Preliminary Technical and Environmental Study Introduction of the SAF BBL DX (5%) + QAV Mixture

1. Introduction

The growing climate urgency and the international commitments made by Brazil in the Paris Agreement, as well as the ICAO global plan (CORSIA), have driven the development of **sustainable aviation fuels (SAF)** as an alternative to fossil aviation kerosene (QAV). **Law No. 14,599/2023**, known as the "Fuels of the Future Law", together with **CNPE Resolution No. 5/2023**, establishes specific guidelines for the progressive introduction of SAF in the national aeronautical supply matrix.

In this scenario, **Brazilian Biocombustíveis Ltda.** presents a preliminary technical, environmental, economic and regulatory feasibility study of the **mixture of 5% of BBL DX biofuel with 95% QAV**, with a view to its approval as a viable, efficient and safe SAF route.

BBL DX is an advanced second-generation biofuel, developed from vegetable oils and superior alcohols, with a patented industrial process that **does not generate glycerin or solid waste**, with high chemical stability, very low pollutant emissions, and full compatibility with internal combustion engines — including aeronautical turbines.

Ente Nazionale per l'Aviazione Civile
Italian Civil Aviation Authority

SELECIONADA OFICIALMENTE PELA
ENAC ITALIA PARA TESTES DE COMBUSTÍVEIS 'SAF'

It is important to highlight that, after laboratory studies in the European Union, Brazilian Biocombustíveis Ltda, was formally authorized by **ENAC ITALIA** – National Civil Aviation Authority of Italy, to participate in the 9th technical table of the National SAF Observatory and, subsequently, to start tests with SAF within the scope of the European program "**A Roadmap for Sustainable Aviation Fuel** ", becoming one of the few Brazilian technologies with international technical validation in the aeronautical sector.

It is also worth mentioning that BBL DX **is miscible to QAV at room temperature, without the need for preheating or mechanical agitation (cold-blendable),** which reduces logistics costs, expands applicability at airports and eliminates additional infrastructure steps.

2. Objectives of the Preliminary Study

- Validate the **physicochemical and operational compatibility** of the mixture 5% BBL DX + 95% QAV;
- Evaluate **measurable environmental benefits** (SO_x, NO_x, CO_2, CO, opacity);
- Check the **oxidative stability, viscosity, flash point and cetane number of** the mixture;
- Identify the **technical requirements for approval as SAF** according to the standards:
  - **ASTM D7566** (SAF)
  - **ICAO-CORSIA**
  - **ANP / ANAC Regulation**
- Consolidate the **economic cost advantages of blending** based on the current market price of QAV and BBL DX.

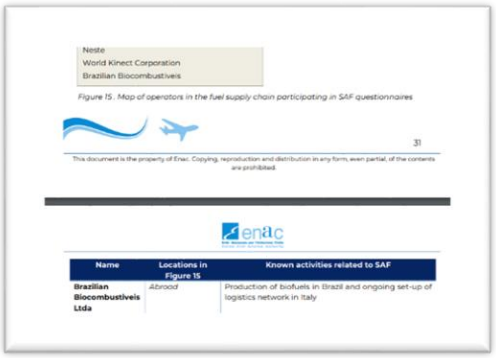
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Figure 15. Map of operators in the fuel supply chain participating in SAF questionnaires

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Name	Locations in Figure 15	Known activities related to SAF
Brazilian Biocombustíveis Ltda	Abroad	Production of biofuels in Brazil and ongoing set-up of logistics network in Italy

3. Technical Characteristics of the Mixture (estimate with BBL DX 5%)

Based on laboratory data for BBL DX 100%, the expected parameters for the 5% blend are:

Parameter	QAV (Jet A1 / ref. Diesel S10)	BBL DX (100%)	Blend 5% BBL DX + 95% QAV
Oxidation stability	~6 h	11.9 h	**>6.3 h** (slight improvement)
SO_x Emission (ppm)	~944 ppm	13 ppm	**~896 ppm** (with synergy)
NO_x Emission (ppm)	~780 ppm	32 ppm	**~740 ppm**
CO_2 emission (%)	2,6%	0,7%	**~2.47%**
Opacity (m^{-1})	~2.5 m^{-1}	0.12 m^{-1}	**~2.4 m^{-1}**
Viscosity at 40 °C (mm^2/s)	1,2–1,4	3,8	**~1.3 mm^2/s** (within standard)
Pour Point (°C)	-47 °C (Jet A1)	-27 °C	**~ -46 °C** (no relevant impact)
Cetane number	~45–47	41,6	**~46.8** (negligible reduction)
Lower calorific value	~43,100 kJ/kg (10,178 kcal/kg)	35,600 kJ/kg (8,520 kcal/kg)	**~42,700 kJ/kg** (<1% reduction)
Cold-blendable	No	Yes	**Yes**

Technical interpretation – Effects of mixing on the new parameters:

Cetane Number (~46.8)

- The cetane number influences the **ease of ignition** in compression combustion engines (such as turbines).
- The slight reduction of ~0.2 to 0.3 points is **operationally irrelevant**, keeping the blend **fully within ASTM D1655/D7566 specifications** for Jet A1.

Lower Calorific Value (~42,700 kJ/kg)

- With 5% BBL DX, the PCI loss is **less than 1%.**
- This **does not compromise the energy performance of the aircraft** and can be offset by environmental gains and fuel cost reduction.

Complementary Technical Summary:

The addition of 5% BBL DX to QAV **does not compromise any of the critical safety or performance parameters of** the mix, maintaining:

- Viscosity, cetane number and PCI within operating tolerances;
- Reducing pollutants;
- And with **the potential for savings per liter of fuel.**

4. Economic Analysis: Reduction of Final Fuel Cost with BBL DX (5%)

In addition to its environmental and operational benefits, the introduction of BBL DX in the blend with QAV presents a **direct and measurable economic advantage**: the **reduction of the final cost per liter of jet fuel**, unlike many SAFs currently on the market, which raise the cost of conventional QAV.

Price Reference: QAV in Brazil – 2025

According to a survey of average prices to the final consumer in Brazil, the **resale value of QAV varies between R$ 3.78 and R$ 6.34 per liter**, according to market data consulted with distributors and approved service stations.

Estimated price of BBL DX (FOB mill): R$ 3.45/L

BBL **DX** is a domestically produced fuel, with efficient production cost and simplified logistics, with a lower price **than QAV in any current market scenario**.

📊 Simulação do Preço Médio da Mistura: 95% QAV + 5% BBL DX

Cenário A: QAV a R$ 6,34/L

$$\text{Blend 5\% BBL} = (0{,}95 \times 6{,}34) + (0{,}05 \times 3{,}45) = 6{,}023 + 0{,}1725 = \mathbf{R\$\ 6{,}1955/L}$$

→ Economia: R$ 6,34 - R$ 6,1955 = R$ 0,1445/L

Cenário B: QAV a R$ 5,00/L (valor médio nacional)

$$\text{Blend 5\% BBL} = (0{,}95 \times 5{,}00) + (0{,}05 \times 3{,}45) = 4{,}75 + 0{,}1725 = \mathbf{R\$\ 4{,}9225/L}$$

→ Economia: R$ 5,00 - R$ 4,9225 = R$ 0,0775/L

Cenário C: QAV a R$ 3,78/L (valor mínimo registrado)

$$\text{Blend 5\% BBL} = (0{,}95 \times 3{,}78) + (0{,}05 \times 3{,}45) = 3{,}591 + 0{,}1725 = \mathbf{R\$\ 3{,}7635/L}$$

→ Economia: R$ 3,78 - R$ 3,7635 = R$ 0,0165/L

Real Economic Impact by Operation

For an aircraft with a consumption of 20,000 liters per flight:

- **Scenario A (R$ 6.34/L):** Savings per flight: 20,000 × R$ 0.1445 = **R$ 2,890.00**
- **Scenario B (R$ 5.00/L):** Savings per flight: 20,000 × R$ 0.0775 = **R$ 1,550.00**
- **Scenario C (R$ 3.78/L):** Savings per flight: 20,000 × R$ 0.0165 = **R$ 330.00**

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Economic Analysis Summary

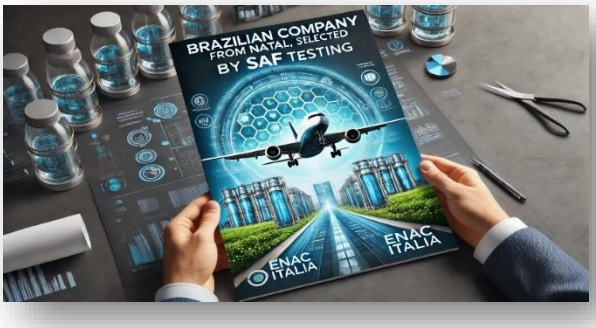
The introduction of BBL DX at 5% in the blend with QAV **reduces the average cost of the final fuel**, **the addition of 5% BBL DX results in immediate savings per liter**, maintaining operational stability and gaining in sustainability. In medium and high QAV price scenarios, the BBL DX blend offers **relevant cost reductions**, with the potential for significant financial impact per flight and per fleet — without compromising energy performance.

In addition to being environmentally advantageous, **BBL DX** presents itself as **an economically viable and financially attractive SAF solution for the Brazilian market**.

5. Economic and Strategic Conclusion

The addition of 5% BBL DX promotes:

- **Direct reduction of the cost per liter**, giving a more competitive price to fuel blends;
- **Expressive total savings in air operations**, given the volumetric scale;
- **Greater adhesion of the air market** to SAF, favored by cheaper sustainable fuels than traditional fossil QAV.



With the support of technical-operational benefits, environmental benefits already highlighted and now proven economic advantage, **BBL DX consolidates itself as an attractive and viable option to accelerate the adoption of SAF in Brazil**.

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