MINISTÉRIO DA
INFRAESTRUTURA

Brazil's Action Plan on CO_2 Emissions Reduction from Aviation

3rd Edition

BASE YEAR **2018**

Brazil's Action Plan on CO_2 Emissions Reduction from Aviation

3rd Edition | Base Year: 2018

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This publication is also based on the following regulations issued by the National Civil Aviation Agency (ANAC): Resolution No. 496/2018 and Ordinance No. 4005/ASINT/2018.

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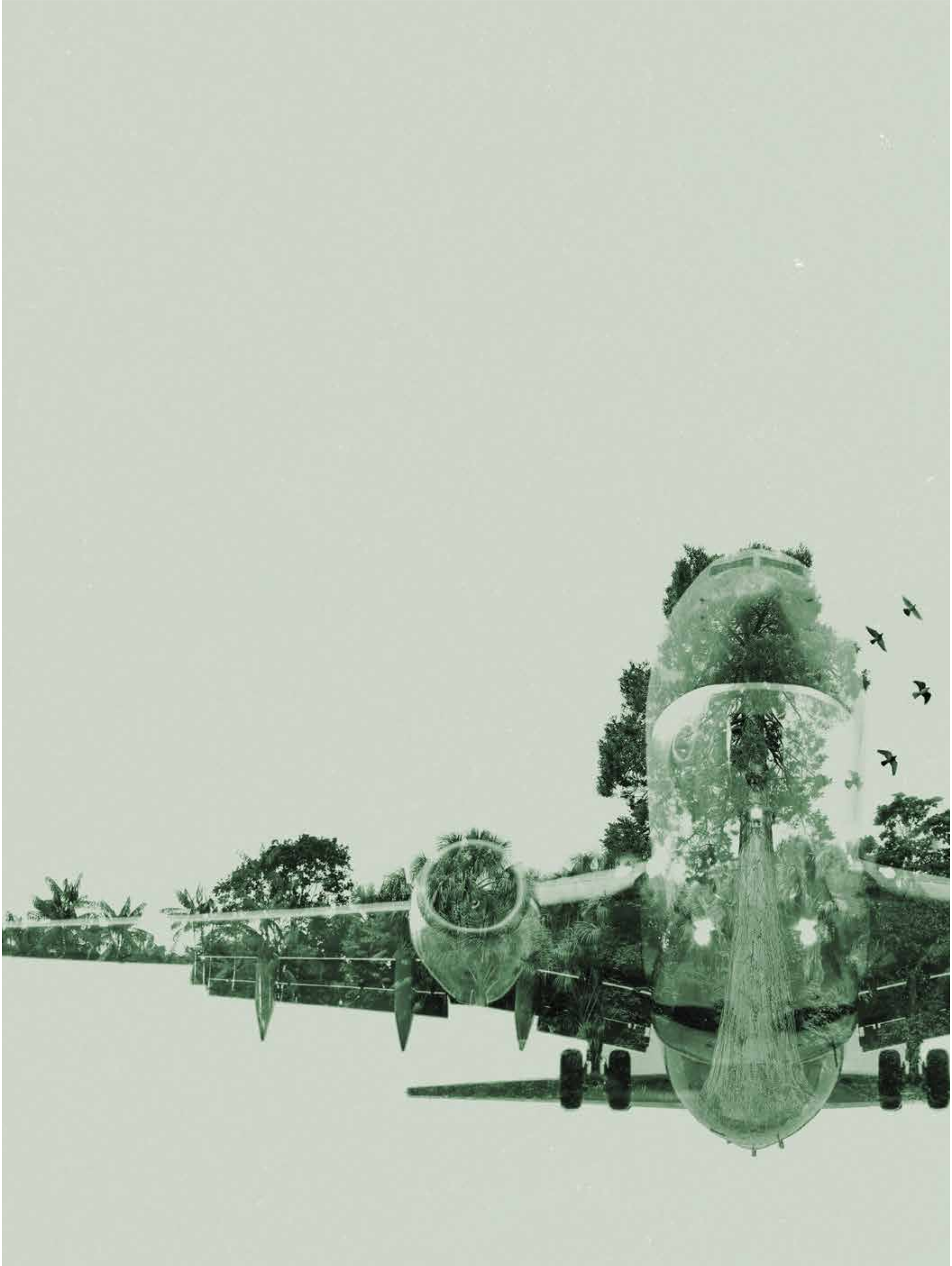
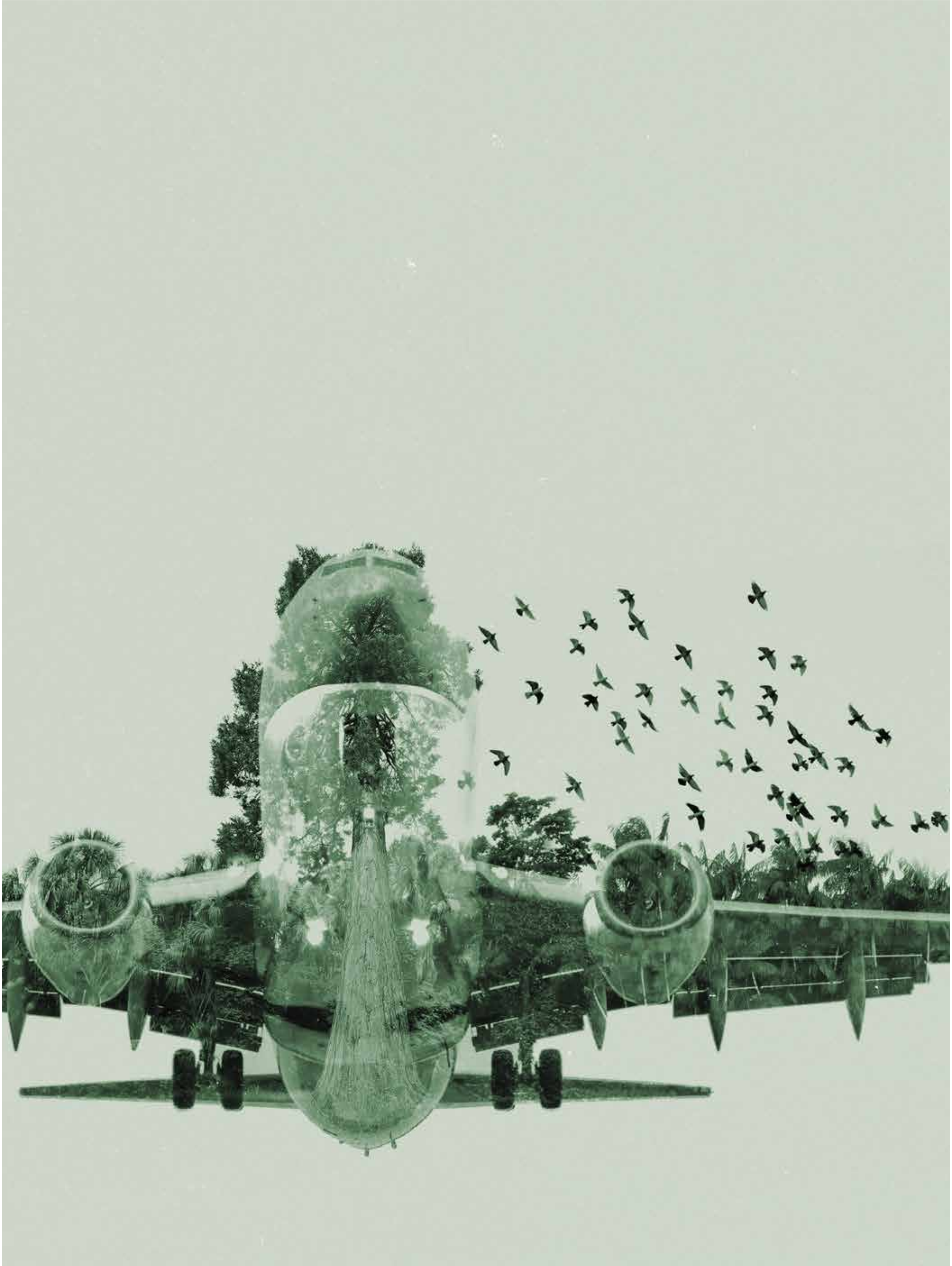


Summary



Executive Summary

Brazil's Action Plan on CO_2 Emissions Reduction from Aviation

This is the 3rd Edition of Brazil's Action Plan, updated and submitted to the International Civil Aviation Organization (ICAO) every three years, in line with recommendations set forth in Resolution A39-2: Consolidated statement of continuing ICAO policies and practices related to environmental protection – Climate change. It describes measures adopted by Brazil to limit or reduce CO_2 emissions from civil aviation.

As a continuous work, constantly being improved, it reflects the collaborative effort of various players and reaffirms the commitment of the Brazilian civil aviation industry to the environment.

In 2018, Ministerial Ordinance No. 514/2018 ordered the creation of a Working Group to coordinate the elaboration of this Action Plan. The Working Group, composed of representatives of the Government and the private sector, became a forum for debates and knowledge exchange that contributed to the formulation of policies and guidelines appropriate to the specificities of the Brazilian civil aviation industry.

The estimation of avoided emissions due to the mitigation measures adopted by Brazil constitutes a major improvement of the 3rd Edition of the Action Plan.

The first two editions of the Action Plan followed the guidelines of the Intergovernmental Panelv on Climate Change (IPCC) for the definition of international flights. According to these guidelines, the previous Actions Plans accounted for emissions from international flights operated by both Brazilian and foreign airlines departing from aerodromes located in Brazil and its territories ("State of origin" criteria).

With the entry into force of the *Carbon Offsetting and Reduction Scheme for International Aviation* (CORSIA), this Action Plan adopts the methodology proposed by ICAO and reports emissions from international flights operated by aircraft registered in Brazil ("State of registration" criteria). Therefore, the current methodology accounts for international flights operated by Brazilian airlines bound to or from Brazil.

Despite most mitigation measures having effect on both domestic and international flights, this Action Plan seeks to segregate their data to the greatest extent. Chapters 4 to 7 describe several ongoing initiatives in the domestic market that further extend the global aspirational goals set by ICAO.

Operational improvements

From 2016 to 2018, the measures adopted by Brazilian airlines to increase operational efficiency led to a reduction of 1,770,828 tonnes of CO_2 emissions from domestic and international flights. They include weight minimization, flap optimization for take-off and landing, thrust reverser optimization, electric taxiing, single-engine taxiing, engine cleaning and zonal dryer.

Air Traffic Management

The Department of Airspace Control (DECEA), subordinate to the Air Force Command, is the organization responsible for the control of the Brazilian airspace, provider of air navigation services that enable flights and the ordering of air traffic flows in Brazil. The improvements implemented by DECEA in air traffic management from 2016 to 2018 represented 1,808,945 tonnes of CO_2 that were not released into the atmosphere.

Airport Improvements

The Brazilian airport concessions programme promotes adjustments in airport capacity to match the forecasted demand for air transport. This ultimately leads to the reduction of airport bottlenecks, as well as less congestion and waiting times for landings and takeoffs, and thus of fuel consumption by civil aviation.

Brazilian airports adopt several measures to reduce emissions, such as replacing incandescent lighting with LED lamps, using alternative sources of energy generation, reducing the distance traveled by ground support equipment and biofuel-operated ground vehicles. These measures are described in Chapter 4. It was not possible to estimate the impact of all actions taken, however, it is estimated that at least 8,250 tonnes of CO_2 were not emitted from 2016 to 2018 due to good practices adopted by airports.

Aircraft Technology Development

Technological development of aircrafts, such as aerodynamic improvements, engine efficiency and the use of lighter materials, contribute to the improved energy efficiency of air operations. Chapter 5 of this document describes the initiatives of the Empresa Brasileira de Aeronáutica

S.A. - Embraer related to research and innovation, especially for the development of fuel-efficient aircrafts. The company also maintains research and development projects for technologies related to sustainable aviation fuels.

Sustainable aviation fuels - SAF

Brazil has extensive experience in the biofuels sector, especially ethanol and biodiesel. Favorable climatic and territorial conditions contribute to the development of the production chain of these fuels, with positive socioeconomic impacts for the country. In this sense, the replacement of traditional energy sources in the transport sector favors efficiency gains in line with energy security and emission reduction objectives.

Brazil supports the 2050 ICAO Vision for Sustainable Aviation Fuels[1] and understands that the use of SAF is the single most important solution to achieve ICAO´s emissions reduction goals in the long term.

1 The ICAO Council endorsed the Declaration of the second ICAO Conference on Aviation Alternative Fuels (CAAF/2), including the 2050 ICAO Vision for Sustainable Aviation Fuels as a living inspirational path and called on States, industry and other stakeholders, for a significant proportion of conventional aviation fuels (CAF) to be substituted with sustainable aviation fuels (SAF) by 2050.

Market-based measures

In view of the lack of supply of sustainable aviation fuels on a commercial scale in the short term, measures within the sector will not be sufficient to achieve carbon neutral growth from 2020 onwards, as committed by ICAO Member States. Thus, the ICAO Assembly adopted CORSIA as a transitional and complementary solution whilst pursuing all opportunities in the basket of mitigation measures to reduce emissions as necessary.

Brazil has already regulated the first obligations related to monitoring, reporting and verification - MRV of emissions from international operations, through ANAC Resolution No. 496/2018 and Ordinance No. 4005/ASINT/2018. With the entry into force of CORSIA in Brazil, it is estimated that more than 9 million tonnes of CO_2 will be compensated by Brazilian airlines by 2035.

CHAPTER 1

Introduction

Air transport has been a major factor in supporting globalization and the quintessential means of national integration in countries with continental dimensions such as Brazil. Over the past 30 years, the Brazilian civil aviation industry has undergone a gradual process of deregulation that has contributed to the sector's rapid response to the changing socioeconomic profile of the country, allowing more than 80 million users to be included in the modal.

This liberalization movement extends to the main structural aspects of a strong airline industry: free pricing and supply; broad and flexible international agreements; adequate airport infrastructure; and diversification of funding sources for airlines. This regulatory framework has transformed Brazil into one of the most open countries in the world for foreign investment in airlines.

Today Brazil has one of the largest domestic domestic airline industries in the world with more than 93.6 million passengers transported in 2018. Demand projection studies indicate that by 2033 the number of passengers could more than double.[2]. Sector policy is about ensuring that this potential is realized in a socially and environmentally responsible manner.

According to the Nationally Determined Contribution (NDC) presented to the United Nations, Brazil pledged to reduce greenhouse gas emissions by 37% by 2025 and indicated a subsequent 43% reduction by 2030. These are absolute targets, relative to base year 2005, which show the scale of the mitigation challenge ahead: while representing a progression from current actions, it is recognized that emissions will grow to meet development and social needs.

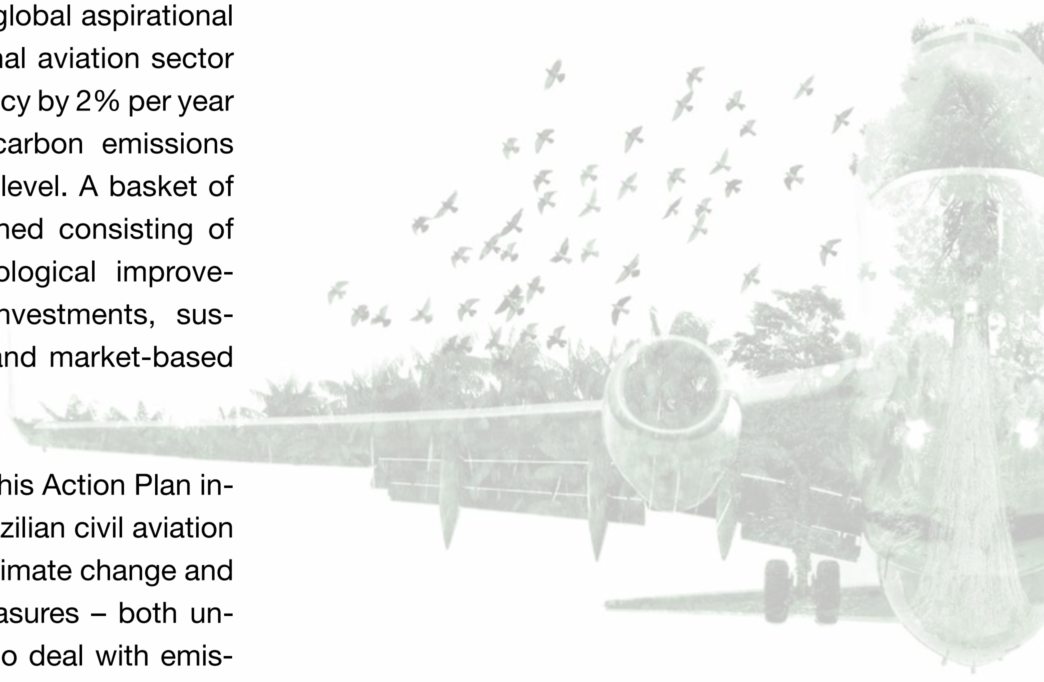
Although not setting specific sectoral targets, the annex to the Brazilian NDC clarifies that it is intended to increase the participation of sustainable bioenergy in the national energy matrix, expanding the consumption of biofuels, including by increasing the share of advanced biofuels (second generation). Specifically in relation to the transport sector, the document highlights

2 Source: National Aviation Plan.

the promotion of efficiency measures, improvements in transport infrastructure and public transport in urban areas.

While domestic aviation emissions are dealt with under the Paris Agreement, the contribution of international aviation to climate change is the responsibility of the International Civil Aviation Organization (ICAO). Thus, in 2010, the 37th ICAO Assembly adopted the global aspirational goals for the international aviation sector of improving fuel efficiency by 2% per year and keeping the net carbon emissions from 2020 at the same level. A basket of measures was established consisting of operational and technological improvements, infrastructure investments, sustainable aviation fuels and market-based measures.

It is in this context that this Action Plan intends to present the Brazilian civil aviation industry, its impact on climate change and the main mitigation measures – both underway and planned – to deal with emissions.



CHAPTER 2

Brazilian civil aviation

Overview of the Brazilian airline industry

The Brazilian Aeronautical Code (Law 7,565, of December 19, 1986) is the main legislation regarding civil aviation in Brazil. Currently, there are several proposals to reform the Code in Congress – both at the Senate and at the House of Representatives –, due to a clear perception that some of its rules hamper the development of civil aviation in Brazil and must be altered, especially when one takes into consideration the fact that it is over three-decades old.

Nevertheless, several advancements were achieved in the past decades in a sense of promoting a liberalization of air transport in Brazil. A set of rules established in 1975 that divided the country in regions that could be explored by only one airline each was abolished in 1991, allowing new airlines to enter the regional air transport market. Ten years later, in 2001, a free price system was introduced, thus removing government rights to establish airfares on the domestic market. In 2008, such policy was extended to flights between Brazil and other countries in South America, and later to the rest of the world.

The establishment of the civilian-led Agência Nacional de Aviação Civil (ANAC, "National Civil Aviation Agency"), in 2006 as the civil aviation authority was a landmark for air transport in Brazil, taking over the role previously exercised by the military-led Departamento de Aviação Civil (DAC, "Department of Civil Aviation"), which was under control of the Ministry of Defense.

In 2011, the creation of the Secretaria de Aviação Civil da Presidência da República (SAC/PR, "Civil Aviation Secretariat of the Presidency of the Republic") as a ministry meant that control over civil aviation in Brazil was to be exercised exclusively by civilian-led institutions – a characteristic that remains to these days, as SAC became part of the Ministry of Infrastructure. The current regulatory framework pertaining civil aviation in Brazil has the Ministry of Infrastructure in charge of the public policies while ANAC regulates and oversees the industry.

The airport concessions programme that has transferred the operation of airports from the Empresa Brasileira de Infraestrutura Aeroportuária (INFRAERO) to the private sector has been equally important for the development of air transport in Brazil in this decade.

In 2011, the concession of the São Gonçalo do Amarante International Airport, near Natal/RN, marked the beginning of a process that has seen 10 (ten) other airports now privately-managed and 12 (twelve) already auctioned and expected to be transferred to private companies in the coming months. This has led to an increase in competition between airports and in quality of service, with major gains for passengers: more comfort, fewer delays, more efficiency and more retail options in airports.

In 2019, Brazil became one of the largest countries to allow airlines to be fully owned and run by foreign nationals, with absolutely no differences in regulation when compared to airlines owned by Brazilian nationals. The Brazilian airline industry is open to investors who perceive its potential, regardless of nationality.

As can be seen, Brazil abandoned a paradigm in which the State strongly regulated the activity of private agents in air transport and acted directly in the provision of air services. In its place, it has adopted a model in which the State is responsible for regulating and overseeing essential aspects, such as operational safety, without interfering in issues such as capacity, prices, and routes.

Air transport data in Brazil

Brazil has 578 public aerodromes[3] as of August 2019, ranging from simple airstrips to major airports. Under federal law, a "public aerodrome" is open to air traffic on a commercial basis. This differs from the concept of "private aerodromes", where commercial exploitation is prohibited. Accordingly, airports included in the Brazilian airport concessions programme are considered public aerodromes.

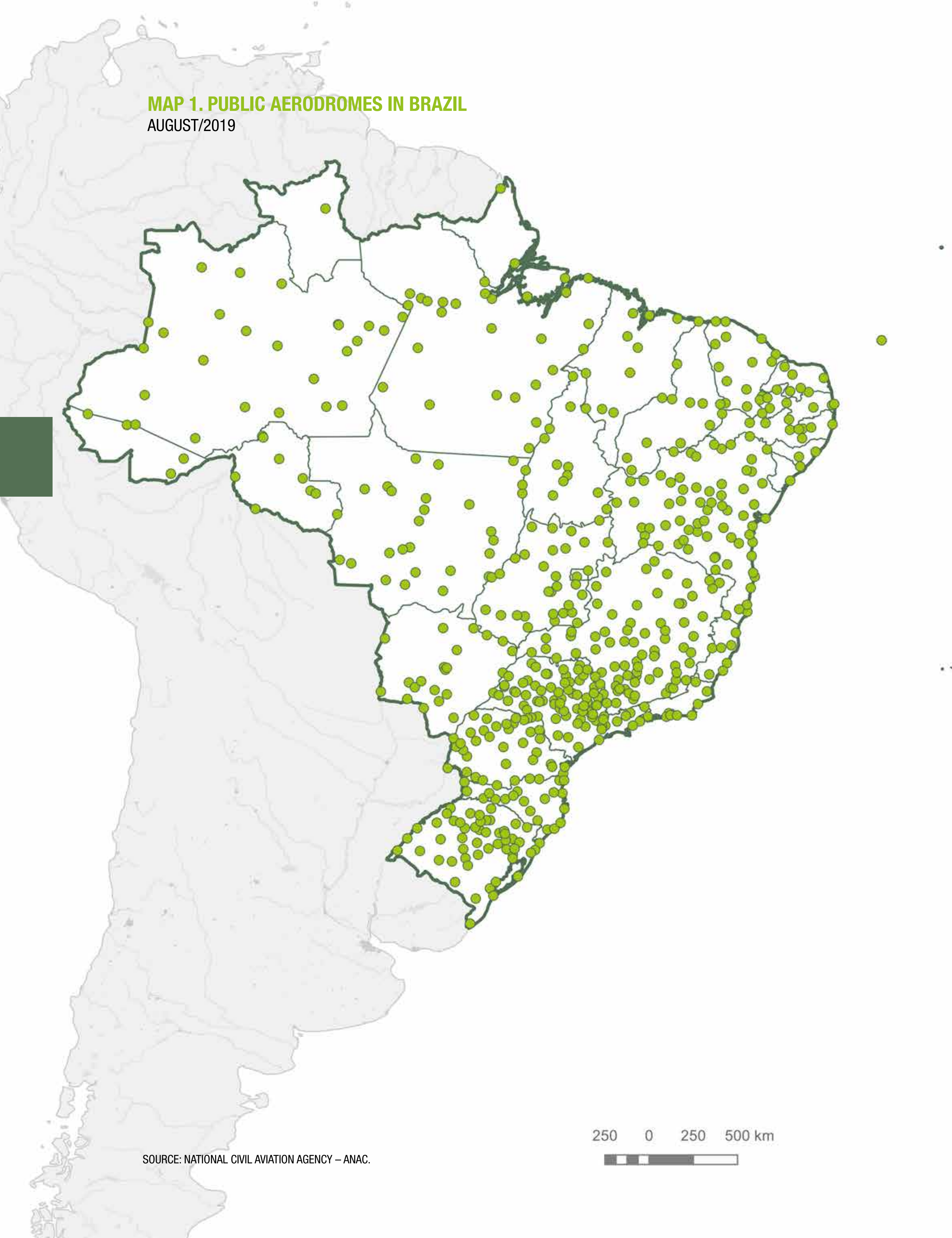
TABLE 1. AERODROMES PER REGION - AUGUST, 2019

Region	Number of aerodromes	Percentage
Southeast	171	29.6%
Northeast	134	23.2%
South	112	19.4%
North	81	14.0%
Central-West	80	13.8%
TOTAL	**578**	**100%**

SOURCE: NATIONAL CIVIL AVIATION AGENCY – ANAC.

3 Source: National Civil Aviation Agency – ANAC.

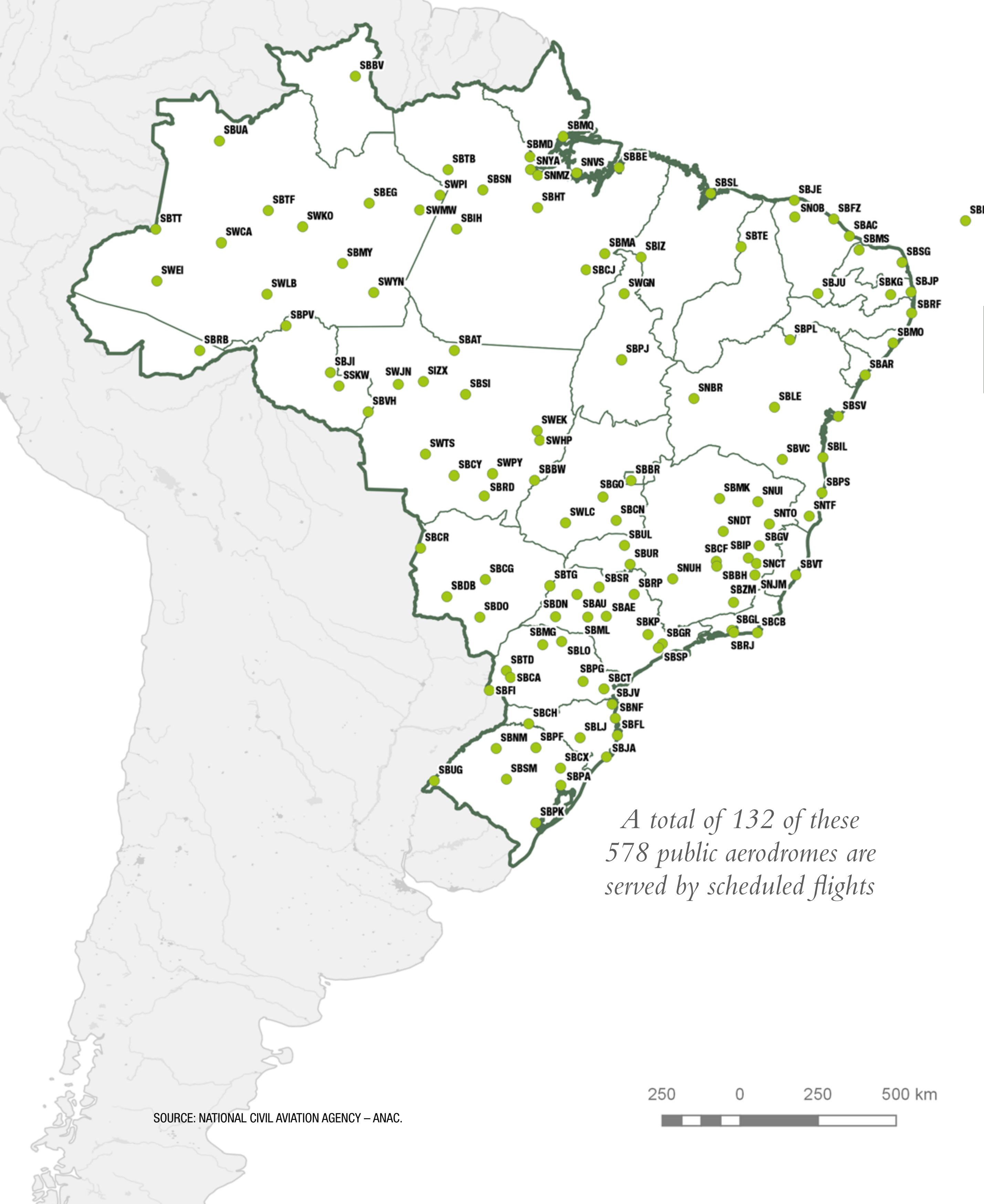
MAP 1. PUBLIC AERODROMES IN BRAZIL
AUGUST/2019



SOURCE: NATIONAL CIVIL AVIATION AGENCY – ANAC.

MAP 2. PUBLIC AERODROMES SERVED BY SCHEDULED FLIGHTS IN BRAZIL

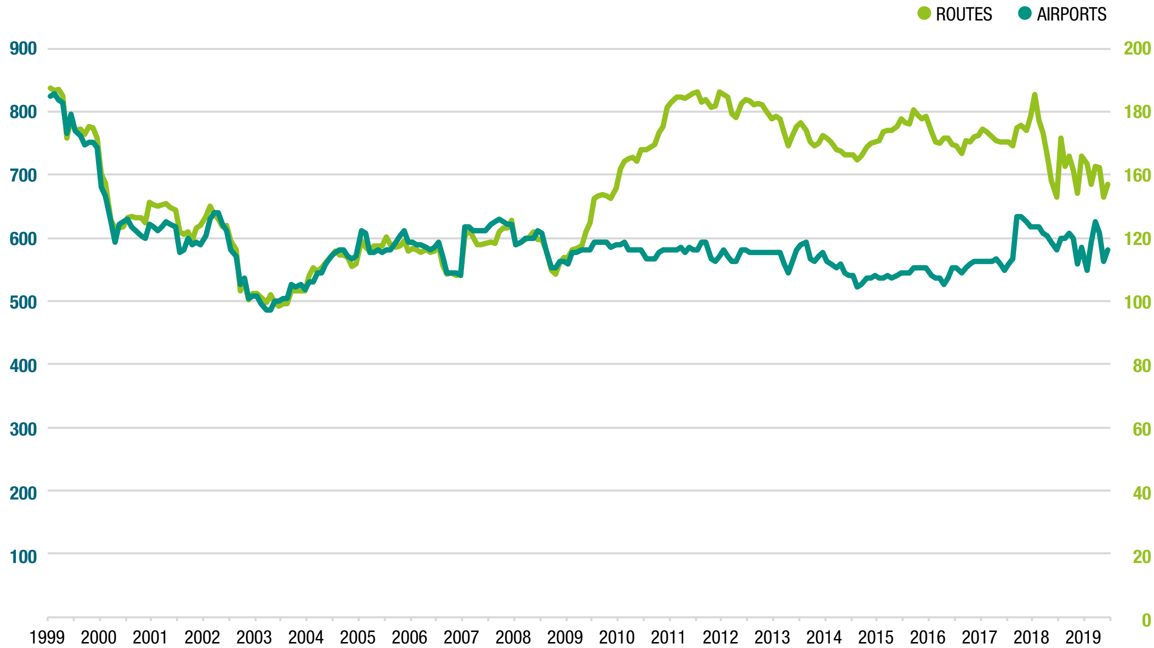
AUGUST/2019



A total of 132 of these 578 public aerodromes are served by scheduled flights

SOURCE: NATIONAL CIVIL AVIATION AGENCY – ANAC.

GRAPH 1. NUMBER OF AIRPORTS AND ROUTES SERVED BY SCHEDULED PASSENGER FLIGHTS – JANUARY/1999 TO JUNE/2019



SOURCE: NATIONAL CIVIL AVIATION AGENCY – ANAC.

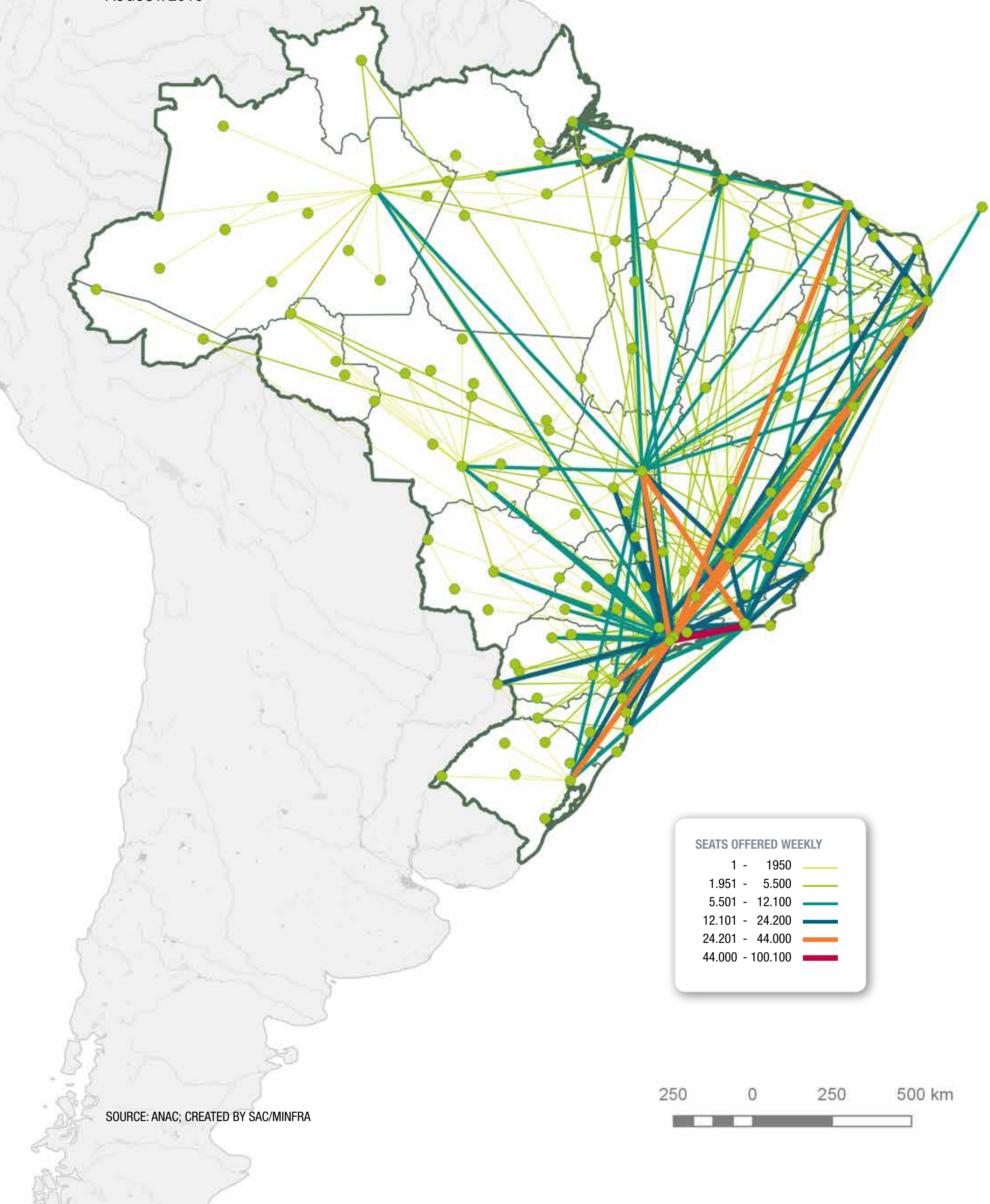
Graph 1 shows the number of airports and routes with scheduled domestic flights from January 1999 to June 2019. There is a sharp drop in the number of airports with scheduled flights from 1999 to 2003. From 2009, a relevant phenomenon in the dynamics of air transport can be observed: a growing number of routes, despite a relatively stable number of airports served by regular flights. This meant an increase in the availability of direct, domestic flights.

In January 1999 there were 182 airports served by scheduled, domestic flights in Brazil, contemplating a total of 837 domestic routes[4]. In March 2003 these numbers were reduced to 108 airports and 498 routes. From the end of 2008 to 2011, however, there was a tendency of increase on the number of routes served by scheduled flights, especially due to the growth of *Trip Linhas Aéreas* and *Azul Linhas Aéreas*.

4 It was considered in the calculation of the number of routes that the route from airport A to airport B is a route, whereas the route from airport B to airport A is a separate route (this is important because some routes do not have return flights through the same airport).

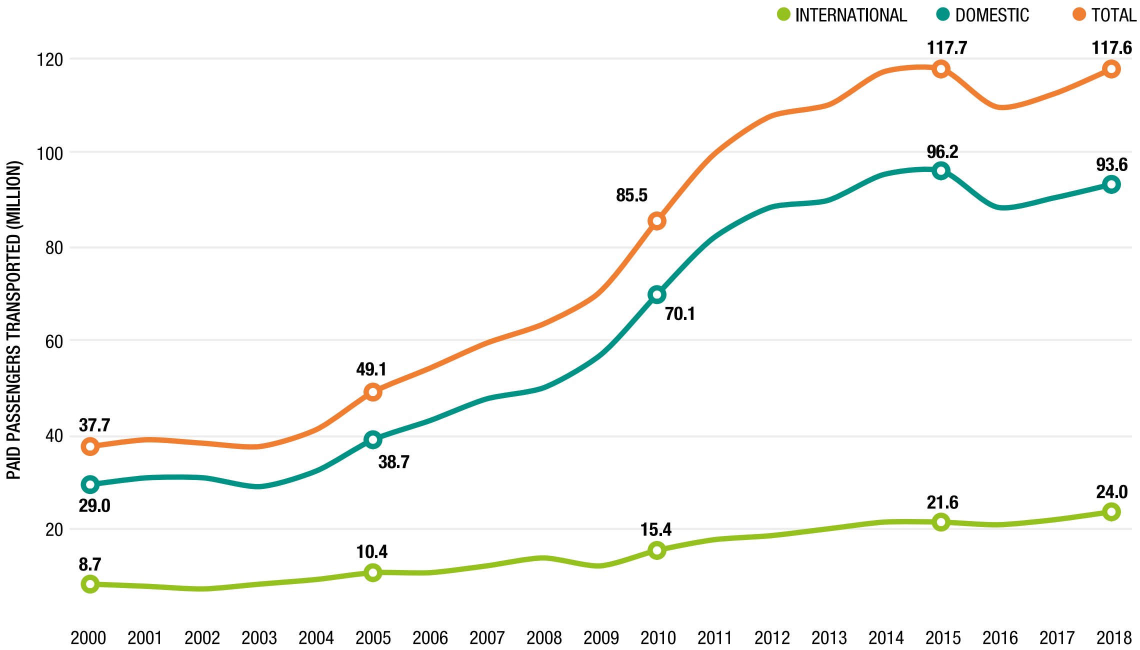
MAP 3. NUMBER OF SEATS OFFERED WEEKLY ON DOMESTIC FLIGHTS BETWEEN PAIRS OF AIRPORTS IN BRAZIL

AUGUST/2019



SOURCE: ANAC; CREATED BY SAC/MINFRA

GRAPH 2. NUMBER OF PAID PASSENGERS TRANSPORTED - DOMESTIC AND INTERNATIONAL MARKETS, FROM 2000 TO 2018 (IN MILLIONS).



SOURCE: NATIONAL CIVIL AVATION AGENCY – ANAC.

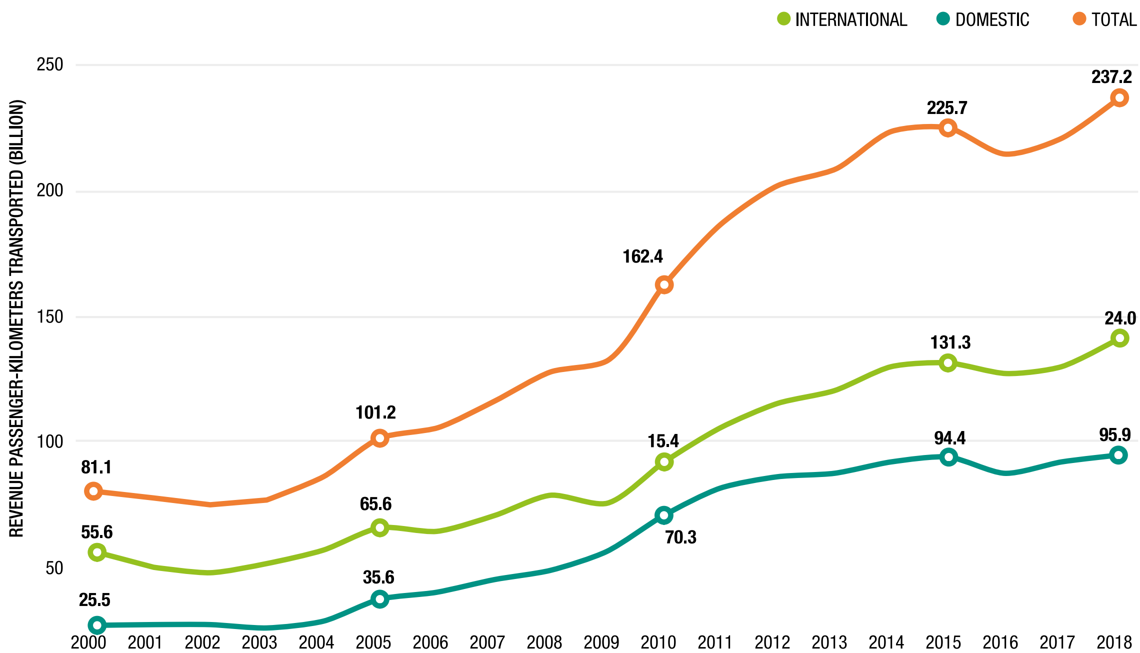
Map 3 shows the number of seats offered by airlines in domestic flights per week. The "*Ponte Aérea*" between São Paulo/ Congonhas airport and Rio de Janeiro/ Santos Dumont airport is Brazil's busiest passenger air route, with over 100,000 seats per week.

Domestic flights are concentrated along the South-Southeast, Southeast-North-east, and Southeast-Central West axes. This is essentially due to the urbanization process that led to higher population density in the coastal areas of the country. Brasília, the country's capital located in the Central West region, serves as the major hub connecting flights from the North region to the rest of Brazil.

The liberalization of air transport in Brazil over the last three decades, coupled with greater economic stability since the implementation of the "Plano Real" in 1994, has resulted in a significant increase in the number of passengers carried by airlines. The number of airline passengers in interstate flights in Brazil currently exceeds those transported by bus in interstate travel.

From 2000 to 2018, the number of paid passengers carried by Brazilian airlines on domestic flights increased from 29.0 million to 93.6 million - an increase of 222.8% in the period. From 2003 to 2014 there was a strong growth in demand for air transport, reaching 259.2% in the accumulated period. From 2004 to 2006 and from 2009

GRAPH 3. NUMBER OF REVENUE PASSENGER-KILOMETERS TRANSPORTED - DOMESTIC AND INTERNATIONAL MARKETS, FROM 2000 TO 2018 (IN BILLIONS).



SOURCE: NATIONAL CIVIL AVATION AGENCY – ANAC.

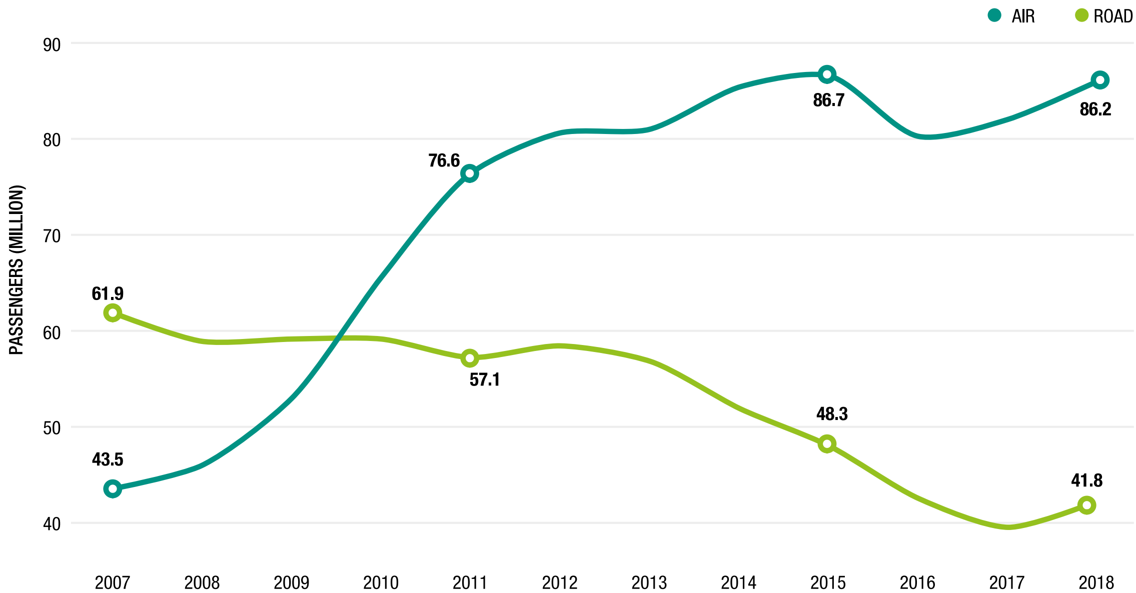
to 2011, growth was always double digits in relation to the previous year - in 2010 it was 22.8% compared to 2009; in 2005, 20.7% over 2004. From 2012 to 2018, however, the pace of growth slowed. The worsening economic crisis in the country during 2016 resulted in a 7.8% drop in the number of domestic passengers compared to 2015, reaching 88.7 million in 2016. However, 2017 showed a recovery of this indicator, with growth of 2.2% and a total of 90.6 million passengers in the domestic market.

The number of passengers on international flights bound to or from Brazil grew 169.1% from 2000 to 2018, increasing from 8.7 million to 24.0 million. When added to the number of passengers on domestic flights, it amounts to a total of 117.6 million passengers in 2018 – a 211.9% increase when compared to the 37.7 million passengers in 2000.

Graph 2 shows the number of paid passengers carried on the domestic and international markets from 2000 to 2018 in Brazil.

The number of passengers carried does not consider the stage distance of each flight. This variable is of fundamental importance for a better measurement of air transport demand. That is why the airline industry frequently uses a metric that shows the number of kilometers (or miles)

GRAPH 4. EVOLUTION OF THE NUMBER OF INTERSTATE LONG-DISTANCE PASSENGERS TRANSPORTED BY AIR AND ROAD, 2007 TO 2018.



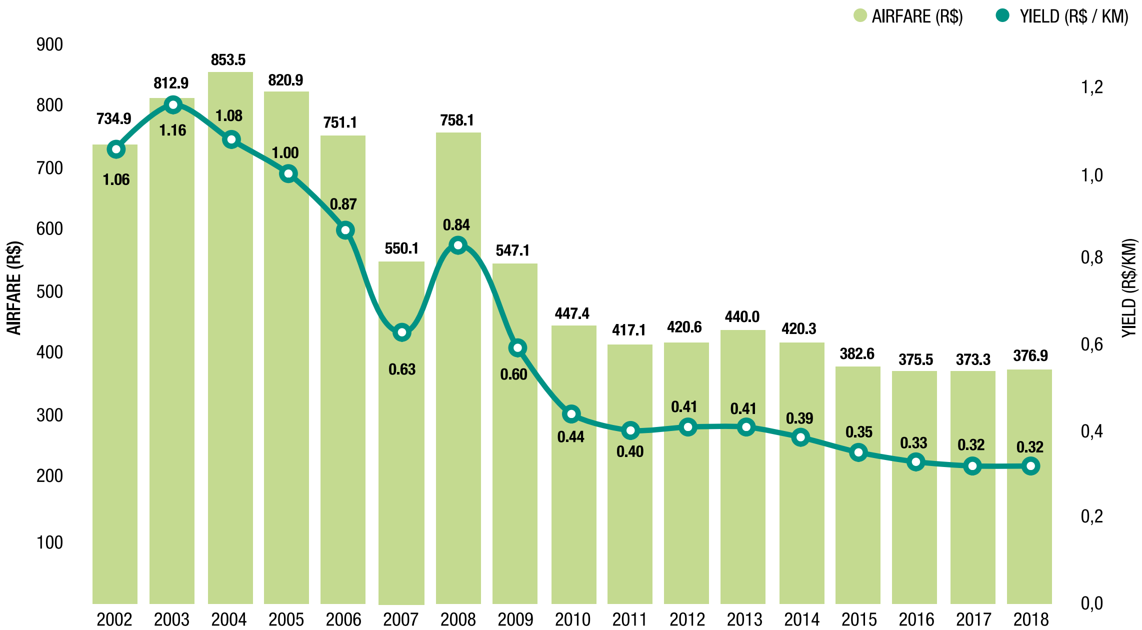
SOURCE: NATIONAL CIVIL AVIATION AGENCY – ANAC.

traveled by paying passengers: Revenue Passenger Kilometers (RPK), obtained by multiplying the number of paying passengers by the distance traveled. Graph 3 shows the RPK for domestic and international flights (from and bound to Brazil) from 2000 to 2018.

Recent growth in air transport has caused the modal to outperform road transport as the primary means of regular interstate travel. Graph 4 shows the evolution of the number of interstate long-distance passengers transported by air and road, from 2007 to 2018. This was largely due to the increase of air services, reduction in the price of airline tickets and improvements in airport infrastructure. It is also important to note that the speed and safety provided by air transport are a fundamental aspect in comparison with road transport in Brazil.

One of the main factors that led to the growth in the number of air passengers was the liberalization of airfares in 2001 - since then there has been a downward trend in prices. Graph 5 shows the average airfare for domestic flights in inflation-adjusted figures for the period from 2002 to 2018. The average yield for domestic flights is also presented. In 2002, the average price of airline tickets in Brazil was equivalent to R$ 734.89 in current values. In 2018, this amount was R$ 376.93 - a reduction of 48.7% in relation to 2002.

GRAPH 5. AVERAGE AIRFARE (R$) AND YIELD - AVERAGE DOMESTIC AIRFARE (R$/KM), IN INFLATION-ADJUSTED PRICES - 2002 TO 2018.



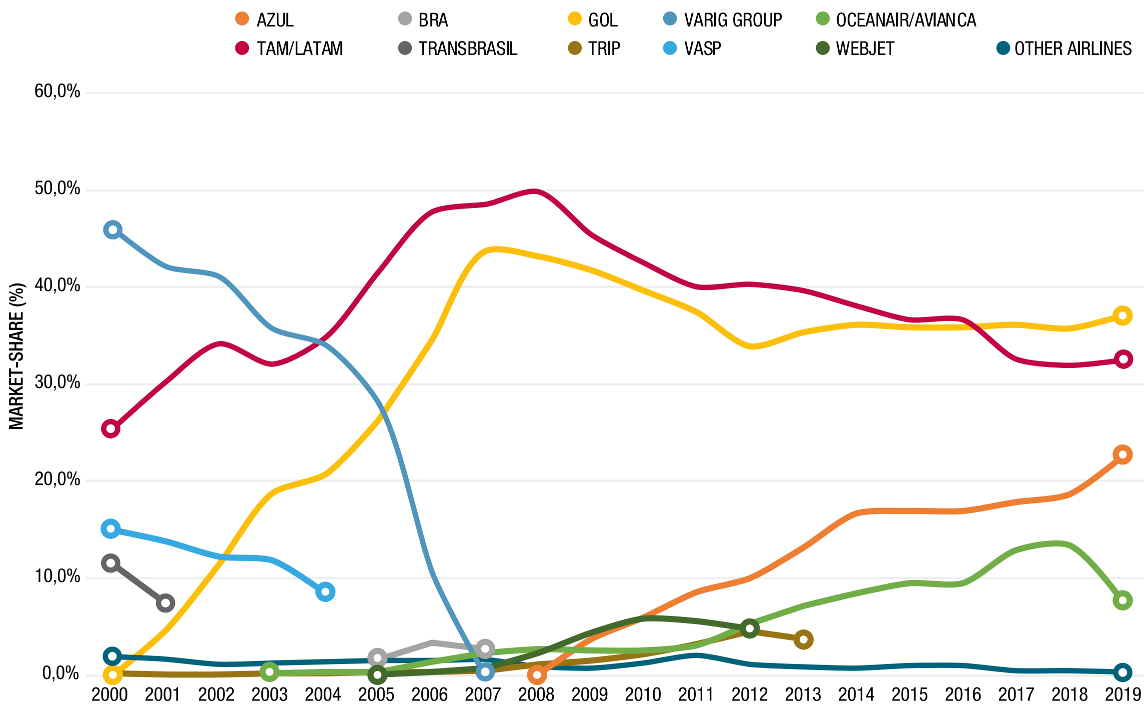
SOURCE: NATIONAL CIVIL AVIATION AGENCY – ANAC.

The reduction in the price of airline tickets has greatly contributed to the inclusion of segments of the Brazilian society that previously resorted to road transport in their medium and long distance travels. As highlighted by ANAC in the report "Domestic Airfares", 3rd edition, referring to the 4th quarter of 2014, *"fare freedom and freedom of supply are important pillars of competition in public air transport services in Brazil. Unlike in the past, the State no longer sets minimum or maximum prices for services or restricts supply. The scenario of free competition attracts investments to the sector and stimulates market growth, the expansion of supply, diversification of services and also price reductions. As a result, more people have access to public air services".*

Corroborating the position expressed by ANAC, it should be noted that the National Civil Aviation Policy (PNAC), approved by Decree No. 6,780 of February 18, 2009, establishes "guidelines that give the market the role of balancing supply and demand, while tariff freedom prevails in air transport services".

In this sense, the development of air transport into a competitive system - which includes among its main aspects tariff freedom - enables greater economic efficiency, higher quality levels and lower prices, contributing to the access of more people to air transport and providing greater social welfare.

GRAPH 6. DOMESTIC MARKET-SHARE BY AIRLINE – 2005-JUNE/2019



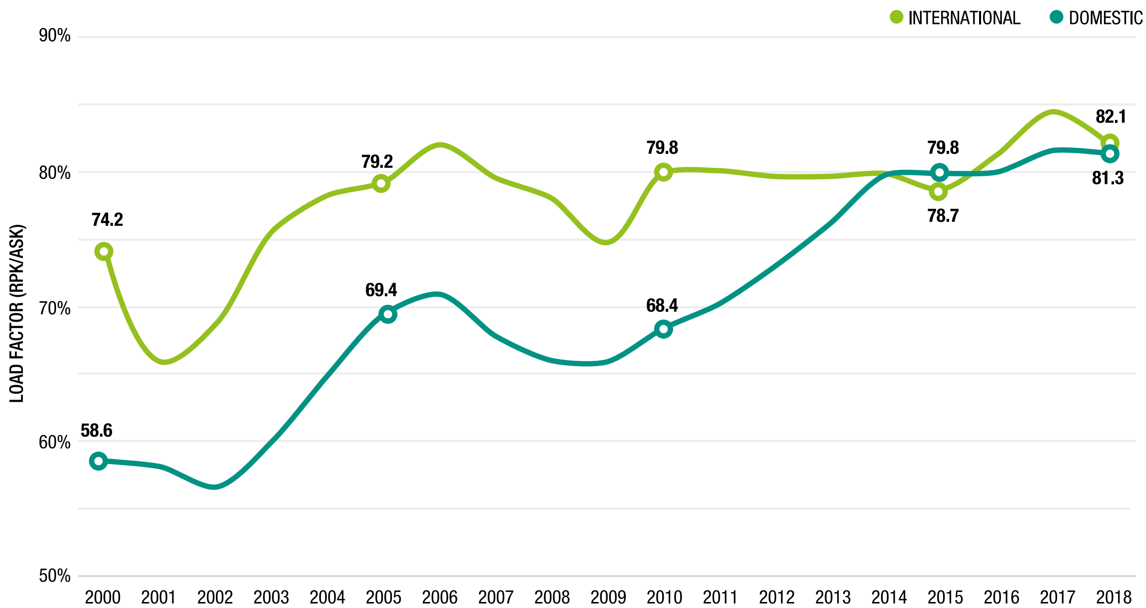
SOURCE: ANAC. CREATED BY SAC/MINFRA.

Graph 6 presents the market share by airline in the domestic passenger air transport market between 2000 and 2019. LATAM (formerly TAM) lost its leadership in the domestic market to GOL in 2017, which currently has a 37.0% market share against 32.4% of its competitor in the first semester of 2019. Azul Linhas Aéreas, launched in December 2008, currently has a 22.5% share of the domestic market.

Avianca launched as OceanAir in 1998, a company initially focused on regional air transport. In 2018 it had a 13.4% share of the domestic market. At the end of 2018, the airline filed for bankruptcy and has ceased to operate in 2019.

Other airlines such as Trip (acquired by Azul in 2012), Webjet (acquired by Gol in 2012) and BRA (whose operations were ceased in 2007) were responsible for a small, but important market share. They have all ceased to operate, as well as airlines such as Varig (which ceased operating in 2006), Pantanal (acquired by TAM), Air Minas, Sol, NHT/Brava, Noar, Mega, Meta, Puma Air, Cruiser, Sete and Team.

GRAPH 7. EVOLUTION OF LOAD FACTOR IN TERMS OF RPK/ASK - DOMESTIC AND INTERNATIONAL MARKETS, 2000 TO 2018.



SOURCE: ANAC.

Graph 7 shows the evolution of aircraft use or load factor[5] in terms of RPK by ASK in the domestic and international markets in Brazil from 2002 to 2017. In 2018, load factor in domestic flights averaged 81.3%, compared to 58.6% in 2000. In international flights, the growth in the aircraft utilization rate was proportionally lower, but in 2017 it also had its best year in the historical series: 84.4%, in contrast to 68.8% in 2002. This indicates an effort by airlines to use their capacity more efficiently through yield management.

5 The utilization rate is the ratio between air transport demand and supply. It is obtained by dividing the Passenger Kilometer Paid Transported (or Tonne Kilometer Used Paid) by the Seat Kilometer Offered (or Tonne Kilometer Offered). This index is known internationally as Load Factor.

CHAPTER 3

Inventory

This section presents both historical data and projections concerning fuel consumption, CO_2 emissions, fuel consumption / RTK ratio[6], mitigation measures, and Emission Intensity (IE)[7]. The separation between domestic and international flights is made taking into consideration only the state from which the flight stage departed and the state where the immediate subsequent landing took place. In this way, stages in which the aircraft takes off and lands in the same country are considered here as domestic flights, even if the complete flight originates and ends in different countries.

All the information presented in this document was obtained through three sources: the National Aviation Plan (PAN), prepared within the scope of the National Civil Aviation Secretariat (SAC), in partnership with the Federal University of Santa Catarina (UFSC); data provided by the air sector actors involved in the preparation of this Action Plan; and the Air Transport Statistical Database - historical series of Brazilian air transport statistical data regulated by ANAC Resolution No. 191/2011, from which the consolidated RTK and fuel consumption data presented in this document for the years 2000 to 2018 were collected. This database includes operations under RBAC 121[8] and 135[9], excluding air taxi operations. These Statistical Data are provided monthly to ANAC, by the 10th day of the following month after the reference month, by Brazilian and foreign airlines operating scheduled and non-scheduled public air transportation services in Brazil. However, only flights to or from Brazil performed by Brazilian companies are within the scope of this inventory.

In this sense, this document differs from the last edition of the Action Plan, which considered ANAC's National Inventory of Air Emissions as a source for fuel con-

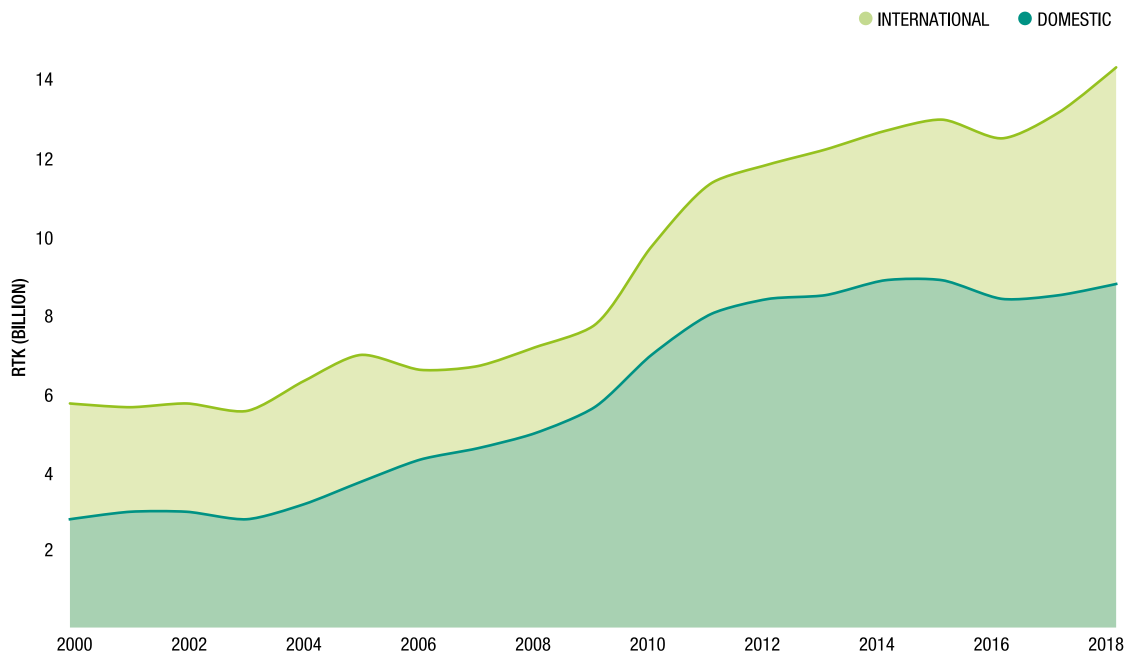
6 Revenue Tonne Kilometers (i.e. Ton Kilometer Paid). Refers to the sum of the product among the paid loaded kilograms. In Brazil, the average of 75 kilos is adopted for each passenger carried, including hand luggage.

7 Ratio: CO_2/RTK emission.

8 National Civil Aviation Agency - ANAC. Brazilian Civil Aviation Regulation – RBAC No. 121, Amendment No. 05. OPERATING REQUIREMENTS: DOMESTIC, FLAG AND ADDITIONAL OPERATIONS.

9 National Civil Aviation Agency - ANAC. Brazilian Civil Aviation Regulation – RBAC No. 135, Amendment No. 04. OPERATING REQUIREMENTS: ADDITIONAL AND DEMAND OPERATIONS.

GRAPH 8. RTK EVOLUTION OF BRAZILIAN AIRLINES, DOMESTIC AND INTERNATIONAL FLIGHTS, FROM 2000 TO 2018.



SOURCE: ANAC.

sumption and included foreign companies operating in Brazil. Any discrepancies in the results from the previous edition are due to this methodological change.

Historical data

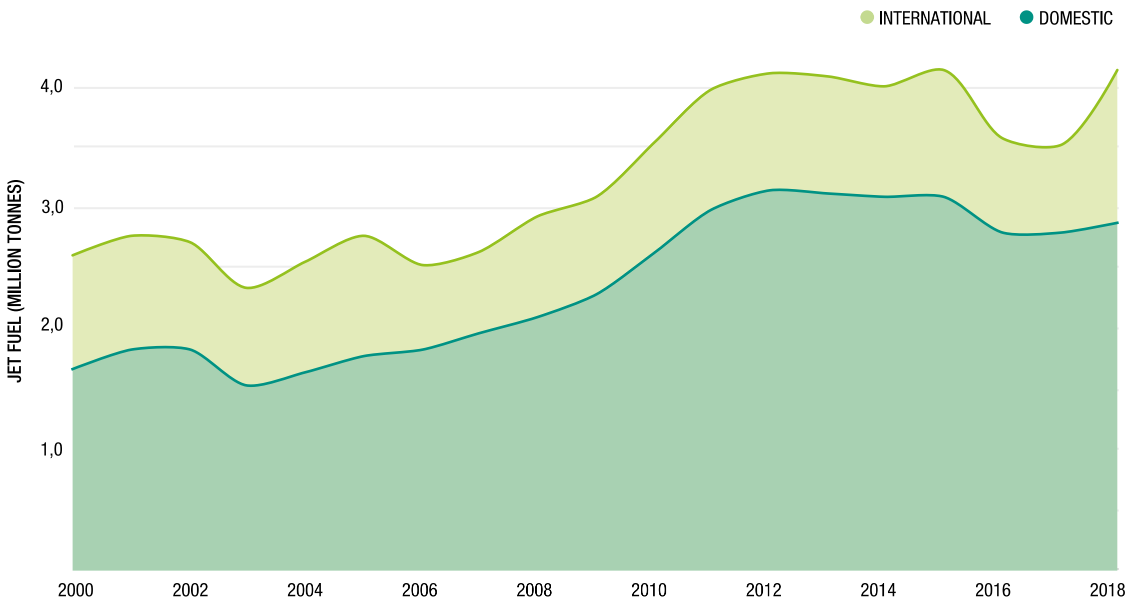
This chapter's graphs show the developments in RTK and fuel consumption from 2000 to 2018, according to the scope outlined above. Graph 8 shows the fluctuations of the Brazilian aviation market both domestically and internationally, through the evolution of RTK. The variation in the use of aviation kerosene can be seen in Graph 9.

From 2000 to 2018, average annual growth of RTK for domestic and international flights was 6.25% and 3.45%, respectively. Considering all flights, the average annual rate was 4.98%, corresponding to an accumulated increase of 151.64% in the period.

Fuel consumption grew at an average annual rate of 2.90% for domestic flights and 1.74% for international flights. This corresponds to an average growth of 2.5% per year and 59.95% in the accumulated period.

It is interesting to note the considerable reduction in consumption soon after the record value of the historical series occurred

GRAPH 9. EVOLUTION OF AVIATION KEROSENE CONSUMPTION BY BRAZILIAN AIRLINES, DOMESTIC AND INTERNATIONAL FLIGHTS, FROM 2000 TO 2018.



SOURCE: ANAC.

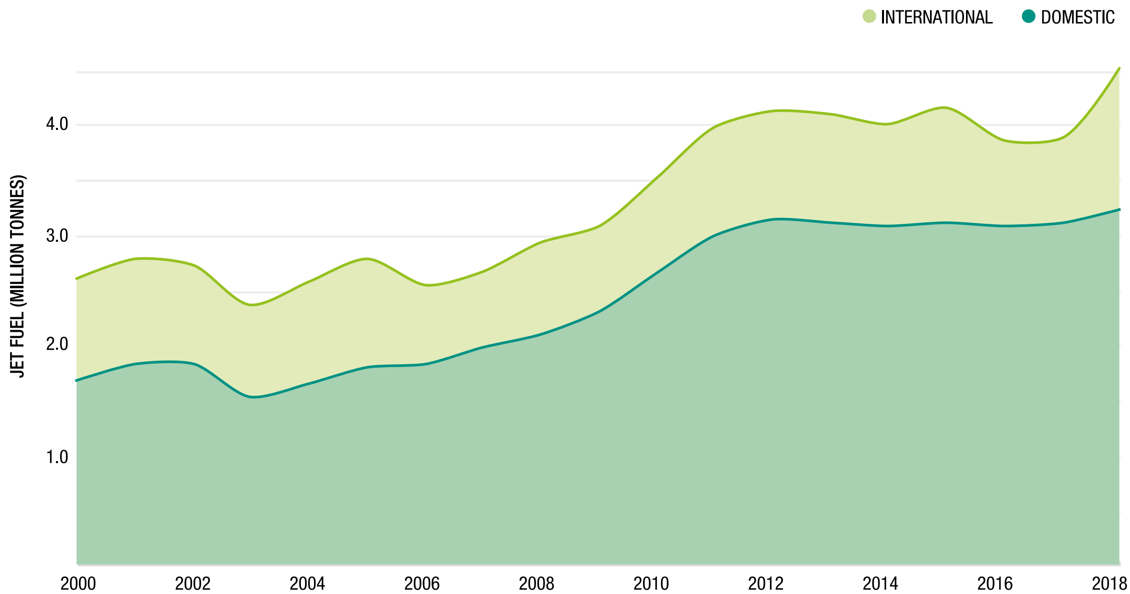
in 2015. That year's levels would not be recovered until 2018. Part of this reduction in consumption is due to the economic crisis that has hit Brazil, leading to a contraction of the air transport industry. In addition, another factor that may have contributed to the decrease in fuel consumption in the period would be a possible inconsistency in the data regarding aviation kerosene consumption on international flights from 2016 to 2018.[10]. Therefore, a failure in the integrity of these data could be the likely cause for the drastic reduction experienced by aviation kerosene consumption on international flights from 2016 to 2018.

In order to account for the efforts to reduce CO_2 emissions for the years elapsed since the last edition of the Action Plan (2016, 2017 and 2018), information was gathered regarding the mitigation measures carried out in the period by the main Brazilian airlines[11] and by the Department of Airspace Control - DECEA, the organization responsible for air traffic control in Brazil. Airlines reported the total amount of fuel saved annually due to the mitigation measures employed. DECEA provided data on the operational procedures adopted, including

10 It is important to note that, until the consolidation of this document, the decrease in LATAM's fuel consumption on international flights from April 2016 to January 2018 was under analysis by ANAC. This information coincides with a sharp drop in consumption for international flights.

11 Avianca, Azul, Gol and Latam.

GRAPH 10: EVOLUTION OF AVIATION KEROSENE CONSUMPTION BY BRAZILIAN AIRLINES (SCENARIO WITHOUT ADOPTION OF MITIGATION MEASURES FOR THE YEARS 2016 TO 2018), DOMESTIC AND INTERNATIONAL FLIGHTS, FROM 2000 TO 2018.



SOURCE: ANAC.

the airports where the measures were implemented and the fuel economy factor of each measure. This information was used to calculate the annual savings generated by the flights that are part of the scope of this Plan.

In possession of that data, the amount of fuel saved was added with the adoption of the measures to that which was effectively consumed, obtaining how much would be consumed whether the measures had not been employed, thus generating the historical baseline of aviation kerosene consumption shown in Graph 10.

The measures implemented from 2016 to 2018 resulted in 4.53% fuel savings due to measures adopted by airlines, and 4.63% fuel savings due to DECEA's operational improvements, corresponding to more than 1,100,000 tonnes of aviation kerosene saved in this period.

The results were estimated according to the methodology proposed by ICAO Document 9988 - Guidance on the Development of States Action Plans on CO_2 Emissions Reduction Activities. Airlines estimated their results based on historical data on operations and energy efficiency.

Projection of fuel consumption growth

The methodology described in ICAO's DOC 9988 was used to predict fuel consumption growth. This methodology is based on a previous estimate of RTK and "fuel efficiency" (a concept established by the DOC and which represents the fuel consumption/RTK ratio) for the next few years.

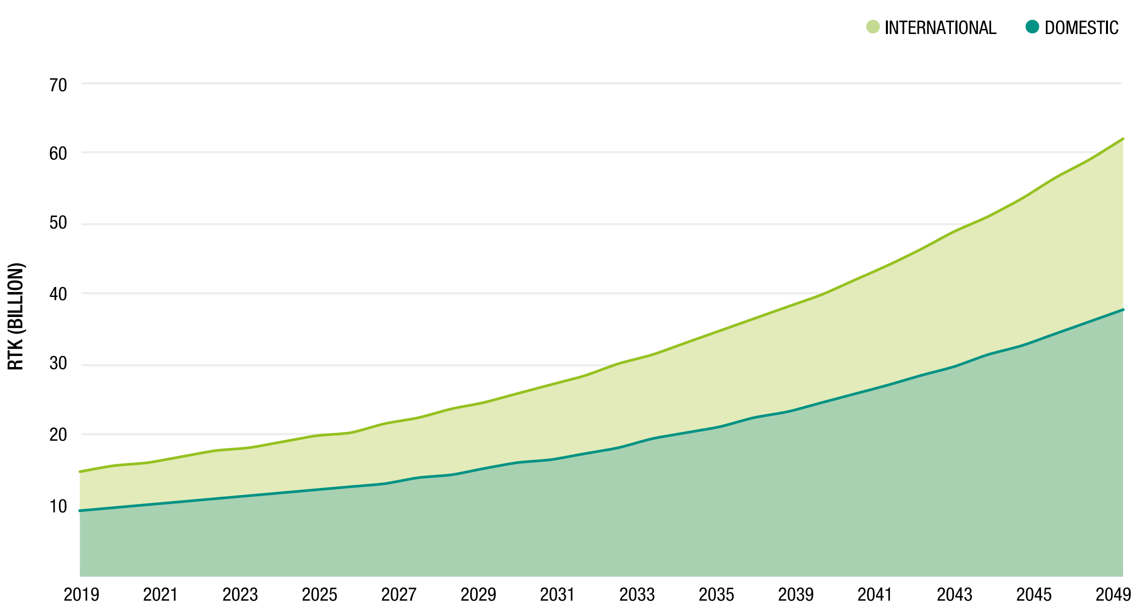
RTK Forecast

The RTK projection curve, shown in Graph 11, was based on the PAN forecast, a study conducted by SAC in partnership with the University of Santa Catarina State (UFSC) that presents growth rates for Brazilian aviation until 2048 for the number of passengers, and until 2037 for tonnes of cargo. The growth rate of the last year was extrapolated to subsequent years until 2050, as shown in Table 2. It was considered that the RTK growth would be reasonably reflected by the combination of the weighted growth of demand for passengers and cargo in the last year. Thus, the total growth for each year was calculated as follows:

$$\text{RTK growth} = \text{Passenger growth} \times \%RTK_{passengers} + \text{Cargo growth} \times \%RTK_{cargo}$$

For both scenarios, with and without the adoption of the measures, it was considered that the growth of RTK would be the same (e.g., the employment of the measures would not influence the demand for flights).

GRAPH 11: FORECAST OF RTK GROWTH OF BRAZILIAN AIRLINES, DOMESTIC AND INTERNATIONAL FLIGHTS, FROM 2019 TO 2050.



SOURCE: ANAC.

TABLE 2. FORECAST GROWTH RATE OF THE RTK FOR PASSENGERS, FREIGHT AND TOTAL RTK, FROM 2019 TO 2050.

	RTK growth rate (%)		
Year	Passengers	Cargo	Total
2019	2.75	3.79	2.91
2020	5.05	3.30	4.78
2021	4.92	2.95	4.63
2022	4.51	2.74	4.24
2023	4.41	2.63	4.14
2024	4.33	2.52	4.06
2025	4.25	2.45	3.98
2026	4.18	2.40	3.91
2027	4.12	2.37	3.86
2028	4.89	2.36	4.51
2029	5.34	2.35	4.89
2030	5.37	2.34	4.91
2031	5.38	2.34	4.93
2032	5.39	2.35	4.94
2033	5.40	2.35	4.94
2034	5.40	2.36	4.95
2035	5.41	2.33	4.95
2036	5.41	2.34	4.95
2037	5.41	2.36	4.95
2038	5.41	2.36	4.95
2039	5.41	2.36	4.96
2040	5.42	2.36	4.96
2041	5.42	2.36	4.96
2042	5.42	2.36	4.96
2043	5.42	2.36	4.96
2044	5.43	2.36	4.97
2045	5.43	2.36	4.97
2046	5.43	2.36	4.97
2047	5.43	2.36	4.97
2048	5.44	2.36	4,97
2049	5.44	2.36	4.97
2050	5.44	2.36	4.97

SOURCE: ANAC.

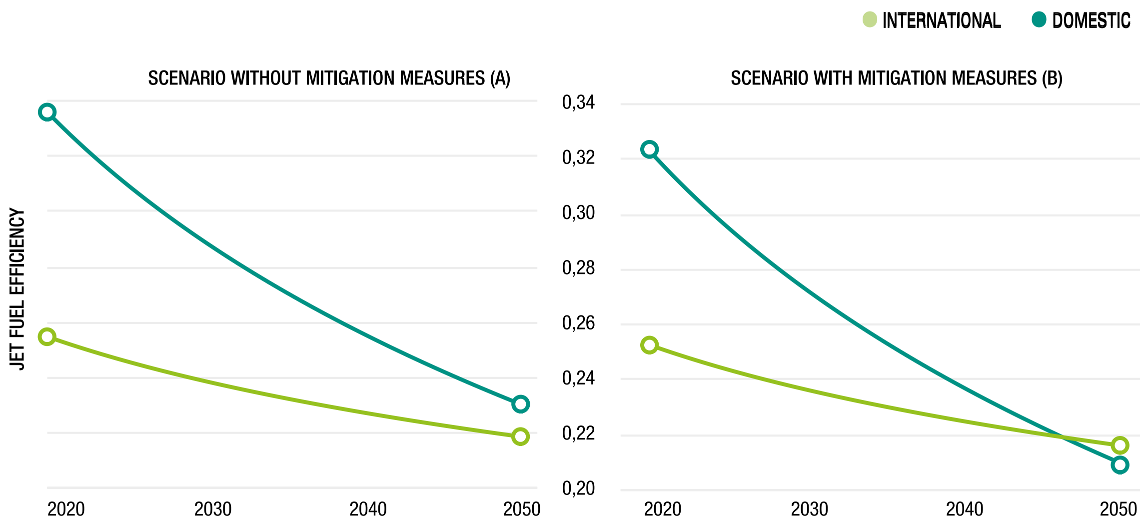
Based on 2018, the projection resulted in an average annual RTK growth of 4.69% or cumulative RTK growth of 332.91% by 2050. Since the PAN data does not allow segregated calculation of RTK growth for domestic or international flights, growth rates for each type of flights are the same as for total RTK.

Fuel Efficiency Forecast

In order to adequately forecast fuel efficiency, several trend lines were adjusted to the historical fuel efficiency data for the period from 2000 to 2018. These curves were then used as a proxy to the evolution of Fuel Efficiency up to 2050. With these projections, the best curve was determined following the criteria adopted by the Environmental Benefits Tool (EBT[12]). Thus, trend lines whose projections resulted in an annual improvement of Fuel Efficiency below 2% for the period from 2000 to 2018 were selected. Finally, the curve with the highest correlation coefficient was chosen among those that met the previous criterion. Thus, Graph 12 shows the extrapolation until 2050 of the logarithmic trend lines, which were those that met all the criteria for the two scenarios, without implementation of mitigation measures (a) and with implementation of mitigation measures (b), both for international, and domestic flights.

12 Environmental Benefits Tool - EBT. Tool developed by ICAO to support Member States in the development of the Action Plan.

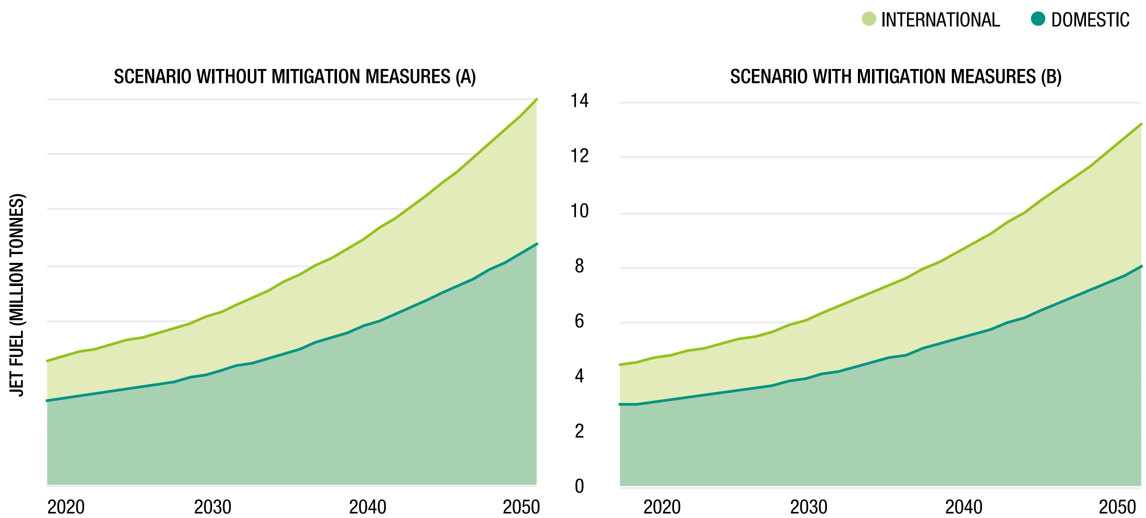
GRAPH 12. FUEL EFFICIENCY PROJECTIONS FOR SCENARIOS WITHOUT THE IMPLEMENTATION OF MITIGATION MEASURES (A), AND WITH THE IMPLEMENTATION OF MITIGATION MEASURES (B) – DOMESTIC AND INTERNATIONAL FLIGHTS, FROM 2019 TO 2050.



SOURCE: ANAC.

Scenario (a) in Graph 12 shows an accumulated improvement in Fuel Efficiency of 36.98% and 10.10% from 2018 to 2050 for domestic and international flights, respectively. Scenario (b) has a slightly lower cumulative improvement of 35.65% for domestic flights and 6.91% for international flights. It is worth noting that efficiency values regarding scenario (b) are lower due to lower fuel consumption by the adoption of measures, while RTK remains unchanged. Scenario (b) also presents an interesting behavior regarding 2046, when it is estimated that domestic flights will surpass international flights. This type of movement consumes, on average, the smallest amount of fuel per kilometer flown. That reflects the methodology applied in this document for the calculation of such measures, which only considers the fuel efficiency actions actually taken in the period from 2016 to 2018 and the future effect of their maintenance. Since operations of the Brazilian airlines for the years aforementioned are characterized by the predominance of domestic aviation, there is a concentration of the effects of mitigation measures on domestic flights. Regarding the curves of the scenario without the adoption of mitigation measures, it is noticed that the Fuel Efficiency trend curve regarding domestic flights has a steeper displacement when compared to the curve for international flights.

GRAPH 13. FUEL CONSUMPTION PROJECTIONS FOR SCENARIOS WITHOUT THE IMPLEMENTATION OF MITIGATION MEASURES (A), AND WITH THE IMPLEMENTATION OF MITIGATION MEASURES (B) – DOMESTIC AND INTERNATIONAL FLIGHTS, FROM 2019 TO 2050.



SOURCE: ANAC.

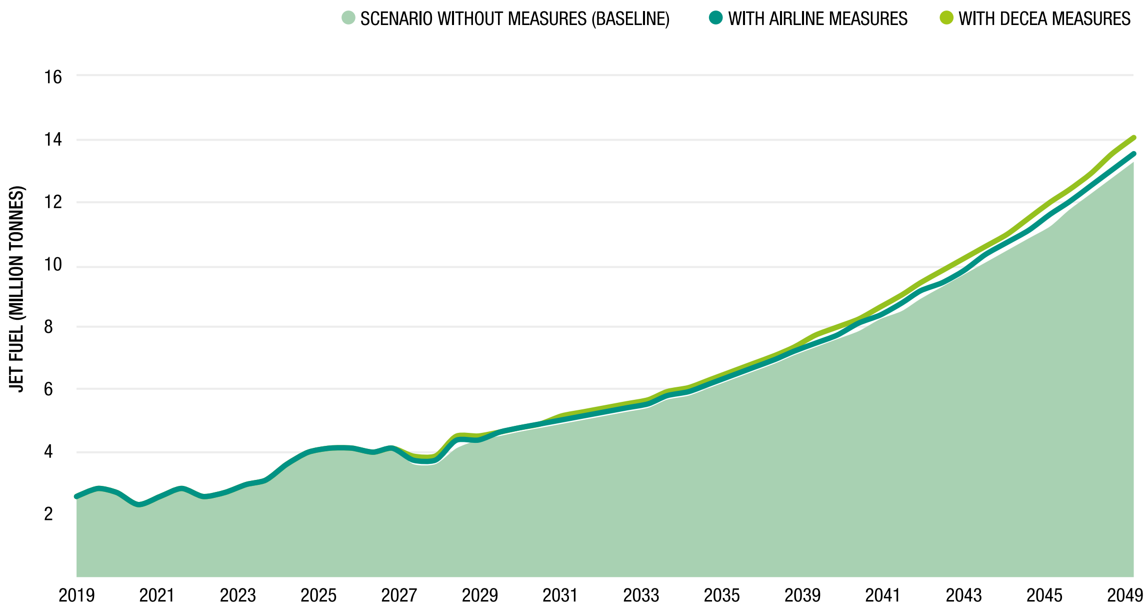
Consumption Forecast

Combining both projections (RTK and Fuel Efficiency), Graph 13 shows fuel consumption projection both for the scenario without mitigation measures (a) and for the scenario with such measures. (B).

The scenario depicted in (a) forecasts a cumulative aviation kerosene consumption growth of 172.84% for domestic flights, and 289.18% for international flights. That forecast results in a total growth of 207.91% from 2018 to 2050. The scenario shown in (b) reflects cumulative growth estimates for the same period of 178.58% and 303.02% for domestic and international flights, respectively. Fuel consumption is projected to rise by 217.54% for scenario (b). Although scenario (b) achieves a lower estimated consumption value by 2050, its growth rates are higher, especially for domestic flights. This is due to the combination of slower evolution of Fuel Efficiency improvement and higher fuel consumption, when considering the effects of mitigation measures, scenario (a), based on 2018 for the calculation of the growth rates.

Graph 14 shows the comparison of fuel consumption for the scenario without the adoption of mitigation measures (base-

GRAPH 14. EVOLUTION OF FUEL CONSUMPTION FOR THE SCENARIO WITHOUT MEASURES (BASELINE) AND THE FUEL ECONOMY GENERATED BY THE MEASURES ADOPTED BY DECEA AND AIRLINES, FROM 2000 TO 2050.



SOURCE: ANAC.

line) and fuel economy when considering measures implemented by DECEA and airlines.

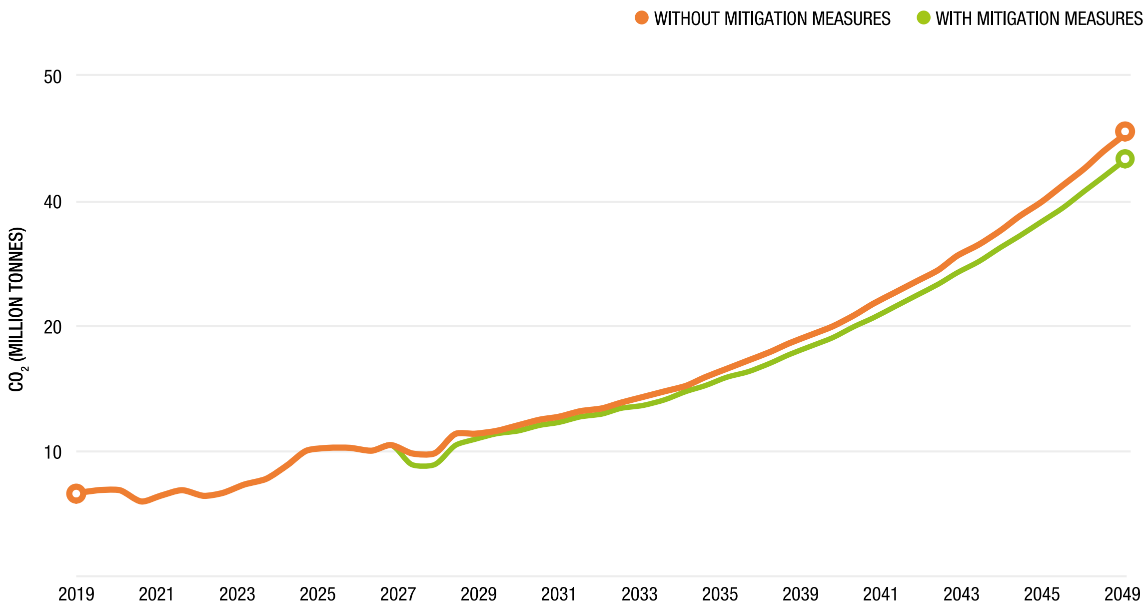
According to the projection, fuel savings by 2050 would be around 6.59% when compared to baseline, with a 3.41% reduction due to measures implemented by airlines, and 3.18% by DECEA. From 2016 to 2050, more than 15 million tonnes of kerosene would be saved. It is noteworthy that these values were calculated based only on RTK growth and energy efficiency projections, without considering the adoption of new measures or expansion of those currently adopted.

Emissions

Once the fuel consumption projections are calculated, the projection of carbon dioxide emissions is obtained through the ratio 1 kg Jet fuel = 3.16 kg CO_2. Graph 15 shows the evolution of CO_2 emissions for scenarios with and without measures by 2050.

By the end of the projected period, ongoing implementation of the measures from 2016 would prevent the emission of more than 47 million tonnes of CO_2, which is more than emissions estimates regarding 2050 alone. The projected reduction in emissions per year would be around 2.9 million tonnes of CO_2, or a 6.59% reduction in emissions.

GRAPH 15. EVOLUTION OF CO2 EMISSIONS CONSIDERING THE SCENARIOS WITHOUT THE ADOPTION OF MITIGATION MEASURES AND THE ADOPTION OF SUCH MEASURES, FROM 2000 TO 2050.



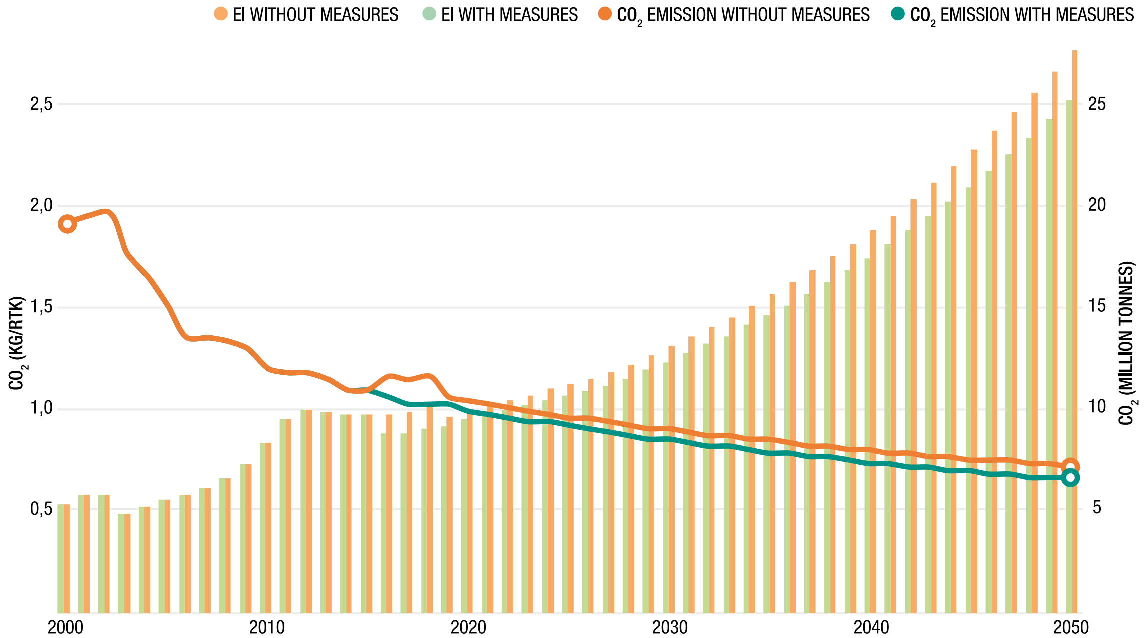
SOURCE: ANAC.

Another relevant concept to consider is Emission Intensity (EI), which represents carbon dioxide emissions by RTK. The comparison between the evolution of CO_2 emissions and Emission Intensity, considering the scenarios with and without the adoption of the measures, is presented in Graph 16, for domestic flights, and Graph 17, for international flights. Both graphs are compatible with the axle scales for easy comparison between domestic and international flights.

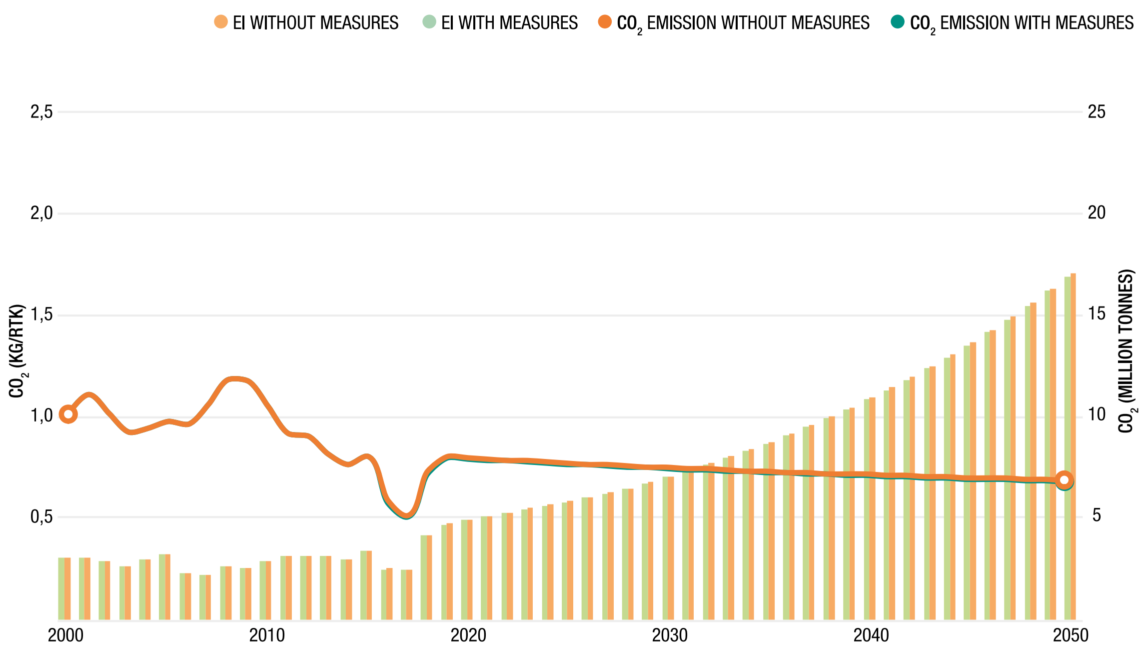
Both CO_2 emissions and Emission Intensity increased in 2016 considering the scenario where mitigation measures are absent. This is due to the methodology adopted in this document, which only considers actions implemented in the years since the last edition of the Action Plan. Thus, even if measures to reduce CO_2 emissions have been implemented before 2016, the effect of these measures were not considered in this Action Plan. If the fuel savings achieved in the years prior to 2016 were added to the total consumption baseline, the result would be expected as a smoother transition from carbon dioxide emissions and emissions intensity from 2015 to 2016.

Graph 16 shows a sharp drop in carbon dioxide emissions and Emission Intensity from 2016 to 2018, the same as occurred for fuel consumption. The reasons for this behavior likely are the same as those pointed out in the fuel consumption analysis.

GRAPH 16. EVOLUTION OF CO_2 EMISSIONS AND EMISSION INTENSITY (EI) FOR DOMESTIC FLIGHTS PERFORMED BY BRAZILIAN AIRLINES – SCENARIOS WITH AND WITHOUT MITIGATION MEASURES, FROM 2000 TO 2050.



GRAPH 17. EVOLUTION OF CO_2 EMISSIONS AND EMISSION INTENSITY (EI) FOR INTERNATIONAL FLIGHTS PERFORMED BY BRAZILIAN AIRLINES – SCENARIOS WITH AND WITHOUT MITIGATION MEASURES, FROM 2000 TO 2050.



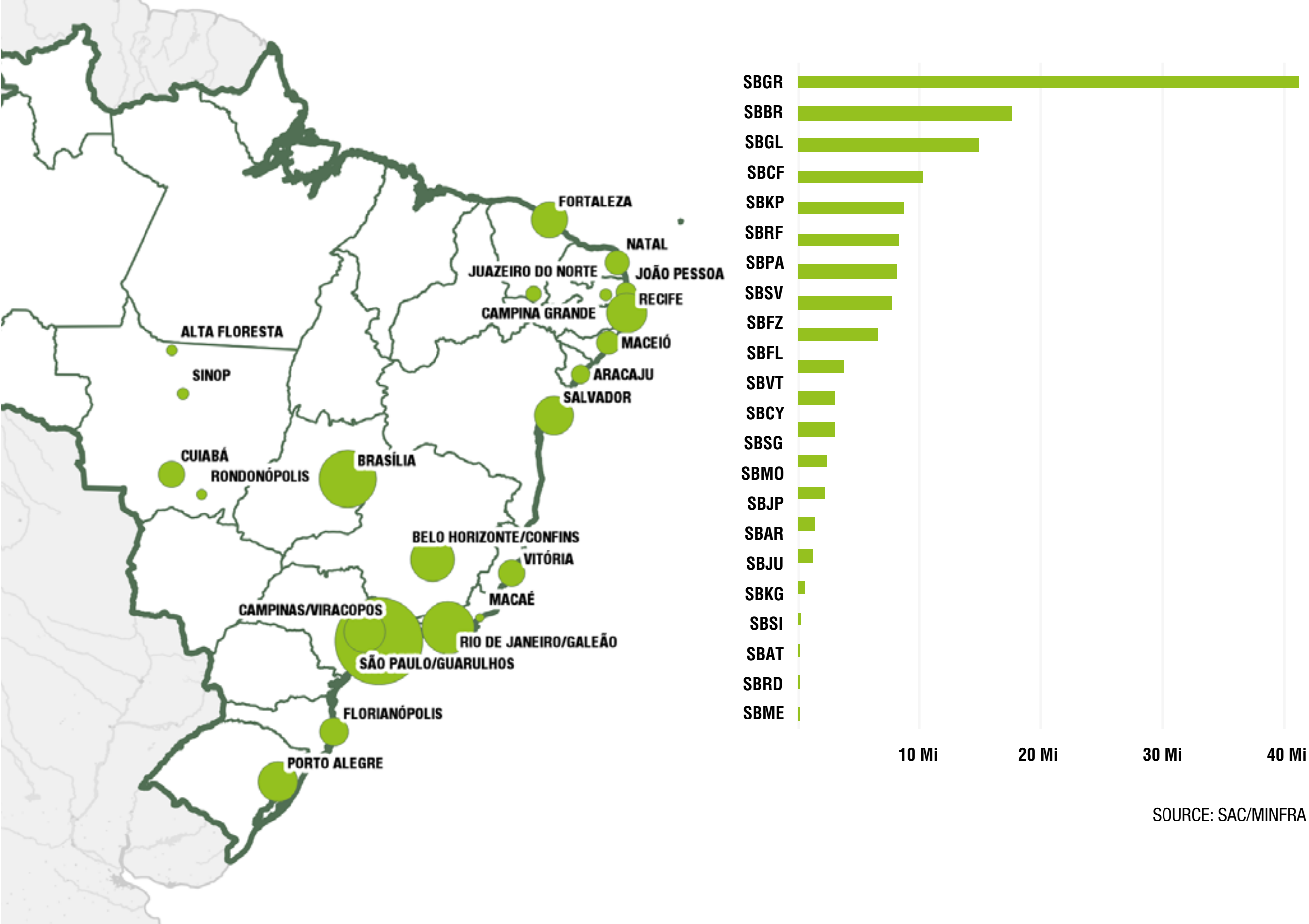
CHAPTER 4

Measures Adopted by Brazilian Airports

The significant growth of the Brazilian airline industry in recent years has resulted in the need for more investments in infrastructure to cope with the additional demand. As a result, the National Airport Concessions Programme launched in 2011 changed the dynamics of the sector by awarding 22 airports to the private sector in five auctions from 2011 to 2019. The state-owned Brazilian Airport Infrastructure Company (Infraero) still is responsible both for managing and operating 53 airports, 12 of which have already been auctioned off and will be transferred to private companies by the end of 2019.

The Brazilian federal government is currently working to auction off 22 airports from 2019 to 2020 (6th Round) and 21 airports in 2022 (7Th Round). Airports in the

MAP 4. BRAZILIAN AIRPORTS CONCEDED TO THE PRIVATE SECTOR



SOURCE: SAC/MINFRA

6th round of auctions were divided among three regional blocks: South, North 1 and Central. The 7th round, scheduled to take place in 2022, will feature 21 additional airports. Payments for the concessions are directed to the National Civil Aviation Fund (*Fundo Nacional de Aviação Civil – FNAC*), and invested in regional airports.

The provision of airport infrastructure is essential not only to foster air connectivity but also to promote energy efficiency during take-off, landing, and taxiing procedures.

This section presents the mitigation measures adopted by Infraero and privately managed airport operators. Even though this Action Plan focuses on international aviation emissions, ICAO also encourages countries to include information regarding other measures that provide supplemental benefits for domestic sectors. Therefore, in addition to emissions related to aircraft operations, this Action Plan describes actions related to "GHG emissions from sources that are owned or controlled by the airport operator" (Scope 1) and "GHG emissions from the off-site generation of electricity (and heating or cooling) purchased by the airport operator" (Scope 2).

The total impact of all these measures could not be estimated. Nevertheless, it is believed that at least 8,250 tonnes of CO_2 were not emitted from 2016 to 2018 due to good practices implemented by airports.

Inventory Management

The Greenhouse Gas Protocol (GHG Protocol) was launched in 1998 by the World Resources Institute (WRI). It is adopted as a mean to understand, quantify and manage greenhouse gas emissions. Currently, the GHG Protocol is the most used method to carry out inventories by companies and governments worldwide, and is compatible with the ISO 14.064 standard and with the quantification methods of the Intergovernmental Panel on Climate Change - IPCC.

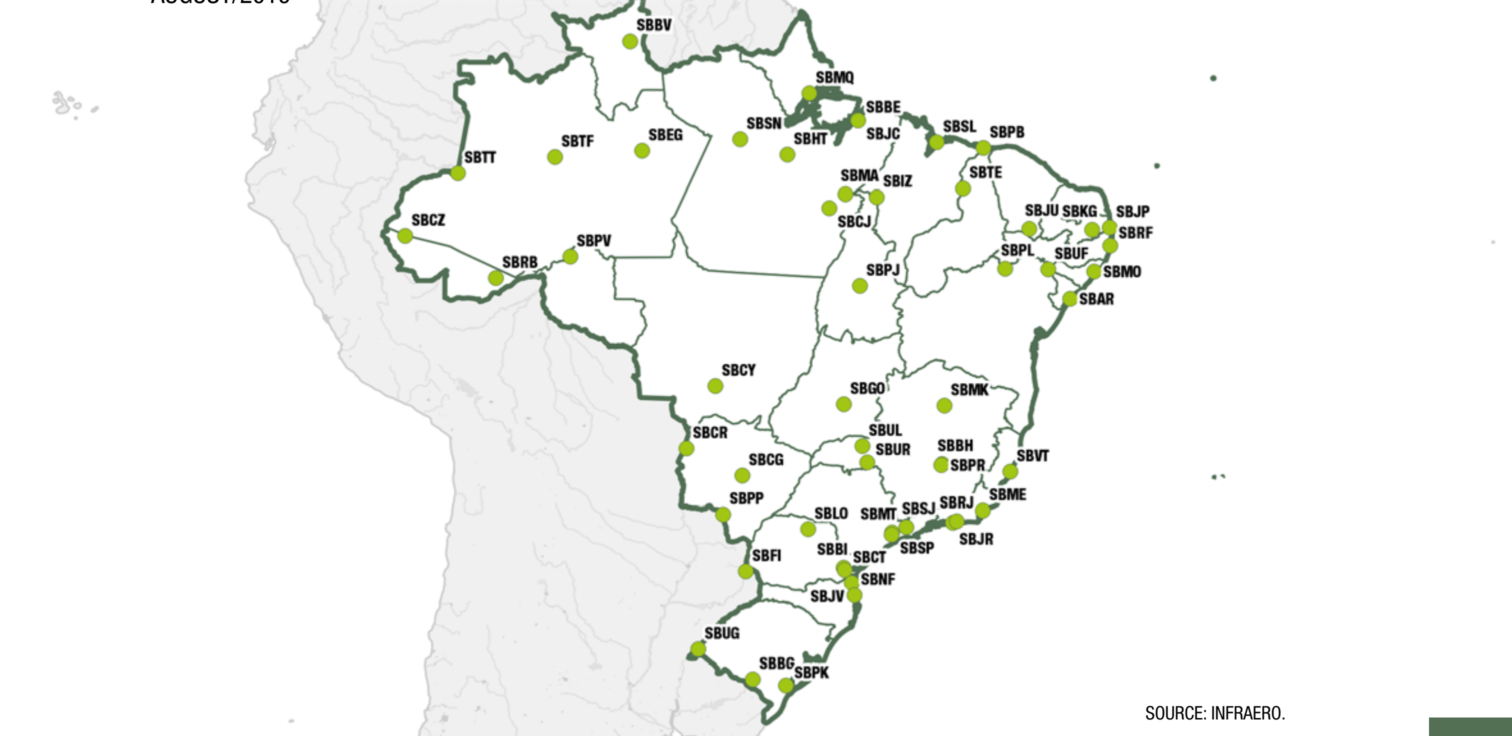
According to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, emissions are divided into three scopes:

- **Scope 1:** GHG emissions from sources that are owned or controlled by the airport operator.
- **Scope 2:** GHG emissions from the off-site generation of electricity (and heating or cooling) purchased by the airport operator.
- **Scope 3:** GHG emissions from airport-related activities from sources not owned or controlled by the airport operator.

The following Brazilian airports currently prepare inventories according to the GHG Protocol Program:

- Viracopos-Campinas International Airport (Campinas, SP)
- Belo Horizonte International Airport (Confins, MG)
- Porto Alegre International Airport (Porto Alegre, RS)

MAP 5. AIRPORTS OPERATED BY INFRAERO
AUGUST/2019



SOURCE: INFRAERO.

- Fortaleza International Airport (Fortaleza, CE)
- São Paulo International Airport (Guarulhos, SP)

1. Airports Managed and Operated by Infraero

The Brazilian Airport Infrastructure Company (Infraero) is a State-owned company. Founded in 1973, Infraero currently is responsible for operating 53 airports, 12 of which were auctioned in March 2019 and will be transferred to the private operators by the end of the current year.

Social and environmental responsibility are principles that guide management practices and corporate governance at Infraero. For over a decade, the company has maintained ten environmental programs related to airport activities in areas such as environmental licensing, as well as waste, noise and fauna management.

Guided by its new strategic planning, Infraero has been modernizing and directing its sustainability actions to the market. In this sense, acting in the provision of services, the company's environmental area, which has a dedicated structure and more than 40 professionals with different backgrounds, has developed a portfolio of 64 services focused on the needs of the market.

FIGURE 1. ENVIRONMENTAL PROGRAMMES AT INFRAERO.

SOURCE: INFRAERO.

Environmental Performance Index

In order to continuously improve environmental performance at Infraero airports, the Environmental Performance Index (IDMAI) was implemented in 2016. IDMAI is an airport environmental quality monitoring and control tool, and consists of 10 different dimensions and 25 specific indicators.

By providing monthly monitoring of IDMAI indicators, Infraero promotes effective actions, recognizes the airports that have stood out and assists those that have not achieved their goals. Currently, according to the latest IDMAI newsletter published in March, the aggregate index for all airports is at 75%, which demonstrates the implementation of several environmental actions by airports and, at the same time, that there are still actions to be undertaken. Many of these actions are directly related to the emissions of GHGs by airports, such as compliance with the diagnostic steps of energy consumption and the atmospheric emissions profile of an airport, both considered indicators of IDMAI.

Actions Related to Reduction of CO_2 Emissions

This section describes the main actions taken by Infraero related to the reduction of CO_2 emissions. These measures were segregated into two types, namely: finished/current measures and planned measures. This distinction is relevant because some measures are in the technical, economic and environmental feasibility evaluation phase, that is, there is no guarantee that they will be implemented, despite the company being committed to environmental issues and to improving airport infrastructure and operations.

Direct Emissions from Stationary and Mobile Combustion (Scope 1)

It is estimated that, on average (last 3 years), the 53 airports currently operated by Infraero emitted 2,500 tonnes of CO_2 per year from the use of fossil fuels such as diesel and gasoline for mobile and stationary combustion.

Main finished/current measures

- Increased use of videoconferences by 25% in 2017, avoiding displacements (although these also contribute to Scope 3);
- Gradual replacement of operational vehicles;
- Periodic maintenance on equipment and internal vehicles.

Planned Measures

- Adhesion of a large airport to the Airport Carbon Accreditation - ACA program led by the Airports Council International (ACI) (06/2020).

Cups and Papers (Avoided Emissions)

In addition to the continuous incentive to reduce white paper printing, an Electronic Document Management System was implemented in August 2018, which allowed for a 17% reduction in emissions associated with the consumption of A4 white paper. It was considered that the production of a ream of paper (500 sheets) emits approximately 3.5 kg of CO_2.

Since 2017 Infraero has been encouraging the use of reusable cups, distributing them to all of its units, thus reducing the number of disposable cups (and the emissions associated with their production) by 40%. The production of a plastic cup was considered to emit approximately 16.69 g of CO_2.

TABLE 3. REDUCTION IN CO_2 EMISSIONS ASSOCIATED WITH CUP AND PAPER CONSUMPTION.

Year	tCO_2/year		% reduction	
	Cup	Paper	Cup	Paper
2017	142.9	96.9	-	-
2018	86.2	80.8	-40	-17%

SOURCE: INFRAERO.

Reduction of Electricity Consumption (Scope 2)

With the information on energy consumption obtained from the Electric Energy Contract Management System (GCE), it was possible to estimate the total GHG emissions (in mass) for electric energy consumption in the 2016-2018 period. In this sense, Infraero airports emitted, in total, about 65,000 tonnes of CO_2 associated with the production of electricity consumed, as shown in Table 4. The calculation was made based on the emission factors provided by the Ministry of Science, Technology, Innovations and Communications (MCTIC).

Even with the reduction in electricity consumption at airports, there was a small proportional increase in GHG emissions in 2017, associated with scope 2. This is explained by the fact that gas-fired power plants had to be turned on to sustain Brazil's energy supply levels. Energy consumption associated with airport activity has a direct effect on GHG emissions and, at the same time, is an indicator of the energy efficiency of these activities.

Infraero seeks to continuously improving its operations, which encompass energy efficiency actions resulting in benefits to the direct and indirect reduction of GHG emissions and air pollutants. Currently, eight out of the ten busiest airports operated by the company provide up-to-date Air Emission Inventories prepared in accordance with ICAO and Intergovernmental Panel on Climate Change (IPCC) standards and methodologies.

Main finished/current measures

- LED Lighting in Passenger Terminals (TPS);
- LED lighting for runways;
- Replacing older equipment with more efficient equipment;
- Power generation system using photovoltaic plates on the roof of the arrivals terminal at Santos Dumont Airport.

TABLE 4. CO_2 EMISSIONS ASSOCIATED WITH SCOPE 2, FROM 2016 TO 2018.

Year	Consumption (MWh)	Emission Factor (tCO_2/MWh)	CO_2 Equivalent (t)	Difference (%)
2016	282,513	0.0817	23,081	-
2017	270,553	0.0931	25,188	9%
2018	216,868	0.0776	16.829	-33%

SOURCE: INFRAERO

Planned measures

Free Energy Market (January / 2020)

- Infraero seeks for acquiring electricity on a free energy market. This measure allows airports to consume energy from SHP, wind, solar, biomass, among others, thus reducing GHG emissions associated with the electricity consumption of the airport.
- As an example, in June 2019 Infraero completed the acquisition of 2.17 Megawatt Average (MWMid) of electricity in the Free Contracting Environment - ACL for Rio de Janeiro Airport - Santos Dumont / RJ.

Automation (June / 2020)

- Infraero is investing in automation solutions for systems that control various equipment at its airports. This enables airports to reduce their energy consumption as automation increases the energy efficiency of systems, thereby reducing GHG emissions associated with airport electricity consumption. Such measures are being implemented at the Rio de Janeiro - Santos Dumont / RJ and Congonhas - São Paulo Airports.

GPU-400 Hz and PCA (air conditioning) at Congonhas Airport - Sao Paulo (June/2021)

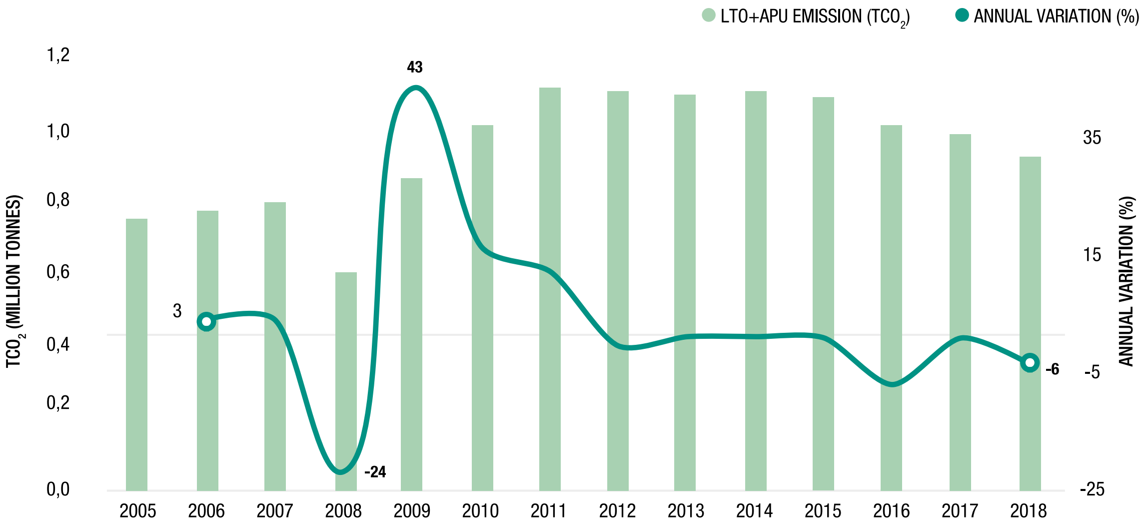
- In a commercial concession format, GPU-400Hz and PCA supply services will be available to aircraft for each of the 29 (twenty-nine) existing parking positions, avoiding the annual emission of approximately 10,000 tonnes of CO_2 per year according to preliminary project estimates.
- The GPU-400Hz consists of a solid-state frequency converter mounted in a self-supporting enclosure with a suitable degree of protection, on a concrete base according to the mentioned parking positions, which provides electric power to the aircraft in 200/115 V at 400 Hz by means of appropriate cable and plug, with capacities varying according to the required size, up to 90 kVA for all parking positions.
- Pre-conditioned air (PCA) is a self-contained, self-controlled, variable-output unit that connects aircraft through appropriate ducts, providing them with air conditioning while on the ground.

Aircraft Movement Emissions (LTO + APU) (Scope 3)

It is estimated that, on average (over the last 3 years), LTO-cycle aircraft movements added to their APU time at the 53 airports currently operated by Infraero have emitted around 944,000 tonnes of CO_2 per year.

However, considering only the 53 airports currently operated by Infraero and making a historical series of estimates of emissions from aircraft movements in them (LTO and APU cycle, there has been a downward trend since 2011. This means that even with a slight increase in passenger numbers, aircraft have become more fuel-efficient and airports have contributed with this process.

GRAPH 17. CO_2 EMISSIONS BY AIRCRAFTS AT INFRAERO AIRPORTS, FROM 2005 TO 2018 - LTO+APU (TCO_2).



SOURCE: INFRAERO

Other measures

It is worth mentioning other specific measures that do not generate significant reduction or that were only performed during testing periods, such as:

- Rio de Janeiro Airport / Santos Dumont (RJ) - Tests with electric bus for passenger transportation;
- Jacarepaguá Airport / RJ - Solar energy pilot project that supplies power to five LED lamps and two sockets. The system consists of two charge controllers, an inverter and two batteries that store the energy that will be used at night;
- Campo de Marte Airport / SP - Nine panels to capture solar energy at Campo de Marte Airport to supply, together with the external network, electricity for lamps and sockets on the ground floor of the administration building;
- Telecommunications and Air Traffic Provider Station (EPTA) of Jacarepaguá (RJ) - Infraero's First Secondary Surface Surface Weather Station powered by solar panels;
- Modernization of GSEs at Congonhas Airport (SBSP) with nine new push back tractors, 8 new towing tractors and 12 new mobile loading tracks.

2. Viracopos International Airport

Viracopos International Airport was conceded in February 2012, when the Consórcio Aeroportos Brasil was granted the right to administer the airport for a period of 30 years. The consortium is formed by the companies TPI - Triunfo Participações e Investimentos, UTC Participações and the French Egis Airport Operation and Infraero.

Among the improvements implemented at the Airport is the construction of the new Passenger Terminal (TPS 01), which has 178,000 m², with a capacity to process 25 million passengers / year; Installation of 28 boarding bridges; 35 new aircraft positions; construction of a garage building with capacity for 4,000 vehicles.

The table below lists the sustainability and energy efficiency measures adopted by Viracopos.

TABLE 5. ACTIONS AND RESULTS ACHIEVED BY VIRACOPOS INTERNATIONAL AIRPORT.

Category	Actions	Results
Airport Infrastructure Management and Improvements	400Hz system (GPU and PCA) installed on all 28 boarding bridges, plus 4 mobile systems to serve in remote positions	Average reduction of 2,862 tonnes of CO_2 per year (base year 2016).
	Replacement of the operational fleet: 12 new vehicles (4 with diesel engines and 8 with flexible-fuel engines), replacing 11 older vehicles (8 with diesel engines and 3 with flexible-fuel engines).	
	Replacement of forklifts used at the Cargo Terminal: 5 diesel forklifts, 28 electric forklifts and 57 LPG forklifts.	
Energy Efficiency Improvements	Replacement of 400 LED mercury vapor lamps on the access roads and road system of the Viracopos airport site.	Average reduction of 43.5 tonnes of CO_2 per year (base year 20015).
	Replacement of 23 mercury vapor lamps with LED lamps in the red channel area of the Viracopos Cargo Terminal.	Average reduction of 6.92 tonnes of CO_2 per year (base year 2015).
	Installation of 190 LED lamps in the extension area of the Cargo Terminal, replacing mercury vapor lamps.	Average reduction of 20.7 tonnes CO_2 per year (base year 2015).
	Installation of 232 LED lamps in the Cargo Terminal Export area, replacing mercury vapor lamps. With this, TECA Exportação started to use 100% in LED lamps in its facilities.	Average reduction of 25.28 tonnes CO_2 per year (base year 2015).

Category	Actions	Results
Improvements in Environmental Management	Waste Management: Waste sorting since 2014, which permanently seeks to add value to the waste generated in the various activities.	In 2018, a total of 3,071 tonnes of waste were generated at the airport site. 1,361 tonnes (44.3%) were sent for recycling, composting, co-processing, etc (44.3%).
	Environmental education: Viracopos raises the awareness of its employees through training, lectures, announcements, and the theme of atmospheric emissions is always present in the activities developed.	
Sustainability Report	Viracopos has been preparing the Greenhouse Gas Inventory since 2013 and, starting in 2016, began publishing it in the GHG Protocol Program, through its holding company TPI - Triunfo Participações e Investimentos.	The Airport has the GHG Protocol Program Gold Seal.

Actions planned by Viracopos airport include:

- Installation of 472 LED lamps in the *TECA Importação* area, replacing the existing mercury vapor lamps. Carrying out this action, the Cargo Terminal will have 100% LED lamps in its facilities. This action will result in an average reduction of 51.43 tCO_2 per year, based on the year of its execution (2019 forecast).
- Installation of LED lamps in the November, Papa and Quebec aprons. As the quantitative survey of lamps has not been finalized, it has not yet been possible to calculate the estimated reduction in tCO_2.

3. Belo Horizonte International Airport

Belo Horizonte International Airport, located in the state of Minas Gerais, was awarded to BH Airport in auction No. 1/2013, held at BMF & BOVESPA on November 22, 2013. The Concession Agreement was signed on April 7, 2014 and its effectiveness began on May 7, 2014. Infraero's operations were transferred to BH Airport on January 11, 2015.

BH Airport and its shareholders are responsible for accounting for greenhouse gas (GHG) emissions from their business activities, annually compiling inventory in accordance with the GHG Protocol guidelines, which enables them to assess business performance and develop Action Plans to mitigate impacts.

Belo Horizonte International Airport was acknowledged, in 2018, at the Level 1 Airport Carbon Accreditation - ACA of the Airport Council International - ACI, for identifying and mapping the sources of greenhouse gas emissions from its activities, by calculating airport carbon footprint for 2017 (equal to 2,480 tonnes of CO_2e in that year). BH Airport has also received the ISO 14.064-1 (Greenhouse Gas Emissions) certification. GHG emissions are monitored by BH Airport through the CERENSA social and environmental governance tool, which assists in the analysis of the use of environmental resources and the identification of opportunities to add energy efficiency.

TABLE 6. CURRENT ACTIONS AT BELO HORIZONTE INTERNATIONAL AIRPORT.

Category	Actions underway
Airport Infrastructure Management and Improvements	Unification of Import storage sectors.
	Expansion of export storage area.
	Verticalization of storage areas, reducing unnecessary loading movements.
	Average reduction of 63 hours/month in forklift handling.
	Transfer of the reserve buses and minibuses to the Ramp Shelter and transfer of the driver's room to the Ramp Shelter to reduce the distance traveled by the buses to perform the services.
	Implementation of a new roundabout in the airport courtyard, in 2018, also to reduce the distance traveled for remote passenger service, generating an average reduction of 30% of the distance traveled and, consequently, the amount of consumed fuel.
	Reduction of fuel consumption of the vehicle fleet.
	Use of inventory for analysis and identification of opportunities to add energy efficiency in the consumption of fuel movements of aircraft and vehicle fleet.
Improvements in Energy Efficiency	Utilization of inventory for analysis and identification of opportunities to add energy efficiency in the consumption of electricity.
	Fuel management of generators.
	Management of the use of LPG in the kitchen and forklifts.
	Managing the use of refrigerants in the air conditioning system.
	Management of CO_2 extinguishers.
	Employee air travel management.

Category	Actions underway
Improvements in Environmental Management	Solid waste management.
	Monitoring of treated effluent volume at the sewage treatment plant.
Environmental education	Recycling of good storage practices for all the operators in order to optimize the implementation of all activities.
Sustainability Report	The airport's carbon footprint was estimated at 2,480 tonnes of CO_2 equivalent in 2017, according to ACA ACI Level 1 Certificate.

4. Florianopolis International Airport

Floripa Airport, owned by the Swiss Zurich Airport, took over Florianópolis International Airport on January 3, 2018, and will be responsible for its operation for the next 30 years.

TABLE 7. PLANNED ACTIONS AND COMMITMENTS TAKEN BY FLORIANÓPOLIS INTERNATIONAL AIRPORT.

Category	Planned Actions	Delivery Forecasts
Airport Infrastructure Management and Improvements	Provide electrical power and air conditioning for aircrafts.	Until 2030
	Construction of a new ecofriendly terminal with: • Taking advantage of TPS natural lighting. • 100% LED lighting. • Automation Systems. • Acquisition of electric cars. • Co-processing of non-recyclable waste for energy use.	October 2019

Category	Planned Actions	Delivery Forecasts
Environmental education	Tenant Handbook: Contractual sustainability guidelines.	
	Commitment to influence and encourage customers and partners towards sustainable behavior.	
Carbon neutralization and reporting targets	Mapping of all sources of greenhouse gas emissions	Until 2019
	5% reduction of GHG emissions per year.	From 2020 to 2025
	Replacement of combustion-powered equipment by electrical equipment.	30% by 2023 50% by 2030
	Accreditation by Airport Council International - ACI in the first 3 levels.	Until 2025
	Provision of exclusive and priority parking spaces for electric and hybrid cars.	
	Prioritization of the acquisition of materials and inputs within a 400 km radius.	
	Commitment to making carbon neutral choices.	
Goals for Energy Efficiency Improvements	Annual reduction of 5% of energy consumption per user.	From 2020 to 2025
	Lighting of the new terminal and surrounding areas using exclusively LED lamps, prioritizing lighting and natural climate	
	Use of low-power smart equipment exclusively by procuring Procel “A” seal equipment .	
	Exclusive consumption of electricity from clean and renewable sources through the Free Energy Market in Brazil.	
Environmental Management - Commitments	Being a Zero Waste airport, continuously seeking the reduction of waste generated.	
	Using natural resources in a balanced and sustainable manner, especially water and energy .	
	Use eco-efficient packaging , gradually eliminating single use plastic utensils.	

5. Rio de Janeiro International Airport – Galeão

Galeão airport, located in the city of Rio de Janeiro, was awarded to concessionaire RIOgaleão at an auction held on November 22, 2013. The Concession Agreement was signed on April 2, 2014 and its effectiveness began on May 7, 2014. The transfer of operations from Infraero to RIOgaleão took place on February 12, 2015.

The Airport has 20 sustainability programs, the main actions of which are described in the Table 8.

TABLE 8. CURRENT ACTIONS AT RIO DE JANEIRO INTERNATIONAL AIRPORT - GALEÃO

Category	Actions in progress
Airport Infrastructure Management and Improvements	Promotion of practices that encourage GHG reduction due to airport activity .
Energy Efficiency Improvements	Fostering the efficient and rational use of airport site energy: energy efficiency plan, innovation studies and projects, monitoring and prevention, and capacity building and training.
Improvements in Environmental Management	Air quality monitoring
	Aeronautical Noise Monitoring: Noise curve verification and noise monitoring.
	Promotion of efficient and rational use of water resources.
	Operation of the collection system, treatment and supply of non-potable water.
	Monitoring of drinking water supply network.
	Maintenance, operation and treatment of sewage system.
	Solid waste management through procedures, flows, monitoring and evaluation of the generation, collection, transportation and final disposal of waste generated at the airport.
	Recovery of degraded areas due to compensatory measures of licensing processes, environmental permits, among others.
	Encouraging the strengthening of the local supply chain / services, encouraging the execution of services and the acquisition of inputs, equipment and products in accordance with the Millennium Goals and Equator Principles.

6. Fortaleza International Airport

Fraport Brazil is a subsidiary of Fraport AG Frankfurt Airport Services Worldwide, a group that has provided airport management, operation and consulting solutions for over 90 years in 31 airports worldwide.

In 2017, Fortaleza International Airport, located in the state of Ceará, was awarded to Fraport in auction No. 4/2017, held on March 16, 2017, for a period of 30 years. The Concession Agreement was signed on July 28, 2017 and its effectiveness began on August 29, 2017. Infraero's operations were transferred to the concessionaire on April 2, 2018.

In 2018, Fortaleza airport operated with a monthly average of 4,400 domestic and 180 international takeoffs and landings. According to the GHG inventory of the same year, for scopes 1 and 2, 1,303 tCO_2e were emitted. This number represents 22.28 $kgCO_2e$ per aircraft, and 0.20 $kgCO_2e$ per passenger.

TABLE 9. FORTALEZA INTERNATIONAL AIRPORT CURRENT AND FUTURE INFRASTRUCTURE

	2018	2023
Passengers	6.6 million	9 million
Terminal area	34,492 m^2	70,000 m^2
Runway length	2,545 m	2,755 m
Aircraft parking positions	18	26
Boarding bridges	7	15
Gates	13	21
Concession stands	89	120
Garage parking spaces	850	1,100

SOURCE: FRAPORT BRASIL.

Given that over 90% of the airport's GHG emissions come from electricity consumption, the mitigation measures being implemented are focused on lighting and the air conditioning system, as shown in Table 10.

TABLE 10. CURRENT ACTIONS AT FORTALEZA INTERNATIONAL AIRPORT.

Category	Actions in progress	Delivery Forecasts
Airport Infrastructure Management and Improvements	Study for the deployment of 400 Hz system for ground aircraft, with development of power supply and air conditioning lines from the airport.	
	Airport terminal expansion works and ancillary facilities.	April 2020
	Runway expansion and accessory installations.	1st semester of 2021
Energy Efficiency Improvements	Airport terminal retrofit: LED lighting switching and efficient lighting positioning study.	April 2020
	Airport terminal: LED lighting installation, efficient elimination positioning and use of natural lighting.	April 2020
	LED lighting in the new road and parking lot.	1st semester of 2021
	Exchange of all utility facilities by LED.	1st semester of 2021
	Exchange of *fan coils* of the air conditioning system.	Underway
	Study of air conditioning leaks in the existing airport terminal	Underway
	Air conditioning system: new coverage over existing one with the aim of reducing the demand for air conditioning.	Underway
Sustainability Report	Preparation of inventory according to the GHG Protocol Program.	Yearly

7. Porto Alegre International Airport

Porto Alegre International Airport, located in the state of Rio Grande do Sul, is also operated by Fraport Brasil SA, and was granted for 25 years in auction No. 4/2017, held on March 16, 2017. Concession was signed on July 28, 2017 and its effectiveness began on August 29, 2017. Infraero's operations were transferred to Fraport on April 2, 2018.

In 2018, Porto Alegre airport operated with a monthly average of 6,600 domestic take-offs and landings, and 458 international ones. According to the GHG inventory of the same year, for scopes 1 and 2, 1,552 tCO_2eq were emitted. This number means 19.16 $kgCO_2eq$ per aircraft, and 0.19 $kgCO_2eq$ per passenger.

TABLE 11. PORTO ALEGRE INTERNATIONAL AIRPORT CURRENT AND FUTURE INFRASTRUCTURE

	2018	2023
Passengers	8.2 million	11.2 million
Terminal area	36,420 m^2	73,000 m^2
Runway length	2,280 m	3,200 m
Aircraft parking positions	25	28
Boarding bridges	8	14
Gates	20	24
Concession stands	79	131
Garage parking spaces	2,684	4,300

SOURCE: FRAPORT BRASIL.

Table 12 lists the main mitigation measures being implemented at the airport.

TABLE 12. CURRENT ACTIONS AT PORTO ALEGRE INTERNATIONAL AIRPORT.

Category	Actions in progress	Delivery Forecasts
Airport Infrastructure Management and Improvements	Study for the deployment of 400 Hz system for ground aircraft, with development of power supply and air conditioning lines from the airport.	
	Runway expansion and accessory installations.	2nd semester of 2021
	Airport terminal expansion works and ancillary facilities	October 2019
Energy Efficiency Improvements	Airport terminal retrofit: LED lighting switching and efficient lighting positioning study.	October 2019
	Airport terminal: LED lighting installation, efficient elimination positioning and use of daylighting (skylights).	October 2019
	Extended patio LED lighting.	2nd semester of 2021
	New LED lighting in all facilities.	2nd semester of 2021
	New air conditioning equipment.	Underway
	New cooling towers of air conditioning system.	Underway
	Exchange of CAVs (thermal exchange) of the air conditioning system.	Underway
Sustainability Report	Preparation of inventory according to the GHG Protocol Program.	Yearly

8. São Paulo International Airport - Guarulhos

São Paulo International Airport was awarded to GRU Airport S.A. in auction No. 2/2012. The Concession Agreement was signed on June 14, 2012 and its effectiveness began on July 11, 2012. Infraero's operations were transferred to GRU Airport on February 15, 2013.

By conducting inventory, GRU Airport maps the GHG emission sources of its activities, which allows them to be quantified, recorded and monitored. To date, the airport has mapped 55 emission sources from processes or equipment use of the following activities: maintenance (42.6% of the total), commercial services (36.4%), terminal operations (15.1%), and others (5.9%). In 2018, the airport emitted 66,356.78 tCO_2e, while the previous year it emitted 69,326.59 tCO_2e.

TABLE 13. CURRENT ACTIONS AT SÃO PAULO INTERNATIONAL AIRPORT - GUARULHOS.

Category	Actions in progress
Airport Infrastructure Management and Improvements	Construction of taxiways and fast exits.
	Construction of 6 new boarding bridges with reduced demand for air conditioning, which also reduces bus traffic.
	Implementation of new service lanes behind aircraft parking positions, reducing the distance traveled by vehicles.
	Terminal 3 *ground handling* fleet 100% electric.
	Study to adopt the 400 VAC source boarding bridges.
Energy Efficiency Improvements	Replacing halogen lamps with LED. 2,740 LEDs have been installed so far.
	Reduced use of air conditioning at night.
	Harnessing sunlight in the passenger terminal.
Improvements in Environmental Management	Installed biodiesel plant, in the final stages of preparation, which will be conducted in partnership with the local community and will enable the use of biodiesel in other vehicles.
Sustainability Report	Prepares inventory according to the GHG Protocol Program.

9. Brasília International Airport

Brasilia International Airport, located in Brazil's capital, was awarded to Inframerica in auction No. 2/2012. The Concession Agreement was signed on June 14, 2012 and its effectiveness began on July 24, 2012. Infraero's operations were transferred to the concessionaire on March 1, 2013.

TABLE 14. ACTIONS AND RESULTS ACHIEVED BY BRASILIA INTERNATIONAL AIRPORT.

Category	Actions Taken	Results
Airport Infrastructure Management and Improvements	Efficient passenger processing; improvements in infrastructure.	
Energy Efficiency Improvements	New piers that allow for better use of natural light and automation systems.	
	Replacing traditional bulbs with LED lighting in the terminal	Reduction of 112.29 tCO_2e from 2017 to 2018.
	Reduction in energy demand.	Reduction of 318.69 tCO_2e from 2017 to 2018.
	Energy use from renewable sources.	Reduction of 1,733.35 tCO_2e in 2017.

Planned measures that will contribute to reduce GHG emissions include:

- LED lighting in the apron area;
- Implementation of a photovoltaic powerplant;
- Air conditioning and electric power supply through a 400 Hz system.
- Preparation of a GHG emissions inventory using the GHG Protocol methodology.

10.Natal International Airport

Natal International Airport, located in the state of Rio Grande do Norte, was awarded to Inframerica in auction No. 1/2011. The Concession Agreement was signed on November 28, 2011 and its effectiveness began on January 24, 2012. Airport operations started on 05/31/2014.

Table 15 lists the main actions at the airport.

TABLE 15. ACTIONS AND RESULTS ACHIEVED BY NATAL INTERNATIONAL AIRPORT.

Category	Actions Taken	Results
Airport Infrastructure Management and Improvements	Efficient passenger processing; improvements in infrastructure.	
Energy Efficiency Improvements	New piers that allow for better use of natural light and automation systems.	
	Reduction in energy demand.	Reduction of 5 tCO_2 in 2018.

Planned measures to increase the airport's energy efficiency include:

- Use of LED lighting in the passenger terminal;
- Preparation of a GHG emissions inventory using the GHG Protocol methodology.

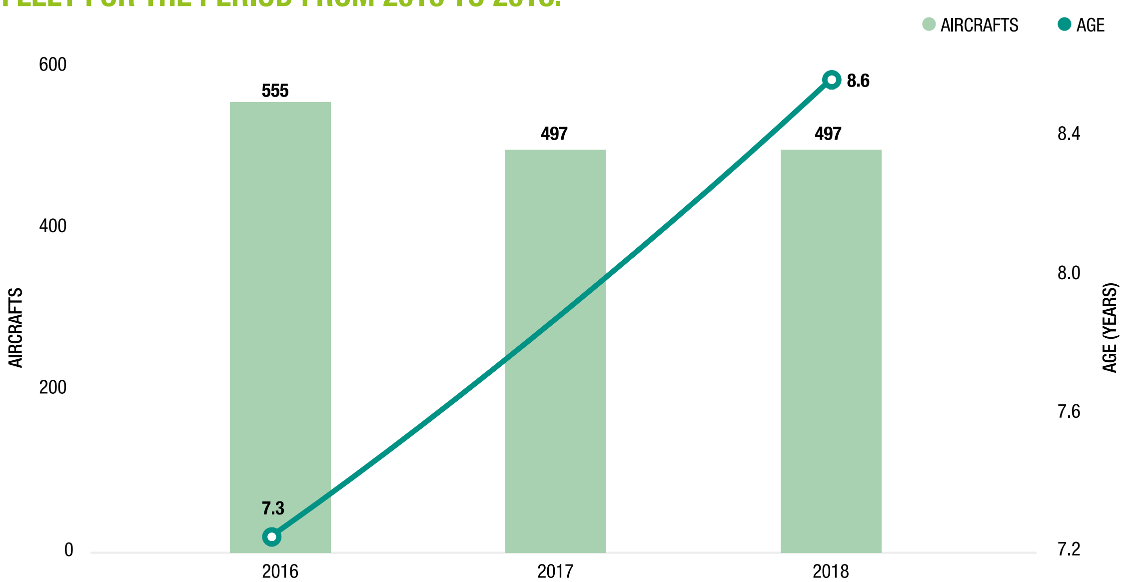
Airspace industry

According to the *ALTA Brazil Aviation Insight*[13] released by the Latin American and Caribbean Air Transport Association, in February 2019, Brazil's commercial air fleet was comprised of 503 aircrafts. The average age of that fleet was 10.7 years with an average use of aircraft of 8 hours per day.

13 Aviation Insight Brazil. ALTA - Latin American and Caribbean Air Transport Association, March 2019.

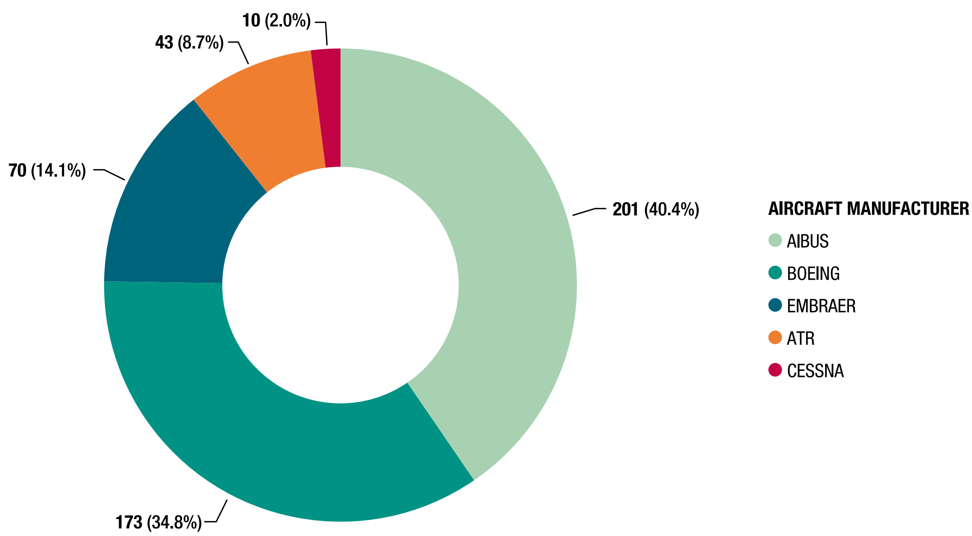
Graph 18 presents, for the years elapsed since the last edition of the Action Plan (i.e. 2016, 2017 and 2018), the average age and size of the Brazilian fleet considering only the aircraft whose movements were effectively considered for the accounting of historical values of fuel consumed and RTK presented in section 4 of this document. In addition, aircrafts that do not hold information referring to the year of manufacturing

GRAPH 18. EVOLUTION OF THE SIZE AND AVERAGE AGE OF THE BRAZILIAN AIRLINES' FLEET FOR THE PERIOD FROM 2016 TO 2018.



SOURCE: NATIONAL CIVIL AVIATION AGENCY - ANAC.
STATISTICAL DATABASE OF AIR TRANSPORT AND BRAZILIAN AERONAUTICAL REGISTRY - RAB.

GRAPH 19. PARTICIPATION OF MANUFACTURERS IN THE COMPOSITION OF THE FLEET OF BRAZILIAN AIRLINES FOR THE YEAR 2018.



SOURCE: NATIONAL CIVIL AVIATION AGENCY - ANAC. AIR TRANSPORT STATISTICS DATABASE.

or present it erroneously in the database of the Brazilian Aeronautical Registry - RAB were also disregarded.

It should be noted that the Brazilian fleet, in addition to being relatively new, is always in the process of renewal. For example, in the transition from 2017 to 2018, the average age grew by less than a year, although the total number of aircraft remained the same.

The composition of the fleet according to the manufacturer can be observed in Graph 19, which was prepared considering the same scope adopted for Graph 18, detailed above.

Embraer

Embraer-Boeing Joint Research Center for Sustainable Aviation Biofuels

The Joint Research Center for Sustainable Aviation Biofuels established by Embraer and Boeing in 2014 commissioned two studies in order to develop sustainable aviation fuels in Brazil.

The companies funded AGROICONE to conduct a study on “Direct and indirect emissions from land use change: evaluation and technical proposal for Brazilian biomass”. The study covered general aspects of life cycle analysis, analysis of how land use change models are being applied to particularities of the Brazilian territory, and contributions to international discussions on risk management practices in low-impact indirect land use changes (iLUC).

AGROICONE also simulated sustainable aviation fuel scenarios in the Brazilian land use model, compared to other iLUC estimates.

The results of this research were shared with representatives of Brazil in the Environmental Protection Committee of the International Civil Aviation Organization (ICAO) to assist in technical discussions on the topic.

Both Embraer and Boeing also funded a project to develop a data management system for Sustainable Aviation Fuels (SAFs) in Brazil. The project was conducted by researchers from the State University of Campinas (UNICAMP) and aimed to provide easy access to information and data related to raw materials of interest for SAF production in Brazil, based on technological routes already certified. This system can be used by various stakeholders, such as investors, researchers, policy makers, non-governmental organizations, as well as the Joint Research Center of Boeing and Embraer itself.

The system is still being structured so that the user can quickly obtain information of interest on various biomass, such as parameters to determine the potential for biomass production, productivity range, land prices and existing infrastructure in a given region and so on.

The study will also include more biomass in its database before its completion in 2020.

New generation of E-Jets E2 commercial aircrafts

In the past two years, Embraer introduced the first models of its new generation of commercial aircrafts with up to 150 seats, the E-Jets E2. This aircrafts set consists of three new models: E190-E2, E195-E2 and E175-E2, which feature a completely new wing design (clean sheet design), intelligent use of lighter materials, full fly-by-wire 4th generation system and new engines, and other improvements that reduce structural weight and increase aircraft aerodynamics. With more modern technologies, lower levels of fuel consumption reduction and greenhouse gas emissions have been achieved.

The E190-E2 aircraft came into operation in April 2018, soon after its certification was granted by the main aeronautical authorities of the world, namely the National Civil Aviation Agency (ANAC) in Brazil, the Federal Aviation Administration (FAA) in the United States and the European Aviation Safety Agency (EASA). The aircraft has achieved a 17.3% reduction in fuel consumption and CO_2 emissions per seat, when compared to the previous version of this model, the E190-E1. In an average regular operation of 2,500 flight hours per year, this represents approximately 3,600 tonnes of CO_2 that are no longer emitted per aircraft annually.

In April 2019, ANAC also certified the E195-E2 model, the largest commercial aircraft ever developed and built by the Brazilian manufacturer. This model achieved a 25.4% reduction in carbon dioxide consumption and emission per seat compared to its previous version, the E195-E1. Furthermore, this aircraft has the lowest external noise level in its category, with a cumulative margin for the ICAO stage IV noise limit ranging from 19 to 20 EPNdB, being 4.0 EPNdB less than its direct competitor. The first operator of this aircraft in the world will be Azul Linhas Aéreas in 2019.

By the end of 2018, a total of 154 E-Jets E2 had already been ordered.

CHAPTER 6

Alternative Fuels

Biofuels in Brazil

Global concerns regarding climate change, high fuel prices, and oil supply uncertainties have resulted in a growing demand in research, development and technological innovation on sustainable fuels. In addition, energy conversion processes have been deemed necessary. In this sense, both production and consumption of ethanol and biodiesel have been increased in recent decades. That trend seeks to meet demand for light vehicles and heavy road and urban vehicles[14].

According to the International Energy Agency (IEA), global greenhouse gas reduction targets will not be met without a significant increase in biofuel consumption. For this expansion to take place, it must necessarily be driven by the reduction of production costs of advanced biofuels[15] and by the adoption of financial risk mitigation measures. The Agency also points out that unless technology continues to be developed and production is increased, biofuels will continue to cost more than fossil fuels.

In Brazil, in line with its energy policy, both production expansion and use of biofuels have been continuously incorporated as national strategic objectives[16]. As a result, Brazil is currently the world´s second largest biofuel producer, trailing only the United States[17].

Ethanol is the main biofuel produced and consumed in Brazil, with a well-established supply chain, launched in the 1970s by the Pro-Alcohol program. Currently, every Brazilian gas station is required to offer gasoline-ethanol blends containing 27% ethanol[18], and most also sell pure ethanol.

14 Source: International Energy Agency – IEA, 2019

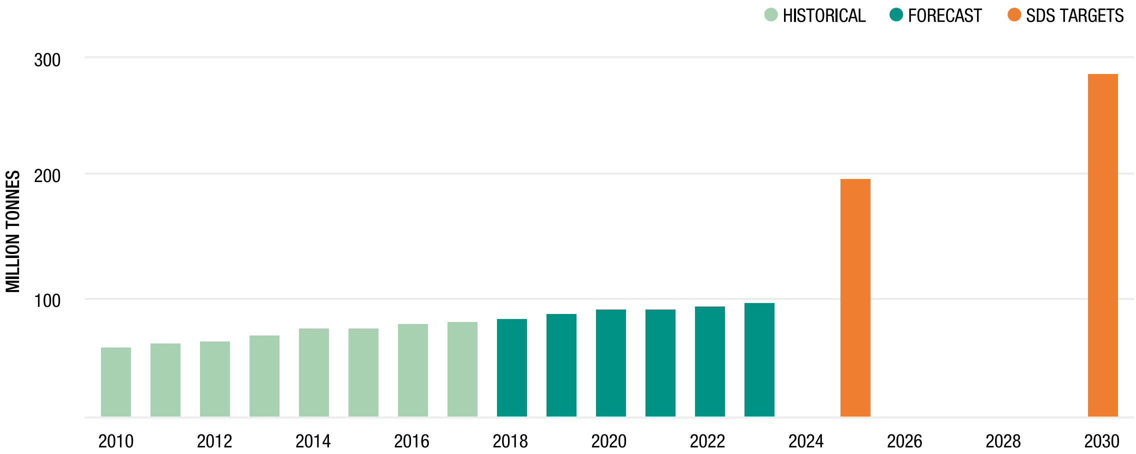
15 IEA (2019) defines advanced biofuels as sustainable fuels produced from non-food sources and capable of generating significant GHG emission reductions compared to fossil fuels that do not compete with end-use cropland or that cause adverse impacts on sustainability.

16 Source: Energy Research Office - EPE, 2018.

17 Source: Statista, 2019.

18 Source: Portaria MAPA Nº 75 of March 5 2015.

GRAPH 20. GLOBAL BIOFUEL PRODUCTION (HISTORICAL AND FORECAST) VERSUS SUSTAINABLE DEVELOPMENT GOALS, FROM 2010 TO 2030.



SOURCE: INTERNATIONAL ENERGY AGENCY – IEA, 2019.

To introduce biodiesel into the Brazilian energy matrix, the Federal Government launched, in December 2004, the National Program for the Production and Use of Biodiesel - PNPB, focusing on social inclusion and regional development. The main outcome of the first phase was the definition of a legal and regulatory framework. From 2008, the mandatory minimum blend of 2% biodiesel to conventional diesel (B2) came into force throughout the country. As the Brazilian market matured, this percentage was successively increased to 10% (B10) nowadays.

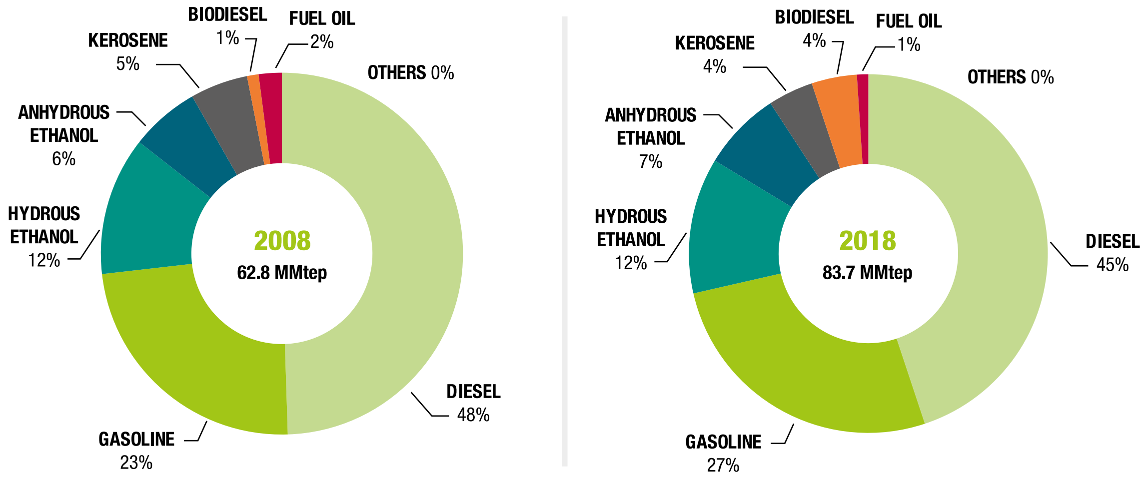
According to information from the Energy Research Office (EPE)[19], the share of biofuels in the transport sector increased from 18.7% in 2008 to 23.1% in 2018, an increase of about 8 million tonnes (approximately 40% of industry-wide increase).

In 2018, emissions avoided by the use of ethanol (anhydrous and hydrated) and biodiesel, compared to fossil equivalents (gasoline and diesel), totaled 63.7 $MtCO_2$. In addition to liquid biofuels, sugarcane bioelectricity has also contributed to the reduction of CO_2 emissions. Considering the exported energy and the self-consumption by the sugarcane units, the emissions avoided by bioelectricity add up to 2.6 $MtCO_2$[20].

19 Source: Energy Research Office (EPE).

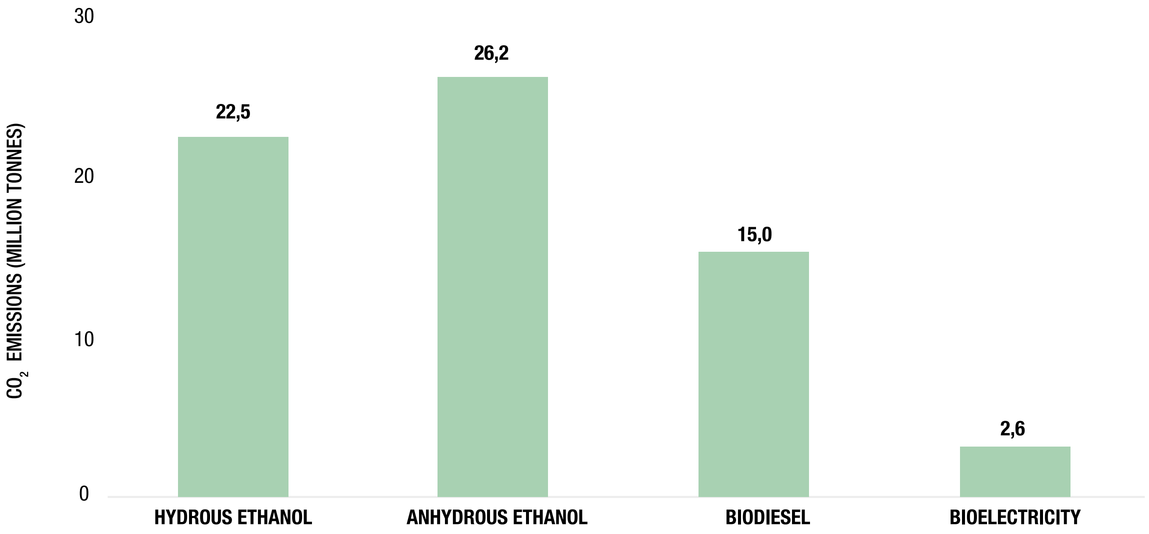
20 To estimate avoided emissions, EPE used the tCO_2 emission factor per MWh generated, calculated by the Ministry of Science, Technology and Innovation (MCTIC, 2019).

GRAPH 21. ENERGY MATRIX - TRANSPORT SECTOR - 2008 AND 2018.



SOURCE: ENERGY RESEARCH OFFICE.

GRAPH 22. CO_2 EMISSIONS AVOIDED IN 2018, BY FUEL USAGE.



SOURCE: EPE, 2019A; IPCC, 2006; ROSA, OLIVERIA, COSTA PIMENTEIRA & MATTOS, 2003; AND MCTIC, 2019.

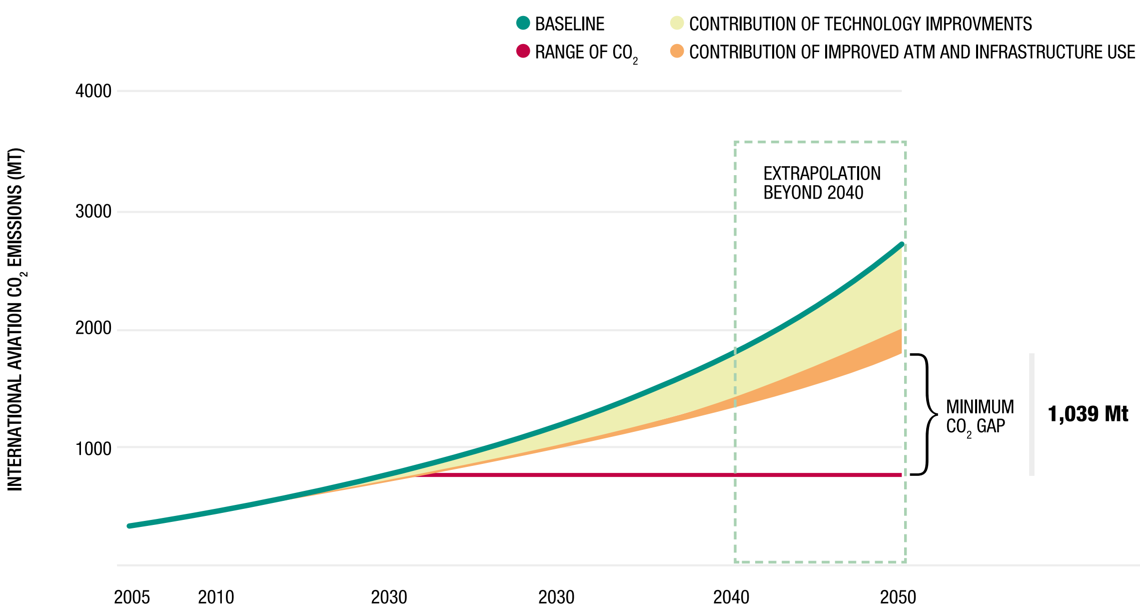
Sustainable fuels for aviation

Despite significant efficiencies achieved through operational, technological and infrastructure improvements, studies estimate that CO_2 emissions will still more than double by 2050. Graph 23 shows the results for the global burning of international aviation fuels from 2005 to 2040, extrapolated to 2050.

To induce the neutral growth of the civil aviation industry by 2020, the use of sustainable aviation fuels is critical. Nevertheless, in Brazil and worldwide, there are industrial and economic challenges to overcome for these fuels to be competitive against fossil fuels. The weighting of the cost/benefit ratio is a prerequisite for changing the energy matrix, given that fuel costs represent the most relevant factor for the operating cost of an airline, at around 30%.

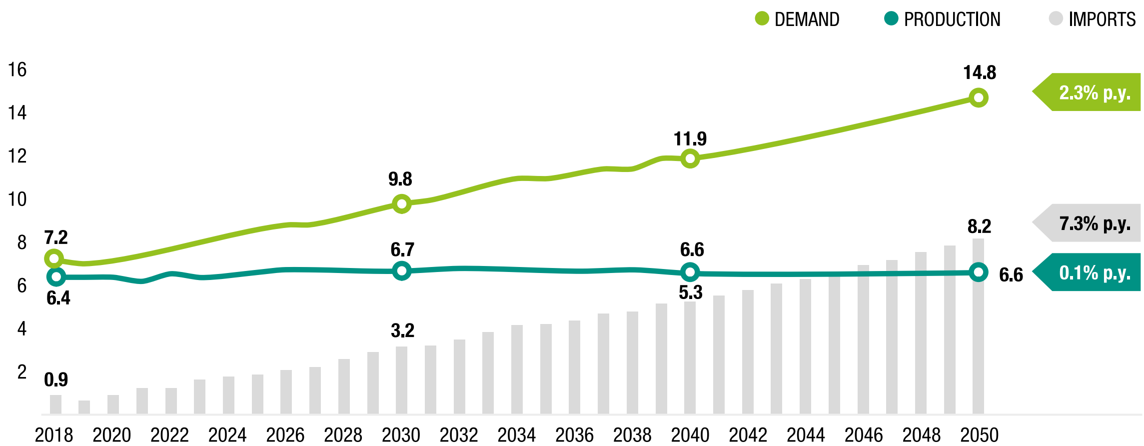
To ensure flight safety, aviation fuels are subjected to high quality requirements that span the entire production and distri-

GRAPH 23. TRENDS IN CIVIL AVIATION CO_2 EMISSIONS FROM 2005 TO 2050.



SOURCE: ICAO ENVIRONMENTAL REPORT 2016.

GRAPH 24. QAV PRODUCTION, DEMAND AND IMPORTS (IN BILLIONS OF LITERS).



SOURCE: ENERGY RESEARCH OFFICE.

bution chain down to aircraft tanks. These requirements are intended to ensure the safety of operations and are similar worldwide to allow interoperability, for example, of international flights. Thus, given their global specification and distributed use across countries, sustainable aviation fuels are developed under the concept of *drop-in*, meaning they can use the same infrastructure and do not require aircraft or engine adaptation.

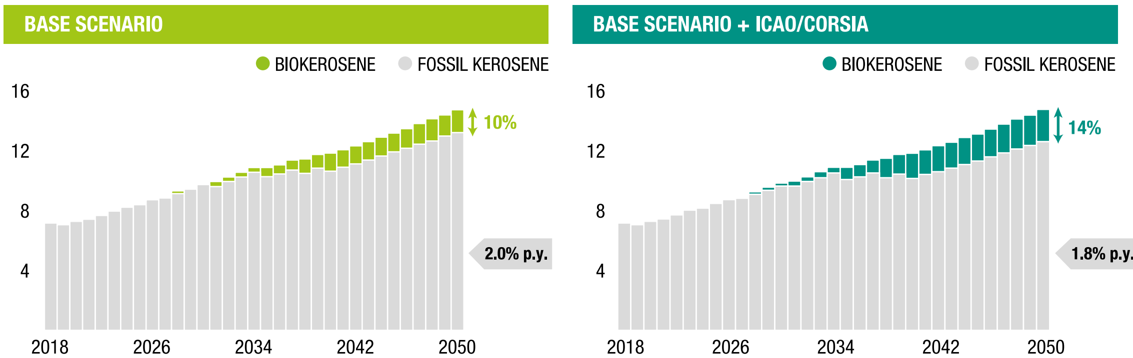
In addition to technical quality requirements, the aviation industry requires certification of the sustainability of fuel production, including raw material production, to ensure that they are produced in accordance with environmental and social requirements.

In Brazil, the most promising raw materials to produce biokerosene, observing the technological processes certified by ASTM International, are babassu, sugar cane, macauba, palm, soybeans and forest resources (eucalyptus).

The first test with biokerosene in Brazil took place in 2010 on a TAM flight, today Latam. Azul and Gol also conducted experiments with sustainable fuels. During the 2014 World Cup, Gol performed over 300 flights with a 4% biofuel blend, which prevented the emission of 239,136.32 kg of CO_2.

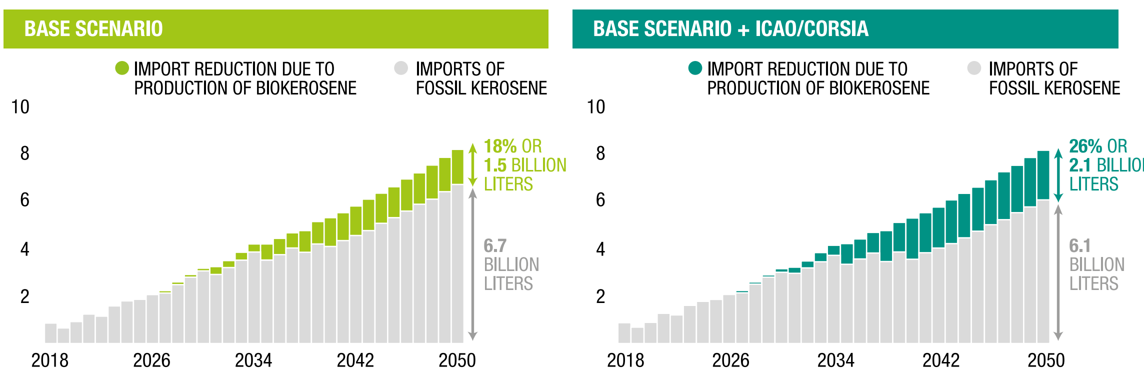
It is noteworthy that biokerosene and renewable aviation hydrocarbons present a competitive advantage in Brazil, as they consist of interesting solutions for decen-

GRAPH 25. BIOKEROSENE SHARE OF TOTAL AVIATION FUEL CONSUMPTION (IN BILLIONS OF LITERS).



SOURCE: ENERGY RESEARCH OFFICE.

GRAPH 26. IMPACT OF BIOKEROSENE ON AVIATION FUEL IMPORTS (IN BILLIONS OF LITERS).



SOURCE: ENERGY RESEARCH OFFICE.

tralized supply and consequent reduction in logistics costs. Currently, more than 80% of national jet fuel production is in the Southeast Region, while consumption is distributed through aerodromes spread throughout Brazil, in many cases in remote areas. Transportation of fuel to these areas incurs in high operational costs.

Moreover, it is an important alternative to the importation of fossil fuels. The national jet fuel balance, conducted by the Energy Research Office (EPE), shows an estimate of growth in demand by 2050 that will not be accompanied by the increase in production, as shown in the chart below.

EPE also estimates that by 2050 the share of biokerosene in the total consumption of aviation fuels could reach 1.5 billion liters, which would reduce the need for imports by 18%. Considering the additional incentive promoted by CORSIA, this amount can reach 2.1 billion liters consumed.

Sustainable aviation fuel research and development initiatives

Petrobras

Petrobras, a mixed economy company based in Rio de Janeiro, currently operates in several countries in the energy segment, primarily in the areas of exploration, production, refining, marketing and transportation of oil, natural gas and its derivatives. The company conducts ongoing projects related to the production of biokerosene and renewable diesel in its refineries.

One possibility is the processing of vegetable oil to produce aviation kerosene with renewable content (co-processing). Petrobras already has a successful experience in producing renewable diesel by co-processing up to 5% vegetable oil in Hydrotreating Units (HDT). Renewable content diesel is superior in quality to the mixture of fossil diesel with the same proportion of transesterification and esterification of fatty materials. There is also technology available for units dedicated to operating exclusively on renewable materials (Hydrotreating processes - HDT), which require, however, new investments.

Given that these processes also produce renewable diesel in significant amounts, the economic viability of the project depends on regulatory adjustment: it is important that renewable diesel production, as well as biodiesel (ester), can generate CBIO Decarbonization Credits at the RenovaBio programme.

Green Airport Programme

Petrobras Distribuidora runs the Green Airport Programme, which promotes the use of technologies and eco-efficient practices at BR Aviation units, with the aim of transforming them into sustainable Aircraft Supply Parks, capable of using natural resources more consciously.

The main goals of the project are to reduce the consumption of treated water; reduce and efficiently use energy; reduce waste generation; as well as reduce and control emissions.

Thus, BR Aviation units with the Green Airport concept are equipped with systems for rainwater collection and reuse, effluent treatment, recycling and selective waste collection, and efficient production and consumption of electricity.

The project was implemented in 31 airports in 21 states. The main results achieved refer to an average reduction of 48% in energy consumption and the control and efficient use of treated water, as well as increased workforce awareness to minimize waste generation and control emissions.

ProQR - Alternative Fuels without Climate Impacts

In August 2017, the Ministry of Science, Technology, Innovation and Communications (MCTIC) and the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), the German Agency for Technical Cooperation, initiated the project

"Alternative Fuels without Climate Impact - ProQR", officially established by the Supplementary Adjustment of June 26, 2017 to the Basic Technical Cooperation Agreement between the Government of the Federal Republic of Brazil and the Government of the Federal Republic of Germany of September 17, 1996.

The ProQR aims to create an international reference case for the application of alternative fuels without climate impacts in air transport. Alternative fuels in this sense are synthetic fuels, whose main input is renewable electricity; they are also called renewable electrofuels. The production of these fuels may be based only on inputs from ambient air and electricity, or include biogenic inputs. The ProQR will contribute to increased production of alternative fuels and reduced greenhouse gases.

In the current scenario, the growing expansion of the air transport network in remote areas in Brazil presents enormous logistical challenges. Long and complicated fuel transportation routes generate high costs and endanger the environment. In addition, the growing demand for fuel cannot be fully met by biofuels such as ethanol and biodiesel.

Brazil has great potential to produce energy from decentralized renewable sources, has a well-developed industry and a growing demand for fuels, in addition to recognized expertise in biofuels. Germany in turn has expertise in the production of environmentally friendly synthetic fuels. In this scenario, the technical cooperation signed between the two countries allows them to work together for global decarbonization and contribute to innovation at a global level in the production of state-of-the-art fuels.

The project aims to create, through a pilot plant, a reference case that proves the plausibility, feasibility and possible international replication of the production and use of sustainable aviation fuels that are entirely climate neutral.

To achieve this goal, in 2017, the Advisory Committee held its first meeting, attended by members of Government, industry, and academia from both Brazil and Germany.

In 2018, studies were conducted on the plausibility of a concept of decentralized production of synthetic fuels, as well as the description of its technical and economic feasibility, market niches and approximation to the technological route (Fischer-Tropsch, approved by ASTM 7566 Annex 1 and 4). In partnership with EPE[21], research was conducted to examine the status quo of the aviation fuel value chain in Brazil and determine the actual market cost of sales by distributors. The project sought to analyze the real costs of fuels, including hidden costs, that could enable local opportunities for alternative aviation

21 Source: "Análise de Conjuntura dos Biocombustíveis, Ano 2017". Energy Research Office.

fuels based on economically restrictive logistical supply conditions.

The results show that the solution created tends to be suitable for remote locations, which have higher logistics costs and demand for reduced quantities of biokerosene (≅ 500 liters/day). Scaling will take place through serial production in the form of ready-made modules, and not by increasing the productivity of a single plant. The survey also indicated that synthetic aviation fuels are expected to be economically competitive after 2030 [22].

In August 2018, a Memorandum of Understanding (MoU) was signed between GIZ and the National Agency of Petroleum, Natural Gas and Biofuels (ANP), which is responsible for certifying the fuels to be produced and for proposing improvements to the production process. In October of the same year a business consortium was formed, also by signing a MoU.

Following the theoretical proof and the engagement of relevant players, from 2019 to 2020, the said international consortium, led by a Brazilian company, will build the pilot plant in Brazil, the facility being financed by Brazilian and international funds. Experiments will be systematically documented, scientifically validated and provided to the international discussion of decarbonisation of the air transport sector.

22 Source: “Análise de Conjuntura dos Biocombustíveis, Ano base 2018”. Energy Research Office.

Brazilian Biokerosene and Renewable Platform

Launched during RIO+20, in 2012, by the Brazilian Airlines Association (ABEAR), Brazilian Union of Biokerosene and Renewables (UBRABIO), GOL Linhas Aéreas and Curcas Diesel Brasil, the Brazilian Platform of Biokerosene and Renewables (PBBR) focuses on the sustainable production of biofuels from oilseeds and residues on logistically optimized regional multi-material and multi-process platforms.

Since its launch, PBBR, through UBRABIO, has been actively involved in formulating public policies for structuring the aviation biokerosene and synthetic hydrocarbons segment and integrating private initiative with local governments and states to make regional projects viable, promoting sustainable development in the region in line with the UN Sustainable Development Goals (SDGs).

Given the continental dimension of Brazil and its various airports, the strategy that has been developed is the implementation of production units close to the sources of raw material and consumption.

Vision 2030 BR

“ Implement a 2030 BR Agenda based on highly integrated regional, ‘ from research to tank’, logistically optimized chains for sustainable biofuels and renewable production to mitigate civil aviation GHGs to serve CORSIA at Brazilian airports,

environmental recovery and reforestation through the use of oilseeds to meet NDC targets for Brazil's insertion into the low carbon global bioeconomy advocated by the Paris Agreement. "

Minas Gerais Biokerosene and Renewable Fuels Platform

Launched in 2014, the Biokerosene and Renewable Fuels Platform integrates 853 municipalities in the state of Minas Gerais, located in the southeastern region of Brazil, in a state platform for innovation and technology, inserting Minas Gerais in the global effort to transitioning to the green economy of biofuels.

In this sense, Vision 2030 MG seeks to foster sustainable development of Minas Gerais in the next decade, leveraging its agricultural base and industrial infrastructure, with the introduction of new disruptive technologies for biomass and waste conversion (circular economy), preparing the state for its entry in the bioeconomy, and contributing to sustainability.

This positive agenda is based on the intensive reforestation action to increase water recharge of the state's aquifers through the environmental restoration of permanent preservation areas (APPs), legal reserves and oilseed degraded pastures of regional biodiversity, intercropped with seasonal crops (energy + food), using agricultural waste and the organic fraction of urban solid waste (MSW), digitally integrated into an advanced artificial intelligence platform (Big Data, IoT, predictive models) for field technification in Agriculture 4.0 and ingress of the Minas Gerais agroindustrial segment in Industry 4.0.

In this systemic approach it is proposed to integrate approaches to biomass and waste to reduce the costs of raw materials and production of Green Diesel (HVO), Biokerosene and Renewables taking advantage of the synergy arising from the integration of high technology processes in production of sustainable biomass and the use of organic waste, promoting sustainable regional development with a strong environmental bias.

Intensive use of Information and Communication Technology (ICT) at all links in the chain will enable substantial reduction in operating costs, as well as the efficiency and productivity of Agriculture 4.0 integrated with Industry 4.0, with strong use of Artificial Intelligence, IoT, and predictive models targeting the replicable paradigm shift to a sustainable ecosystem - "from research to the wing of the plane".

Vision 2030 MG is based on three initiatives to achieve the sustainable development goals of the State of Minas Gerais:

Water: water as an integrating element of the regional Agenda 2030 of the different regions of the state, with the recovery of the Paraibuna basin of Zona da Mata Mineira as a pilot experience supported by the National Water Agency (ANA). Vision 2030 MG promotes reforestation with native oilseeds in the Biomass approach, with native palm tree macauba (Acrocomia aculeata) as the main native species, given its productivity and ability to increase water permeability in relation to the crown leaf characteristics and the thorns of the stem, improving the hydrological cycle of the state watersheds.

Biomass: sustainable production of biomass in the Agriculture 4.0 vision with intensive use of Information and Communication Technology in highly replicable models, combining annual crops with perennial oilseeds (APLs), aiming at the qualification of family farming and rural entrepreneurship. The initial implementation of Demonstration Technical Units (DTUs) in all municipalities adhering to the project enables the qualification and training of farmers in energy and food production.

Waste: structured from innovative Circular Economy processes, this initiative converts agricultural waste, organic fraction of urban waste (MSW), sewage sludge, sugarcane bagasse, eucalyptus chips, sawdust into high value-added products: bio-oil, synthesis gas and bio-coal as inputs for RenewCo's Integrated Biorefining Platform for the Juiz de Fora Proof of Concept. It promotes strong social inclusion through the integration of Recyclable Waste Pickers Associations in all municipalities for the collection of oils and waste fat (OGR) and in the sorting and conditioning of urban solid waste.

Zona da Mata Biokerosene and Renewable Fuel Platform

The Zona da Mata Mineira is one of the mesoregions of the state of Minas Gerais, made up of 142 municipalities that, according to data from the João Pinheiro Foundation, showed the lowest per capita GDP growth from 1999 to 2011, among all 12 state regions. Historically, the region was one of Brazil's first agricultural frontiers when, in the first half of the 19th century, it was one of the country's leading coffee producers.

In this sense, the City of Juiz de Fora has been coordinating multi-stakeholder actions with the participation of the Federal Government, Government of Minas Gerais, EMBRAPA, EMATER, Federal Universities (Minas Gerais, Juiz de Fora, Viçosa, Lavras), UBRABIO, GOL Linhas Aereas, Curcas Diesel Brasil, Agropecuária Serra Negra/Entaban S.A, Geoflorestas, RenewCo among others, mobilizing efforts together with other 45 municipalities in the region to implement a regional development model aligned to the principles of Agenda 2030 reiterated in the Paris Agreement (COP 21), consolidating the concept of Circular Economy, in a collaborative platform, with insertion of regional municipalities in the global green economy.

Launched on June 5, 2018, the project will promote environmental restoration in 130,000 hectares of degraded areas established in pastures and conservation areas, aiming to increase the recharge capacity of regional springs and the concomitant improvement of water quality, from the implementation of agrosilvipastoral and agroforestry systems using native oilseed species, such as macauba, structured in the broader concept of reforestation and sustainable agroecological management.

The Zona da Mata Biokerosene and Renewable Platform Proof of Concept established specific projects to promote a replicable process and competency integration model to synergize all existing local infrastructure and resources, reducing Capex (fixed investment), optimizing Opex (operating costs), productivity, and increasing employment and regional income.

From the Proof of Concept, the following results are expected:

- Validation of the concept of highly integrated regional chains, from research to tanks, for distributed production of biofuels and renewable products from biomass and organic waste in compact distributed production units with innovative technologies.
- Positive Agenda for sustainable regional development of the municipalities of Zona da Mata based on forest restoration with macauba, for replication in all municipalities of Minas Gerais.
- Environmental Recovery of the Atlantic Forest Biome, with water recharge of springs and carbon sequestration of reforestation.
- Technological development of biofuels supported by FIEMG's CIT/SENAI.
- Supply of biokerosene to Zona da Mata Regional Airport/MG, Santos Dumont Airport/RJ and Galeao International Airport/RJ with reduction of GHG from Brazilian civil aviation and compliance with CORSIA.

Based on the HEFA - Hydroprocessed Esters and Fatty Acids and TCR - Thermo Catalyst Reforming conversion processes, the Integrated Biorefine Platform will be able to produce 1,250,000 liters of biokerosene by 2023 and could reach over 200 million liters by 2031.

TABLE 16. ESTIMATION OF BIOKEROSENE PRODUCTION.

Year	Biokerosene (liters)
2023	1,250,000
2024	1,637,257
2025	6,132,397
2026	15,122,677
2027	37,598,377
2028	71,311,927
2029	116,263,327
2030	172,452,577
2031	266,169,500

SOURCE: CURCAS BRASIL.

The production chain will be certified by the Round Table on Sustainable Biomaterials (RSB), sustainability consulting, certification criteria for smallholders and integrated biokerosene value chain.

Brazilian Network of Biokerosene and Renewable Hydrocarbons for Aviation

The Brazilian Network of Biokerosene and Renewable Hydrocarbons for Aviation (RBQAV) was launched on May 24, 2017 at the seminar “Biodiesel and Biokerosene: Economic and Environmental Sustainability”, promoted by the Brazilian Union of Biodiesel and Biokerosene (Ubrabio).

RBQAV is an initiative of the Ministry of Science, Technology, Innovations and Communication (MCTIC), companies related to the oleochemical sector and universities and research institutes that work in research on biokerosene and renewable hydrocarbons.

The network aims to carry out research, development and innovation through partnerships between governmental institutions, research institutions and private companies in the productive and consumer sector, and thus support the development of the aviation biokerosene sector nationwide. In addition, the network supports the creation of public policies and enabling actions for the production of biokerosene and renewable hydrocarbons contributing to the reduction of emissions from the civil aviation market, in line with the Brazilian NDC targets, the international commitments made by Brazil and the RenovaBio Program.

National Agency of Petroleum, Natural Gas and Biofuels - ANP

In Brazil, the National Agency of Petroleum, Natural Gas and Biofuels (ANP) is responsible for the technical specifications of aviation fuels as well as for the supervision of the segment’s activities, which includes the control of fuel quality along the supply chain. Recently, the ANP has revised the quality standards for fossil aviation (ANP Resolution No. 37/2009) and renewable (ANP Resolution No. 63/2014). The review aimed at improving the quality of fuels, and to align these specifications with ASTM International ones.

ASTM International, formerly the American Society for Testing and Materials, is a not-for-profit international consensus standards association that collects, standardizes and disseminates technical information. Founded in 1898, it has over 30,000 members around the world, representing oil producers, OEMs, manufacturers of physicochemical analysis equipment and regulatory institutions from different countries.

In civil aviation, ASTM standards are a world reference for the technical specifications of aviation fuels. ASTM’s Subcommittee D02.J0 is responsible for the development of standards for aviation fuels, which include specifications for petroleum aviation kerosene, aviation gasolines and alternative aviation kerosene, as well as specific fuel certification test methods. Its member organizations include Boeing, Embraer, GE, Pratt & Whitney, Honeywell, FAA, SwRI, Exxon Mobil, Petrobras, ANP, among others.

In this sense, the harmonization of aviation fuel specifications is a requirement of the aviation industry, since the aircraft refueled in Brazil can be refueled in any region of the world, which requires the availability of fuel with a minimum standard of quality in any location.

Thus, after undergoing Public Consultations and Hearings, Resolution ANP 778/2019 brings the aforementioned two resolutions into a single standard, in order to facilitate understanding of the regulations.

Located in Brasília/DF, ANP's Center for Technological Research and Analysis - CPT is the Agency's laboratory and its main duties are: i) to perform physical-chemical tests on fuel and lubricant samples, to meet ANP's demands and ii) develop studies and research in the area of quality of oil, derivatives and biofuels. The Center has modern analytical infrastructure for complete certification of gasoline, ethanol, diesel, biodiesel (B-100), lubricating oils and petroleum, and is accredited according to ISO 17025.

Regarding aviation fuels, the Center currently has the infrastructure to certify about 60% of the tests required in the ASTM D7566 and RANP 63/2014 alternative aviation kerosene specifications, and ASTM aviation gasoline specifications. D910 and RANP 5/2009 (estimated at around R$ 5 million reais). In addition, the CPT has expertise in the subject, as it is often demanded by institutions such as the Center for Research and Prevention of Air Accidents (CENIPA) and the Federal Police not only to perform physical and chemical tests, but also to issue technical advice and recommendations on sampling operational procedures and best practices for aviation fuel quality assurance.

CPT/ANP has been working R&D and has expanded its capacity and competence for certification and quality control of sustainable aviation kerosene, including the acquisition of analytical equipment and specific training of human resources. Thus, improvements of the laboratory infrastructure will allow to fully meet the demands of government institutions related to aviation.

Regarding innovative initiatives, the CPT will play an active role in the Brazil-Germany cooperation project "Alternative Fuels without Climate Impact - ProQR", which aims to contribute to the gradual decarbonisation of aviation. The most promising niche was identified as the decentralized production of aviation fuels, and the most appropriate route to ensure product reliability and quality is the Fischer-Tropsch route using renewable hydrogen and some renewable source of carbon dioxide.

CPT will be responsible for the certification of the fuels to be produced and to suggest adjustments of the production process in order to reach the highest quality level, possibly beyond the fossil fuel quality. Such participation was formalized by the signing, on August 24, 2018, of a memorandum of understanding between the ANP and the German Cooperation Agency GIZ.

CHAPTER 7

Market-based measures

Carbon Offsetting and Reduction Scheme for International Aviation – CORSIA

In 2016, ICAO Member States agreed to create the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), a global market-based measure (GMBM) scheme for simple offsetting of emissions on international flights exceeding 2020 levels, taking into account special circumstances and respective capabilities. The scheme was approved by Resolution A39-3: Consolidated statement of continuing ICAO policies and practices related to environmental protection - Global Market-based Measure (MBM) scheme.

It is a transitional solution (up to 2035 or further) and is complementary to a broader package of measures, so that the sector can achieve its global aspirational goal.

Thus, the average emissions from international operations in 2019 and 2020 will compose the line that will serve as a comparative basis for the calculation of emissions growth in the coming years.

There are three main aspects to CORSIA implementation that should be highlighted:

Phased implementation: the scheme is divided into 3 phases (i) pilot phase (2021-2023); (ii) first phase (2024-2026); and (iii) second phase (2027-2035). Participation in the first two phases is voluntary. From 2027 through 2035, CORSIA applies to all States that have an individual share of international aviation activities in RTKs in year 2018 above 0.5 per cent of total RTKs or whose cumulative share in the list of States from the highest to the lowest amount of RTKs reaches 90 per cent of total RTKs. States with international activity below these levels, as well as Least Developed Countries (LDCs), Small Island Developing States (SIDS), and Landlocked Developing Countries (LLDCs) have compensation-free routes unless they volunteer to participate.

Route approach: in order to avoid competitive distortions, a route will only be covered by offsetting requirements when both source and destination States are participating in the scheme. This prerogative ensures that obligations will apply to all operators in the same market.

Distribution of obligations: initially, the amount of CO_2 emissions required to be offset arising from the growth of international aviation as a whole will be distributed among the operators in a sectoral manner. As a result, each aircraft operator's offset requirement will be proportional to its market share. From 2030 onwards, individual growth in relation to the baseline will have an increasing weight. It should be noted that the individual approach has been criticized by Brazil as it favors established airlines and creates a disproportionate burden on new entrants. An economic regulation that translates into differentiated treatment among actors in the same market is incompatible with the role and objectives of government action. Moreover, the distribution of obligations in an individual manner establishes a kind of "acquired right" to issue to incumbents, while new operators, as well as those with reduced market share in the years 2019/20, will be more severely penalized.

Brazilian routes will be subject to compensation in CORSIA from 2027 on. Despite the sector's recognition that its growth must be accompanied by sustainability policies, the Brazilian aviation market is still immature, i.e., it tends to grow more, in relation to the 2020 levels, than other established markets. In Brazil, the number of trips per capita - number of trips per air transport in relation to the population - is still low (0.56) [23] when compared to other countries and the expectation is that new users are added to the modal.

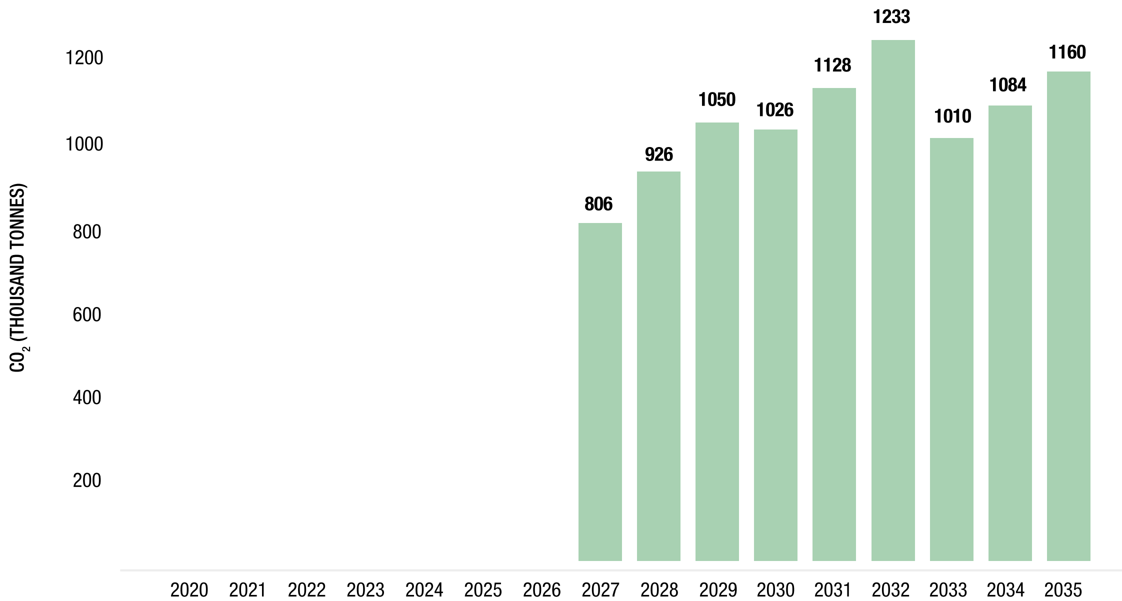
It should be noted that Brazil has actively participated in the ICAO discussions that enabled the establishment of this GMBM scheme. As with any international negotiation, accommodating different national and regional realities in a single set of rules requires adaptation mechanisms. The use of a phased implementation for the CORSIA was the solution found to some extent to recognize the historical responsibilities as well as the State's different stages of development. Thus, participating in the scheme earlier than initially agreed would result in the need to restore the balance between the elements that make up the CORSIA agreement.

Nevertheless, CORSIA's monitoring, reporting and verification - MRV system is already in place as from 1 January 2019. Brazil has internalized the MRV SARPs to the domestic regulatory framework through ANAC Resolution No. 496/2018 and Ordinance No. 4005 / ASINT / 2018.

It is also noteworthy that in 2018 a cooperation project between Brazil and the European Union was developed to implement the CORSIA MRV system in Brazil, in view of the European experience with EU-ETS. Within the scope of the partner-

23 Source: ANAC.

GRAPH 27. EVOLUTION OF CO_2 OFFSETTING OBLIGATIONS OF BRAZILIAN AIRLINES (THOUSAND TONNES)



SOURCE: TECHNICAL NOTE NO. 38/2017/ ASINT/ANAC - CORSIA COST-BENEFIT ANALYSIS.

ship, an orientation guide[24] was published, aimed at airlines, to level the understanding of emission control requirements on international flights.

The project also enabled the development of an electronic system for checking the data reported by airlines under CORSIA. The comparison is made by crossing these data with those available in the ANAC Database. This is a very important tool for fulfilling the Agency's obligations towards CORSIA as it determines the level of compliance between both sources of information.

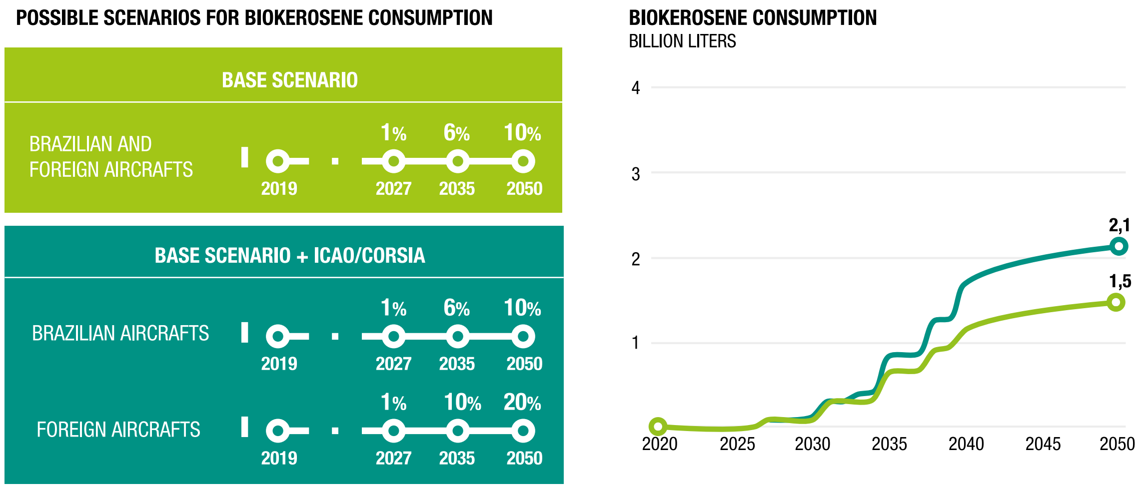
In a simulation conducted by ANAC in 2017[25], it is estimated that Brazilian air operators should offset more than 9 million tonnes of CO_2 on international flights from 2027 to 2035, as shown above[26].

24 Source: "Guia CORSIA - Monitoramento, Reporte e Verificação das Emissões de CO² da Aviação Internacional". Available at http://infraestrutura.gov.br/component/content/article/17-ultimas-noticias/8685-sac-elabora-guia-para-orientar-companhias-aéreas-sobre-monitoramento-de-emissão-de-co².html

25 Source: Technical Note No. 38/2017/ASINT/ANAC - CORSIA Cost-Benefit Analysis.

26 The simulation used long-term ICAO international aviation growth scenarios, which are aggregated by route groups; in the Brazilian case, the scenarios provided for international flights from Latin America were used, applying them only to the routes that will be subject to CORSIA.

GRAPH 28. BIOKEROSENE SCENARIOS



SOURCE: PROJECTION OF JET FUEL AND BIOKEROSENE SUPPLY AND DEMAND IN BRAZIL - ENERGY RESEARCH OFFICE, MINISTRY OF MINES AND ENERGY.

In addition, studies by the Energy Research Office (EPE) estimate that CORSIA could promote an additional increase in biokerosene consumption of 600 million liters by 2050, as shown above.

Support to third countries - CORSIA Buddy Partnerships

The program is part of ICAO's Action Plan to support Member States in the implementation process of CORSIA. Under the partnerships, technical experts from donor states work with beneficiary country focal points to provide on-site training, and follow-up on the preparation and implementation of emission monitoring, reporting and verification - MRV mechanisms, especially in relation to the creation of regulatory framework.

In cooperation with Italy, Brazil provided support to other lusophone and Latin American countries in preparing for the implementation of the scheme. Thus, Brazilian technicians went to Angola, Cape Verde, Colombia, Mozambique, Paraguay and Sao Tome and Principe to provide assistance.

RenovaBio

The National Biofuels Policy (RenovaBio) was instituted by Law No. 13.576, of December 26, 2017, and its main objective is to recognize the strategic role of biofuels in the Brazilian energy matrix regarding energy security and mitigation of greenhouse gas - GHG emissions in the fuel sector. The policy seeks to value the positive environmental externalities of biofuels and thereby promote the process of decarbonization of the fuel market.

Thus, RenovaBio intends to provide an important contribution to the fulfillment of Brazil's Nationally Determined Contribution (NDC) under the Paris Agreement; promote the proper expansion of biofuels in the energy matrix, with emphasis on the regularity of fuel supply; and ensure predictability for the fuel market by inducing energy efficiency gains and reducing GHG emissions from biofuel production, sales, and use.

Unlike traditional measures, RenovaBio does not propose the creation of subsidies, carbon tax, presumed credit or volumetric mandates to add biofuels to fossil fuels. The program seeks to stimulate the production and use of biofuels through two instruments:

- **Establishment of national emission targets** for the fuel matrix, set for a period of ten years. National targets will be broken down into individual targets annually for fuel distributors according to their share of the fossil fuel market. The law provides for fines in case of failure to meet the targets; and
- **Individual certification of biofuel producing units**, giving grades inversely proportional to the carbon intensity[27] of the biofuel produced. The note will accurately reflect each producer's individual contribution to mitigating a specific amount of GHGs relative to its fossil substitute (in tonnes of CO_2 equivalent). The three eligibility criteria defined are:
  I. Certified raw material must not originate from deforested area after December 26, 2017, date of signing of RenovaBio law;
  II. Sugarcane producers must have a Rural Environmental Registry (CAR) with updated or pending status; and
  III. Cultivation areas must respect the agroecological zoning of sugar cane (ZAE Cana) and oil palm.

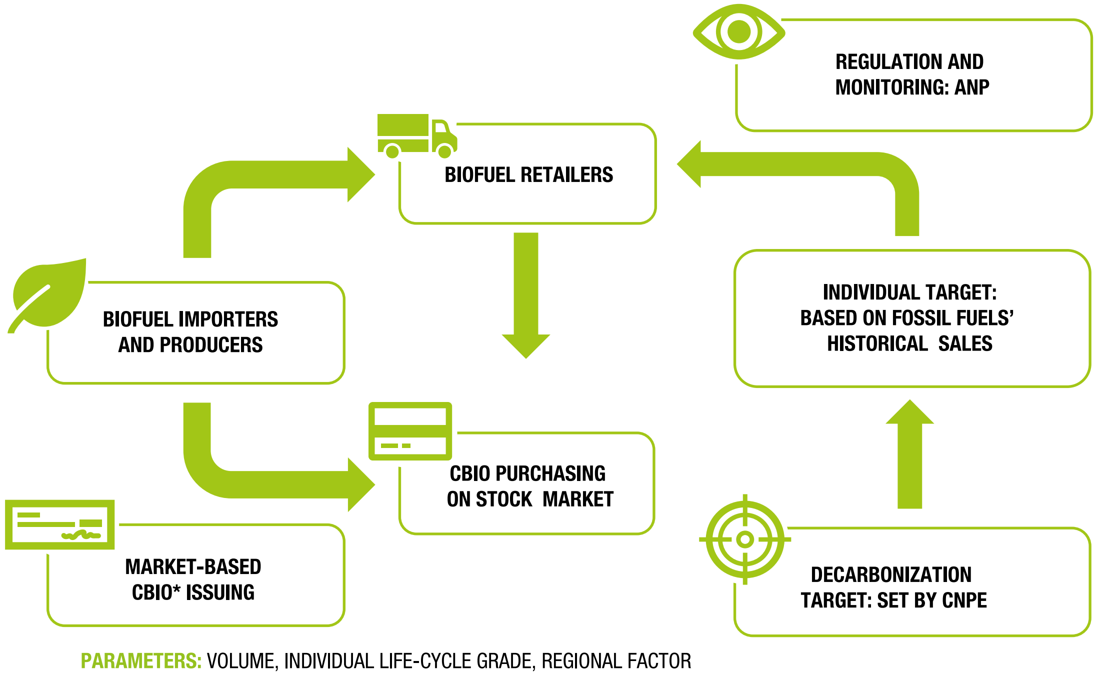
These two instruments will be linked to the creation of the Biofuel Decarbonization Credit - CBIO: a financial asset, traded on the stock exchange and issued by the biofuel producer after its commercialization (invoice)[28].

The amount of CBIOs emitted should vary according to the volume of biofuels traded and the Energy Efficiency Note of each primary issuer. Thus, the lower the carbon intensity in the life cycle of biofuels, the more CBIOs will be emitted for a given volume traded. Fuel distributors will meet the target by demonstrating ownership of the CBIOs in their portfolio. The figure below illustrates the process of RenovaBio deployment and issuance of CBIOs.

27 Ratio of greenhouse gas emissions, based on life cycle assessment, calculated in the fuel production process, per unit of energy.

28 Value attributed in the Certificate of Efficient Biofuels Production, which represents the difference between the carbon intensity of its substitute fossil fuel and its carbon intensity established in the certification process.

FIGURE. RENOVABIO AND CBIO RENOVABIO MARKET DEPLOYMENT PROCESS.



SOURCE: MINISTRY OF MINES AND ENERGY - MME.

As noted, RenovaBio establishes a market-based mechanism that seeks to diversify fuel supply in the country, inducing energy and environmental efficiency, given that the certification process both values and recognizes the best biofuels in terms of the highest amount of energy generated with lower GHG emissions. This mechanism should ensure the necessary security for investments in new plants, as CBIOs will offer more revenue to producers.

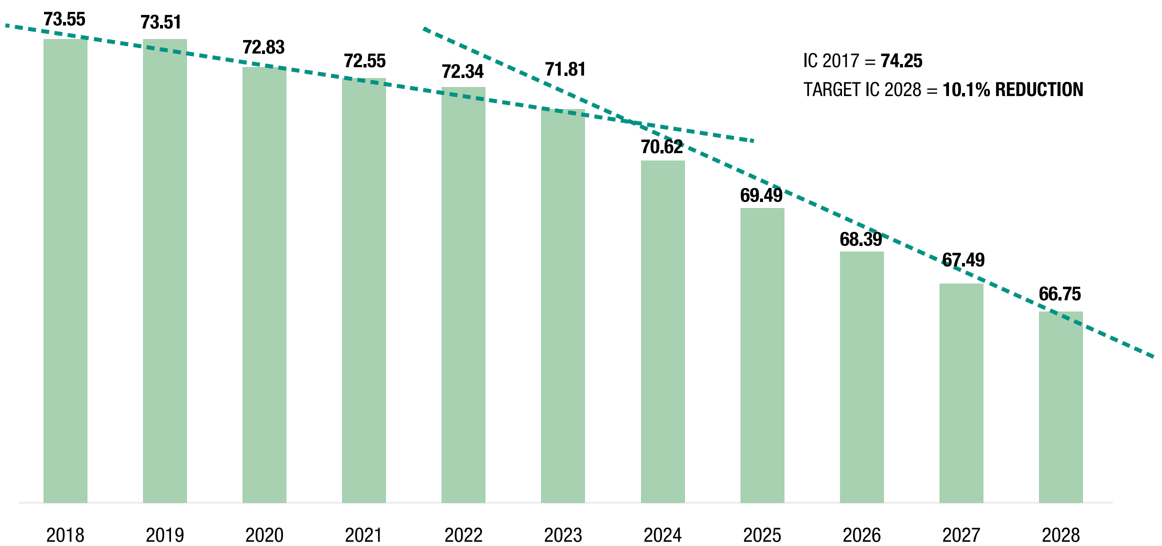
In this sense, "by creating a fuel decarbonization certificate (CBIO) market, RenovaBio allows for the internalization of positive environmental externalities of biofuels and therefore the industry's remuneration for this GHG emission abatement service. It is this additional compensation that, by expanding the revenue pool and contributing to the apportionment of costs, allows the biofuel supply to expand to the optimum social level. [29] "

The program therefore strives for promoting free competition in the biofuels market, adding value to Brazilian biomass, and for economic and social development and inclusion.

In line with Brazil's NDC, RenovaBio has set for the period from 2019 to 2028 the target of 10.1% reduction of carbon in-

29 Source: "Análise de Conjuntura dos Biocombustíveis, 2017" - Energy Research Office, Ministry of Mines and Energy.

GRAPH 29. FUEL MIXTURE AVERAGE CARBON INTENSITY (GCO_2E/MJ)



SOURCE: MINISTRY OF MINES AND ENERGY - MME.

tensity of the fuel matrix. Thus, the policy provides, by 2028, the increase to 28.6% for the share of renewable fuels in the matrix, which will reduce emissions from an estimated 425 million tonnes of CO_2 to 345 million in 2028.

According to analyzes and simulations, it is estimated a 0.84% price drop for fuels in Brazil.

Initially, given the lack of commercially available aviation biofuels, the market share of aviation kerosene will not be part of the calculation of distributors' targets[30].

However, there is no impediment for aviation biofuel producers and importers to benefit from the issuance of CBIOs.

It should be noted that the Ministry of Mines and Energy - MME expects that CBiOs could be used within CORSIA to fulfill airlines offsetting requirements. To do so, they must meet the Emissions Unit Criteria (EUC) established by ICAO.

RenovaBio should also stimulate the development of new sustainable fuel production technologies, including aviation fuels.

30 Source: Resolução CNPE Nº 5 of June 05 2018.

CHAPTER 8

Closing remarks

This Action Plan reflects the collaborative actions of the Working Group - WG members institutionalized by Ordinance No. 514 of October 1, 2018. In February 2019, the WG met for a three-day workshop, which guided the information now presented. At the time, ways to systematize and standardize the methodologies and procedures for data collection were also discussed.

Since 2015, significant progress has been made in implementing the Action Plan. The results show that Brazilian airlines continue to improve annual energy efficiency. In 2018, the international aviation fuel consumption rate was 29 liters[31] per 100 RTK, while for domestic operations it was 40.8 liters per 100 RTK. Compared to 2015, the energy efficiency of Brazilian aviation evolved at an accumulated rate of 8.74%, which represents an improvement of 3% per year.

The document also presents the great diversity in the composition of the Brazilian airport network and the efforts by the Federal Government to improve airport infrastructure. Although most airports have structured sustainability programs, it is possible to observe the different levels of maturity in relation to the monitoring and control of GHG emissions.

During the WG workshop to prepare this Action Plan, it became clear how the increased competitiveness among airport operators, resulting from the concession process, also beneficially extends to the environmental area. At the occasion, airport representatives emphasized the importance of the event, which promoted the sharing of information and the exchange of experiences not only between the sustainability areas of the airports, but also between them and airlines. They also highlighted the many challenges shared with airlines, such as those related to solid waste treatment and emergency management.

Regarding the development and use of sustainable fuels, the document gives a broader picture of the energy matrix of the national transport sector, which in 2018 had a 23.1% share of biofuels, responsible for preventing the emission of 63.7 $MtCO_2$.

31 The density of kerosene was considered equal to 0.8.

In addition, in order to promote the proper expansion of renewable fuels in Brazil, the RenovaBio Program was created, foreseeing the increase of biofuels participation to 28.6% by 2028, which will lead to a reduction of 80 million tonnes of CO_2 in that year. Production and importation of aviation biofuels may also benefit from the Program.

Several Brazilian entities are engaged in overcoming the challenges to develop the sustainable aviation fuel chain, from the production of raw materials (Brazilian Biokerosene Platform), to disruptive technologies (ProQR), adaptation of existing refineries (Petrobras), and investments in fuel measurement and certification laboratories (ANP).

Regarding the implementation of CORSIA, the first obligations of the scheme have already been internalized by Brazil, through ANAC Resolution No. 496/2018 and Ordinance No. 4005 / ASINT / 2018. In cooperation with the European Union, a computerized system has been developed that will assist ANAC in undertaking the order of magnitude check.

Simple offsetting is an important initiative for immediate control of aviation's impact on climate change. However, resource mobilization for new technologies and solutions with potential to address the problem within the sector itself is an efficient and definitive alternative that should be sought.

This edition has innovated when compared to previous editions by the effort to quantify the impact of the measures adopted. Nevertheless, over the next three years there should be a higher density of monitored data, which will allow greater precision in the calculations.

Another challenge faced refers to the lack of clarity regarding the planning of new measures or expansion of those currently adopted, which made it impossible to project fuel economy based on this information. Thus, the evolution of emissions up to 2050 was estimated considering only RTK growth and energy efficiency projections. For the RTK, the growth rate calculated in the National Airway Plan 2018-2038, extrapolated to 2050, was used. For the energy efficiency projection, the logarithmic trend line for the historical data (from 2000 to 2018) was used, according to the tool methodology developed by ICAO, the Environmental Benefits Tool (EBT).

Brazilian civil aviation has broad growth potential and this Action Plan reflects Brazil's commitment to national efforts as to achieve the sector's sustainable development strategic goals, with increased accessibility, connectivity and efficiency, while preserving the environment. In this context, Brazil reinforces its voluntary commitments to energy efficiency, carbon neutral growth and continually improving its Action Plans. In addition, Brazil will make efforts to contribute to the achievement of the 2050 ICAO Vision for Sustainable Aviation Fuels.

Inventory Data

Table 1 presents historical RTK, fuel and carbon dioxide data for domestic and international flights, for the years 2000 to 2015.

TABLE 1. RTK, FUEL AND CO_2 DATA OF BRAZILIAN AIRLINES. DOMESTIC AND INTERNATIONAL FLIGHTS. 2000 TO 2015.

	Flights					
Year	Domestic			International		
	RTK (000')	Fuel (ton)	CO_2 (ton)	RTK (000')	Fuel (ton)	CO_2 (ton)
2000	2,763,115.5	1,660,602.1	5,247,502.7	2,937,769.2	938,828.0	2,966,696.3
2001	2,946,411.7	1,814,358.8	5,733,373.9	2,702,761.4	938,603.1	2,965,985.6
2002	2,951,685.8	1,825,583.8	5,768,844.8	2,792,506.9	894,495.5	2,826,605.8
2003	2,735,651.5	1,520,246.7	4,803,979.6	2,807,562.8	816,788.5	2,581,051.7
2004	3,048,290.5	1,584,238.0	5,006,192.0	2,851,402.5	853,994.1	2,698,621.3
2005	3,709,487.9	1,769,857.1	5,592,748.4	3,229,970.6	989,527.8	3,126,907.7
2006	4,281,691.3	1,816,696.4	5,740,760.6	2,314,539.5	699,781.3	2,211,308.9
2007	4,613,370.1	1,955,502.8	6,179,388.8	2,037,880.1	677,755.8	2,141,708.4
2008	4,943,894.6	2,092,499.6	6,612,298.7	2,222,812.6	820,821.8	2,593,796.9
2009	5,610,077.3	2,287,258.4	7,227,736.6	2,144,404.9	789,590.8	2,495,106.9
2010	6,992,246.5	2,632,853.6	8,319,817.3	2,709,555.5	887,407.6	2,804,208.0
2011	8,017,532.3	2,984,922.5	9,432,355.1	3,364,502.3	970,753.5	3,067,581.0
2012	8,426,164.9	3,138,443.3	9,917,480.8	3,371,785.3	959,435.1	3,031,814.8
2013	8,491,665.4	3,098,710.5	9,791,925.0	3,760,524.2	970,407.5	3,066,487.6
2014	8,911,730.2	3,079,413.2	9,730,945.8	3,833,776.5	925,608.0	2,924,921.4
2015	8,886,422.9	3,089,048.2	9,761,392.4	4,145,881.1	1,050,100.7	3,318,318.2

The data used for construction of the baseline are shown in Table 2, which gathers RTK, fuel and carbon dioxide data if mitigation measures were not adopted.

TABLE 2. SCENARIO WITHOUT MITIGATION MEASURES. ANNUAL RTK, FUEL AND CO_2 DATA FOR BRAZILIAN AIRLINES. DOMESTIC AND INTERNATIONAL FLIGHTS. 2016 TO 2050.

	Flights					
Year	Domestic			International		
	RTK (000')	Fuel (ton)	CO_2 (ton)	RTK (000')	Fuel (ton)	CO_2 (ton)
2016	8,375,444.5	3,091,759.6	9,769,960.4	4,131,242.2	789,922.3	2,496,154.6
2017	8,520,490.6	3,102,707.7	9,804,556.2	4,646,317.0	788,536.4	2,491,775.0
2018	8,750,229.3	3,206,498.2	10,132,534.4	5,595,419.7	1,383,817.2	4,372,862.3
2019	9,004,752.3	3,023,055.9	9,552,856.5	5,758,176.9	1,477,394.1	4,668,565.4
2020	9,435,629.6	3,116,185.8	9,847,147.0	6,033,705.6	1,537,318.6	4,857,926.8
2021	9,872,345.1	3,209,014.6	10,140,486.0	6,312,967.6	1,597,728.4	5,048,821.7
2022	10,291,089.6	3,293,930.1	10,408,819.1	6,580,737.9	1,654,796.7	5,229,157.6
2023	10,717,611.5	3,379,399.5	10,678,902.4	6,853,481.5	1,712,711.1	5,412,167.1
2024	11,152,309.2	3,465,513.4	10,951,022.3	7,131,453.1	1,771,527.9	5,598,028.3
2025	11,596,168.9	3,552,538.7	11,226,022.3	7,415,283.6	1,831,395.6	5,787,210.0
2026	12,050,075.6	3,640,697.6	11,504,604.5	7,705,538.7	1,892,443.6	5,980,121.6
2027	12,514,929.0	3,730,205.9	11,787,450.5	8,002,793.7	1,954,801.5	6,177,172.6
2028	13,079,185.6	3,847,021.9	12,156,589.1	8,363,613.1	2,032,200.9	6,421,754.8
2029	13,718,757.6	3,983,089.5	12,586,562.8	8,772,593.6	2,120,696.3	6,701,400.2
2030	14,392,663.5	4,125,932.8	13,037,947.7	9,203,529.4	2,213,831.8	6,995,708.4
2031	15,101,665.8	4,275,521.8	13,510,649.0	9,656,907.9	2,311,672.7	7,304,885.8
2032	15,847,029.8	4,431,970.6	14,005,027.0	10,133,538.2	2,414,361.8	7,629,383.4
2033	16,630,266.0	4,595,456.6	14,521,643.0	10,634,386.2	2,522,078.0	7,969,766.4
2034	17,453,054.7	4,766,196.9	15,061,182.1	11,160,526.5	2,635,024.3	8,326,676.9
2035	18,316,214.5	4,944,166.4	15,623,565.7	11,712,482.4	2,753,272.5	8,700,341.1
2036	19,222,795.1	5,129,937.6	16,210,602.8	12,292,204.2	2,877,228.5	9,092,042.2
2037	20,174,949.3	5,323,821.2	16,823,274.9	12,901,068.6	3,007,159.5	9,502,624.1
2038	21,174,570.3	5,526,046.7	17,462,307.7	13,540,286.0	3,143,291.2	9,932,800.1
2039	22,224,038.1	5,736,960.0	18,128,793.5	14,211,378.5	3,285,919.3	10,383,505.0
2040	23,325,872.5	5,956,927.6	18,823,891.2	14,915,957.2	3,435,357.1	10,855,728.4
2041	24,482,734.5	6,186,336.6	19,548,823.6	15,655,723.9	3,591,935.3	11,350,515.6
2042	25,697,431.2	6,425,594.2	20,304,877.6	16,432,473.6	3,756,002.7	11,868,968.5
2043	26,972,920.4	6,675,128.1	21,093,404.7	17,248,097.7	3,927,926.3	12,412,247.2
2044	28,312,317.3	6,935,386.7	21,915,821.8	18,104,588.1	4,108,092.5	12,981,572.2
2045	29,718,900.8	7,206,839.8	22,773,613.7	19,004,041.7	4,296,907.2	13,578,226.8
2046	31,196,122.0	7,489,979.2	23,668,334.3	19,948,665.2	4,494,797.4	14,203,559.9
2047	32,747,611.8	7,785,319.7	24,601,610.2	20,940,780.5	4,702,211.6	14,858,988.7
2048	34,376,286.3	8,093,186.7	25,574,470.0	21,982,252.3	4,919,491.6	15,545,593.5
2049	36,085,961.4	8,414,102.3	26,588,563.3	23,075,520.8	5,147,104.9	16,264,851.4
2050	37,880,665.8	8,748,616.6	27,645,628.5	24,223,162.1	5,385,544.7	17,018,321.1

Table 3 gathers RTK, fuel and carbon dioxide data when considering the reduction in fuel consumption achieved as a result of mitigation measures implemented by DECEA and airlines from 2016 to 2018, as well as the future effect of the continuous adoption of these measures.

TABLE 3. SCENARIO WITH THE ADOPTION OF MITIGATION MEASURES. ANNUAL RTK, FUEL AND CO_2 DATA FOR BRAZILIAN AIRLINES. DOMESTIC AND INTERNATIONAL FLIGHTS. 2016 TO 2050.

	Flights					
Year	Domestic			International		
	RTK (000')	Fuel (ton)	CO_2 (ton)	RTK (000')	Fuel (ton)	CO_2 (ton)
2016	8,375,444.5	2,795,828.7	8,834,818.7	4,131,242.2	756,311.4	2,389,943.9
2017	8,520,490.6	2,770,767.7	8,755,625.9	4,646,317.0	749,610.4	2,368,768.9
2018	8,750,229.3	2,856,112.2	9,025,314.6	5,595,419.7	1,301,771.2	4,113,597.1
2019	9,004,752.3	2,902,224.4	9,171,029.0	5,758,176.9	1,456,194.2	4,601,573.5
2020	9,435,629.6	2,985,889.9	9,435,412.0	6,033,705.6	1,514,454.9	4,785,677.4
2021	9,872,345.1	3,069,014.3	9,698,085.3	6,312,967.6	1,573,158.6	4,971,181.3
2022	10,291,089.6	3,144,332.3	9,936,090.1	6,580,737.9	1,628,539.6	5,146,185.0
2023	10,717,611.5	3,219,952.7	10,175,050.6	6,853,481.5	1,684,722.3	5,323,722.6
2024	11,152,309.2	3,295,957.8	10,415,226.8	7,131,453.1	1,741,761.8	5,503,967.3
2025	11,596,168.9	3,372,596.7	10,657,405.5	7,415,283.6	1,799,803.2	5,687,378.2
2026	12,050,075.6	3,450,074.3	10,902,234.8	7,705,538.7	1,858,973.1	5,874,355.1
2027	12,514,929.0	3,528,588.1	11,150,338.5	8,002,793.7	1,919,397.9	6,065,297.2
2028	13,079,185.6	3,632,642.4	11,479,150.1	8,363,613.1	1,994,553.7	6,302,789.7
2029	13,718,757.6	3,754,506.6	11,864,240.7	8,772,593.6	2,080,552.1	6,574,544.6
2030	14,392,663.5	3,882,346.1	12,268,213.5	9,203,529.4	2,171,049.9	6,860,517.8
2031	15,101,665.8	4,016,100.3	12,690,877.1	9,656,907.9	2,266,107.1	7,160,898.5
2032	15,847,029.8	4,155,844.2	13,132,467.6	10,133,538.2	2,365,859.4	7,476,115.8
2033	16,630,266.0	4,301,711.4	13,593,408.0	10,634,386.2	2,470,478.1	7,806,710.8
2034	17,453,054.7	4,453,871.5	14,074,233.8	11,160,526.5	2,580,157.9	8,153,299.0
2035	18,316,214.5	4,612,267.1	14,574,763.9	11,712,482.4	2,694,964.8	8,516,088.8
2036	19,222,795.1	4,777,397.5	15,096,575.9	12,292,204.2	2,815,291.9	8,896,322.5
2037	20,174,949.3	4,949,514.9	15,640,467.2	12,901,068.6	2,941,396.1	9,294,811.8
2038	21,174,570.3	5,128,794.7	16,206,991.4	13,540,286.0	3,073,493.6	9,712,239.7
2039	22,224,038.1	5,315,518.2	16,797,037.6	14,211,378.5	3,211,868.7	10,149,505.0
2040	23,325,872.5	5,509,984.0	17,411,549.4	14,915,957.2	3,356,822.7	10,607,559.7
2041	24,482,734.5	5,712,507.1	18,051,522.5	15,655,723.9	3,508,673.8	11,087,409.2

Year	Flights					
	Domestic			International		
	RTK (000')	Fuel (ton)	CO_2 (ton)	RTK (000')	Fuel (ton)	CO_2 (ton)
2042	25,697,431.2	5,923,419.0	18,718,004.0	16,432,473.6	3,667,757.3	11,590,113.0
2043	26,972,920.4	6,143,067.1	19,412,092.1	17,248,097.7	3,834,426.2	12,116,786.9
2044	28,312,317.3	6,371,815.5	20,134,937.0	18,104,588.1	4,009,052.0	12,668,604.2
2045	29,718,900.8	6,610,044.8	20,887,741.5	19,004,041.7	4,192,025.0	13,246,798.9
2046	31,196,122.0	6,858,152.8	21,671,763.0	19,948,665.2	4,383,755.5	13,852,667.4
2047	32,747,611.8	7,116,555.3	22,488,314.8	20,940,780.5	4,584,674.7	14,487,572.1
2048	34,376,286.3	7,385,491.9	23,338,154.4	21,982,252.3	4,795,109.3	15,152,545.5
2049	36,085,961.4	7,665,379.1	24,222,598.1	23,075,520.8	5,015,508.2	15,849,006.0
2050	37,880,665.8	7,956,655.8	25,143,032.2	24,223,162.1	5,246,345.1	16,578,450.4

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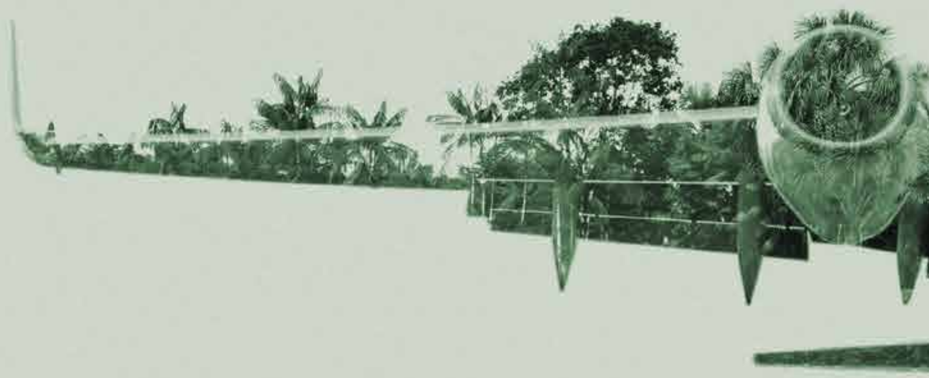

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