Energetic and economic impacts of energy efficiency measures in a fleet of long-haul vehicles

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Abstract: The objective of this dissertation is to quantify the energetic and economic impact of the application of energy efficiency measures in the automobile fleet of the company *Transportes Gama* to reduce its' energy consumption. It was carried out the energetic characterization of the fleet regarding the data of February 2020. Variables that influence the energy consumption were correlated to the drivers' years of experience and age. Three measures to reduce energy consumption were also analysed as well as the energetic and economic impact of the COVID-19 pandemic.

The first measure consists in renewing the fleet with Euro 6 vehicles, replacing 104 less efficient vehicles with ones that consume less fuel. This allows an 11% reduction in energy consumption and its' payback time is 15 years. The second measure consists in studying drivers' training and the potential of eco-driving and its' impact. This measure allows a reduction in energy consumption of 6.5% and its' payback time is 1 month. The third measure studies the economic impact of the introduction of vehicles with alternative fuel sources in the company (electric and fuel cell vehicles). The introduction of electric vehicles leads to 53% of fuel cost savings and to annual savings of € 18,499 per vehicle. The payback time of this measure is 2 years.

The COVID-19 pandemic let to a decrease in fuel consumption of 162,047 litres and had a negative economic impact of € 235,616 between the first semesters of 2019 and 2020.

Keywords: energetic characterization; energetic impact; economic impact; eco-driving; electric vehicles; fuel cell vehicles.

1. Introduction

Nowadays, there are several environmental concerns regarding the impact of fossil fuels and energy consumption. Thus, several measures have been taken to reduce the emission of pollutants and the use of fossil fuels [1] (which has been decreasing [2]) and increasing the use of renewable energies [1]. In 2017, the transport sector consumed 30.8% of the energy in Europe [2], making it the largest consumer in the energy sector. In Portugal, road transport corresponds to 85.9% of the freight transport [2], being one of the essential sectors for the country's economy. So, it is extremely important to act on this sector and try to reduce its energy impact and the costs associated with fossil fuels.

Since there is an urgent need to reduce the energy impact, as well as to reduce the emission of polluting gases in the freight transport sector, it is necessary to study measures to reduce them. One of the measures that reduces the energy impact of a fleet is the renewal of the fleet, since newer vehicles tend to have less energy impact than older vehicles, as well as less emission of polluting gases [3]. New strategies have been applied to engines, such as fuel cell systems, electric propulsion systems, hybrid vehicles or vehicles powered by liquefied natural gas (LNG). There is also a concern to make combustion engines more efficient, so that the release of pollutants is reduced and has less environmental impact. All the technologies mentioned above aim to reduce the energy and environmental impact of vehicles.

New strategies have emerged to reduce the energy impact of the fleet without spending money in fleet renovation. One of these strategies is eco-driving. Eco-driving aims to reduce fuel consumption and pollutant emissions. It is estimated that the fuel reduction can reach up to 18% when an eco-driving strategy is adopted [3] and the reduction in greenhouse gas emissions is between 5% and 15% [4].

The objective of this dissertation is to quantify the energetic and economic impact of the application of energy efficiency measures in the automobile fleet of the company *Transportes Gama* to reduce its' energetic consumption. In order to collect the data that supports this work, an internship was carried out at the company within the scope of the Galp21 project.

2. State of the Art

Alternative vehicle technologies powered by renewable energy sources, such as vehicles with electric propulsion, hybrid vehicles and fuel cells vehicles are already a reality for the long-haul

vehicles. To reduce fuel consumption there are also energetic measures that are efficient in reducing fuel consumption and the emission of greenhouse gases, such as eco-driving. Other measures can also be used to reduce the energetic impact such as route planning and optimization, vehicle maintenance and drivers' training [4].
Regarding the vehicle characteristics and the mechanical components, there is a large consumption of fuel associated with the vehicle's engine and aerodynamic design. To reduce fuel consumption, it is necessary to improve the efficiency of the engines and the transmission systems. It is also important to make the vehicle aerodynamically more efficient and to improve the resistance of the tires. Using lighter materials in the cabin and semi-trailer decreases the mass of the vehicle, which decreases the fuel consumption [5].
Hybrid vehicle technology engines are more efficient than diesel engines. When the vehicles travel at low speeds this technology can recover the energy used to brake the vehicle and store it in a battery. A hybrid long-haul vehicle has a reduction in fuel consumption of 20% to 22%, depending on the route [5].
A long-haul electric vehicle consumes three times less energy than a conventional diesel vehicle [6] and has less 53% of fuel costs [7]. An electric long-haul vehicle can reduce the emissions of pollutants by 70% [7] which makes electric vehicles a very promising alternative for the transport sector. However, electric vehicles have little autonomy and have to be recharged in the middle of the trips. Long-haul fuel cell vehicles have a reduction in fuel consumption between 18% and 34% [8] and a greenhouse gas emissions reduction in 45% [9]. Nowadays, adopting these new technologies can be expensive.
Fleet renewal with most recent Diesel vehicles can lead to a 12% decrease in CO_2 emissions [10]. It can also lead to fewer accidents when they are equipped with collision alarm systems [10] and other safety equipment. Euro 6 vehicles have a reduction in fuel consumption of around 3% compared with vehicles of previous standards [11]. With the improvement of technologies and vehicles, there has been a 27% decrease in fuel consumption between older vehicles in 1995 and recent vehicles in 2010 [12]. This reveals the importance of renewing the fleet with efficient vehicles. For the same period, the reduction in greenhouse gas emissions was 29% [12].
It is possible to affirm that renewing the fleet with Euro 6 vehicles is a good option to improve the emission of polluting gases, with the benefit of reducing the fleet's fuel consumption.
TCO is defined by Ellram (1995), as a purchasing tool and philosophy, which is aimed at understanding the true cost of buying a particular good or service from a particular supplier. Fuel cell vehicles are the latest vehicle technology. As so, they are the most expensive technology at the moment. Nowadays, a fuel cell vehicle is estimated to be approximately 40% more expensive than an electric vehicle and 90% more expensive than a conventional diesel vehicle [13]. However, it is estimated that this type of vehicle has the same costs per 100 km traveled as a conventional diesel vehicle in 2026 and an electric vehicle in 2027 [13]. Although fuel cell and electric vehicles may have higher costs today, they are more efficient [13], which is good for the fleet. TCO analysis of electric vehicles and fuel cell vehicles project that, for 2030, these vehicles are viable options and their costs are very close to internal combustion engine vehicles [14]. It is also expected that these vehicles will reduce by 30% their CO_2 emissions and the vehicles with combustion engines will become less appealing due to the high rates and taxes for high CO_2 emissions [14].

3. Methodology

3.1. – Case Study

For the development of this thesis, an internship was carried out at *Transportes Gama*, based in Lisbon and with physical centers in Seixal and Aveiro. The company has 76 years of activity and specializes in the freight transport. The fleet of the company has 186 vehicles. This company expresses great interest in energy efficiency, having currently operational lease of two vehicles powered by liquefied natural gas (LNG).
The company also implements strategies of eco-driving, drivers' training, and safety at work. The drivers have eco-driving lessons in real driving environment and their consumption is also monitored through platforms such as *Frotcom*. Monetary awards are also given to the drivers who perform the best.

3.2. – Fleet characterization

The data of the entire fleet was analyzed for the month of February 2020. In order to characterize the fleet, the following parameters were analyzed:
• **Energy consumption per vehicle**: liters of fuel consumed, distance travelled (km), average consumption in liters of fuel per 100 km travelled (l/100 km), average speed (km/h);
• **Type of vehicles in the fleet:** model, vehicle age (years), engine capacity (cm^3), maximum usable power (kW), gross vehicle weight (kg) and type of fuel used; and
• **Calculation of the cost (€) for each vehicle.**
Since it is not feasible to analyze every vehicle of the company, it was necessary to select vehicles that represented the company’s fleet. The five vehicle models that met the requirements were: models R 410, R 420 and 12 L from SCANIA; model TGX 18.480 from MAN and model Premium 450 DXI from Renault. All the vehicles mentioned above correspond to 68% of all the company's vehicles. Table 1 and Table 2 present the data for the five models.

Table 1 - Characterization of the sample.

Model	Qty. of vehicles	Age (years)	Average speed (km/h)	Average consumption (l/100km)	Standard deviation of average consumption
R 410	40	3.0	75.5	27.2	1.9
R 420	29	12.7	54.1	33.0	2.0
12 L	9	13.9	52.0	33.8	1.3
TGX 18.480	12	6.8	66.3	31.2	1.8
P. 450 DXI	35	12.4	51.7	34.3	2.4

Table 2 - Characterization of the sample (cont.).

Model	Distance travelled (km)	Total consumption of fuel (l)	% total consumption of fuel	€/km	€/vehicle
R 410	424,060	115,429	35.2%	0.40	4,196
R 420	99,511	32,579	9.9%	0.48	1,633
12 L	52,329	17,233	5.3%	0.48	2,784
TGX 18.480	78,539	24,326	7.4%	0.45	2,947
P. 450 DXI	104,745	35,861	11.0%	0.50	1,490

The vehicles in the sample considered account for 69% of the total fuel consumption of the company's vehicles and correspond to € 348,285 of the fuel costs.
The R 410 model is the vehicle that consumes the most liters of fuel, but also the one with the highest distance travelled, since it is the most used vehicle model in international freight service. On the other hand, the Premium 450 DXI model has the second highest total fuel consumption but does not have a significant monthly mileage. Thus, this vehicle is expected to be less efficient. The lowest cost per distance traveled (km) corresponds to the most efficient vehicle model: R 410. The least efficient model (Premium 450 DXI) has the highest cost per distance traveled. It should be noted that both the 12 L model and the R 420 model, both from SCANIA, have the same cost per kilometer. Both models have an average vehicle age higher than the Premium 450 DXI model, which indicates that the Premium 450 DXI is apparently less interesting from an economic and energetic point of view. The R 410 model has the highest cost per vehicle (€ 4,196 per vehicle), although the average fuel consumption is low when compared to the other models. The high cost per vehicle is not indicative of a less efficient vehicle, in this case. The data in Table 2 shows that the R 410 is the model that travels the most kilometers (55.9% of the kilometers traveled by all the vehicles), as well as the one with the highest number of vehicles allocated (22% vehicles of the company's fleet), which justifies the disparity between the values of cost per kilometer and cost per vehicle.

3.3. – Drivers characterization

It is important to correlate the drivers' characteristics and the characteristics of the vehicles, in order to study how fuel consumption may be affected and suggest measures, namely eco-driving strategies. The drivers characteristics that were studied were the age of each driver in the fleet, the years of experience of each driver and their gender. In total, the company had 171 drivers in February 2020, when the data was collected. Figure 1 and Figure 2 show the drivers characterization.

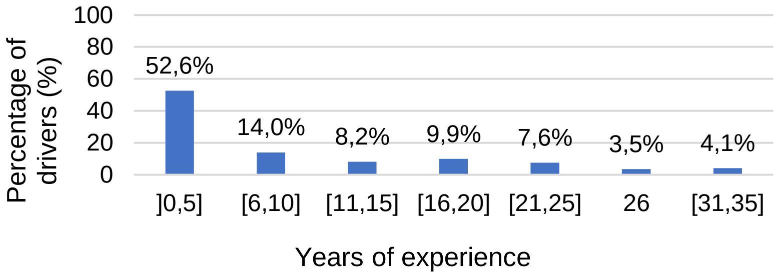

Figure 1 - Number of drivers versus their years of experience.

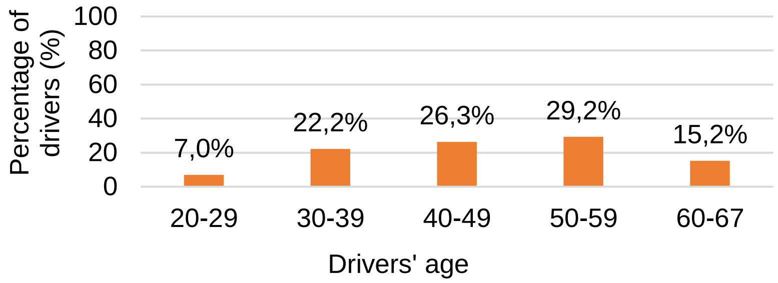

Figure 2 - Number of drivers versus their age.

After observing the figures, it is possible to conclude that the company is mainly constituted by drivers with little experience (52.6% of drivers have a maximum of 5 years of experience), the company is mainly made up of middle-aged drivers (55.5% of the drivers are between 40 and 59 years old). The company is also mainly made up of male drivers (98.8% of drivers) and only has 1.2% of female drivers.

3.4. – Fleet renewal

The first measure studied was the fleet renewal. The objective is to understand the economic and energetic impact of the acquisition of new vehicles similar to the old vehicles of the fleet. It was considered that 104 vehicles had to be replaced to keep the average age of the fleet below 10 years. This corresponds to a renewal of 56% of the total fleet.

For this analysis, it was used the data of the 10% of the company's most efficient vehicles to calculate the reduction in fuel consumption and the monthly savings in fuel costs compared to the current situation of the fleet. Then, the results of the 10% of the most efficient vehicles of the company were extrapolated to the remaining vehicles of the fleet in order to obtain the most efficient fleet possible. Using the total fuel consumption (l), it was calculated the energy difference between the initial situation of the fleet (with the old vehicles) and the situation of its renewal. Thereafter, the monthly fuel cost savings (€) were calculated using the following equation (1):

$$\mathrm{FCS} = \mathrm{PD} * (\mathrm{FC_i} - \mathrm{FC_f}) \tag{1}$$

Where:

FCS = monthly fuel cost savings (€);

PD = average price of diesel in February 2020 (€/l);

FC_i = Fuel consumption (l) of the initial situation of the fleet;

FC_f = Fuel consumption (l) of the most efficient situation of the fleet.

The project's payback time was also calculated. The monthly fuel cost savings (€) were used to estimate how long it takes to pay for the investment of the purchase of 104 new vehicles to renew the fleet.

3.5. – Eco-driving potential

To study the eco-driving potential, 10% of the company's most efficient drivers were analyzed. First, the data from the initial situation of the fleet was collected. Then, the average consumption per 100 km traveled (l/100 km) of the 10% of most efficient drivers was calculated. It was also calculated the total fuel consumption (l) and the distance travelled (km). The results were extrapolated to the entire fleet, so that all the company's vehicles had the most efficient drivers.
To compare the eco-driving potential with the initial fleet conditions it was calculated the difference in total fuel consumed (l) between the two situations. Finally, the monthly fuel cost savings were calculated using equation (1). However, to calculate the monthly savings of using eco-driving strategies, it was necessary to calculate the cost of the drivers' training. The training cost includes the trainer's annual salary, the costs of training sessions and the cost of the software used. Equation (2) was used to calculate the monthly cost savings in relation to the eco-driving potential:

$$\mathrm{CSEP} = \mathrm{FCS} - \mathrm{TC} \quad (2)$$

Where:
CSEP = monthly cost savings of using eco-driving measures (€);
FCS = monthly fuel cost savings (€);
TC = Training costs (€).

Finally, payback time was calculated to determine how much time was needed for the cost savings to be greater than the training costs.
A second analysis was made regarding the eco-driving potential, to determine whether driver training is beneficial in the short and long term. For the analysis of the benefits of eco-driving in short term, three drivers were analyzed to understand the effects of training on their performance. It was collected the data 15 days before and after the day of the training. To analyze the benefits of long-term eco-driving, it was analyzed if there was improvement one month after the training sessions of two drivers. These drivers were chosen randomly and entered in the company at the time of this report.

3.6. – Adoption of vehicles with alternative fuel sources

To study the economic and energetic impact of different vehicle technologies, a Total Cost of Ownership (TCO) analysis was carried out in order to compare the different technologies with conventional vehicles. This analysis included the following vehicles:

- Conventional diesel vehicle (VC);
- The company's most efficient conventional diesel vehicle (VCE);
- Conventional diesel vehicle on a leasing contract (VCL);
- Most efficient conventional diesel vehicle on a leasing contract (VCEL);
- LNG vehicle (VGNL);
- Electric vehicle in a scenario in 2020 (VE20) and 2030 (VE30) with no battery change;
- Electric vehicle in a scenario in 2020 (VEB20) and 2030 (VEB30) with one battery change;
- Fuel cell vehicle in a scenario in 2020 (VPC20) and 2030 (VPC30) with no battery change and
- Fuel cell vehicle in a scenario in 2020 (VPCB20) and 2030 (VPCB30) with one battery change.

It was decided to do the TCO analysis considering two different cases for the batteries of new technology vehicles because batteries have been developing rapidly over time and, today, there are battery manufacturers who claim that their battery lasts 10 years [15]. However, this option is considered to be an optimistic one. To study all possible situations, it was also analyzed the situation where a vehicle needs to change its battery once during its lifetime. The duration of this battery is 6 years [16] which for the vehicle considered corresponds to about 2,000 cycles. This is considered the average life of a battery [17].
To perform the TCO analysis, different vehicles were simulated in *FASTSim* software and collected the energy consumption of each vehicle using real world drive cycles. This software was used to simulate a conventional diesel vehicle, an electric vehicle, and a fuel cell vehicle. The LNG vehicle was analyzed according to the actual data of the company's LNG vehicles. To perform this analysis were used speed cycles that were measured on board of a vehicle

representative of the company, using a Garmin GPS (*GPSMap 76CSx*). Table 3 shows the specifications of the vehicles simulated in *FASTSim*.

Table 3 - Specifications of the simulated vehicles.

Vehicle type	ICEV	BEV	FCV
Length (mm)	6,800	8,355	9,745
Width (mm)	2,550	2,500	2,515
Height (mm)	3,700	3,080	3,730
Vehicle type	Diesel	EV	FC
Curb weight (kg)	7,350	9,726	9,795
Autonomy	480 L	200 km	400 km
Engine power (kW)	358	150	350
Load (kg)	18,000	18,000	18,000
Maximum speed (km/h)	90	90	85
Battery (kWh)	-	217	73.2
Fuel Cell Power (kW)	-	-	190
Drag coefficient	0.542	0.542	0.542
Rolling resistance coefficient	0.006	0.006	0.006
Wheel coefficient of friction	0.7	0.7	0.7
Wheelbase (m)	3.6	3.825	5.13

The company does not have a scale to weigh the load of the vehicles. For this analysis, the load mass was assumed to be 18,000 kg to compare the conventional vehicle with the vehicles of the other technologies, since the maximum load that the electric vehicle can transport is 18,000 kg. Assuming this value may not give the exact average consumption of the vehicle, however the result was considered acceptable, since the relative error is relatively low (9%). To perform the TCO analysis, it was necessary to collect several data from the existing literature to project the costs of new technologies. For the VC, VCE, VCL and VCEL vehicles and the VGNL vehicle, all costs were provided by the company. For the vehicles VE20, VE30, VEB20, VEB30, VPC20, VPC30, VEPCB20, VPCB30 the costs were collected, namely the vehicle purchase price (€) [18], the fuel price (€) [19, 20], the vehicle repair and maintenance costs (€) [21], the residual price (€) [22, 23], the battery costs [24] and the costs of taxes and fees applied to vehicles.

3.7. – Impact of the COVID-19 pandemic

The COVID-19 pandemic has had several consequences for all sectors of the global economy. The impact that the pandemic had on *Transportes Gama* from January to June 2020 was studied (when the first wave of the pandemic occurred in Portugal). In order to analyze the impact of the pandemic, the first semester of 2019 was compared with the first semester of 2020. The parameters analyzed were the difference between the kilometers traveled, the total consumption of fuel and the difference in costs associated with the fuel consumption between the first semester of 2019 and the first semester of 2020.

4. – Results

4.1. – Fleet and drivers' characterization

The results of the analysis show that the model that stands out as the more efficient is the R 410. This model has higher average speed, higher mileage, and lower average consumption of fuel among all the models. The vehicle with the highest fuel consumption and the lowest speed is the Premium 450 DXI.
After the drivers' characterization and analysis by age and years of experience, it is possible to conclude that the highest average fuel consumptions are located, mainly, in the middle aged and senior drivers which tend to be more reluctant in adopting eco-driving practices, when exposed to them, than younger drivers [25]. The younger drivers tend to drive at higher speeds and middle-aged drivers tend to travel more kilometers. However, 55.5% of the company's drivers are middle aged drivers, which affects the results.

When the analysis is based in the drivers' years of experience, it is possible to conclude that the inexperienced drivers have greater consumption of fuel, as well as the more senior drivers who may be reluctant to change their driving habits. The drivers who tend to travel at higher speeds are also the drivers who already have some experience and are more confident. The drivers who traveled the most kilometers were the drivers with less experience. However, 52.6% of the company's drivers are inexperienced drivers, which affects the results.

4.2. – Fleet renewal

The results of fleet renewal are in Table 4. The savings costs were calculated with equation (1). It is possible to observe that, after the fleet renewal it was saved 36.170 liters of fuel monthly, which corresponds to a monthly fuel cost savings of € 52,591.

Table 4 - Results of fleet renewal.

Average fuel consumption (l/100 km)	Total fuel consumption (l)	Traveled distance (km)	Fuel savings (l)	Monthly fuel cost savings (€)
26.4	291,440	1,105,174	36,170	52,591

After the fleet renewal there is a decrease in fuel consumption of 11%. Changing old vehicles in the fleet with more recent vehicles of the same type is a measure with strong energetic and economic impact. The project's payback time was also analyzed. The previous data was extrapolated to calculate the annual fuel cost savings. Each vehicle has a cost of € 90,000. Annual fuel costs savings correspond to € 631,093 when analyzing the fleet with 100% of the most efficient vehicles. Since 104 vehicles need to be renewed, the economic impact and initial investment will be high. Thus, the project's payback time corresponds to 15 years.

4.3. – Eco-driving potential

To study the economic impact of the eco-driving potential it was collected the data for the 10% of the most efficient drivers. Then, the data was extrapolated for all the drivers of the fleet. The difference of fuel consumption (l) was calculated. It was subtracted the fuel consumption of the fleet with 100% of efficient drivers to the fuel consumption of the initial fleet. Finally, the monthly cost fuel savings was calculated using equation (1) and equation (2).
The results are presented in Table 5. It is possible to observe that the fuel savings were 21,240 l, which is equivalent to a fuel costs savings of € 30,883. After removing the training costs, it is obtained the final costs savings of € 27,711 per month.

Table 5 - Results of eco-driving potential.

Average fuel consumption (l/100 km)	Total fuel consumption (l)	Traveled distance (km)	Fuel savings (l)	Monthly fuel cost savings (€)	Training cost (€)	Monthly savings (€)
27.7	306,370	1,105,174	21,240	30,883	3,172	27,711

It is possible to conclude that, when applying eco-driving measures there is a decrease of 6.5% of fuel consumption. Adopting eco-driving measures is considered to be a good strategy for reducing the energetic impact, even if the energetic impact is smaller than the fleet renewal's impact. Finally, the payback time was calculated. Since the training costs are much smaller than the monthly savings after using eco-driving strategies, it is expected that the payback time will be only one month. The payback time is much smaller than the payback time for fleet renewal. Thus, it is possible to conclude that eco-driving is a good measure for the energetic and economic impact of the company, and it should be adopted.

It was also studied whether drivers training is beneficial in the short-term and in the long-term. For the short-term situation, it was collected the data of the training day and the data of the 15 days before and after the training day.

In the short-term analysis, all the drivers showed an improvement in fuel consumption and an increase in average speed in the 15 days post-training. Thus, it is concluded that the drivers' training is beneficial in the short-term, for the sample considered.

In the long-term analysis, one of the drivers benefited from the training and the other driver deteriorated his performance, since the average fuel consumption increased significantly. After analyzing the long-term effects of eco-driving, it is important to note that the drivers training should be continuous, as drivers can worsen their driving habits over time in the absence of training and increase the fuel consumption.

4.4. - Adoption of vehicles with alternative fuel sources

The results of the TCO analysis are presented in Table 6. The electric vehicles are a more economical option than the conventional vehicle (either under a lease or owned by the company), which appears to be a good option to decrease the fuel consumption and emissions. The introduction of electric vehicles is equivalent to 53% of fuel cost savings and is equivalent to a total annual savings of € 18,499 per vehicle. The payback time of the fleet renewal considering electric vehicles is 2 years.

Table 6 - Results of the TCO.

Vehicle type	Total costs (€)	€/km
VC	500,791	0.70
VCE	393,850	0.55
VCL	577,191	0.81
VCEL	473,250	0.66
VGNL	419,623	0.59
VE20	315,798	0.44
VE30	255,103	0.36
VEB20	398,145	0.56
VEB30	291,381	0.41
VPC20	636,949	0.89
VPC30	482,377	0.68
VPCB20	664,727	0.93
VPCB30	494,615	0.69

Conventional diesel vehicles are always more expensive than electric vehicles, even when electric vehicles require one battery replacement. This seems an interesting measure for fleet renewal. The most efficient diesel vehicle (VCE) is the second with lower costs in 2020, which demonstrates the importance of adopting eco-driving measures. The VGNL vehicle is also one of the most interesting options for fleet renewal in 2020, being the third most economical. The fuel cell vehicle is the most expensive because it is the most recent technology.

4.5. – Impact of the COVID-19 pandemic

The results of the analysis of the impact of the COVID-19 pandemic in the company can be observed in Table 7. It was calculated the total fuel consumption difference between the pre-pandemic situation (first semester of 2019) and the first semester of 2020. The difference in total fuel consumption was 162,047 liters. This difference is directly related to the fact that the freight transport suffered a considerable decline over the first semester of 2020 and some of the drivers had to be quarantined. Analyzing the fuel costs difference, it is possible to affirm that the company had a decrease in fuel costs of € 235,616. The fuel costs were calculated using a diesel price of 1,454€ per liter (including VAT), which is the average price of diesel purchased by the company in the first half of 2020. This difference in fuel costs indicates that the company, in a pre-pandemic scenario, spent € 235,616 more on fuel compared to the first half of 2020. This savings, however, does not report a positive situation. This difference in fuel costs exists because the volume of orders decreased, so fuel consumption also decreased, as well as the costs associated to the fuel. This difference shows the potential freight transport that the company could have done in the first half of 2020 if there was no COVID-19 pandemic.

Table 7- Results of the impact of the COVID-19 pandemic.

	Total fuel consumption (l)	**Traveled distance (km)**	**Fuel cost savings (€)**
	Difference between 2020-2019	**Difference between 2020-2019**	**Difference between 2020-2019**
January	-8.511	15,784	12,374 €
February	-24.865	-71,785	-36,154 €
March	-17.710	-78,933	-25,751 €
April	-32.082	-103,606	- 46,647 €
May	-88.359	-267,769	-128,474 €
June	-7.542	9,318	-10,966 €
TOTAL	-162,047	-496,991	-235,616 €

5. – Conclusions

This work aimed to assess the energetic and economic impact of energy efficiency measures to reduce the fuel consumption of the company's fleet. The possibility of acquiring vehicles with alternative fuel sources was also analyzed. It was carried an economic analysis to assess the feasibility of acquiring these technologies in order to meet the previous objective.

After analyzing the characterization of the fleet, the models with the highest and lowest energy consumption were identified. The model with the highest energy consumption is the Premium 450 DXI and the model with the lowest energy consumption is the R 410. The R 410 model is the most efficient and the Premium 450 DXI is the less efficient.

The potential for fleet renewal shows that switching from current vehicles to Euro 6 vehicles leads to a 11% decrease in fuel consumption. The drivers training and the application of eco-driving measures helps to reduce fuel consumption by 6.5% with no need to replace vehicles in the fleet. However, it is necessary to have continuous training sessions to maintain the fuel consumption reduction. This measure has a very low payback time so eco-driving and training are considered important measures to reduce the energetic and economic impact.

The results of the TCO analysis show that the most economic vehicle is the electric vehicle. The payback time of a full fleet renewal with 100% of electric vehicles is 2 years. Fuel cell vehicles are not yet the most interesting option, from an economic point of view. However, the fuel cell vehicle has more autonomy and is quicker in recharging its' battery than the electric vehicle. The electric vehicle has the disadvantage of requiring to recharge the batteries in the middle of the trip.

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