SUSTAINABLE AVIATION FUELS IN BRAZIL

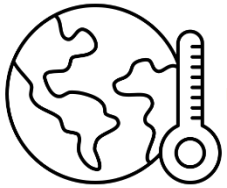
Future Perspectives

Department of Oil Products and Biofuels
Division of Oil, Gas and Biofuels Studies

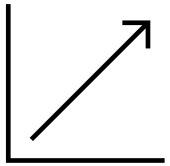
August 2024

Imagem

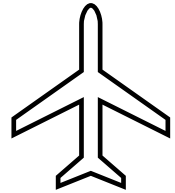
Context



Climate change calls for global actions to mitigate greenhouse gas emissions (GHG).
The challenge is even greater for hard-to-abate sectors, such as aviation, which accounted for 2% of global emissions in 2022

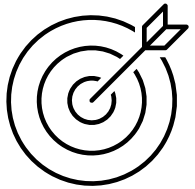


It is estimated that the demand for aviation kerosene will continue to grow, and consequently, GHG emissions, even with improvements in aircraft efficiency and systemic gains



Sustainable Aviation Fuels (SAF) constitute one of the primary measures to mitigate emissions from the sector

Brazil, with its experience in biofuel production and availability of renewable feedstocks, can assume a leadership role in the renewable fuels market and accelerate the transition to a sustainable economy



The International Civil Aviation Organization (ICAO) has set emissions reduction targets for the sector and aims to achieve net-zero carbon emissions by 2050.

Brazil is also developing a program for the sector - the ProBioQAV.

EPE conducted this study to assess the possible pathways Brazil can take in pursuit of these objectives

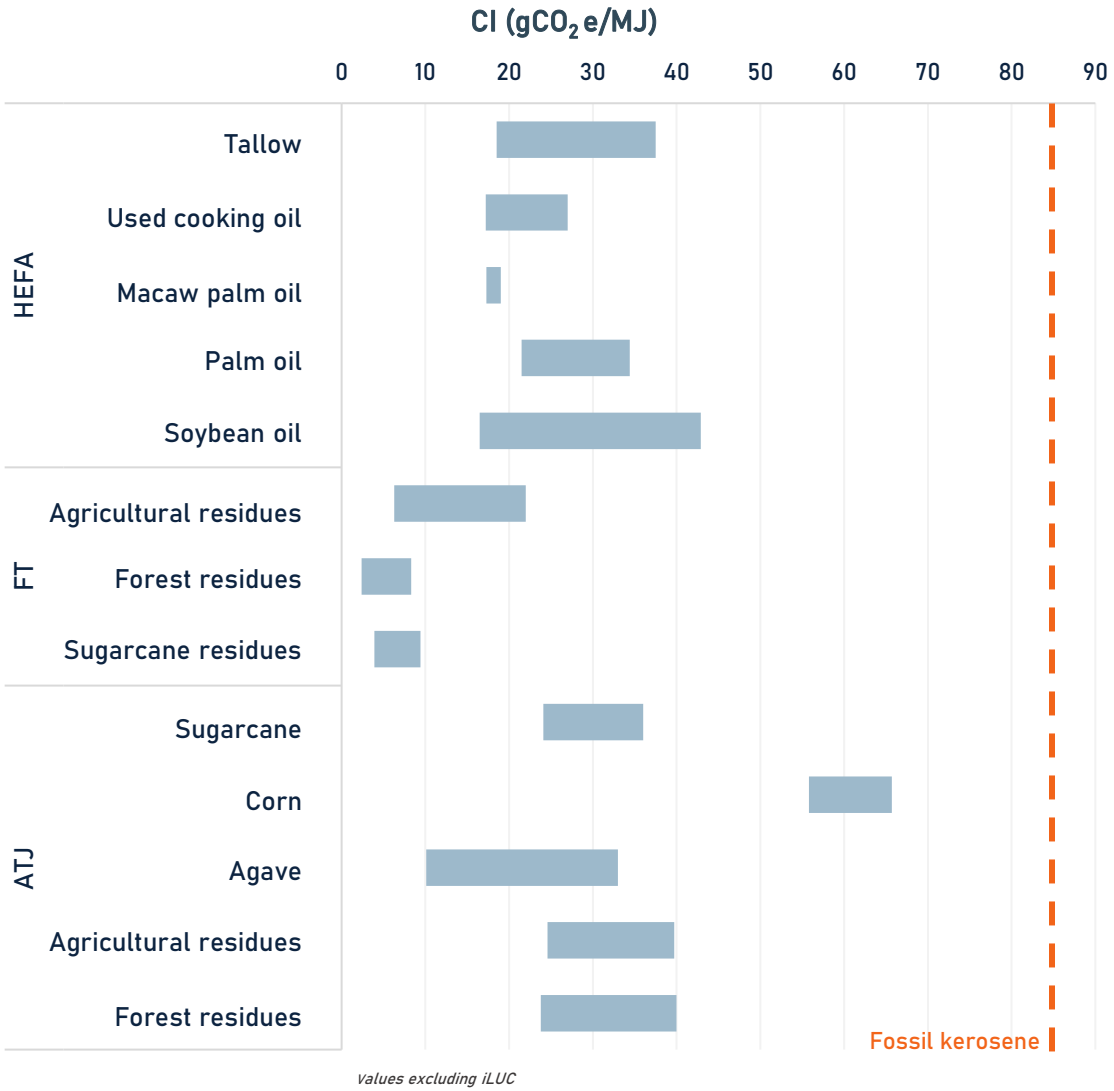
Conversion processes & Feedstocks

Approved conversion processes

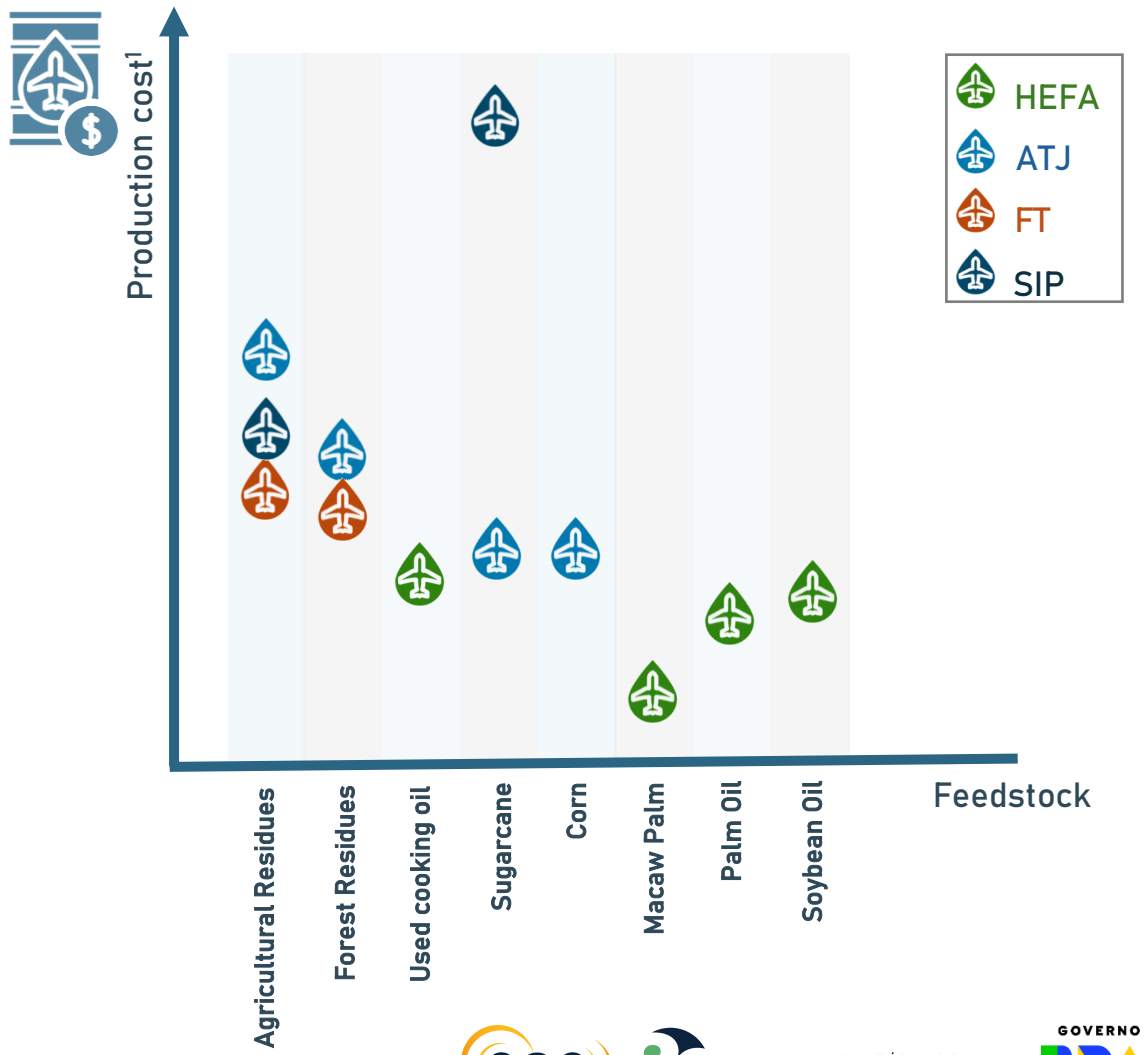
Primary feedstocks		Conversion processes approved by ASTM D7566 and ANP Res. 856/2021	Blend limit[1]
Lipids: Oilseeds, algae, and residual oils and fats	HEFA	Hydroprocessed esters and fatty acids	50%
	HC-HEFA	Hydrocarbon-Hydroprocessed Esters and Fatty Acids	10%
	CHJ	Catalytic hydrothermolysis jet fuel	50%
Lignocellulosic biomass: Eucalyptus, pine, elephant grass, sugarcane bagasse	FT-SPK	Fischer- Tropsch Synthetic Paraffinic Kerosene	50%
	SPK-A	Synthetic Paraffinic Kerosene with Aromatics	50%
	SIP	Synthesized iso-paraffinic	10%
Sugars and starches: Sugarcane, corn, beetroot, cassava	ATJ	Alcohol to Jet	50%

[1] Blend limit: maximum percentage allowed for blending with fossil aviation kerosene in ANP resolution
Source: 9, 10

Carbon intensity (CI) and Costs



values excluding iLUC

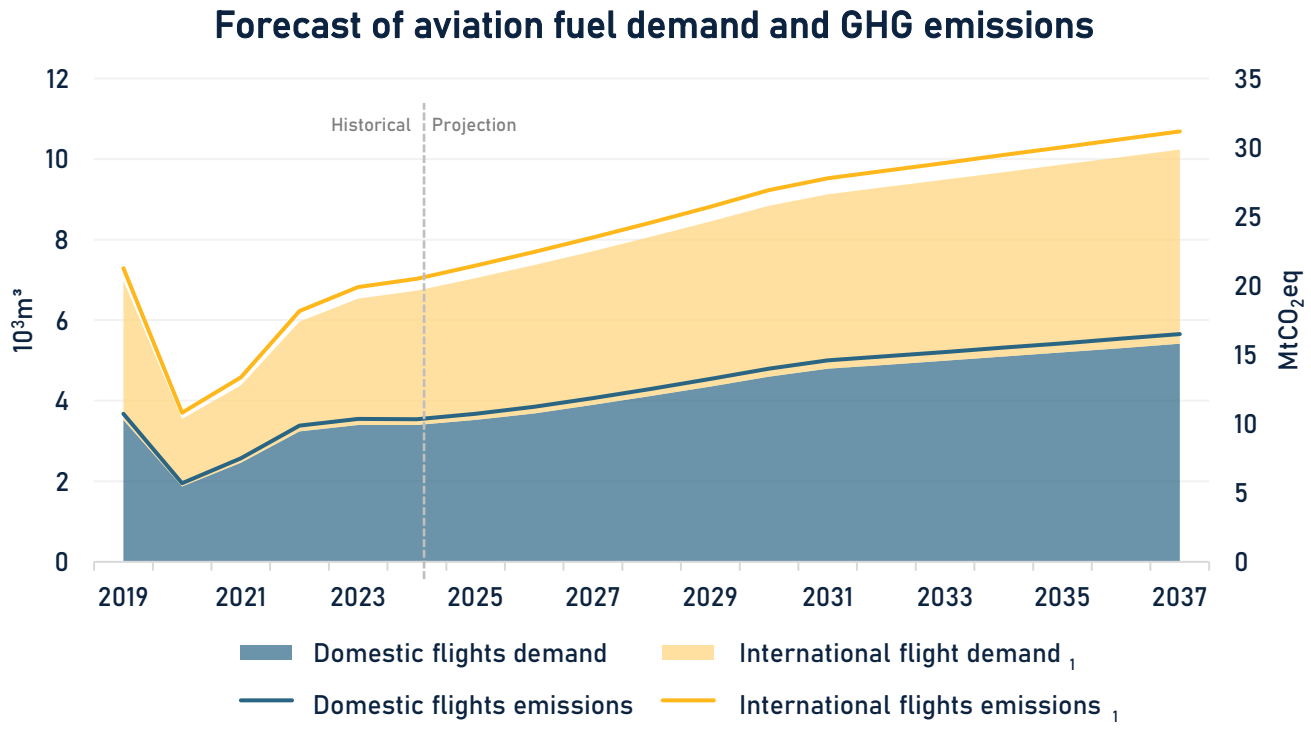


[1] The production cost per conversion process is represented by the minimum selling price of SAF

Source: 11, 15, 16, 20, 21, 25, 26

Scenarios for SAF Supply in Brazil

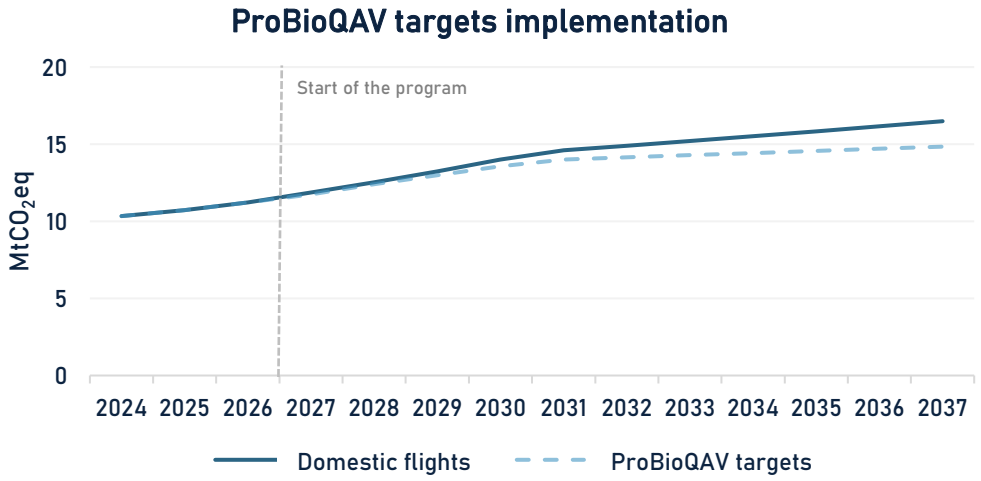
The demand for aviation fuel will continue to grow in the coming years

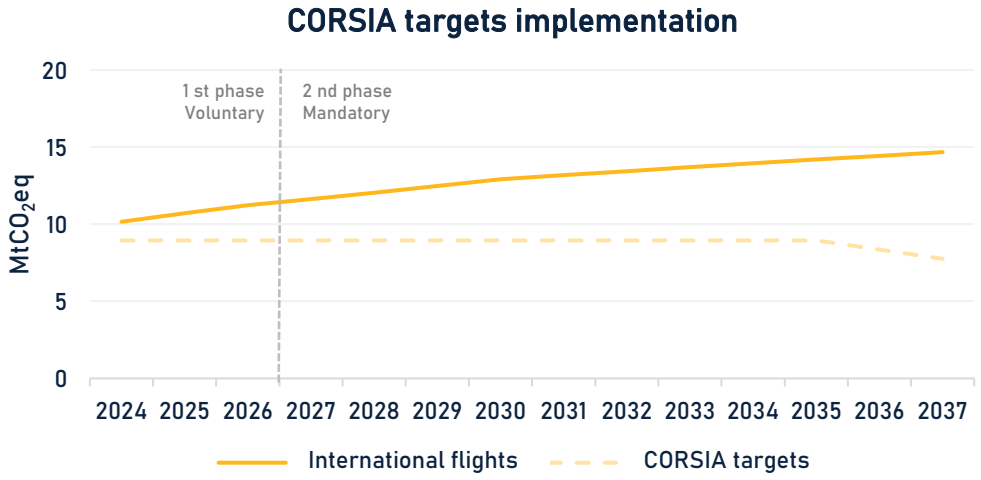


- To keep up with the sector's demand rebound post-pandemic, both domestic production and aviation fuel imports in Brazil are expected to increase.
- Despite improvements in aircraft efficiency and travel planning, emissions from the sector are also on the rise.
- In this context, SAF production must play a pivotal role in aviation decarbonization through the ProBioQAV and CORSIA programs.
- Brazil can stand out in SAF production due to its expertise in biofuels and the abundance of biomass and other renewable energy sources.

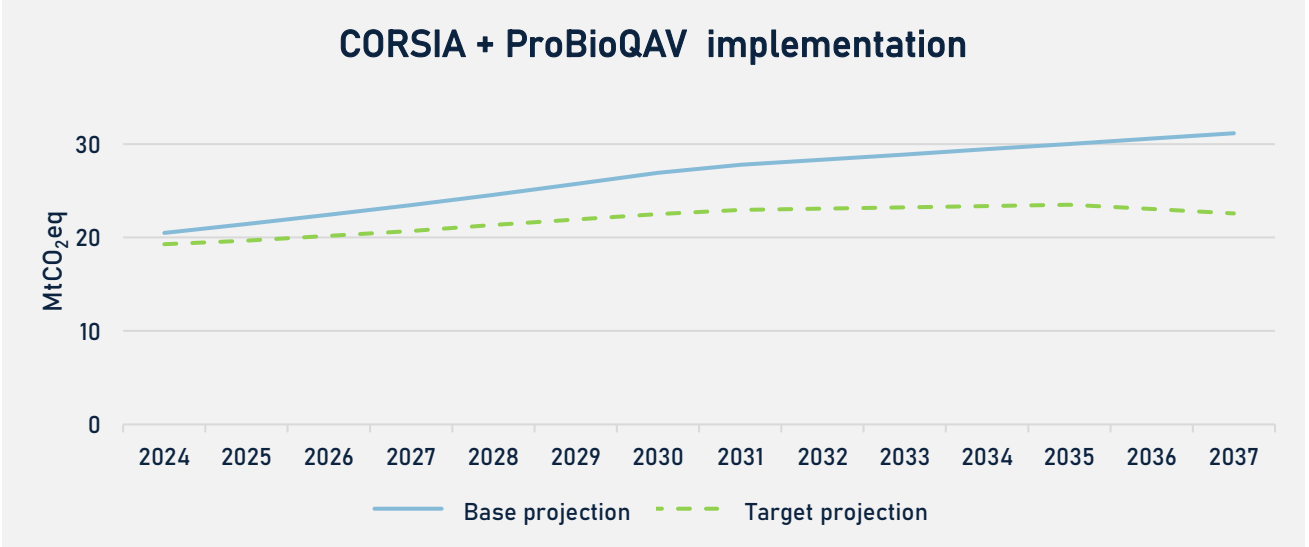
[1] Flights operated by domestic or foreign companies with origin/destination outside of Brazil.
Source: EPE, based on 34

Emissions reduction targets



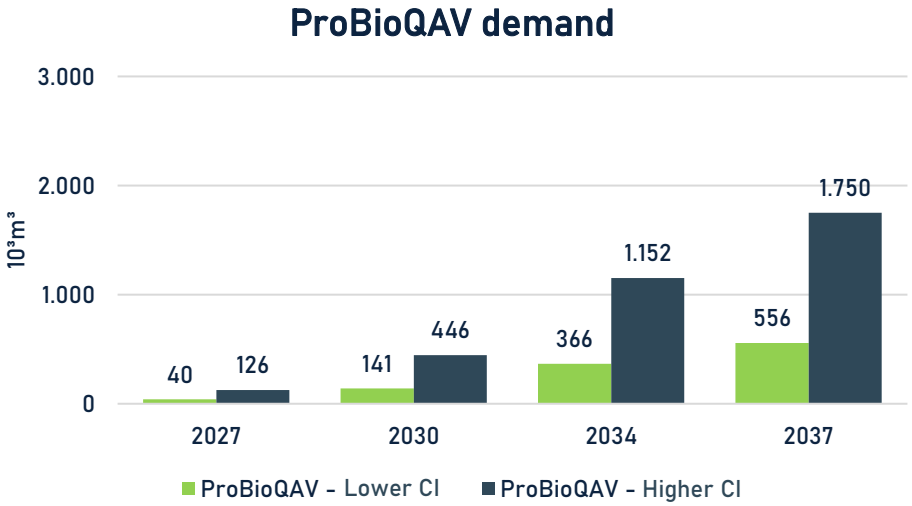


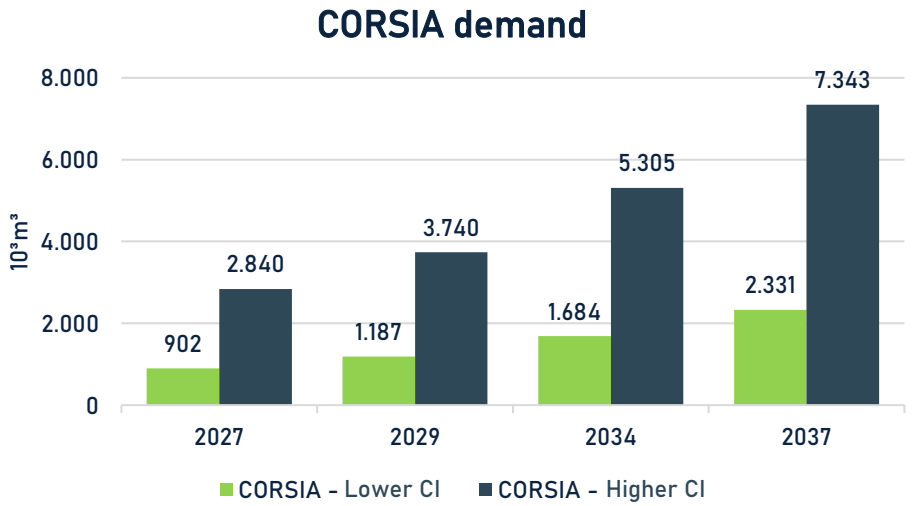
- ProBioQAV and CORSIA are not based on volumetric mandates, but rather on emissions reduction targets
  - **ProBioQAV** – gradual emissions reduction percentagem Applied to domestic flights, starting at 1% in 2027 and increasing to 10% by 2037.
  - **CORSIA** – carbon-neutral growth until 2035, followed by reduction to achieve net zero emissions in international aviation by 2050.
- The implementation of both programs results in emissions reduction that can be met with SAF.



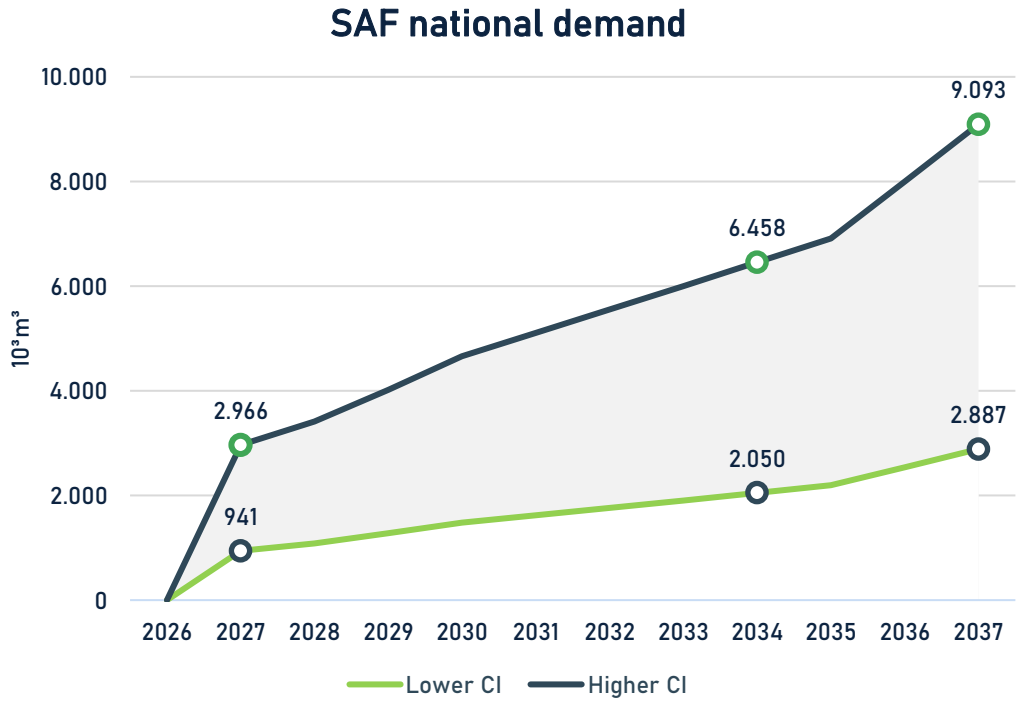
Source: EPE, based on 2, 8, 34

SAF demand in Brazil





- The volumetric demand for SAF will vary according to the carbon intensity (CI) of the fuel produced, as CORSIA and ProBioQAV set emission reduction targets.



Fonte: elaboração própria, com base em 2, 8, 34

Proposed scenarios

Announced projects

Are the announced projects sufficient to meet the emissions reduction targets?

Feedstocks

Traditional

How can soybean oil, first-generation sugarcane ethanol, and corn ethanol contribute to achieving the targets?

Alternatives

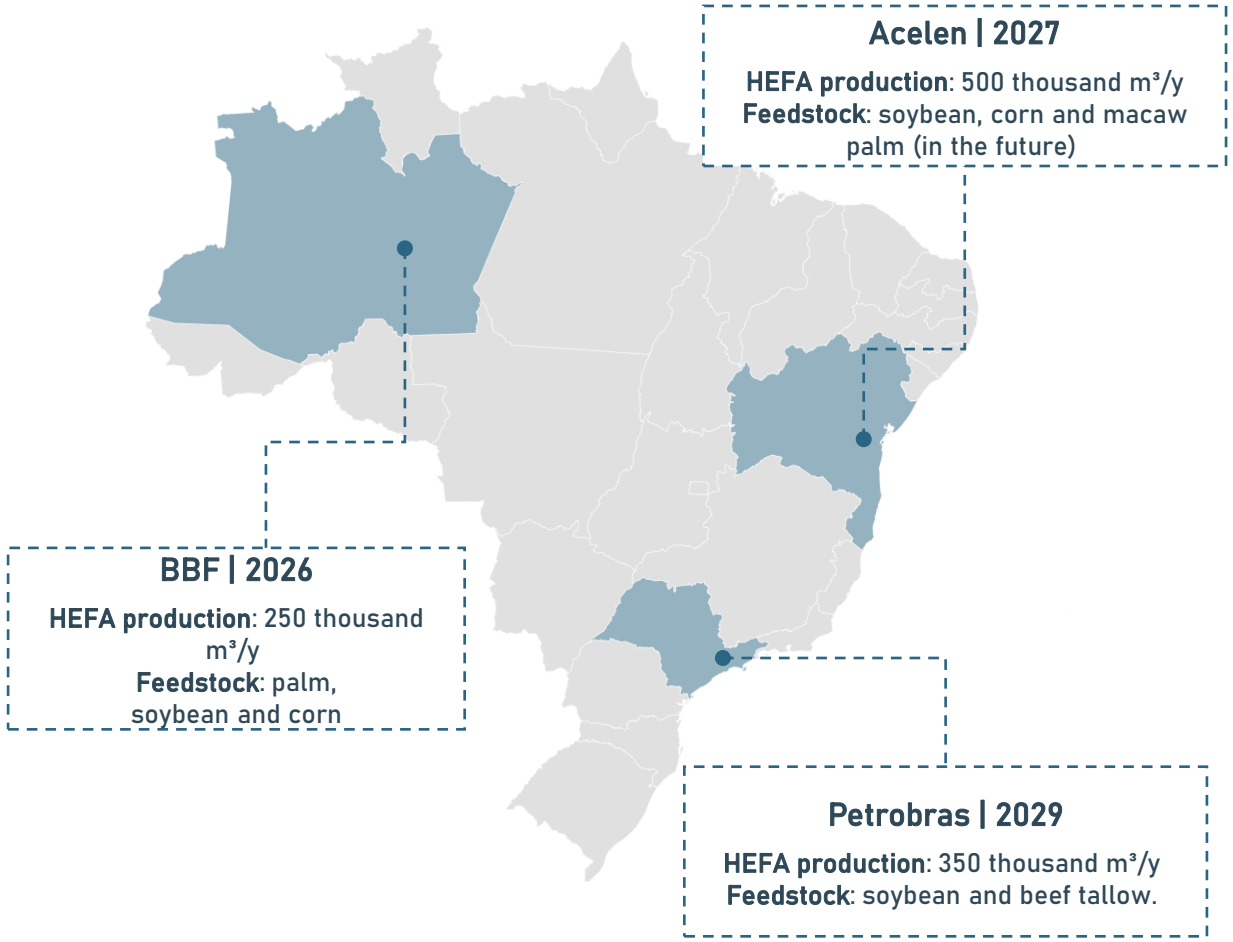
How can alternative feedstocks contribute to meeting the targets?

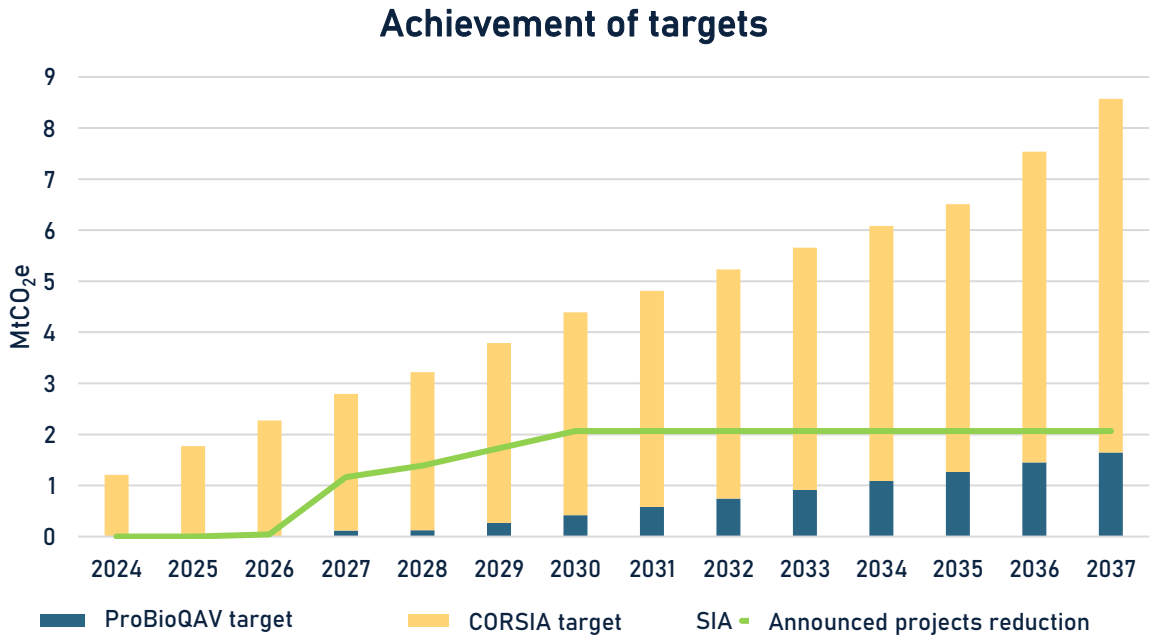
Residues utilization

What is the production potential of SAF from organic residues available in Brazil?

Scenario I | Announced Projects

Announced projects partially meet the emissions reduction targets



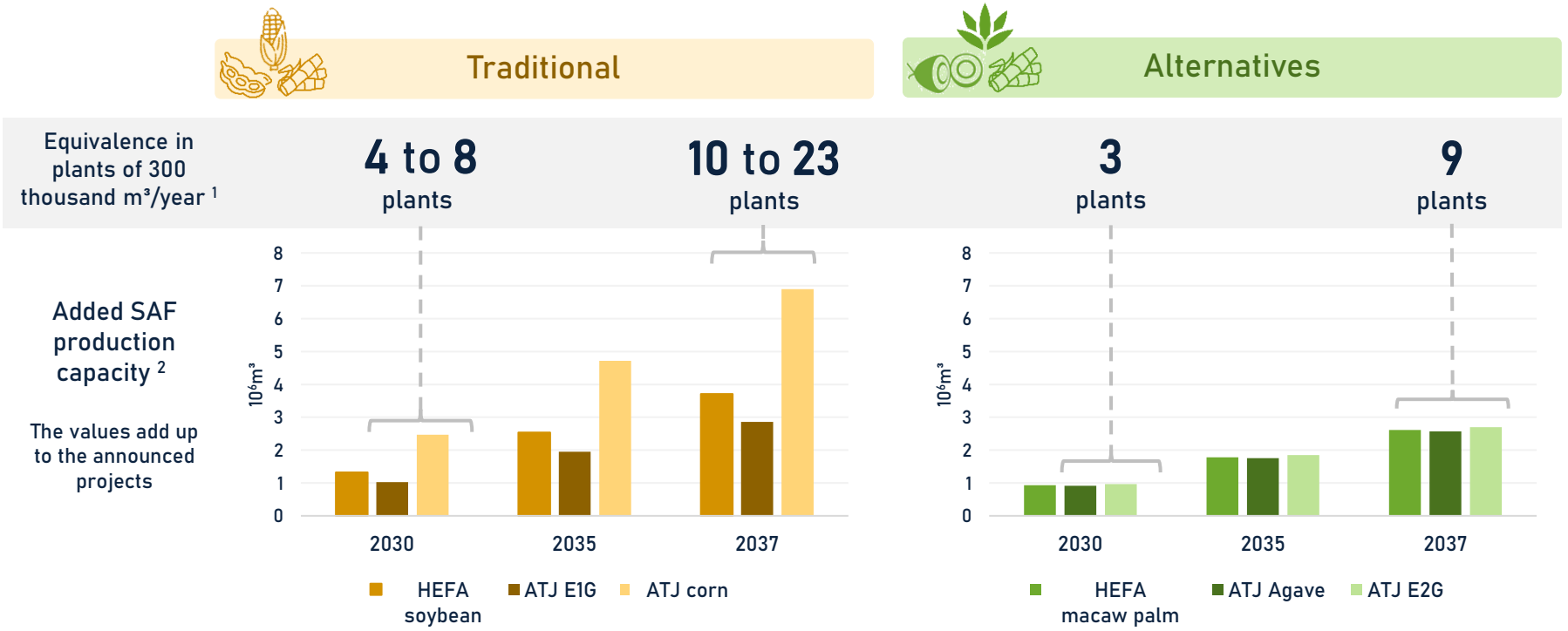


- From 2027 to 2037, projects meet na average of 38% of the emissions reduction targets set by CORSIA and ProBioQAV.
- Considering only ProBioQAV, the announced projects are sufficient to meet the established targets until 2037.

Note: There are projects to build plants that use the AtJ and HEFA routes, with a lower degree of certainty, that were not included in this study.
Source: EPE, based on 2, 8, 16, 20, 34, 35, 36,

Scenario II | Traditional and alternative feedstock

Production capacity varies according to the conversion process and feedstock



- The mix of conversion processes and feedstock will depend on the evaluation of several factors.
  - Ex: availability of feedstock, logistics, costs, environmental aspects, etc.
- In 2037, SAF production is expected to range from **3.7 to 8 million m³/year**, depending on the chosen conversion processes. This production range includes the announced projects.
- SAF could represent between 36% and 78% of the volumetric demand for QAV[3].

Note: The analyses are mutually exclusive.

[1] Average specific capacity based on announced projects and market reports (29).

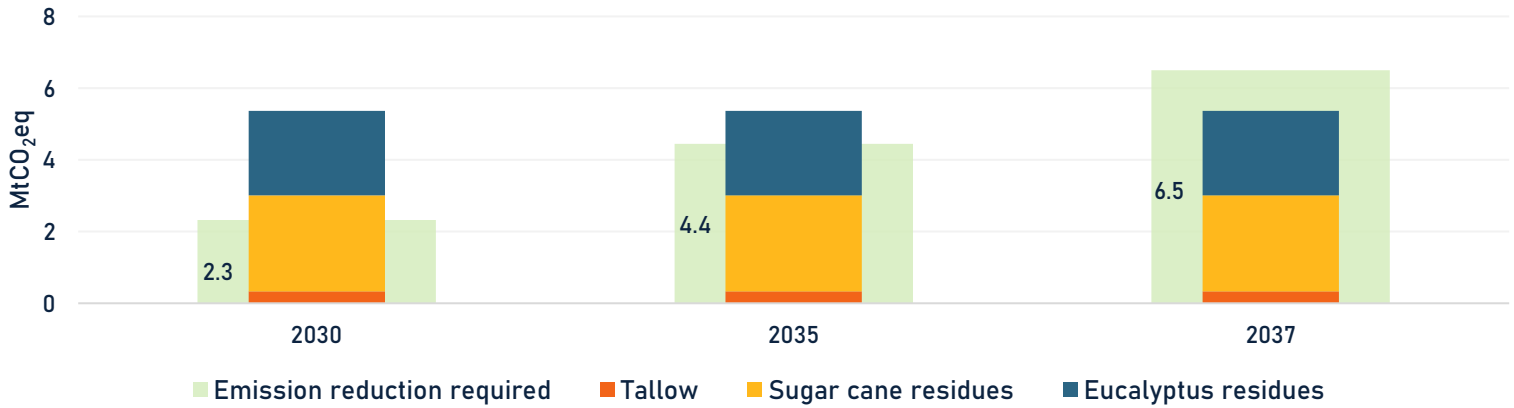
[2] The calculations used the additional emissions reduction required each year and IC values indicated on this page of the Notebook.

[3] At present, the maximum blending limit is 50%.

Source: EPE, based on 2, 8, 16, 20, 25, 34, 35, 36, 37

Scenario III – Residues utilization

	Beef tallow	Sugarcane Residues	Eucalyptus Residues
Utilization rate [1]	20%	10%	40%
Estimate of available residues	**215** thousand tons/year	**26,5** million tons/year	**16,6** million tons/year
SAF Production Potential	**~140** thousand m³/year via HEFA	**~915** thousand m³/year via FT	**~790** thousand m³/year via FT
Equivalence in plants	**1** plant of 140 thousand m³/yr	**3** plants of 300 thousand m³/yr	**3** plants of 300 thousand m³/yr



- The use of organic residues is attractive due to the low cost of feedstock acquisition and low carbon intensity.
- **This trajectory considers the level of utilization of available residues and indicates the potential for SAF production from them.**
- If the full utilization potential were realized, it would be possible to meet 82% of the emission reduction targets for 2037 using only residues biomass.

[1] The utilization rates were defined considering portions of these residues that are already used for other purposes. In the graph, the level of emission reduction from residues remains constant, as the availability in 2022/2023 was used as a reference..

Source: EPE,based on 16, 18, 38, 42, 43

Summary of 2037 scenarios

	Scenario I	Scenario II		Scenario III
	Announced projects	Traditional	Alternatived	Residues utilization
Addedd capacity[1]	**1,100** thousand m³/year	**3,000 to 6,900** thousand m³/year	**~2,700** thousand m³/year	**~1,940** thousand m³/year
Equivalence in plants	**3** plants 500, 250, 350 thousand m³/year	**10 to 23** plants of 300 thousand m³/year	**9** plants of 300 thousand m³/year	**7** plants 6 of 300 + 1 of 140 thousand m³/year
Estimated investment[2]	**R$ 8.7** billion	**R$ 21 to 48** billion	**R$ 19** billion	**R$ 13.6** billion

[1] The added capacity for SAF production in Scenarios II and III is based on the emission reduction targets of CORSIA and ProBioQAV, and on the IC of each conversion process/feedstock.

[2] The investment estimate was based on the average cost of announced projects in Brazil. It is noted, however, that CAPEX will vary for different conversion processes. There is also the possibility of scale and scope gains that were not considered in this calculation.

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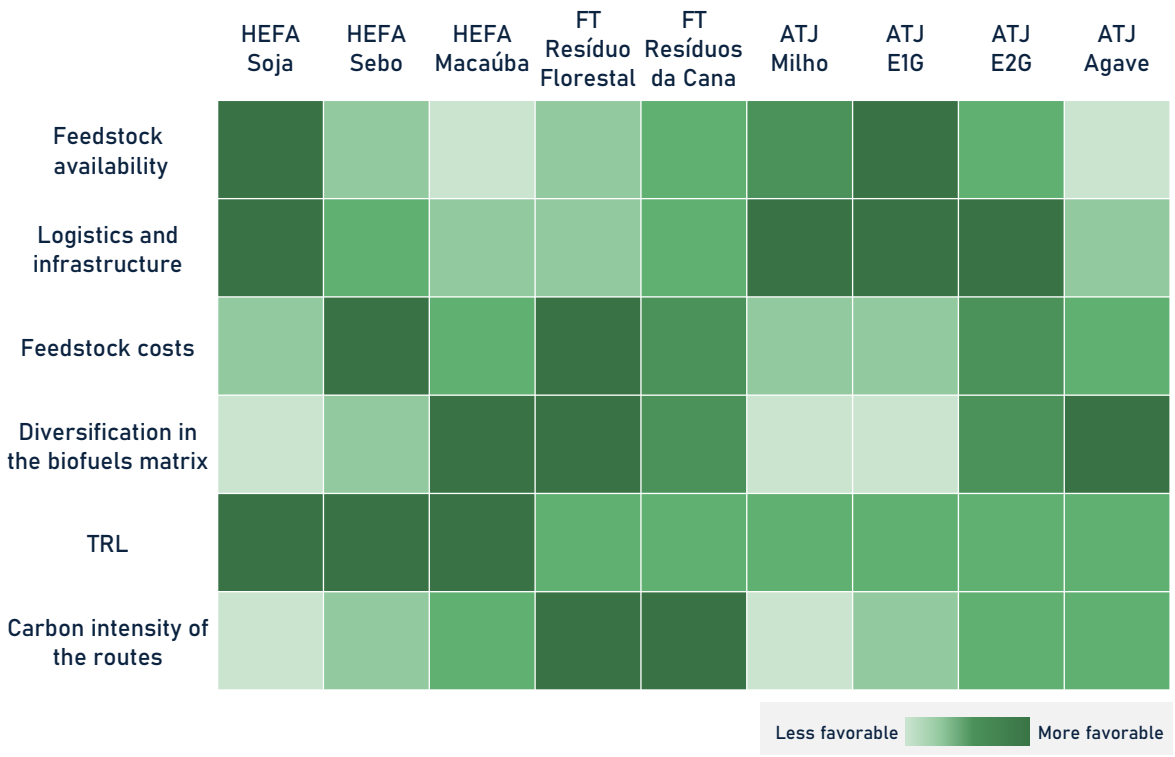
Multi-criteria analysis

The combination of conversion processes and feedstocks will depend on the assessment of various factors and constraints

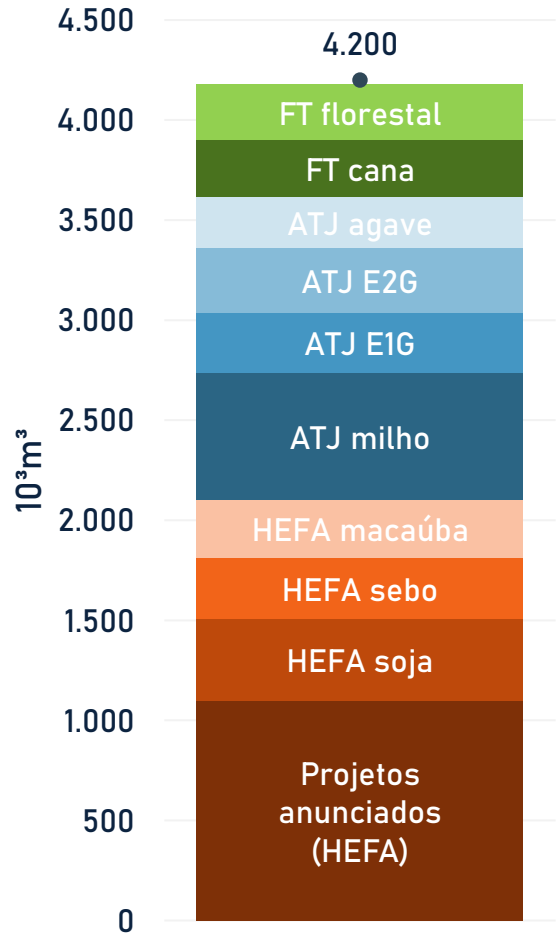
- The combination of conversion processes and feedstocks will depend on the evaluation of various factors and constraints, such as:



- Other factors may also influence the composition of the mix, such as financing, geopolitical aspects, national strategy, etc.

- The weighting of different criteria suggests a **possible SAF production** route composition aimed at meeting sector emission reduction targets and diversifying feedstocks.
  - Diversifying feedstocks for biofuel production still requires investments to achieve scale
  - However, this could be a key driver for regional development, pasture recovery, and job creation.

SAF production by conversion process 2037



Source: EPE,based on 2, 8, 16, 20, 25, 34

Key messages

Key messages

SAF production in Brazil can have a **lower carbon intensity compared to the same conversion processes in other countries** due to integrated plants.

Existing initiatives for the construction of biorefineries **can meet a portion of the emissions reduction** required by CORSIA and ProBioQAV.

But, in the long term, it is necessary to **diversify the feedstocks used in biofuels production**, which could catalyze **job creation** and **income distribution** to rural areas in Brazil.

The scenarios outlined in this study indicate a range of solutions. However, **an integrated perspective is necessary to optimize decarbonization efforts**, given the competition with other industries for resources such as land, feedstock, financing, etc.

Brazil can stand out in SAF production due to its **expertise in biofuels** and the availability of **land**, **biomass**, and other **renewable energy sources**.

It is important to **allocate resources towards RD&I** to establish a **strong industry** aligned with the **just energy transition towards a low-carbon economy**.

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