

MAIN CONCLUSIONS

AIRWAY



TRANSPORT COALITION

HOW TO MAKE THE TRANSPORT SECTOR AN ACTIVE
CONTRIBUTOR TO THE REDUCTION OF BRAZILIAN EMISSIONS



CNT / SEST SENAT / ITL
Sistema Transporte





CONTEXT AND MOTIVATION

- Brazil's New National Determined Contribution (NDC) and Climate Plan **represent opportunities to position the country as a global decarbonization leader**, especially as it is the host of COP30 in 2025.
- The transport sector is critical, accounting for **~11% of national gross emissions (260 Mton in 2023, well-to-wheel vision¹)**; **~4% of transport emissions come from the airway mode**.
- Given the expected growth for the country, in an inaction scenario, the emissions of the airway mode can **reach 13,4 Mton CO₂e in 2050**.



THE COALITION

- The magnitude of the challenge **requires widespread engagement and debate** by the transport sector.
- **Led by Motiva, CEBDS, CNT and Insper's Mobility Observatory, the Coalition** mobilized **+50 entities of 6 groups**: urban mobility, road, rail, coastal & inland navigation, airway and infrastructure/cross-sectionality.



INITIAL OBJECTIVES

- The effort, started in Nov/2024, developed from the **active contribution and expertise of coalition entities and primary data** available until Feb/2025, materialized important deliveries, such as:
 1. Measurement of the emissions baseline in 2050²;
 2. Mapping of 90 decarbonization levers;
 3. Quantification of impacts for decarbonization path.

The conclusions of this study are the result of a collective effort in favor of sustainable decarbonization of the transport sector, based in the technologies and information currently available, and may evolve with new future advances.

1. Emissions from the transport sector calculated based on sources external to SEEG; 2. Baseline 2050 is a projection based on estimates of passenger and cargo growth and inertial vision of the fuel consumption matrix.

AIRWAY - MEMBER ENTITIES

The present document was supported by the following entities of the airway transport mode.



COORDINATION



OTHER MEMBERS



CNT / SEST SENAT / ITL
Sistema Transporte

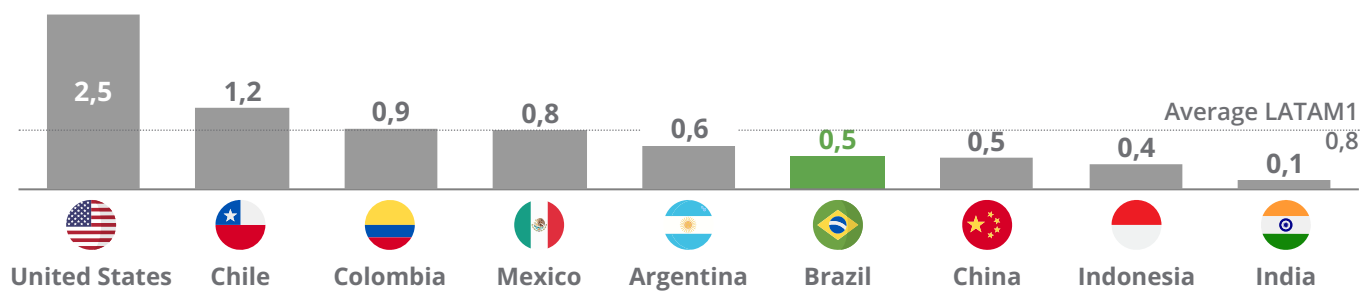


CONSULTIVE CROSS-SECTION ENTITIES

When comparing the penetration of passengers of the airway mode per inhabitant in different countries, it is observed that Brazil still has space to grow.

TOTAL PASSENGERS PER INHABITANT

(PAX / 1000 inhabitants) 2023

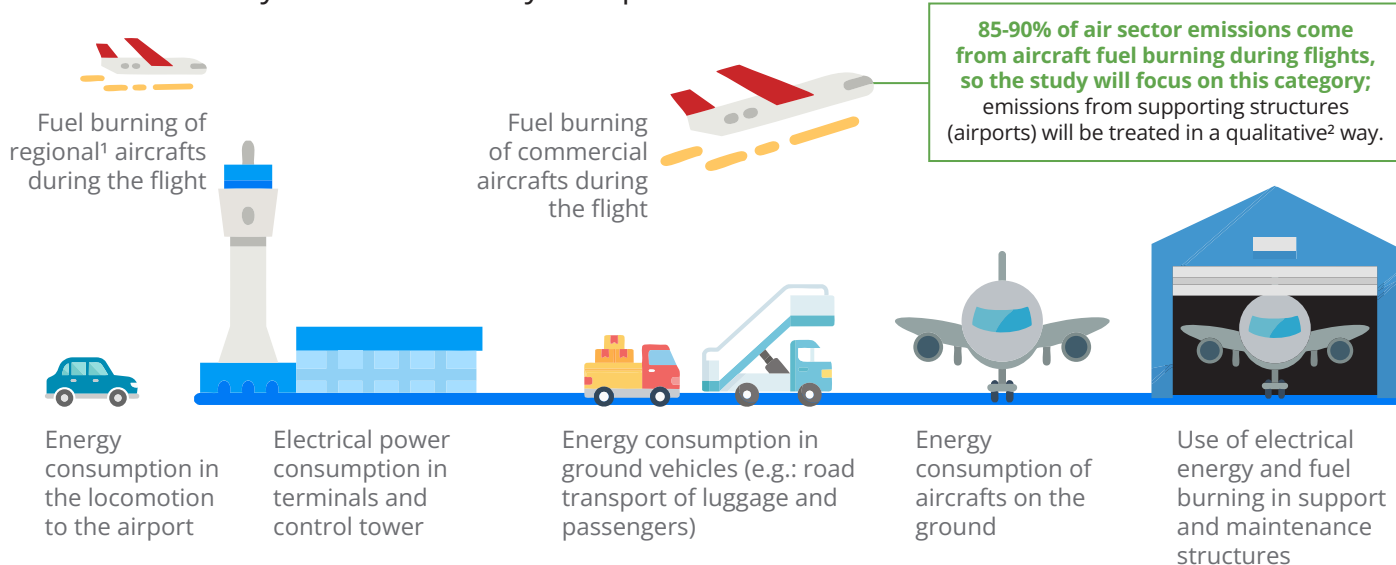


Brazil has a **PAX/inhabitant penetration 38% lower than the average LATAM¹**.
When we look at countries like the **United States**, this number is **5x smaller**.

1. Only Chile, Colombia, Mexico, Argentina and Brazil are considered. Source: IATA; OAG; ICAO; UNWTO; EIU; ANAC.

AIRWAY EMISSIONS COME MAINLY FROM TRANSPORT, WITH LOWER INFRASTRUCTURE IMPACT

Emissions ecosystem of the airway transport mode

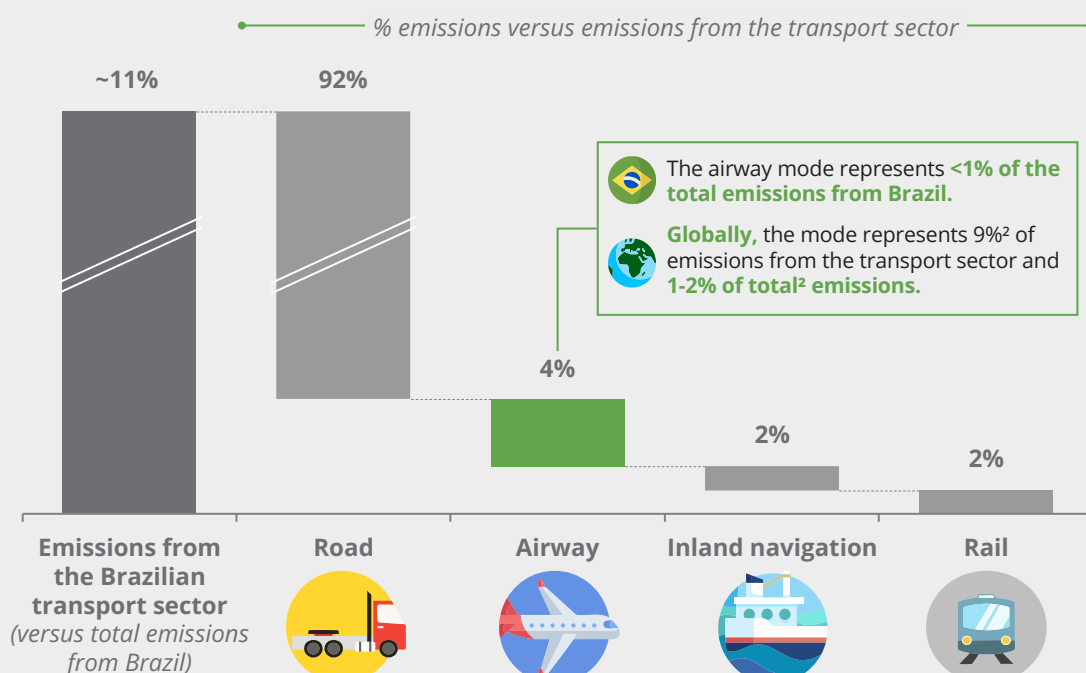


1. Regional aircrafts include all non-commercial categories; 2. Airport emissions are estimated to account for 10-15% of total airway sector emissions globally. Source: SEEG; interviews with industry experts.

EMISSIONS¹ OF AIRWAY MODE REPRESENT ~4% OF THE TOTAL FROM TRANSPORT IN BRAZIL

GROSS EMISSIONS FROM THE TRANSPORT SECTOR

(%) – BRAZIL (2023)



1. Transport emissions reported by SEEG are restricted to burning fuels; 2. Global value (2019) excluding Brazil and considering emissions from international flights; Source: Anfaeva; SEEG; CAIT; Climate TRACE.



CURRENT OVERVIEW

Relevant indicators help to understand the current state of the airway mode

2023

96 billion
Domestic RPK

514
Aircraft fleet¹

789 thousand
Domestic flights

91 million
Domestic PAX

159
Public airports²

3B kg
Domestic fuel – kerosene

10 Mton
CO₂e emissions – 2022

1. Size per # of passengers: Small (up to 100), medium (101-250) and large (251+); 2. Airports that received regular domestic flights. Source: ANAC.

APPROACH I THREE STEPS FOR DECARBONIZATION OF AIRWAY MODE



Definition of projections for the total emissions of the sector, **WITH changes in the participation of different modes of transport;**



Mapping the levers for **reducing emissions applicable to transport mode;**



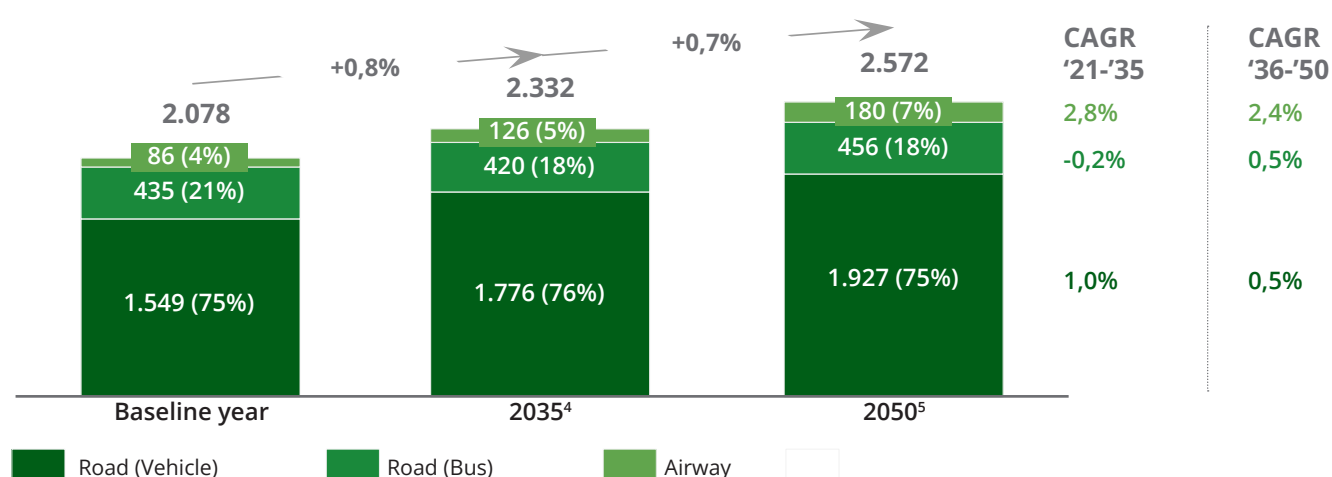
Proposition of possible **sensitivities based on levers mapped.**

1 DEFINITION OF BAU¹ CONSIDERING THE GAIN OF REPRESENTATIVENESS IN THE PASSENGER MATRIX

In the first stage, a future scenario based on PNL and Sector Plans was explored, in which the participation of the airway mode could be expanded, impacting the distribution of passengers transported between the different modes.

EVOLUTION OF THE PASSANGERS² MATRIX

(Passengers, %) million PAX, baseline year³



1. Bau = Business-as-usual; 2. Designed based on Transport Sector Plans and PNL 2035 – National Logistics Plan; 3. Baseline Year = 2021, with PNL being projected to the respective CAGRs of the Reference Scenario versus 2017; 4. 2035 T-KM values refer to scenario PSR1 of the PSTR and PAX come from the referential scenario of the passenger matrix of PNL 2035; 5. T-KM projected according to GDP with share of scenario PSR3 of the PSTR and PAX projected according to population growth without share changes; Note: Passengers reported in the PNL only contemplates intermunicipal and interstate routes, and do not consider passengers inside the urban centers. Sources: Infra S.A; Ministry of Transport; Ministry of Infrastructure.

2 LEVER MAPPING FOR EMISSION REDUCTION

After the presentation of the transport matrix, **levers with potential to reduce emissions in the airway mode were identified by the working group.**

Such levers were mapped into three large blocks as described below. For each of them, a qualitative feasibility analysis¹ was performed and local and global references were presented that illustrate the respective application.

1. The complete details of the viabilities and references can be found in the complete document of the airway mode, which can be accessed via QR Code at the end of material.

LEVER BLOCKS FOR REDUCING EMISSIONS in airway mode



EFFICIENCY



BIOFUELS



ELECTRIFICATION AND POWER-TO-X



EFFICIENCY

Levers - Aircrafts (flight time)

- 1 **Accelerated renewal of the current fleet**, with the fastest replacement of older aircraft with more efficient models (e.g.: Max and Neo models) and with better design.
- 2 **Intelligent route optimization and fleet allocation** by modernizing the air traffic operating system, reducing average distance and other effects.
- 3 **Act on the behavior of engines and pilots** through eco-efficient and assisted driving programs to optimize the high dispersion of energy consumption between the different flights.
- 4 **Better utilization of aircrafts**, focusing on load factor elevation.

Source: Skypower Reports; EPE; The Economist; ProQR; FAPESP.

Levers - Airports and ground emissions

- 1 **Improvement of operational management¹** (e.g.: ground ops., ground control, flight control, etc.) and landing and take-off trajectories through **the modernization of systems and strengthening of airport infrastructure**.
- 2 Support for **increased efficiency of aircraft energy consumption on the ground** (e.g.: use of electric tugs, use of electric GPUs – e.g.: 400Hz – instead of APUs etc.).
- 3 Implementation of **efficiency gain strategies in electricity consumption, soft gases, waste and water** (e.g.: LED lamps, use of natural ventilation, etc.).
- 4 **Accelerated renewal of the fleet and current support machinery**, with the replacement by more efficient models.

First two levers consider impact/feasibility of reducing emissions by aircrafts.



BIOFUELS

Levers - aircraft (flight time)

- 1 **Intensification of the use of bio-SAF** directly as an alternative to aviation kerosene and aviation gasoline.
- 2 **Use of Book & Claim¹ practices** through the acquisition of SAF credits.

Potential intensification of biofuels to reduce the carbon footprint can be applied provided that the technical, mechanical, operational and laboratory viability of the said energy input is verified, as well as respecting the diversity of matrices and regional specificities.

Cutting emissions relative to SAF at another stage of the chain may not happen within the scope of domestic brazilian emissions².

1. Practice in which a particular airline buys the credits corresponding to the SAF produced, but uses conventional fuel in its flights, another part of the system consumes the physical SAF and the buyer company receives carbon credits; 2. Although it can be counted in CORSIA. Source: Skypower Reports; EPE; The Economist; ProQR; FAPESP; goal.

Levers - Airports and ground emissions

- 1 **Use of clean fuel in support machinery** such as APU (Auxiliary Power Unit) and GPU (Ground Power Unit).
- 2 **Use of clean fuels in support fleet** (e.g.: internal buses and GNC or ethanol-based baggage tractors).
- 3 **Support for the provision of clean fuels** to aircrafts (e.g.: infrastructure, facilitation, etc.).

Potential intensification of biofuels to reduce the carbon footprint can be applied provided that the technical, mechanical, operational and laboratory viability of the said energy input is verified, as well as respecting the diversity of matrices and regional specificities.

Source: ICAO; NLR; FAPESP; ACI.



ELECTRIFICATION AND POWER-TO-X

Levers - aircraft (flight time)

- 1 **Use of Power-to-Liquid** (PTL: E-SAF¹) solutions as a power source.
- 2 **Use of hydrogen solutions as a direct energy source** (through direct combustion or fuel cell).

Levers can be applied since the technical and operational viability of the respective solutions are verified.

Other initiatives that are potential levers for smaller and short-haul aircrafts, such as electrification/hybridization, have not been analyzed in detail given the limitation of the solution and implementation time.

1. Synthetic fuels produced from green hydrogen, renewable electricity and captured CO₂ - synthetic gas needs to go through a conversion process (Fischer-Tropsch) to produce liquid products that can be refined for fuels; Source: Skypower Reports; EPE; The Economist; ProQR; FAPESP.

Levers - Airports and ground emissions

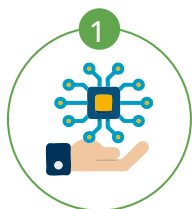
- 1 **Use of renewable energy** (e.g.: photovoltaic matrix) in operations (terminals, patio and administratives).
- 2 **Electrification** (or use of hybrid batteries) **of the fleet** (e.g.: buses and baggage tractors) and **supporting machinery** (e.g.: GPU).
- 3 **Use of clean energy matrix** in electric/hybrid support systems and machines (e.g.: GPU).
- 4 **Improvement of airport infrastructure**, allowing electrification (e.g.: plug infrastructure, adapted transmission power grid, etc.).

Levers can be applied since the technical and operational viability of the respective solutions are verified.

Source: ICAO; NLR; FAPESP; ACI.

3 PROPOSITION OF SENSITIVITIES BASED ON THE MAPPED LEVERS

Finally, sensitivities were proposed to evaluate the impact of different decarbonization paths:



Current technologies

Restricted to the application of efficiency levers and compliance with regulatory requirements;



Intensification of biofuels

Predominance of the application of levers for intensification of the use of biofuels;



Acceleration of Electrification / Power-to-X

Predominance of electrification/power-to-x levers of the aircraft fleet;



Transformational

Combination of efforts considering the levers of sensitivities 1, 2 and 3 for closer reach of zero net emissions.

PROPOSED SENSITIVITIES CONSIDERED DIFFERENT ASSUMPTIONS:

As the same as on BaU¹, the **increase in SAF penetration does not impact passenger matrix** in any sensitivity.

The use of aircraft with new emission profiles (e.g.: hybrid/electric, eVTOL)² is not foreseen on a large scale.



CURRENT TECHNOLOGIES

TRANSFORMATIONAL



Airports efficiency

All efficiency levers were considered in different sensitivities.



Aircrafts efficiency

New models up to 25% more fuel efficient vs. old, with such orders entering before the expected date³.

SAF use (biofuel⁴)

Follows BaU¹ penetration, with bio-SAF reaching 11% of the total fuel matrix in 2050.

More optimistic scenario, with bio-SAF reaching penetration of 22% in 2050.



PTL Route (E-fuels/E-SAF)²

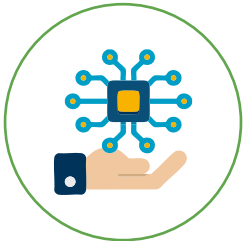
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The PTL route (E-SAF) reaches 11% of the total matrix in 2050.

1. Bau – business-as-usual (emission baseline); 2. Given focus on commercial aviation of large size and immaturity of the respective solutions for the mode, electrification, evtol and use of pure hydrogen are not being considered in the model; 3. Total fleet is, on average, 30% more efficient in 2050 versus baseline year; 4. Potential intensification of biofuels to reduce the carbon footprint can be applied provided that the technical, mechanical, operational and laboratory viability of the said energy input is verified, as well as respecting the diversity of matrices and regional specificities. Sources: AviationWeek; IATA; sustainability report of brazilian airline companies; ReFuelEU legislation; U.S. Department of Energy; S&P; EPE; ICAO; Argus; interviews with industry experts.

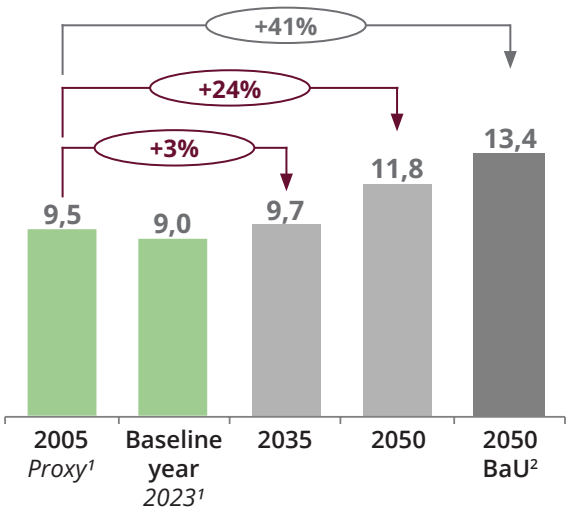
RESULTS OF SENSITIVITIES ON EMISSION IMPACT

Due to expected passenger volume growth, industry emissions can **reach 13,4 absolute Mton CO₂e in 2050** in the baseline scenario (BaU), a growth of ~50% vs. 2023. With the implementation of the mapped levers, the sector should **reach 9,6 absolute Mton CO₂e (+7% vs. 2023)** in transformational sensitivity in 2050, a 28% reduction vs. BaU, reaching **53gCO₂e/PAX (-46% vs. 2023 and -28% vs. BaU) relative emissions**.

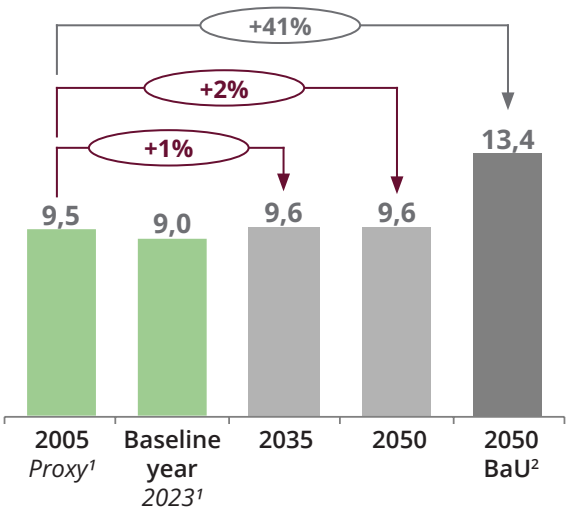


CURRENT TECHNOLOGIES

ABSOLUTE¹ EMISSIONS
(MtCO₂e)



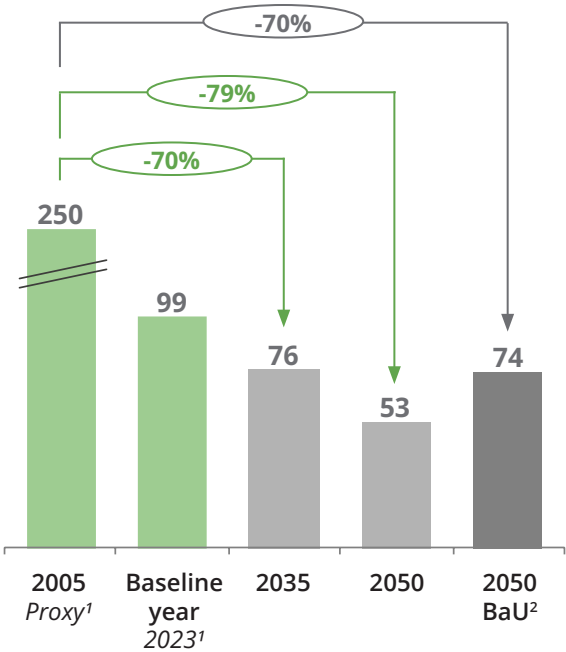
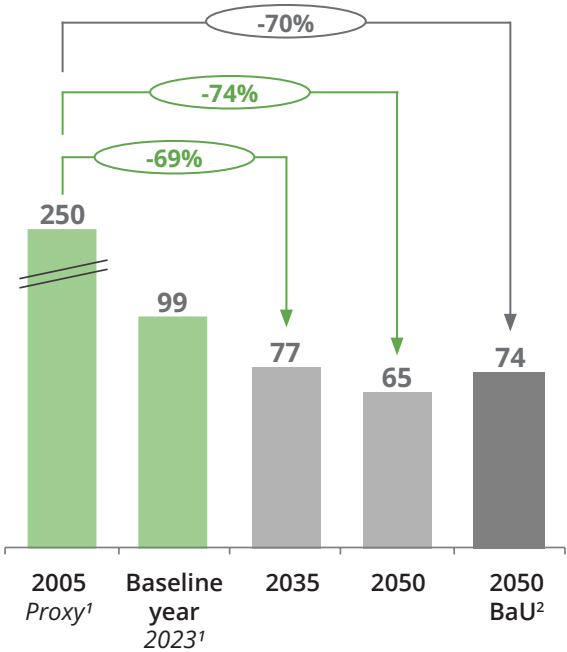
TRANSFORMATIONAL



PAX (M)



RELATIVE¹ EMISSIONS
(gCO₂e / PAX)



1. The SEEG 2005/2023 emissions (2023: proxy per GLEC emission factor) were adjusted by a well to tank emission factor (WTT) / tank to wheel emissions (TTW) of the mode; 2. BaU = Business-as-Usual; Source: SEEG; AviationWeek; IATA; airline sustainability reports; ReFuelEU legislation; U.S. Department of Energy; S&P; EPE; ICAO; Argus; interviews with industry experts.



EXAMPLES ILLUSTRATE HOW ENABLERS HELP THE APPLICATION OF DECARBONIZATION LEVERS

PUBLIC GUIDELINES AND INCENTIVES TO ENABLE AIRWAY MODE EMISSIONS REDUCTION

CORSIA

Regulation that establishes mandatory targets for compensation and reduction of carbon emissions in international aviation, impacting domestic aviation.

MULTI-SECTOR COORDINATION MECHANISMS THAT FOSTER INFRASTRUCTURE AND AVAILABILITY OF SAF

Sea-Tac¹ International Airport, in collaboration with 13 airlines, is adjusting its infrastructure to supply 10% of SAF flights by 2028. 

REGULATION THAT ENCOURAGES PUBLIC AND PRIVATE INVESTMENTS IN CLEANER FUELS

Fuel law of the future (“Lei do Combustível do Futuro”)

+20 Global and Brazilian partners (e.g.: Embraer) committed to financing more than U\$200M in projects aimed at decarbonization of airway transport.

TANGIBLE MECHANISMS FOR FOSTERING PRIVATE FINANCING

Sustainable Flight Fund

+20 Global and Brazilian partners (e.g.: Embraer) committed to financing more than U\$200M in projects aimed at decarbonization of airway transport.

EMISSION ACCOUNTING WITH BOOK-AND-CLAIM

ICAO

CORSIA recognizes and systematizes the Book-and-Claim model, allowing the use of these credits to account for emission reduction and alleviate the shortage of SAF in countries with lower availability.

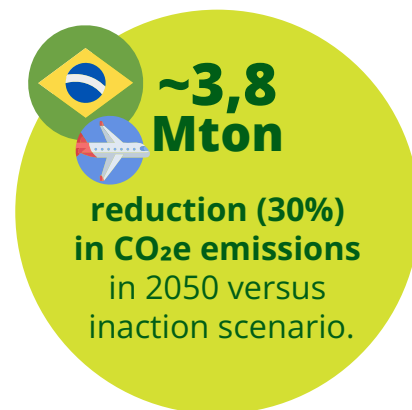
CONCRETE STEPS FOR BRAZIL TO BECOME A PROTAGONIST IN THE GLOBAL CHAIN OF SAF

In 2024, Raízen carried out the first shipment of sugarcane ethanol from Brazil to the United States, destined for conversion into SAF on a plant in Geórgia. 

1. Seattle-Tacoma; 2. Including Alaska Airlines, Delta Air Lines, Emirates, Horizon Air, Icelandair and Lufthansa. Sources: Bloomberg; FINEP; IATA; United Airlines Ventures; Aero Magazine; Embraer; Airport Technology News.

WE AIM FOR SUSTAINABLE GROWTH FOR THE AIRWAY MODE

Given the significant growth in the number of passengers transported by the airway mode (+100% 2023-2050) and its greater representativeness in the Brazilian matrix (7% vs 4% in the baseline year¹), **the remaining emissions in 2050 would represent 7,0% of the total transport emissions in Brazil even in the most transformational sensitivity.**



Conclusions sought by the work toward the airway mode in Brazil in 2050:

CURRENT¹ AIRWAY



~4% OF AIRWAY MODE PASSENGERS (equivalent to ~91M of PAX³).



~0 B L OF BIOFUELS CONSUMED (focused on the use of fossil options⁴).



~0% of the fuel matrix FROM PtX⁵ OR HYDROGEN SOLUTIONS.

FUTURE² AIRWAY



~7% OF AIRWAY MODE PASSENGERS (~180M), growing at +2.5% per year.



~1.1 B L OF BIO-SAF consumed, representing 22% of the mode's fuel matrix.



~11% OF AIRCRAFTS using synthetic fuels⁶ (PtX – eSAF).

1. 2023 Proxy; 2. Transformational 2050; 3. Passengers; 4. Kerosene or aviation gasoline; 5. Power-to-X; 6. Given the focus on commercial aviation of large size and the immaturity of the respective solutions for the mode, electrification, eVTOL and use of pure hydrogen are not being considered. Source: SEEG; AviationWeek; IATA; ReFuelEU; U.S. Department of Energy; S&P; EPE; ICAO; Argus; interviews with industry experts.

AIRWAY MODE

Scan the QR Code to access the full document

