The Implementation of Sustainable Aviation Fuels (SAF) in the BASIC countries – Brazil, South Africa, India and China.

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ABSTRACT

The main contribution of this research is to advance on studies of Sustainable Aviation Fuels (SAF), specifically in the BASIC countries - Brazil, South Africa, India and China. The mitigation of civil aviation emissions is negotiated in the ICAO (International Civil Aviation Organization), of the United Nations. Countries are committed to carbon-neutral growth from 2020 onwards and its neutrality by 2050. The essential alternative to achieving the targets is the use of SAF, gradually replacing traditional fuels. Manufacturing technologies and methodologies have already been approved, depending on the production model and the raw material used, such as biomass, oils, residues or algae. BASIC countries have conditions for the development and use of SAF. This research aims to answer two questions: How is the development and implementation of SAF in BASIC countries? The hypotheses are that the four countries have interest and potential to meet national needs and export alternative fuels, according to national characteristics.

Keywords: BASIC, SAF, ICAO, Climate Change

Introduction

In 2009, negotiations to extend the Quito period, emerging countries agreed, for the first time, to adopt voluntary emission reduction targets. This change occurred due to meetings and agreements between these countries, recognizably the BASIC group - Brazil, South Africa, India and China. These countries showed an increase in their emissions, especially China, which in 2006 became the main global emitter. In this way, there were pressures for these countries to participate in global cooperation, applying targets and mitigation measures. Thus, in a joint understanding, as a block, BASIC agreed to have voluntary targets, an unprecedented action, signaling a more positive transition in external climate policies (Hallding et al, 2011; Hochstetler; Viola, 2012).

The BASIC group was created as a result of the convergence of interests: defense of historical responsibilities, developed countries need to be more active in emission reductions; development, are still economies and transition, with various social problems; and sovereignty, non-intervention in domestic climate affairs and policies. The group changed its position, previously always close to the developing countries, or G77, which did not accept targets, not even voluntary ones (Hallding et al, 2011; Hochstetler; Viola, 2012). BASIC operates in international climate negotiations, with periodic meetings, aligning its foreign policies and negotiating as a block. These countries are central actors in international politics and in the climate context, due to their emissions, territories, populations andeconomy.

In 2015, a new agreement on climate change negotiation was drawn up, recognized as the Paris Agreement. The difference is that all countries, voluntarily, indicated targets for reductions or peak emissions, to avoid a 2° rise in temperature, with efforts to 1.5°. In this way, the division between blocks of developed and developing countries was no longer explicit. However, just as at the beginning of negotiations in 1992, the Paris Agreement contemplates the “principle of common but differentiated responsibilities”, in which developed countries need more efforts in mitigation, due to their historical emissions and economic differences (Falkner, 2016; Estevo, 2021).

The civil aviation is also extremely relevant scope to climate issue, although less widespread, such as the use of coal or forest fires. Air transport represents about 2% of all global emissions, but the value can reach up to 5%, depending on the metric used and gases considered. The trend is for an increase in rates, with an increase in the number of passengers and flights (Baledón, Kosoy, 2018; Larsson et al, 2019; Liao et al, 2021).

In 2009, 290 airlines from 120 member countries of the (IATA) International Air Transport

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Association (IATA) committed themselves to emission reduction targets, with increased efficiency in fuel consumption and zero CO^2 growth from 2020, that is, to limit the increase in emissions. ICAO has also started negotiations, with countries only, to implement mitigation measures in the sector. The first agreement took place in 2013, where it was established for a fuel consumption efficiency of 2% per year, until 2020. (Gonçalves, 2017; ICAO, 2019). In the year 2022, at the ICAO General Assembly, the countries agreed that by 2050 the sector would be carbon neutral (ICAO, 2022).

ICAO has established measures to be implemented to help reduce emissions. The first is an advance in aircraft technologies. The second alternative is improvements in the operations of airports and companies. The third is the negotiation of reductions and the last one is the substitution of fuels, especially the implementation of SAF. This work is an early stage of broad postdoctoral research, which aims to understand the role of BASIC countries within the SAF.

Sustainable Aviation Fuels and the BASIC Countries

Fuel costs represent a relevant portion of airline operations, changing them is difficult, since the requirements in the sector are very high, certainties are needed for a new fuel to be used. Thus, several attempts, studies, tests have been and are being carried out in the world. The implementation of the SAF will greatly assist in the mitigation of the sector, far beyond the other ICAO proposals. However, there are still lots of difficulties for this fuel transition, since the theme is still recent, lacking in successful technologies, to be established in all flights in the world, with an affordable price. Some alternatives are known, being tested in different locations (Thomaz et al, 2022; Efthymiou, Ryley, 2022).

So far, according to ICAO, seven routes and nine SAF processes have been approved by the American Society for Testing and Materials International (ASTM), the body responsible for developing and publishing technical standards for various sectors. SAF can be used as part of the fuel, in combination with TAF (Traditional Aviation Fuel) such as Kerosene, the amount of mixture depends on each source. The first route is that of Paraffinic Kerosene synthesized by Fischer-Tropsch (FT), this can be used in up to 50% of the combination with TAF.

Its main sources are urban, agricultural and forestry solid waste biomass; and non-renewable raw materials such as coal and natural gas. The FT/A Paraffinic Kerosene route synthesized by Fischer-Tropsch with aromatics, also uses the mentioned materials and has the same mixing level. And in the same way, with 50%, the HEFA route, Paraffinic Kerosene synthesized by hydroprocessing of esters and fatty acids, from vegetable and animal fat oils, as reusable cooking oil (ICAO, 2022; Thomaz et al ,2022). ASTM also certified the ATJ route with 50%, Paraffinic Kerosene synthesized from alcohols, its raw material comes from the use of starches, sugars and cellulosic biomass, ethanol from sugar cane and isobutanol are some examples. Another route is the CHJ catalytic hydrothermolysis, with the same percentage of mixture, also having its sources of vegetable and residual oils, such as soy, jatropha, camelina and carinata oil. With a mixture of 10% are HEFA-SPK, Paraffinic kerosene synthesized by bioderived hydrocarbons, fatty acids and hydroprocessed esters, which uses the production of biofuels with algae and SIP, Iso-paraffins synthesized by hydroprocessing of fermented sugars, which uses biomass from sugar production (ICAO, 2022; Thomaz et al, 2022). According to ICAO, two more co-processing processes are considered, both with 5% of mixture and from petroleum industry sources, the co-processed HEFA and co-processed FT, the first coming from using fats, oils and greases, the second of hydrocarbons (ICAO, 2022).

The production and use of AFS are concentrated in OECD countries (Organization for Economic Cooperation and Development), around 90%. BASIC countries are not on this list, but with other non-member countries, they are responsible for almost 50% of aviation fuel use. According to Malina et al (2022, p.30) The SAF feedstock potential in non-OECD countries is estimated to b equivalent to a production of approximately 510 million tons of SAF. Currently, European countries are prominent in the implementation of SAF. Sweden, Norway Finland has a SAF mix target of 30% SAF by 2030. France will also require 5% in 2030 and Spain 2% in 2025.BASIC countries have interest and potential to meet national needs and export alternative fuels, according to national characteristics, in different routes and raw materials, as we will see below.

In the case of Brazil, national policies for biofuels have recently been highlighted, such as Bill No. 14,248, of 2021, which established the National Biokerosene Program, aiming to encourage research and production of energy based on biomass for Brazilian aviation. Bill 1873/21, which established a timetable for gradually adding aviation kerosene to traditional fuels between 2027 and 2030, created a federal program to support research, production and consumption of advanced biofuels in Brazil. Brazil signed, at the last ICAO conference, its participation in the ACT-SAF Programme, which aims at the development

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of joint actions by several countries to promote research and application of SAF. On September 14, 2023, the federal government, with the Ministry of Mines and Energy, handed over to Congress the Bill for the Fuel of the Future, with the aim of reducing emissions, incentives for national biofuels, decarbonization of the sector of transport. The Project creates the National Sustainable Fuel Program for Aviation, with the purpose of "encouraging the production and use of SAF. For the new policy, air operators are obliged to reduce carbon dioxide emissions carbon by 1% from 2027, reaching a reduction of 10% in 2037". (Brazil, 2023). The text still needs to pass through both legislative houses and could suffer changes.

Brazil is one of the largest producers of biofuels in the world, due to its high agricultural production capacity. Within the scope of the SAF, there is great potential in the routes: HEFA, using soy oil and animal fat. The country also has good possibilities of advancing on the ATJ route, as it is one of the main sugarcane producers in the world, which also gives it an advantage on the SIP route. And yet, in the use of agricultural, forestry and urban biomass, for FT. Compared to other BASIC countries, Brazil already has the advantage of having advanced biofuel technology, with a good supply of raw materials (Thomaz et al, 2022).

South Africa has great potential for SAF development. In particular to produce the HEFA route, through Solaris tobacco seeds, which is being developed for use as AFS, already tested on a flight in 2016. The country is also a sugarcane producer, thus having advantages for the route SIP and ATJ, the latter can also be developed by the process of industrial effluents from steel and ferroalloys, captured to produce third generation ethanol. Furthermore, there is capacity to use biomass from forest residues in the FT route (Bole-Rentel et al, 2022). According to the country's document **Green Transport Strategy for South Africa (2018-2050)**, investment should be made in more efficient routes, as the trend is towards an increase in passengers and thus emissions (South Africa, 2018).The state-owned company PetroSA has great possibilities for the development of aviation biofuels, through the biomass produced in the country, especially on the ATJ route, but which still needs to be implemented (Bole-Rentel, Chireche, 2021). A project led by Fetola, Worldwide Fund South Africa and SkyNRG, intends to use the biomass of urban waste to develop SAF, still a pilot project, but which should expand to more companies, creating a local industry (WWF, 2018).

In 2022, China launched its 14th Five-Year Civil Aviation Plan, which describes a plan for a Green Civil Aviation, with more environmental responsibilities. In the last Plans, the country created targets for CO^2 emissions, demonstrating the need to transition to a change in the sector (China, 2022). However, the development of SAF is still slow, the state-owned company SINOPEC has shown the best results, with a plant built, certified and starting production in the country. The main route is HEFA, with reuse of reusable cooking oil (RSB, 2022). Honeywell and Oriental Energy formed a partnership to produce HEFA using animal fat and reusable oil (Honeywell, 2022). Among BASIC, China has the lowest development of this AFS market. The biofuel sector is still developing, the difficulty essentially lies in production, finding the best raw materials, so that there is no dispute between food and fuel production.

This problem is also faced by India, the difficulty of food supply and biofuel production, in the largest populations in the world. For India, there is great potential in production on the HEFA route, with animal and vegetable fat, but above all in the reuse of oil, greater potential for the country. The FT route can also be used, but it depends on investment in the treatment of urban waste, by biomass from agriculture and forests, but depends on better collection infrastructure. There is a potential for TKA, with the production of sugar to use isobutanol (IBA), an intermediate product that serves as input for the AFS (World Economic Forum, 2021). The Indian Air Force already operated flights with SAF in 2018, using a blend of 10% jatropha oil (India, 2018). The country intends to expand studies and promote the development of the SAF, to be able to fulfill its goals. The SpiceJet airline, one of the main airlines in the country, announced an ambitious goal of flying 100 million domestic passengers, with a mix of SAF, by 2030 (SpiceJet, 2022). The country does not yet have legislation for mitigation in the sector, only that it must initiate incentives to reduce emissions, such as improving routes and controlling gasses at airports, nothing specific about SAF or targets (Government of India,2023).

Preliminary conclusions and study projections

The production of SAF depends on the domestic factors of each country, the availability of raw material. The development of each AFS route depends on the production of the most widely available fuel in each country. This research will seek to explore what are the capabilities and availability of raw materials for Brazil, South Africa, India and China. Data on which are the main sources, which include different routes, will be the basis of this study. To do so, we explored data from each country, such as agricultural production, biofuel development, main production areas, which companies are engaged, state

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actors involved in biofuel production and possible scenarios for increasing production, to supply the domestic market and possible export of SAF. Understanding the capacity, which are the main production areas, the most accessible raw materials, are essential for understanding which AFS routes each country will be more promising.

As highlighted, this is the beginning of the research. And this article aims at the debate on the topic of research and scenarios, paths for its development. To this end, seminar discussions are essential to find answers and further develop the research. There is, therefore, no result, just a conclusion of the great potential of the BASIC countries in the production and use of SAF, these will be essential for mitigating the air sector, nationally and internationally.

A highlight is at the national political level. Brazil is the only one of the BASIC countries that has made progress in implementing actions on the topic, such as the recent bill sent to congress, with goals and incentives for the sector. China, despite not promoting more concrete laws, has sought to indicate reduction targets, together with its five-year plans, which indicates the relevance of the issue. India and South Africa have not made laws or targets available yet but are present in international negotiations and presenting studies on the topic. Despite the potential for SAF production, these countries need to create, organize and implement policies for the sector, which will help with production and use in their aircraft, contributing to the mitigation of the sector.

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