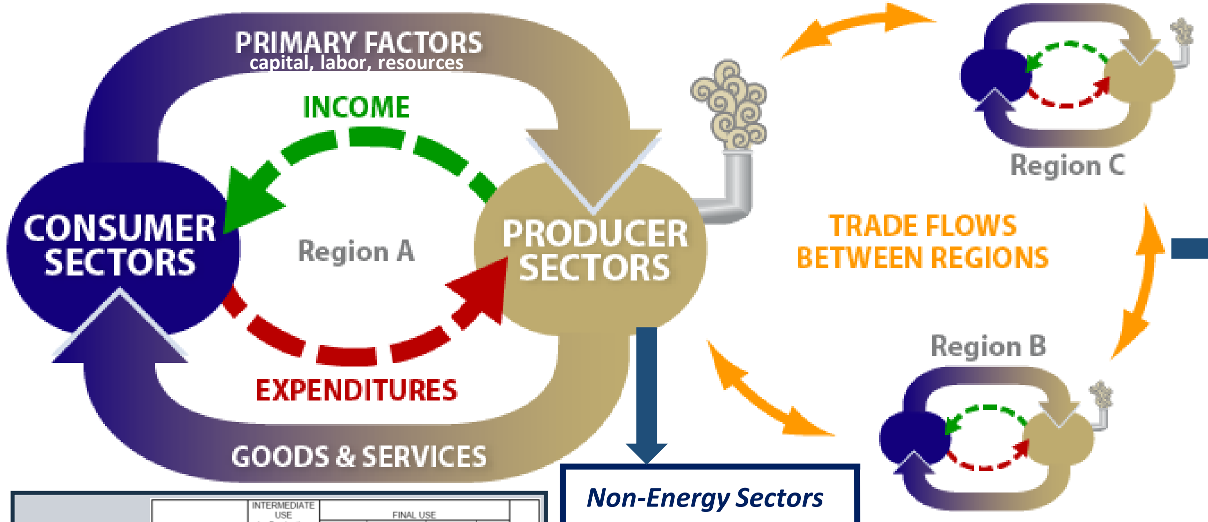
SAF Production Costs in Chile



*Pioneer plant CO_2 Cost = 600 $/t, H_2 Cost = 2.2 $/kg
Mid-point plant CO_2 Cost = 375 $/t, H_2 Cost = 2.1 $/kg
nth plant CO_2 Cost = 150 $/t , H_2 Cost = 1.7 $/kg

MIT Economic Projection and Policy Analysis (EPPA) Model

Multi-sector, multi-region computable general equilibrium (CGE) model of the world economy for energy, economy and emissions projections



Updated for this study

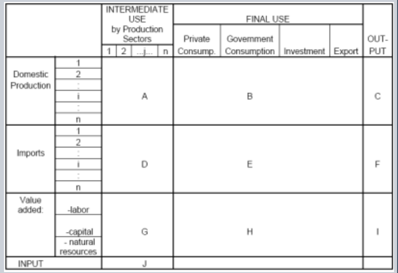
13 Regions
- USA
- Brazil
- Chile
- Colombia
- Ecuador
- Peru
- Mexico
- Europe
- Japan
- China
- India
- Africa
- Rest of World

Key Features
Global Coverage & International Trade
Economy-Wide Coverage & Inter-Industry Linkages
Feedbacks Across Regions & Sectors
Theory-Based (microeconomics w/ full input-output data)
Endogenous Prices, Investments & Capital Accumulation
GDP and Welfare Effects
Policies (emissions limits/prices, sector/technology regulations…)
Distortions (taxes, subsidies, etc.)
Accounting for Physical Quantities (energy, electricity, land)

Links to MIT Earth System Model (MESM) for climate projections (temperature, precipitation, etc.)

Technical Features
Written in GAMS using MSPGE
Recursive-Dynamic
Uses GTAP Database
Calibrated to current economic and energy levels based on IMF and IEA
Documented in peer-reviewed literature
Publicly Available Version
2100+ (in 5-year steps)

Full Input-Output Data for Every Region



Regions and sectors can be added for special studies

Non-Energy Sectors
- Crops
- Livestock
- Forestry
- Food
- Energy-Intensive Industry — Iron & Steel; Cement; Chemicals; Non-Ferrous Metals; *+ low-carbon options*
- Manufacturing
- Services
- Air Transport
- Household Transport — ICE (gasoline & diesel); Plug-in Electric; Battery Electric; Hydrogen

Energy Sectors
- Crude Oil
- Refined Oil
- Jet Fuels — Traditional; Biojet; Synthetic
- Other Biofuels
- Oil Shale
- Coal
- Natural Gas (conv., shale, tight)
- Electricity — Conv. Fossil (coal, gas, oil); Adv. Fossil (NGCC, Adv Coal); Coal with CCS; Coal + Bio Co-firing w/ CCS; Gas with CCS; Gas with Advanced CCS; Nuclear; Advanced Nuclear; Hydro; Solar; Wind; Renewables with Backup; Biomass; Biomass with CCS
- DAC

New Technologies Continually Added

SAF Pathways
Alcohol-to-Jet
Fischer-Tropsch (PTL)
HEFA

Crops for SAF
Corn
Sugarcane
Rapeseed Oil
Palm Oil
Soy Oil
Biofuels (Cellulosic)

Land Use
Land availability & prices
Endogenous land use change
Direct & indirect land use change emissions
Crop production and transport

Land Types:
Crops
Livestock
Forestry
Natural Grass
Natural Forest
Bioenergy
Other

Key Outputs
GDP
Consumption
Emissions (GHGs, Air Pollutants)
Primary/Final Energy Use
Electricity Generation
Technology Mix
Commodity and Factor Prices
Sectoral Output
Land Use
At global and regional levels

Key Inputs
Policy Assumptions
Population Growth
Capital/Labor Productivity Growth
Energy Efficiency Improvements
Technology Costs
Rate of Technology Penetration
Elasticities of Substitution
(related to labor, capital, energy, fuels, etc.)
Fossil Fuel Resource Availability
Urban Pollutant Initial Inventories & Trends
Land Productivity

Key Equations
Firms maximize profit: choose technology, level of output and inputs subject to production functions and costs
Household maximize welfare: choose savings and consumption subject to budget constraint
Equilibrium Conditions: Market-Clearing, Zero-Profit, Income Balance

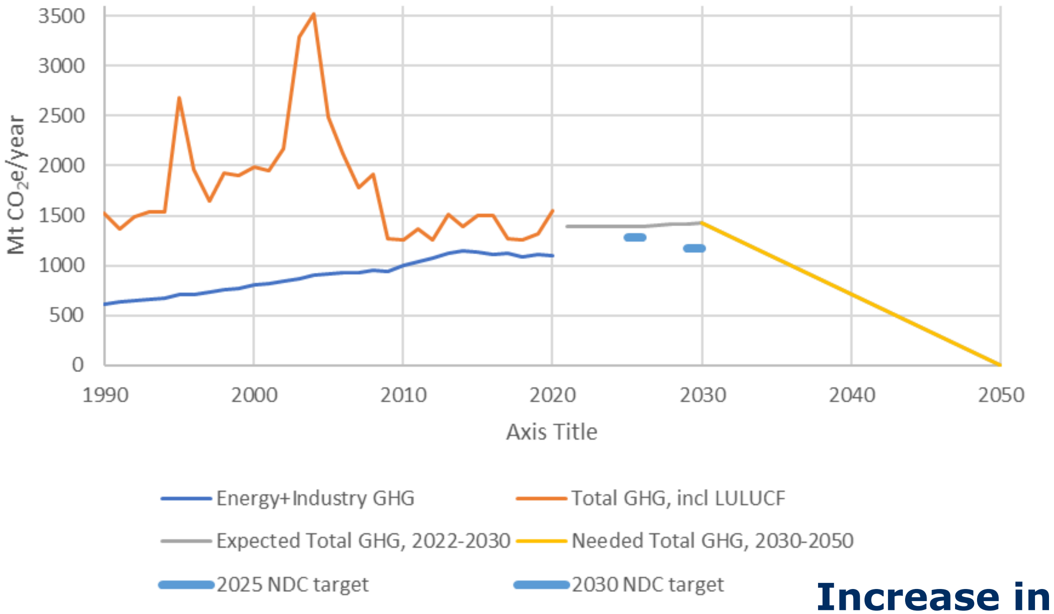
https://globalchange.mit.edu/research/research-tools/human-system-model

Brazil

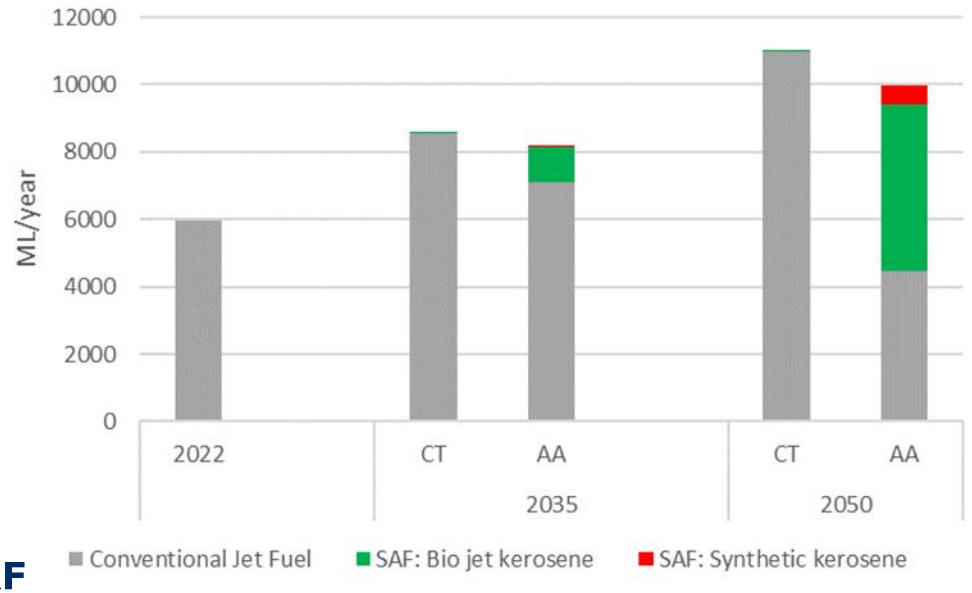
Domestic SAF policy: *Proposal in development*

Year	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
Minimum Percentage Emission Redcution	1%	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%

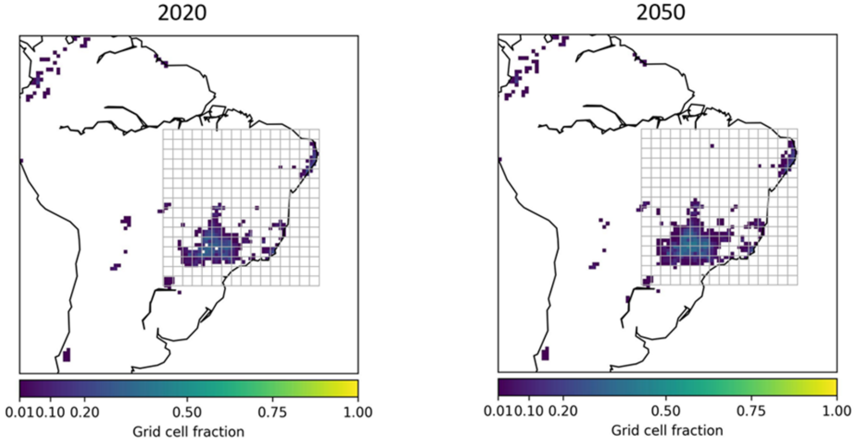
Economy-Wide Emissions



Projected jet fuel use



Increase in land use for SAF



Economy-Wide Emission Targets:

2030: 53.1% reduction below 2005

2050: climate-neutral

For 2050 target:
Uncertainty in LUC

*For **2035**: **1 ML SAF***

*For **2050**: **5.5 ML SAF***

*Estimated impact on **RPK in 2050**: decrease by 8% relative to the baseline*

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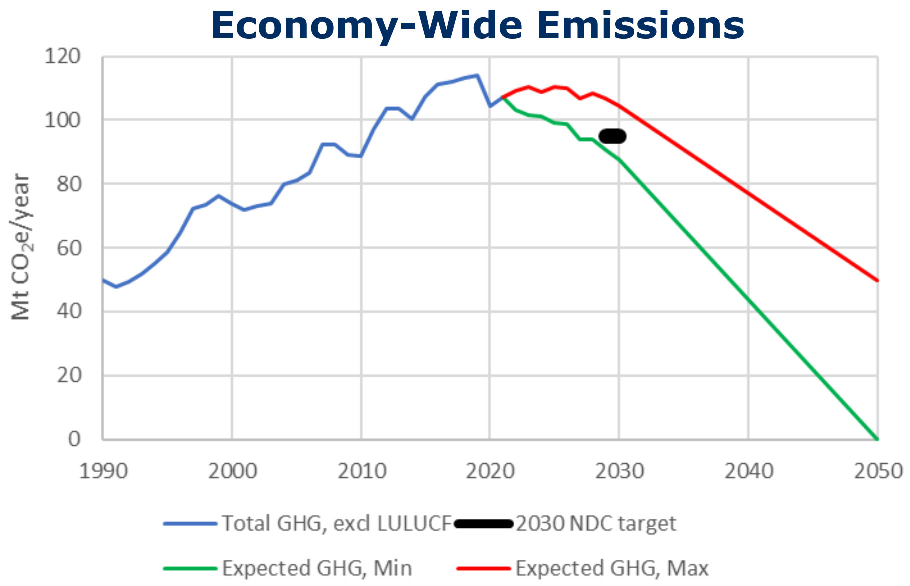
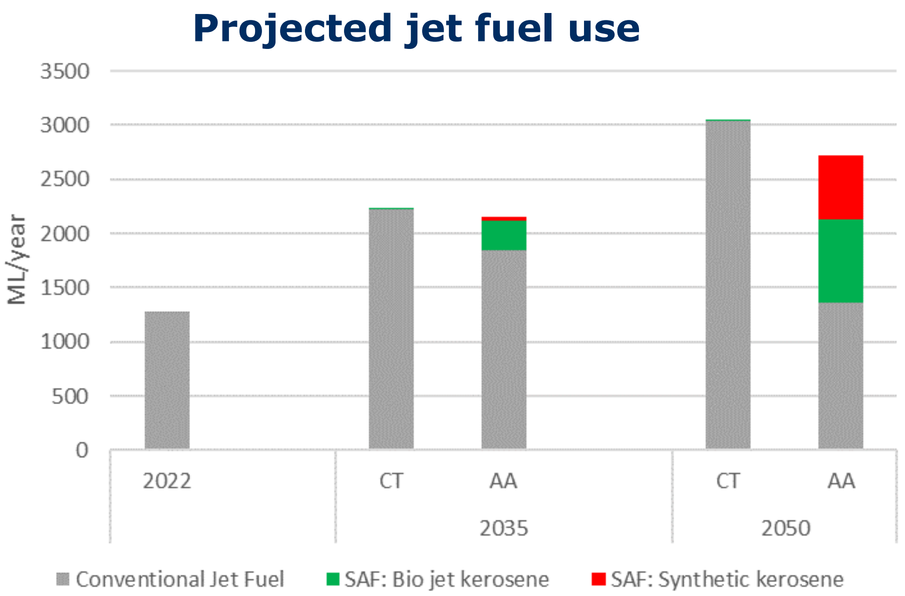
Chile

Domestic SAF policy: *Proposal in development*





Economy-Wide Emission Targets:
2030, unconditional: 95 $MtCO_2$
2050: net-zero GHG

For 2050 target:
It might heavily rely on negative emissions by forests (up to 50% of the required reduction)

For ***2035****:* ***0.3 ML SAF*** *(mostly bio-jet SAF)*

For ***2050: 1.3 ML SAF*** *(both bio-jet and synthetic SAF)*

Estimated impact on ***RPK in 2050****: decrease by 7-10% relative to the baseline (Current Trends), but RPK is still about twice as large in comparison to 2022.*

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Summary

- ✓ **Aviation** is committed to reaching a **net zero target by 2050,** engaging in **multiple** decarbonization **options. Decarbonization** is a **needed** but very challenging task.
- ✓ **Sustainable aviation fuels (SAF)** is the most significant decarbonization pathway, but **other measures** will be required (operational efficiency, air traffic efficiency, new airplane technology (fleet renewal and alternative forms of propulsion) and carbon offsets) to reach net-zero.
- ✓ **Latin America** has a **potential** for a competitive advantage in SAF production; however, our **estimated cost** of SAF production is **higher** than jet fuel price.
- ✓ Current **jet fuel price** is around \$0.70/liter. Carbon pricing (\$200-250/tCO_2) might result in almost **doubling** jet fuel prices by 2050.
- ✓ Our estimated SAF costs for **mature bio-jet-fuel** plants in Brazil are \$0.90-1.60/liter.
- ✓ Our estimated SAF costs for **mature synthetic-jet-fuel** plants in Chile are \$2-4/liter.
- ✓ Sugarcane and corn-based ETJ in Brazil and rapeseed-based HEFA in Chile offer **attractive near-term** opportunities for SAF.

Summary (cont.)

- ✓ Increased fuel costs would affect ticket prices and **aviation demand**, impacting **connectivity** and **economic growth**.
- ✓ Government **policy mechanisms** will be required to create the enabling conditions to make SAF **commercially viable** in the region, while **balancing** the impact of **decarbonization** measures on passenger traffic and **connectivity**.
- ✓ **Aircraft manufacturers** need to accelerate incremental and **disruptive technologies,** fuel efficiency and R&D for **alternative propulsion options** (hydrogen, electric, and hybrid aircrafts)**.**
- ✓ For **fuel producers,** it is essential to seek **economies-of-scale,** to establish **robust supply chains,** and to develop **innovative** SAF production pathways.
- ✓ **Unification** of decarbonization approaches between countries will be **beneficial** to ensure **competitiveness** and economy-of-scale**,** while low-income customers/low-income countries may require **supporting mechanisms.**
- ✓ Need for **region-specific studies** that involve **local** and international experts.

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