ACTION PLAN
FOR REDUCING GREENHOUSE GAS EMISSIONS OF BRAZILIAN CIVIL AVIATION
BASE YEAR 2015
2nd EDITION
## Contents

1. Executive Summary 5
2. Introduction 7
3. 2. Brazilian Action Plan Scope 9
   - 2.1 Domestic aviation and international aviation: concepts 11
   - 2.2 The Calculation of Fuel Consumption and GHG Emissions: Methodology Adopted 12
4. 3. Brazilian Aviation: data of the sector 13
5. 4. The Carbon Footprint of Brazilian Aviation 19
   - 4.1 Fuel Consumption 20
   - 4.2 Fuel Consumption Growth Forecast 22
   - 4.3 Greenhouse Gas Emissions 23
6. 5. Emissions Intensity and Fuel Efficiency 25
   - 5.1 Emissions Intensity (IE) 28
   - 5.2 Fuel Efficiency (EE) 31
7. 6. Measures which Contribute to Reducing the GHG Emissions of Aviation 35
   - 6.1 Contributions of Airports 36
     - 6.1.1 Infraero 36
     - 6.1.2 Airport of Guarulhos/ Governador André Franco Montoro 39
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1.3 Airport of Campinas/Viracopos</td>
<td>42</td>
</tr>
<tr>
<td>6.1.4 Airport of Belo Horizonte/Confins</td>
<td>45</td>
</tr>
<tr>
<td>6.1.5 Airports of Brasilia/Presidente Juscelino Kubitschek e São Goçalo do Amarante/Governador Aluízio Alves</td>
<td>47</td>
</tr>
<tr>
<td>6.2 Aeronautical Industry: Technological Development</td>
<td>48</td>
</tr>
<tr>
<td>6.2.1 Embraer</td>
<td>48</td>
</tr>
<tr>
<td>6.3 Contributions of Airlines</td>
<td>49</td>
</tr>
<tr>
<td>6.3.1 Gol Linhas Aéreas Inteligentes</td>
<td>49</td>
</tr>
<tr>
<td>6.3.2 TAM Linhas Aéreas – LATAM Group</td>
<td>54</td>
</tr>
<tr>
<td>6.4 Aviation Biofuels</td>
<td>57</td>
</tr>
<tr>
<td>6.4.1 Minas Gerais Platform of Bio Jet Fuels and Renewables</td>
<td>57</td>
</tr>
<tr>
<td>6.4.2 Actions of the Air Carrier Gol Linhas Aéreas Inteligentes</td>
<td>60</td>
</tr>
<tr>
<td>6.4.3 Actions of the Air Carrier TAM Linhas Aéreas</td>
<td>62</td>
</tr>
<tr>
<td>6.5 Improvements in Air Traffic Management</td>
<td>63</td>
</tr>
<tr>
<td>Conclusion</td>
<td>67</td>
</tr>
<tr>
<td>Stakeholders</td>
<td>69</td>
</tr>
</tbody>
</table>
Executive Summary

The Action Plan aims to present an overview on the impact of domestic and international Brazilian aviation on climate change. It concerns an update of the document delivered to the International Civil Aviation Organization – ICAO, in 2013. This new edition includes information regarding fuel consumption and Greenhouse Gas emissions – GHG of Brazilian aviation up to end of 2015.

Besides the data, the document also brings the description of mitigating actions adopted in the country, which will contribute to the development of aviation with less impact on the environment. Among these actions, the following stand out:

1. **Operational improvements**: actions that promote greater efficiency of operations and reduced fuel burning and Greenhouse Gas Emissions.

2. **Air Traffic Management**: Implementation of procedures that increase the operations efficiency in route and in Terminal Control Areas.

3. **Aircraft Technological Development**: Aerodynamic improvements, engines efficiency, use of light materials, etc.

4. **Development of biofuels for aviation**: R&D actions to create an aviation biofuel production chain in Brazil.

5. **Airports**: Supply of air-conditioning and electricity at the boarding gate (avoids fuel burning of the aircraft on the ground and reduces greenhouse gas emissions); intelligent buildings (use of renewable energy, LED lamps and natural illumination), among others.

This Action Plan was prepared to contribute to ICAO’s efforts to reduce greenhouse gas emissions of international aviation, as requested by the Organization. Nevertheless, the document is more encompassing and contains information related to domestic aviation. The contents are the result of joint work between governmental bodies, airport administrators, airlines, aeronautical industry, and Brazilian and Minas Gerais biojet fuels Platforms.

Thus, a coordination was achieved between the stakeholders related to the sustainable development of the sector, which will be able to contribute to the effective implementation of mitigating measures. There remains a lot to be done, as, for example, establishing harmonized methodologies to calculate the impact of the mitigating measures on reducing greenhouse gas emissions, developing regulatory milestones which make the adoption of some of the measures feasible and mobilizing the financial resources available. This will require continuous work with the involvement of the private sector and the support of public bodies.
Introduction

Climate change is an issue that requires the involvement of all society and especially national governments, which must adopt urgent and shared solutions to avoid the global warming to critical and irreversible levels. The Brazilian government takes part actively in international negotiations regarding the issue in the UN Framework Convention on Climate Change – UNFCCC. In the last meeting of the Conference of the Parties (COP21) of UNFCCC, held in Paris, in December 2015, Brazil presented a document (INDC) with ambitious mitigating commitments. The Brazilian INDC emphasizes that the country already reduced its emissions by more than 41% in 2012, when compared with 2005. The document also indicates that Brazil has one of the largest and most successful biofuel programs, including the cogeneration of electricity from biomass. The Brazilian energy matrix is composed of 40% of renewable energy and, if we consider only the electricity generation, this value attains 75% of renewable energy. The Brazilian intention presented in the document (INDC) is to reduce greenhouse gas emissions to 37% below the levels of 2005, in 2025; and 43% below the levels of 2005, in 2030. This commitment refers to all the domestic economy.

Regarding aviation, despite there is not a specific sectoral goal, several actions are in course for reducing the emissions of the sector, in both the domestic and international market. Civil aviation contributes with approximately 2% of total anthropic emissions of greenhouse gases in the planet. ICAO, during its 37th Assembly, held in October 2010, approved Resolution A37-19, which endorses a range of measures to deal with the contribution of international civil aviation to climate change. The adoption of these measures was reinforced in 2013 upon the occasion of ICAO’s 38th Assembly (Res. A38-18). Among the recommendations contained in ICAO’s Assembly Resolutions is the request to the Member Countries to submit, voluntarily, their respective Action Plans. Is it relevant to highlight that the member countries also agreed with a voluntary commitment to seek an improvement of 2% a year in fuel efficiency, considering 2010 as the baseline.

1 “Intended Nationally Determined Contribution – INDC”.

2 The Kyoto Protocol, in its article 2.2, checks the responsibility of international air transportation emissions at the International Civil Aviation Organization.
This Action Plan is an update of the Action Plan for Reducing the Greenhouse Gas Emissions of Brazilian Civil Aviation presented to ICAO in 2013. The first part of the document contains explanations about the scope of the Action Plan and the methodologies used for measuring the emissions. It also presents the Brazilian aviation economic data and the sector’s fuel consumption and GHG emissions. The second part of the Plan lists the mitigating actions in course or planned that shall lead to aviation’s GHG emissions reduction. This document incorporates information, which does not appear in the previous document, concerning the actions of mitigating greenhouse gases of Infraero and the administrators of the airports granted. This report also presents measures undertaken by some of the Brazilian domestic airlines related to fuel efficiency and investment in renewable fuels. Measures related to the technological development of aircraft are also described. Furthermore, the data related to improvements on air traffic management were updated. Another relevant measure mentioned in the Action Plan is the project of developing a production chain of bio jet fuel in Brazil, which involves several public and private entities. This Project is strategic for the long-term reduction of aviation’s domestic and international greenhouse gas emissions.

As emphasized in the previous Action Plan, this document does not constitute a domestic sectorial plan for Brazilian aviation, as defined by article 11 of the Federal Law 12.187/09. The Action Plan for Reducing the Brazilian Aviation GHG Emissions consolidates data on fuel consumption and emissions of the sector and gather the mitigation information adopted or planned to address these emissions. The main objective is to share this information with ICAO and its member states in order to contribute to the global effort of combating climate change.
2. BRAZILIAN ACTION PLAN SCOPE
This second edition of the Action Plan updates data concerning the sector’s growth, the fuel consumption and the GHG emissions presented in the document of 2013. First, there is an analysis of the Brazilian aviation economic data. Subsequently, there is the evolution of fuel consumption and associated emissions and a forecast of the fuel consumption growth, with the notification that it is a simplified analysis, based on traffic evolution data for a limited period.

The document also presents measures already adopted or planned to improve aviation’s fuel efficiency. They involve initiatives of different public and private institutions, which aim to increase the efficiency of the aviation sector, reduce costs and diminish the volume of GHG emissions. It is worthy to stress that the experience acquired in the preparation of the previous Action Plan allowed a greater commitment of the sector’s stakeholders who contributed with information regarding the mitigation measures already adopted or planned. Some of the contributions received bring numerical data regarding the impact of each measure in reducing GHG emissions. Nevertheless, many measures are in the phase of assessing their impacts and, therefore, there is not yet data about reducing emissions associated with them.

ICAO’s Guide on the development of Action Plans (Doc. 9988) establishes great flexibility in terms of scope, contents and format of the Action Plans. ICAO requests consolidated information about international aviation fuel consumption and GHG emissions to control the evolution of this indicator that, by article 2.2 of the Kyoto Protocol, is the Organization responsibility. Nevertheless, ICAO’s Doc. 9988 also encourages States to indicate actions that have an impact on domestic aviation emissions, which also encompass the airlines domestic operations, the airports emissions and other actions as the production of aviation biofuels.

Thus, this Action Plan presents information concerning fuel consumption on international operations, as requested by ICAO, but also other information that completes the scenario of the aviation sector emissions in Brazil. The following sections describe the concepts and methodologies adopted to present the information and data.
2.1 Domestic Aviation and International Aviation: Concepts

The methodology used in this document follows the guidelines of the IPCC Intergovernmental Panel on Climate Change. In accordance with the IPCC Good Practice Guide (2006), for a multiple-stage flight, each stage must be separately classified as domestic, if it involves transportation of passengers and cargoes between two points in the same country. Under any other circumstances, the stage is considered an international flight. The MIATA (Mapping of Environmental Impact of Air Transportation) system developed by ANAC to calculate the emissions of civil aviation, assumes that for international flights operated by Brazilian companies, the stages inside Brazil are considered domestic stages.

Furthermore, foreign companies operating flights from or to Brazil cannot execute - due to domestic legislation and bilateral agreements in force - operations characterized as domestic stages. Thus, all the stages operated by foreign companies are considered international stages. There are few routes operated by Brazilian companies overseas in which the Fifth or Sixth Freedom Rights apply, with the right to take on board and discharge passengers and cargoes between two points outside Brazil. These routes are generally operated between countries of South America and the Caribbean and are not calculated by the MIATA system. Nevertheless, due to the small quantity of these flights, their total impact is considered negligible.

No attempt is made to reconcile the data generated by the MIATA system with the data of ICAO’s Form M, compiled, filled in and submitted by the National Civil Aviation Agency - ANAC to ICAO, based upon information supplied by the air carriers concerning fuel consumption. The methodology for differentiation between domestic and international flights converges with that recommended by the IPCC and not with the one proposed by ICAO in the first edition of Doc. 9988. The data was compiled in this manner bearing in mind the procedure already adopted to calculate the sector’s emissions inventory, which compose the domestic communication to the UNFCCC. Nevertheless, aiming to provide the data required by ICAO for the consolidation of the information about international civil aviation emissions, this document also makes the distinction between international operations executed by Brazilian companies and international operations executed by foreign companies.
2.2 Fuel Consumption and GHG Emissions Calculation: Adopted Methodology

The data presented in this document was calculated by the MIATA system. The system is based upon the aircraft movement information supplied by the Air Traffic Control Department - DECEA. This data was used to prepare the Reference Report for the civil aviation sector, which is part of the National Announcements Regarding GHG Sources and Sumps, submitted periodically to the UNFCCC, as part of the commitments assumed by adhesion to the Kyoto Protocol.

The fuel consumption and emission calculations are made separately for general aviation, freight and commercial aircraft. The methodology IPCC Tier 3rd is used, based upon the distance flown (approximation by great circle distance) and using the emission factors, for each type of engine, specified by EEA (European Environment Agency) and ICAO (EMEP/EEA CORINAIR Emission Inventory and ICAO Aircraft Engine Emissions Databank, respectively). For turbo propeller aircraft, the emission factors contained in the database of the Sweden civil aviation authority is used.

The system does not calculate emissions of military aircraft or helicopters. Due to these particularities, a reconciliation is made at the end of the calculations with the total of aviation kerosene distributed in the country, per year, according to official data disclosed by the National Agency of Petroleum, Natural Gas and Biofuels - ANP. It is important to highlight that the emissions coming from the consumption of aviation gasoline type fuel represents less than 1% of the sector’s total CO₂ emissions in Brazil and, therefore, were not included in the scope of this work.

Finally, except for the emissions related to the aircraft, the ground operations emissions (such as transportation of people, auxiliary equipment on the ground, generators, air-conditioning of airports, etc) were not included in this document. Despite presenting data about emission reduction volumes obtained by many of these actions individually, it was not possible to calculate the total of their reduction, bearing in mind the incompleteness of the data and the different methodologies adopted by the various actors.

---

3 Data of the 2nd Second National Communication Regarding GHG Sources and Sumps.
3. BRAZILIAN AVIATION: DATA OF THE SECTOR
In the last sixteen years, the domestic market of passengers predominated in the Brazilian scenario compared to the international market⁴ (see Graph 1). On average, 81% of the Brazilian market (in terms of passengers transported) corresponded to domestic flight stages. In 2015 (preliminary data), for example, the volume of passengers was 117 million, with there being 96 million in the Brazilian market and 21 million in the international market. The domestic market also had greater growth between 2000 and 2015 (8.3% a year and 231.2% accrued) than the international market (6.5% a year and 156.4% accrued). On the other hand, the international market grew 13.5% in the period between 2012 and 2015, while the domestic market expanded 8.5%.

In the international market, the volume of passengers transported in the period 2008-2015 had an average annual growth of 7.0% (if considering only the period 2008-2014, the average annual rate attains 8.1%), while the rate of 5.2% was recorded in the period 2000-2007, as illustrated in Graph 2. Such market behavior reflects not only an increase in income and cheaper air tickets, but also the regulatory repositioning of Brazilian civil aviation, expressed in the negotiation of less restrictive air service agreements (freedom on tariffs determination, multiple designation and free capacity, for example). The Brazilian position on international negotiations is based on national rules such as Resolution number 007/2007 of the Civil Aviation Council - CONAC and the National Civil Aviation Policy - PNAC (Decree n. 6.780, of February 18, 2009).

---

⁴Brazilian and foreign airlines that provide public air transportation services in Brazil were considered.

Graph 1: Quantity of paying passengers transported in domestic and international flights in Brazil (in millions) – 2000-2015*.
In Brazil, the main regions of international passengers’ origin or destination were South America (with 33% of market share), Europe (29%) and North America (29%) as shown in Graph 3. On the other hand, other regions are gaining market share, mainly Central America (see Graph 4).

Graph 3: Quantity of passengers transported in international flights arriving to or departing from Brazil, by continent of origin or destination – 2000-2015*.

Source: ANAC *Preliminary Data: 2015
Graph 4: Share by continent in the total of passengers transported in international flights to and from Brazil, by continent of origin or destination – 2000-2015*.

Graph 5 and 6 showed that the USA led in the last sixteen years as the main destination in passenger volume, transporting 5.4 million in 2015, which meant a share of more than a quarter of the Brazilian international market (25.9%). There also stand out, in 2015, Argentina with 14.7% of share, Portugal with 6.8%, Chile with 6.8% and Spain with 4.7%.

Graph 5: Quantity of passengers transported by Brazilian and foreign airlines in international flights between Brazil and the five countries of greatest movement of passengers (in millions) – 2000-2015.
Graph 6: Percentage distribution of passengers transported by Brazilian and foreign airlines in international flights between Brazil and the five countries of greatest movement of passengers (in millions) – 2000-2015.

Comparing the Brazilian domestic and international markets with other countries, using the quantity of passengers who went through airports (embarkation + disembarkation), it is found that, in 2014, according to the report of the Airports Council International (ACI), Brazil is the 5th placed in the world, considering the total number of passengers transported. Regarding the size of the domestic market, Brazil is the 4th placed; and the 36th in the international market.

Graph 7: Domestic and International Markets: Comparative analysis.

Source: ANAC *Preliminary Data: 2015


* The size of the bubble of each country represents the total volume of passengers.
4. FUEL CONSUMPTION AND ASSOCIATED EMISSIONS
4.1 Fuel consumption

The growth trend in the movement of domestic flights and, consequently, in the consumption of jet fuel, already presented in the first edition of the Action Plan, was maintained for 2013 and 2014. Nevertheless, a small retraction was noted in 2015, as shown in Graph 8.

Graph 8: Fuel consumption – Domestic and international operations – 1990-2015

The proportion between jet fuel consumption in the domestic and international operations was maintained, in the last three years, at approximately 60% of the consumption of jet fuel for domestic and 40% for international flights. Table 1 describes the domestic operations, the international operations executed by Brazilian airlines and the total international operations (which include the international stages operated by domestic and foreign airlines). In Table 1, 2005 is adopted as the baseline and the fuel consumption data of the last three years is presented. The accrued growth rate of jet fuel consumption refers to the total consumption of each year related to the consumption of the base year 2005.
There is a noticeable growth in the consumption of domestic jet fuel of approximately 75% as of 2005. The same occurs in the international segment, at rates of about 52%. In particular, a recovery is found in the consumption of Brazilian airlines in the international segment, which had a fall related to the volumes consumed in 2005 and outlined a recovery above this level in 2015. A possible explanation for this increase in the consumption is related to the increase in the international weekly frequencies flown by Brazilian air carriers and the start of the operations of Azul Linhas Aéreas to the USA. Graph 9 presents the historical series of fuel consumption in international operations, segregated by foreign and Brazilian air carriers.

### Graph 9: Jet fuel consumption by Brazilian and foreign airlines in international flights departing from Brazil (in tons) -2005-2015.

![Graph 9: Jet fuel consumption by Brazilian and foreign airlines in international flights departing from Brazil (in tons) -2005-2015.](source: ANAC)
4.2 Fuel Consumption Growth Forecast.

To forecast the fuel consumption growth, it was used data on the evolution of total consumption, per year, of the airlines (both Brazilian and foreign) operating in the international segment, for the period 2000-2015. Another analysis made was the annual fuel consumption by RTK-Revenue Tonne Kilometer\(^5\), in the same period. From these series, a curve with the best adjustment for the points found was obtained. The best adjustment found for both cases was an exponential function. Considering this function and the growth rates forecasted by ICAO of 5.5% per year for the international RTK and of 5.4% per year for the RTK of Brazilian airlines operating in the international segment (Brazil forecast growth RTK 2014 - 2030 ICAO Doc. 9940), an extrapolation was made of the consumption growth by RTK until 2050. From this extrapolation the forecast value for fuel consumption growth until 2050 can be estimated.

\(^5\) Data obtained in the Statistical Yearbooks of the ANAC.

Graph 10: Forecast of consumption growth of jet fuel by Brazilian and foreign airlines in international flights with origin in Brazil (in tons) -2016-2050.

Graph 10 shows a forecast increase of approximately 203.4% in the fuel consumption of international flights departing from Brazil in 2050, related to the base year of 2005. This indicates a forecast consumption of 4.6 million tons of jet fuel per year in 2050.
Using the same methodology, the forecast value for fuel consumption growth in the domestic market up to 2050 was estimated. Graph 11 shows a forecast consumption of 14.4 million tons of jet fuel per year in 2050, which reflects a forecast increase of approximately 618.4% in the fuel consumption of domestic flights up to 2050, related to the base year 2005.

Graph 11: Growth forecast of jet fuel consumption in the domestic market (in tons) -2016-2050.

4.3 Greenhouse Gas Emissions - GHG

Graphic 12 disclose the historical series with the total emissions of the sector. The conversion of GHG into CO$_2$e (CO$_2$ equivalent) is executed as per values presented in the 2nd National Communication of Brazil to the UN Framework Convention on Climate Change$^6$. The series of Graph 12 reflects the fuel consumption series presented in Graph 8. Thus, the annual growth rate of GHG emissions between 1990 and 2015 was maintained at approximately 3.85% on average for the domestic segment and 3.23% on average for the international segment.

$^6$ The GWP Global Warming Potential factors are 1 for CO$_2$, 21 for CH$_4$ and 310 for N$_2$O.
Graph 12: Total GHG emissions of the sector – Series 1990-2015.

Source: ANAC
5. EMISSIONS INTENSITY AND FUEL EFFICIENCY
This section presents the results of the indicators used to follow up the evolution of the sector, in terms of emission per passenger transported (Emissions Intensity) and efficiency improvement in fuel consumption (Fuel Efficiency).

The Statistical Yearbook of the Brazilian Civil Aviation, prepared by ANAC, has information available about RPK⁷ (Revenue Passenger Kilometer) and RTK⁸ (Revenue Tonne Kilometer) for both Brazilian and foreign airlines. Tables 2 and 3 present, respectively: the evolution of RPK and RTK of Brazilian Airlines on domestic and international operations; and the evolution of RTK and RPK for all the air carriers (Brazilian and foreign) operating on international flights with origin in Brazil.

Table 2: Quantity of paid passenger-kilometers transported (RPK) and paid ton-kilometers transported by Brazilian airlines in the domestic and international markets – 2005-2015 (in millions)

<table>
<thead>
<tr>
<th>Year</th>
<th>RPK (x10⁶)</th>
<th>RTK (x10⁶)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>International</td>
<td>Domestic</td>
</tr>
<tr>
<td>2005</td>
<td>22,730</td>
<td>35,561</td>
</tr>
<tr>
<td>2006</td>
<td>16,057</td>
<td>40,556</td>
</tr>
<tr>
<td>2007</td>
<td>14,353</td>
<td>45,911</td>
</tr>
<tr>
<td>2008</td>
<td>18,933</td>
<td>49,563</td>
</tr>
<tr>
<td>2009</td>
<td>19,293</td>
<td>56,731</td>
</tr>
<tr>
<td>2010</td>
<td>23,485</td>
<td>70,238</td>
</tr>
<tr>
<td>2011</td>
<td>26,045</td>
<td>81,452</td>
</tr>
<tr>
<td>2012</td>
<td>26,193</td>
<td>87,005</td>
</tr>
<tr>
<td>2013</td>
<td>27,478</td>
<td>88,226</td>
</tr>
<tr>
<td>2014</td>
<td>29,142</td>
<td>93,332</td>
</tr>
<tr>
<td>2015</td>
<td>33,153</td>
<td>94,380</td>
</tr>
</tbody>
</table>

Source: ANAC

⁷ It represents, in general lines, the demand for passenger air transportation. To calculate the index, in each remunerated flight stage, the quantity of paid passengers transported is multiplied by the quantity of kilometers flown (1 passenger-kilometer is the same as 1 passenger who flew 1 kilometer). (Statistical Yearbook of ANAC, 2014)

⁸ It represents, in general lines, the demand for air transportation in terms of capacity of tons, including the tons for passengers. To calculate the index, in each remunerated flight stage, the paying weight transported is multiplied by the stage distance. In Brazil the average of 75 kilos is adopted for each passenger transported, already including hand baggage. The unit of measurement is ton-kilometer, which represents 1 ton transported for 1 kilometer. (Statistical Yearbook of ANAC, 2014)
To separate national and international stages and segregate the operations between local and foreign transporters, air traffic control data is required. The database with tower movements available starts in 2005. Thus, the calculations of fuel efficiency and emissions intensity start in 2005 for the Brazilian airlines, segregating the operations into domestic and international stages.

**Table 3: Quantity of paid ton-kilometers transported (RTK) and paid passenger-kilometers transported (RPK) by Brazilian and foreign airlines in international flights with origin in Brazil – 2000-2015 (in millions).**

<table>
<thead>
<tr>
<th>Year</th>
<th>RTK (x10⁶)</th>
<th>RPK (x10⁶)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>7,331</td>
<td>51,334</td>
</tr>
<tr>
<td>2001</td>
<td>6,597</td>
<td>47,864</td>
</tr>
<tr>
<td>2002</td>
<td>6,640</td>
<td>45,889</td>
</tr>
<tr>
<td>2003</td>
<td>6,960</td>
<td>49,313</td>
</tr>
<tr>
<td>2004</td>
<td>4,756</td>
<td>55,898</td>
</tr>
<tr>
<td>2005</td>
<td>8,354</td>
<td>62,264</td>
</tr>
<tr>
<td>2006</td>
<td>8,242</td>
<td>62,138</td>
</tr>
<tr>
<td>2007</td>
<td>8,779</td>
<td>67,757</td>
</tr>
<tr>
<td>2008</td>
<td>9,514</td>
<td>77,522</td>
</tr>
<tr>
<td>2009</td>
<td>8,894</td>
<td>75,385</td>
</tr>
<tr>
<td>2010</td>
<td>11,821</td>
<td>89,913</td>
</tr>
<tr>
<td>2011</td>
<td>13,638</td>
<td>102,586</td>
</tr>
<tr>
<td>2012</td>
<td>14,139</td>
<td>109,925</td>
</tr>
<tr>
<td>2013</td>
<td>14,698</td>
<td>114,180</td>
</tr>
<tr>
<td>2014</td>
<td>16,468</td>
<td>130,529</td>
</tr>
<tr>
<td>2015</td>
<td>16,386</td>
<td>130,644</td>
</tr>
</tbody>
</table>

Source: ANAC

To calculate the indicators of Emissions Intensity and Fuel Efficiency, besides the RPKs and RTKs listed in Tables 2 and 3, the CO₂ emission and fuel consumption data presented in the previous section is used.
5.1 Emissions Intensity

The calculation of GHG emissions intensity is based upon the emissions per kilometer flown and per passenger transported. Thus, the variables of increase in the number of passengers transported and growth in the number of routes and distances flown are isolated. Graph 13 consolidates the information about emissions intensity and regarding the evolution of CO$_2$e emissions in domestic operations. The vertical bars show the annual volume of emissions and the horizontal line presents the evolution of emissions intensity.

Graph 13: Volume (in tons) and Intensity of CO$_2$ Emissions in domestic flights – 2000-2015.

Taking as base year 2005, the volume of CO$_2$e emissions of domestic aviation increased at an average annual rate of 5.9% and grew more than 77.9% accrued between 2005 and 2015. Nevertheless, the emissions intensity had a significant reduction, at an average annual rate of 3.9% in the same period. In 2015, the emissions intensity was 12.0 kg CO$_2$e per 100RPK, i.e., 12 Kg of CO$_2$e per each 100 passengers transported, per kilometer flown.

Graph 14 shows the evolution of the emissions intensity in the international operations of Brazilian airlines between 2005 and

Source: ANAC
2015. The vertical bars represent the annual volume of emissions in these operations, while the points on the horizontal line indicate the intensity of the emissions per year. Brazilian air carriers in international operations had an average annual reduction in emissions intensity of 3.9% per year and an average total emissions volume growth of 0.35% per year. The accrued growth of the emissions volume as of 2005 was 3.6%, against a reduction in the accrued emissions intensity of 29.0% in the same period.

Certain oscillations are noted in Graph 14 in the line about emissions intensity. The reasons for this behavior are the same as those already presented in the First Action Plan, i.e., effects of the bankruptcy of the former Brazilian company, VARIG, which closed its operations in 2006. With the sector’s reorganization, the new operators underwent a process of adjustment between supply and demand of seats and this was reflected in the increase in the emissions intensity from 2006 to 2008. In 2009, the sector had already adjusted itself and the Emissions Intensity fell to values below those of 2005.
Finally, Graph 15 shows the evolution of the emissions intensity in the total international operations, which include the Brazilian and foreign companies operating from Brazil, between 2000 and 2015.

Thus, the global result was an average annual reduction in the emissions intensity of the airlines international operations, in flights originating in Brazil, of 3.0% per year between 2005 and 2015 and an increase in the total volume of emissions of 4.5% per year in the same period. The accrued growth of the sector emissions in the international segment was 54.9%, taking as baseline 2005, against a reduction in the accrued emissions intensity of 26.2% in the same period. In 2015, the emissions intensity in the international operations from Brazil was 5.8 kg of CO₂e per 100RPK.

**Graph 15: Volume (in tons) and Intensity of CO₂e Emissions per Brazilian and foreign companies in international flights originating in Brazil – 2000-2015.**
5.2 Fuel Efficiency

The calculation of the fuel efficiency is based upon the fuel consumption per weight transported (paying passengers and cargo) and distance flown. Thus, it is possible to analyze the efficiency of fuel use in the rendering of air services. To calculate the fuel efficiency, the total fuel consumed is divided by the weight of passengers and cargo transported.

Graph 16 deals with the domestic operations and shows an improved fuel efficiency of 2.9% per year, on average, since 2005, against an average increase in fuel consumption of 5.9% per year. In the accumulation, as of 2005 the efficiency improved by 25.7% while the consumption increased by 77.9%. Bearing in mind that the fuel consumption of the domestic segment had a faster growth than the international one, it can be assumed that the improved fuel efficiency in domestic operations has contributed positively to the reduction in the growth rate of total Brazilian emissions.

Graph 17 presents the results of fuel efficiency in international operations of Brazilian airlines, based upon fuel consumption by RTK, as of 2005. The vertical bars represent the annual fuel consumption and the horizontal line the evolution of the fuel efficiency.

Regarding the international operations of Brazilian airlines (Graph 17) an improved fuel efficiency is noted of, on average, 2.4% per year, as of the base year of 2005, against an average increase in fuel consumption of 0.35% per year. As already observed in the first version of this Action Plan, this improvement is slightly better than the aspirational goal of 2% per year, as of 2010, established by ICAO for international aviation (line traced on the graph). In the accumulation, as of 2005 the efficiency improved by 21.4% while the consumption increased by 3.6%. It is worth pointing out the noticeable reduction in fuel consumption between 2005 and 2006, with a drop of almost 33%.

Finally, Graph 18 presents the evolution of the fuel efficiency in the total international operations, which include the Brazilian and foreign
airlines operating from Brazil, between 2000 and 2015.

An improved fuel efficiency is noted of, on average, 2.3% per year, as of the base year of 2005, against an average increase in fuel consumption of 4.5% per year. This improvement is slightly better than ICAO’s aspirational goal of 2% per year, as of 2010. In the accumulation, as of 2005 the efficiency improved by 20.9% while the consumption increased by 55.1%.

The data of this second edition of the Action Plan corroborated the conclusions of the first edition of the Action Plan (2013) that Brazilian civil aviation, both domestic and international, is evolving in a sustainable environmental manner regarding GHG emissions. Thus, the aspirational goal to improve 2% per year of efficiency in fuel consumption established by ICAO for international aviation has been attained in the operations to and from Brazil.
6. MEASURES WHICH CONTRIBUTE TO THE REDUCTION OF AVIATION GHG EMISSIONS
6.1 Contributions of Airports

Brazil has 2,463 aerodromes registered by ANAC (1,806 private and 657 public), but 98% of the air sector’s embarkations and disembarkations in the country are concentrated in 65 (sixty-five) airports. Of these airports, six were granted to private initiative, and another four are in the process of being granted. The granting process, started in 2011, aims to promote investments in the expansion and modernization of the domestic airport infrastructure. The first airport granted was that of São Gonçalo do Amarante, in Rio Grande do Norte, in 2011. In February 2012, the federal government granted the airports of Brasília (DF), Guarulhos (SP) and Campinas (SP) to private initiative. In December 2012, the airports of Galeão (RJ) and Confins (MG) were granted. The next airports to be granted are Fortaleza (CE), Salvador (BA), Porto Alegre (RS) and Florianópolis (SC). The amounts collected in the auctions compose the National Civil Aviation Fund (FNAC), for investments in the other Brazilian airports. The Brazilian Airport Infrastructure Company – Infraero continues to be responsible for the operation of 60 (sixty) airports in the country.

Measures for reducing GHG emissions adopted or in evaluation by Infraero and by the airport administrators of the airports granted will be presented below. It is important to highlight that despite the scope of the Action Plan being centered upon the emissions of international aviation, ICAO encourages the countries to include information about general measures implemented by the airports, which reduce GHG emissions. Thus, besides the emissions related to the operations of the aircraft, actions are also described related to the reduction of direct emissions of airports (Scope 1) and of indirect emissions, usually related to the consumption of electricity (Scope 2)9.

6.1.1 Infraero10

INFRAERO has several measures in course and actions planned which will be able to contribute to the reduction of GHG emissions of the sector.11 They are as follows:

---

9 R2006 IPCC Guidelines for National Greenhouse Gas Inventories
11 For estimating the reduction of CO2 emissions measures of scope 1 (sources belonging to or controlled by the airport), scope 2 (generation of electricity) and scope 3 (sources not belonging to or not controlled by the airport), in accordance with 2006 IPCC Guidelines for National Greenhouse Gas Inventories.
Supply of electricity (400 Hz) and air-conditioning at the boarding bridges

Airport of Congonhas/SP – SBSP (in evaluation of feasibility): Studies were conducted to compare the emissions related to the use of GPU-Ground Power Unit and APU-Auxiliary Power in the current scenario and in a scenario which considers the operation of 12 boarding bridges with the supply of electricity (400Hz) and air-conditioning (Fixed Facilities). The emissions for generating electricity for the Fixed Facilities system (indirect emissions) were taken into account. It was concluded that the implementation of the fixed facilities system for electricity and conditioning in 12 (twelve) boarding bridges will lead to, if the project is implemented, an estimated reduction of **1,081 tons of CO₂ per year**. Concerning the costs of this measure, Infraero studies the adoption of a bidding model for commercial development of the system, which would not require any direct investment from Infraero. There is also a forecast of expanding the Airport of Congonhas with the installation of new ten (10) boarding bridges with fixed facilities (400Hz and air-conditioning). The fixed system of supplying electricity (400Hz) and air-conditioning in ten boarding bridges will have, if implemented, the potential to reduce the emissions by approximately **887 tons of CO₂ per year**. It should be pointed out that the impact of this measure would be restricted to domestic aviation, as the airport of Congonhas does not receive international commercial flights.

Airport Eduardo Gomes – Manaus/AM – SBEG (in execution). Currently, the International Airport of Manaus has 8 items of 400Hz and air-conditioning equipment, but there is not yet the infrastructure to connect them to the boarding bridges. The installation of the 8 equipment items will lead to an estimated emissions reduction of **469 tons of CO₂ per year**. It is worthy to remind that the execution of this project still depends on investments of around R$ 9,500,000.00 and Infraero is seeking the resources required. This action has an impact upon international civil aviation as the Airport of Manaus receives international commercial flights.

---

12. In all the calculations which involved the consumption of electricity (typical of scope 2 of the GHG Protocol) using the average annual factor of CO₂ emission of 2014, corresponding to 0.1355 tCO2/MWh, available at the site of the Ministry of Science, Technology and Innovation – MCTI.

13. To obtain an idea of the size of the investment in fixed facilities, one can consider: the amount quoted for acquiring equipment in August 2014 (market research) and the amount paid for the equipment (400Hz + Air-conditioning of SBEG in 2013, plus the amount of the Infrastructure. Therefore, the investment for implementing the system of Fixed Facilities (400Hz + Air-conditioning + Infrastructure) would come to the total amount of R$ 1,200,000.00 for each bridge (amount already restated for inflation (IGP-M) and quotation of the dollar at R$ 4.00).
2 Use of illumination with LED lamps in passenger terminals and for lighting.14

By June 2020, Infraero intends to replace 26,550 fluorescent tubular lamps by LED lamps in the passenger terminals. This replacement will lead to reduced CO₂ emissions of approximately **2,384 tons**, considering an operation of 24 hours between the period from Jun/2015 to Jun/2020.15 This measure will be implemented in thirteen (13)16 airports administered by Infraero with the cost of R$ 2,083,034.00. Regarding the use of LED lamps for lighting, the Airport Salgado Filho (Porto Alegre/RS) was the first airport in South America to have installed in its landing and takeoff runway light fixtures with LED technology of high intensity17. The use of the LED lamps for illuminating the runway in Porto Alegre led to an estimated **annual emissions reduction of 65 tCO₂** for all the 6,680 lamps considering an operation of 12 hours18. The cost of the measure was R$ 876,988.26. Other airports administered by Infraero will also receive LED light fixtures in their lighting.

3 Plant generating solar energy

(Airport of Palmas/TO – in evaluation of feasibility): The initial idea is to implement a photovoltaic plant of 1MW which, besides supplying the airport demand in the periods of generation (approximately 12 hours/day), when there is excess, it can be distributed in the network generating credit for reduction in the electricity bill of other units of the company. The forecasted investment is R$ 5 million in an area of approximately 8,000m². This measure can lead to emissions reduction estimated at **308 tons of CO₂ per year**19.

---

14 Scope 2 - 2006 IPCC Guidelines for National Greenhouse Gas Inventories

15 For the calculation the average annual CO₂ emission factor (2014) corresponding to 0.1355 tCO₂/MWh (MCTI,2014), was used.

16 Airports: SBCT, SBFL, SBMT, SBSP, SBBH, SBRI, SBGO, SBIL, SBMO, SBFZ, SBRF, SBBE and SBIL.

17 Among the airports where LED lamps are currently installed in the lighting, the following stand out: Airport of Bacacheri (PPD); Airport of Pelotas (PPD); International Airport of Ponta Porã (taxiway and maneuvering yard); Airport of Macaé (taxiways); Airport Santa Genoveva – Goiânia/GO (taxiways); International Airport of Belém/Val-de-Cans/Júlio Cezar Ribeiro (taxiways); Airport of Imperatriz/Prefeito Renato Moreira (taxiway); International Airport of São Luís (side lighting of the taxiways of runways 06/24 and 09/27); Airport of Vitória – Eurico de Aguiar Salles (lighting of helicopter yard and taxiway Alfa); Airport of Joinville - Lauro Carneiro de Loyola (taxiways); Porto Alegre (high intensity lighting – mandatory for the aerodromes which operate with ILS (Instrument Landing System)).

18 Using as parameter the calculation made for the conventional illumination technology in the lighting (incandescent lamps) in comparison with emissions associated with LED technology for passenger terminal. For the calculation the average annual CO₂ emission factor (2014) was used, corresponding to 0.1355 tCO₂/MWh (MCTI,2014).

19 The emissions were calculated using the average annual CO₂ emission factor (2014) corresponding to 0.1355 tCO₂/MWh (SOURCE: MCTI,2014) as well as an emission factor for generation by means of solar plates (photovoltaic) of the type “rooftop” Reference: “Energy Payback Time and CO₂ Emissions of 1.2 kWp Photovoltaic Roof-Top System in Brazil”- USP, May 2013 by the International Journal of Smart Grid and Clean Energy. The emission factor used was then 0.0149 tCO₂/MWh. The average annual demand of the airport of Palmas, which was 0.584 MW for 2015, was used.
4 Other measures with less reduction impact

Infraero implemented other specific measures, of which the following stand out: Airport Santos Dumont (RJ) - Tests with electrical bus for transporting passengers; Airport of Jacarepaguá (RJ) - Pilot project of solar energy; Airport of Campo de Marte (SP) - Panels for capturing solar energy; EPTA$^{20}$ of Jacarepaguá (RJ) - solar panels.

6.1.2 Airport of Guarulhos/Governador André Franco Montoro$^{21}$

Several measures are being studied to improve the operations efficiency in the International Airport of Guarulhos (SP) and, thus, reduce the unnecessary aircraft fuel burning. Considering that it is the largest international airport in the country, the measures have great potential to reduce the Brazilian international aviation emissions. They are as follows:

1 Operational Procedures: taxiing

Aircraft taxiing contribute significantly to emissions in airports. The emissions volume is related to the taxi time of the aircraft, in addition to other factors as, power system, quantity of engines and Standard Operational Procedure used by each air operator, related to cutting the engines in taxi maneuvers. Thus, in 2016, it is intended to execute a study, in a work group constituted of the air operators to make it feasible to adopt an operational procedure for taxi maneuvers with only one engine for twin-engine aircraft and two engines for four engine aircraft.

2 Operational Procedures: use of APU

Another relevant factor for reducing emissions related to aircraft in operations in airports is the use time of APU (Auxiliary Power Unit) when on the ground. Thus, in 2016, a study will be done to make it feasible to adopt an operational procedure for reducing the use of APU when on the ground.

3 Reduced Waiting Time for Aircraft Parking Positions

This condition is already coordinated by the Operational Control Center (CCO) of the Airport of Guarulhos and can be

---

$^{20}$ Air Traffic Telecommunication Services Contracting Station

$^{21}$ The information was provided by the Concessionaire of the International Airport of Guarulhos. Report sent by Official Letter DR/0076/2016, of January 15, 2016.
Measures Which Contribute to the Reduction of Aviation GHG Emissions

BASE YEAR 2015 Action Plan for Reducing Greenhouse Gas Emissions of Brazilian Civil Aviation

optimized to also handle reduced emissions. Thus, in 2016, it is intended to make a study to promote the implementation of indicators, which guide actions intended to reduce aircraft waiting time.

4 Reduced Aircraft Taxi Time

This action can lead to a significant reduction in aircraft emissions in maneuvers on the ground. Through coordination between CCO and EPTA SP-GRU it is possible to optimize these operations aiming at gains in current time, with reduced emissions of GHG and pollutants. By December 2016, it is intended to conclude a study to establish goals to reduce taxiing time for the aircrafts that leave from and arrive at Guarulhos.

5 Use of ethanol in the “flex” fleet (Scope 1)

The airport of Guarulhos has a fleet of 22 “flex” vehicles (they can be supplied with ethanol and gasoline). The consumption presented by this fleet in 2015 was 54,446 liters of gasoline and 9,329 liters of ethanol. Currently, the ethanol price is equivalent to approximately 67% of the gasoline price. Therefore, there is potential for reducing costs with the increase of the proportion of use of ethanol in the flex fleet. Thus, it is planned to increase from 15% to 30% the direct use of ethanol in the airport flex fleet, which will reduce GHG emissions. This substitution will be implemented throughout 2016.

6 Use of biodiesel in the fleet (Scope 1)

The airport of Guarulhos has a fleet of 80 vehicles driven by diesel. The consumption of this fleet in 2015 was 166,748 liters of diesel. A feasibility study will be made about using biodiesel to supply this fleet. There is a potential economy in this substitution, as the biodiesel coming from the Bioplanet project (social investment - SUB C -BNDES) can be acquired at a lower price than that of the diesel practiced in the market. The study shall be concluded in September 2016.

7 Optimization of the Air-Conditioning System (Scope 2)

The air-conditioning system has noticeable proportional consumption of electricity in the airport (estimated at between 30 and 35%). The total energy consumption in 2015 was 152,585 MWh and represented for the concessionaire a cost of R$ 65,254 million. Thus, it is intended to install in the passenger terminals and in the cargo terminal air-conditioning functioning adjustments, which allow its disconnection and alterations in the temperature in accordance with the times of movement and climatic conditions. This action shall be concluded by December 2016.
Optimization of illumination System of EDG – Garage Building (Scope 2)

The illumination system in the Garage Building has power installed of 177,200 kWh/month. It is intended to optimize the illumination system of the Garage Building with the disconnection of 50% of the light fixtures and making use of natural light. This action will be concluded by December 2016.

Partial substitution of the sodium vapor lamps by LED lamps in the Cargo Terminal

The illumination system of the Cargo Terminal Import Warehouse, composed of sodium vapor lamps has installed power of 192,500 kWh/month and had points of low luminosity. The substitution of part of the lamps by LED lamps reduced the monthly electricity consumption by 60% and improved the illumination of the cargo terminal. The measure had the cost of R$ 1.24 million and was concluded in December 2015.

Use of LED on the landing and takeoff runways

The illumination system of the landing and takeoff runways, with integral use of halogen lamps, consumed 195,000 kWh/month and required partial substitution of its lamps. In 2015 the halogen lamps of runway 09/27R were replaced by LED lamps. The action cost R$ 4.245 million and led to an average monthly saving of 10% in electricity consumption of the illumination system of the landing and takeoff runways.

Residue recycling: Group D

In 2015, the airport of Guarulhos generated approximately 11,041 tons of group D residues (not hazardous), most of it being sent to landfills located at 30km from the airport. This quantity had a management cost of R$ 3,015,983. Most of this cost refers to transportation and landfill rates. The recycling of this material can generate a significant cost reduction, evaluated at approximately R$ 8,427,586 (2016 to 2027). Furthermore, the action would have environmental gains, including reduced GHG emissions. Thus, it is intended to present, by August 2016, a study of implementing a sorting station for treatment of group D residues in the cooperative area of collectors, district of Taboão - SP.
12 Recycling of wooden pallets

In 2015, the pallets collected in the Cargo Terminal (100t/month on average) were sent to a sanitary landfill. The decomposition of this material generates GHG emissions due to the generation of methane gas. It is estimated that the recycling of the wooden pallets can generate reduced GHG emissions of about 4,300 tCO₂e/year. Thus, as of 2016, it is intended to send for recycling all the wooden pallets collected in the cargo terminal.

13 Replacement of the GSE fleet by more efficient equipment

The Ground Service Equipment fleet, which on the whole is constituted of tractors driven by diesel, produces significant emissions. The replacement of this fleet by more efficient vehicles will be a relevant measure for reducing emissions of the Airport of Guarulhos. It is planned to make a feasibility study about replacing the GSE fleet (tractors) by ESATAS by December 2016.

6.1.3 Airport of Campinas/Viracopos

The International Airport of Campinas/Viracopos has prepared inventories of greenhouse gas emissions since 2013. This mapping and the quantification of the emission sources allow one to know the profile of the emissions of the organization, in order to trace strategies, which direct the activities of the Airport to a low carbon scenario. To elaborate the inventories it was considered the direct GHG emissions (scope 1) and the indirect GHG emissions by use of electric imported and consumed (scope 2).

Graph 19: Profile of Emissions - 2013

In 2013, a study made indicated that Viracopos emitted a total of 4,331.81 tons of carbon equivalent (tCO₂e), there being 2,097.86 tCO₂e in scope 1 and 2,233.95 tCO₂e in scope 2. Graph 19 represents these amounts in percentages for the year when the inventory was concluded.

---

In 2014, Viracopos emitted a total of 5,306.18 tons of carbon equivalent (tCO₂e). Of this amount, 2,342.47 tCO₂e refer to direct emissions (scope 1) and 2,963.71 tCO₂e to indirect emissions (scope 2). Graph 20 shows the results in percentages for the year when the inventory was concluded.

Despite the short time series, of two years, the importance of investing in strategies related to the increase of fuel efficiency in the airport becomes clear. The 2015 inventory is being prepared. The airport of Viracopos has several projects and activities already implemented and in progress in order to contribute to the reduction of greenhouse gas emissions, among which the following stand out:

1. **Environmental Awareness**
   Viracopos understands that the change in attitude and actions of its users and coworkers is essential to attain a scenario of reduced atmospheric emissions. The actions include: spaces for disclosing information and forums about the environment and climate change.

2. **Infrastructure – “Check In” Clusters**
   The passenger boarding area of the new terminal (TPS1) will have 72 positions for “check in”, divided into 3 clusters. The operating differential is that these clusters are made available parallel to the entry flow of the passengers (boarding flow), which grants greater fluidity to the movement of people and contributes to a more efficient procedure during the embarkation of passengers.

3. **Infrastructure – Boarding Bridges**
   The new terminal will have 28 boarding bridges for domestic and international flights. Thus, the passengers will be able to embark without needing to use the bus for transportation in the yards, a fact which will represent less burning of fossil fuels and reduced emissions associated with airport activities (scope 1).

4. **Infrastructure – New Yards**
   With the Viracopos expansion, three new aircraft yards were created (Yards N, P and Q) with a total of 72 aircraft positions. Due to the dimensioning of these structures, operations that are more efficient are expected in the airport, representing less greenhouse gas emissions on the ground. This measure has an impact on international aviation, considering that
the airport of Viracopos receives international commercial flights.

**Illumination in LED: Cargo Terminal, New Route Access, Administrative Building and ATR Yard**

LED technology reduces energy consumption and greenhouse gas emission in scope 2. The Project was started in the Cargo Terminal (TECA), with the replacement of the metallic vapor lamps of 250 watts by LED model TSL 77 lamps of 156 watts. Furthermore, the illumination of the duplication of the means of access to the Airport of Viracopos was executed using LED lamps. The administrative Building of Viracopos is also receiving illumination in LED. At the end of the activity 2,560 units of conventional tubular fluorescent lamps of 32w will have been replaced by counterparts of TUBLED illumination of 16w. The illumination of Yard 1 was also replaced by LED lamps. In all, 9 (nine) conventional lamps of metallic vapor (1,000W each) were replaced by 10 lamps with LED technology of 250W.

**ATR Yard – infrastructure for connection of electrical GPUs**

A work of infrastructure improvement was executed in yard 1 of Viracopos, which receives ATR aircrafts. In all, 5 power supply sockets were installed (one for each position) for use of the electrical GPU equipment, which does not have direct emissions (scope 1). When compared with conventional GPUs, which generate electricity with the burning of fossil fuel, the GHG emissions fall considerably.

**Natural Illumination in the New Passenger Terminal (TPS1)**

The new passenger terminal has a large facade and the piers and corridors were also built taking into consideration the objective of making use of natural light. Thus, there is reduction in the consumption of electricity and emissions related to scope 2.

**Skylights with photovoltaic films – covering of the New Terminal (TPS1)**

The covering of the TPS1 is sustained by structures called “trees” (there are 33 in all). At the end of these sustaining structures, a skylight is fastened, which allows the passage of natural light. Furthermore, these structures are being prepared for generating electricity from an installed system of photovoltaic films (scope 2).

**Modernization of equipment / fleet of forklifts / baggage tractors**

Viracopos has a total of 103 forklifts. Of these, only 5 are driven by diesel, as they are equipment whose purpose is to move cargoes of a large size, requiring more force. Of the remainder, they are equipment driven by gas and electricity, which are less pollutive from the point of view.
of GHG. Moreover, due to the configuration of the new baggage system (BHS) of the TPS1, all the tractors and transportation vehicles shall be driven by electric motors, in replacement of the old diesel tractors.

**Boarding Bridges – Electrical systems 400Hz GPU and PCA**

For the new passenger terminal, we shall have 28 boarding bridges, each one equipped with electrical fixed equipment of GPU (Ground Power Unit) and PCA (Pre-Conditioned Air). This equipment furnishes electricity and air-conditioning to the aircraft on the ground, not requiring the use of the APU (which burn jet fuel). Furthermore, there are another 4 GPUs and 4 mobile electrical PCAs, to handle remote positions or also be used as a reserve if the others break or require maintenance. This measure impacts international aviation as it contributes to reducing the fuel burned by the aircraft on the ground.

**Feasibility study for reducing greenhouse gas emissions.**

A technical study is being prepared to reduce the emissions of Viracopos, handling all the material sources of emission, mainly mobile combustion, fugitive emissions and fuel efficiency. It is also understood that preparing inventories, accompanied by a monitoring of the results, is an essential issue for ensuring the applicability of a future plan for reducing emissions. Viracopos intends, during the future increases of the airport site, to adopt measures that can bring the airport to a low carbon and efficient operating model.

### 6.1.4 Airport of Belo Horizonte/Confins

In 2015, the CCR Group (largest private shareholder of the concessionaire) was selected, for the fifth time running, as a member of the Business Sustainability Index (ISE) of BM&F Bovespa. While in 2016, BH AIRPORT, concessionaire of the airport of Belo Horizonte/Confins will be part of the GHG Emissions Inventory of the CCR Group and to do so is filling in monthly the information required in the software CERENSA, which is also the tool used for monitoring the sustainability indicators referring to environmental issues. At this moment, the concessionaire is studying several projects, which would have the premise of reducing the consumption of electricity and fuels, but at this initial stage of the concession it is not yet possible to specify accurately the end effects planned.

---

23 Information contained in Official Letter BHA-PRE-0202, 2015, signed by the Contractual Manager of the Airport of Confins, on November 30, 2015.
It is important to point out that, in the current scenario of the airport, the absolute reduction of the consumption of water and energy specifically for the biennium 2015 /2016 is unlikely. The reason for this is that the consumption of these resources in the airport tends to increase, due to the new infrastructures, which have been built and delivered, such as: Passenger Terminal 3 (TPS 3); Aircraft Yard 2; Renovations in Passenger Terminal 1 (TPS 1); Implementation of energy system in 400 Hz; Work on airside and New Assignees. On the other hand, the investments made during the previously mentioned biennium (estimated at R$ 750 million) will bring greater operational efficiency to the airport, which will contribute to reducing greenhouse gas emission. For example, currently to handle the various remote embarkations (by bus) in this airport, the permanent movement of up to 10 buses, with high consumption of diesel oil is required. With the implementation of 17 new positions by boarding bridges on TPS 2, the remote embarkation will be practically limited to small aircrafts.

Besides that, certain actions with impact on the relative reduction of water and electricity consumption were taken throughout 2015, such as: acquisition of equipment with consumption seal "A" of Procel24; preventive maintenance in the energy and water systems; acquisition of low consumption lamps; installations of LED lamps in the renovation of the restrooms of TPS1; installation of low consumption devices in the new hydrosanitary installations of TPS3; update of the automatic on/off scheduling of the air-conditioning and illumination systems; optimization of maintenance processes, as cleaning of the water tanks, irrigation, etc.

In the following study stage for optimizing natural resources, certain goals of relative consumption reduction shall be established. To do so, alternatives will be analyzed in order to report the consumption of water and energy by passenger unit, cargo or aircraft, as well as indicators associated with buildings and/or processes. While in the long term, several initiatives are being considered, such as: reuse of grey water and rainwater in TPS1 and TPS2; adoption of illumination in LED in TPS2; adoption of efficient systems in electromechanical equipment (conveyors, elevators, escalators, boarding bridges, etc.); adoption of architectural solutions which favor natural illumination and fuel efficiency; efficient and economical air-conditioning solution. Besides reducing the use of natural resources, the concessionaire also intends to study alternatives that allow the generation of clean energy in its installations. Having large areas and permanent in-

---

24 The Procel Seal is a promotional instrument granted annually since 1994 to the equipment which has the best fuel efficiency indices in its category. It aims to encourage the domestic production of more efficient products in the energy saving item, and guide the consumer, in the act of purchasing, to acquire equipment which has better levels of fuel efficiency.
Measures Which Contribute to the Reduction of Aviation GHG Emissions

BASE YEAR 2015

Action Plan for Reducing Greenhouse Gas Emissions of Brazilian Civil Aviation

6.1.5 Airports of Brasília/Presidente Juscelino Kubitschek and São Gonçalo do Amarante/Governador Aluízio Alves

The administration of the airport of Brasília has made studies about the possibility of implementing measures which lead to reduced greenhouse gas emissions both in Scope 1 (direct emissions), and in Scope 2 (indirect). Regarding the emissions of Scope 2, the airport studies the installation of LED lamps in replace of the traditional ones and will analyze the potential for making use of solar energy. In the process of the airport expansion, south and north piers were built with the implementation of certain energy efficiency measures, such as double-glazing, illumination with LED, natural light and automation systems. These alternatives will be considered in the projects for constructing new buildings.

Another measure that will be implemented is the installation of infrastructure in the boarding bridge for supply of air-conditioning and electricity for the aircraft on the ground. This measure avoids the fossil fuel burning during passenger embarkation and disembarkation caused by the use of APUs and GPUs.

The Project is in the final phase of preparation and will be presented to the ANAC in the first six months of 2016. Regarding the yard and runway infrastructure, it should be pointed out that, in December 2015, the simultaneous operation of the runways was started. The aircrafts started to follow new arrival and departure routes in the airport of Brasília which contribute to reduced waiting time of landing and taking off, and, consequently, to avoiding unnecessary burning of fuel and reducing GHG emissions.

The Airport of Brasília seeks to coordinate the scheduling of flights taking into consideration the time of confirming flights, the quantity of passengers, the meteorology and the air traffic management. Thus, the allocation of the resources has as basis the information transferred by the Airlines in order to prioritize operational logistics, resources and services. Thus, it is possible to optimize the operations, avoid delays and promote greater efficiency in the aircraft fuel consumption. Such measures

---

25 Information sent by official letters IA # 0021/SBSG/2016 (airport of Natal) and IA # 0064/S8BR/2016 (airport of Brasília), on January 19, 2016.
can affect the aircraft fuel consumption, including in international aviation, as the airport of Brasília receives international commercial flights.

The airport of São Gonçalo do Amarante, as well as the airport of Brasília, is administered by Infraerica. The measures of improved energy efficiency and reduced GHG emissions of scope 2 include the modernization of the air-conditioning and energy plants and the use of energy from renewable sources. In the construction of the terminals, certain energy efficiency measures were implemented, as double-glazing, making use of natural light and automation systems. The implementation of LED lamps is in the feasibility study phase. The supply of air-conditioning and electricity in the boarding bridges to avoid burning of fossil fuel of the aircraft on the ground in the airport of São Gonçalo do Amarante is also part of the feasibility study.

6.2 Aeronautical Industry: technological development

6.2.1 Embraer

One of the ways of reducing fuel consumption is to make relevant alterations in the aircraft. The engineers of Embraer have found an economical manner of restructuring existing aircraft models to improve their efficiency potential, without jeopardizing their original mode of operation. In June 2013, the second generation of the E-Jets Family was launched, denominated E-Jets E2 and composed of three new airplanes: E175-E2, E190-E2 and E195-E2. These jets, which seat between 88 and 132 passengers, will come into service in 2018. The E-Jets E2 aircraft utilize high-aspect ratio wings with a distinctive, swept tipped wing structure that optimizes the aerodynamics, reducing drag. The use of advanced technology in the engines, wings and avionics (including fly by wire) of the new jets will allow reduced fuel consumption, emissions, noise and maintenance cost, besides maximizing the airline operational efficiency. The improvements described lead to a saving of 16 to 24% in fuel consumption, in a typical operation, and reduced CO₂ emissions by approximately 3,600 tons per aircraft per year.

Regarding the E175, it is estimated that the combination of aerodynamic changes can reduce the fuel consumption by approximately 6.4% on a typical flight. These improvements

27 Fly-by-wire is a type of control of the mobile surfaces of an airplane by computer. This allows that any modification of the direction of an aircraft made by the pilot is “filtered” and transferred to the mobile surfaces: aileron, elevator, rudder.
include new wing tips, optimization of systems and improvements to the aerodynamic surface. The Project had the direct participation of 600 people, specialists of Embraer and great contribution of ten suppliers located in the USA, Europe and Japan. Most of the Embraer departments were involved, from market intelligence, flight testing and engineering, to the departments of sustainability and customer support. It is worth pointing out that the changes have not altered the operational features of the original aircraft and, therefore, do not require new training for the pilots or other operational costs. The modifications to the E175 have the potential to reduce CO₂ emissions by more than a ton a year.

6.3 Contributions of Airlines

6.3.1 Gol Linhas Aéreas Inteligentes

The consumption of jet fuel is the main cause of environmental impact in the operations of GOL, arising from GHG emissions. To reduce both its emissions and costs, the company seeks to minimize the consumption of this non-renewable and pollutive resource. It should be pointed out that, besides being a pollutant, kerosene is a petroleum derivative and therefore subject to price variance, which can generate negative impacts on the financial result of the company. In this respect, GOL seeks solutions that involve reduced consumption of fossil fuels and the use of fuels from renewable resources.

Below there is a graph which portrays the variance in the total CO₂ emissions of Gol between 2010 and 2014.

---

Graph 21: Total emissions of CO₂ (in tons) by Gol Linhas Aéreas – 2010-2014.

The graph below shows the variance of the emissions by seat/kilometer offered between 2010 and 2014.


Source: Gol Linhas Aéreas
All the airlines are exposed to risks arising from natural occurrences due to climatic changes, as adverse meteorological conditions, which can come and affect their operations. With a view to mitigating these risks, GOL executes evaluations of long-term impacts and studies of climatology and economic-environmental impact in the regions where it operates. GOL monitors the meteorological behavior in all the bases of operations and routes, in order to ensure the least impact on its customers.

Another concern of GOL is being in agreement with the limits of CO₂ emissions that may be established by domestic and international bodies. To avoid that future international operations or code-share agreements with foreign companies are affected by requirements related to GHG emission limits, the company has taken measures to reduce the use of fossil fuel and, thus, reduce its emissions. The most important measures include the management of a young fleet, with new technologies, and the Biofuels and Renewable Energy Program, which is connected to the precepts of the Intergovernmental Panel on Climate Change (IPCC) and aims to reduce the impacts of CO₂ emissions.

Regarding navigation technology, GOL was the first Brazilian company to operate aircraft with the system by satellite RNP-AR in the airport Santos Dumont, in Rio de Janeiro. The technology ensures safe landing even with poor visibility, due to the great accuracy and reliability of the system by satellite. After the introduction of this new technology, the “ceiling” – i.e., the height of the clouds related to the ground – for landing went from 300 to 93 meters in the airport Santos Dumont. The initiatives of the company for reducing fuel consumption and the associated emissions always observe, in first place, safety requirements.
### Table 4. GOL measures for reducing fuel consumption and associated emissions

<table>
<thead>
<tr>
<th>Measure</th>
<th>Description</th>
<th>Reduction in Fuel Consumption</th>
<th>Reduction in CO₂ Emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>winglets</strong></td>
<td>108 aircraft of GOL have a component at the wing tip which generates improved aerodynamics and, consequently, fuel saving.</td>
<td>Project in measurement phase or not measurable.</td>
<td></td>
</tr>
<tr>
<td><strong>Split Scimitar Winglet</strong></td>
<td>Modification to the aerodynamics of the wings: improves efficiency of fuel consumption, mainly on long routes. It is installed in three aircrafts and does not alter the methodology of calculating performance of taking off and landing. Estimated 1% fuel saving on long routes.</td>
<td>Project in measurement phase or not measurable.</td>
<td></td>
</tr>
<tr>
<td><strong>Required Navigation Performance (RNP):</strong></td>
<td>System of navigation by satellite, which offers guidance and control of the aircraft in ground flying – reduces the dependence on the communication with the ground and promotes reduction in distance flown, which reduces fuel consumption.</td>
<td>31.754 kg (2014) CO₂ - 96.641 kg (2014)</td>
<td></td>
</tr>
<tr>
<td><strong>Aircraft communication Addressing Reporting System (Acars):</strong></td>
<td>System of communication by satellite, which provides the dispatch of data from/to the aircraft, in ground flying, and allows more assertive communication and a shared decision-making process in advance – minimizes route deviations and ensures greater efficiency of operations.</td>
<td>Project in measurement phase or not measurable.</td>
<td></td>
</tr>
<tr>
<td><strong>Fuel and Carbon Solutions</strong></td>
<td>Program developed since 2010 aiming to optimize the use of fuel and, to do so, has 16 initiatives that develop intellectual capital, implement greater control of processes, define new rules and increase operational safety.</td>
<td>Project in measurement phase or not measurable.</td>
<td></td>
</tr>
<tr>
<td><strong>Destination Maneuvering:</strong></td>
<td>Change of values of MVD index (fuel calculated between the last point of navigation and the destination aerodrome) referring to the approach process, based upon descent performance calculations.</td>
<td>1.071.140 kg (2014) CO₂ - 3.331.244 kg (2014) 647.720 kg (2015*) CO₂ - 2.014.410 kg (2015*)</td>
<td></td>
</tr>
</tbody>
</table>

* 2015 Partial
Measures Which Contribute to the Reduction of Aviation GHG Emissions

**BASE YEAR 2015**

**Action Plan for Reducing Greenhouse Gas Emissions of Brazilian Civil Aviation**

<table>
<thead>
<tr>
<th>Measure</th>
<th>Description</th>
<th>Reduction in Fuel Consumption</th>
<th>Reduction in CO₂ Emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dynamic Taxi</strong></td>
<td>The quantity of fuel sent for the aircraft route on the ground went from a fixed value to a flexible one – based upon the evaluation of consumption by airport and time range. Thus, the chance of fuel lack or excess in flights was eliminated.</td>
<td>63.385 kg (2014) 30.828 kg (2015*)</td>
<td>CO₂ - 197.126 kg (2014) 95.875 kg (2015*)</td>
</tr>
<tr>
<td><strong>Air Traffic Management (ATM)</strong></td>
<td>Céus Verdes do Brasil: Parceria com a General Eletric, Departamento de Controle do Espaço Aéreo – DECEA, ANAC, Infraero e operadores aéreos, o projeto visa o engajamento de órgãos reguladores para melhorar o gerenciamento do espaço aéreo do país.</td>
<td>Project in measurement phase or not measurable.</td>
<td></td>
</tr>
<tr>
<td><strong>Program APU</strong></td>
<td>Developed since January 2011. It is part of the program Fuel and Carbon Solutions and is divided into two phases: 1) Project APU (Overnight): already implemented, it aims to reduce the use of APU of aircraft overnight. 2) Project APU (Transit): in implementation, it seeks to reduce the use of APU during the transit of aircraft, replacing it by support equipment on ground (ACU/GPU) and with less consumption per hour.</td>
<td>2,023,916 kg (2014) 352,559 kg (2015*)</td>
<td>CO₂ - 6,294,378 kg (2014) 1,096,458 kg (2015*)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>*Information related to project “overnight”</td>
<td>*Information related to project “overnight”</td>
</tr>
<tr>
<td><strong>Crew Space</strong></td>
<td>Space in the airport for the crew to rest in the period that they remain on the ground. It aims to encourage them to disembark from the aircraft, which will minimize the use of APU. On 07/02/15, the first Crew Space was inaugurated in the International Airport of Confins. There are negotiations with Concessionaires for implementing this room model in: Recife, Salvador, Fortaleza, Natal and Manaus.</td>
<td>1,685,868 kg (Network 2015)</td>
<td>CO₂ - 5,243,049 kg (Network 2015)</td>
</tr>
</tbody>
</table>

* 2015 Partial

Source: Gol Linhas Aéreas
The LATAM Group is formed by airlines LAN and TAM, headquartered in Chile and Brazil, respectively, but they operate throughout Latin America. In accordance with the Sustainability Report presented by the company LATAM in 2014, in its environmental strategy the group aims to be one of the world leaders in combating climate change, which will contribute to the company’s efficiency and competitiveness. The group developed a program for improving efficiency in fuel consumption and the efforts were acknowledged in the gains obtained in international initiatives, as the Dow Jones Sustainability Index (DJSI).

LATAM understands that climate change can directly affect its operations with the increase of temperature and volume of rain, alterations to winds and extreme climatic events. They are in the phase of structuring the following goals for all the group: improve efficiency in fuel use; achieve neutral carbon growth in 2020; attain by 2050 a reduction of 50% in liquid emissions of CO₂ related to the levels of 2005; have Neutral Carbon Ground Operations in 2020; improve by 10% the energy efficiency of the company’s infrastructure in 2020; obtain a saving of US$ 200,000 in the energy consumption of the installations in 2020; reduce by 10% the volume of residue in 2020; and implement and Environmental Management System in all the main operations in 2016.

The efforts of the LATAM Airlines Group to attain the highest efficiency levels are based upon three actions:

1. **Young fleet**: allows operating with engines of greater yield and which contribute with the air quality and reduced noise level. In 2014, the average age of the fleet was seven years, thanks to the incorporation of 19 new aircraft. In 2015, 28 new aircraft were incorporated.

2. **Improvements to the infrastructure**: programs of efficient use of energy, water and residue disposal management were developed. It should be pointed out that the ground operations correspond to a small fraction of the group’s carbon footprint. Initiatives were implemented with the use of electrical vehicles and changing incandescent lamps in the hangars for more efficient light fixtures, among other measures.

3. **Fuel efficiency**: the LATAM Airlines Group improved by 1.2% its fuel efficiency, resulting from saving programs. The Lean Fuel (LAN) and Smart Fuel (TAM) programs combine technological and procedural improvements with optimization and ensuing fall in CO₂ emissions and include, respectively, 17 and 14 initiatives. They allowed in 2014 a reduction in consumption of 31 million gallons of fuel, equivalent to the reduction of 298,184 tons of CO₂. Table 6 details the initiatives related to fuel saving.

---


30 These goals are related to the objectives listed by IATA for combating climate change.
### LEAN FUEL E SMART FUEL

#### 1 Optimization of weight aboard:
- The quantity and distribution of weight aboard directly influence fuel consumption. Several initiatives aim to reduce the structural weight of the flights and distribute it in the best manner possible in the aircraft.
  - Improvement of load factor: combination between flights of passengers and cargo, aiming to optimize the aircraft transportation capacity.
  - Incorporation of lighter materials aboard.
  - Optimization of distribution of the load, in order to obtain a more appropriate center of gravity for the aircraft.

#### 2 Optimization of routes, cruising speed and landing:
- Route planning which avoids adverse climatic conditions or turbulence can improve fuel efficiency.
  - Privilege direct routes and continuous descent landing procedures.
  - Use of the OSA navigation system, which calculates the best routes in accordance with climatic conditions checked in real time, rates for use of air space and fuel consumption.
  - Use of RNP, a system of navigation by satellite which guides the aircraft by GPS in an automatic manner. The system allows more efficient and safer approach procedures.
  - Optimization of cruising speed to obtain greater efficiency in the use of fuel without flight delays.
  - Standardization of approach and landing operations, in order to increase their efficiency.

#### 3 Optimization of engine use on ground:
- Taxi operations with the use of only one engine.
- Minimization of use of APU, thanks to improved airport infrastructure.

#### 4 Maintenance panel:
- Development of program which corrects failures that affect fuel yield.
  - Tasks to increase efficiency.
  - Engine washing, which allows more efficient combustion and reduced emission of PM10 particles.

#### 5 When preparing the aircraft for passenger flights:
- Use of only one item of equipment for acclimatization and pressurization of the cabin instead of two, saving fuel.

#### 6 Activities of continuous improvement panel:
- Allows identifying opportunities of fuel efficiency from maintenance improvements.
**Transparency** - The company discloses its results in the area of sustainability in the following manner: in the Carbon Disclosure Project (CDP) - since 2011, the group discloses its carbon footprint in this platform, rising in category each year in the ranking of CDP; and by means of the Environmental Support Document - own document of public access which presents in depth the company’s environmental performance and strategy.

**Compensation of emissions** - In 2014, the company implemented the program Neutravel, which allows customer companies to know their carbon footprint in corporate trips and compensate with initiatives that neutralize the CO₂ emissions. During the World Cup in Brazil, 100 thousand tons of greenhouse gas emitted by the flights which connected the 12 host cities were compensated. The carbon emissions include the CO₂ equivalents arising from burning fuel of fixed and mobile sources (Scope 1), the generation of electricity (Scope 2) and other emissions related to company activities (Scope 3). LATAM is improving its data collection system to increase the coverage of the emissions calculation (mainly of Scope 2 and 3).

---

**Table 5. Emissions of the LATAM Group – 2013 and 2014**

<table>
<thead>
<tr>
<th>EMISSION TYPE</th>
<th>UNIT</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂ Scope 1</td>
<td>t CO₂e</td>
<td>11,844,687</td>
<td>11,716,772</td>
</tr>
<tr>
<td>CO₂ Scope 2</td>
<td>t CO₂e</td>
<td>18,597</td>
<td>18,003</td>
</tr>
<tr>
<td>CO₂ Scope 3</td>
<td>t CO₂e</td>
<td>4,283</td>
<td>7,091</td>
</tr>
<tr>
<td>Intensity of GHG emissions in flight operations</td>
<td>kg CO₂e/100 RTK</td>
<td>81,09</td>
<td>80,14</td>
</tr>
<tr>
<td>Gases which affect the ozone layer</td>
<td>kg CFC-11e</td>
<td>2,985</td>
<td>2,218</td>
</tr>
<tr>
<td>Nitrogen oxides</td>
<td>t Nox</td>
<td>40,752</td>
<td>40,022</td>
</tr>
<tr>
<td>Intensity of nitrogen oxides</td>
<td>gNOx/RTK</td>
<td>2.68</td>
<td>2.64</td>
</tr>
<tr>
<td>Sulfur oxides</td>
<td>t Sox</td>
<td>1,850</td>
<td>2,800</td>
</tr>
<tr>
<td>Intensity of sulfur oxides</td>
<td>gSOx/RTK</td>
<td>12.69</td>
<td>19.22</td>
</tr>
</tbody>
</table>

RTK: revenue tonne kilometers transported
6.4 Aviation Biofuels

6.4.1 Minas Gerais Platform of Biojet Fuels and Renewables

The Minas Gerais Platform of Biojet Fuels and Renewables gathers Minas Gerais state government bodies, universities and research centers, companies and other domestic and international actors. The objective of the Minas Gerais Platform is to make feasible in Minas Gerais an integrated value chain for producing aviation biofuels and other renewable products. The macaw (Acrocomia aculeata), a native palm of the state, is the main raw material which is being studied, as it has huge potential for producing biofuel. The structuring of the production chain of the macaw involves two aspects: the extractivism (family agriculture in the clumps of macaw around the municipality of Dores do Indaiá) and the agribusiness (commercial planting in the municipality of João Pinheiro).

The Minas Gerais Platform was created in June 2014. Partnerships established with the Interamerican Development Bank – BID, the air carrier GOL Linhas Aéreas Inteligentes and UBRA-BIO allowed the development of the concept of an integrated, multi-material and multi-process chain (“from research to plane wing”). In the last eighteen months, the Government of Minas Gerais, with the support of Curcas, consolidated the concept and encouraged the integration of the various “stakeholders” in a collaborative and logistically optimized platform.

The macaw was chosen by the Agrarian Development Ministry - MDA as raw material with potential for family agriculture. Thus, an understanding was formalized with Curcas Diesel Brasil to promote the macaw in the Minas Gerais Platform of Biojet Fuels. The macaw is in the R&D phase and the Federal University of Viçosa has performed in the research of this plant in the last ten years, sponsored by Petrobras.

Nanum Nanotecnologia, producer of a combustion optimizer, entered in the Platform to conduct the selection of processes of converting vegetable oils and animal fats into synthetic hydrocarbons, in the form of green diesel, biojet fuels and renewable chemical products. Nanum intends to implement a biorefinery with capacity of 50,000 ton/year in the industrial area of Uberaba/MG using the Axens technology of France. The negotiations of the licensing of this innovating technology for producing HEFA using soy oil, macaw and

---

31 A Report sent by representatives of the Brazilian Platform of Biojet Fuels and the Minas Gerais Platform of Biojet Fuels and Renewables, on 02/10/2016.

32 Curcas Diesel Brasil LTDA is a company founded in 2007 in order to develop an integrated and sustainable chain for producing biodiesel."

33 HEFA: hydroprocessed esters and fatty acids.
animal fats, besides a process of converting agricultural residue into bio-oil, all integrated in a single platform for synergy of processes, are in the final phase. GOL Linhas Aéreas Inteligentes is considered a strategic and founding partner of the Minas Gerais Platform of Biojet Fuels, with commitments of “off-take” contracts of biojet fuels, already formalized with Amyris\textsuperscript{34} for SIP\textsuperscript{35}, and with Nanum for HEFA, besides encouraging the productive chain of macaw.

In April of 2015 the Workshop of Alignment of the Minas Gerais Platform of Biojet Fuels, and Renewables was held. In May 2015, the Action Plan of the Minas Gerais Platform was submitted to public inquiry and, in June of the same year, the document was published in the State Official Gazette, which completed the legal formalities for its institution. As of August 2015, UBRABIO made countless consultations with the Federal Government for introducing macaw as a native species for recovery of Permanent Preservation Areas - PPAs, legal reserves and recovery of degraded pasture, in the commitment of reforestation assumed by Brazil’s INDC in COP21 – Paris Agreement. The Action Plan of the Minas Gerais Platform foresees the implementation of Demonstration Technical Units - UTDs in several municipalities of the State, in a partnership of the MDA with the State Secretariat of Agriculture, Livestock and Supply of Minas Gerais for qualification and training of family agriculture in the consortium of macaw with alternatives of annual harvest. The Consortium of MacaubaBR was formed in January 2016 (CURCAS, AGROTOOLS, NANUM, GOL, ACROTECH, ECODATA)\textsuperscript{36} by Curcas Diesel Brasil for structuring the integrated chain of macaw and implementing the pilot project of the Minas Gerais Platform of Biojet Fuels and Renewables.

The objective of the Pilot Project is to show the technical-economic feasibility of using macaw to produce aviation biofuel. From the project, a plantation of 1 million hectares of macaw in Minas Gerais, used in the recovery of PPAs, legal reserves and degraded pasture is sought by 2030. The project involves, beside the government of Minas Gerais, several other actors. Table 8 lists the other actors involved and the main actions developed by each one of them.

\textsuperscript{34} North American company headquartered in São Paulo State which has technology for producing biofuel rom sugar-cane.

\textsuperscript{35} SIP - Synthesized Iso-Paraffinic, fuel produced by company Amyris, in Brotas (SP).

\textsuperscript{36} Agrotools - Company of territorial management and socioenvironmental analyses for agribusiness; NANUM - Company of Minas Gerais focused on producing nanometric metallic oxides; ACROTECH – Company of Minas Gerais which produces and sells Macaw seed; ECODATA - Brazilian Agency of Environment and Information Technology.
### Table 6. Other actors and actions of the Minas Gerais Platform of Biojet Fuels and Renewables.

<table>
<thead>
<tr>
<th>Actor</th>
<th>Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ministry of Agrarian Development</td>
<td>Support for the extractive chain of Macaw, PGPM/BIO, and implementation of UTDs with the planting of Macaw associated with beans.</td>
</tr>
<tr>
<td>Ministry of Agriculture - MAPA</td>
<td>Support for Macaw zoning, in partnership with UFV/EPAMIG, and disclosure of the technological mastery of this cultivation through Field Day Circuits.</td>
</tr>
<tr>
<td>Secretariat of Civil Aviation - SAC</td>
<td>Institutional support for the Minas Gerais Platform of Biojet Fuels aiming at alignment of Brazilian industry in the effort to mitigate the civil aviation GHG emissions.</td>
</tr>
<tr>
<td>ACROTECH</td>
<td>Supply of Macaw seedlings for the UTDs of the pilot project.</td>
</tr>
<tr>
<td>Altitude Engineering/PG</td>
<td>System of follow-up of planting, monitoring of recovery projects of PPAs, legal reserves and degraded pastures, with images through “drones” (VANTs)</td>
</tr>
<tr>
<td>Banco do Brasil</td>
<td>Program of Sustainable Regional Development and Social Technology of the Banco do Brasil Foundation.</td>
</tr>
<tr>
<td>BNDES</td>
<td>Support through FUNTEC and other programs for the development of the productive chain including the pilot biorefinery.</td>
</tr>
<tr>
<td>BDMG</td>
<td>Financial support for the projects of commercial planting and improvement of Macaw.</td>
</tr>
<tr>
<td>COMASF</td>
<td>Consortium of the Municipalities of the Basin of Alto São Francisco: supporting implementation of regional small enclosures (seedlings).</td>
</tr>
<tr>
<td>GE</td>
<td>Supply of technology and support of the Global Research Center in the tests with green diesel and biojet fuels in turbines and engines, including tests with the fuel optimizer (Nanum).</td>
</tr>
<tr>
<td>GOL</td>
<td>MOU of off-take of the production of green diesel and biojet fuels with Nanum Nanotecnologia.</td>
</tr>
<tr>
<td>AGROTOOLS</td>
<td>Supply of platform for the integration of the “agricultural internet” with “big data” associated with CAR of agricultural properties and integrated with the ISA system and monitoring of planting of Altitude.</td>
</tr>
<tr>
<td>Nanum Nanotecnologia</td>
<td>Implementation of biorefinery unit of 50,000 t/y in the industrial area of Uberaba, MG.</td>
</tr>
<tr>
<td>Ômega Ambiental</td>
<td>Projects of PPAs recovery, legal reserves and degraded pasture, with use of Macaw (etc.).</td>
</tr>
<tr>
<td>RSB</td>
<td>Support in certification of Agribusiness chain of Macaw and pilot biorefinery.</td>
</tr>
<tr>
<td>SOLEA</td>
<td>Rational planting and improvement unit of coconut of Macaw of APL 02 - Joao Pinheiro, MG</td>
</tr>
<tr>
<td>UBRABIO</td>
<td>Institutional support and governmental relations (National Congress: National Program of Biojet Fuels; ANP, MAPA, Bilateral Agreements with the USA and Germany and resources of G7 for revitalizing the Basin of Alto São Francisco).</td>
</tr>
<tr>
<td>UFMG</td>
<td>Characterization of vegetable oils for the process of thermal cracking of Nanum Nanotecnologia, certification of green diesel, biojet fuels, and renewable chemical products.</td>
</tr>
<tr>
<td>UFV, EPAMIG, EM-BRAPA and other research institutions</td>
<td>Continuity of R&amp;D program of Macaw (cloning), and support in implementing Technical Demonstration Units of Macaw and association with annual cultivation.</td>
</tr>
</tbody>
</table>
The construction of an aviation biofuel industry and renewables in Minas Gerais State using macaw as the main raw material will provide, besides economic and environmental gains, social advantages, bearing in mind the insertion of family farmers in the extractive process.

In addition to that, the environmental benefits are not restricted to the reduction of GHG emissions, as the planting of macaw will play a role in the recovery of Hydrographic Basin of the Rio São Francisco and recovery areas of the PPAs and degraded pasture.

6.4.2 Actions of the Company GOL Linhas Aéreas Inteligentes

In order to reduce its GHG emissions and its dependence upon fuels of non-renewable sources, GOL, since 2012, has had a Biofuel program, which seeks to encourage and create circumstances to allow the construction of a value chain of bio jet fuels in Brazil. They consider that bio jet fuels have the potential to reduce by up to 80% the emissions of a flight. Thus, GOL performs a series of activities for promoting this new industry, among which the following stand out:

Minas Gerais – GOL composes the Minas Gerais Platform of Biojet Fuels and Renewables, as described in the previous item. On June 5, GOL hosted in its hangars of the Maintenance Center (MRO) in the airport of Belo Horizonte/Confins, the Minas Gerais Platform of Biojet Fuels official launching event. The Platform has among its objectives transforming the Airport of Confins into the first “green airport” in Brazil.

Pernambuco – In Pernambuco, GOL has worked with the State Government to neutralize the carbon footprint in Fernando de Noronha, a natural Paradise visited by thousands of tourists every year. As most of the emissions generated by the region of the archipelago arises from air transportation, biofuel is one of the best options to contribute to reducing the carbon footprint and drastically reduce the total CO₂ emissions of the island. Nevertheless, the state faces challenges, as there is not a structured productive chain to produce and distribute the bio jet fuels.

São Paulo – São Paulo is the most developed Brazilian State in producing biofuel and has a manufacturing unit of Amyris, a North American company that has technology to produce biofuel from sugarcane. Nevertheless, most of the biofuel produced in the State is biodiesel, due to the granting of subsidies by São Paulo city hall for its use in the buses that circulate in the capital of São Paulo State. Amyris is

---

fully able to produce bio jet fuels, nevertheless, due to several factors, cannot yet attain a competitive price that would awake the airlines commercial interest.

**Rio Grande do Sul** - The efforts to produce biofuel in Rio Grande do Sul are being led by Boeing, commercial partner of GOL. The state is a great producer of biomass and one of the largest of biodiesel (which, in this case, comes from soybean) in Brazil, but there are great challenges arising from the absence of an industry converting biomass into bio jet fuels. To overcome this challenge, GOL has joined the Rio Grande do Sul Industrial Development Agency (AGDI) to seek solutions. They include the possibility of enabling the Rio Grande do Sul Oil Refinery (RPR) – which lost competitiveness in the field of refined gasoline – to produce renewable fuels. Besides the great Rio Grande do Sul production of biomass, the RPR has a strategic localization, as it has maritime, river and railroad access.

**Certification** - Besides encouraging the production of biojet fuels, GOL - by means of the Brazilian Union of Biodiesel and Biojet fuels (Ubrabio) - has performed directly in seeking domestic and international regulatory certifications, which aim to ensure and allow the wide use of fuel from renewable sources. In 2014, Resolution n. 20 of the National Petroleum Agency (ANP) was published, which authorizes the use of bio jet fuels for domestic flights. In order to celebrate the Environment Week, on June 4, 2014, GOL executed flight 2152, which took off, using bio jet fuels, from the airport Santos Dumont, in Rio de Janeiro, towards Brasilia. In this same event, a protocol of understanding was signed for the contributions of the civil aviation industry to reducing the sector’s GHG emissions. Another regulatory milestone of 2014 was the international certification issued by the *American Society for Testing and Materials* – ASTM, which authorized the use of biofuel made from sugarcane produced in Brazil in aircraft. To commemorate the certification, GOL made its first international flight using *Synthesized Iso-Paraffinic* (SIP) – the biofuel recently certified by the ASTM. The flight started in Orlando (USA), with a stopover in Santo Domingo (Dominican Republic), and final destination at the Guarulhos Airport, in São Paulo (Brazil).

**Bio Jet Fuels in the World Cup** - In the period of the World Cup in Brazil, GOL made 365 domestic flights with biofuel and, thus, the company made the 2nd largest campaign of flights with renewable fuels in history. The operation was concentrated in the Airport of Galeão, in Rio de Janeiro, where 69 tons of bio jet fuels were stored – which were mixed with the fossil fuel. Besides the impact in the disclosure of the program, the experience of this campaign was important to test the technical and logistical feasibility of the operations with bio jet fuels.
Consumption of biofuel: In 2014, in the company GOL, 69 tons of biofuel HEFA (of UOP) and 3 tons of “blend” SIP (of Amyris) were used in the supply of the aircraft, which avoided the emission of **239,136.32 Kg of CO₂** (scope 1)\(^{38}\). The figure includes domestic and international supply.

6.4.3 Actions of the company TAM\(^{39}\)

The LATAM Airlines Group supports the use of sustainable alternative fuels, which allow the reduction not only of the carbon footprint, but also the exposure to the volatility of the oil price. The company supported the research concerning emerging biofuel technologies such as *Hydro Carbon to Direct Sugar* (HCDS) and *Alcohol to Jets* (ATJ). They believe in the potential of mass production of these technologies as a promising market opportunity. In recent years, the group has advanced in studies concerning alternative fuel technologies in collaboration with local distributors, in order to promote the use of biofuels. In spite of these advances in research related to sustainable alternative fuels, their implementation on a large scale depends upon the development executed by the producers of fuels and manufacturers of engines and aircraft, besides the creation of public policies which promote their use. The group continues participating actively in forums related to these issues, including IATA, International Civil Aviation Organization (ICAO), *Sustainable Aviation Fuel Users Group* (SAFUG), Brazilian Platform of Biojet Fuels and Chile Bio Renewable.

---

\(^{38}\) For the calculations of bio jet fuel the density of 0.75 Kg/L was used. The methodologies used for the calculation were: IPCC, mobile fuel, Civil Aviation e Tier2.

6.5 Improvements in Air Traffic Management

Air traffic management is extremely relevant to the good functioning of the air transportation. The concept ATM (Air Traffic Management) specified by ICAO refers to, besides air navigation technologies, a series of coordinated procedures that provide greater efficiency in air traffic operations in route and in Terminal Control Areas. The result of this efficiency is reduced fuel consumption and GHG emissions. Thus, in compliance with international commitments (resolution A36-2341 of ICAO’s 36th Assembly), Brazil started, in 2007, the optimization of the operations in the areas of air space in route (upper and lower), as well as the operations in the Terminal Control Areas, as described in the Action Plan of 2013. The procedures are in accordance with ICAO’s PBN (Performance Based Navigation) concept and are based upon the technological capacity aboard the aircraft, which provide the definition of flexible flights trajectories and optimized flights profiles.

In the air space in route, Brazil implemented and published a total of 111 Upper ATS routes (54 domestic routes and 57 international routes), based upon Air Navigation specification (RNAV) and accuracy (RNAV5). There is also a total of 4 ATS RNAV10 routes published and made available for international routes. It is forecast for 2016 the publication of all the upper continental ATS routes with specification of Air Navigation (RNAV) and accuracy (RNAV5).

In the Terminal Control Areas, the PBN concept has been adopted by means of establishing departures (SID) and arrivals (STAR) standardized by approach procedures and instruments (IAC), based upon RNAV and/or Navigation Based upon Performance (RNP). Table 7 presents a summary with the type and quantity of procedures adopted, as well as the planning for the coming years.

---

40 Information provided by the Secretariat of Air Navigation of the Secretariat of Civil Aviation. Source: DECEA.

41 Urged the States to implement ATS routes and approach procedures in accordance with the PBN concept.
The planning for the complete adoption of the PBN concept in all the Brazilian TMA is presented in the timescale of Table 8.

Table 7: PBN Procedures

<table>
<thead>
<tr>
<th>Procedure type</th>
<th>Implemented</th>
<th>Planned</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Year</td>
</tr>
<tr>
<td>RNAV STARs</td>
<td>135</td>
<td>2016</td>
</tr>
<tr>
<td>RNP STARs</td>
<td>-</td>
<td>362 2018</td>
</tr>
<tr>
<td>RNAV SIDs</td>
<td>215</td>
<td>2016</td>
</tr>
<tr>
<td>RNP SIDs</td>
<td>-</td>
<td>156 2018</td>
</tr>
<tr>
<td>BASIC GNSS RNAV APPROACH</td>
<td>162</td>
<td>2016</td>
</tr>
<tr>
<td>RNP APPROACH only LNAV</td>
<td>74</td>
<td>227 2016</td>
</tr>
<tr>
<td>RNP APPROACH with Baro/VNAV</td>
<td>88</td>
<td>227 2016</td>
</tr>
<tr>
<td>RNP AR APPROACH</td>
<td>4</td>
<td>24 2016</td>
</tr>
</tbody>
</table>

Source: Air Space Control Department

Table 8: PBN Implementation at Brazilian TMA

<table>
<thead>
<tr>
<th>Brazilian TMAs</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brasilia &amp; Recife</td>
<td>2010</td>
</tr>
<tr>
<td>São Paulo &amp; Rio de Janeiro</td>
<td>2013</td>
</tr>
<tr>
<td>Belo Horizonte</td>
<td>2015</td>
</tr>
<tr>
<td>Curitiba, Florianópolis &amp; Navegantes</td>
<td>2017</td>
</tr>
<tr>
<td>Belo Horizonte, Salvador &amp; Vitória</td>
<td>2019</td>
</tr>
<tr>
<td>Fortaleza, Natal &amp; Vitória</td>
<td>2021</td>
</tr>
<tr>
<td>Belém, Manaus &amp; São Luís</td>
<td>2023</td>
</tr>
<tr>
<td>Foz do Iguaçu &amp; Campo Grande</td>
<td>2024</td>
</tr>
<tr>
<td>Boa Vista, Porto Velho &amp; Rio Branco</td>
<td>2026</td>
</tr>
<tr>
<td>Aracaju, Ilheus &amp; Porto Seguro</td>
<td>2028</td>
</tr>
</tbody>
</table>

Source: Air Space Control Department
As shown in Table 8, the implementation of the PBN was already concluded in the TMAs of Brasília, Recife, São Paulo, Rio de Janeiro and Belo Horizonte. Regarding the terminals of Curitiba, Florianópolis and Porto Alegre, the conclusion is expected for July 2017. Adjustments were made in the terminals of Brasília, Belo Horizonte and São Paulo in order to implement simultaneous parallel operations, changing the air traffic design of the terminal and increasing their capacity.

For the PBN Rio/ São Paulo it was estimated that there would be an emissions reduction of 640 thousand tons of CO₂ per year, but this value was not attained due to several variable found in the operation, which are being corrected gradually. Shortly an evaluation will be made of the real fuel saving and reduction in emissions attained by implementing the PBN operations in Rio de Janeiro and in São Paulo. In Belo Horizonte, in the project of TMA-BH (2015), the estimated reduction is 2 thousand tons/year of CO₂.

The Terminal Control Areas which already have PBN technology implemented (i.e., Rio de Janeiro, São Paulo, Belo Horizonte, Brasília and Recife) have an average of 90% of the operating aircrafts capacitated for RNAV use and using the PBN procedures. For the international flights this figure attains 98% of aircraft capacitated for RNAV use.

The implementation of the PBN procedures in Brazil led to an average expense, taking into account expenses with air tickets and daily rates for the training required, of R$ 5,000,000.00 per year, in 2013, 2014 and 2015. A consolidated calculation has not yet been made of the reduction of emissions attained by the implementation of the PBN in the five TMAs mentioned. Nevertheless, the work is in progress and the calculation of the emissions for the TMAs are being done using a simulation tool called TAAM - Total Airspace and Airport Modeller, of the Air Space Control Institute (ICEA).

Besides the implementation of the PBN, other actions related to the optimization of routes and automation of the air traffic control system are in progress and have the potential to contribute to the sector’s GHG emissions reduction.
Conclusion

Civil aviation plays an important role in the development of international business, trade and tourism and, therefore is a dynamic factor in the economy. International aviation has grown a lot in the last two decades, as has the domestic aviation in Brazil – the fourth largest in the world currently, despite the reduction in the pace of growth in recent years. The Brazilian government supports the growth of the air sector as an important vector for national integration and international connection, which must occur in a sustainable manner and taking into consideration the requirement of minimizing its impact on climate change.

This document presented some of the actions adopted that contributed significantly to reducing aviation GHG emissions. The aeronautical industry, for example, advanced in the aircrafts technological development, which increased efficiency in fuel consumption and reduced the emissions intensity of the sector. The Brazilian airlines have implemented measures to improve the efficiency of their operations and methodologies to calculate their GHG emissions. The administration of the Brazilian airports has also sought to increase the operational efficiency of the airports and adopted other measures that contributed to the expansion of the airport infrastructure in an environmentally responsible manner.

The alternative fuels represent a great opportunity for reducing GHG emissions of the sector in the mid and long terms. The studies and prospections executed by the Minas Gerais and Brazilian Platforms of biofuels for aviation show the high potential of Brazil for the development of this new industry, which is strategic in the global context of a progressive search for the economy decarbonisation.

The Brazilian government acts to improve air traffic management constantly and optimize the operations in the domestic air space. Furthermore, in the last decade Brazil has adopted an economic regulation with great freedom for performance in accordance with the market (free determination of both tariffs and routes), which contributed to the efficiency of the sector.

Bearing in mind that aviation is a highly interconnected sector, it is essential to harmonize rules, standards and procedures for its effective development. Thus, the Brazilian government supports the multilateral approach, in the scope of the International Civil Aviation
Organization-ICAO. The Brazilian government participates actively in the negotiations in ICAO, including those related to the objective of reducing the impact of civil aviation on climate change. Brazil is a member of the Environmental Protection Committee – CAEP and was the Reporter of the Task Force on aviation biofuels. Furthermore, Brazilian technicians took part in the discussions concerning the definition of CO₂ emission standards for aircraft engines. Regarding climate change, Resolution A38-18 defined that ICAO should create a market based mechanism (MBM) to reduce the GHG emissions of international aviation. This work was conducted by a group called EAG (Environmental Advisory Group), composed of 17 countries, of which Brazil was an active member. The final document will be analyzed by the next ICAO’s Assembly, to be held in September/October 2016.

This document is part of the contribution of the Brazilian government to ICAO’s efforts to reduce the impact of international aviation on Climate change. It is the result of joint work of stakeholders linked to the issues of fuel efficiency, environmental management and reduced GHG emissions in the various segments that compose the national system of civil aviation, which are: governmental bodies; Airports; Brazilian and Minas Gerais Platform of Bio jet Fuels, airlines and aeronautical industry. The partnership between aviation public and private entities is essential for the effective implementation of the mitigating measures described throughout the document.

One of the challenges that remains is that of calculating the impact of the mitigating measures on GHG emissions. Certain actors calculated this impact and presented the figures in CO₂ tons, as well as the methodologies adopted. This result already represents an evolution related to the previous Action Plan, in which there was little data of emissions reduction associated with the mitigating measures. Nevertheless, it is necessary to establish harmonized methodologies, basic indicators and concepts of performance, which allow the appropriate follow-up of the impact of each measure.

The Action Plan offers a general framework regarding the greenhouse gas emissions of both domestic and international Brazilian aviation. The Brazilian government intends to monitor these indicators and update the data presented in this second edition of the Action Plan periodically, as requested by ICAO. It is understood that this process of periodically updating the Action Plan provides an important means of articulation between the stakeholders involved in the task of seeking the sustainable development of Brazilian aviation, with the reduction of its impact on climate change.
Stakeholders

Infraero
Arthur Neiva Fernandes e Charles Rocha

Viracopos Aeroport
Bibiana Roth, José Angeja e Gustavo Müssnich

GRUAIRPORT
Renato Pires, Marcos Eugenio de Abreu e Comte. Miguel Dau

BH Airport
Guiherme Motta Gomes e
Adriano Gonçalves de Pinho

Inframérica
Rodrigo Gomes de Paula e Camila Máximo

Embraer
Mariana Luz e Daniel Bassani

Plataforma Brasileira de Bioquerosene
Mike Lu

GOL Linhas Aéreas e UBRABIO
Pedro Rodrigo Scorza

DECEA
Ten. Coronel Jorge Wallacy Paiva de Azevedo, Capitão Luís
Antônio dos Santos,
Brigadeiro Gustavo Adolfo Camargo de Oliveira

SENAV/SAC
Juliano Noman e Giovano Palma
Brazilian Action Plan Scope
Action Plan for Reducing Greenhouse Gas Emissions of Brazilian Civil Aviation