Brazil's ethanol sector and sustainable aviation fuel: Preparing for takeoff

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Contents

Summary

Brazil's ethanol producers view rising global demand for sustainable aviation fuel (SAF) as a potential source of new demand. Policy to support the emergence and growth of a SAF market is already advanced in the EU and the US. Meanwhile, legislation to create a national SAF mandate in Brazil is working its way through Congress.

Our analysis indicates that even if 100% of Brazil's projected domestic SAF requirement under the proposed legislation were to be produced from ethanol, the volume required would be some 3.5bn liters by 2037, which is not a game changer in terms of volumes. Local production of ethanol is currently over 30.0bn liters a year.

The domestic market for SAF could, nevertheless, evolve into an interesting premium market for a subset of local ethanol players. Furthermore, several large ethanol suppliers are already integrated with the country's leading distributors of fuel, including aviation fuel.

Overseas, the aviation fuel markets in the US, the EU, and Japan are far larger than Brazil's, and Brazilian ethanol players are optimistic that the low carbon intensity of ethanol or SAF produced in Brazil should make them competitive exporters. Still, they recognize that access and competitiveness will also depend on the policies adopted in these markets.

Constructing an alcohol-to-jet SAF facility represents a very large investment. Although none have been announced in Brazil, analysis is underway. While many uncertainties around the evolution of the SAF market remain, the cane and ethanol sectors have often dealt with uncertainty by exploiting various arbitrages they have available in terms of products and markets.

We believe that an approach to business and growth that preserves flexibility and optionality allied with major ethanol players' existing proximity to fuel distributors will guide the industry toward developing a business model for SAF that is both robust and flexible.

Introduction

The world's sustainable aviation fuel (SAF) market is still in its infancy. Uncertainties around its evolution are considerable, none more so than which technologies[1] and raw materials for SAF production will ultimately prove most competitive in terms of cost and carbon intensity. In the short to medium term, pathways based on conventional first-generation raw materials and biofuels will be major contributors to supply.[2] As a result, Brazil's ethanol producers view rising

[1] At present, eight different technical pathways are approved for SAF production.

[2] For a comprehensive introduction to SAF, as well as a detailed analysis of the US market for SAF, refer to our 2023 publications *Sustainable Aviation Fuel Policy Primer* and *The Future of Sustainable Aviation Fuels*.

global demand for SAF as a potential source of new demand for the ethanol they produce from sugar cane and from corn.

The current state of technology and policy

Most of the SAF produced in the world today is made from vegetable oil via the hydrotreated esters and fatty acids (HEFA) pathway, but significant investment in the alcohol-to-jet (ATJ) pathway is expected. Today, there is only one commercial ATJ facility in the world: LanzaJet's plant in Soperton, Georgia (US), which began operating in early 2024 using imported Brazilian cane-based ethanol as a raw material owing to its relatively low carbon intensity.

Based on the stated SAF production capacity of the Soperton plant, we estimate the facility will require some 60m liters of ethanol annually. This flow is more symbolic than significant, as it represents a small portion of Brazil's annual ethanol exports and production (2.5bn liters and 35.9bn liters, respectively, in 2023/24).

Some 20 ATJ plants are reportedly in various stages of planning or construction around the world, principally in Europe, the US, and Japan. This could create greater demand for Brazilian ethanol in the future, given its competitiveness in terms of cost and carbon intensity.

Meanwhile, a package of measures in Brazil dubbed the "Fuel of the Future" (Combustível do Futuro) is working its way through Congress. The package aims to encourage greater use of alternative fuels and contains a proposal for introducing a mandated blend of SAF in aviation fuel starting in 2027, with an emissions reduction target that starts at 1% and rises to 10% by 2037.

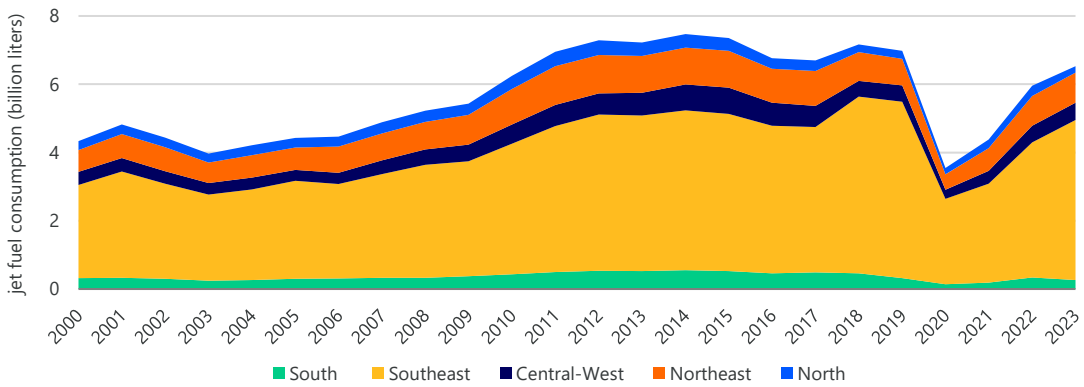
Brazil's aviation fuel market

Regional structure and recent developments

Figure 1 illustrates total aviation fuel sales in Brazil by region. The first thing to note is that the pandemic's impact on air travel is very evident, and the data indicates that even by the end of 2023 fuel use had yet to return to pre-pandemic levels (see figure 1).

Another striking feature is the dominance of the southeast region with respect to total fuel use, accounting for two-thirds or more of total national fuel consumption. This region comprises the states of São Paulo, Rio de Janeiro, Minas Gerais, and Espírito Santo and contributes around half of Brazil's total GDP. It is also home to the country's largest airports, Guarulhos in São Paulo and Galeão in Rio de Janeiro, which are the principal points of arrival and departure for international flights to and from Brazil.

Figure 1: Aviation fuel use in Brazil by region, 2000-2023

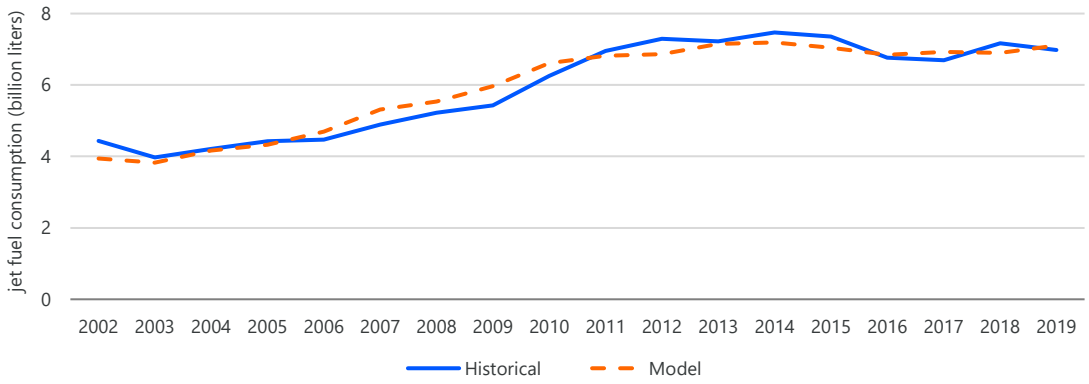


Source: The Brazilian National Agency of Petroleum, Natural Gas, and Biofuels, RaboResearch 2024

The outlook for aviation fuel demand

To evaluate the possible size of the SAF market in Brazil in the future, we constructed a simple model using population, per capita GDP, and the real (inflation-adjusted) local price of aviation fuel as variables. To exclude the impacts of the pandemic years, we used annual data for the years 2002 to 2019, and the model's results align reasonably well with past aviation fuel sales (see figure 2).

Figure 2: Historical aviation fuel use in Brazil, actual vs. model, 2002-2019

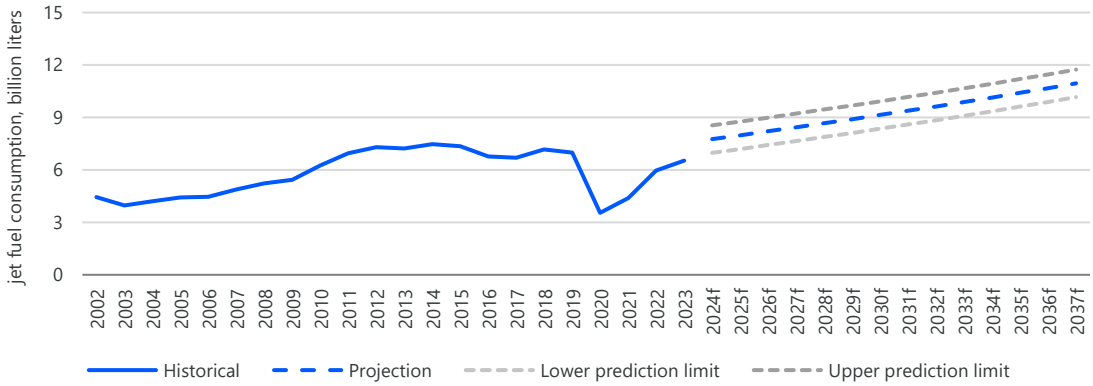


Source: RaboResearch 2024

We then employed this model to simulate aviation fuel demand to 2037 using forecasts of Brazil's population (the United Nations' World Population Prospects 2022), trend real GDP growth of 2% (RaboResearch Global Economics & Markets), and a simple assumption that, in real terms, the price of aviation fuel will remain at its 2023 average price over the forecast period.

Based on these assumptions, the model suggests that demand for aviation fuel should rise from a starting point of 6.5bn liters in 2023 to reach around 11.0bn liters by 2037 (forecast range 10.2bn to 11.7 bn liters, see figure 3). Naturally, changing the assumptions impacts the result – if we assume a 3% rate of real GDP growth over the forecast period, the projected volume of demand rises to close to 13.0bn liters by 2037 (forecast range 12.1bn to 13.7bn liters).

Figure 3: Aviation fuel use in Brazil, 2002-2037f



Source: RaboResearch 2024

The addressable market for SAF in Brazil

We can combine our forecast development of the aviation fuel market with the proposed SAF blending schedule laid out in the "Fuel of the Future" proposal to estimate the size of the total addressable market for SAF in Brazil up to 2037. Furthermore, if we assume that ethanol-based SAF meets 100% of this demand, we can derive a maximum volume of ethanol that this evolving market will require for SAF production.

The result of this exercise should be taken as nothing more than a ballpark estimate. The precise volume of ethanol-based SAF required to achieve mandated emissions reductions will depend upon the carbon intensity of the ethanol used. In this case, we have used standard values from ICAO/CORSIA for the carbon intensity of aviation fuel and for Brazilian first-generation cane-based ethanol. We have also made a conservative assumption that 1.8 liters of ethanol are required in the ATJ process to make 1 liter of SAF (see table 1).

Table 1: Projected maximum demand for ethanol-based SAF for domestic use in Brazil, 2027f-2037f

		2027	*2028*	*2029*	*2030*	*2031*	*2032*	*2033*	*2034*	*2035*	*2036*	*2037*
A	Projected national demand for jet fuel (billion liters)	8.4	8.7	8.9	9.1	9.4	9.6	9.9	10.1	10.4	10.7	10.9
B	Emissions-reduction target for national air transport (%)	1%	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
C	Carbon intensity of jet fuel (g CO2e/MJ)	90	90	90	90	90	90	90	90	90	90	90
D	Carbon intensity of SAF from sugar cane via ATJ (g CO2e/MJ)	33	33	33	33	33	33	33	33	33	33	33
E	Blend of ATJ SAF required to achieve target (%) (A*B)/((C-D)/C)	2%	2%	3%	5%	6%	8%	9%	11%	13%	14%	16%
F	SAF required to substitute jet fuel (billion liters) = A*E	0.13	0.14	0.28	0.43	0.59	0.76	0.93	1.12	1.31	1.51	1.72
G	**Ethanol required (bn liters), 1.8L ethanol to 1.0L SAF @ 90% efficiency**	**0.27**	**0.27**	**0.56**	**0.86**	**1.18**	**1.52**	**1.87**	**2.23**	**2.62**	**3.02**	**3.45**

Sources: Ministério de Minas e Energia; ICAO, *CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels*, SAF Rules of Thumb; ICCT, *Assessing the Sustainability Implications of Alternative Aviation Fuels*; RSB, *The viability of South African sugarcane as feedstock for sustainable aviation fuel production*; Industry sources; RaboResearch calculations, RaboResearch 2024

Even if 100% of Brazil's projected SAF requirement were produced from ethanol, the volume required would only be some 3.5bn liters by 2037. Under the assumption of a higher trend growth of GDP, this number rises to 4.1bn liters.

While any additional demand is welcome, this volume is not transformational. Average annual national production of ethanol already exceeds 30.0bn liters. Moreover, the forecast range of 3.5bn to 4.1bn liters assumes that 100% of SAF used in Brazil will be ethanol-based. In practice, ethanol will compete with other raw materials, such as vegetable oils, for use in SAF production. Petrobras, Acelen Renewables, and Grupo BBF have already publicly announced HEFA-based SAF projects.

Getting ethanol-based SAF off the ground – where, how, and who?

The local market: a niche, but with a premium?

So the potential size of the domestic market for SAF doesn't look like a game changer at a sector level given the current scale of total ethanol production and the likelihood of competition from other production pathways.

However, the domestic market for SAF could still be very interesting for a subset of local ethanol players. Indeed, all of the country's major players in supplying regular jet fuel (Vibra, Raízen, and Air BP) are now connected in some way with ethanol production and/or distribution via ownership or joint ventures.

Regardless of who produces and buys ethanol-based SAF, ethanol supply contracts are likely to be relatively few and large, and we believe that a premium will emerge in the market for ethanol that scores consistently well in terms of carbon intensity and is deliverable in large quantities. This

could create interesting opportunities for individual ethanol suppliers even if the total volume required is not game-changing at the sector level.

Competitive advantage in any market for SAF is likely to be determined by the carbon intensity reduction delivered per US dollar or Brazilian real. Brazil's geography of ethanol production (concentrated in the southeast) matches closely with the geography of jet fuel use (see figure 1). Minimizing the costs and carbon intensity associated with ethanol and SAF logistics will be key not only for being a competitive supplier of SAF, but also for reducing the impact of mandated blending on the cost of air travel. Geography and supply chain logistics could, therefore, work in ethanol-based SAF's favor.

The export market offers volume

The Brazilian ethanol industry is hopeful that its cost-competitiveness as a supplier of ethanol with a low carbon intensity will enable it to export either ethanol for SAF or SAF itself to markets where demand for SAF is expected to grow significantly.

The potential market for exports is certainly much larger than the domestic market. The Energy Institute's latest Statistical Review of World Energy shows that 2023 sales of jet fuel in the US were 15 times the volume of Brazil's sales; for the EU and Japan, volumes were eight and four times larger, respectively.

In addition to carbon intensity scores, the rules and regulations established by individual countries and blocs may determine the extent to which Brazilian ethanol or SAF exports can access opportunities in export markets. Policy is key to prospects both at home and abroad.

Writing the rule book: policy

Policy to support the emergence and growth of a SAF market is most advanced in the US, the EU, and the UK. In the US, Brazilian cane ethanol is already being used to produce SAF via the ATJ process. But EU legislation only accepts SAF made from non-food raw materials, ruling out the use of first-generation cane ethanol.

However, Brazil's cane industry has technology to meet the EU's requirements. Raízen already produces and exports cellulosic ethanol made from cane bagasse, and Copersucar announced in June 2024 a venture with Geo bio gas&carbon to produce SAF via the Fischer-Tropsch pathway using biogas made from the residue of sugar and ethanol production (filter mud and vinasse).

In Brazil itself, the proposed legislation for an SAF mandate is making its way through Congress. The draft sent by the lower house to the Senate indicates the thinking that underlies key pillars of the policy. First, the airlines are identified as the "obliged parties" for achieving the mandated blend and will suffer consequences (fines) if targets are not met. Second, the need to "optimize logistics in distribution and use of SAF" is highlighted.

In EU SAF policy, the fuel suppliers, rather than the airlines, are the obliged parties. They are a small group of large, rock-solid companies who are integral players in the supply chain. As offtakers for long-term contracts with SAF producers, they may look more like robust counterparties than airlines.

The directive in the proposed Brazilian legislation to optimize logistics is an encouraging signal. For obliged parties, the mandate is likely to operate by means of averaging national operations or a book-and-claim system, which would free the supply chain from having to achieve blending targets at all airports in the country and instead concentrate SAF supply where it is most efficient and cost-competitive.

Industry participants suggest that, in addition to the "stick" of the mandate, policy ought to include one or more "carrots" to encourage investment. Suggestions include tax breaks or the ability to raise debt via tax-exempt debentures (*debêntures incentivadas*).

Building the supply chain: contracts, partnerships, flexibility

While exporting ethanol is business as usual for Brazil's cane industry, producing SAF for local or export sales is certainly not. At the time of writing, Brazil has no capacity to produce SAF from ethanol via the ATJ pathway. So who needs to do what to get things off the ground?

Hundreds of millions of dollars need to be spent to construct just one commercial-scale ATJ facility. For such investments to happen in Brazil, the development of a robust supply chain of strong players and solid contractual arrangements between parties will be critical for creating confidence among individual players and their finance providers.

Here, the ethanol sector is certainly not starting from zero. Ethanol production and distribution already have significant integration with each of the major distributors of jet fuel in Brazil (Vibra/Copersucar, Raízen, and BP/Air BP), all of which have the characteristics of possible platforms for commercial-scale SAF production and distribution backed by strong players.

Furthermore, these partnerships are linked with major export markets via both global fuel distributors such as BP and Shell (one of Raízen's major shareholders) and via the ethanol sector – Copersucar's subsidiary Eco-Energy is an ethanol distributor in the US. In addition, Summit Next Gen, which is constructing an ATJ facility on the US Gulf Coast, has the same parent company as FS Bioenergia, a major Brazilian corn ethanol producer.

What is currently not visible in Brazil (but certainly under analysis/discussion behind closed doors) is the involvement of technology providers for the ATJ process, either by direct participation and operation or by some sort of licensing arrangement.

No one seems to be concerned about a lack of future demand for SAF. However, risks and unknowns certainly exist, such as the scale of investment required to produce SAF, the uncertainty about the relative competitiveness of the various technical pathways for producing SAF, and the vulnerability of policy-driven markets to changes in the rules of the game by a simple stroke of a pen.

How then to move forward? The cane sector's ability to diversify into different markets and to find arbitrages that create optionality – for example, sugar versus ethanol, exports versus domestic sales, selling bagasse versus generating electricity for the grid – is one of its greatest attributes and has served it well when facing uncertainty. The announcement of the Copersucar-Geo project appears to offer another possible option: producing SAF either via ethanol or via biogas. We believe that an approach to business and growth that preserves flexibility and optionality allied with major ethanol players' existing proximity to fuel distributors will guide the industry toward developing a business model for SAF that is both robust and flexible.

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