The Influence of HVO Addition in Diesel on Lubricant Performance: A Case Study

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ABSTRACT

In the context of climate change and the ongoing energy transition, the utilization of biofuels in the transportation sector has become increasingly prominent. Among these biofuels, Hydrotreated Vegetable Oil (HVO) stands out as a particularly promising option due to its chemical similarity to traditional diesel, in contrast to biodiesel, which presents greater challenges for lubricating oil performance. Therefore, this study aims to investigate the effects of adding HVO into Diesel B14 on the performance of lubricating oils designed for diesel engines. In this regard, a field test was conducted on trucks at the Galeão airport in Rio de Janeiro, comparing the performance of lubricating oils in vehicles fueled with Diesel S10 B14 and Diesel S10 B14 with 10% of HVO. Initial results indicated that the addition of 10% of HVO had no negative impact on lubricant performance, making it possible to maintain the standard drain interval for its performance. Next steps will include evaluating the possibility to work with extended drain interval beyond the impact of the combination of HVO and premium lubricants.

RESUMO

Com o cenário das mudanças climáticas e a transição energética em foco, uso de biocombustíveis no setor de transporte ganha destaque. Entre estes biocombustíveis, o HVO (*Hydrotreated Vegetable Oil*) se destaca como uma alternativa promissora devido à sua semelhança química com o diesel tradicional, diferentemente do biodiesel que traz uma maior severidade no desempenho do óleo lubrificante. Nesse sentido, este estudo se propõe a investigar o impacto da adição de HVO ao Diesel B14 na performance dos óleos lubrificantes para motores diesel. Uma análise de campo foi conduzida em caminhões no parque aeroportuário do Galeão, no Rio de Janeiro, comparando o desempenho dos óleos lubrificantes em veículos abastecidos com diesel S10 B14 e diesel S10 B14 com a adição de 10% de HVO. Os resultados da primeira fase indicaram que a inclusão de 10% de HVO não teve efeito negativo no desempenho do lubrificante, sendo possível manter o intervalo de troca padrão quanto sua performance. Próximas etapas incluirão a avaliação da viabilidade de estender o intervalo de troca além do impacto da combinação do uso de HVO e lubrificantes premium.

INTRODUCTION

The effects of human activity on the planet, through burning of fossil fuels (coal, oil, gas) are the principal villains on the changes in our climate – characterized by diverse weather patterns and temperatures drastically shifting in the long-term. According to the National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce, with information from the Science & Information For a Climate-Smart Nation, Earth's temperature has risen in average by 0.06 ºC per decade since 1850, and three times as fast since 1982: 0.20ºC per decade. [1]

One of the main contributors to the effects of climate change are greenhouse gas emissions. These gases are meant to entrap heat and make the planet warmer, which is responsible in creating a hospitable environment for life on Earth. However, the intensification of industrial production since the 19th century has exceedingly contributed to these gases emissions, making the planet even warmer than it should and contributing to climate change, as seen by the rising global temperature below on Figure 1.

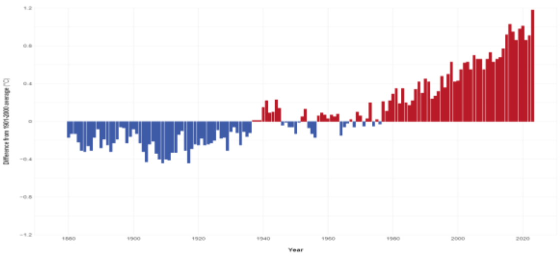


Figure 1. Global Average Surface Temperature.

According to the United States Environmental Protection Agency (EPA), transportation is the economic sector that most contributes to greenhouse gas emissions (28%) [2], by burning fossil fuels for cars, trucks, ships, trains, and planes. Thus, innovations in the automotive industry are paramount for reducing emissions without prejudicing an important economic sector, as well as combating the effects of climate change.

One of these important solutions is the Hydrotreated Vegetable Oil (HVO). An alternative to fossil fuels, the biobased diesel fuel has advantages over ester-type biodiesel fuels and can be regarded as renewable and sustainable, an ally for energy transition from fossil fuels.

In this study, the aim is to investigate the effects of adding HVO into Diesel B14 on the performance of lubricating oils designed for diesel engines. In this regard, a field test was conducted on trucks at the Galeão airport in Rio de Janeiro, comparing the performance of lubricating oils in vehicles fueled with Diesel S10 B14 and Diesel S10 B14 with 10% of HVO. Initial results indicated that the addition of 10% of HVO had no negative impact on lubricant performance, making it possible to maintain the standard drain interval for its performance. Next steps will include evaluating the possibility to work with extended drain interval beyond the impact of the combination of HVO and premium lubricants.

GREEN DIESEL: HVO PRODUCTION, PROPERTIES AND APPLICATIONS

Green Diesel is a biofuel for diesel engines produced from renewable raw materials. It consists of hydrocarbons produced from renewable sources, with chemical properties similar to conventional diesel. In 2019, global biofuel production included 114 billion liters of Ethanol, 47 billion liters of Biodiesel and 6.5 billion liters of Green Diesel. Green Diesel represented only 12% of the total biofuels for diesel engines.

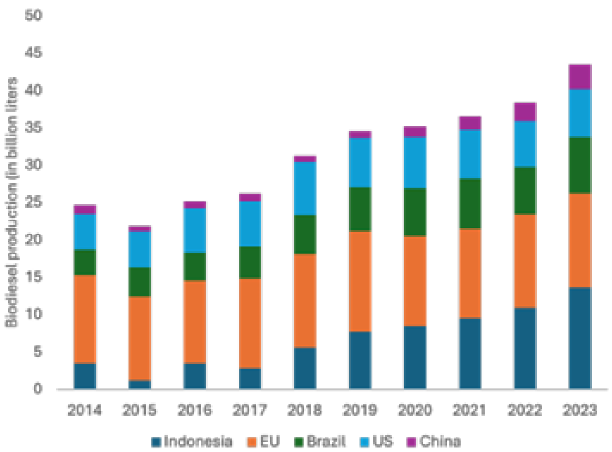


Figure 2. Top 5 global biodiesel producers 2014-2023. [3]

According to data from the 2024 Global Bioenergy Statistics Report [3], the US led HVO production in 2023, with a production of 11 billion liters, almost double the production of the previous year. In second place is the European Union with a production of 4 billion liters, followed by China, which increased its annual production in 2023 to 1.4 billion liters. Brazil is among the top five global producers of this biofuel, completing the list with Indonesia. Observing Figure 2 below, it can be seen that global HVO production went from just under 25 billion liters in 2014 to approximately 45 billion liters in 2023, practically doubling in the period and reinforcing the evolution of biofuels for diesel-powered vehicles.

Looking at Figure 3 below, HVO production in 2014 was predominantly European, and did not reach 4 billion liters when added to American production. Over the subsequent years, however, American production has evolved significantly, and China has intensified investments in HVO production, especially since 2021. [3]

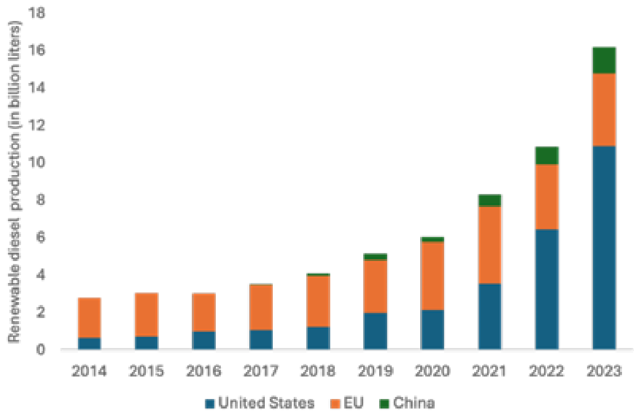


Figure 3. HVO production in the USA, European Union and China (2014-2023). [3]

According to the International Energy Agency's (IEA) Renewables Report 2024 [4], other initiatives around the world are being encouraged, such as in the case of Malaysia, which supports the refining of HVO and sustainable aviation fuel (SAF). The report also highlights, with an analysis and forecasts for 2030, that the USA, Europe, Brazil, Indonesia and India concentrate the main destinations for biofuel consumption, which together represent 85% of demand.

In addition, the report predicts that demand will intensify in the coming years in sectors other than road transport, especially for aviation and for the maritime sector. However, according to the report, the scenarios and estimates for intensification of biofuel use for the coming years still do not meet the zero emissions targets by 2050 by 1.6 to 14 times, between the road, aviation and maritime sectors. Thus, significant efforts and investments are needed to develop the biofuels sector to decarbonize key mobility operations in order to achieve net-zero emissions targets for 2050. In the case of Brazil alone, the IEA report predicts that 51 billion liters of biofuels will be needed, representing the largest increase for all the countries studied

– largely due to the consumption of ethanol, biodiesel, and the extensive fleet of flex-fuel vehicles in Brazil.

In this scenario of growing demand for biofuels, the production of biodiesel and green diesel will become increasingly important in the coming years, in Brazil and worldwide. Regarding their production processes, the main differences between Biodiesel and Green Diesel are that Biodiesel is composed of alkyl esters of long-chain fatty acids, derived from vegetable oils or animal fats. Green Diesel is produced from renewable raw materials, but also requires fossil inputs, such as hydrogen gas from natural gas. The use of Green Diesel can increase fuel consumption compared to high fossil diesel blends.

In Brazil, biofuels are basically ethanol and biodiesel, based on sugarcane and soy; biodiesel is obtained from animal fats and oilseed plants through alkaline esterification, cracking and esterification. There is an alternative route through green diesel, produced from vegetable such as sugarcane, alcohol and biomass. Biodiesel can be used as drop-in fuel to be mixed with conventional diesel and is a renewable fuel produced from renewable biomass. [5]

According to data from the Brazilian Association of the Vegetable Oil Industry (ABIOVE), the Association of Biofuel Producers of Brazil (APROBIO) and the Brazilian Union of Biodiesel and Biokerosene (UbraBio) [6], in 2019, the global production of Green Diesel reached 6.5 billion liters, representing 12% of biofuel for the diesel cycle. In 2021, conventional biodiesel reached 6.2 billion liters, while Green Diesel reached 3.0 billion liters. [7] The growth of Green Diesel is higher than that of traditional biodiesel. Biodiesel and green diesel are not only different in process, but also in product; therefore, Green Diesel is a promising alternative to reduce dependence on fossil fuels and mitigate environmental impacts.

Brazil is a country with a long history of producing biofuels from renewable sources – one of the main agricultural activities, sugar production, has been in the country since the 16th century. With the ever-growing challenge of energy transition and climate change, the need for alternative and renewable sources for fuel production becomes even more evident. Dependence on non-renewable sources such as petroleum compromises both the objectives of sustainable development and diminishing the emission of greenhouse gas emissions to halt climate change.

According to Milanez et al. (2022), the transportation sector in Brazil accounts for 30% of the total energy usage in the country, in which diesel responds to 40% of the sector's consumption. The authors highlight how the transition to renewable fuels in the sector has the potential to substantially reduce emissions and solidify the commitment to a sustainable development model. [7]

Milanez et al. (2022) highlight the important factor of the drop-in characteristic of HVO fuel, because of the proximity in physicochemical properties with fossil diesel; HVO can even be used 100% without affecting the performance of diesel engines. World biodiesel production has grown from 410 barrels per day in 2012 to 847 barrels per day, a 106,58% increase. In Brazil, production of biodiesel has gone from 40 barrels per day to 93 barrels per day in 2012-2022, a 132,5% increase in 10 years[1].

Aatola et al. (2008) [8] list out some of the main properties and advantages of HVO in comparison to ester-type biodiesel fuels, such as reduced emissions, effects on the engine, storability problems or poor cold properties. For the authors, the HVO shows potential and "could be used in optimized low emission diesel power trains in captive fleet applications like city buses, indoor fork-lift trucks, or mine vehicles" (AATOLA et al., 2008, p. 1251).

As pointed out by No (2014) [9], one of the main impediments of utilizing HVO for diesel engines (compression engines or CIs) is the poor low-temperature properties. The author tests for different production methods for HVO, concluding that "HVO could play an important role in providing a sustainable source of transportation fuels during the coming decades" (NO, 2014, p. 88).

Dimitriadis et al. (2018) [10] conduct an experiment on Euro 5 diesel engine, using HVO fuel to assess emissions reduction in comparison to using conventional diesel fuel and find promising results: "The use of the HVO fuel enables appreciable reductions in soot, HC and CO emissions without any modification to the engine control" (DIMITRIADIS et al., 2018, p. 17).

Hartikka, Kuronen & Kiiski (2012) [11] provide an extensive compilation on 40 studies regarding the performance of HVO in diesel engines, concluding that it "can be used as a drop-in-fuel and that it has properties beneficial for the engine and the environment" (HARTIKKA, KURONEN & KIISKI, 2012). One of the performance indications highlighted are the good lubricity properties when treated with lubricity additives.

With a comprehensive study on emissions, engine performance and physicochemical properties of HVO, Szeto & Leung (2022) [12] briefly discuss how neat hydrocarbons such as HVO need friction modifiers because of poor lubricity properties. That is, discussing the performance of lubricant oils in diesel engines running on HVO is an important topic in the research agenda.

DIESEL VEHICLES AND LUBRICANTS MARKET, REVERSE LOGISTICS AND SUSTAINABILITY

Lubricants are an essential product for the automotive industry, responsible for reducing wear, corrosion, oxidation, contributing to preserving engine integrity and to guarantee automobile functionality. According to data from

[1] Data from the 2023 Statistical Review of World Energy. Available at: https://www.energyinst.org/__data/assets/pdf_file/0004/1055542/EI_Stat_Review_PDF_single_3.pdf.

Brazil's National Petroleum Agency, in the Dynamic Pannel of the Lubricants Market [13], 1.265,68 m³ of lubricants were produced for sales in Brazil in 2024, of which 24,99% (321,35 m³) lubricants for diesel engines, making it the second-largest lubricant market in Brazil, only after internal combustion engines lubricants (33,8%).

In Brazil, the diesel engines lubricants market is primarily concentrated in the Southeast region, with the states of RJ (115,995 m³), SP (93,902 m³) and MG (31,775) as the largest manufacturers in the country, followed by PR (20,868 m³). In the case of lubricant consumption, SP (62,273 m³), MG (37,810 m³) and PR (36,502 m³) are also the largest consumers in the country, followed by RS (22,021 m³) and SC (18,487 m³). In addition to being one of the largest markets in terms of consumption volume in the country, diesel engines lubricants are essential for Brazilian road transport.

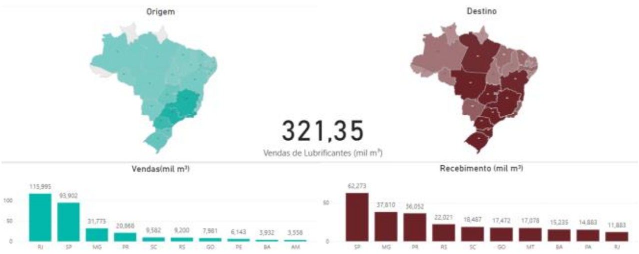


Figure 4. Brazilian diesel engines lubricants market, 2024. [13]

Finished lubricating oils are manufactured from a formula that combines base oils and additives. Depending on the base oil used, lubricants can be classified as mineral, semi-synthetic or synthetic. The first category, mineral, is the most traditional and common on the market, manufactured from petroleum refining. Synthetics are obtained through chemical reactions of components usually found in petroleum, and semi-synthetic lubricants are composed of a mixture of base oils. In general, 80 to 90% of the lubricant formulation is composed of base oils, complemented by additives.

Additives are added to the formulation for different reasons, depending on the specific application of the lubricant and its specific purpose. They can be viscosity improvers, which improve the oil's performance at different temperatures, for example; and additives that improve engine performance, such as dispersing agents, detergents and protective agents, which act to help the oil protect equipment against corrosion, friction and the accumulation of deposits that harm the vehicle's performance and the equipment's useful life. In the same line, the oil's viscosity depends on the specific application of the lubricant, and the most modern ones have multiviscosity characteristics – ensuring the best lubrication whether the equipment is in colder or hotter temperatures.

The Brazilian road transport system is the main transportation system in the country where these vehicles travel. According to data from the National Traffic Secretariat, Road Cargo Transportation is made up of a fleet of more than 3.5 million trucks that circulate on 1.7 million roads, with 75,000 of these roads being federal, and is responsible for approximately 75% of all goods circulated throughout the country [14]. Furthermore, according to research by the National Transport Confederation [15], approximately 95% of passenger transportation in Brazil is done by road. A service of essential importance for Brazilian economic activity, road transportation justifies the development of studies towards the sustainability of the operation, using more renewable matrices and encouraging the decarbonization of transportation.

According to data from the National Union of Automotive Components (Sindipeças) [16], the Brazilian truck fleet in 2023 is 2.18 million units, representing 4.6% of the total fleet in circulation in Brazil. Considering new vehicle registrations, since 2021 Brazil has had more than 100,000 new trucks registered per year, unlike the period 2015-2018 which represented numbers below 100,000, as observed in Figure 5 below. Diesel vehicles had the second highest number of new registrations in 2024, with 386,651 vehicles, behind only flex-fuel vehicles, with 1,967,275 vehicles. [17]

Unidades / *Units*

ANO *Year*	SEMILEVES *Semi-light*	LEVES *Light*	MÉDIOS *Medium*	SEMIPESADOS *Semi-heavy*	PESADOS *Heavy*	TOTAL *Total*
2002	6.898	19.627	9.907	15.276	13.972	65.680
2003	5.460	17.925	8.485	16.883	17.209	65.962
2004	5.943	20.245	8.647	22.308	24.341	81.484
2005	6.891	19.943	8.449	22.597	21.653	79.533
2006	7.451	19.385	9.538	20.189	19.408	75.971
2007	8.468	22.639	11.239	27.940	28.299	98.585
2008	8.863	25.441	11.888	37.434	38.661	122.287
2009	6.604	25.823	11.503	34.773	31.124	109.827
2010	7.325	34.466	14.038	49.985	51.893	157.707
2011	7.893	39.453	14.052	57.955	53.517	172.870
2012	6.551	33.346	11.849	45.877	41.551	139.174
2013	5.522	34.090	11.135	47.943	55.886	154.576
2014	3.967	28.725	11.699	44.883	47.781	137.055
2015	3.709	19.375	6.965	22.459	19.144	71.652
2016	3.514	13.161	4.221	14.186	15.478	50.560
2017	3.518	11.687	4.449	13.295	18.994	51.943
2018	4.122	11.554	7.677	17.414	35.238	76.005
2019	5.079	11.242	10.069	22.805	52.140	101.335
2020	4.859	9.049	8.357	23.120	44.293	89.678
2021	6.586	12.577	11.185	32.191	66.140	128.679
2022	7.553	10.811	10.423	32.852	65.004	126.643
2023	8.594	9.040	8.320	28.776	53.294	108.024
2024	7.298	10.237	9.712	34.810	62.876	124.933

Figure 5. Registration of new trucks by category. [17]

The Brazilian diesel engines lubricants market is highly concentrated, with five companies comprising over 80% of the market's volume in sales. The companies are well-established enterprises in Brazil for many years, with strong brand recognition, a vast distribution network and significant research and development investments. Given it is a production derived from the oil industry, many challenges for sustainable development are faced by the lubricants manufacturers: it is a highly toxic, low degradable material that can pollute large hydric bodies.

When lubricating oil deteriorates over time, it loses its lubricating properties and is considered toxic waste known as Lubricant Oil Used and Contaminated (LOUC), which must be disposed of correctly so as not to harm the environment. Resolution 362/2005 of the National Environment Council (CONAMA) establishes the system for collecting and disposing of LOUC and prohibits the disposal of LOUC in soil, water, sewage and wastewater. The National Solid Waste Policy (PNDR in Portuguese) establishes, by Law No. 12,305/2010, that members of the production chain (manufacturers, distributors, traders) must structure and implement reverse logistics systems for lubricating oils, waste and packaging. Through interministerial ordinances, between the Ministry of the Environment and Climate Change (MMA) and the Ministry of Mines and Energy (MME), the LOUC collection targets are established for subsequent years, and Ordinance No. 4 of December 2023 establishes the minimum collection percentages for the four-year period 2024-2027:

Ano	Regiões					Brasil
	Nordeste	Norte	Centro-Oeste	Sudeste	Sul	
2024	41,0%	41,2%	40,9%	52,8%	50,9%	48,3%
2025	42,0%	42,4%	41,8%	53,6%	51,8%	49,2%
2026	43,0%	43,5%	42,6%	54,3%	52,7%	50,1%
2027	44,0%	44,7%	43,5%	55,1%	53,6%	50,9%

Figure 6. Collection targets of the LOUC system in Brazil. [18]

Establishing goals for the reverse logistics system for LOUC is important not only to comply with the standards and regulations of the component environmental agencies. The correct functioning of the system prevents the incorrect disposal of toxic waste, which has a significant damaging capacity for water and soil; and irregular disposal is one of the main challenges of the current system, since LOUC can be used irregularly for burning, contributing greatly to air pollution.

The LOUC reverse logistics system ensures the collection and disposal of waste for re-refining. Specialized companies authorized by the competent authorities participate in the collection system and are responsible for receiving the waste and passing it through a process that removes all impurities contained in the LOUC, in addition to unwanted products, and at the end of the process, they return a re-refined oil in conditions equal to the first refining base oil, which can be reused in the production of new finished lubricating oils.

Reverse logistics offers several benefits to the system, as it generates greater efficiency in the management of solid waste, ensures the correct disposal of OLUC, which contributes to reducing the environmental impact of this waste, in addition to returning to the market a finished oil manufactured through the reuse of OLUC - which reduces dependence on first-refined oils, thus reducing the need to purchase base oil and dependence on petroleum, which is a finite resource. Furthermore, initial estimates indicate that the re-refining process has a smaller carbon footprint than the first-refining production, which offers a significant advantage in terms of sustainability and decarbonization of the sector.

In the State of São Paulo, Brazil, it is estimated that this process of reverse logistics has collected 152 million liters of used or contaminated oil and reforwarded it to re-refinery, avoiding 30 tons of CO2 EQ emissions in the atmosphere. The state currently has 8 re-refineries that make up this reverse logistics system.

METHODOLOGICAL PROCEDURES

In this case study, the aim is to investigate the effects of adding HVO into Diesel B14 on the performance of lubricating oils designed for diesel engines. In this regard, a field test was conducted on trucks at the Galeão airport in Rio de Janeiro, comparing the performance of lubricating oils in vehicles fueled with Diesel S10 B14 and Diesel S10 B14 with 10% of HVO.

After a review of the available truck fleet, six vehicles were selected for performance/performance sampling: three pairs of the same model and year. For each pair, one truck was filled with Diesel S10 B14 and the other was filled with Diesel S10 B14 with 10% HVO.

The oil collection procedure for performance sampling followed a collection schedule for a duration of 300 running hours of the truck fleet sample. With four oil collection, in each oil change of the 500 hours for each vehicle (0h, 250h, 400h and 500h).

Table 1. Truck Fleet for Performance Sampling, by Model/Year, Fuel and Lubricant for Sample.

Model/Year	Fuel	Lubricant
VW 10.160/2014	DIESEL S-10	API CI-4 15W40
VW 10.160/2014	S-10 + HVO	API CI-4 15W40
MB ATRON 1719/2013	DIESEL S-10	API CI-4 15W40
MB ATRON 1719/2013	S-10 + HVO	API CI-4 15W40
VW 10.160/2014	DIESEL S-10	API CI-4 15W40
VW 10.160/2014	S-10 + HVO	API CI-4 15W40

Source: own elaboration.

METHODOLOGY DESCRIPTION

In order to evaluate the effects of HVO on the performance of the oil, a thorough set of physical and chemical analyses was executed on the oil samples collected at the Galeão base, to compare performance between S-10 and HVO addition in the fuel. The tests comprehended are as follows, showed on Table 2.

Table 2. Used Oil Tests.

Test	Method
Kinematic Viscosity at 100 °C and 40 °C	ASTM D445
Viscosity index	ASTM D2270
Basic Number	ASTM D4739
Acid Number	ASTM D664
Metals (Fe, Cu, Pb, Al)	ASTM D6595

Source: own elaboration.

CASE STUDY

Through an initial alignment meeting with the operational team at the Vibra base at Galeão Airport in Rio de Janeiro, the foundations of an ESG project were established regarding the use, performance and performance of HVO and lubricants in the company's operational fleet at the air base. The initial meeting served to identify some important challenges regarding the concern with sustainability and the environmental impact of the operation. For example, difficulties related to the increase in the proportion of biodiesel in diesel (increase to 14%) and the challenges this poses for engine performance – in addition to concerns about the use of fossil fuel and its greater carbon footprint.

The alignment, therefore, forwarded a proposal to implement a project in the Galeão operational fleet, using a portion of HVO in diesel instead of fossil fuel. One of the motivations for this approach is the significant reduction in the carbon footprint of HVO in relation to traditional diesel, presenting itself as a more sustainable alternative also due to its plant-based base. Thus, the project would indicate, in addition to the portion of biodiesel according to the regulations, also adding HVO to the fuel of the trucks in the operational fleet.

The inspiration for monitoring the performance of lubricating oil, together with the addition of HVO, was justified by the need for standardized tests of lubricating oil performance with this fuel category, reinforcing previous results in engine protection and fuel economy, but also to monitor the challenges related to biodiesel. Regarding physical and chemical properties, HVO has a production process that is better aligned with fossil diesel than biodiesel, which is produced by transesterification and results in less compatibility with diesel. In addition, the project also aims at sustainability, by reinforcing the circular economy and the destination of used oil for the re-refining cycle.

The air base operations team provided a summary of the truck fleet – composed of Tanker Trucks (CTA), which are used to refuel aircraft of various sizes at the airport, and Hydrant Servers (SRV), which perform refueling through a piping system at the airfield.

The Galeão Air Base has several service demands, one of the main ones being the delivery of aviation kerosene to airlines (commercial and executive) at Antônio Carlos Jobim International Airport, in addition to also providing service to the FAB – Brazilian Air Force, through the Galeão Air Base. Among the operations' many commitments and objectives, the delivery of this fuel on time, quality and safety is one of the main ones.

The fleet is comprised of UAA's, short for Aircraft Fueling Units, is made up of CTA's (Aviation Refuellers in Portuguese) and SRV's (Hydrant Dispensers in Portuguese). Both have the purpose of refueling aircrafts, however their characteristics are different.

Figure 6. Representation of Aviation Refueller for commercial aircrafts.

CTA's (Aviation Refueller Trucks) are equipped with a fuel tank whose storage capacity can vary between 20 m³ or 35 m³, for example. A significant gain through these aircraft supply units is that the CTA has freedom and autonomy in meeting the aircraft regardless of its parking position, as well as agility in supplying aircrafts (more simplified procedures). However, a negative aspect is that the CTA has a height limitation for serving long-service aircrafts, given its physical limitation in the fuel tank. Depending on the supply volume requested by the airline, for example, the CTA may not be well-suited, and it would be necessary to come to the filling islands to fill the respective product.

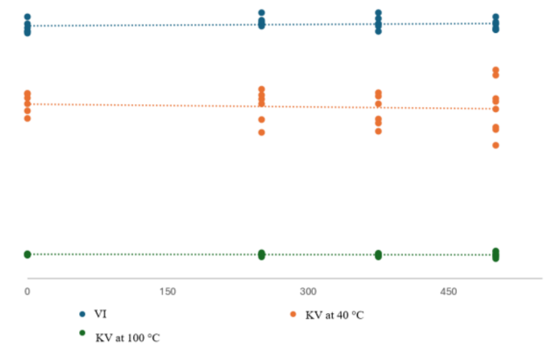
The SRV's (Hydrant Dispenser) do not have tanks and use hydrant pits from the entire hydrant network that is distributed throughout the aerodrome (aircraft patio). A significant gain through these aircraft supply units is that the SRV, as it does not have a fuel tank, has complete freedom in relation to the capacity to fuel an aircraft, given that through a hydrant pit, this truck uses all the hydrant network (underground) that is directly connected to the Base.

Through the 3 large fuel tanks available, which store approximately 33 million liters of aviation kerosene, the SRV attaches a hose to the hydrant pit (nozzle that is on the floor) called a secondary valve that "pulls" product directly from one of the 3 tanks from the Base. The SRV also attaches another hose to the aircraft, called the primary valve, and then starts refueling, without any physical restrictions that the CTA would have. Another advantage of this vehicle is that it has a lifting platform capable of providing service to any aircraft at any height. A negative aspect is that not every aerodrome has hydrant pits, therefore, the use of the SRV is unfeasible.

Despite circulating a great deal around the aerodrome, which is the largest in terms of dimensions and physical space in the country, both CTA and SRV consume plenty of their respective engines when stopped when refueling aircrafts. Both are equipped with mechanisms, accessories and sensors that depend on the engine to operate regularly.

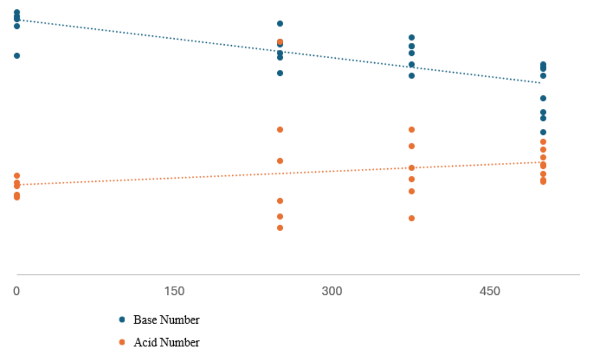
Initial results indicated that the addition of 10% of HVO had no negative impact on lubricant performance, making it possible to maintain the standard drain interval for its performance as shown on figures 7, 8 and 9.

Figure 7. Kinematic Viscosity at 40 °C (cSt), 100 °C (cSt) and Viscosity Index results.



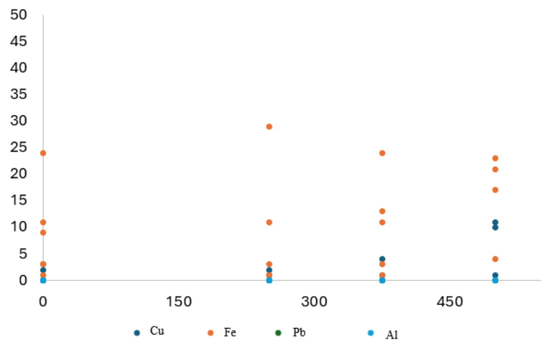
Source: own elaboration.

Figure 8. Basic and Acid Number results (mg KOH/g)



Source: own elaboration.

Figure 7. Metals Results (ppm)



Source: own elaboration.

The oxidation values of all samples remained within acceptable limits throughout the monitored drain intervals. There was no statistically significant difference between the control and the HVO group. Kinematic viscosity at 100 °C showed normal variation for both fuels, with no abnormal thickening or signs of thermal degradation. These findings are consistent with the literature, which indicates that HVO, due to its paraffinic and low-aromatic composition, has low reactivity and combustion residue generation.

TBN depletion trends were comparable between both fuel types. This suggests that the introduction of HVO did not alter the acid-generating dynamics in the combustion process in a way that would challenge the lubricant's detergent system. TBN retention supports the hypothesis that the HVO blend does not accelerate lubricant aging under the tested duty cycles.

No statistically significant differences were observed in the concentrations of wear metals between the two fuel types. All values remained within expected operational ranges for the engine models under the observed duty cycles. This result reinforces that the use of HVO at 10% concentration does not promote abnormal wear or accelerate component degradation.

Based on the stability of the lubricant properties observed throughout the monitored period—regardless of the fuel used—there is a technical basis to investigate the extension of the oil drain interval. Although the current test used an API CI-4 lubricant, preliminary internal assessments indicate that the use of a premium API CK-4 lubricant, specifically designed for EURO VI diesel engines, may support a 50% to 100% increase in drain interval, depending on operating conditions and fuel quality as summarize on Table 3.

Table 3. Preliminary test with CK-4 Oil

Running Hours	Fuel	VI	Acid Number (ASTM D664)	Base Number (ASTM D4739)	Kinematic Viscosity at 100°C (ASTM D445)
0	Diesel S10	124	178,0	6,0	13.8
124	Diesel S10	139	2.6	7.4	13,9
178	Diesel S10	139	2.7	7,0	13.9
6	Diesel S10	139	2,8	6,8	14,0
794	**Diesel S10**	**139**	**2.5**	**7.4**	**14,0**
391	Diesel S10 + 10%HVO	142	2,8	7,2	15,0
125	Diesel S10 + 10%HVO	142	2,8	7,5	14,5
0	Diesel S10 + 10%HVO	138	2,9	7,0	14,3
1053	**Diesel S10 + 10%HVO**	**141**	**2,8**	**7,5**	**14,2**
245	Diesel S10 + 10%HVO	140	2,7	7,5	14,3
125	Diesel S10 + 10%HVO	140	2,7	7,5	14,1
621	Diesel S10 + 10%HVO	143	2,5	7,5	13,2
423	Diesel S10 + 10%HVO	146	2,5	6,7	13,1
270	Diesel S10 + 10%HVO	138	2,5	7,3	13,6
0	Diesel S10 + 10%HVO	140	2,7	7,5	14,1

Despite the challenges of implementing the initiative, which involved everything from supplying the necessary material for sampling; the availability of equipment for preparing the project; the displacement of personnel involved in the implementation – whether operational, technical development, laboratory and maintenance – which required considerable effort for this action. In addition, a new strategy that involves the use of renewable resources in a sustainability proposal, which also presupposes certain challenges in technical requirements and availability of products for the viability of the project. Galeão airport is one of the largest in the country, involves international trade routes, and has a considerable operation, which does not make it easy to develop a new initiative based on the use of renewable resources and environmental responsibility.

FINAL REMARKS

The present paper covered a case study of adding Hydrotreated Vegetable Oil as a drop-in fuel into diesel fuel, against pure diesel fuel, in lubricant performance. The test was performed using refueller and dispenser trucks utilized in the Galeão Airport, in Rio de Janeiro, vehicles that run on diesel fuel.

A significant array of studies highlights the viability of biofuels as a renewable alternative for traditional fossil fuels, such as diesel. However, some of these fuels, i.e. biodiesel, do not hold similar properties to the traditional choice, that can be prejudicial to lubricant oils. On the other hand, HVO fuel undergoes a hydrotreatment chemical process conceiving a product that contains physicochemical properties analogous to those of traditional diesel that do not affect lubricant performance. Also, HVO has a drop-in characteristic, making it possible to have a fuel mixture with a higher renewable source, less emissions and that does not affect lubricant performance.

Tests performed with 6 refueller and dispenser diesel engine trucks at the airport base did not find results to indicate that the comparative between S-10 diesel and the S-10 with 10% added HVO had a negative impact on lubricant performance.

The project proved to be viable, as no difficulties were identified related to its design, implementation, and monitoring. The fleet operation at the airfield, with the help of the base's operational team and the mechanical and maintenance personnel, functioned normally and was able to continue with the day-to-day refueling of commercial aircraft at Galeão.

The used oil could be collected and disposed of correctly, in accordance with current legislation and regulations and in accordance with the environmental responsibility that guides the initiative, and the use of S-10 diesel fuel with the addition of HVO functioned normally, without causing downtime or problems for the operation's equipment. The collected oil samples were sent for laboratory analysis, to examine the conditions of the oil and equipment. Initial estimates on decarbonization indicate that, in relation to the fuel used, the reduction in carbon footprint could be 10% to 20%, and in relation to the oil and operational optimization of the activity, in addition to responsibility in the disposal and management of waste, the reduction in carbon footprint could be in the order of up to 40%.

The next steps include a thorough assessment of the results related to the initiative, such as laboratory analyses and the equipment used, alignment with the base's operational and maintenance teams to develop the next stages of the project, and an assessment with the development team on the possibility of expanding the environmental responsibility initiative, which involves increasing the operational fleet using renewable resources and adding more HVO to the fuel that supplies trucks, achieving more significant results towards decarbonization.

The expansion of these environmental responsibility initiatives can be crucial to the energy transition and decarbonization goals of the Brazilian transportation sector. Economic activity depends immensely on the functioning of the country's road transport system, and concern about carbon emissions and the environmental impact of operations is extremely important for the future of commerce, industry and the well-being of the Brazilian population – with fair access to quality environmental resources and services, in line with a territory with such a rich diversity of biomes, water resources and species of fauna and flora.

For future endeavors, it will be considered studies to evaluate working with extended drain interval for the lubricants with different fuel mixtures and premium oils.

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