Technical Study Summary

Problems of Traditional Biodiesel and Limitations to Increasing Blending in Fossil Diesel

Introduction

Traditional biodiesel, obtained mainly by the process of transesterification of vegetable oils (such as soybean, palm, castor bean) or animal fats, has been one of the most used alternatives in the partial replacement of fossil diesel in several energy matrices, especially in Brazil and the European Union. However, the increase in the proportions of biodiesel in the blends (above B12 or B14, for example) encounters **technical, operational and environmental barriers**, widely documented in the scientific literature and in technical reports from the ANP, ASTM and the European Union.

Main problems of traditional biodiesel

1 . Low oxidation stability

- Biodiesel contains a high content of oxygenated compounds and unsaturated fatty acids.
- Oxidation stability **typically ranges between 3 and 6 hours** (ASTM D6751 / EN 14214), which results in the formation of peroxides, acids, and sediments during storage.

2 . Low thermal and hydrolytic stability

- Biodiesel is hygroscopic (attracts water) and **susceptible to hydrolysis**.

- The presence of water **accelerates degradation processes** and contributes to the formation of free acids and corrosive compounds.

3 . Microbiological growth

- The humid environment of biodiesel favors **the proliferation of bacteria**, fungi and yeasts.
- This results in **the formation of biofilm** in tanks, fuel lines and injection systems, generating operational failures and higher maintenance costs.

4 . Low storage time

- Conventional biodiesel has a **reduced useful life**, usually between **3 and 6 months**, compared to more than 12 months for fossil diesel.
- In tropical and humid climates (such as Brazil), the time frame can be even shorter due to **rapid oxidation and microbial contamination.**

5 Increased formation of deposits and residues

- The combustion of biodiesel in a high proportion can **generate carbonaceous deposits** in the injection system and in the combustion chambers.
- **Clogging of filters and injector nozzles** due to the formation of sludge, in addition to performance problems and greater need for maintenance in the engines
- This translates into lost efficiency, **increased fuel consumption,** and higher particulate matter emissions.

6 . Impact on materials and components

- Biodiesel, in high concentration, is **incompatible** with certain **elastomers, plastics, and metals** commonly used in older engines and fuel systems.

- It can cause swelling, softening, or premature failure in seals and hoses.

7 . Logistical difficulties

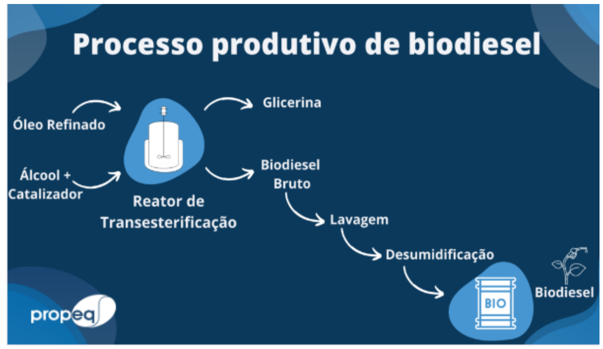
- Greater need for **special care in transport** and storage: dedicated tanks, addition of antioxidants, constant monitoring of free water and sediments.
- This raises the **cost of logistics infrastructure** and limits application in regions with less technical support.

8. Environmental impact

- The increase in biodiesel can lead to an **increase in emissions** of polluting gases, **especially CO2**

9. Costs

- Although biodiesel is considered a renewable fuel, its **production can be more expensive than fossil diesel**, which can impact the final cost of the fuel.



Practical limitations to increasing the biodiesel content in the blends

Due to the problems described, the **maximum large-scale blending** adopted in many countries is limited to:

- **B14 in Brazil** (with recent discussions for controlled increase to B15);
- **B7 in the European Union (EN 590)** for heavy vehicles;
- **B2, B5, B20 in the USA (ASTM D975)** as standard blend.

Attempts to lift above these limits (e.g., B15 or B20) are only feasible with adapted engines, systems, and logistics, and with appropriate additives — which is not always economically or technically possible.

Second Part of the Study

Brazilian Biocombustiveis' (BBL DX) Technological Breakthrough in Blending with Traditional Biodiesel and Fossil Diesel

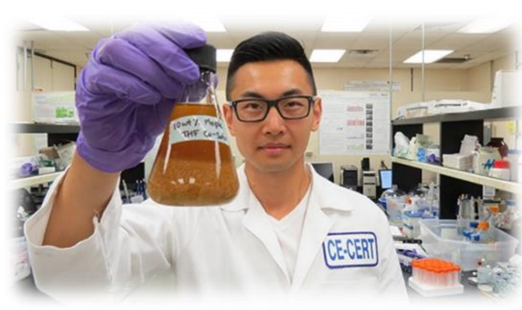
Introduction

The progress of decarbonization and sustainability goals in the fuel sector comes up against the limitations of traditional biodiesel, and the percentage of blending with fossil-based diesel, as presented in the first part of this study. Given this scenario, **BBL DX** emerges as an innovative solution, demonstrating perfect miscibility not only with fossil diesel (S500, S10), but also with traditional biodiesel (e.g., B100 soybean). Practical studies have proven that blends **of 50% BBL DX + 50% traditional biodiesel** (or other percentage blend) are stable, compatible with conventional diesel engines and free from the operational problems commonly associated with high proportions of pure biodiesel.

BBL DX's Potential Technological Breakthroughs in Blending with Traditional Biodiesel

1 Improved oxidative stability

- BBL **DX** has superior oxidation stability (>11.9 h in standardized tests), while traditional biodiesel reaches values of 3 to 6 h.
- The addition of 50% **BBL DX** can raise the stability of the blend to levels suitable for international standards (EN 14214, ASTM D6751), reducing the need for antioxidants.



2 Reduction of microbiological risk

- BBL **DX** has lower hygroscopicity and less tendency to form an environment conducive to microbial growth, mainly due to the presence of alcohol in its formulation.
- In the **50% BBL + 50% biodiesel** blend, the risk of biofilm formation and bacterial and fungal growth is significantly reduced, reducing biocide and maintenance costs.

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3 . Increased storage time

- **BBL DX,** due to its greater chemical stability and the complete elimination of the harmful effects of glycerin**, allows for longer storage time.**
- Blending with traditional biodiesel at 50% can **extend the shelf life of the final fuel** from 3–6 months (pure biodiesel) to **up to 12/18 months**, depending on storage conditions.

BLL DX 100 - Status dos bicos injetores do gerador Vonder GDV 5500, após 2000 horas de operação

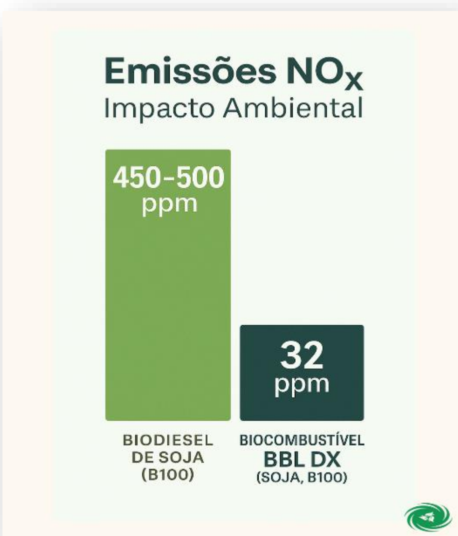
4 . Reduction of deposit formation

- BBL DX has better combustion behavior and eliminates the formation of carbonaceous residues.
- 50% BBL blends **reduce the risk of injector clogging** and deposits in the combustion chamber.

5 . Compatibility with materials and systems

- Studies show that **BBL DX** in 50% with biodiesel **does not present additional deleterious effects** on elastomers, plastics and metals, making it feasible to use it in non-modified systems.

6. Environmental Impact



- Studies show that **BBL DX** by 50% with biodiesel, would significantly reduce (more than 30%) **the emissions** of polluting gases, **especially CO2, NOX, SOX and Sulfur Content.**

7. Costs

- The BBL DX and Biodiesel blend would lead to a **reduction in the final cost** of the product, between **10% and 20%,**

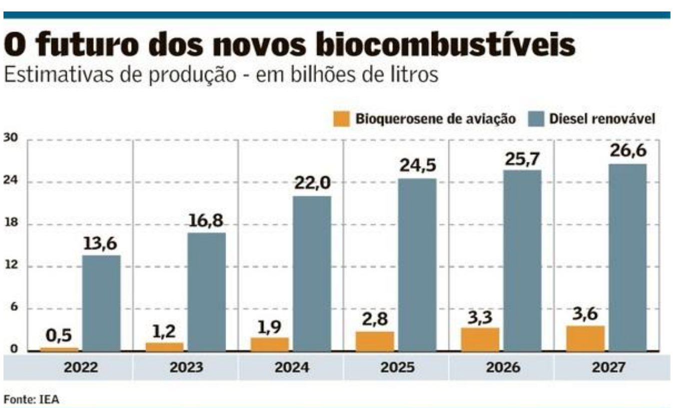
Potential for increasing biofuel content in the mixture with fossil diesel

The combination of **biodiesel + BBL DX** can allow a safer increase in the biofuel content in the final blend with fossil diesel, overcoming current limitations:

CURRENT MIX	PROBLEMS	POTENTIAL WITH BIODIESEL + BBL DX
B14 (BRAZIL TODAY)	**Deposits, oxidation, biofilm**	**B25–B30 blends possible without additional risk**
B7–B10 (EU)	**Stability and materials**	**Most viable B15–B20 blends**
B2,B5, B20 **(USA)**	**Compatibility and oxidation**	**B30 blends with increased stability**

- In B20 blends composed of 50% biodiesel and 50% BBL DX, stability and operational safety parameters are significantly improved, allowing use in fleets and critical applications with lower technical risk.

Overall Study Conclusion



BBL DX, when blended with traditional biodiesel, represents a real technological breakthrough that can:

- **Extend the life of the fuel;**
- **Improve microbiological stability and safety;**
- **Reduce costs with additives and maintenance;**
- **Enable the increase of biofuel content in fossil diesel, aligning with decarbonization goals and ESG requirements, without compromising engine components.**

Traditional biodiesel represents an important initial step in the energy transition, but its technical and logistical limitations prevent the safe elevation of the blend in conventional engines and infrastructures. BBL **DX,** by proving to be miscible and functional in high proportions with both biodiesel and fossil diesel, emerges as a new generation technological solution. Its use in hybrid blends solves most of the challenges of pure biodiesel, such as stability, storage and operational compatibility, in addition to significantly reducing sulfur content and pollutant emissions.

In this way, BBL DX contributes not only as an advanced biofuel, but as **an enabling agent for the increase of biofuel content in the national and international energy matrix**, promoting real and effective sustainability.

The continuity of this study may deepen the economic, operational and regulatory impacts of these mixtures and their applications in the different sectors (road, maritime and aeronautics).

Technical References

1. ASTM D6751 (U.S. Biodiesel Standard)
2. EN 14214 (European Biodiesel Standard)
3. ANP Reports (e.g., Technical Report ANP/PRH-ANP 36)
4. Articles reviewed: *"Biodiesel Stability: A Review"* (Knothe, 2007); *"Microbial contamination of biodiesel and its blends"* (Hillion et al., 2016)