Brazil's Action Plan on CO_2 Emissions Reduction from Civil Aviation

Base year: 2024

5th EDITION

Departamento de Controle do Espaço Aéreo
Department of Airspace Control

ANAC NATIONAL CIVIL AVIATION AGENCY - BRAZIL

MINISTRY OF PORTS AND AIRPORTS

BRAZILIAN GOVERNMENT
BRASIL
UNITING AND REBUILDING

MINISTRY OF PORTS AND AIRPORTS
National Civil Aviation Secretariat – SAC
Directorate of Sustainability – DSUST
Address: Esplanada dos Ministérios, Bloco R, Ed. Anexo
Brasilia – DF – Brazil
ZIP Code: 70.044-900

NATIONAL CIVIL AVIATION AGENCY – ANAC
Superintendence of Governance and Environment – SGM
Address: Setor Comercial Sul, Quadra 09, Lote C, Edifício Parque Cidade Corporate, Torre A
Brasilia – DF – Brazil
ZIP Code: 70.308-200

DEPARTMENT OF AIRSPACE CONTROL – DECEA
Subdepartment of Administration - SDAD
Environmental Management and Sustainability Subdivision
Subdepartment of Operations – SDOP
Address: Av. General Justo, 160, Centro
Rio de Janeiro – RJ - Brazil
ZIP Code: 20021-130

National Secretary for Civil Aviation - SAC/MPOR
Daniel Ramos Longo

Director of Airport Concessions, Assets, and Regulatory Policies – DOPR/SAC/MPOR
Clarissa Costa de Barros

Director of Sustainability – DSUST/MPOR
Larissa Carolina Amorim dos Santos

Superintendent of Governance and Environment – SGM/ANAC
Marcelo Rezende Bernardes

Environmental and Energy Transition Manager – GMAT/SGM/ANAC
Marcela Braga Anselmi

Head of the Environmental Management and Sustainability Subdivision, SDAD/DECEA
Mariana da Silva Mello Nogueira Contreiras Cesar

Written by
Bruno Garcia Franciscone – SDPO/DECEA
Carlos Henrique Gomes – GMAT/SGM/ANAC
Daniel Marcellos Calçado – GMAT/SGM/ANAC
Fátima Cristina Conceição de Gouvêa – SDAD/DECEA
Gustavo Fleury – DOPR/SAC
Henrique Costa Tavares – GMAT/SGM/ANAC
Lucas Camargo de Carvalho – SDAD/DECEA
Luciano Lopes de Azevedo Freire – GMAT/SGM/ANAC
Priscilla Brito Silva Vieira – GMAT/SGM/ANAC
Rafaela Côrtes – DOPR/SAC
Ricardo Antonio Binotto Dupont – GMAT/SGM/ANAC
Tiago Cunico Camara – GMAT/SGM/ANAC

Brasilia, September 2025

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Executive Summary

The 5th edition of the Action Plan for the Reduction of CO_2 Emissions from Brazilian Civil Aviation provides a broad overview of the sector's trajectory in Brazil with regard to CO_2 emissions, reviewing recent trends and projecting future developments. The document details how the sector's operational growth has been accompanied by improvements in environmental efficiency, with fuel consumption increasing at a slower pace than transport activity. This reflects technological and operational advances as well as fleet renewal. Projections from the previous Plan proved to be accurate, with relatively small deviations in fuel consumption and efficiency estimates.

Brazil has also strengthened its regulatory framework for sustainability in civil aviation, reaffirming its ongoing commitment to global climate goals. Key initiatives include the establishment of the National Program for Sustainable Aviation Fuel (ProBioQAV), which sets mandatory decarbonization targets for domestic aviation through the use of Sustainable Aviation Fuel (SAF). Other measures include the revision of the National Climate Plan, the country's main climate policy instrument, and the development of the Brazilian Sustainable Taxonomy, aimed at classifying sustainable economic activities to attract green investment. ANAC's Environmental Action Plan formalizes the Agency's policy of integrating environmental considerations into its activities, while CORSIA (Carbon Offsetting and Reduction Scheme for International Aviation) has been fully incorporated into national regulation. In addition, the Sustainability Policy of the Ministry of Ports and Airports seeks to integrate environmental, social, and governance (ESG) practices into transport infrastructure.

With regard to SAF, recent reports explore different pathways to meet emission reduction targets, taking into account announced projects, the use of both established and alternative feedstocks, and the potential of waste utilization. *Conexão SAF*, a multi-stakeholder forum, was created to identify proposals and solutions for decarbonizing Brazilian aviation through SAF. In parallel, the Research Network on Sustainable Aviation Fuels (RPSAF) was established to advance the SAF research agenda. Significant investment is also being directed toward the development of biorefineries and new technologies.

Airline and airport operators in Brazil have shown growing commitment to sustainability. Programs such as Sustainable Airports encourage the adoption of best practices in airport environmental management and rank airports according to their performance. Similarly, the SustentAr Program promotes and recognizes proactive sustainability initiatives in the operations of Brazilian airlines. The Brazilian aerospace industry, led by Embraer, is focused on technological innovations to improve aircraft efficiency and SAF compatibility. The company is also investing in alternative propulsion systems, such as hybrid-electric and fully electric technologies, as well as in urban air mobility with electric vertical take-off and landing vehicles (eVTOL).

Operational improvements in air traffic management are also seen as having significant short-term potential to reduce CO_2 emissions. Airlines already apply measures to optimize fuel consumption, and the Department of Airspace Control (DECEA) is leading the modernization of the air traffic control system, incorporating environmental considerations and adopting operational procedures in line with international guidelines. These efforts include projects to enhance route accuracy and predictability, optimize landings and take-offs, and prepare infrastructure for emerging air mobility technologies.

Looking ahead, the Action Plan's projections – based on internationally recognized methodologies – indicate that, despite expected air traffic growth, CO_2 emission intensity is likely to decline. This trend will be driven by a combination of technological and operational measures, the use of SAF, and carbon offsetting under CORSIA.

The Action Plan reaffirms Brazil's commitment to the progressive decarbonization of aviation, emphasizing the importance of the technical and economic viability of SAF, the advancement of aeronautical technologies, and the role of airports and airlines as drivers of best environmental practices. Its successful implementation, however, will depend on strong governance, effective green financing instruments, and the consolidation of public policies that foster innovation and industrial competitiveness.

This Action Plan therefore reaffirms Brazil's commitment to reducing GHG emissions in civil aviation, in line with international targets agreed within ICAO and with national ecological transition strategies. The document is designed as a dynamic instrument, requiring continuous monitoring, realignment of objectives, and open dialogue with multiple stakeholders, and is essential to building a more efficient, resilient, and environmentally sustainable aviation sector in the long term.

CHAPTER I

Historical Evolution of Emissions

Overview

This chapter outlines the historical trajectory of CO_2 emissions from Brazilian civil aviation, with the aim of supporting the design and monitoring of policies to mitigate greenhouse gas (GHG) emissions in the sector. The analysis covers the period from 2005 to 2024 and distinguishes between domestic and international operations of Brazilian air carriers, following the methodology established by the International Civil Aviation Organization (ICAO).

In this 5th edition of the Action Plan, the accuracy of the projections presented in the 4th edition (using 2021 as the base year) and the extent to which the previously defined objectives were achieved were assessed. This integrated approach enables the identification of bottlenecks, the reassessment of assumptions, and the refinement of strategies for decarbonizing the aviation sector.

The methodology adopted for compiling historical data and projecting future emissions is the same as that used in the 4th edition of the Action Plan. As in previous editions, the information was drawn from ANAC's Statistical Air Transport Database[1], which consolidates, on a monthly basis, the data reported by domestic and foreign operators active in Brazil, as required by ANAC Resolution No. 191/2011. The operations included are those regulated under Brazilian Civil Aviation Regulations (RBAC) 121 and 135, excluding air taxi services and other special categories. For international flights, in accordance with ICAO guidelines under CORSIA, only emissions from aircraft registered in Brazil were accounted for.

1 https://www.gov.br/anac/pt-br/assuntos/dados-e-estatisticas

Historical evolution of the sector and its emissions

The performance of the Brazilian air transport sector over the past 20 years shows a consistent relationship between operational growth and gains in environmental efficiency. Between 2005 and 2024, domestic RTK (Revenue Tonne-Kilometer) – a metric that measures the volume of passengers and cargo transported per kilometer – grew at an average annual rate of 4.35%, while international RTK increased by 2.55%. Over the same period, fuel consumption grew at a slower pace – 2.40% for domestic flights and 0.43% for international flights – highlighting technological and operational advances as well as fleet renewal.

In the post-COVID-19 recovery period (2020 to 2024), domestic and international RTKs expanded at average annual rates of 19.40% and 30.78%, respectively. In contrast, the average annual growth in fuel consumption was more moderate, at 17.08% for domestic operations and 27.14% for international operations.

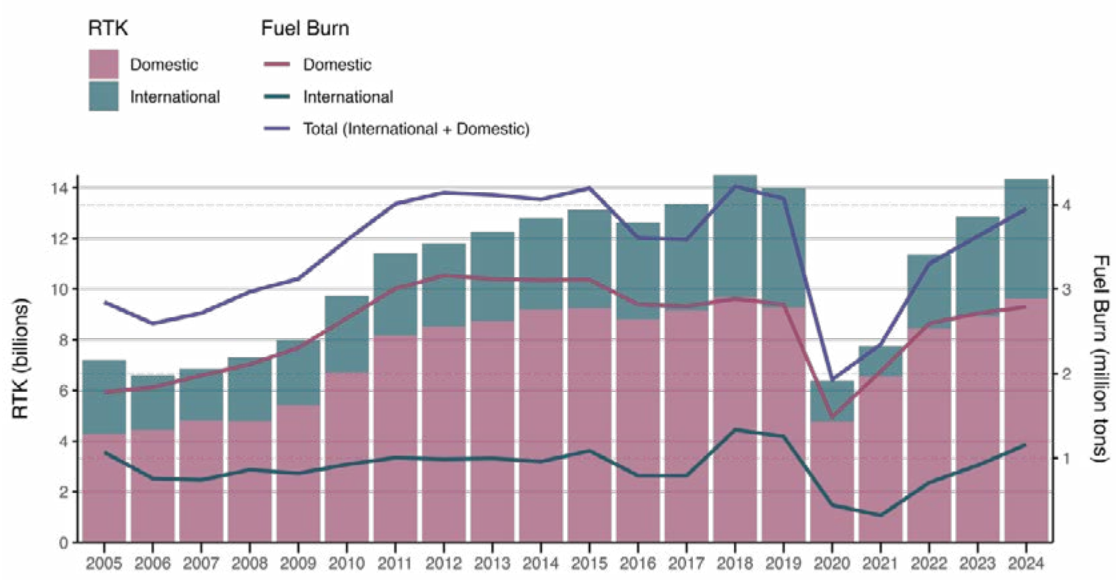

Figure 1 – Evolution of Jet Fuel Consumption per RTK.

Accuracy of the 4th Edition projections

The projections developed in the 4th edition of the Action Plan (based on the National Air Transport Plan – PAN and ICAO's post-COVID forecasts) showed deviations of less than 20% in fuel consumption estimates between 2022 and 2024. For the domestic market, projected fuel use was close to actual consumption in 2022 but overestimated the levels recorded in 2023 and 2024. For international flights, projected values were higher than observed in 2022 and 2023, while slightly below the actual figure for 2024.

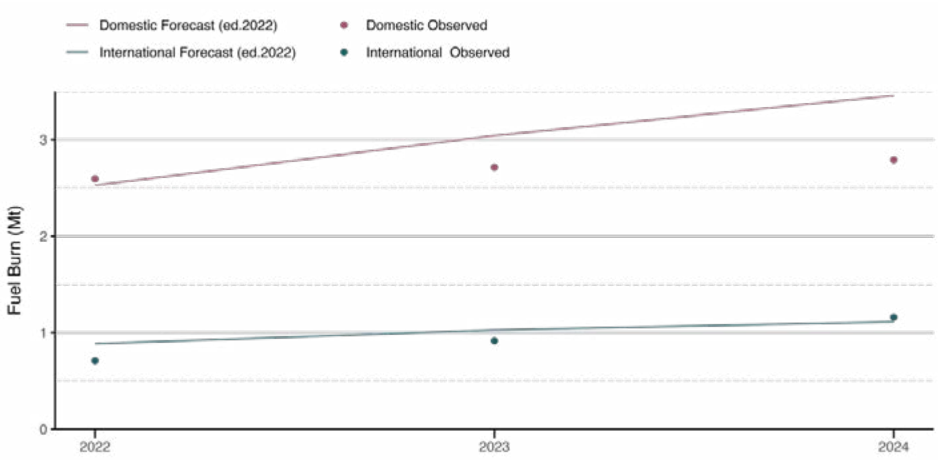

Figure 2 – Evolution of Jet Fuel Consumption (Projected vs. Actual Annual Consumption).

The efficiency gains projected in the 4th edition of the Action Plan, estimated by extrapolating historical trends, were consistent with the data observed during 2022–2024. The deviations between projected and actual results remained below 3.7%.

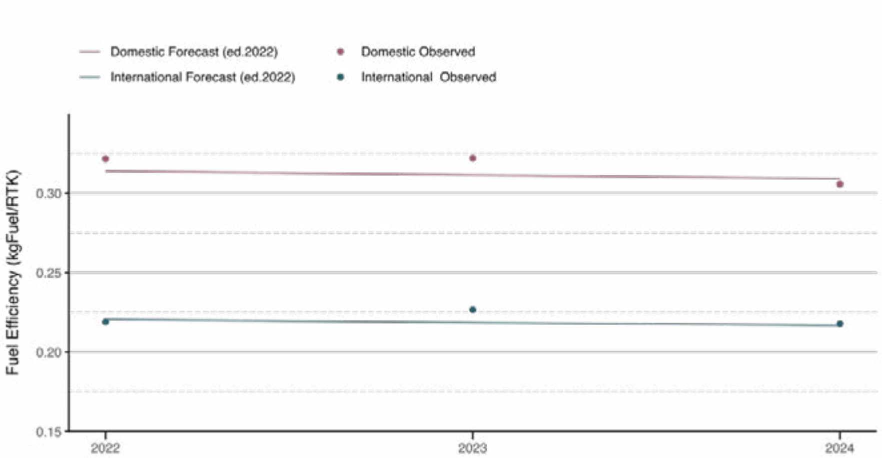

Figure 3 – Evolution of Jet Fuel Efficiency (Projected vs. Actual Annual Consumption).

CHAPTER II

National Policies and Nacionais

Since 2021, Brazil has been strengthening its regulatory framework for sustainability in civil aviation, as part of a continuous effort that underscores the country's commitment to global climate targets. This progress has taken shape through the creation and refinement of laws and regulations designed to reduce GHG emissions and to encourage an appropriate energy transition in the aviation sector.

Several recent initiatives highlight this regulatory evolution and are briefly outlined below.

National Program for Sustainable Aviation Fuel (ProBioQAV)[2]

The *Future Fuels Law*[3], enacted in 2024, established the National Program for Sustainable Aviation Fuel (ProBioQAV), which introduced mandatory annual decarbonization targets for domestic civil aviation through the use of SAF.

ProBioQAV was designed to stimulate the production and use of Sustainable Aviation Fuel (SAF), setting binding emission-reduction targets for air carriers operating domestic flights through the specific use of SAF. The targets start with a 1% reduction in emissions from SAF use in 2027, rising progressively to 10% by 2037. The National Agency of Petroleum, Natural Gas and Biofuels (ANP) is tasked with evaluating SAF production pathways, carbon accounting methodologies, and sustainability certification criteria, while the National Civil Aviation Agency (ANAC) defines the methodology for verifying emission reductions and oversees compliance with these obligations.

A key innovation of this legislation is the creation of a regulatory framework that stimulates demand for sustainable fuels based on carbon intensity (gCO_2e/MJ). This approach allows different feedstocks and SAF production pathways to compete on the basis of their actual environmental performance, fostering innovation and environmental optimization. This contrasts with the common practice of introducing demand through physical blending mandates expressed in volumetric percentages.

2 https://www.planalto.gov.br/ccivil_03/_ato2023-2026/2024/lei/l14993.htm#:~:text=Disp%C3%B5e%20sobre%20a%20promo%C3%A7%C3%A3o%20da,do%20Produtor%20e%20Importador%20de

3 Law No. 14,993/2024. Available in Portuguese at: https://www.planalto.gov.br/ccivil_03/_ato2023-2026/2024/lei/l14993.htm

In addition, Brazil has recognized the need for methodological alignment with ICAO's eligibility and certification requirements for SAF. This is expected to create a SAF market in Brazil that is harmonized with internationally defined ICAO standards, facilitating the global acceptability of Brazilian SAF and enabling foreign airlines to purchase it for compliance purposes under CORSIA and in other jurisdictions.

Climate Plan[4] and Brazilian Sustainable Taxonomy[5]

The National Climate Change Plan (*Plano Nacional sobre Mudança do Clima – Plano Clima*) is Brazil's main instrument for climate planning. It is currently undergoing a reformulation process to reflect international commitments and the requirements of climate governance.

The update of the Climate Plan (*Plano Clima*) involves the revision and creation of sectoral plans aimed at adaptation and mitigation measures and is directly linked to the Brazilian government's ecological transition strategy.

In turn, the Brazilian Sustainable Taxonomy (*Taxonomia Sustentável Brasileira*), whose development is being led by the Ministry of Finance, will establish criteria to classify economic activities as sustainable, thereby attracting investment in areas such as green airport infrastructure, SAF production, and low-carbon technologies. This taxonomy, aligned with international standards, will facilitate access to green financial instruments for the aviation sector.

Together, these initiatives are intended to contribute to the decarbonization of Brazilian civil aviation, foster industrial innovation, and position Brazil within the global low-carbon economy.

4 https://www.gov.br/mma/pt-br/composicao/smc/plano-clima

5 https://www.gov.br/fazenda/pt-br/orgaos/spe/taxonomia-sustentavel-brasileira

ANAC's Environmental Action Plan[6] and Incorporation of CORSIA[7]

The ANAC Environmental Action Plan 2025–2027 (*Plano de Ação Ambiental da ANAC 2025–2027*) formalizes the Agency's policy for integrating environmental considerations into its activities. Its six Environmental Strategic Objectives focus on contributing to emission mitigation, developing a safe SAF market, and promoting sustainable airport infrastructure. Performance indicators, such as compliance with CORSIA and the reduction of emission intensity through SAF, were established to measure progress in the Action Plan's implementation.

Programs such as *SustentAr* (for airlines) and Sustainable Airports (*Aeroportos Sustentáveis*, for airport operators) are action instruments designed to foster the voluntary adoption of environmental measures aimed at improving environmental management, enhancing operational performance, and reducing emissions and noise. Additional action instruments under ANAC's Environmental Action Plan include the development of a portfolio of environmental projects and the Aviation Environmental Network (*Rede Ambiental da Aviação*), a collaborative platform that brings together public and private stakeholders, of which *Conexão SAF* is a part.

In addition to the ANAC Environmental Action Plan 2025–2027, Brazil has fully incorporated the provisions of CORSIA into national regulation through ANAC Resolution No. 743/2024. This regulation not only sets requirements for monitoring, reporting, and verification of emissions from Brazilian airlines operating international flights, but also establishes obligations for the reduction and offsetting of emissions that exceed the CORSIA baseline.

6 https://www.gov.br/anac/pt-br/assuntos/meio-ambiente/arquivos/plano-de-acao-ambiental-2025-2027

7 https://www.anac.gov.br/assuntos/legislacao/legislacao-1/resolucoes/2024/resolucao-743

Sustainability Policy of the Ministry of Ports and Airports[8]

The Sustainability Policy of the Ministry of Ports and Airports (*Política de Sustentabilidade do Ministério de Portos e Aeroportos*), published on January 27, 2025, seeks to integrate Environmental, Social and Governance (ESG) practices into transport infrastructures, with a focus on decarbonization, social inclusion, and climate resilience.

The policy is structured around three pillars: (1) Planning and Governance, (2) Environment and Climate Change, and (3) Social Responsibility. The Sustainability Pact (*Pacto pela Sustentabilidade*), a voluntary commitment, enables companies operating in the aviation sector to obtain recognition through sustainability labels.

8 https://www.in.gov.br/web/dou/-/portaria-n-58-de-24-de-janeiro-de-2025-608930192

CHAPTER III

Sustainable Aviation Fuels

Overview of SAF in Brazil

The Energy Research Office (*Empresa de Pesquisa Energética – EPE*), an entity linked to the Ministry of Mines and Energy (*Ministério de Minas e Energia – MME*), published in September 2024 the Outlook Report on the Future of Sustainable Aviation Fuels in Brazil (*Caderno de Perspectivas Futuras dos Combustíveis Sustentáveis de Aviação no Brasil*)[9]. Its objectives were: (1) to consolidate relevant information on the topic, (2) to present in an objective manner the SAF production pathways already approved by ANP, (3) to compare the main aspects of these pathways, and (4) to outline production trajectories for SAF in Brazil, aimed at meeting GHG emission reduction programs in civil aviation – ProBioQAV for domestic flights and CORSIA for international flights.

The volumetric demand for SAF in Brazil will vary according to the carbon intensity (CI) of the fuel mix produced, since both CORSIA and ProBioQAV apply emission-reduction metrics, each with its own eligible compliance options. The EPE report presents three possible pathways to meet the requirements of these two programs:

- **Pathway I – Announced Projects:**

  Announced biorefinery projects provide an additional SAF production capacity of 1,100 thousand m^3/year.

- **Pathway II – Established and Alternative Feedstocks:**

  New ventures are expected to begin operations. The use of established feedstocks, such as soybean oil, first-generation sugarcane ethanol (E1G), and second-crop corn ethanol, may be scaled up. In particular, SAF production from sugarcane E1G ethanol represents a new market opportunity, with the potential to consolidate ethanol plants as biorefineries.

  Alternative feedstocks, such as *macaúba* and agave, are also promising for diversifying biomass sources, strengthening family farming, restoring degraded areas, and fostering regional development. By 2037, SAF production from unannounced projects involving either established or alternative feedstocks could range from 3,800 to 8,000 thousand m^3/year, representing between 36% and 78% of the volumetric demand for jet fuel.

9 https://www.epe.gov.br/pt/publicacoes-dados-abertos/publicacoes/combustiveis-sustentaveis-de-aviacao-no-brasil-perspectivas-futuras

- **Pathway III – Waste Utilization:**

  The use of organic waste, such as tallow and residues from sugarcane and eucalyptus, offers low acquisition costs and low carbon intensity. The production potential of SAF from these residues is significant: around 140 thousand m^3/year via the HEFA pathway using tallow, 915 thousand m^3/year via the FT pathway using sugarcane residues, and 790 thousand m^3/year via the FT pathway using eucalyptus residues. If this potential were fully developed, it would be possible to meet 82% of the emission reduction targets by 2037 using only waste. The additional production capacity in this pathway would be approximately 1,940 thousand m^3/year.

Further information on the subject is available in the Outlook Report on the Future of Sustainable Aviation Fuels in Brazil (*Caderno de Perspectivas Futuras dos Combustíveis Sustentáveis de Aviação no Brasil*) [10], published by EPE.

Summary of 2037 scenarios

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

10 https://www.epe.gov.br/pt/publicacoes-dados-abertos/publicacoes/combustiveis-sustentaveis-de-aviacao-no-brasil-perspectivas-futuras

Conexão SAF[11]

Conexão SAF is a forum established by ANAC and ANP to bring together public and private stakeholders for the identification and development of proposals and solutions that enable the Brazilian aviation sector to achieve decarbonization through the use of SAF. The forum is recognized by the ANAC Environmental Action Plan (*Plano de Ação Ambiental da ANAC*) as an environmental action instrument for achieving its strategic environmental objectives.

The activities of *Conexão SAF* aim to promote a continuous and structured dialogue to identify technical, regulatory, tax, production, and logistical challenges to fostering SAF production and consumption in Brazil, while proposing alternatives and initiatives to make these fuels economically viable. Its vision is to bring together all institutions interested in discussing the opportunities and challenges of promoting SAF production and consumption in Brazil. As of June 2025, the forum comprised 114 public and private entities from the aviation, energy, finance, and government sectors, among others.

Currently, *Conexão SAF* serves as a platform for social participation to support Brazilian government agencies in regulating ProBioQAV. Its work is carried out through the following Technical Groups (*Grupos Técnicos – GTs*): (1) GT Product Certification and Quality, (2) GT Infrastructure and Distribution, (3) GT Regulation of the Airlines Mandate, (4) GT Incentives and Financing, and (5) GT Taxation and Fiscal Aspects of the SAF Value Chain.

Investments and R&D&I in SAF

Brazil has intensified public investment and institutional coordination efforts aimed at Research, Development, and Innovation (R&D&I) in SAF.

In parallel with *Conexão SAF*, a forum composed primarily of industry stakeholders, the country established in 2024 a network of academic researchers dedicated exclusively to developing the SAF agenda: the Research Network on Sustainable Aviation Fuels (*Rede de Pesquisa em Combustível Sustentável de Aviação – RPSAF*).

11 https://hotsites.anac.gov.br/conexaosaf/

RPSAF was created through a partnership between the Ministry of Ports and Airports (*Ministério de Portos e Aeroportos – MPOR*) and the National Council for Scientific and Technological Development (*Conselho Nacional de Desenvolvimento Científico e Tecnológico – CNPq*). Its main objective is to build scientific, technological, and analytical capacity for the development and implementation of the SAF value chain in Brazil, including the evaluation of production pathways, life cycle analysis, logistical feasibility, quality certification, operational use, and strategic inputs for public policy design. The initiative also includes mapping feedstocks, identifying promising technological pathways, regulatory barriers, infrastructure gaps, and potential economic and environmental impacts of large-scale SAF deployment.

Furthermore, to boost the development and production of SAF in the country, the National Bank for Economic and Social Development (*Banco Nacional de Desenvolvimento Econômico e Social – BNDES*) and the Funding Authority for Studies and Projects (*Financiadora de Estudos e Projetos – Finep*), linked to the Ministry of Science, Technology and Innovation (*Ministério de Ciência, Tecnologia e Inovação – MCTI*), launched in August 2024 a joint public call to select business plans focused on the implementation of biorefineries and the development of technologies for sustainable aviation and marine fuels. A total of R$ 6 billion (approximately USD 1.1 billion) was made available. Each proposal was required to present a business plan with credit needs exceeding R$ 20 million (USD 3.7 million). The call received 76 proposals, amounting to a potential investment of R$ 167 billion (USD 30 billion), 43 of which were focused on SAF production.

The establishment of RPSAF, combined with the financing and technological development efforts led by institutions such as BNDES and Finep, represents a qualitative leap in the governance of Brazil's aviation decarbonization agenda. By linking science, innovation, public policy design, and industrial strategy within a collaborative and nationally integrated framework, the country aims to secure a strategic position in the global market for sustainable fuels.

CHAPTER IV

Airline and Airport Operators

Brazilian aviation has shown a growing commitment to sustainability, driven both by sector-wide initiatives and by independent efforts from the operators themselves. For example, since 2011, with the concessions of Brazil's main airports, there has been a cycle of significant investment in infrastructure modernization and adaptation. These investments not only improved the operational capacity of airports but also encouraged the implementation of various measures to enhance environmental management and energy efficiency.

Such actions, ranging from the optimization of natural resource use to waste management and emission reductions, represent an important part of Brazil's contribution to international sustainability objectives.

Likewise, airlines have adopted their own strategies to mitigate the environmental impact of their operations, seeking greater fuel efficiency, exploring cleaner technologies, and contributing to discussions on access to SAF and the development of this market in the country. These initiatives are essential for advancing the sector's decarbonization and reflect the commitment of operators to a more sustainable future for aviation[12].

Sustainable Airports Program

Created as a tool to promote and disseminate best practices in airport environmental management, the *Aeroportos Sustentáveis* program is a voluntary initiative of ANAC open to participation by airport operators. Within the scope of the program, Brazilian airports are classified into levels of environmental sustainability according to the measures implemented and based on their annual passenger traffic category.

Aeroportos Sustentáveis is now in its sixth edition and, in its current format, assesses actions adopted by airports in areas such as the use of natural resources, solid waste management, social development of local communities, corporate governance, aircraft noise management, pollutant and GHG emissions, and climate resilience.

12 Details on the measures implemented by airport and airfield operators can be found in the Appendices at the end of this Action Plan.

The latest edition of the program included the participation of 35 airports that presented their climate-related initiatives, representing all five regions of Brazil and all four operational profiles of aerodromes. These initiatives include, among others, emissions quantification, the creation of a carbon management plan, stakeholder engagement, climate risk assessment, and the design of adaptation measures.

Currently, *Aeroportos Sustentáveis* incorporates ACA certification developed by Airports Council International (ACI), as a result of a partnership between ANAC, ACI, and Airports of Brazil (*Aeroportos do Brasil – ABR*), aimed at knowledge sharing to foster the sustainable development of the civil aviation sector.[13]

SustentAr Program

Inspired by the Sustainable Airports Program (*Programa Aeroportos Sustentáveis*), the *SustentAr Program* (*Programa SustentAr*) is also an initiative of ANAC, based on voluntary participation, serving as a non-regulatory incentive tool designed to promote and recognize proactive sustainability actions in air operations. The program is directed specifically at air transport companies and its main objective is to foster the adoption of good environmental management practices and to publicize sustainable initiatives implemented by airlines active in Brazil.

Currently in its third edition, *SustentAr* evaluates participants according to environmental criteria such as environmental policy and management, emission and pollutant reduction measures, and SAF use. Its editions took place in 2021, 2022, and 2023.

The most recent edition included the participation of six qualified companies. Highlights were AZUL Linhas Aéreas in the airline category and CHC Helicópteros in the air taxi category. Participants were ranked as "First Class" or "Business Class" based on their final score relative to the simple average of their category, excluding those with a score below 25%.[14]

13 Details on the program's evaluation criteria and the performance of participants are available, in Portuguese, at: https://www.gov.br/anac/pt-br/assuntos/meio-ambiente/aeroportos-sustentaveis

14 Details on the program's evaluation criteria and the performance of participants are available, in Portuguese, at: https://www.gov.br/anac/pt-br/assuntos/meio-ambiente/sustentar

CHAPTER V

Aerospace Industry

Beyond the use of SAF, emission mitigation in the aviation sector relies heavily on technological advances in aircraft, with a focus on energy efficiency and flexibility in fuel type.

In this context, Embraer stands out as a Brazilian manufacturer of aircraft with up to 150 seats, active in the commercial, executive, defense, and urban air mobility segments. The company has set environmental targets, including achieving carbon neutrality in its operations by 2040. To this end, it plans to use SAF in 25% of its activities by that date and to develop aircraft fully compatible with 100% SAF. Embraer also sees smaller aircraft as key platforms for testing new propulsion technologies.

The E2 family of aircraft, currently in operation, is considered among the most fuel-efficient in its class, with roughly a 25% reduction in fuel burn per seat compared to the previous generation. In 2024, the company advanced in defining requirements for sustainable aircraft, engaging with operators, authorities, and suppliers.

Embraer is also investing in alternative propulsion systems, such as hybrid-electric, all-electric, fuel cell, and dual-fuel (hydrogen and SAF) technologies. These alternatives are expected to be applicable initially to aircraft of up to 50 seats, with maturity anticipated in the second half of the next decade.

In the field of urban air mobility, Eve Air Mobility – an Embraer subsidiary – is developing an electric eVTOL with low noise levels and the potential to reduce CO_2 emissions by up to 80%. Letters of intent have already been signed for the sale of around 2,800 units, with customers in several countries.

Internally, the company has adopted measures such as electrification of processes, the use of renewable energy, and the promotion of SAF throughout its value chain. Since 2021, these actions have contributed to a reduction of more than 13,000 tons of CO_2.

CHAPTER VI

Operational Improvements

Operational improvements in air traffic management have strong potential to reduce CO_2 emissions in the short term by increasing efficiency across all phases of flight. Unlike more costly technological solutions, these measures can often be implemented with the current fleet and directly result in fuel savings. Responsibility for these initiatives is shared among airlines, airport operators, and the body responsible for managing national airspace – in Brazil's case, the Department of Airspace Control (*Departamento de Controle do Espaço Aéreo – DECEA*) of the Air Force Command.

Brazilian airlines already apply practices such as Single Engine Taxi, Auxiliary Power Unit shutdown (APU OFF), optimized climb techniques, and route rationalization. However, many of these measures depend on airport infrastructure and on operational procedures under DECEA's authority.

In this context, DECEA leads major initiatives under the SIRIUS Program (*Programa SIRIUS*), which aims to modernize the Brazilian Airspace Control System (*Sistema de Controle do Espaço Aéreo Brasileiro – SISCEAB*), incorporating environmental considerations. Notable measures include the adoption of operational procedures aligned with ICAO guidelines, such as Continuous Descent and Continuous Climb Operations (CDO/CCO), Performance-Based Navigation routes (STAR, SID), ADS-B surveillance, Airport Collaborative Decision Making (A-CDM), among others. These procedures are already contributing to emission reductions, as demonstrated by technical data.

Currently, new projects are being implemented with strong potential to further enhance operational efficiency, reducing aircraft fuel consumption and associated carbon emissions. Examples include:

- TBO (Trajectory-Based Operations): Aims to improve route accuracy and predictability through data exchange between aircraft and ground systems.
- PBCS (Performance-Based Communication and Surveillance): Allows for reduced separation between aircraft in remote areas, increasing air traffic efficiency.
- Wake Turbulence Separation: Optimizes landings and takeoffs at busy airports with a new aircraft categorization system, reducing waiting times.
- BR-UAM (Advanced Air Mobility – *Mobilidade Aérea Avançada*): Prepares the regulatory and operational infrastructure for eVTOL aircraft, such as electric air taxis in urban centers.

- BR-UTM (Unmanned Traffic Management – *Gerenciamento de Tráfego Não Tripulado*): Structures drone operations up to 400 feet, in four progressive phases based on complexity and proximity to aerodromes.
- SISMET: Enhances the integration of meteorological data, expanding the predictive capacity of the Integrated Aeronautical Meteorology Center (*Centro Integrado de Meteorologia Aeronáutica* – CIMAER) and optimizing operational decision-making.
- REDEMET: Modernizes the Air Force's meteorological network, integrating national and international data to improve forecasting and weather monitoring across Brazilian airspace.

These projects form part of Brazil's strategy to make air traffic management more efficient, safe, and sustainable, with a direct impact on reducing GHG emissions from the aviation sector, as shown in the table below:

Measure	2022		2023		2024	
	Low End (ton)	High End (ton)	Low End (ton)	High End (ton)	Low End (ton)	High End (ton)
CDO	162454	162454	170571	170571	175630	175630
PBN STAR	150167	375418	158932	397329	16365	409137
CCO	556984	1856614	584814	974690	602161	1003601
PBN SID	0	225251	0	238397	0	245482
A-CDM	-	-	-	-	-	-
ADS-B Surveillance	2638898327	10555593308	2770751240	11083004961	285293644	11411745778
radius to fix PBN procedure:	226001418	448624077	239191915	474807871	24630031	488918397
RNP AR AP/CH	7151,71	8822,31	7569,11	9337,23	779,41	9614,71
A-SMGCS peak	4676	9352	5318	10635	6110	10635
A-SMGCS low visibility	534	1069	608	1069	698	1397
A-SMGCS night	134	268	152	305	175	350

(CO_2 Emission Reductions (tons) – Source: DECEA)

CHAPTER VII

Projections

As in previous editions of the Brazilian Action Plan, future emissions were estimated in accordance with the methodology set out in ICAO Doc 9988. This methodology requires the use of fuel efficiency trend curves ($kgCO_2$/RTK) derived from statistical modeling. The emission factor applied was 3.16 kg of CO_2 per kg of jet fuel (*Querosene de Aviação* – QAV), in line with internationally recognized parameters.

Fuel Consumption Projection

Based on data updated through December 31, 2024, this edition of the Action Plan revises the sector's growth and fuel consumption projections, as well as updates the parameters for energy efficiency and emission intensity.

RTK projections for the period 2025–2050 used the National Air Transport Plan (*Plano Aeroviário Nacional – PAN*) as the reference for domestic traffic and ICAO's Long Term Forecast (LTF) for international traffic. The expected average annual growth is 2.65% for the domestic segment and 3.03% for the international segment.

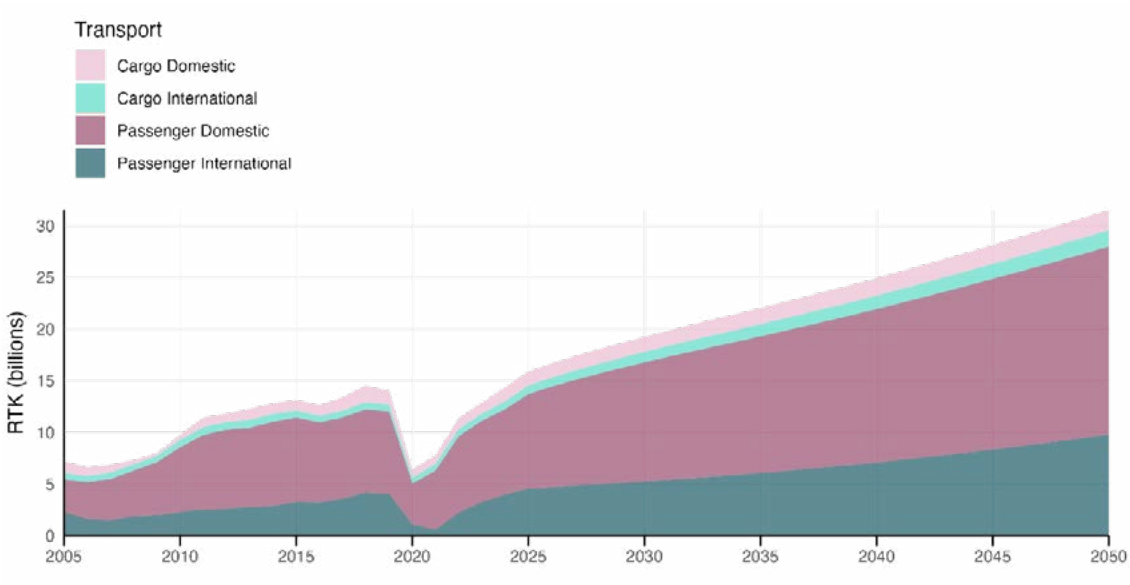

Figure 4 – RTK Projections for 2025–2050.

The updated fuel efficiency curve [15], as in previous editions, applied logarithmic modeling to the kgJF/RTK ratio, capturing the fact that efficiency improvements diminish over time. The cumulative efficiency gain estimated for the period 2024–2050 is 7.73% for the domestic segment and 10.24% for the international segment, reflecting the fact that international flights are longer and have greater passenger-carrying capacity. These improvements include planned investments over the coming years in technological upgrades (e.g., fleet renewal, aircraft adaptation) and operational enhancements (e.g., route optimization and airspace improvements).

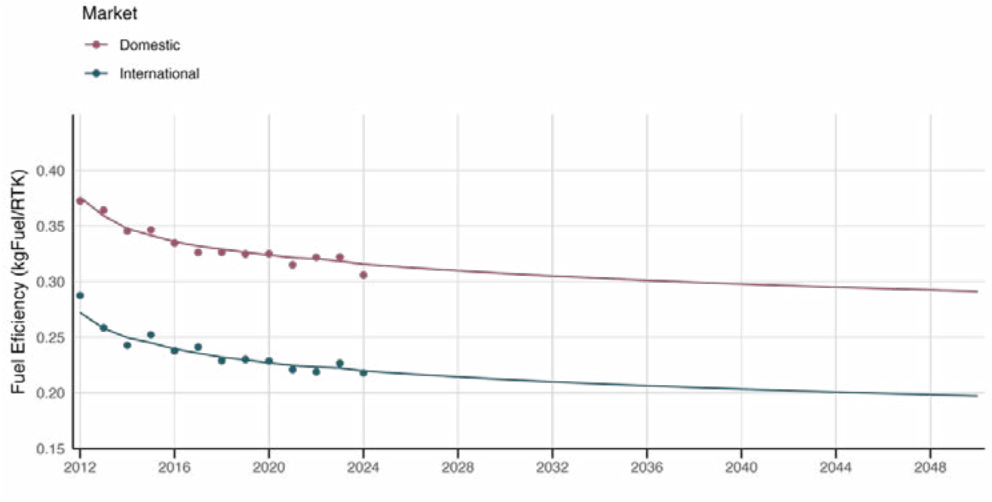

Figure 5 – Projected Jet Fuel Efficiency Curve vs. Actual Efficiency.

By combining the two projections (RTK and fuel efficiency), the resulting fuel consumption projection is presented separately for domestic and international operations. According to this projection, cumulative fuel consumption between 2024 and 2050 will increase by 99% overall, with 93% growth in the domestic segment and 116% in the international segment.

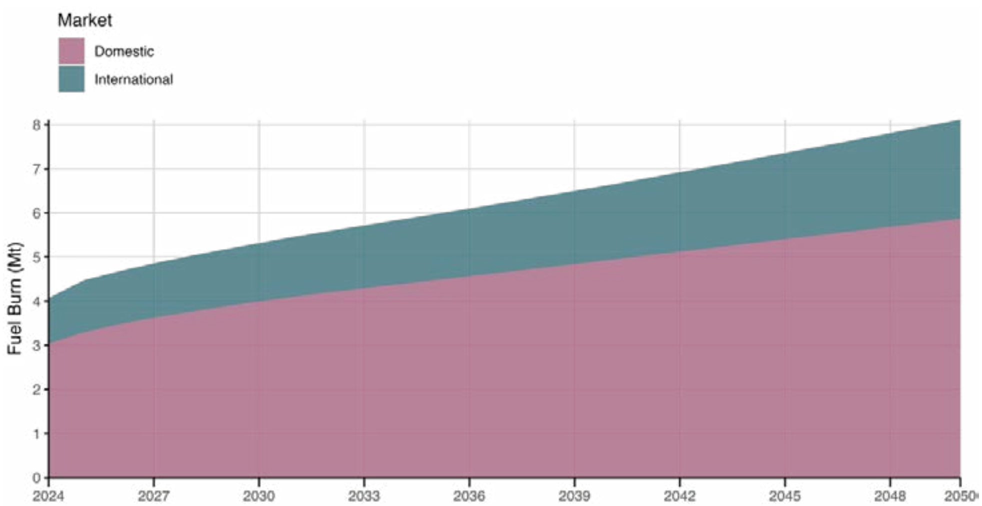

Figure 6 – Projected Fuel Consumption in Brazil.

15 The metric Fuel Efficiency is used as defined in ICAO Doc 9988. It represents the annual amount of fuel consumed per unit of RTK, such that the lower the value, the greater the efficiency of air transport.

Emission Reduction Scenario

Based on the fuel consumption projection presented earlier, converted into CO_2 emissions (conversion factor = 3.16 kgCO_2/kg of jet fuel – *QAV*), scenarios were considered for emission reductions through the use of SAF and the claim of carbon credits under CORSIA.

For SAF use, Trajectory I from EPE's report *Future Outlook for SAF in Brazil* (*Perspectivas Futuras para SAF no Brasil*) was adopted, which takes into account the projects already announced for SAF production up to 2035. From 2035 onward, SAF production was assumed to follow the global growth projection[16].

For carbon offsets under CORSIA, ANAC's projections for the growth of Brazilian airlines were combined with ICAO's projections for the growth of the international civil aviation sector.

It was further assumed that SAF produced in Brazil would be available for use by Brazilian airlines for carbon reduction under either ProBioQAV or CORSIA. Priority was assigned to compliance under ProBioQAV, focused on domestic aviation, with any surplus SAF allocated to CORSIA, applicable to international aviation, through 2035. For the subsequent period, the distribution of available SAF was projected in proportion to fuel use in the domestic and international segments.

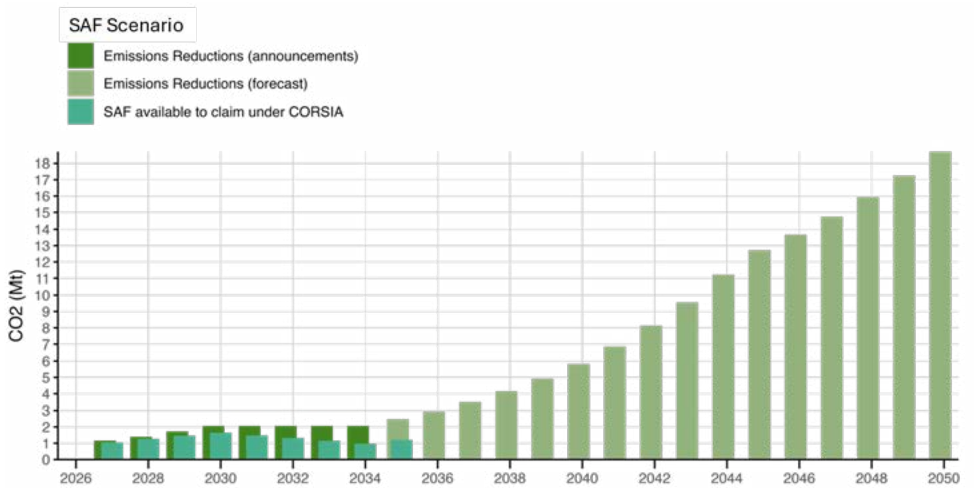

Figure 7 – Projections of Emissions and SAF Availability in Brazil.

16 The growth of emissions reductions from the use of SAF in scenario F1 of the ICAO LTAG report was considered, available at: https://www.icao.int/environmental-protection/LTAG/Pages/LTAGreport.aspx

The resulting emission projection is shown in Figure 8, together with the partial reductions from technological and operational measures expected in the coming years, the reductions from SAF use in both domestic and international operations, and the remaining offsets under CORSIA.

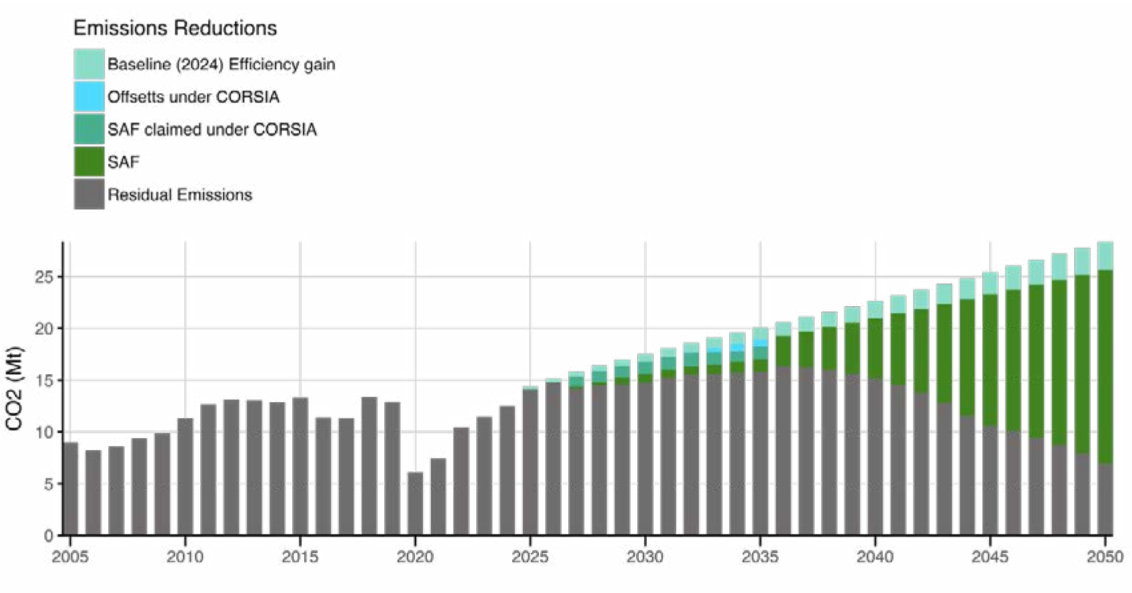

Figure 8 – Projection of Emissions from Brazilian Civil Aviation.

Emission Intensity

Another relevant concept is Emission Intensity (EI), which represents the net carbon dioxide (CO_2) emissions per RTK. The comparison between the evolution of CO_2 emissions and Emission Intensity is shown in Figure 9, for both domestic and international flights.

In general terms, there is a downward trend in Emission Intensity throughout the projected period, even though total emissions are expected to rise until 2035. In other words, while absolute emissions increased during the period, when compared to the volume of air operations and the number of passengers and cargo transported per kilometer flown, emissions declined in relative terms. This outcome is made possible by the implementation of each component of the basket of measures for GHG reduction, making air operations in Brazil more environmentally efficient.

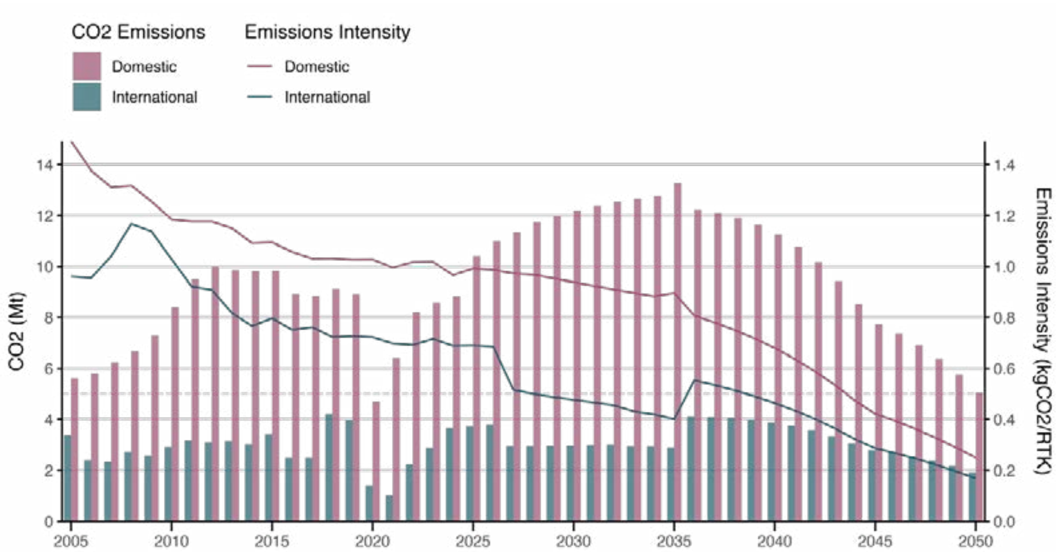

Figure 9 – Projections of CO_2 Emissions and Emission Intensity in Brazilian Aviation.

Conclusion

This Action Plan reaffirms Brazil's commitment to reducing GHG emissions in the civil aviation sector, in alignment with the international targets agreed under ICAO and with national guidelines for ecological transition. By integrating regulatory initiatives, investments in innovation, operational improvements, and support for the production and use of sustainable fuels, the country consolidates a cross-sector strategy for the progressive decarbonization of aviation.

The historical analysis demonstrates concrete gains in energy efficiency, while future projections indicate that, even in the face of growing air traffic, it is possible to decouple this growth from a proportional increase in emissions, provided that government, industry, and civil society act in coordination. In this regard, the technical and economic feasibility of SAF, advances in aeronautical technologies, and the role of airports and airlines as catalysts of best environmental practices will be decisive in moving toward cleaner aviation.

The success of implementation, however, depends on robust governance, the availability of green financing instruments, and the consolidation of public policies that foster innovation and industrial competitiveness.

Finally, this Action Plan should be understood as a dynamic instrument, requiring continuous monitoring, the realignment of targets, and openness to dialogue with multiple stakeholders. Only through such an approach will it be possible to build an aviation sector that is more efficient, resilient, and environmentally sustainable in the long term.

APPENDIX I

Environmental Commitments of Airport Operators

The table below provides information on the main commitments of airport operators with respect to planning actions aimed at reducing greenhouse gas emissions.

The data refer to actions carried out in the past three years or included in company planning within the timeframe of this Action Plan. In line with the commitment made by the National Civil Aviation Agency (*Agência Nacional de Aviação Civil – ANAC*), the information voluntarily submitted by economic agents has been anonymized.

Status	Commitment	Category
Planned	Environmental education for employees, staff, and stakeholders	Education and Engagement
Planned	Installation of awareness stickers on conscious electricity use	Energy Efficiency
Planned	Absolute reduction of 20% in GHG emissions (Scopes 1 and 2) by 2037 (baseline 2018)	Goals and Certifications
Planned	Transition of ACA certification from Level 2 to Level 3+ by 2037	Goals and Certifications
Planned	5% reduction in electricity and water consumption per passenger by 2037	Goals and Certifications
Planned	20% reduction in solid waste sent to landfills by 2037	Goals and Certifications
Planned	Carbon neutrality (Scopes 1 and 2) by 2045	Goals and Certifications
Planned	19% reduction in electricity consumption by 2025	Goals and Certifications
Planned	Progressive decarbonization goals aligned with the Paris Agreement, including carbon neutrality for Scopes 1 and 2 and decarbonization pathways for Scope 3 by 2050	Goals and Certifications
Planned	59% reduction in Scope 1 and 2 emissions by 2033 (baseline 2019)	Goals and Certifications
Planned	27% reduction in Scope 3 emissions by 2033 (baseline 2019)	Goals and Certifications
Planned	Engagement of 81% of customers to develop science-based goals by 2026	Goals and Certifications
Planned	Acquisition of water meters and flow/pressure sensors for a water telemetry system	Other Contributions
Planned	Installation of awareness stickers on conscious water use	Other Contributions
In Progress	Planned acquisition of hybrid and electric vehicles for the operational fleet	Fuels and Fleet

Status	Commitment	Category
In Progress	Feasibility study for the use of low-emission "drop-in" biofuels	Fuels and Fleet
In Progress	Pilot study on automation of split-type air conditioning equipment, with an expected 18% reduction in consumption	Energy Efficiency
In Progress	Assessment of the feasibility of installing window films in terminals to reduce heat exchange	Energy Efficiency
In Progress	Improvements in waste segregation and recycling processes, including composting and new waste treatment solutions	Waste Management and Circular Economy
Under Evaluation	Technical and economic feasibility study for the implementation of Sustainable Aviation Fuel (SAF)	Fuels and Fleet
Under Evaluation	Evaluation of replacing gasoline use with ethanol	Fuels and Fleet
Under Evaluation	Study on the introduction of electric forklifts	Fuels and Fleet
Under Evaluation	Study for the construction of a second deep-water well for cooling towers	Other Contributions
Implemented	Optimization of vehicle routes on the apron to reduce fossil fuel consumption	Fuels and Fleet
Implemented	Acquisition of more efficient combustion vehicles (fleet renewal)	Fuels and Fleet
Implemented	Awareness campaigns for employees through training sessions, lectures, and communications on air emissions	Education and Engagement
Implemented	Celebration of Tree Day with forest visits and planting of native seedlings	Education and Engagement
Implemented	"We Are Sustainable" (Somos Sustentáveis) program to encourage and recognize sustainable practices among employees, aligned with the UN SDGs	Education and Engagement
Implemented	Stakeholder engagement plan and partnerships for reducing indirect emissions (Scope 3), including workshops, technical meetings, and environmental clauses	Education and Engagement
Implemented	Systematization of processes to eliminate 100% of paper use (Airport Now tool)	Education and Engagement
Implemented	Installation of 400Hz systems on boarding bridges to replace diesel generators (GPUs)	Energy Efficiency
Implemented	Replacement of conventional lighting with LED	Energy Efficiency
Implemented	24-hour monitoring of energy-consuming systems (HVAC, lighting, conveyors, elevators)	Energy Efficiency
Implemented	Use of bioclimatic architecture in airport expansions (cross ventilation, shading, skylights, double glazing)	Energy Efficiency
Implemented	Purchase of certified clean energy (since 2023)	Energy Efficiency
Implemented	Construction of a photovoltaic power plant to supply the administrative building	Energy Efficiency

Status	Commitment	Category
Implemented	100% renewable energy certified by I-RECs	Energy Efficiency
Implemented	Modernization of lighting systems (LED), automation of escalators and conveyors, modernization of cooling systems	Energy Efficiency
Implemented	Preparation and regular updating of the GHG Emissions Inventory (GHG Protocol) since 2018	Emissions Management and Inventory
Implemented	Annual publication of the carbon management plan	Emissions Management and Inventory
Implemented	Monitoring supplier performance and sustainability risk	Emissions Management and Inventory
Implemented	GHG inventory covering Scopes 1, 2, and 3	Emissions Management and Inventory
Implemented	Publication of emission data in annual sustainability reports	Emissions Management and Inventory
Implemented	Reduction of solid waste sent to landfills (promotion of reuse and recycling)	Waste Management and Circular Economy
Implemented	Disposal of non-recyclable waste in urban solid waste-to-energy plants (RDF – Refuse-Derived Fuel production)	Waste Management and Circular Economy
Implemented	Selective waste collection program	Waste Management and Circular Economy
Implemented	Wood reuse project for the production of pallets, furniture, and accessories	Waste Management and Circular Economy
Implemented	100% reuse of milling residues (RAP) in construction works	Waste Management and Circular Economy
Implemented	Refurbishment of essential airport equipment (circular economy)	Waste Management and Circular Economy
Implemented	Refurbishment and modernization of firefighting trucks (CCI) to avoid premature disposal	Waste Management and Circular Economy
Implemented	Adoption and progression in the Airport Carbon Accreditation (ACA) program	Goals and Certifications
Implemented	Neutralization of 8.5% of Scope 1 emissions and 100% of Scope 2 emissions (targets achieved in 2024)	Goals and Certifications
Implemented	ISO 14001 certification for effective environmental management	Goals and Certifications
Implemented	Air quality monitoring	Other Contributions
Implemented	Forest restoration projects for CO_2 sequestration	Other Contributions

APPENDIX II

Environmental Commitments of Airlines

The table below provides information on the main commitments of airlines with respect to planning actions aimed at reducing greenhouse gas emissions.

The data refer to actions carried out in the past three years or included in company planning within the timeframe of this Action Plan. In line with the commitment made by the National Civil Aviation Agency (*Agência Nacional de Aviação Civil – ANAC*), the information voluntarily submitted by economic agents has been anonymized.

Status	Commitment	Category
Planned	Use of SAF	SAF
In Progress	Fleet renewal	New technologies
In Progress	Use of more efficient routes	Operational
In Progress	Promotion of SAF research	SAF
In Progress	Advocacy actions for the promotion of SAF production	SAF
In Progress	Installation of AeroShark on B777 aircraft	New technologies
In Progress	Purchase of carbon credits to offset residual emissions	Others
Implemented	APU Off	Operational
Implemented	Use of software and artificial intelligence to improve operational efficiency	Operational
Implemented	Single Engine taxi	Operational
Implemented	Improved climb – flap 1 – increase in climb gradient	Operational
Implemented	Idle reverse	Operational
Implemented	Improvement in aircraft weight planning prior to flight	Operational
Implemented	Reduction of aircraft operational weight	Operational
Implemented	Selection of only one alternate aerodrome	Operational
Implemented	Optimization of fuel requirement forecasting	Operational
Implemented	Adjustment of onboard water supply volumes	Operational
Implemented	Efficient cargo positioning to reduce drag	Operational
Implemented	Maintenance of aircraft painting to reduce aerodynamic drag	Operational

Departamento de Controle do Espaço Aéreo
Department of Airspace Control

ANAC NATIONAL CIVIL AVIATION AGENCY - BRAZIL

MINISTRY OF PORTS AND AIRPORTS

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