Brazil's Action Plan on the **reduction of Greenhouse Gas Emissions** from aviation

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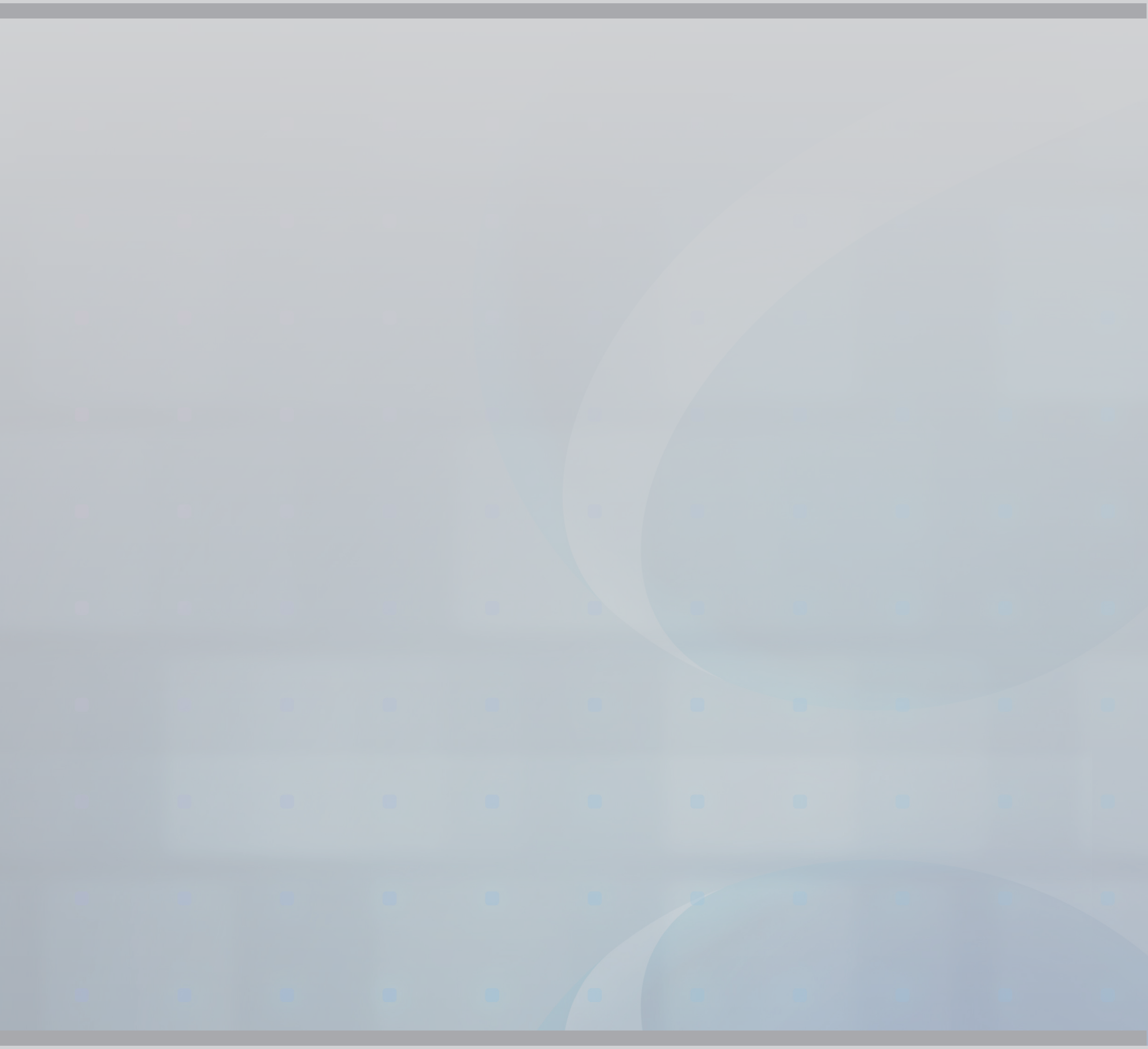
Summary



1 - Introduction

Brazil is a country with continental dimensions which underwent significant economic growth and substantial reduction of social inequalities in the last decades. Not to mention other aspects of this processes, poverty reduction and the growth in the general population purchasing power resulted in a sustained growth on the demand for air transportation in the country. Liberalization of domestic and international markets, while promoting competition and removing obstacles to the establishment of services and routes, resulted in substantial reductions on average air fares, thus also strengthening demand for air transportation.

As happened in other countries which liberalized their aviation sectors and experienced economic growth, established passengers were able to fly more frequently, while new passengers had the opportunity to fly for the first time in their lives. Recent data shows that the number of travels per capita in Brazil in 2011 was 0.42, indicating that, despite the recent changes in the dynamics of the Brazilian civil aviation sector, and the relative maturity of it as an economic activity, there is still substantial potential for growth.

Being a continental country, civil aviation displays a key role in the Brazilian economy and in the lives of its citizens. The transport mode connects the country, promotes regional integration, is essential for business, for the full development of tourism throughout the country and for permitting dynamism to the Brazilian economy. Furthermore, the accessibility to isolated regions can only be made by air, highlighting the strategic importance of civil aviation to connect more isolated segments of the country to the national transportation network.

Brazil has historically been doing its fair share in combating climate change, and is prepared to sustain its leading role in the context of the global effort to tackle the problem. Brazil was the first country to sign the United Nations Framework Convention Climate Change, resulting from the United Nations Conference on Environment and Development - Rio-92, held in Rio de Janeiro, in June 1992. The Framework Convention was ratified by the Brazilian National Congress in 1994.

The latest and one of the most effective initiatives by Brazil in this arena was the establishment of the National Policy on Climate Change - PNMC, by means of Law no 12,187/09. The voluntary mitigation actions at national level included in it had been announced in Copenhagen, in December 2009, during the High Level Segment of the 15th Conference of the Parties to the Convention on Climate Change - COP-15 and the 5th Conference of the Parties serving as the Meeting of the Parties to the Kyoto Protocol - CMP-5. In accordance with this law, Brazil will pursue voluntary actions for the mitigation of greenhouse gas emissions with a view to reducing its projected emissions by 36.1%-38.9% by 2020.

As a result of domestic programs and initiatives, Brazil has a comparatively “clean” energy mix, with low greenhouse gas emission levels per energy unit produced or consumed. Around 50% of the Brazilian energy matrix is obtained from sustainable sources (biofuels, hydroelectric power etc). Other initiatives, such as the fight against deforestation, as well as the case for biofuels and energy efficiency, also help to achieve development goals, with a sharp deviation in the trend of greenhouse gas emissions curve in Brazil.

Internationally, Brazil has demonstrated outstanding engagement with a view to strengthening the multilateral response to climate change and to ensuring the full, effective and enhanced implementation of the UNFCCC, in accordance with its principles and provisions, in particular the principles of equity and common but differentiated responsibilities and respective capabilities. Actions to tackle greenhouse gas emissions from international civil aviation must be, thus, considered in the context of results already delivered as part of its contribution to the international response to climate change and in light of countries' historical responsibilities.

It is essential to bear in mind that this Action Plan does not constitute a domestic Sector Plan for the Brazilian Civil Aviation, as defined by article 11 of the Law nº 12.187, 2009. This document has the purpose of gathering information on civil aviation emissions, and actions planned or already in place that might contribute to its reduction. The purpose of the Brazilian Action Plan is to share information with ICAO's Secretariat and Member States with a view of contributing to the global effort of reducing GHG emissions from international civil aviation.

2 - Brazil's Action Plan Scope

During the 37th ICAO Assembly in October 2010, the Member States approved Resolution A37-19 endorsing a range of measures to address the international civil aviation's contributions to climate change. The Assembly Resolution encourages ICAO's Member States to submit, on a voluntary basis, their Action Plans. These Plans are an opportunity given to the States for showing the specific voluntary measures that they intend to adopt with the purpose of improving the fuel efficiency of the sector and thus contributing with the desirable environmental objectives agreed during the Assembly.

Hence, this Action Plan for the reduction of greenhouse gas emissions of the Brazilian civil aviation has the intention of portraying the sector's evolution and the greenhouse gas emissions which followed this evolution in the last decade. This inventory of emissions is preceded by an analysis of the economic data and evolution of the national air fleet. From this data, the evolution of the fuel consumption and associated emissions is presented, showing an improvement of the energy efficiency of the Brazilian air sector, verified over the period under analysis.

This Plan also aims to present the actions already in course and ones intended to be implemented for the improvement of the civil aviation fuel efficiency. These actions are initiatives from public and private institutions which aim to reduce the airlines' operational costs and decreasing the greenhouse gas emissions volume. These initiatives, despite being implemented by different players, will contribute to the common objective of the sustainable development of the Brazilian civil aviation industry and the reduction of anthropic GHG emissions associated to the sector.

2.1 DOMESTIC AND INTERNATIONAL CONCEPT

The methodology used in this document follows the orientations of IPCC Intergovernmental Panel on Climate Change. According to IPCC Good Practice Guidance (2006), for a multiple stage flight, each stage shall be separately classified as domestic, if involving passengers and freight transportation between two points of a same country. Under any other circumstance, the stage is considered as an international flight. The system assumes that, for international flights operated by Brazilian companies, the stages inside Brazil are considered, by the IPCC methodology, as domestic stages.

In addition, foreign companies operating flights from or to Brazil cannot, due to the national legislation and bilateral agreements in force, perform operations which are characterized as domestic stages, thus, all the stages operated by foreign companies are considered as international stages. There are only a few routes operated by Brazilian companies abroad where the Fifth or Sixth Freedoms of the Air are applied, with the right of embarking and disembarking passengers and freight between two points outside Brazil. These routes are, in general, operated between countries of South America and the Caribbean and are not computed by the system. However, due to the small quantity of these flights, their total impact is considered negligible.

No attempt was made for conciliating the data generated by the system with the data from the ICAO'S M form, compiled, filled, and submitted by the National Agency of Civil Aviation – ANAC to ICAO based on information on the fuel consumption provided by the operators. It is understood that, according to the provisions on the "Guidance Material for the Development of States' Action Plans", the methodology for differentiating the domestic and international flights converges with the one recommended by IPCC and not with the one proposed by ICAO. The data was compiled in such a way bearing in mind the procedure already adopted for the sector's emissions inventory calculation, which is part of the national communication to UNFCCC. However, with the purpose of providing the necessary data to ICAO in order to consolidate the information on the international civil aviation emissions, this document also makes the differentiation between the international operations performed by Brazilian companies and international operations performed by foreign companies.

It is understood that ICAO's activity is focused on international civil aviation; therefore, the Action Plan's scope shall be centered on the actions related to international stages. Nonetheless, this Plan will present, for information purposes, the information on the domestic aviation, segregated from the information on the international aviation. This happened because the actions for reducing the emissions have impact both in the domestic and international civil aviation and the domestic stages represent great part of the Brazilian airlines' activity.

2.2 METHODOLOGY FOR FUEL CONSUMPTION AND EMISSIONS VOLUME CALCULATION

The data presented in this document was generated from a system developed by the National Agency of Civil Aviation – ANAC for computing fuel consumption and CO2 emissions in the Brazilian civil aviation industry. The system is based on aircraft movement data provided by the Department of Airspace Control – DECEA. This data was used to produce the Reference Report for the aviation sector which is part of the 2nd National Communication on GHG Emissions and Removals, submitted to the United Nations Framework Convention on Climate Changes – UNFCCC, in 2010, as part of the commitments assumed in the Kyoto Protocol.

The fuel burn and emission calculations were made on a flight-per-flight basis for all commercial, scheduled, non-scheduled and general aviation flights (IPCC tier 3a level), based on the distance flown (great circle distance) and on the emissions factors available at the CORINAIR and ICAO Emissions Databank. For turboprop engines, the emissions factors used are the ones available on the FOI database, maintained by the Swedish Civil Aviation Authority.

The system does not calculate APU (Auxiliary Power Units) emissions from aircrafts nor helicopters. Due to these peculiarities, conciliation is made at the end of the calculations with the total aviation kerosene distributed in the country, per year, according to the official data publicized by the National Agency of Petroleum, Natural Gas and Biofuels – ANP.

According to the data from the 2nd National Report on GHG Emissions and Removals, the emissions and consumption of aviation gasoline-type fuel is responsible for less than 1% of the total CO_2 emissions from the sector in Brazil, and their calculation is not part of the scope of the present study. Lastly, the emissions from non-aircraft ground operations such as the transport of passengers, ground support equipment, generators, airport air conditioning, among others, were not considered in this document.

3 - The Brazilian Civil Aviation

3.1 ECONOMIC DATA

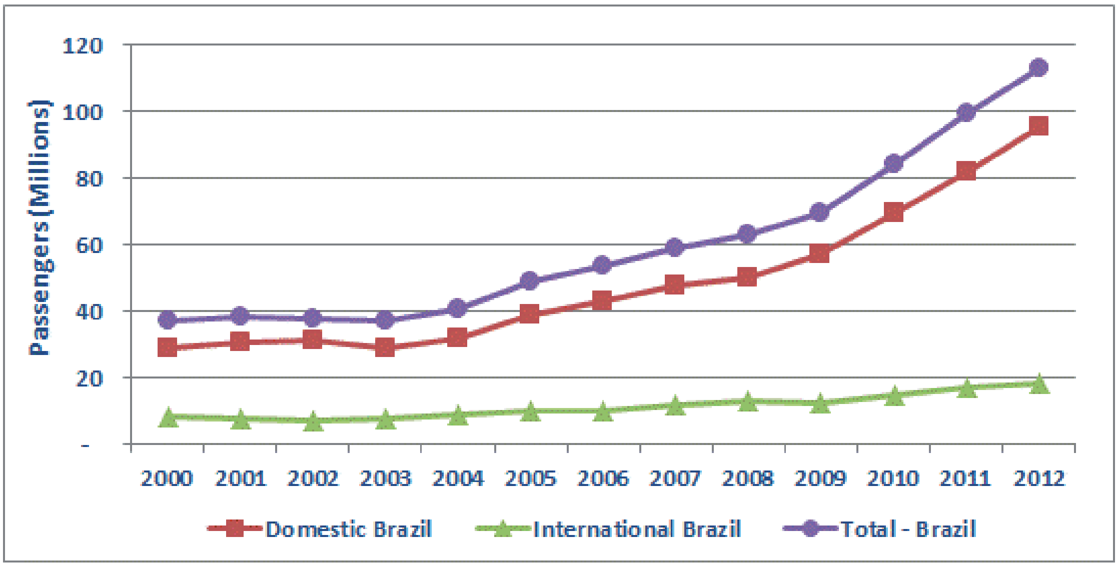
Data compiled up to 2009 shows that the civil aviation sector contributes with around 32 billion Reais, or 1.0% of the Brazilian GDP. The air sector generates around 684,000 jobs, approximately 0.7% of the Brazilian labor market. When taking into consideration the aviation contribution to the tourism sector, the numbers rise to 1.3% of the GDP and around 938,000 jobs, or, 1.0% of the Brazilian labor market.

In Brazil, the air transportation is growing faster than the global average. Studies indicate that Brazil is already the world's 3rd domestic air traffic market. In 2010, the Brazilian aviation sector transported around 71 million passengers and 870 thousand tons of air freight. The Brazilian demand for aviation fuel in 2011 was 7 million cubic meters, around 2,8% of the global demand. It is important to highlight that 75% of the fuel consumed was produced by Brazilian refineries, while the rest was imported.[1]

In the last thirteen (13) years, the domestic market prevailed in the Brazilian air sector scenario, in comparison to the international market (Brazilian and foreign airlines included). In average, 81% of the Brazilian market consists in domestic flights. Passenger transport in 2012, for example, was around five times higher in the domestic market (95,347,421) than in the international market (17,997,831). The domestic traffic was characterized by a strong growth from 2000 to 2012 (10.4% per year and 228% accrued), higher than the international traffic growth (6.9% per year and 122% accrued) in the same time period.

Figure 1 shows the increase in number of transported passengers in the country, in domestic flights (red line), international flights (green line) and the total passengers transported evolution (purple line) from the year 2000 to 2012.

Figure 1: Air traffic of domestic and international passengers

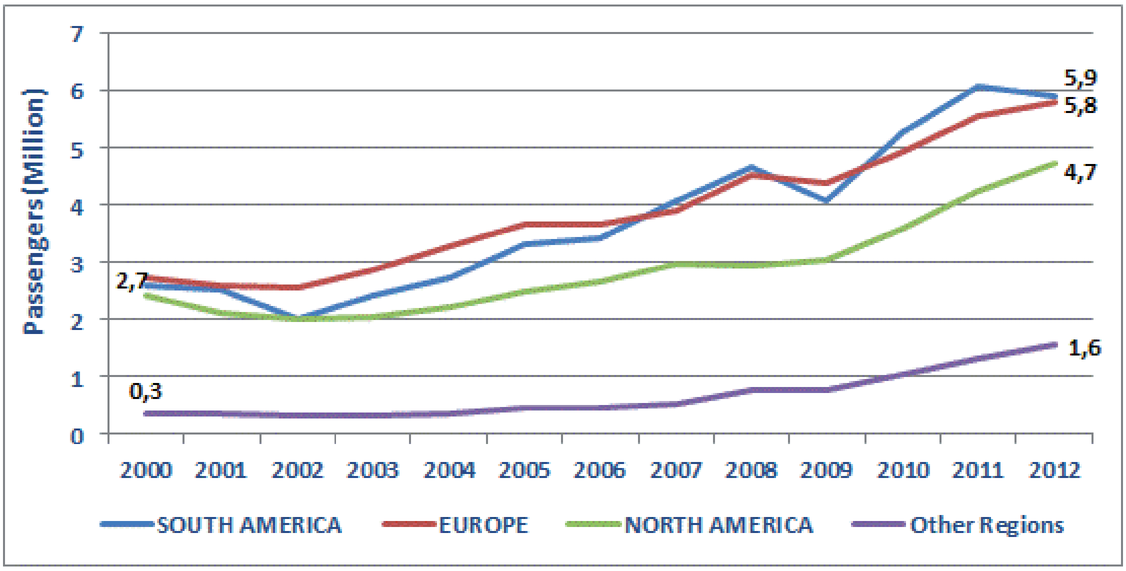


Source: National Civil Aviation Agency - ANAC

[1]Source: Economic Benefits from Air Transport in Brazil – Oxford Economics 2011

Regarding the Brazilian international air transportation, Figure 2 shows the passenger transportation evolution for the main destination regions, which are: North America, South America, Europe, among others. According to Figure 2, the region of most interest in the Brazilian international air traffic was South America, with 5.9 million passengers in 2012. The second main destination region was Europe with 5.8 million.

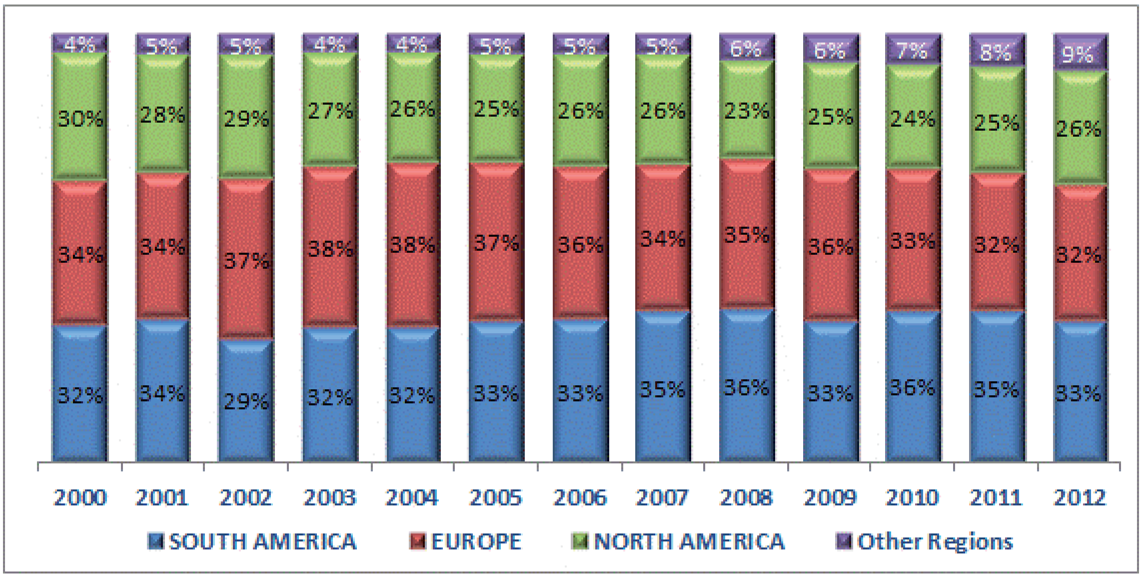
Figure 2: Passenger Traffic per Region



Source: National Civil Aviation Agency Brazil - ANAC

From the evolution analysis of the number of passengers transported to the main international destinations, it can be verified that Europe and North America have reduced their participation in the market in the last 13 years. On the other hand, other regions increased their participation in the market, mainly Africa and Central America. The South America region maintained its market share, according to Figure 3.

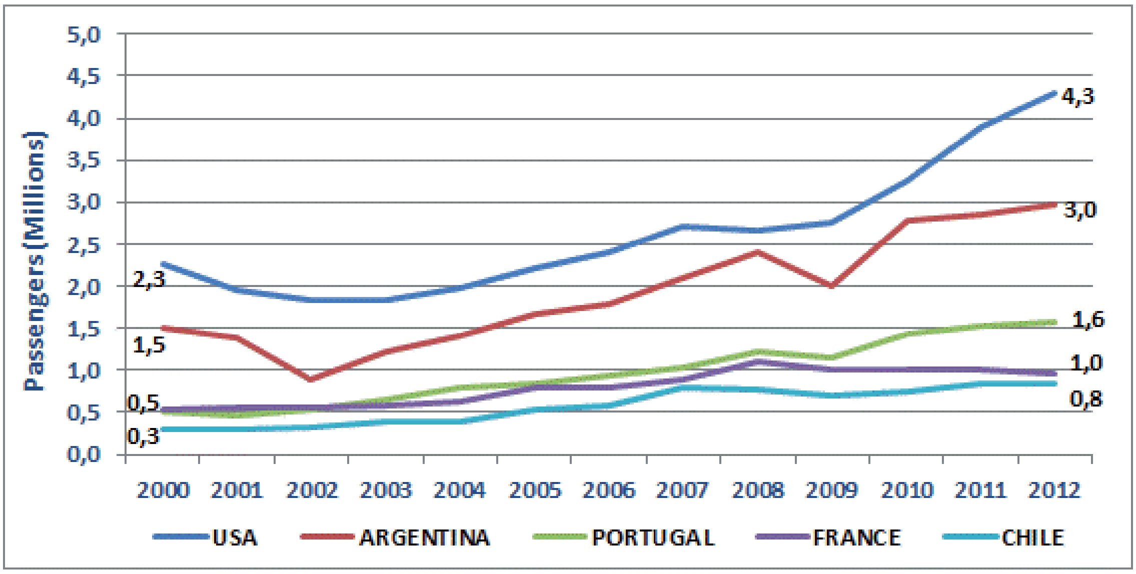
Figure 3: International Traffic of Passengers – Market Share per Region



Source: National Civil Aviation Agency Brazil - ANAC

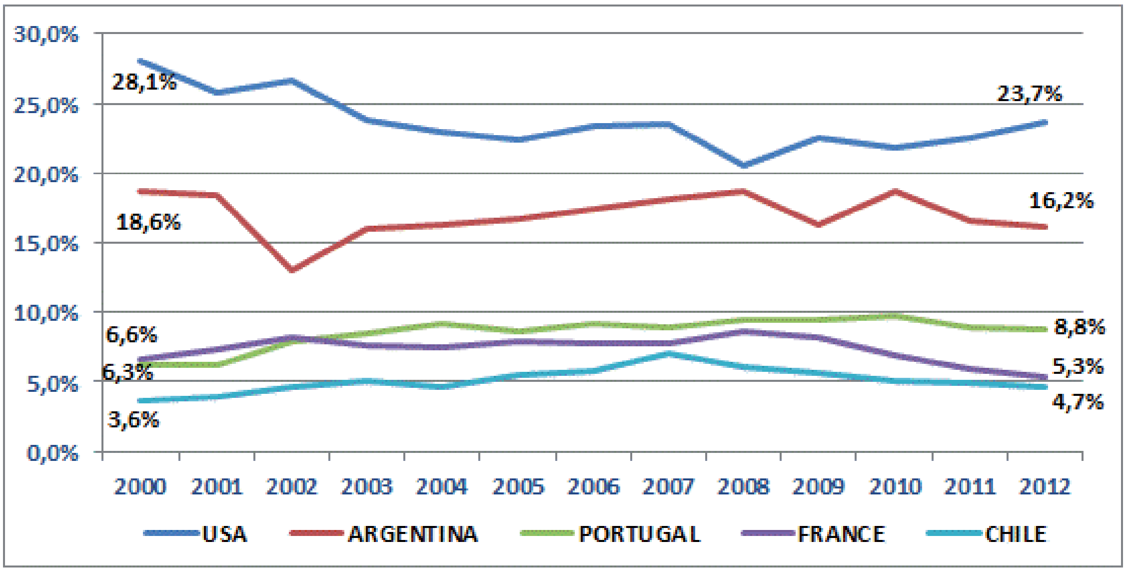
Besides the analysis of the number of passengers transported in international flights per region, the main international destinations from Brazil were also analyzed, per country, as indicated in Figures 4 and 5. It can be noted that the United States were the leaders, during the last 13 years, in terms passengers volume, with around one fourth of the Brazilian international market (23.7%) in 2012. Other important markets were: Argentina, with a market share of 16.2% in 2012; Portugal, with 8.8%; France, with 5,3%; and Chile, with 4.7%.

Figure 4: International Traffic of Passengers – Five main destinations



Source: National Civil Aviation Agency - ANAC

Figure 5: International Traffic of Passengers – Market Share per Country



Source: National Civil Aviation Agency Brazil ANAC

3.2 FLEET EVOLUTION

As per recent data from 2000 to 2011, the number of commercial passenger aircraft operating in Brazil grew 4%, from 452 to 468 aircraft. In December 2011, 87% of this total was equipment with turbofan propulsion and the remaining 13% turboprops while back in 2000 the percentage of turbofan where 77% and turboprop 23% of the total fleet. The Brazilian airlines experienced during the last decade a moment of acquisition of new aircraft for both capacity expansion and to renew their fleets.

Table 1: Fleet Evolution

	2000	2001	2002	20 03	2004	2005	2006	2007	2008	...	2012
Average seats (Narrow Bodies)	117	123	128	130	133	139	147	156	161	...	146
Average seats (Wide Bodies)	240	242	250	256	272	280	268	231	235	...	257
Qty of airplanes (Narrow Bodies)	181	226	231	195	196	194	206	221	243	...	338
Qty of airplanes (Wide Bodies)	38	43	40	34	36	32	31	30	31	...	31
Total airplanes (jets + turboprops)	340	348	321	281	288	270	285	316	347	...	469

[2]Source: National Civil Aviation Agency Brazil - ANAC - Statistic Yearbook, 2010

Regarding the seats average per aircraft, it is possible to observe an increase in the seat average from 2000 till 2008 for narrow bodies. After that there is a decrease on the narrow bodies average seat capacity, mainly due to the beginning of operations of *Azul Linhas Aéreas*', in 2008. *Azul* operates mainly with Regional Jets aircrafts, such as Embraer E190 and E195, with smaller seats capacity (106 and 116 seats respectively).

On the other hand, it is possible to observe an average increase on the seats capacity of wide bodies aircraft used in international stages, due to large aircraft incorporation into TAM's fleet, such as the Boeing 777, and the gradual return of the Boeing 767 from VARIG's fleet and, subsequently, from Gol's fleet. Taking into account the data from 2012, Brazil has a relatively new aircraft fleet, with an average age of around eight years. The country's largest airlines are operating almost entirely with last generation equipment. Aircraft with 20 years or more represent less than 3% of the fleet in operation, according to 2012 data.

The growth in the average size of aircraft, from 2000 to 2004, was due to the market entry of GOL, using new B737-700NG (with a larger capacity than the B737-500 used by VARIG) and the fact that TAM received its first Airbus A319/A320.

In 2006, GOL started replacing the old B737-300 with the new 737-800 and TAM started the retirement process of Fokker 100, with the arrival of more A320 aircraft, which became the main type of equipment in service at this company. In the same period, TAM promoted a retrofit on the seats configuration of their A320 aircrafts, which increased the seats capacity in around 15%.

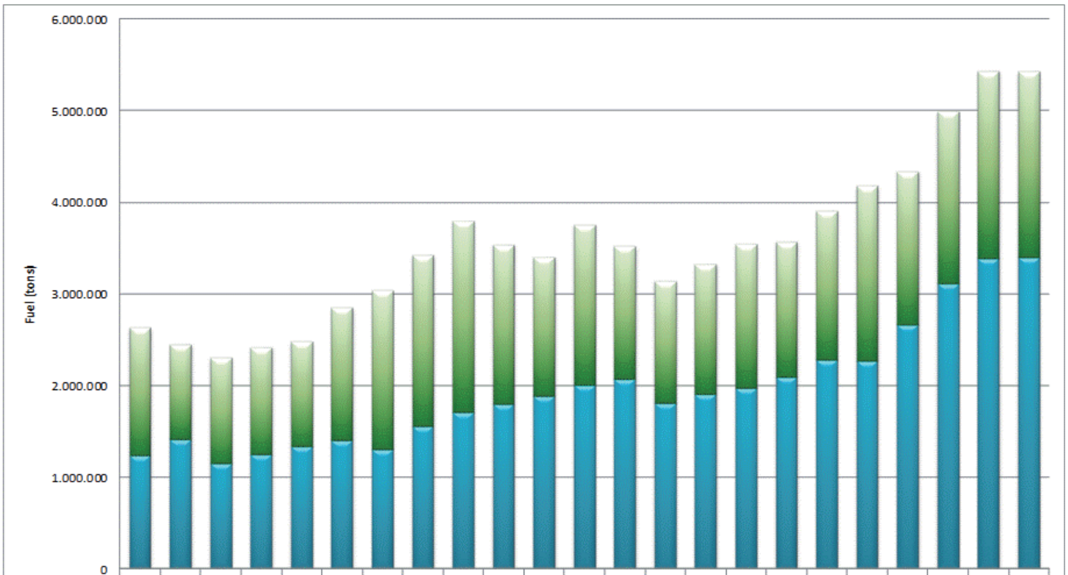
During Varig's bankruptcy process, most of its airplanes were gradually withdrawn from operation. Between 2005 and 2006, VARIG started its large-size jets return. GOL Linhas Aéreas, which bought VARIG, on April 2007, has also promoted the aircraft replacement, which gradually reduced the average size of their aircraft until the end of 2007. In 2008, TAM started operating with the new B777-300, intensified the use of the Airbus A330 and started operating with the A340 in some international routes.

The aircraft fleet renewal process had a direct impact over the fuel efficiency and, therefore, over the emissions *per capita* in air travels. The following topics present a brief analysis of these indicators.

4 - Fuel Consumption and Associated Emissions

The last decade has witnessed an intense domestic traffic growth in Brazil. The international segment has also grown, but at a slower rate than the domestic one. Currently, more than 80% of the regular flights are domestic flights. However, the fuel consumption and the volume of emissions do not reflect this difference in the same proportion, as shown in Figure 6.

Figure 6: Evolution on the fuel consumption - QAV



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
International	1.385	1.036	1.156	1.167	1.149	1.445	1.732	1.864	2.085	1.735	1.512	1.748	1.449	1.329	1.415	1.559	1.468	1.620	1.905	1.675	1.876	2.042	2.030
Domestic	1.242	1.410	1.146	1.250	1.334	1.404	1.304	1.555	1.710	1.799	1.888	2.008	2.068	1.809	1.907	1.980	2.099	2.287	2.270	2.661	3.116	3.392	3.399

Source: National Civil Aviation Agency Brazil – ANAC

In 1990, around 47% of the aviation fuel consumption was due to domestic operations, while 53% was due to international operations (including overseas airlines servicing Brazil). In 2012, this proportion changed to 63% of fuel consumption in domestic flights and 37% in international flights. This data confirms the rapid growth in domestic operations.

The somewhat high international segment participation on the fuel share can be explained by the relatively long distance between Brazilian airports and some of the main international traffic destinations, notably North America and Europe, making a relevant part of the international flights necessarily very long.

Table 2 lists the domestic operations, the international operations performed by Brazilian companies and the total international operations (which include the international stages performed by national and foreign companies). The fuel consumption separation between national and foreign companies in international stages has the objective of meeting ICAO's need of obtaining data specifically on the GHG emissions of Brazilian companies, on the international flights operations. The fuel burn for international services operated by Brazilian air carriers is included in the total international operations fuel burn.

Table 2: Evolution of fuel consumption from 2009 to 2012

Kilograms of Jet A	2009	2010	2011	2012
Domestic operations	2.661.972.652	3.116.979.892	3.392.101.829	3.399.994.766
International operations Brazilian airlines	416.980.982	443.654.063	488.658.657	422.852.328
Qty of airplanes (Narrow Bodies)	1.675.306.164	1.876.851.049	2.042.512.335	2.030.051.096

Source: National Civil Aviation Agency Brazil – ANAC

Table 3 uses part of the data on fuel consumption for presenting the GHG emissions growth between 1990 and 2010.

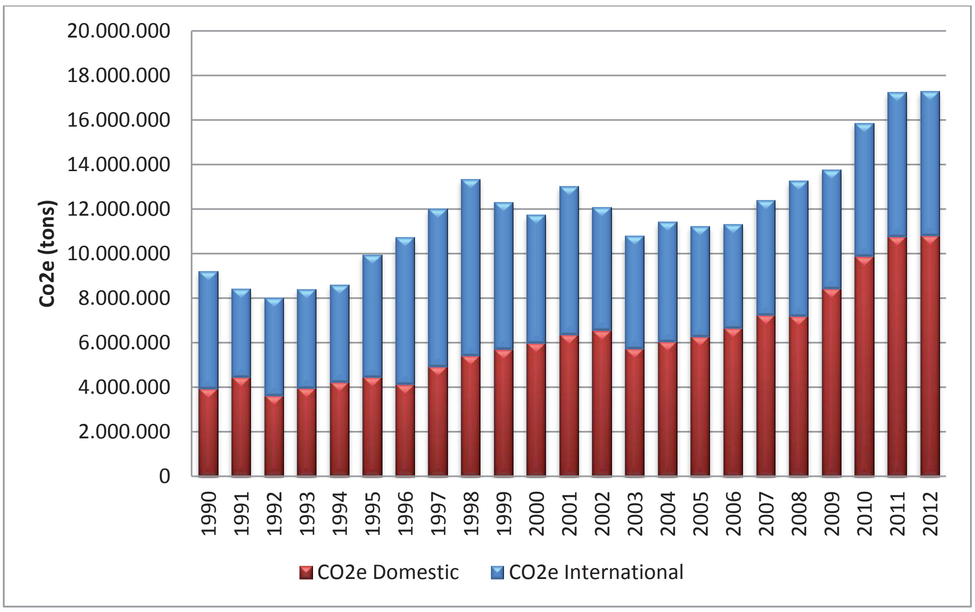
Table 3: CO_2 Emissions Growth Rate

	CO2e (kg) Emissions			Growth Rate (%)	
	1990	2000	2010	1990 - 2000	2000 - 2010
Domestic	3.912.135.696	5.946.536.038	9.853.974.043	34,2	39,7
International	5.267.328.683	5.747.817.783	6.051.976.209	8,4	5,0

Source: National Civil Aviation Agency Brazil – ANAC

According to the 2nd National Communication on GHG Emissions and Removals, it can be verified that, although the aviation sector is responsible for only around 0.5% of the total GHG emissions in Brazil, the sector's emission volume has grown faster than most of the other sectors of the economy. In line with the numbers presented, it is possible to conclude that the domestic air traffic growth was the main contributor to the CO_2 emissions volume elevation within the sector.

Figure 7: CO2 Emissions – domestic and international flights



Source: National Civil Aviation Agency Brazil – ANAC

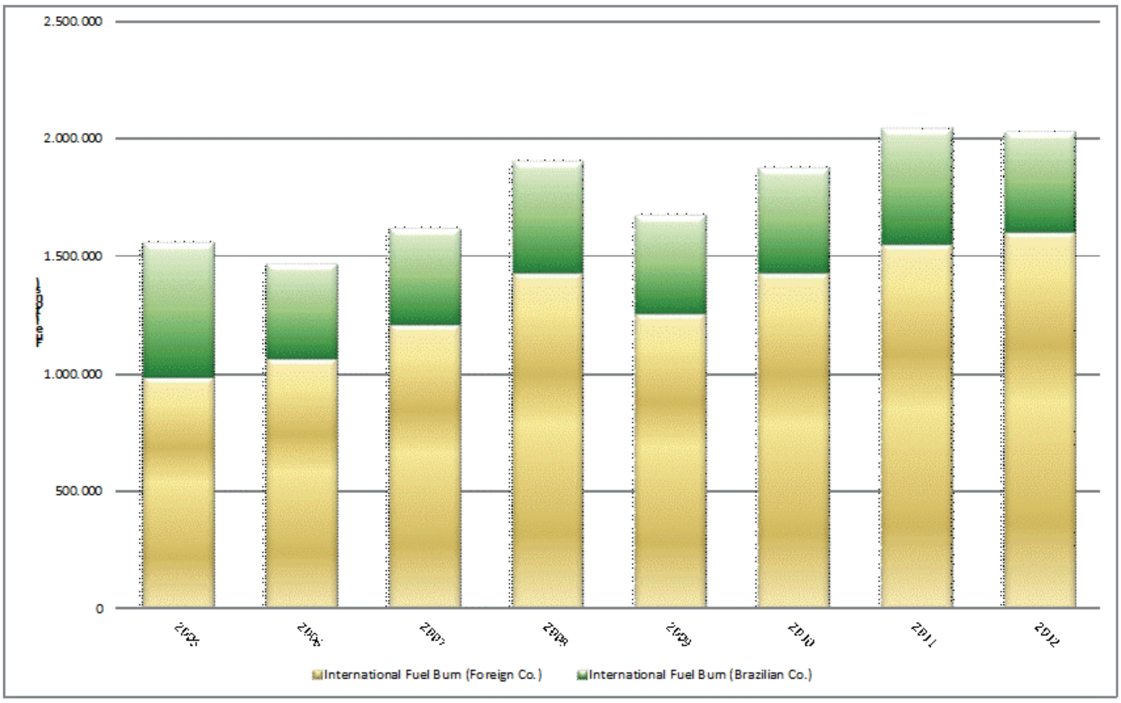
Figure 7 reflects the increase in the volume of CO_2 emissions for domestic and international aviation, from 1990 to 2012, which mirrors the fuel consumption data presented in Figure 6. Also according to the data presented in Figure 7, the absolute national and international emissions grew in an annual average rate of 3% from 1990 to 2012. The graphic also shows the acceleration of the domestic operations participation on the total emissions in the last two decades.

On international operations, the aggregated fuel consumption data, including Brazilian and foreign operators, shown on a yearly basis, indicates large oscillations that are associated to both domestic and international economic crises. Additionally, in the last decade the bankruptcy process of the former Brazilian flag carrier, VARIG, which ended its operations in 2005, contributed to the observed oscillations.

As seen in Figure 7, the projected emissions growth for domestic and international operations in Brazil is 6.1% and 2.5% respectively, in an annual basis, between 2010 and 2020. This projection was obtained through a simple linear extrapolation of the data on fuel consumption from 2005 to 2012 (Figure 8). Given the small amount of available data, it was not possible to use of a robust method for estimating the fuel consumption from 2020 to 2050.

Nevertheless, a forecast using a simple linear extrapolation can provide some useful results. The result of the linear extrapolation leads to an approximate value of fuel consumption of 2.6 million tons in 2020 and 4.8 million tons in 2050, with a scenario without great alterations in the airlines' business environment. These estimations shall be refined in the future.

Figure 8: Growth trend of fuel consumption in international operations



Source: National Civil Aviation Agency Brazil – ANAC

5 - Emissions Intensity and Fuel Efficiency

5.1 CALCULATION METHODOLOGY

The purpose of this section is to present historical data on the evolution of CO_2 emissions in the Brazilian Civil Aviation sector and, notably, present the Fuel Efficiency and Emissions Intensity variations, in the domestic and international operations of civil aviation.

The calculation of emissions intensity is based on the emissions per kilometer by transported passenger. Thus, the following variables were isolated: the increase in number of transported passengers, and the growth on the number of routes and distances flown.

The fuel efficiency calculation is based on the fuel consumption per weight (paying passengers and cargo) and distance travelled. This way it is possible to analyze the fuel efficiency of the air services. The Statistic Yearbookt for the Brazilian Civil Aviation, elaborated by ANAC, has information available on the RPK[2] *Revenue Passenger Kilometer* and RTK[3] *Revenue Tonne Kilometer* for the Brazilian companies. In order to calculate the emissions intensity, the total CO_2 emissions is divided by the sector's RPK. Thus, the volume of emissions per kilometer per transported paying passenger is obtained.

For the fuel efficiency calculation, the fuel consumption volume is divided by the RTK. It should be noted that for the international stages, the RTK is calculated only for flights departing from Brazil. Tables 4 and 5 below present, respectively, the evolution of RPK and RTK for the Brazilian airlines. The data is divided in domestic and international operations.

Table 4: RPK Series

(x1000)	2005	2006	2007	2008	2009	2010	2011	2012
RPK intern stage Brazilian airlines	11.576.938	8.233.942	7.275.923	9.565.195	9.683.426	11.804.322	13.032.906	13.075.117
RPK domestic stage	35.561.273	40.556.504	45.911.269	49.563.781	56.731.273	70.238.141	81.452.344	87.005.961

Source: National Civil Aviation Agency Brazil – ANAC

[2]Revenue Passenger Kilometer is a measure which demonstrates the number of passengers transported per kilometer flown.

[3]Revenue Passenger Kilometer is a measure representing the paid weight (passenger + paid load) per kilometer flown). For calculating the weight of the passenger, the passenger weight calculation of 100 kilograms per person is used.

Table 5: RTK Series[4]

(x1000)	2005	2006	2007	2008	2009	2010	2011	2012
RPK intern stage Brazilian airlines	1.625.962	1.114.336	946.743	1.048.003	1.008.181	1.280.636	1.609.857	1.588.198
RPK domestic stage	3.709.205	4.280.856	4.625.431	4.931.610	5.599.076	6.989.039	8.016.456	8.428.886

Source: National Civil Aviation Agency – ANAC

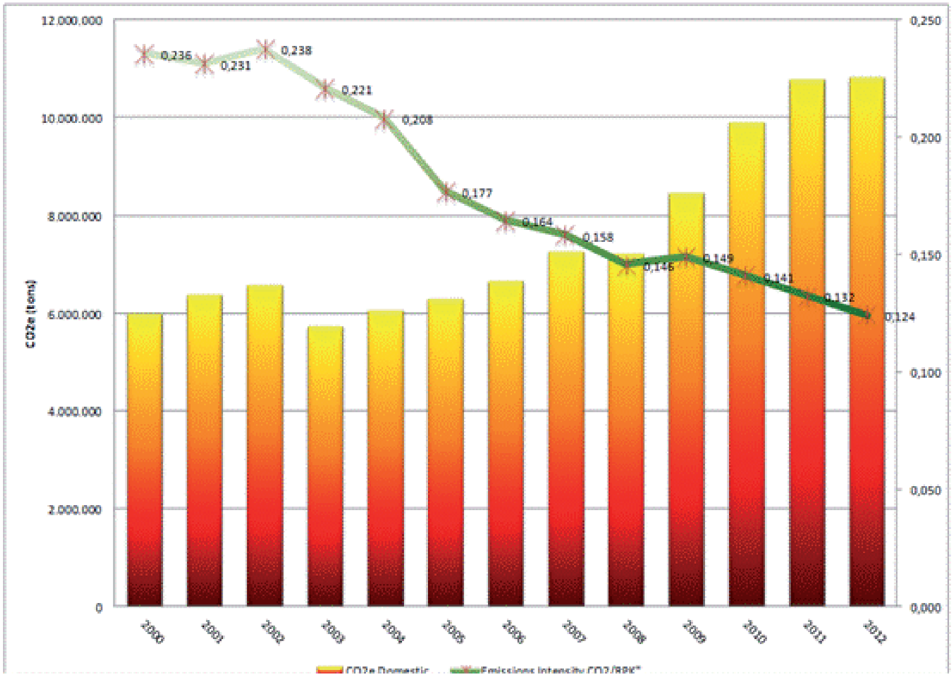
In order to divide the domestic and international stages and segregate operations between local and overseas carriers, the ATC operations database records are necessary. The database available started in 2005 so the series, for international stage, presented started in 2005, segregated by domestic and international operation.

5.2 EMISSIONS INTENSITY AND FUEL EFFICIENCY: DOMESTIC OPERATIONS

Although it is not this Action Plan main scope, information on the Brazilian domestic civil aviation emissions intensity and the fuel efficiency arepresented.

The **emissions intensity (EI)** information and the CO_2 emissions evolution on domestic operations is presented on Figure 9. The vertical bars show the annual emissions volume and the line presents the **emissions intensity (EI)**.

Figure 9: Domestic Operations – CO_2 Emissions and Emissions Intensity (EI)



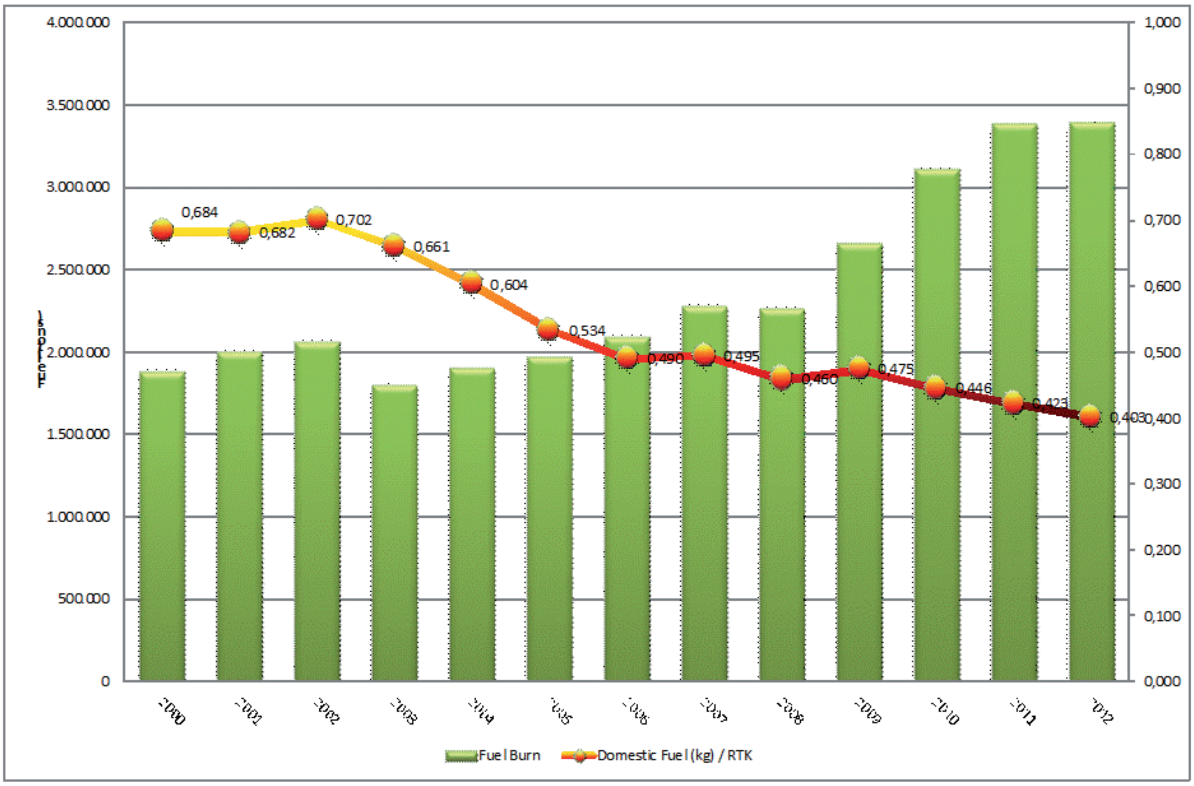
Source: National Civil Aviation Agency Brazil - ANAC

[4]Both for the RPK and for the RTK related to international stages of Brazilian companies, the numbers only include flights leaving Brazil.

As per the domestic operations, Figure 9 shows that CO_2 emissions have been increasing at an annual average rate of 5.4% per annum since 2000. The total emissions grew more than 79% since 2000. But the EI steadily improved at an average annual rate of 5.1% between 2000 and 2012, so that by 2012 it had reached 12.4kg CO2 per 100RPK in comparison with the 23.6 CO2 per 100RPK of the year 2000.

On figure 10, for the domestic operations, is possible to observe a 4,3 % average annual FE (fuel efficiency) improvement since 2000. Taking in consideration that the emissions for this segment had a faster growth than the international it is possible to conclude that this energy efficiency improvement on the domestic operations has positively contributed to a reduction on the total emissions and fuel burn within the country. These efficiency improvements are mainly due to fleet renewal, operational, and air traffic management improvements.

Figure 10: Domestic Operations – Fuel consumption and Fuel Efficiency (FE).

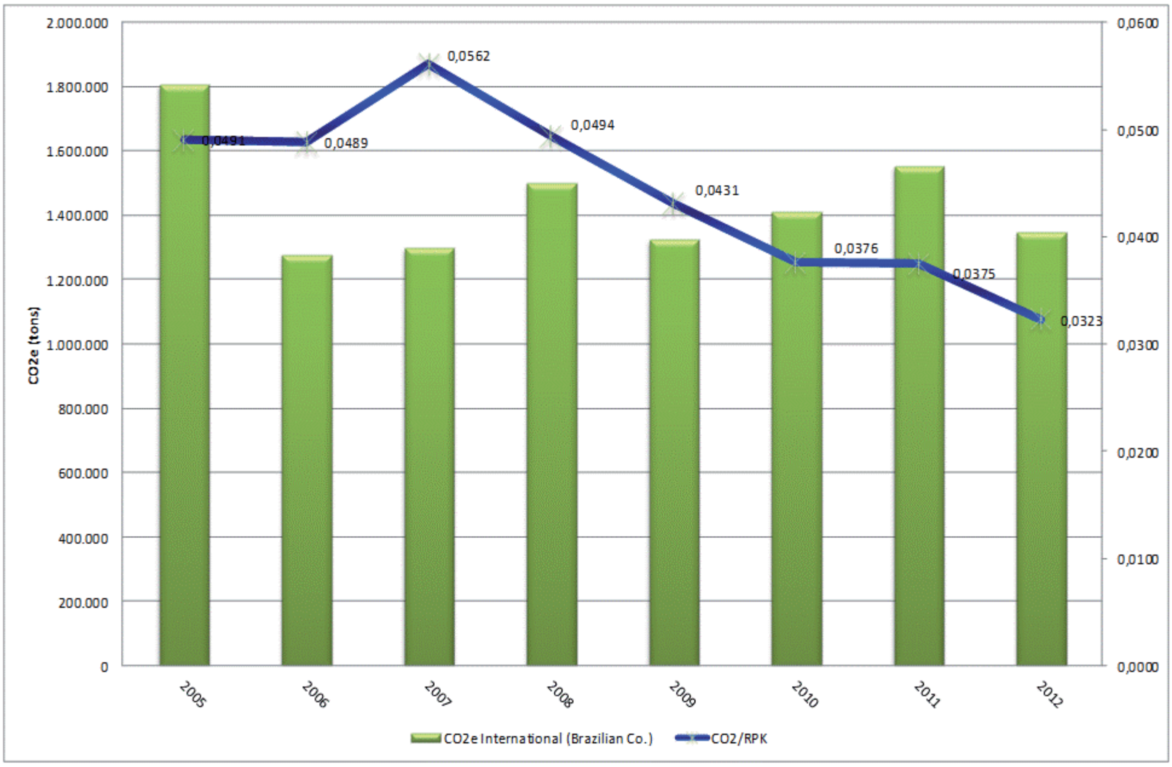


Source: National Civil Aviation Agency Brazil – ANAC

5.3 EMISSIONS INTENSITY AND FUEL EFFICIENCY: INTERNATIONAL OPERATIONS

The graphic below (Figure 11) shows the EI evolution of the Brazilian airlines international operations from the year 2005 to 2012. The vertical bars represent the annual emission volume in these operations, while the line indicates the EI per year.

Figure 11 : International Operations – Brazilian Companies – CO_2 Emissions and Emissions Intensity (EI)

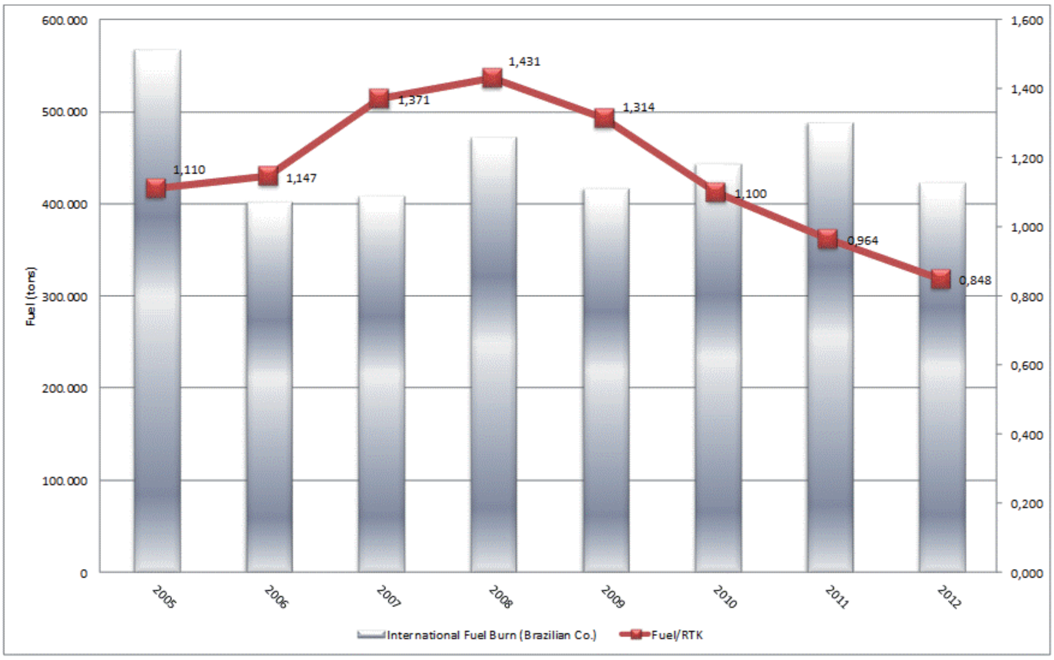


Source: National Agency of Civil Aviation – ANAC

Figure 11, confirms what was stated before, international market went through a period of re-organization due to the cease of operations from the flag carrier VARIG. The new operators went through a process of adjustment between supply and demand of seats and this can be seen by the increase on EI among the years of 2006 and 2007. By 2009 the sector had adjusted and the EI dropped to values close to the ones in 2005. Also during the year 2008 is possible to observe a significant increase on the emissions that accompanies the increase in international traffic that year, the international crises is accounted for the reduction observed on the year 2009. The overall result was reduction in the EI by 4.4% on a year basis between 2005 and 2012 and a decrease on net emissions of 2.5% on the same period. For the years 2010 and 2011, although is possible to observe an increase on the net CO_2 emissions the EI is virtually the same for these years.

The international operations FE was also calculated based on the fuel consumption per RTK. Figure 12 shows the evolution of the fuel consumption (vertical bars) and the FE (line) for the Brazilian carriers in international operations.

Figure 12: International Operations – Fuel Efficiency (FE)



Source: National Agency of Civil Aviation – ANAC

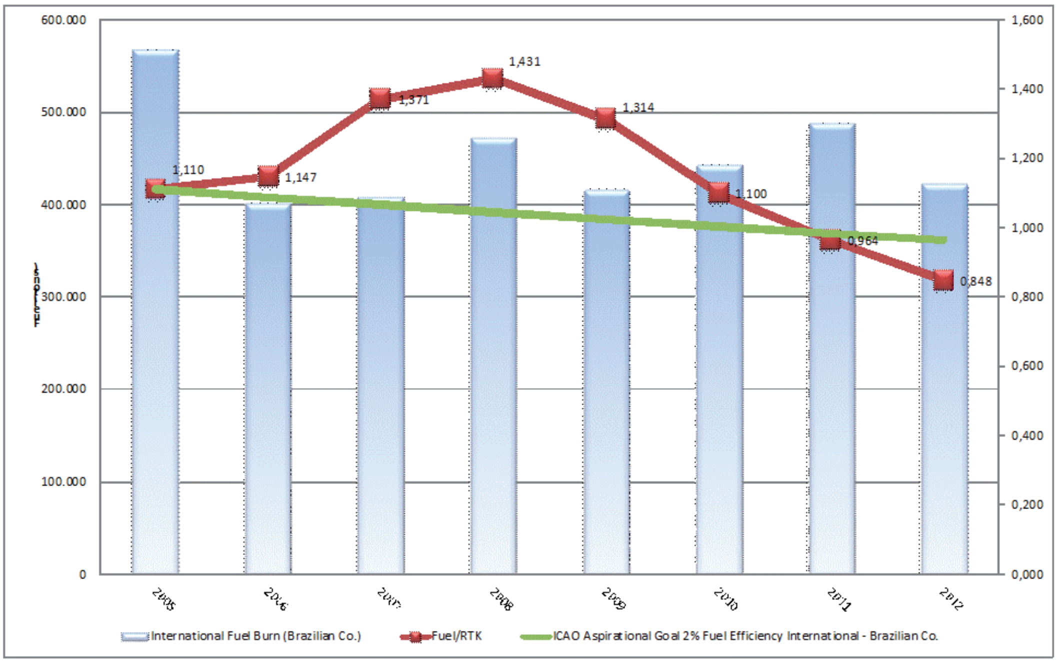
For Brazilian airlines on international operations, Figure 12, shows an improvement on average of 2,3 % on an annual basis on the FE, slightly above the 2% aspirational goal established by ICAO. The result wasn't better due to accommodation of the sector to the bankruptcy o VARIG, as showed before, the FE level have returned to the levels of 2005 by 2010 and now the system has achieved even lower FE levels. The fuel burn on the same period was reduced by around 2,5 % on an annual basis, but the reduction alone from 2005 to 2006 was almost of 30 %.

5.4 ICAO'S FUEL EFFICIENCY GOAL

Resolution A37-19, approved by ICAO's 37th Assembly, establishes the continuity of ICAO's policies and practices related to environmental protection and specifically address the subject of civil aviation and climate change. The referred resolution defines, in item 4, that the States shall work through ICAO for reaching a global fuel efficiency improvement goal, of 2%, in average, per year up to 2020 and a aspirational fuel efficiency improvement goal of 2% per year from 2021 to 2050.

Figure 13 repeats the information on Figure 12 with the insertion of a line that represents ICAO's goal of 2% fuel efficiency improvement per year, using 2005 as baseline. It is observed a hump from 2006 to 2010, above the ICAO aspirational line. However, in 2011 the fuel efficiency improvements reaches values below ICAO's goal. It is important to notice that the line was plotted arbitrarily beginning in 2005, but the Resolution mentions 2010 as the baseline for this calculation. In this case, the fuel efficiency improvements would be even greather.

Figure 13: Ful Efficiency x ICAO objectives



Source: National Agency of Civil Aviation – ANAC

The observed behavior suggests that Brazilian aviation is on an environmentally friendly way and that even though the international operations were heavily affected by the departure and arrival of new airlines to the market the sector as a whole should comply with the aspirational goal of 2% fuel efficiency improvement established by ICAO, even if the goals are not mandatory or binding.

6 - Mitigation Measures

6.1 INTRODUCTION

The civil aviation impact on greenhouse gases emissions increase and, consequently, on the global warming phenomenon, has been widely debated by public and private players in Brazil.

The International Civil Aviation Organization points out the necessary measures for reducing the sector's emissions and they are: the adoption of alternative fuels, improvements on the air traffic management, improvements on the infrastructure, operational improvments, regulatory and economic measures.

This section presents the actions in course or planned in Brazil, which will impact over the greenhouse gases emissions reduction through the enhancement of the Brazilian civil aviation energetic efficiency.

6.2 ALTERNATIVE FUELS

The development of alternative fuels for aviation is a strategic element for the aircrafts refueling future, due to two main reasons: decreasing the dependence regarding fossil fuels and reducing the greenhouse gases emissions. The international oil price oscillation has a strong impact over the airlines costs structure in Brazil. Thus, the alternative biofuels availability, mainly as drop-in (mixed to the main fuel), could contribute for the fuel supply and prices stabilization.

Furthermore, the biofuels for aviation development would result on a decrease of civil aviation impact on the world total greenhouse gases emissions. Currently, the civil aviation has contributed with around 2% of the total emissions. Aeronautic engineering improvements, technological and operational advances, shall contribute to the aircrafts fuel burn reduction and also for the decrease of the carbon emissions.

However, the gains with technology and operational improvements will not be enough for compensating the global emissions increase expected as a consequence of air traffic growth. Biofuels produced from renewable oils biomass offer the potential to reduce the greenhouse gases life cycle and, therefore, decrease the aviation contribution to climate change.

Brazil is internationally recognized by its experience on biomass use for energetic purposes, such as wood, sugarcane ethanol and biodiesel. The modern bioenergy represents around 30% of the countries' energetic matrix. Brazil is a country with a long history of conciliating biofuel production, food safety and rural development[5]. In this context, the aviation biofuels production represents as a new challenge.

With this challenge in mind, on May 06th, 2010, the Brazilian Alliance for Aviation Biofuels – ABRABA was created. The alliance has the purpose of promoting public and private initiatives for sustainable aviation biofuels development and

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[5] SABB

certification. ABRABA gathers the following institutions: Algae Biotechnology, Amyris Brazil, ABPPM, AIAB, Azul, Embraer, GOL, TAM, TRIP and ÚNICA.

Another important initiative undertaken in Brazil related to aviation biofuels development was the Boeing and Embraer project in collaboration with the Research Foundation of the State of São Paulo (FAPESP). The project had the objective of performing a national assessment of technologic, economic and sustainability challenges and opportunities, associated with the aviation biofuels development and commercialization in Brazil. The State University of Campinas – UNICAMP, chosen for coordinating this study, was responsible by heading a research team. The project's team performed eight workshops with the active participation of more than 30 stakeholders from the private sector, from governmental institutions, from NGOs and from the academy. The assessment included the following topics: agriculture, conversion technology, logistics, sustainability, commercialization and policies. As a result, on July 2013, in São Paulo, it was released a document entitled: "Flight Plan for Aviation Biofuels in Brazil: Plan of Action". It was a report on the Workshops main conclusion which provides a diagnosis on the current situation and recommendations of measures for the biofuels development in Brazil.

The report identified soy, sugarcane, and eucalyptus as promising raw materials for the aviation biofuel production, arising from these biomasses great availability and low productions costs. The research group also assessed the refinery technologies including the gasification, fast pyrolysis, liquefaction by solvent, enzymatic hydrolysis of cellulosic and lignocellulosic biomass, alcohol oligomerization for aviation fuels (ATJ), hydroprocessed esters and fatty acids (HEFA), as well as the fermentation of sugars and waste (in other words, urban solid residues, combustion gases, industrial waste) in alcohols, hydrocarbons (DSHC) and lipids. According to the report, in Brazil, several of these technologies have been tested for producing biofuels used in new demonstration flights as possible sustainable biofuels alternatives.

However, besides the technical difficulties, issues of economic feasibility and demonstration of environmental benefits, such as the reduction of GHG emissions shall be faced. The report concludes that it is necessary improving research for establishing biofuels refinement technologies and commercial and distribution strategies which may contribute to the biojetfuels economic feasible. It also concludes that this economic feasibility depends on investments in transports logistics and public policies.

The main Brazilian airlines have already performed experimental flights with the use of biofuels for aviation. TAM and Airbus were the first ones to flight with biofuel based on *Jatropha Curcas* in Latin America, on November 23rd, 2010, using an Airbus A320 aircraft. The biofuel was used as drop-in with a mixture of 50% biokerosene based on *jatropha curcas* produced in Brazil and 50% of conventional aviation kerosene.

The airlines Gol and Azul performed experimental flights on June 19th, 2012, during the environment summit (Rio+20), in Rio de Janeiro. The flights had as destination Santos Dumont Airport, in Rio de Janeiro. Gol flight departed from Congonhas Airport, in São Paulo, and Azul flight departed from Viracopos Airport, in Campinas, São Paulo. Azul used renewable sugarcane-based fuel, created by the company Amyris, on the rate of 50% related to the conventional fuel. "Azul+Verde" project was also developed in partnership with the aviation engines manufacturer GE and Embraer. Gol used, in Boeing 737/800, the biokerosene imported from the American company UOP, produced from the mixture of ICO (inedible corn oil coming from the corn ethanol production) and OGR (oils and residual fats).

Embraer and General Electric – GE also performed a series of tests flights with the objective of establishing a reference for the operational characteristics of the airplanes with GE CF34-8E engines when filled with HEFA (Hydro-processed Esters and Fatty Acids) fuel, inside a wide range of specific flight conditions.

Notwithstanding the advances in research, development and certification of aviation biofuels, the commercial use of the product faces the challenges of economic feasibility. The final biokerosene for aviation price is considerably higher than the conventional kerosene price. Taking into account the airlines lower profit margin and the high percentage that the fuels represent in the air carriers total costs (above 30%), it is not likely that biofuels are going to be used in large scale as long as the price is not competitive.

Thus, public and private players in Brazil have studied mechanisms to reduce biofuels production costs, such as: research on abundant raw materials and with lower costs, analysis of refinery methods, more efficient production and transportation logistics, among others. In this sense, Brazil and the United States signed a Memorandum of Understanding for cooperation on biofuels for aviation development. The Brazilian government believes that this partnership can be very useful for technology and information sharing aiming at the development of aviation biofuels.

The most recent initiative regarding the Biofuels for aviation development in Brazil was the creation of the Brazilian Biojetfuel Platform[6], in August 8th, 2013. The Platform involves the following partners: Curcas, Amyris, Boeing, RSB Services, GE, UFRJ, IICA, Byogy, Bioeca, GOL, ABEAR[7] and UBRABIO[8].

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[6] Formal Structure: Advisory Board: Mr. Adalberto Febeliano, ABEAR. Mr. Adilson Liebsch, UBRABIO, Mr. Al Bryant, Boeing, Mr. Pedro Scorza, GOL Airlines. Steering Committee:, Mr. Adilson Liebsch, Amyris (DSHC), Mr. Donato Aranda, UFRJ (Technology), Mr. Fernando Correa, Byogy (ATJ), Mr. Jamil Macedo, IICA(Feedstock); Mr. Luís Rodrigues, Solazyme (DSHC); Mr. Mario Fontes, Bioeca (Camelina); Mr. Mike Lu, Curcas (coordinator/integration); Mr. Santiago Giraldo, SGB (Jatropha); Mr. Sergio Zuqim, GE (R,D&I-ATM) .

[7] ABEAR (Associação Brasileira das Empresas Aereas) is the Association of the Brazilian Airlines (AVIANCA, AZUL, GOL, TAM e TRIP), founded in 2012 to represent the Brazilian Civil Aviation.

[8] The Brazilian Biodiesel and Biojetfuel Union (Ubrabio) is a national private non-profit trade association, acting as a interface to engage stakeholders and policy makers to develop the Brazilian biofuels sector.

According to a Report[9] delivered to the aviation governmental authorities, the Brazilian Biojetfuel Platform represents a general agreement on the high level conclusions derived from the outcomes of the parallel works carried out by different organizations or corporations in the frame of the study, particularly the SAB study funded by Boeing, Embraer, and FAPESP. The stakeholders involved are committed to undertake collaborative actions to promote the implementation of a multi feedstock and multi process biojetfuel value chain in Brazil.

It is presented bellow some parts of this Report in order to inform on the work planned to be carried out by the Platform in Brazil on bringing together key stakeholders to promote the implementation of a highly integrated biojetfuel and renewables value chain, "from R&D to the wing", to fill in the gaps identified by the Sustainable Alternative Biojetfuel study sponsored by Boeing, Fapesp and Embraer.

" Due to the continental dimensions of Brazil, the Platform has divided the country into four production hubs in order to better address the regional opportunities, based on a balanced scorecard evaluation of land and labor availability, climatic conditions, local inputs and logistic integration.

a) North/Northeast – sustainable feedstock production hub, optimal export logistics to USA, Europe and Asia.
b) East – integration into the infrastructure of Polo Petroquimico de Camaçari, availability of Hydrogen, downstream consumption of green naphtha and renewables, and export facilities through the Port of Aratu.
c) Center/West – addressing the demand of central hub of Brasilia, consolidating grain production of Center/West States.
d) Southeast – pilot multi-feedstock, multi-process value chain to address the major demand of biojetfuel of Southeastern Airports of Brazil.

The Biojetfuel Production Matrix

There is no single pathway for transforming biomass to aviation biofuel. Instead, there are currently several different pathways and there will be more in the future. Based on the SABB study sponsored by Boeing, Embraer, and IADB, the Brazilian Biojetfuel Platform will establish Green Economy projects to cover the gaps identified by the study, onto a highly integrated multi feedstock, multi process value chain. The Platform is technology agnostic, providing a supportive, open and collaborative framework for all feedstock and processes.

[9]Report on the Bio Brazilian Biojetfuel Platform elaborated by Mr. Javier Mate – Curcas, Mr. Mike Lu – Curcas with the collaboration of: Mr. Adilson Liebsch – Amyris, Mr. Al Bryant – Boeing, Ms. Aurea Nardelli – RSB Services., Mr. Daniel Fischer – GE., Prof. Donato Aranda- UFRJ, Mr. Jamil Macedo – IICA, Mr. Kevin Weiss – Byogy, Mr. Mario Fontes – Bioeca, Mr. Pedro Scorza – GOL., Mr. Priscila Gatti – GOL., Mr. Rodrigo Gabizo – GE, Mr. Sergio Zuquim – GE.

Regional Sustained Development

Aviation is not the only potential user of renewable biomass resources and it will have to compete for these limited resources with the road transportation segment. Furthermore, large land area requirements indicate that it is unlikely that a single region could create sufficient biomass to meet worldwide demand for biofuels. Hence, the Platform's view is that large-scale implementation of biofuels would arise through a combination of regionally appropriate feedstocks. Due to the continental dimensions of Brazil, the Platform has divided the country into four production hubs in order to better address the regional sustained development opportunities. Green Economy biofuel projects will be evaluated and selected through a balanced scorecard evaluation based on land and labor availability, climatic conditions, local inputs, infrastructure, social development and logistic integration.

a. North/Northeast – export oriented sustainable feedstock production hub based on the regional diversity and port infrastructure of Itaqui, MA and Pecem,CE:
    - Babassu biomass collection program from the 18 million hectare natural forest of babassu covering primarily the States of Maranhão, Piauí, and Tocantins.
    - Dende oil from the Federal Dende Program in the State of Para.
    - Jatropha Food+Energy Program in Northern Piauí, intercropping Jatropha with food short cycle crops in 200 Family Farming settlements in a 150 km radius of the 10,000 hectare Fazenda Tiracanga anchor farm, supported by an adjacent crushing unit and Jatropha Excellency Center in Piracuruca, PI.
b. East – integration into the infrastructure of Polo Petroquimico de Camaçari, availability of Hydrogen, downstream consumption of green naphtha and renewables, and export facilities through the Port of Aratu.
c. Center/West – addressing the demand of central hub of Brasilia, consolidating grain production of Center/West States.
d. Southeast – pilot multi-feedstock, multi-process value chain to address the major demand of biojetfuel of Southeastern Airports of Brazil. Sugar cane, Camelina, Jatropha, Tallow, and UCO are the feedstocks considered in Phase I, Amyris 50 million liter DSHC plant in Brotas - SP, Solazyme plant in Orindiuva - SP, ATJ and a two-step 300,000 tons of HEFA biorefinery in Guaratinguetá - SP compose the industrial processes of the Southeastern Hub.

Research, Development & Innovation

The Platform has engaged several high level research institutions in Brazil to pursue the domestication and introduction of alternative feedstocks for the production of biojetfuel and renewables. Ongoing research projects include:

1. Embrapa Agroenergia with a network of research institutions on the BRJatropha program, Macauba, Dende and Jatropha.

2. GE - technical support and alternative fuels landscape and assessment, implementation of new technologies and analytics.
3. IICA - LAC – Latin American and Caribbean Network on Jatropha Research.
4. IAPAR on the Camelina introduction in Paraná.
5. IAC, CTC on the continued research on sugar cane.
6. Federal University of Rio de Janeiro -UFRJ on HEFA process and Algae.
7. Federal University of Minas Gerais – UFMG for Macauba and biomaterials research.
8. University of Florida on Jatropha hybrids, TC propagation protocol, and Jatropha Excellency Center in Piracuruca – PI.
9. SGB – Jatropha Research program, and Jatropha Excellency Center Hybrid trials and pre-commercial plantation pilots in multiple locations within Brazil.

Feedstock

Based on the Brazilian biodiversity, land availability, climate, and labor, the Platform is taking an initial regional approach on the following feedstock supply chains:

a) Jatropha intercropped with food cultures with family farmers, and extensive plantations with agribusiness in Piauí.
b) Camelina introduction as a winter crop, "safrinha", after soy harvest, in Paraná, to make use of 2 million hectares of land available during the Winter.
c) UCO – systematic UCO collection program in Vale do Paraíba, integrating the Metro regions of São Paulo and Rio de Janeiro.
d) Sugarcane for the Amyris and Solazyme plants in São Paulo. Those will be integrated upstream from traditional supply chains, like Tonon Bioenergia, São Martinho and Bunge.
e) Macauba in the State of Minas Gerais.
f) Algae in the States of Maranhão, and Piauí.
g) Babassu as biomass from the 18 million hectares of natural forest in the States of Piauí, Maranhão and Pará.
h) Tallow, and chicken fat in Piauí and São Paulo.

Refining processes

a) DSHC pathway – Amyris has commissioned a 50 million liter/year farnesene plant in Brotas, SP, with finishing process (hydrogenation) in Paulínia, SP for the supply of DSHC biojetfuel. This production unit is less than 250km from the main airports of São Paulo State, and has been producing commercially since Q4 2012, with sugarcane supply by Tonon Bioenergia. The ongoing ASTM DSHC certification process is expected to be concluded in 2013. Amendment to ANP Resolution 20/2013 will be required in Brazil to allow the use of blend up to 10% of sugarcane derived jet fuel into regular fossil jet fuel.
b) Algae – Solazyme will commission its plant in December 2013 in Orindiúva, SP, to provide basic feedstock for Solajet.

c) HEFA pathway – Curcas is structuring the technical project with UFRJ for a plant co-sited at the BASF chemical plant in Guaratinguetá, SP.

Logistics

The logistics for biojetfuel in Brazil will be structured on two pilot supply chains:

1) The North/Northeastern Hub Jatropha Crude Oil Export value chain to be implemented based on the Jatropha production of Fazenda Tiracanga and future production of the rural settlements in a radius of 150 km from the crushing plant of Brasil Ecoenergia in Piracuruca, PI. Logistics will rely on tanker trucks for the initial low volume Jatropha Crude Oil for export through the Port of Pecem in Ceará.
2) The logistics for DSHC supply chain based on the Amyris Farnesene plant in Brotas, SP is being structured by the Infrastructure Work Group of the Platform for operational kick in June 2014, based on the Flying Green Program of participating airlines. GOL is projecting 200 domestic flights from CGH, GRU, SDU and GIG airports during the games. Following the games, the provisional logistic procedures will be improved for the GOL commercial flights between Sao Paulo (GRU) and Rio (GIG).

Sustainability- RSB/Curcas certification projects for the Brazilian Biojetfuel Platform

RSB Services has joined the Brazilian Biojetfuel Platform to support the sustainability certification of the multi-feedstock and multi-process value chains of the Platform, including the development of a small holders certification process, and also assist with the GHG calculation engine for the Platform Carbon Footprint Management System. The following requirements are required for each process/ operator involved in the supply chain, to allow for sustainability declaration of the value chain related to “green flights” under RSB:

Requirement	Feedstock producer	Feedstock processor	Biofuel producer	Blender/ Distributor	End consumer (airline)
Evifonmental/ Social	✓	✓	✓		
GHG emissions	✓	✓	✓	✓	
Coc: Mass balance	✓	✓	✓	✓	✓

- <u>Small holders group certification</u>. A pilot of RSB small holders standard and group certification was carried out in Londrina/Rolandia in August 2013 (part of a project of RSB/EPFL, with support of Aidenvironment and, in Brazil with participation of RSB Services and Planapec). The pilot consisted in field evaluation and interviews with small holders involved in soy plantations, to collaborate in the construction of an easier and relevant standard for group certification of smallholders. Additionally, the project will also lead to a set of recommendations for the RSB on how to increase smallholder access to the standard and alternative options for smallholder definitions.

- Camelina value chain certification. RSB Services will support and provide guidance to Planapec for a RSB certification of a group of Camelina producers in the Londrina, PR region. Since this is a new feedstock being introduced in Brazil by IAPAR as a "safrinha" (or winter crop after soy), it is necessary to work closely with this research institute and producers, to define alternatives for the challenges that may impact the certification process. IAPAR will be conducting the Camelina placement trials with cultivars from Camelina Company in 9 sites in the state of Parana in 2014, under a 5 year research program with the Platform. Commercial trials will be conducted with Cooperatives in Northern Paraná, therefore RSB certification of the respective Camelina value chain is planned for May 2014.
- Jatropha value chain certification. Certification of the a value chain of Jatropha oil in Piracuruca, PI will include the Jatropha plantation at Fazenda Tiracanga, the crushing process of Brasil Ecoenergia in Piracuruca, PI, and the delivery of Jatropha Crude Oil to the Port of Itaqui in Maranhao and/or Port of Pecem in Ceara. Export through the Port of Luis Correia will be considered after the retrofitting of the port infrastructure under the Federal Government PAC program. Fazenda Tiracanga is a 10,000 hectare private investment focused on Jatropha, and will serve as the anchor farm to support the Food+Energy Program of the Secretary of Rural Development of the State of Piauí. This Program will to intercrop Jatropha with short cycle cash crops in the rural settlements with a 150 km radius from Piracuruca, PI, where the Fazenda Tiracanga and the Brasil Ecoenergia crushing station are located. In the region there are 200 rural settlements with an average of 25 families each. Family farming will be very important component of the jatropha value chain in Northern Piauí.
- Amyris DSHC value chain certification - This should be the first certified commercial biojetfuel value chain in Brazil. The sustainability certification of this chain will involve:
    i. Feedstock producer and processor: Sugar cane certification by Bonsucro for Tonon, including the gaps related to the benchmarking study comparing Bonsucro and RSB standards. It will allow the mill to achieve a dual certification and provide certified feedstock to Amyris that is recognized by the RSB certification scheme.
    ii. Biofuel producer: RSB certification of Amyris DSHC plant in Brotas, SP will also include the hydroprocessing finishing step of Farnasene at the Air Liquide plant in Paulinia, SP, since the custody of the product will remain with Amyris.
    iii. Blender: Upon definition of the final blending sites, the blenders will be certified

to keep the integrity of the value chain. Multisite certification is allowed, in the case of an operator is managing more than one site. Requirements related to GHG emissions and traceability based on mass balance methodology are applied by site. The transportation does not require a separate certificate. The controls of flows (products and documents) and GHG emissions related to the transport of certified products between an operator to another is under responsibility of the operator which has the custody of the product. Additional support will be provided to blenders and distributors to complete the value chain. They should be certified to calculate GHG emissions at the end of the chain and to allow final clients (as airlines) to do declarations and claims related to sustainable certified biojet fuel used in the "green flights".

iv. End users: The airlines interested in doing declarations about use of RSB certified biojet fuel should be certified under chain of custody standards. They should evidence the amounts of biojet fuel they are buying and using.

Carbon Footprint Management System of the Brazilian Biojetfuel Platform.

The system will be based on the RSB GHG emissions calculation tool, with recognized methodology in line with international parameters (including the EU-RED). The GHG emissions related to the flights using sustainable biojet fuels will be calculated for each feedstock and process and will give information about savings and benefits of the initiative in comparison with the fossil fuel. It will provide the carbon footprint of the whole value chain, to be shared with stakeholders of the Platform, ANAC and, other governmental entities and the public in general. The Platform will built the Carbon Footprint Management System prototype based on the jatropha value chain in Piracuruca -PI and the Amyris DSHC value chain in Brotas –SP."

6.3 AIR TRAFFIC MANAGEMENT

The implementation of the Global ATM Operational Concept, announced by ICAO, aims to obtain benefits for all the members of ATM community. One of these benefits is related to environmental protection. The strategic objective is the reduction of the fuel consumption and, consequently, the decrease of GHG emission.

Thus, regarding the international commitments assumed related to environmental protection, particularly in accordance with the resolution A36-23[10], adopted at the 36th session of the ICAO General Assembly, Brazil started, in 2007, the introduction of Area Navigation (RNAV) and Required Navigation Performance (RNP) procedures supported by Global Navigation Satellite System (GNSS) to

[10] Urges all States to implement RNAV and RNP Air Traffic Services (ATS) routes and approach procedures in accordance with the ICAO PBN concept laid down in the Performance-Based Navigation Manual (Doc 9613).

optimize en route and Terminal Control Area (TMA) operations in accordance with the ICAO PBN concept, providing the implementation of a more flexible and efficient flight path.

Regarding ATS routes, Brazil has implemented and published a total of 111 RNAV5 procedures (54 domestic and 57 international routes). The planned implementation RNAV5 procedures amount to 49 routes (27 domestic and 22 international routes). Additionally, there are also a total of 4 RNAV10 procedures published (for international routes). The information are summarized in Table 5.

Table 5: En-route PBN Operations

Navigation Specification	Completed (Number of routes)		Planned implementation (Number of routes)	
	Domestic	International	Domestic	International
RNAV 10	-	4	-	-
RNAV 5	54	57	27	22
RNAV 2	-	-	-	-
RNP 4	-	-	-	-
RNP 2	-	-	-	-
TOTAL	54	61	27	22

At the TMA, the PBN concept has been implemented through Standard Instrument Departure (SID) and Standard Instrument Arrival (STAR), as well as approaching procedures, based on RNAV and/or RNP. Table 6 presents a summary of the type and number of implemented procedures, as well as the planned implementation for the next years.

Tabela 6: PBN Procedures

Type of procedure	Completed (Number of routes) Domestic	Planned	
		Number	Year
RNAV STARs	71	135	2014
RNP STARs	-	362	2018
RNAV SIDs	165	215	2014
RNP SIDs	-	156	2018
BASIC GNSS RNAV APPROACH	162	-	-
RNP APPROACH only LNAV	74	227	2016
RNP APPROACH with Baro/VNAV	88	227	2016
RNP AR APPROACH	4	24	2016

The full implementation of the PBN concept in all the Brazilian TMA is presented in the schedule according to Table 7.

Table 7: PBN Implementation at Brazilian TMA

Brazilian TMAs	Year of implementation
Brasilia and Recife	2010
São Paulo and Recife	2013
Belo Horizonte and Salvador	2015
Curitiba, Florianópolis and Navegantes	2017
Porto Alegre and Natal	2019
Manaus and Fortaleza	2021
Porto Seguro and Ilhéus	2023
Foz do Iguaçu and Campo Grande	2025
Maceió and Aracajú	2027
Belém and Anápolis	2029
Boa Vista and Porto Velho	2031
São Luiz and Vitória	2033
Uberaba and Bauru	2035
Rio Branco and Teresina	2037
Anápolis and Santa Maria	2039

Source: Department of Air Space Controle

As it can be seen in Table 7, the implementation of the PBN concept was already concluded in the TMA of Brasília and Recife. For the TMA of São Paulo (TMA-SP) and Rio de Janeiro (TMA-RJ), the conclusion is foreseen for November 14th, 2013. Taking into account both TMA, they concentrate approximately 50% of the national air movement. So, it can be verified that, after concluding its implementation, the PBN concept will cover around 50% of the Brazilian airspace.

In general, based on the expected reductions by the application of the PBN concept in the TMA-SP and TMA-RJ, the flight times will be reduced in about 10 minutes. As next steps, it is planned to perform data modeling, using the simulation software known as TAAM (Total Airspace and Airport Modeler), which will accurately calculate the time gains and fuel economy with the implantation of the new procedures.

6.4 OPERATIONAL IMPROVEMENTS

The Brazilian airlines have implemented some initiatives with the purpose of reducing the fuel consumption and, consequently, the CO2 emissions. These initiatives include:

- preflight procedures, such as the aircraft's internal weight reduction, flight planning, taxi and reducing the use of APU (Auxiliary Power Units);
- flight procedures: take-off, climbing, sinking, waiting and approaching procedures; and
- maintenance measures.

The Brazilian airline Gol Linhas Aéreas, for example, is implanting a project for reducing the APUs use during its aircrafts night maintenance. According to this project, the maintenance shall be made with the use of GPUs (Ground Power Units). This considerably reduces the fossil fuels burning, because the GPU uses the common diesel as fuel and it consumes much less fuel per hour for producing the same electricity. It shall be highlighted that, besides the CO_2 emissions volume reduction, the use of GPU substantially diminishes the noise in the airport area.

The national airlines are also involved, along with the DECEA[11], on the PBN (Performance Based Navigation) technology implementation which defines more efficient approaching, landing, taking-off and depart procedures. Besides the air navigation infrastructure availability, which is DECEA's responsibility, this project also involves air carrier's initiatives on the installation of technology inside the aircrafts and the aircrafts certification by the National Civil Aviation Agency Brazil - ANAC. According to what was previously exposed, this project shall provide significant efficiency gains on fuel consumption.

It is highlighted a joint initiative of the airline Gol and GE and the Brazilian Company of Airports Infrastructure – Infraero, for encouraging the use of electric sources and air conditioning generated by the airport. This initiative has the purpose of reducing: the carbon emissions, the aircraft noise and the fuel consumption. Congonhas Airport, in São Paulo, has already performed tests using the airport electricity source to provide power to the aircrafts in one of its parking positions and other Brazilian airports have already studied the adoption of the measure. Although it is still under analysis by the airport administrators, the use of electricity and air conditioning provided by the airports has the potential of significantly reduce the sector's emissions.

The Brazilian airlines have shown interest on fuel efficiency improvements, not only for reducing costs, but also for contributing with the sustainable development of the sector. One of the great national companies, Gol Linhas Aéreas, has several projects which aim at improving the fuel efficiency on their operations and it is already trying to quantify the environmental gains arising from the implantation of these projects. These projects include more efficient approaching maneuvers (destination maneuvering), flights' dispatch time reduction (minimum dispatch) and a policy of selecting alternative airports that differ from the one of certain flight

[11] Air Space Control Department – Aeronautic Control.

destination, based on the operational, infrastructure and weather conditions, involving a certain time period before and after the arrival time foreseen for each flight (alternate selection).

According to the company, besides the economy generated, related to the fuels consumption decrease, such procedures, from the months of January to June 2013, promoted a reduction of 1.055 tonnes of fuel burn and 2.598 tonnes of CO_2 emissions.

6.5 IMPROVEMENTS ON THE INFRASTRUCTURE AND REGULATORY MEASURES

The investments in airport infrastructure have the potential of: increasing the airports capacity efficient use and planning, promoting better passengers and freight processing, reducing the aircraft time in land and reducing the traffic for landings and take-offs. Thus, these measures, while providing more efficient operations for the airlines and airport administrators tend to reduce the unnecessary fuel burning and contribute to improve the fuel efficiency. The Brazilian government has tried to enlarge and modernize its airport infrastructure so that the development of the sector is made in an effective and sustainable way. In addition to this some recent Brazilian government regulatory measures aim to increase the efficiency of the sector. They are: the concession of big airports to the administration of the private sector and slots management rules. The present text tries to present the actions in course in the country for the expansion of the airport infrastructure and for the modernization of its management.

Currently, the Brazilian airport infrastructure is formed by 720 public aerodromes. Among them, there are airports delegated to states and cities, as well as granted to the private initiative, such as Brasília, Guarulhos, Viracopos and São Gonçalo do Amarante. The main infrastructure, serving the capitals, counts on 31 airports with regular flights. Besides, 98 regional airports receive regular aviation flights. So, the Brazilian airport infrastructure is, at the present date, formed by 129 aerodromes receiving regular flights.

The Presidency of the Republic of Brazil launched the "Program of Investment in Logistics: Airports", which reunites a set of measures for improving the services quality and the airport infrastructure, and widening the air transportation offer to the Brazilian population. The main measures compounding this program are:

- two airports concession - Galeão (RJ) and Confins (MG);
- Infraero Serviços creation, an Infraero' subsidiary, which, in partnership with an international operator, will offer planning, consulting, administration services, support to operation, workforce training and others related to the exploration of airports in Brazil and abroad;
- strengthening and widening the regional aviation through investments and incentives;

- regulatory improvement for slots (arrivals and departs times) in airports which are already operating in the capacity limit;
- Authorizations for airports dedicated to the general aviation.

The airports concession to the private administration has the main objective of widening and perfecting the Brazilian airport infrastructure, promoting improvements in the services and in the quality levels of the services supplied to the air transportation consumers in Brazil.

The privatization of Brazilian airports administration began in August, 2011, with a greenfield concession of "São Gonçalo do Amarante Airport" (ASGA). The ASGA airport will be located in Natal, Rio Grande do Norte (Northeast of Brazil), and it is planned to be ready by 2015. Later in the same year, Brazil started to organize what is became known as the "first round" of concessions. The airports involved in this round were: Guarulhos International Airport, Campinas International Airport and Brasilia International Airport. The first two serve the metropolitan region of São Paulo and the last is one of the main hubs of the Brazilian airport system. These are the Brazilian airports that concentrate the largest investment requirements for the next thirty years and that is why they were chosen to be part of the first round of the concessions.

Galeão (Rio de Janeiro) and Confins (Minas Gerais) airports are, at the present date, under a concession process. Regarding ownership structure of privatized airports in Brazil, Infraero remains a minority partner with a share of 49% in all the consortia responsible for the management of granted airports. This participation is aimed to ensure that the best management practices and operating technologies brought by different airports operators can be transferred to smaller airports in Brazil that still are going to be operated by Infraero, ensuring that the gains of introducing competition in the sector are not restricted to granted airports, but also achieve other important airports in the system.

Another objective of the Investments Program is strengthening and widening the regional air transport networks. For such, the Federal Government plans the investment of R$ 7.3 billion in the first step of the regional aviation plan. The measures will allow perfecting the quality of the service supplied to the passenger, aggregating new airports to the regular air transportation network and increasing the number of routes operated by airlines.

The investments foreseen are around R$ 1.7 billion in 67 airports in the North region; R$ 2.1 billion in 64 airports in the Northeast region; R$ 924 million in 31 airports in Mid-West; R$ 1.6 billion in 65 airports at Southeast; and R$ 994 million in 43 airports in the South region. The program aims at increasing the access of the Brazilian population to air services. The objective is that 96% of the Brazilian population is at least 100 kilometers away from an airport able to receive regular flights.

The projects will promote the improvement, the refit, the reform and the expansion of the airport infrastructure, both in physical facilities and in equipment.

The investments will include, for example, reform and building of runways and taxiways, improvements in passengers terminals, revitalization of signaling and pavement, among others. The resources will come from the National Fund of Civil Aviation (FNAC).

In order to prioritize the investments, it was defined a set of criteria for the analysis of the aerodrome relevance, which includes: the volume of passengers and freight, the regular flights and the operational results. Besides, social and economic aspects, the level of accessibility in Legal Amazon, the touristic potential, and foment of the national integration will be taken into account.

Another relevant action related to the modernization of Brazilian aerodromes refers to the publication of a standard regulating the conditions for the authorization of public civil aerodromes exclusively dedicated to the general aviation. This modality includes services such as the executive aviation, air taxi, instruction and training (air clubs and aviation schools), specialized (agricultural, advertising, firefighting) services, aero sport, between others.

The standard aims to increase the supply of airport infrastructure in Brazil dedicated to the general aviation, which is of great importance for the economy of the country. According to the Brazilian Association of General Aviation (ABAG), in 2011, the Brazilian fleet in this segment reached 13,094 aircraft, representing an increase of 6.3% over 2010. Thus, airports primarily focused on private air services can be planned and structured with greater speed and efficiency to meet different markets, kept all the rules and safety standards in force for the operation of airports in the country. It is intended, therefore, to add public and private efforts in the provision of airport infrastructure in Brazil.

The described measures are aimed at meeting the large projected growth of the Brazilian civil aviation. From this projection, it is understood as essential to have a long-term planning for the expansion of the Brazilian airport infrastructure. As described earlier in this document, the sector's growth will naturally be accompanied by an increase in total emissions. However, an effective planning for infrastructure expansion and modernization of its management will avoid congestions and other operative inefficiencies, and will certainly contribute so that the rhythm of growth (or intensity) of the emissions is attenuated.

7 - Conclusions

The Brazilian air transport, both domestic and international, tends to grow fast. As exposed earlier in this document, the number of travels per person, per year in Brazil is only 0.42. This means that a Brazilian makes, in average, one airplane travel every two years. Taking into account Brazil's continental dimensions and the countries distance from the main international destinations, this number shall substantially grow. The Brazilian market is not a mature market yet. There is a potential for the incorporation of new passengers, creation of new routes and consolidation of the routes already existent. This reality requires public policies to assure the aeronautic infrastructure to the sector, regarding: airports, air navigation services, and the availability of qualified workforce.

Bearing in mind the strategic importance of the sector in national integration and economic dynamism, the government has adopted a series of measures for promoting the civil aviation development in Brazil, previously described. It shall be highlighted that there is a concern that this development is sustainable, from the economic, social and environmental point of view. Regarding the environmental subject, the National Civil Aviation Agency Brazil – ANAC regulates the issues of noise and emissions affecting the local air quality.

The measures related to the civil aviation greenhouse gases emissions reduction are getting great relevance on the Brazilian governmental agenda, mainly from the international debates in the context of UNFCCC and ICAO. It shall also be highlighted the Brazilian private sector initiatives related to technologic development, research and development of biofuels, and deployment of more efficient operations.

The governmental bodies are also involved in actions which shall contribute to reducing the GHG emissions, such as: biofuels research and development (EMBRAPA and FAPESP) and international cooperation on biofuels with the USA (MRE), deployment of new technology which improves the efficiency of the air traffic management (DECEA), and regulatory measures such as the concession of airports to the private administration and SLOTS management (ANAC and SAC). The Brazilian government is also performing a great effort for measuring the sector's emissions, both for reporting to UNFCCC and ICAO.

In this context, the Brazilian government recognizes the important role of ICAO on the unification of rules and standards allowing a safe and harmonic development of the international civil aviation. Bearing in mind the eminent global nature of the international civil aviation activities, the debates on the sector's GHG emissions shall be made in the scope of ICAO. Thus, the Brazilian government intends to support the Organization's work on the theme in a constructive and cooperative way with the purpose of contributing to a sustainable development for the world's civil aviation.