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Department of Oil Products and Biofuels

Sustainable aviation fuel in Brazil and synergy with green diesel

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MINISTÉRIO DE MINAS E ENERGIA

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DO LADO DO POVO BRASILEIRO

TECHNICAL SHEET | Sustainable aviation fuel in Brazil and synergy with green diesel

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Disclaimers

This publication provides information on sustainable aviation fuel (SAF) and green diesel supply and demand from different technological routes, based on studies by the Energy Research Office (EPE).

This document is for informational purposes and aims to support the planning of the national energy sector. Therefore, EPE expressly disclaims for any actions and decision-making (such as strategic guidelines definitions, investment decisions, or business strategies) taken by economic agents, and anyone based on information contained in this document.

Public Value

EPE conducts studies and research to support the formulation, implementation and evaluation of Brazil's energy policy and planning.

In this report, EPE analyzes the panorama of sustainable aviation fuel productions and its relationship with green diesel, the current Brazilian public policies and internacional agreements, and project the supply and demand of these biofuels in Brazil.

With this study, EPE enhances transparency and reduces information asymmetry by presenting data and facts that can support discussions about the efforts towards energy transition in Brazil, thereby supporting the decision-making process of interested stakeholders.

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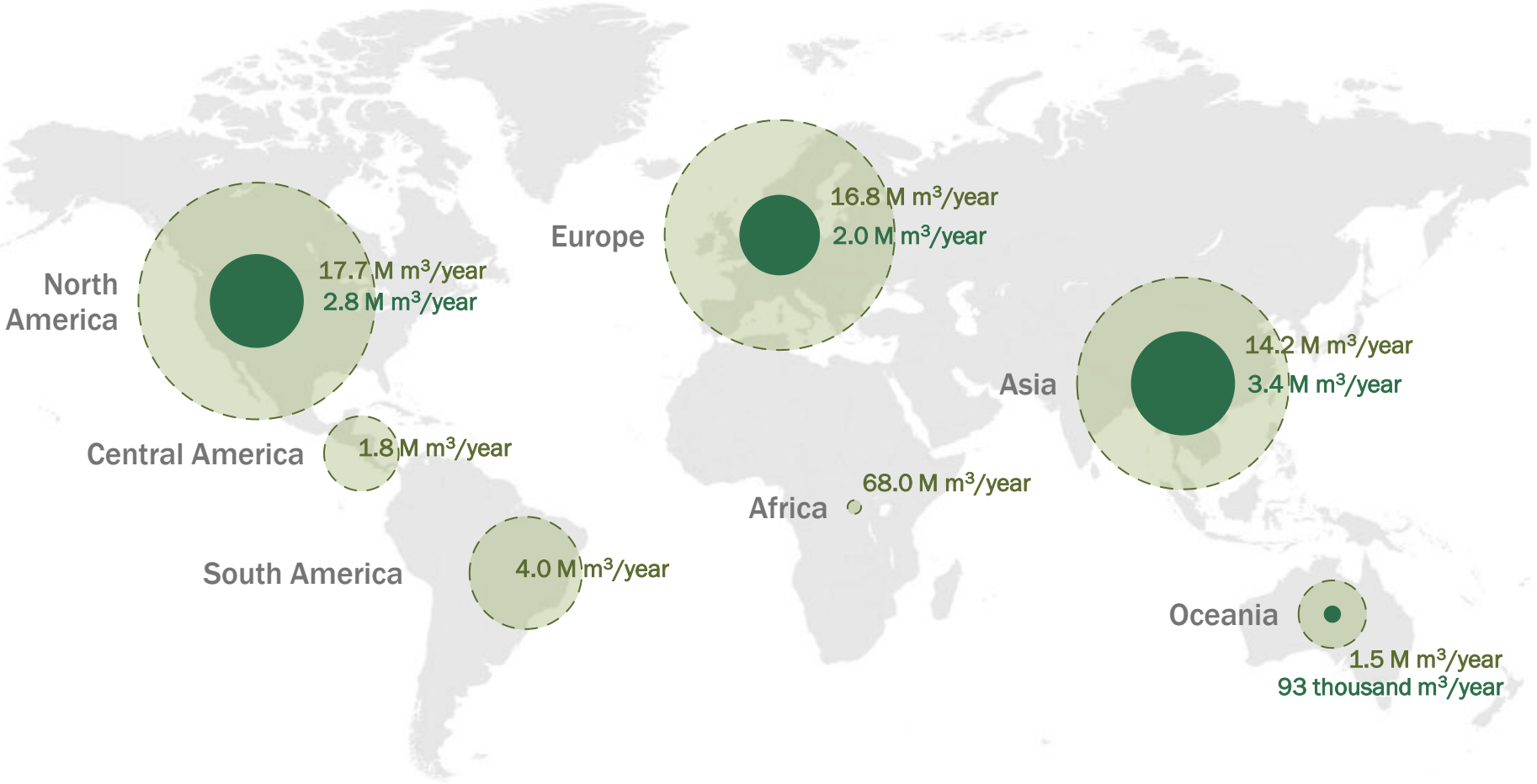
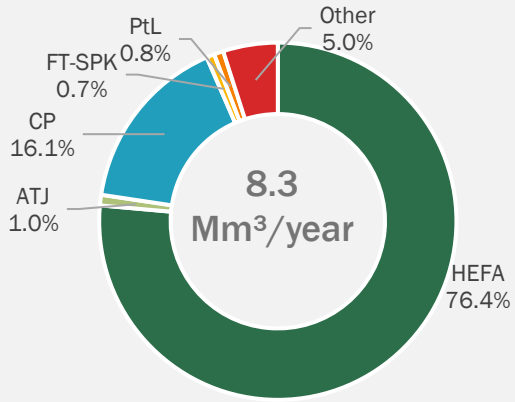
International panorama of SAF

Installed and planned SAF capacity worldwide

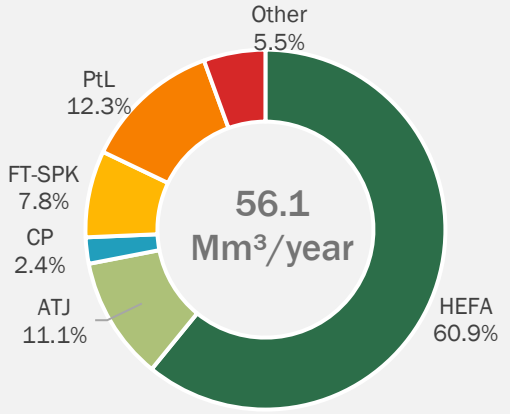


Legend

Installed capacity



Projected capacity

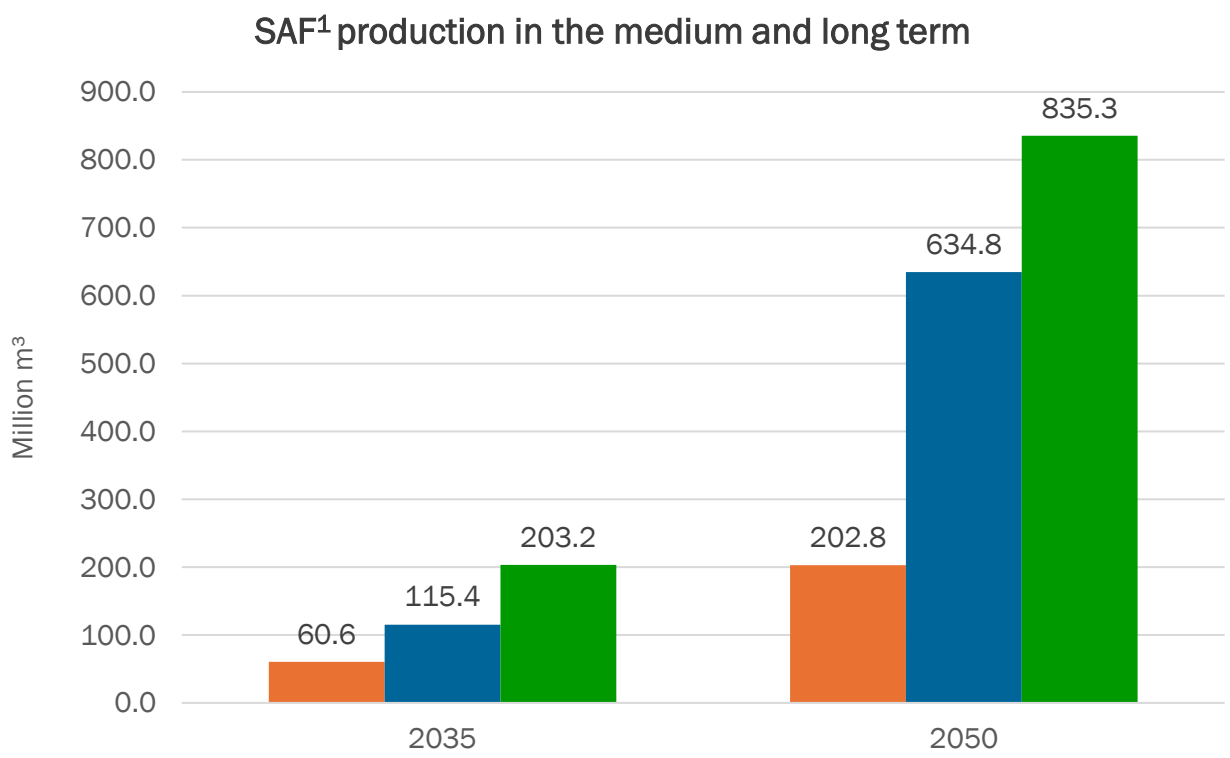


*Other: GTL, MTJ. Pyrolisys
*CP = Co-processing

Source: Argus 2025, SAF Capacity Map. Petrobras, 2025; Energis8, 2025; Acelen, 2025.
Note: planned capacity untill 2033.

Global SAF demand projection

The ICAO, through the Committee on Aviation Environmental Protection (CAEP), developed SAF production scenarios for the medium term (up to 2035) and long term (2035–2050).



Note: [1] Average density as detailed in ASTM D1655/D7566 standards.
Source: EPE based on IEA, 2022.

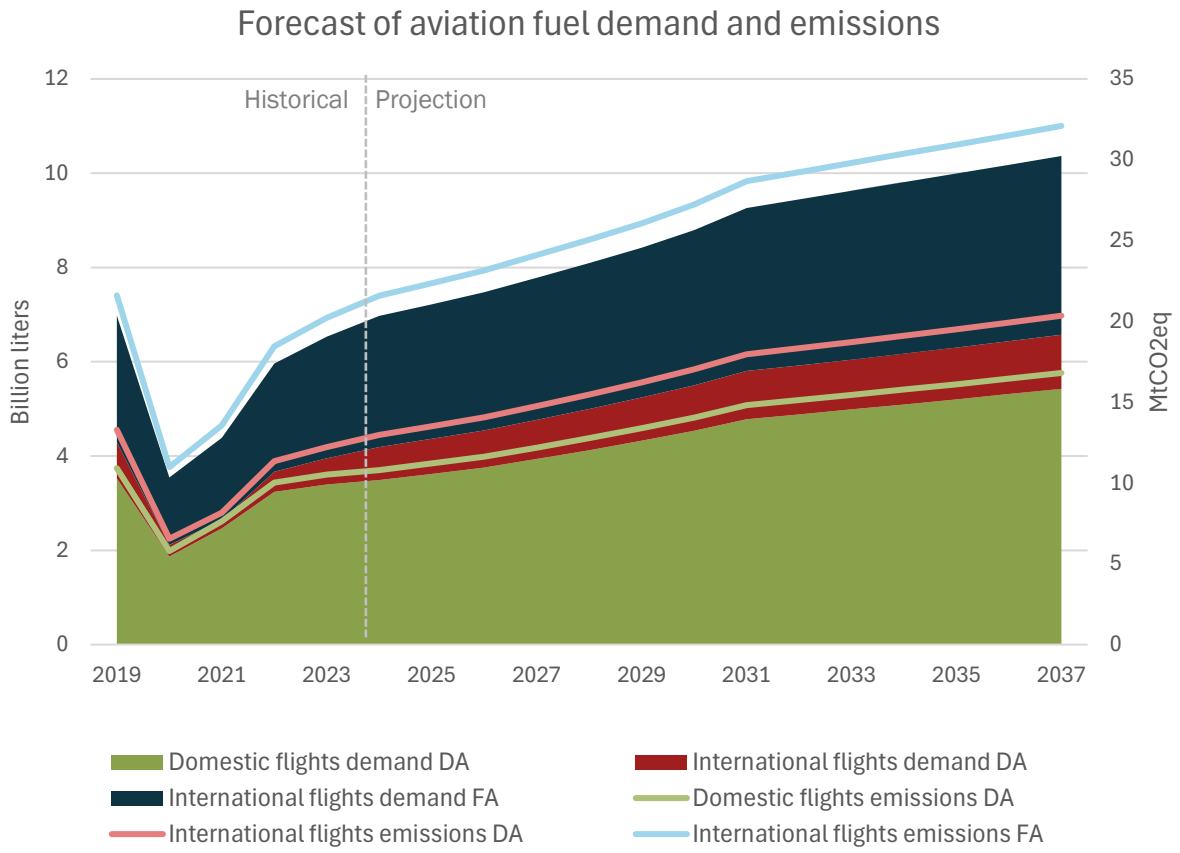
F1: Scenario with the lowest GHG reduction from SAF fuels (biomass-based and CO_2) and low-carbon aviation fuels (LCAF).

F2: Scenario with an average reduction of GHG emissions from SAF and LCAF fuels.

F3: Scenario with the highest GHG reduction from SAF, LCAF and non drop-in fuels (electricity, liquefied gaseous fuels for aviation and cryogenic hydrogen).

National panorama of SAF

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

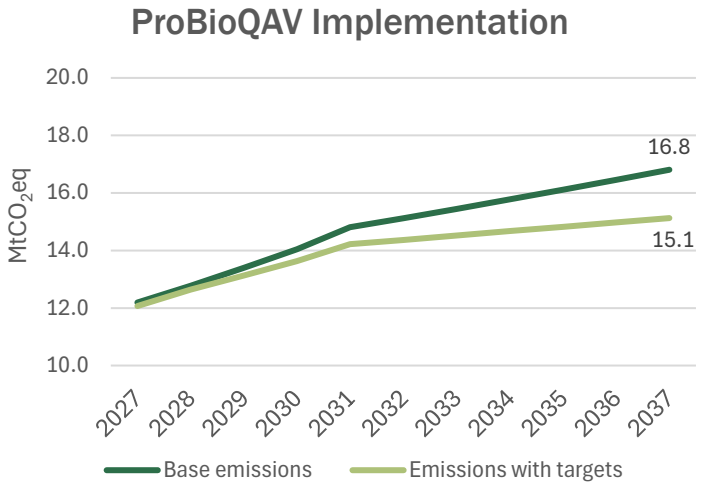


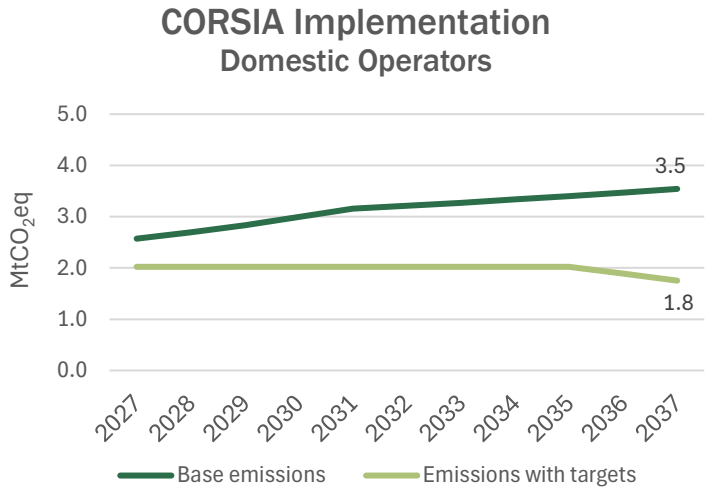
Source: EPE based on PDE 2035.
Note: DA – Domestic Airlines , FA – Foreign Airlines.

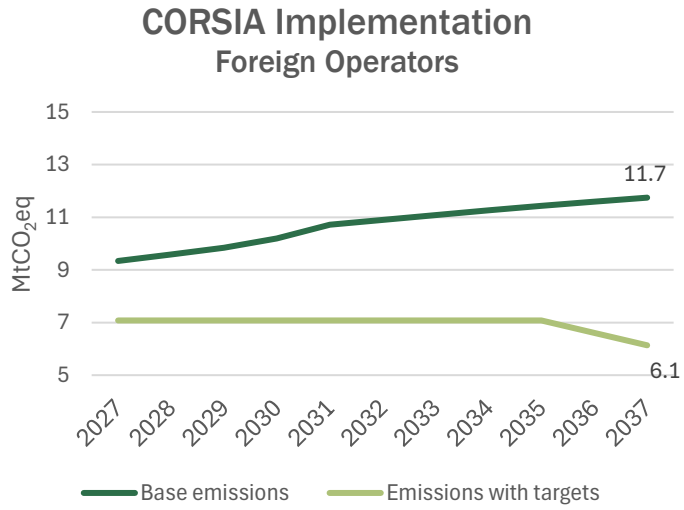
- To keep up with the sector's demand rebound post-pandemic, both domestic production and aviation fuel imports in Brazil are expected to increase.
- Despite improvements in aircraft efficiency and travel planning, emissions from the sector are also on the rise.
- In this context, SAF production must 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.

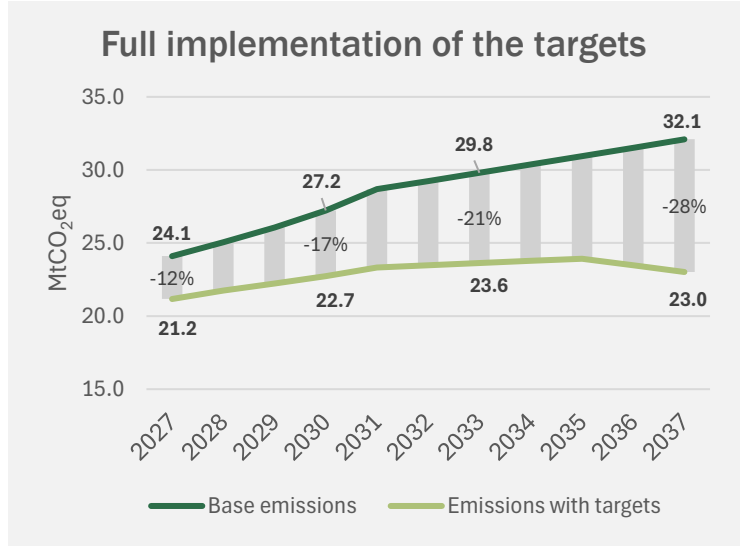
Aviation emission reduction programs applicable to the Brazilian context

- ProBioQAV sets progressively increasing emission reduction targets from 1% to 10% between 2027 and 2037.
  - The Program, as well as other provisions of Fuel of the Future Law, is still in the regulatory phase.
- Starting in 2027, Brazil will also be required to offset emissions from international flights that exceed 85% of levels recorded in 2019 to meet the carbon-neutral growth target of Internacional Civil Aviation Organization (ICAO).
  - This offsetting can occur through the acquisition of carbon credits or the use of eleigible fuels to CORSIA, in particular SAF.
  - The Brazilian obligation is applicable only to flights of national operators.[1]



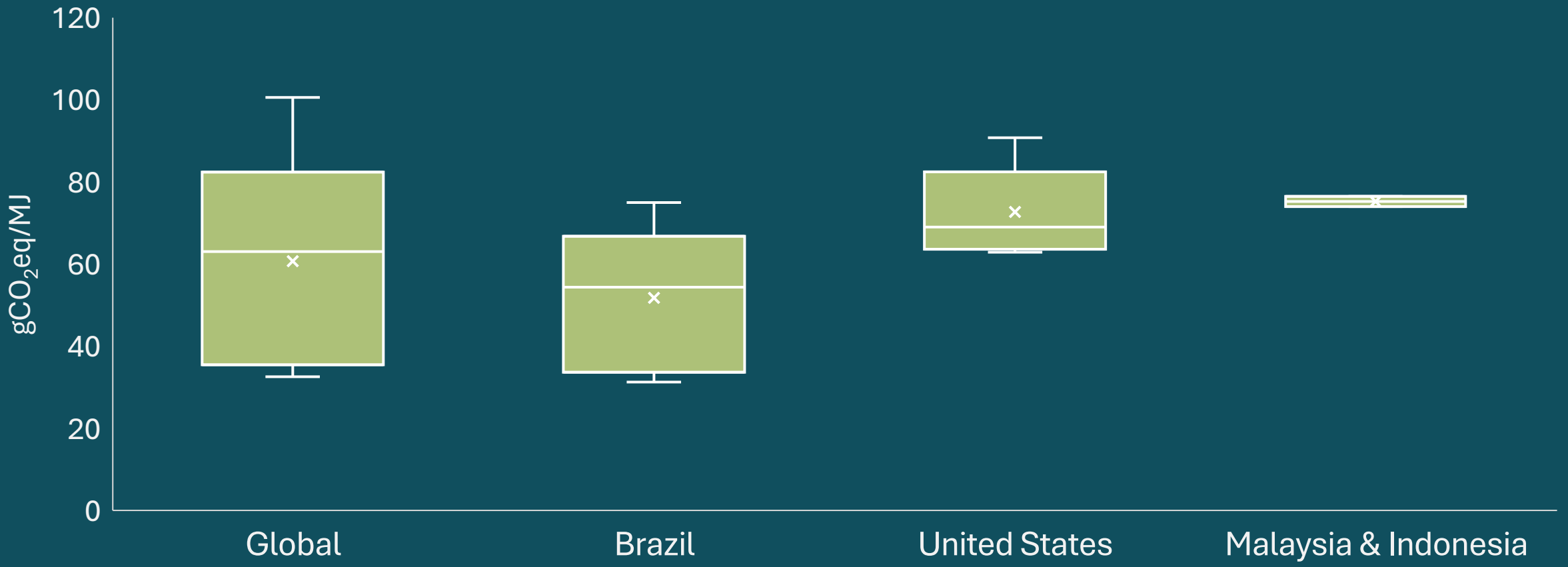






Source: EPE based on PDE 2035, Law 14.993/2024 e ICAO.
Note: 1 – Resolution ANAC No 743, 2024/05/15

In terms of carbon intensity, the SAF production from consolidated raw materials in the biofuels supply chain tends to be more competitive in Brazil than in other countries

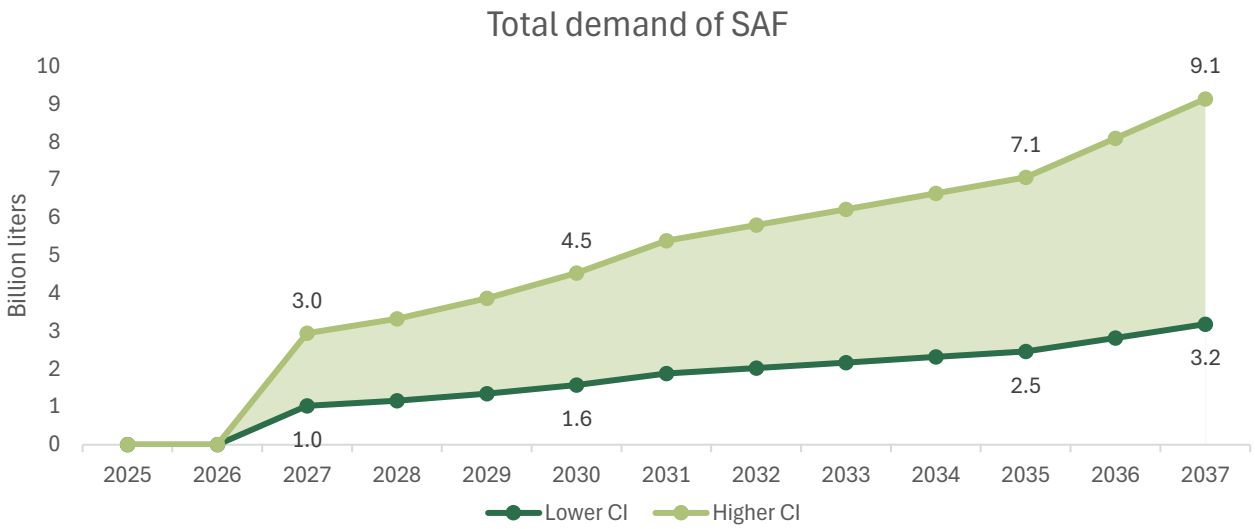


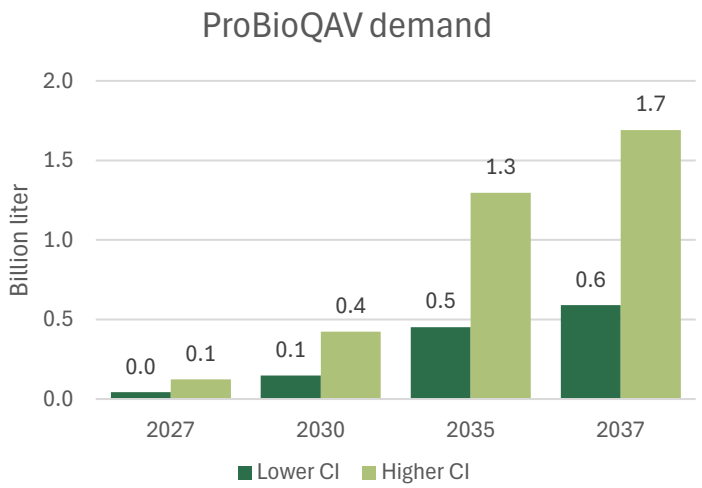
Note: Standard CORSIA values (Core LCA + ILUC) were considered for each region, and consolidated feedstock were selected – soybean oil, palm oil, sugarcane and corn.

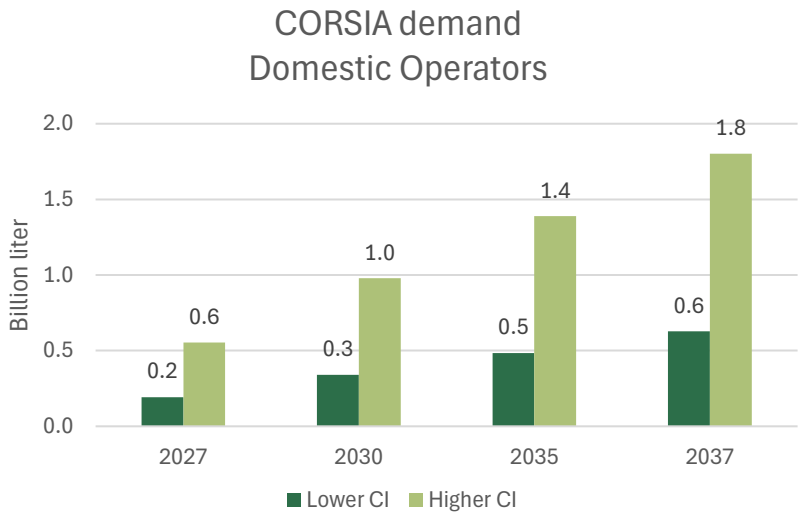
Source: ICAO 2025 - CORSIA default life cycle emission values for CORSIA eligible fuels

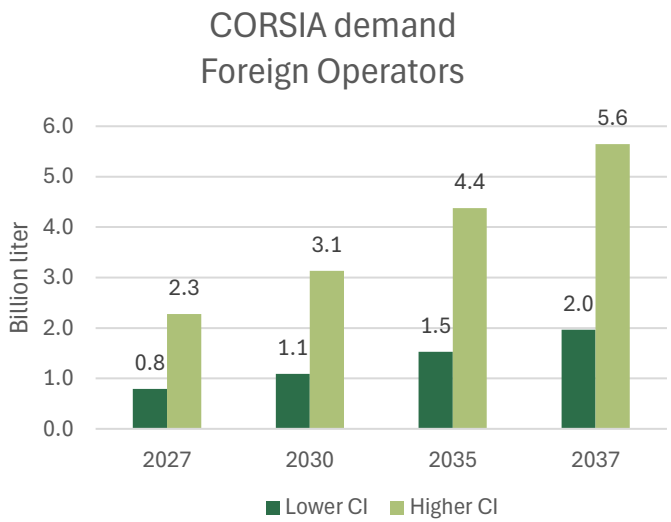
Projection of SAF demand in Brazil

- Due to the emissions reduction targets, SAF demand in Brazil will vary according to the carbon intensity (CI) of this fuel production routes.
- Considering extreme CI values, SAF demand in 2037 is projected to be between **3.2 and 9.1 billion liters**, with 18% allocated to ProBioQAV and 82% to CORSIA.







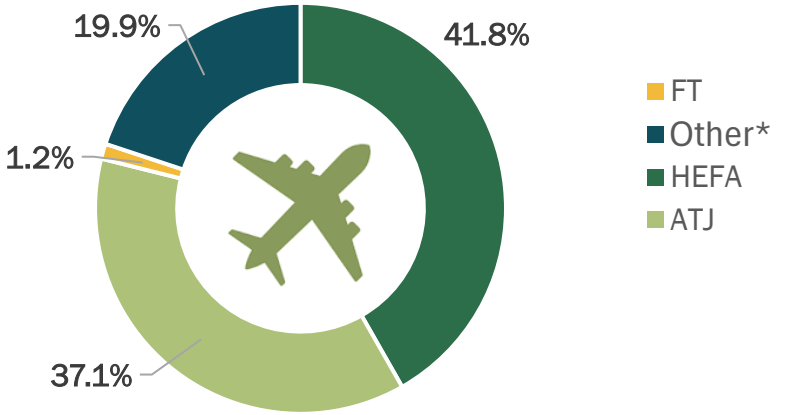


Source: EPE based on PDE 2035, Law 14.993/2024, ICAO, 2023 and ICAO, 2025.
Note: The lower limit oh the demand considered the CI FT route using agricultural residues; the upper limit considered the CI of the ATJ route ATJ using corn.

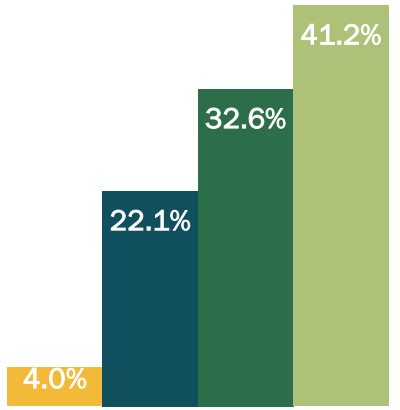
Growing demand for financing SAF projects

- In August/2024, BNDES and FINEP launched a Public Call for the selection of business plans for investments in sustainable and low-carbon aviation and shipping fuels.
- With na initial forcast of **R$ 6 billion** in resources for projects, the public call received proposals[1] totaling a potencial investment of **R$75 billion for SAF production.**
- Totaling an estimated production potential of **8.6 billion liters of SAF by 2030.**

Technological routes share registered in the public call



Investment by technological route registered in public call



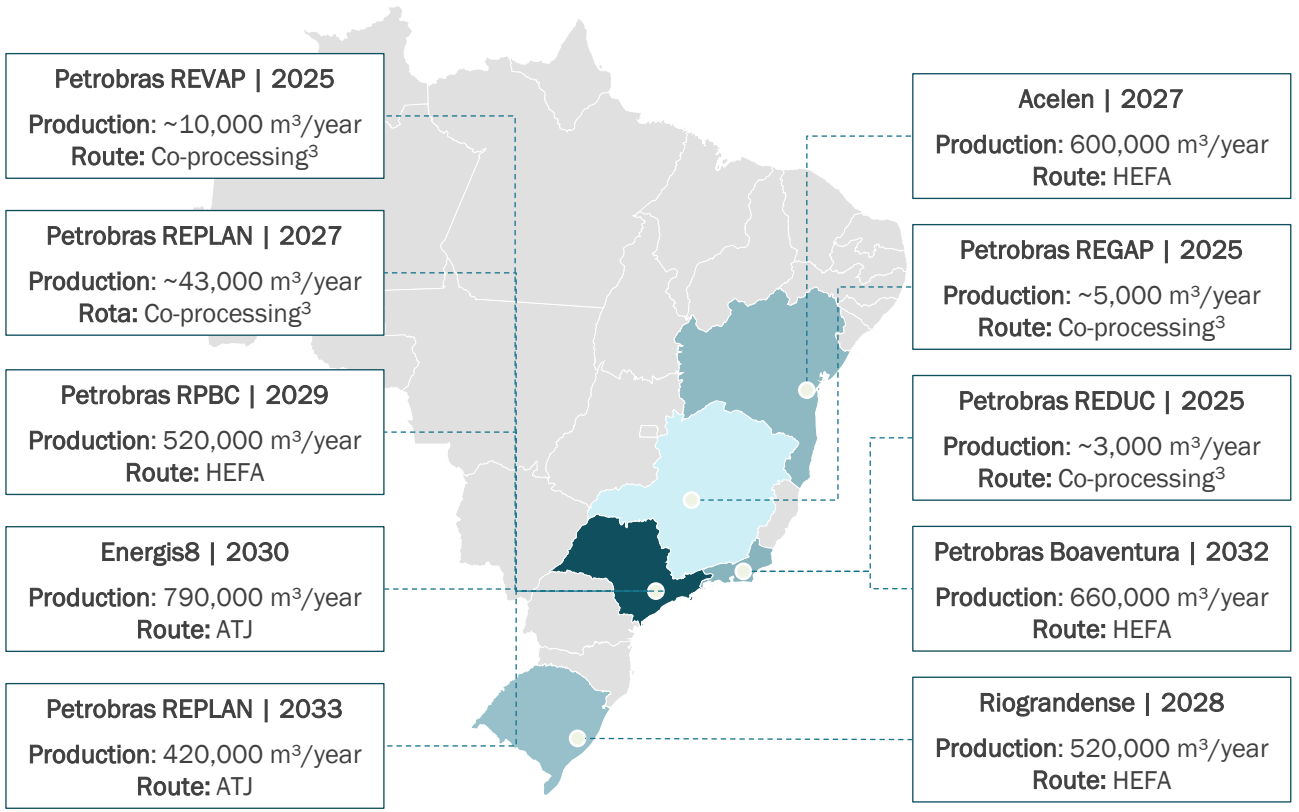
*Other: HDT (HydroDeoxygenation Technology); TCR (Thermo-Catalytic Reforming) e MTJ (Methanol-to-Jet);

CAPEX per liter

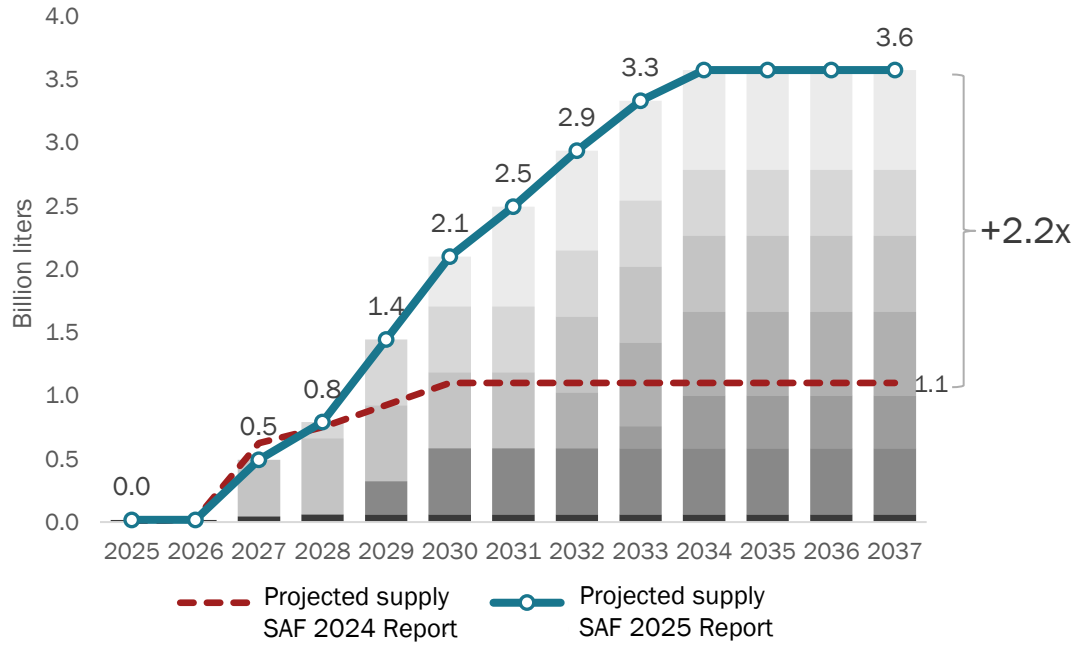
Source: EPE based on BNDES, 2024
Note: 1 – The institutions are analyzing possible associations between the projects.

Projection of SAF supply in Brazil

- Announced comercial-scale projects[1] total a supply of **2.1 billion liters of SAF per year by 2030** and reach **3.6 billion liters by 2035**.[2]



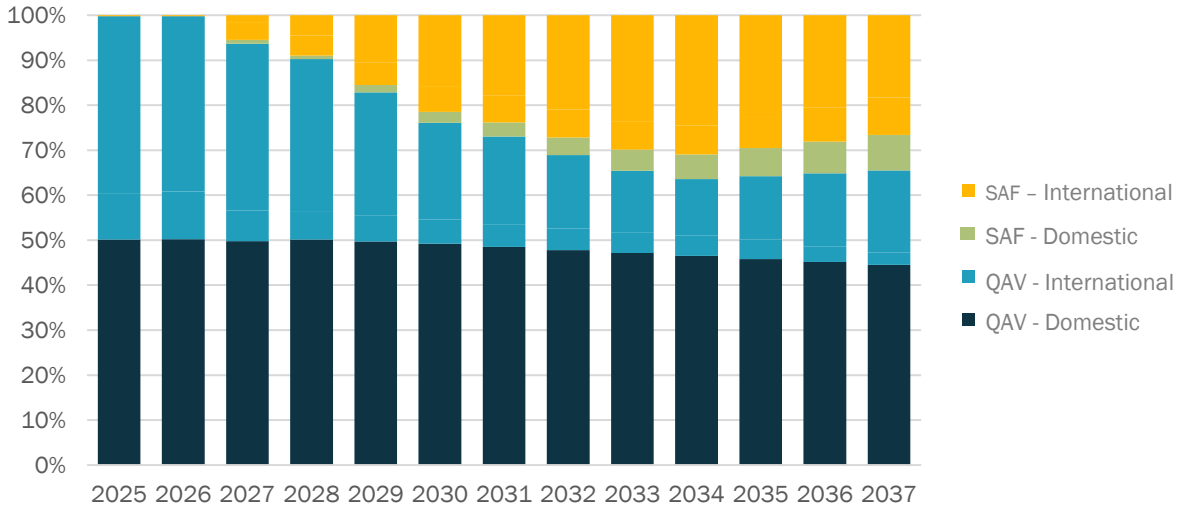
- The updated projected **SAF supply[4] volume has increased 2,2x** compared to the 2024 survey.



Notes: 1 – Announced projects confirmed by companies through contacts made for the preparation of this document were considered; 2 – The nominal capacity of the projects was adjusted based on effective utilization fator of refining and an operating mode that maximizes SAF production, as detailed in the PDE 2035 Report. 3 – For projects using the co-processing route, only the renewable share of the fuel was considered. 4 – The color gradient in the graph refers to each announced Project (co-processing aggregated).

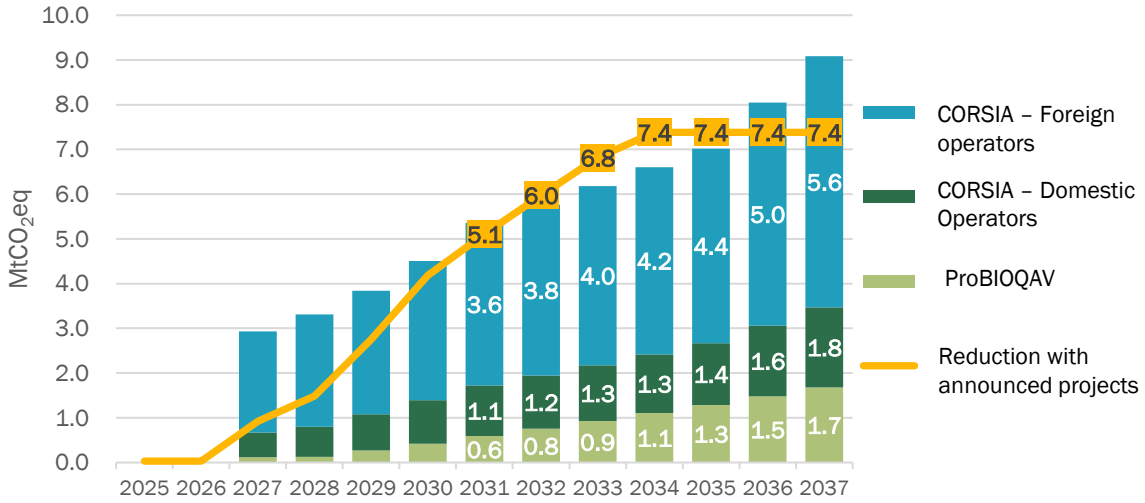
How do the announced projects meet the targets

SAF share in meeting demand by category



Source: EPE

Meeting emission reduction targets



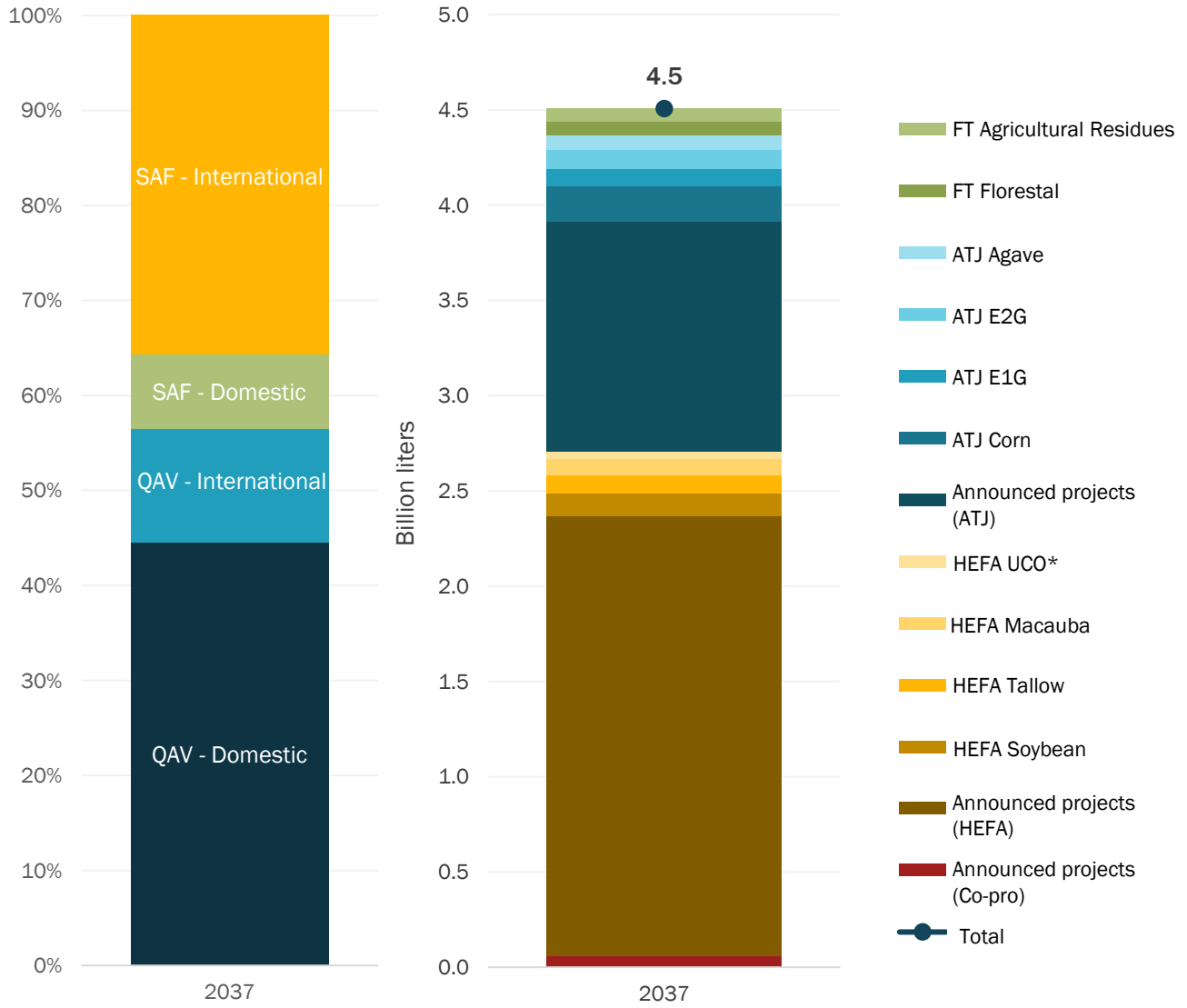
Source: EPE

- The estimated capacity of the announced projects represents, on average, 27% of the projected aviation fuel demand between 2027 and 2037.
- The share exceeds 20% by 2030 and reaches up to 36% by 2034, when all announced projects will be operating.
- In the graph, SAF utilization was priorized to meet ProBioQAV target, with the excess volume allocated to meet CORSIA goals.

- Between 2027 and 2037, the announced projects meet, na average, about 85% of GHG mitigation emission targets sets by ProBioQAV and CORSIA.
- Considering only ProBioQAV and compliance with CORSIA requirements by domestic airline companies, the announced projects are sufficient to reach the established targets.
- New SAF projects may also be developed in Brazil, both to meet CORSIA targets for foreign airlines and to enable SAF exports.

Additional projects to fully meet the targets

- The assessment of different criteria[1] suggests a possible composition of SAF production routes focused on meeting the sector's emission reduction targets and diversifying feedstocks. Under this scenario, **production is projected to reach 4.5 billion liters of SAF by 2037**.
- The diversification of feedstocks for biofuel production still requires investments to reach scale. However, it could become an important driver of regional development, restoration of degraded pastures, and generation of employment and income.
- Based on this composition, **SAF would represent approximately 43% of aviation fuel demand in Brazil by 2037**, with most of it allocated to meeting CORSIA targets.



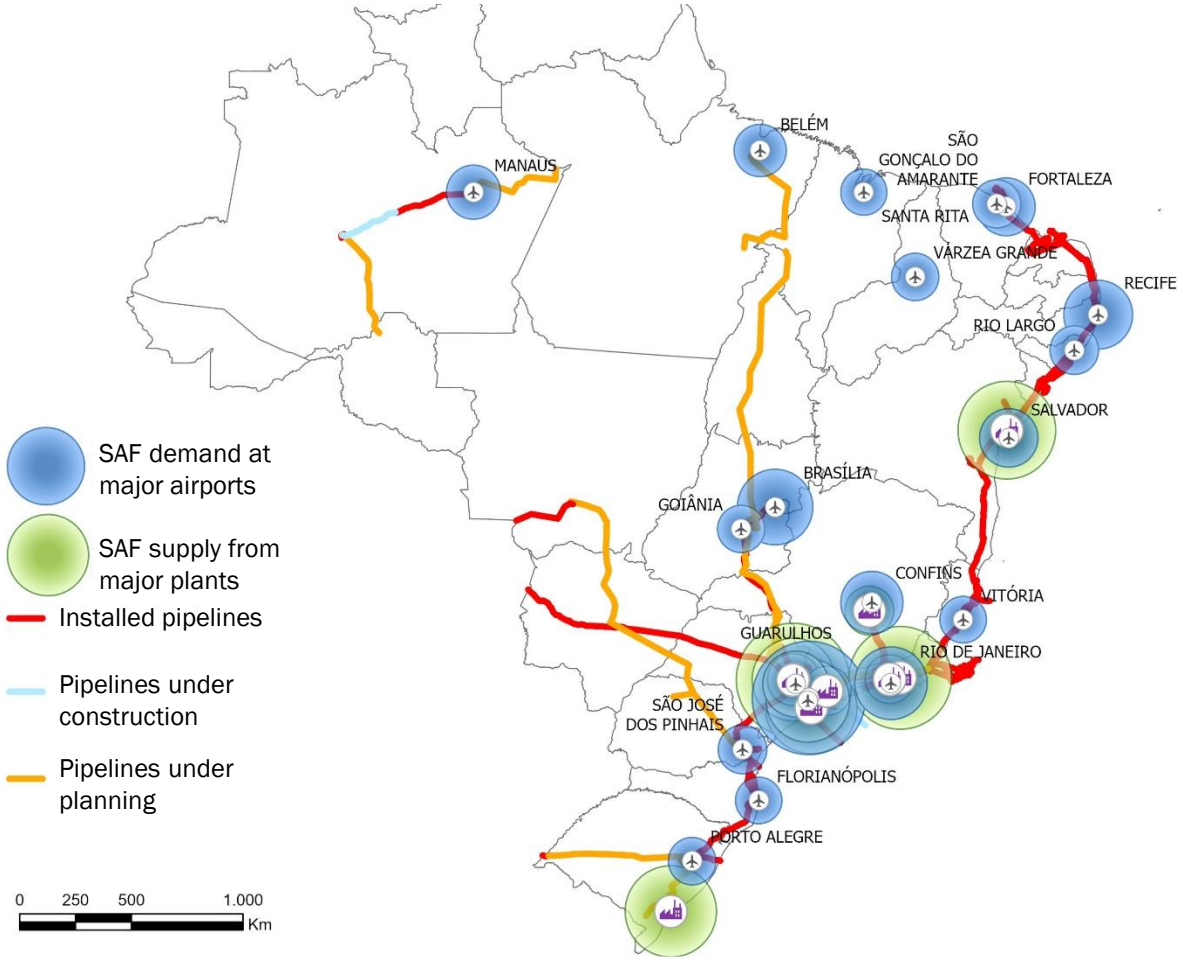
Source: EPE

*UCO = Used cooking oil

Note: 1 – For further details, access Caderno de Combustíveis Sustentáveis de Aviação no Brasil – Perspectivas Futuras

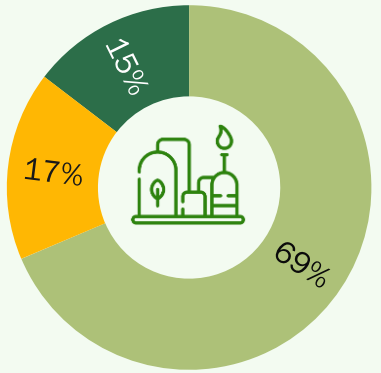
Logistics and *Book & Claim*

SAF supply x demand in Brazil – logistical challenge



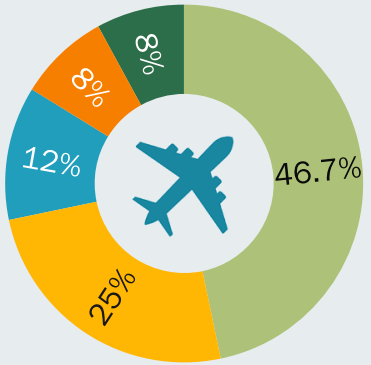
Source: EPE

SAF supply by region



SAF supply is characterized by a strong geographical concentration, with an effective production limited to the South, Sotheast, and Northeast regions. The **Southeast stands out as the hub with the largest installed production** in the country.

SAF Demand by region

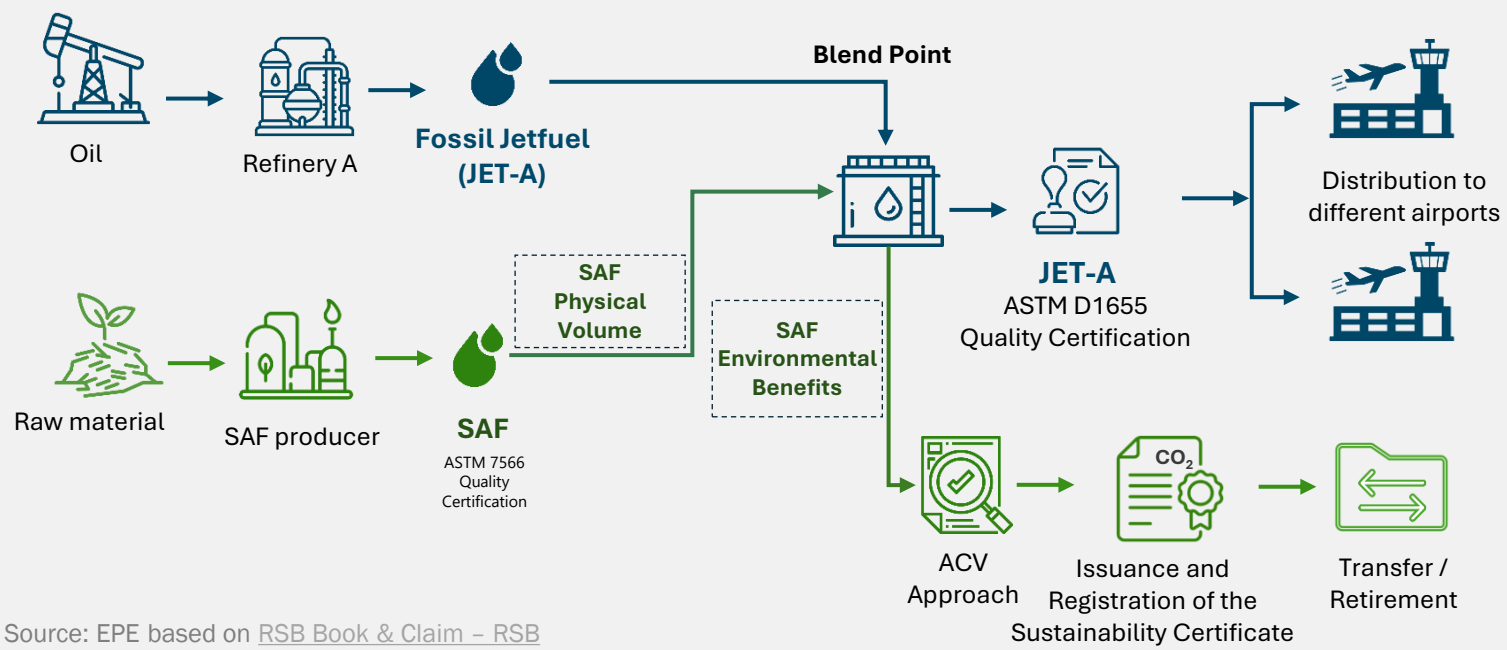


In contrast, demand is **geographically dispersed across the entire national territory**, with consumption peaks at airports in major urban centers, which creates a logistical challenge for moving SAF from production units to the main demand points.

South
Southeast
Central-West
Northeast
North

Book & Claim – Alternative for logistical challenges

Simplified Diagram



Source: EPE based on RSB Book & Claim – RSB

- A producer generates SAF and receives certificates of this production;
- The certificates are **booked** in a reliable platform or system, ensuring that each sustainable is accounted for;
- A buyer acquires the certificates and not necessarily the physical product. Thus, they can **claim** sustainable use, even if the physical product they use is not the same as the one produced sustainably.

SWOT Analysis of *Book & Claim* Model

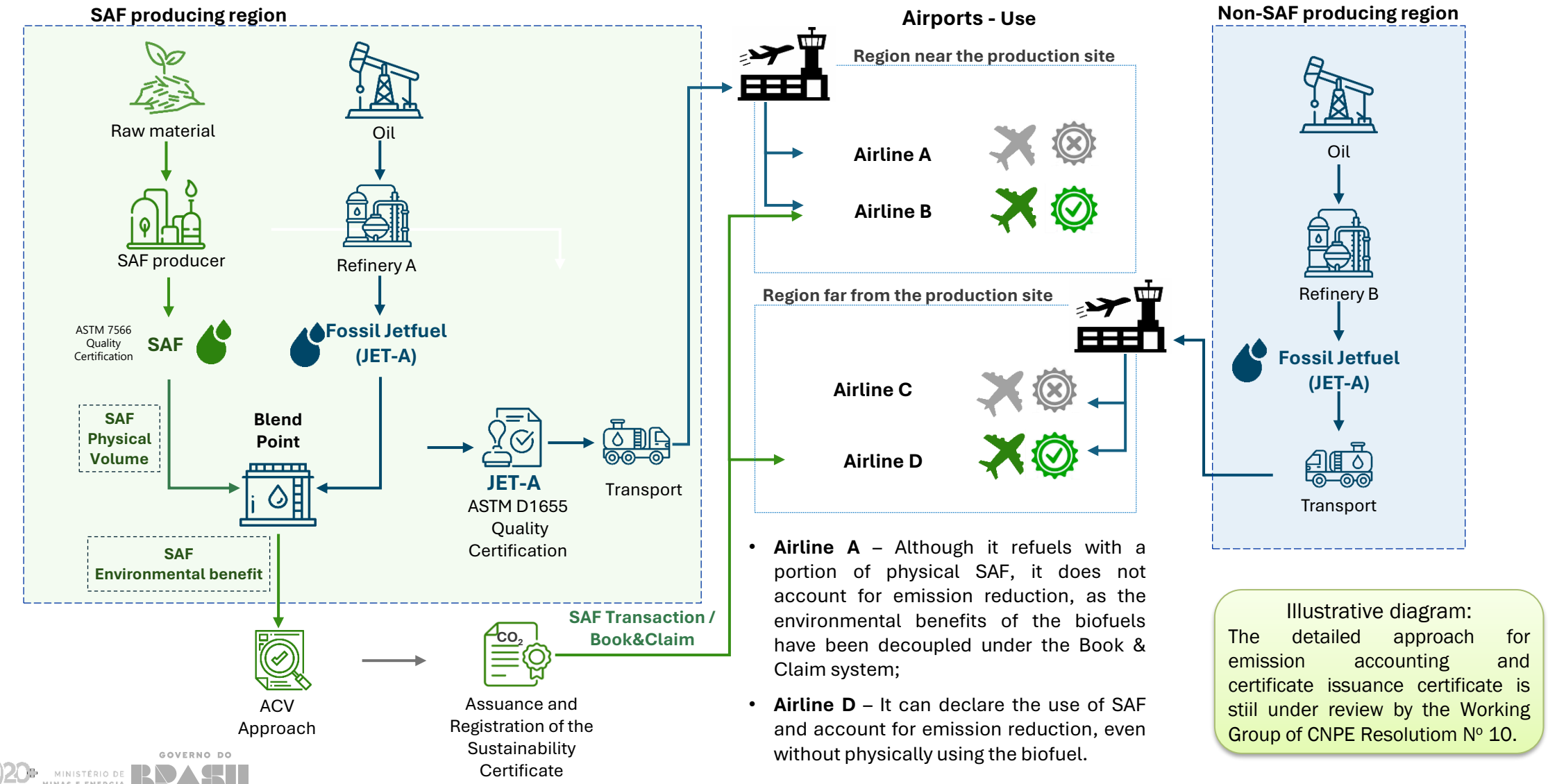
✅ Strenghts
- Access to SAF without physical requirement.
- Reduction of logistical complexity.
- Encouragement of production and investments.
- Support for decarbonization targets.

❌ Weaknesses
- Risk of double counting.
- Need for regulatory standardization.
- Robust certification standards.
- Complexity in emission accounting.

🚀 Opportunities
- Expansion of the SAF market.
- Alignment with ESG goals.
- Development of digital platforms.
- Application in other transport sectors.

⚠️ Threats
- Lack of trust due to lack of transparency.
- Limited supply and high cost of SAF.
- Regulatory changes.

Book & Claim – Complete diagram



- **Airline A** – Although it refuels with a portion of physical SAF, it does not account for emission reduction, as the environmental benefits of the biofuels have been decoupled under the Book & Claim system;
- **Airline D** – It can declare the use of SAF and account for emission reduction, even without physically using the biofuel.

Illustrative diagram:
The detailed approach for emission accounting and certificate issuance certificate is stiil under review by the Working Group of CNPE Resolutiom Nº 10.

Icons obtained from Flaticon free

Synergy between SAF and Green Diesel (GD) production

SAF production routes also produce green diesel (GD)

Triglycerides

Oilseeds, algae, oils and residual fats

Lignocellulosic biomass

Eucalyptus, pine, elephant grass, sugarcane bagasse

Starches and sugars

Sugarcane, corn, beetroot, cassava

HEFA Route

Catalytic hydrogenation → Hydrotreating

Catalytic hydrothermolysis → Hydrotreating

CHJ Route

FT Route

Gasification → Fischer-Tropsch synthesis → Hydrotreating / Hydrocracking

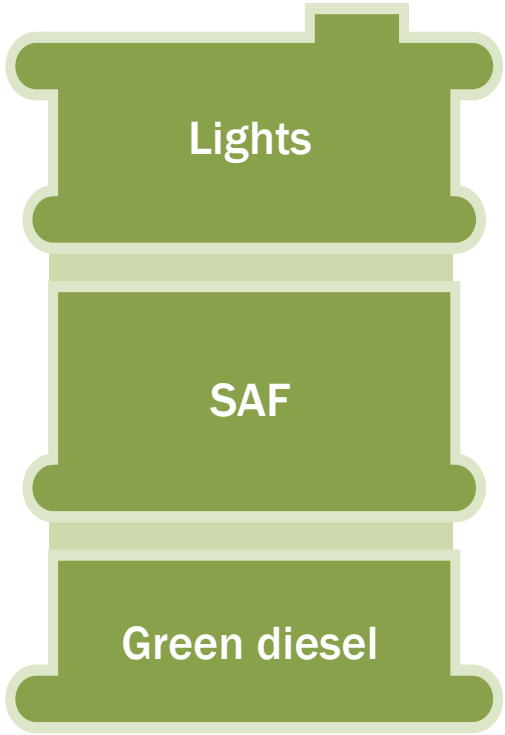
SIP Route

Enzymatic Hydrothermolysis → Fermentation → Hydrotreating

ATJ Route

Fermentation → Dehydration → Oligomerization → Hydrogenation

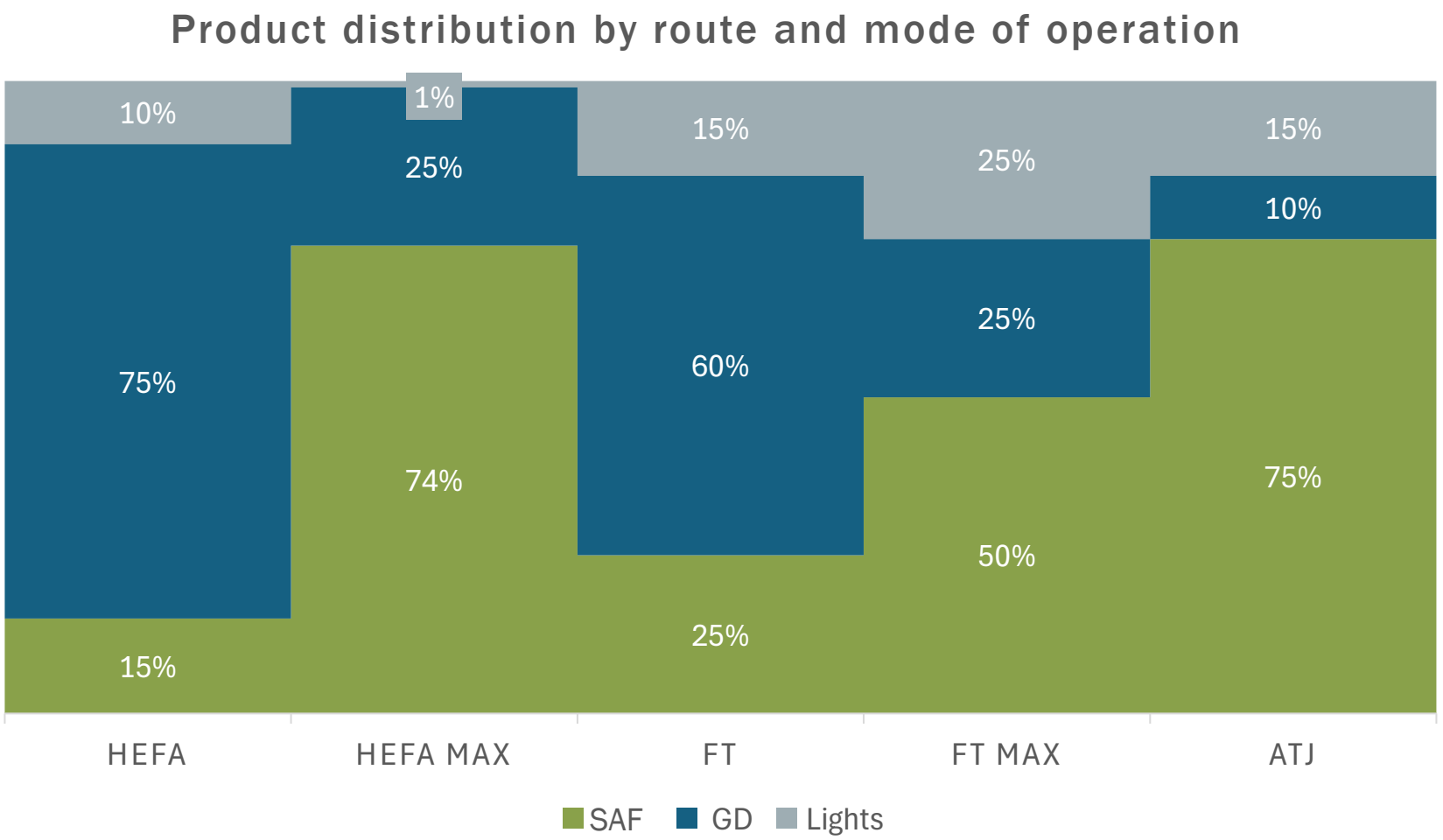
ATJ Route



Note: For further details, access Caderno de Combustíveis Sustentáveis de Aviação no Brasil – Perspectivas Futuras

These tecnological routes also gererate, as co-product, a fraction of BioLPG and renewable naphtha.

SAF production routes also produce green diesel (GD)



Although the main processes can be optimized to maximize the amount of SAF output, the available routes provide not only SAF, but also green diesel and other light products.

Source: EPE based on IEA Bioenergy T39, 2024, Decarbonisation Technology, 2024 and ICCT, 2019

Note: There are cases in which the production through AtJ route can reach a maximum of 90% of SAF production.

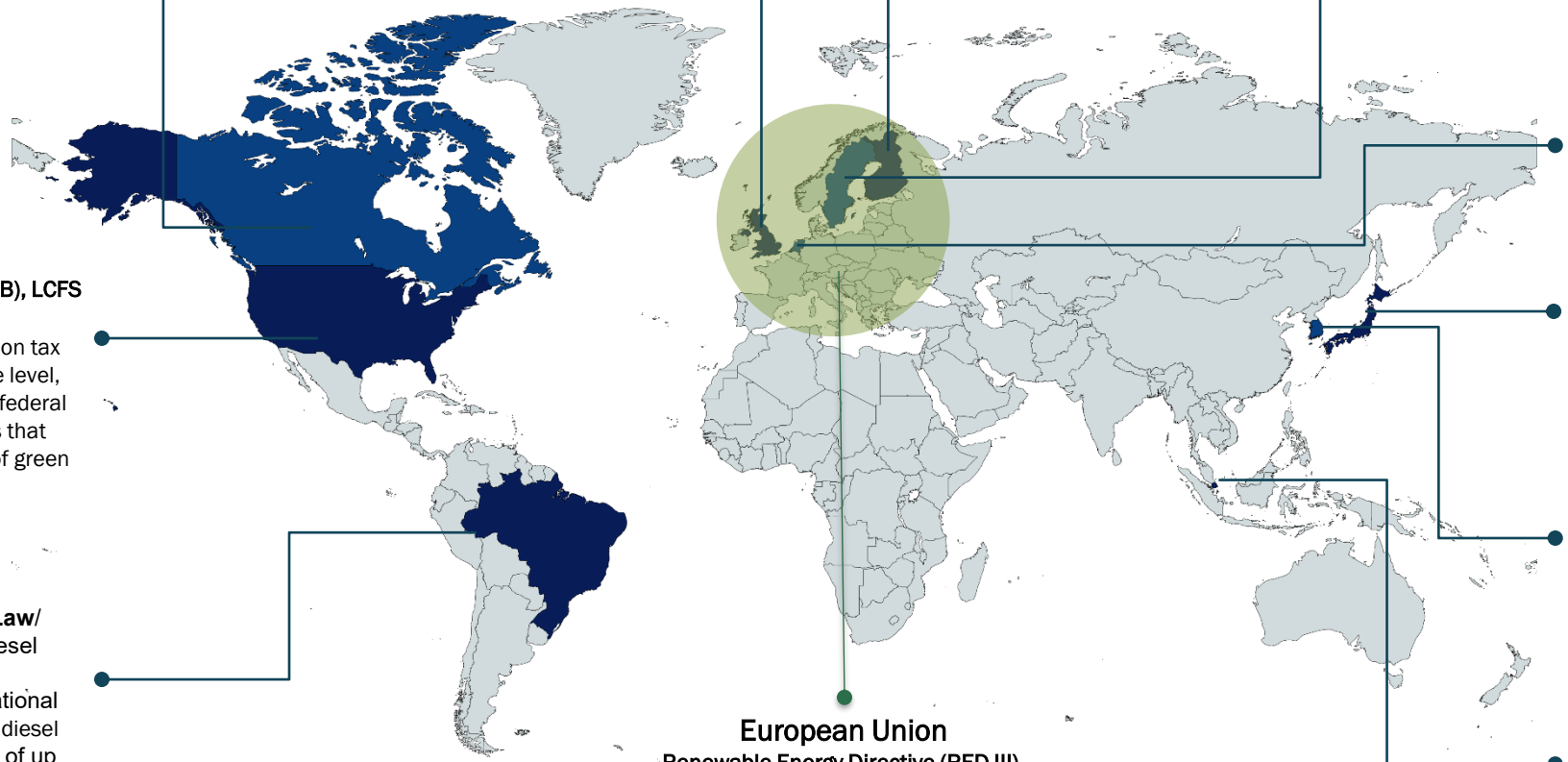
Internacional panorama of green diesel

Canada
Clean Fuel Regulation (CFR).
It requires reducing carbon intensity of fuels, creating a credit market for green diesel, like California's LCFS.

United Kingdom
Renewable Transport Fuel Obligation (RTFO).
It requires that a percentage of fuels come from renewable sources, with green diesel being one of the main options for generate certificates and meeting the target.

Finland
Biofuel Obligation Act.
A pioneering law that establishes a 34% biofuel blending mandate, making the country one of the most mature market for renewable diesel.

Sweden
Reduktionsplikt.
It requires the greatest GHG reduction in diesel in Europe, making Sweden one of the largest per capita consumers of green diesel in the world.



United States
***One Big Beautiful Bill Act* (OBBB), LCFS & RFS.**
The OBBB provides production tax credits, while the LCFS (state level, e.g., California) and the RFS (federal level) create credit markets that encourage the consumption of green diesel.

Netherlands
Hernieuwbare Energie Vervoer (HDE).
System that creates renewable energy "tickets" (HBEs) to meet emission targets, encouraging the use of low-carbon footprint green diesel.

Japan
Target of 10% of SAF by 2030
The strong incentive for SAF is driving the green diesel production infrastructure, with expansion plans for other sectors.

Brazil
Combustível do Futuro Law/ PNDV (National Green Diesel Program).
Estabishes a progressive national mandate for blending green diesel with fossil diesel, with a limit of up to 3%.

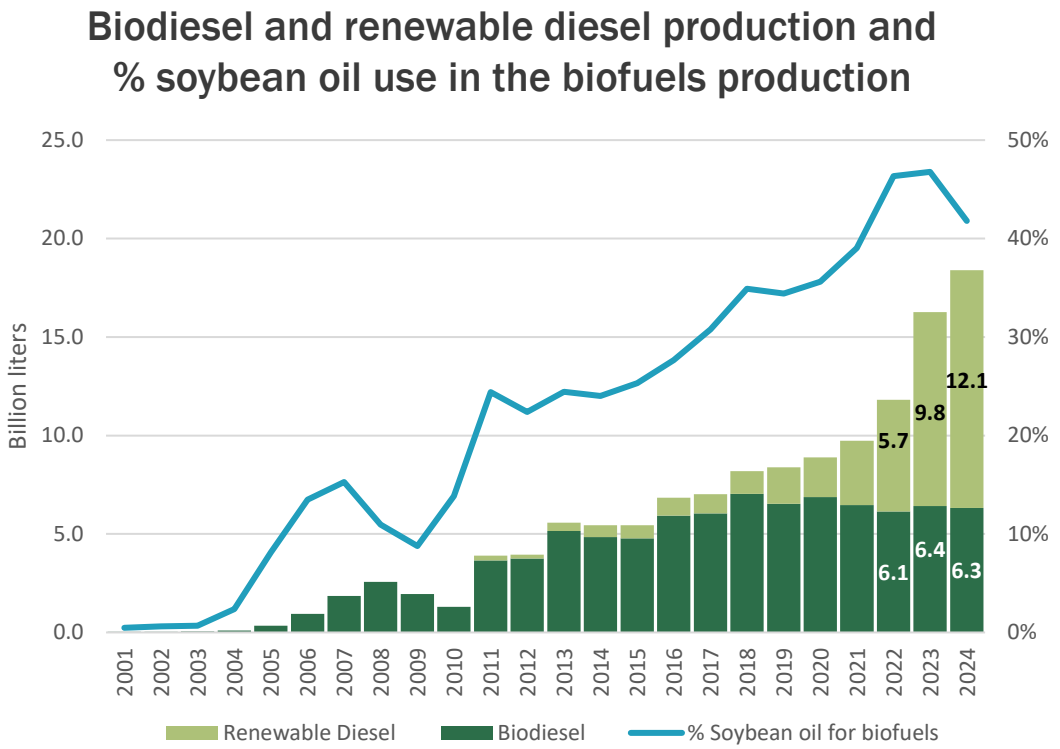
South Korea
Renewable Fuel Standard (RFS).
The biodiesel blending mandate is being expanded to include green diesel. The government is also promoting SAF, fostering local production.

European Union
Renewable Energy Directive (RED III).
General directive that raises renewable energy targets in transport to 29%, boosting HVO market across the bloc as a premium solution.

Singapore
Singapore Green Plan 2030
Focus on becoming a global hub of green diesel and SAF production and export, attracting major refineries with incentives, without a road consumption mandate.

Note: 1 – For further details, access Mapa Interativo dos Mandatos de Teor de Biocombustíveis Líquidos do Setor de Transportes no Mundo

International panorama of green diesel: U.S. Case



Note: Between 2020 and 2024, on average, 52% of U.S. soybean production was processed domestically (oil extraction) and 46% was exported, with the remainder used for seeds, feed and residues. Of the total processed soybean oil, 42% was used for biofuels, 53% was allocated to other uses, and 5% was exported.

Source: USDA, 2024 and 2025

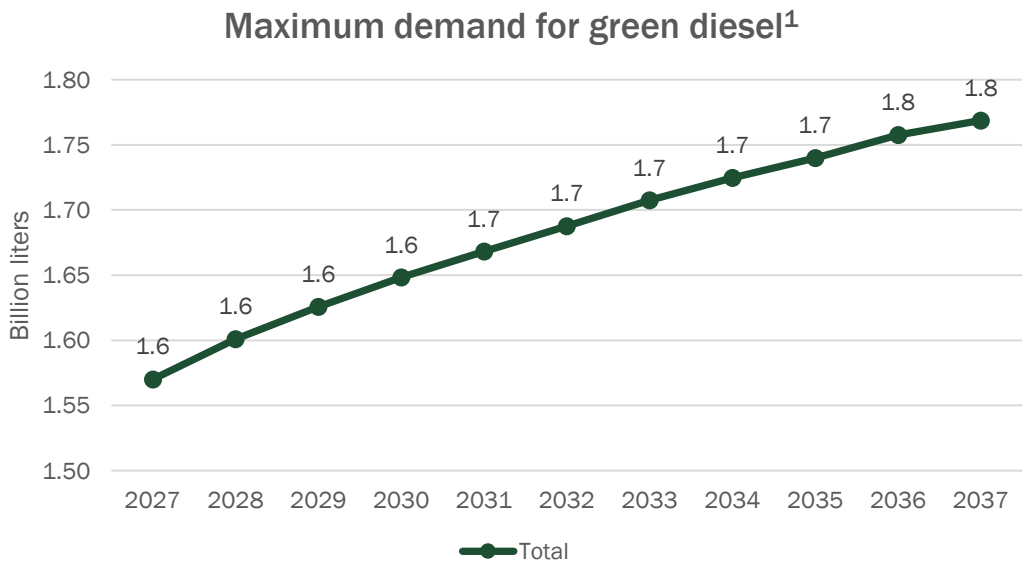
- *Renewable Fuel Standard* (RFS): Federal mandate that establishes a minimum volume blending requirement for each biofuel category. The credit mechanism (RINs) creates a captive and stable demand for biomass-based diesel (D4), mitigating market risk for producers
- *Low Carbon Fuel Standard* (LCFS): State-level standard (e.g., California) that creates a market based on credits and deficits, generated according to the fuel's life cycle Carbon Intensity (CI). The system monetizes the decarbonization by granting a financial premium to low-CI routes, like green diesel from residues.
- *One Big Beautiful Bill Act* (OBBB): Federal program that modified and extended the per-gallon production tax credit, originally created by the Inflation Reduction Act (IRA), whose value is associated with emissions reduction performance (PTC/45Z mechanism). This reduces investment risk and accelerates the expansion of production capacity for low-carbon green diesel.

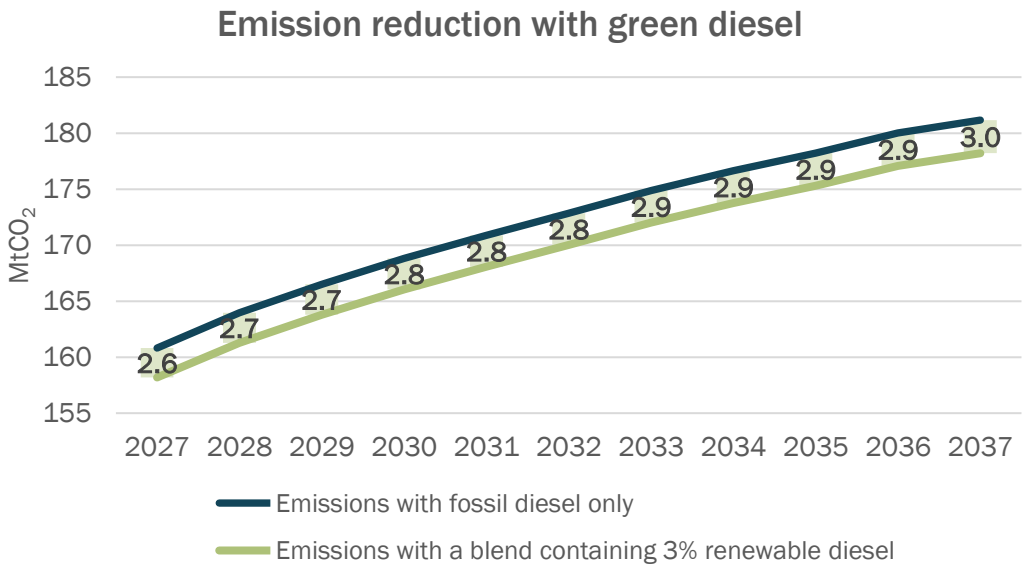
The growth of green diesel was gradual after the implementation of the RFS (2007) and LCFS (2011). However, its production began to accelerate from 2018, surpassing biodiesel in 2023. This progress coincided with the tightening of LCFS targets and the introduction of new federal tax incentives, such as the IRA (2022), which strongly boosted investments in its production.

National green diesel program – PNDV

- The PNDV, established under the Fuel of the Future Law, aims to promote research, production, commercialization and energy use of green diesel in Brazil's energy matrix.
- To achieve this, an annual mandatory minimum volumetric share of this biofuel in the diesel sold to the end consumer will be established.
- **The mandatory share can not exceed the limit of 3%.**

- **The renewable share in commercialized diesel can reach 23%**, considering the maximum blend of green diesel (DV3) and the biodiesel (FAME) percentagem projected for 2030 under the Fuel of the Future Law (B20).
- The displacement of fossil diesel generated by the **green diesel blend has the potencial to reduce emissions by around 3 $MtCO_2$ per year**[2], which is equivalent to 21 million trees[3] (~18 thousand soccer field or 1 Paris' city covered by tropical forest).

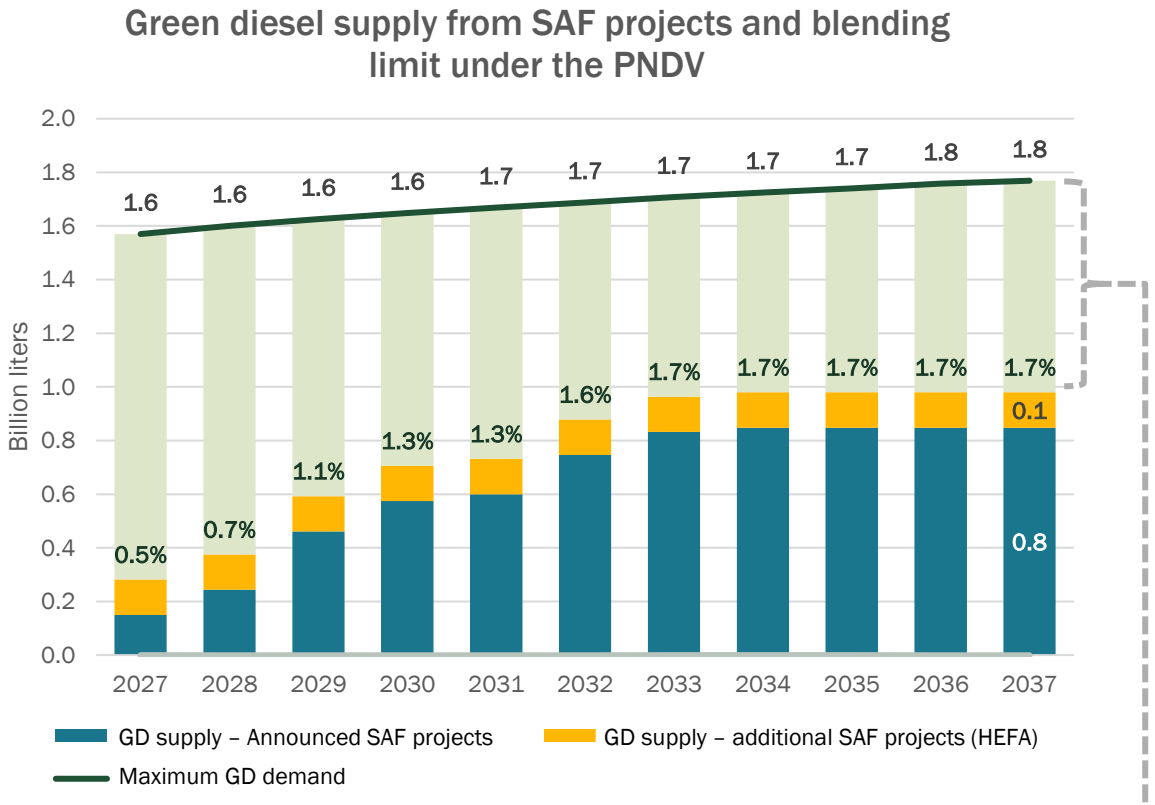




Notes: 1 – Considering projected diesel A demand in PDE 2035; 2 – Considering the carbon intensity of green diesel as 40.7 gCO_2eq/MJ based on the average of projects certified by Low Carbon Fuel Standard (LCFS Pathway Certified Carbon). 3 – Considering 7 trees per ton of CO_2.

The projected SAF supply contributes to meeting the PNDV targets, but there remains significant potential to develop other projects

- Considering an operation mode that maximizes SAF production (slide), the announced projects can produce, in a consortium, a maximum of 850 million liters of green diesel by 2034.
- Considering the same operating mode, additional projects aimed at meeting aviation emission reduction targets are expected to add 130 million liters of green diesel by 2037.
- Throughout the period, **the volume of green diesel from SAF projects meets, on average, 45% of the maximum mandatory blending limit indicated in the PNDV**.
  - Volumes may vary depending on producers' operational adjustments.
  - In 2037, the consortium production of green diesel in SAF units reaches 55% of the PNDV's maximum demand.
- **There is significant potential to develop new green diesel projects, thereby increasing supply and enabling the mandatory blend to be set at the highest level.**



Opportunities and challenges for green diesel

Opportunities

- **Drop-in fuel**: compatibility with existing fleet and infrastructure enables immediate decarbonization.
- **No blending limit**: it can be used pure or in any proportion with fossil diesel.
- **Local air quality co-benefits:** almost sulfur-free and with lower production of soot and irritating gases.
- **Chemical characteristics:** calorific value close to diesel and high cetane number contribute to a competitive energy performance.

Properties	Green Diesel[1]	Diesel[2]	Biodiesel[3]
Specific mass in 20°C (kg/m³)	761.2 – 806.5	815.0 – 850.0	850.0 – 900.0
Viscosity in 40° (cSt)	2.00 – 4.50	2.00 - 4.50	3.00 – 5.00
Lower heating value (MJ/kg)	37 – 44 *[4]	42.3 [5]	37.68 [5]
Cetane number (-)	51	48	Record
Flash point, min. (°C)	38	38	100
Cold filter plugging point, max. (°C)	-6	-11	-6

Note: *The lower heating value of HVO was considered for this indicator.
Source: [1] ANP, 2021; [2] ANP, 2013; [3] ANP, 2023; [4] AATOLA et al., 2009; [5] BEN, 2025.

Challenges

- **High price premium**: disputed raw materials + H_2 intensive process increase the cost compared to fossil diesel.
- **Technical attention:** low lubricity demands aditives.
- **Supply and infrastructure:** currently there is no dedicated plant operating in Brazil to ensure large-scale supply..
- **Competition with SAF**: prioritization of plants/oil sources for aviation reduces the supply for the road transport sector.

Key messages

Targets covered

With the announced projects, Brazil fully meets the ProBioQAV and CORSIA targets for national operators.

There is significant potential for developing new projects to meet international operators' demand and exports.

The role of SAF

Essential to reduce emissions from aviation sector and meet national and international GHG targets.

Book & Claim

Reduces logistics complexity by enabling compliance with targets without physical transport of fuel.

Strategic co-production

SAF production routes generate green diesel (and light fractions), contributing to the PNDV blending policy.

Decarbonization freight transport

Green diesel is a drop-in fuel, with no blending limit. At its maximum blend under PNDV, it can avoid ~3 $MtCO_2$/year.

BIOS

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