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PROPOSAL FOR INSERTION OF ELECTRIC VEHICLES IN THE TRANSPORT OF LOADS FROM A DISTRIBUTION CENTER

Douglas Vieira Barboza[1], Marcelo Jasmin Meiriño[2], Marcio Zamboti Fortes*[3] and Carlos Diego dos Santos Tavares[4]

[1, 2, 3, 4] Federal University of Fluminense - UFF. Niterói, Rio de Janeiro, Brazil.

[1] http://orcid.org/0000-0002-2653-8541, [2] http://orcid.org/0000-0001-9165-2300, [3] http://orcid.org/0000-0003-4040-8126, [4] http://orcid.org/0000-0002-0886-9742

Email: douglasbarboza@id.uff.br, marcelojm@id.uff.br, *mzamboti@id.uff.br, diee.tavares@gmail.com

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ABSTRACT

This article deals with the sustainable question about electric vehicles in front of the fossil fuels paradigm, as well as possibilities of self-management of its energy matrix. The economic feasibility of changing these vehicles is necessary for the reduction of polluting gases in the atmosphere and considering the challenges that the greenhouse effect imposes, a cultural transition is necessary for a sustainable planet. The methodology used in this research was bibliographic and documentary research, besides data collection of diesel vehicles which belong to the Central of Distribution of goods located in São Gonçalo, Rio de Janeiro, Brazil. In order for the purchase of large electric vehicles to be viable, it is necessary to adopt fiscal incentives to offset the high cost of acquisition, but these incentives are still insufficient in Brazil.

I. INTRODUCTION

With the expected scarcity of fossil fuels and the need to reduce greenhouse gases, the adhesion of electric vehicles becomes considerable to meet the demands of distribution in the transportation of goods along with the Brazilian road network. In this way, the present article aims through the case study of a Distribution Center of food products located in São Gonçalo, RJ, to analyze the feasibility of the use of the prototype electric vehicle "TESLA Semi" as a possible sustainable action of the organization that other shipping companies could employ.

It is important to emphasize that the study proposed to be developed requires the application of the interdisciplinary premises since it depends on the use of knowledge from the areas of engineering, environmental sciences, and applied social sciences to integrate technical, environmental, and economic characteristics in order to develop a sustainable strategy for the supply chain management.

According to [1], the demand for the use of electric vehicles is directly linked to fuel economy and reduction of carbon dioxide emissions to the atmosphere. As well as to innovate a whole technological market, but that demands the capture and generation of energy electricity from vehicles from renewable sources since if electric vehicles are recharged from electricity produced from conventional technology plants like oil or coal-fired power plants, they can produce greenhouse gas emissions equal to or sometimes larger than conventional gasoline vehicles. The use of electric vehicle timeshare is another optimal solution that can be explored as reported by [2].

The importance of the electric vehicle in the sustainability is the main theme in several research as the discussion about the battery electric vehicle contributing to the sustainable urban logistic in [3], a comparison with hydrogen fuel vehicles [4], the use of personal carbon dioxide trade [5] and the experience of Netherlands with the electric vehicle adoption [6].

In Brazil the theme of electric vehicles and sustainability are discussed on different topics as hybrid vehicles [7], purchase intentions compared with other countries [8], and subsidies to accelerate the integration of the electric vehicle [9], impact of the electric vehicle connection in the distribution network [10-11] and the electric vehicles used in postal deliveries [12].

In the case of this study, we can observe that the use of the electric vehicle for the case studied, even though it brings environmental and social gains, is still economically infeasible, due to the acquisition and maintenance costs, which, even when disregarding fiscal charges, can reach on average three times the cost of the diesel model.

II. METHODOLOGY

As reported by [13] the mobility limits are imposed by geography and the speed, energy, and ergonomic constraints of travel models. In order to answer if the use of electric powered vehicles in Brazil is viable, the methodological procedures were based on data collection of the electric vehicle through two information systems: The Tesla Motors website (https://www.tesla.com/semi) for the data collection on the "Semi" prototype, and the McKinsey & Company website (https://www.mckinseyenergyinsights.com/insights/new-reality-electric-trucks-and-their-implications-on-energy-demand/), as well as searches on other informative platforms and videos, to better understand the features of the model. To conduct research on the diesel vehicle, model CRM6X2, manufactured by Volkswagen, data collection was realized out at the place of use of the same, where it was possible to diagnose the costs related to the acquisition and use of the vehicle from the ERP system CiSS Poder, which has the database of the company used in this case study.

Load acceleration tests and fuel consumption tests were carried out from data collection with drivers, with the mechanical workshop that handles the fleet for more than 10 years, and cost reports were made available by the other tracking software (OpenSat). Regarding the value of fuel consumption, a calculation was made as to the total kilometers travelled by these vehicles linked to the total fuel, considering the initial tank as zero, thus obtaining the average of all vehicles of the same model that travel in different urban areas of the Rio de Janeiro state. It should be noted that the data corresponding to the load capacity was obtained through the vehicle manual itself, as well as, the information obtained in the trucks themselves, which are authorized by ANTT (Agência Nacional de Transportes Terrestres – Brazilian National Road Transport Agency) to operate, and the data sources and methods defined are adequate to answer the question of research.

III. RESULTS

Table 1 presents information that was collected in the field and data obtained through the Tesla Motors tests and made available on its website (https://www.tesla.com/semi). Information based on the Dollar price referring to R$ 3.74 and Diesel price at R$ 3.48 (Liter). In this way, performing the direct conversion, without adding any other financial charges. The base date for 06/06/2018.

Table 1: Data of the searched vehicles.

	Volkswagen (CRM 6x2)	**TESLA Semi (300 mile range)**
Vehicle cost (R$)	231,000.00	635,800.00
Consume	1.68 km/l	2 km/kWh
Fuel Cost (Base 2019)	R$ 3.48	R$ 0.81
Fuel value/km	R$ 2.07	R$ 0.41
Lifespan (years)	10	15
Acceleration	40 seconds with 24 tons	20 seconds with 36 tons
Maximum speed	100 km/h	96 km/l
Capacity (load)	24 tons	36 tons

Source: Authors, (2022).

Based on the data obtained and making a direct comparison between the two proposed vehicles, we noticed initially a large difference in the stipulated value of the cost of each truck. Therefore, more accurate analysis of the values to maintain this type of vehicle is necessary for the best choice according to the location of the road network of each location. Tesla Motors' vehicle proposal is directly linked to sustainability and environmental viability, see that there is a drastic reduction in the emission of polluting gases from the burning of fossil fuels and the emission of CO^2 generated by diesel vehicles. In addition to these environmental factors, one factor that makes the feasibility of electric vehicles effective is the issue of fuel economy, according to Tesla Motors Website (https://www.tesla.com/semi) there will be a substantial reduction in the value of fuels. Thus, a reduction of more than US $ 200,000.00 (R$ 740,000.00 + in direct conversion with the dollar price used in this research) over two years. In this way, the vehicle is paid in that period. Official note from Tesla's website: "Electric energy costs are half those of diesel. With fewer systems to maintain, the Tesla Semi provides $200,000+ in fuel savings and a two-year payback period."[14]. In Liu and Meng [15] there is an interesting comparative study considering innovation, ecological environment, market positioning and, business model with Tesla, Toyota, and BYD electric vehicles.

One of the factors disregarded in this research was the vehicle maintenance, where it is not yet possible to predict some incidents that may occur during the vehicle usage, as well as little information on periodic maintenance related to the Tesla model, has still not been released officially.

According to [16], the race for electric vehicles, whether small, medium, or large, will be subdivided into three main regions: United States, Europe, and China. Thus, with the rise of this type of vehicle throughout the world, it is believed that by 2030 electric vehicles are widely exploited. However, it should be noted that there has been researched in this area since the 2000s, in addition to the idea of electric vehicles was started more than 100 years ago, said that we can consider that this estimate changes and that in the coming years there are positive surprises in this follow-up of vehicle development, sustainability, and economic and social integration.

Figure 1 depicts the future possibility of electric vehicle racing across the globe.

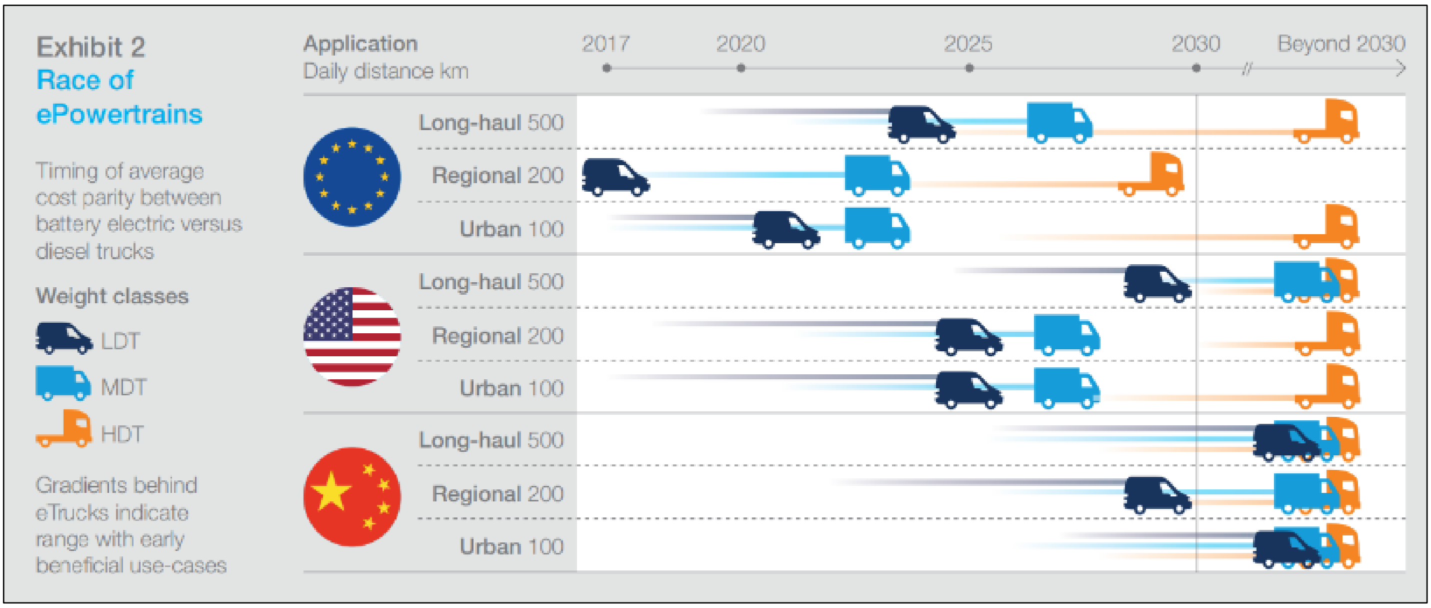

Figure 1: Race of ePowertrains.
Source: [17].

Still, according to [16], it is possible to understand that the replacement of diesel vehicles will generate a great change in the economy in the years following the transition of fleet change. With electric power costing less than half of diesel as a form of fuel, different ways to self-sufficiency can be created to make this type of vehicle viable. Thinking strategically at a Distribution Center, we envisage a series of methods that can aid in this process of electric vehicle deployment, as well as meet the sustainability requirements proposed by the vehicle change. Among the proposed methods, we have:

• Implementation of power plants from solar panels coupled throughout the Distribution Center;

• Implementation of solar panels in the vehicles themselves, optimizing the use of the battery;

• Regenerative load serving as an extra battery, where it would be implanted in the vehicles themselves, recharging through the truck's brakes, in this way, the kinetic energy recharges the auxiliary battery. (This method may damage the battery lifespan)

In addition to the modes presented, others can be developed over the years, considering that the technology tends to evolve more and more, we have great possibilities of sustainable viability on this type of vehicle. As one of these modes, induction recharging, refers to a new technology presented by Qualcomm (an American multinational semiconductor and telecommunications equipment company)[18] where the battery of the vehicle would be recharged without the need for contact between the vehicle and the charger, thus providing the vehicle can be recharged in motion. Although it is a great innovation in this sector, we are still far from achieving it due to the many reasons inherent to the road network. Thus, the trend of acquiring this type of vehicle tends to be greater over the periods, and, perhaps, becoming more used than diesel vehicles.

Table II (Appendix) shows a complete analysis of the fleet studied in this proposal, where the consumption discrepancy between vehicles can be seen more clearly.

Considering the data obtained through the analysis and field tests carried out on the vehicles of the distribution center, we can consider a series of factors that contribute to the diffusion of the thought of the fleet exchange of vehicles driven by combustion engines for vehicles with electric motors. From the environmental bias, we must consider the amount of gases emitted by these vehicles and think of methods to mitigate them. From the economic point of view, we have the question of average daily fuel consumption ranging from 21 liters to the most economical up to 86 liters per day. These values directly impact the company's revenue as its operating costs, since, depending on the vehicle and its use, there may be a daily fuel cost of approximately R$ 301.00, on the other hand, if the vehicle depended on an electric motor, that figure could have been reduced by 67% of the cost, and if there were clean and sustainable production of electricity (wind and solar are more prone in the region), this could become self-sufficient, reducing fuel costs by 100%(From data obtained by OpenSat). As proposed by [19], other renewable energy sources can be considered and analyzed so that sustainable bias can be achieved in full.

According to [20], with the increasing urban expansion in the transport sector, the burning of fossil fuels from these vehicles increases gradually and implies a series of environmental and social factors. Much is said about electric vehicles and their viability within urban centers as a mitigating agent for the emission of gases that contribute to the greenhouse effect. However, in addition to tax incentives to replace the diesel fleet, other assumptions must be studied, analyzed, understood, and designed for the efficient reduction of the polluting gases, as well as to structure in an intelligent and technological way that pole for reference in sustainability. Within this assembly line of electric vehicles, the battery is the main component of this automobile and, consequently, the item with the highest value in its production and acquisition of it. Considering this fact, since the assembly line must pay special attention to the production of this item and after its useful life, a more relevant factor is its discard. Certainly, this issue of battery disposal will be the industry's biggest challenge globally. There are specific studies about the re-use of the electric vehicle batteries in stationary applications as discussed in [21].

IV. CONCLUSION

According to the objective, it is possible to conclude that in the current scenario, Brazil is very distant from the implantation of large electric vehicles, so that this new step towards the sustainable future it is necessary that there be fiscal incentives not only for the acquisition of imported vehicles, but also that it allows the implantation of assemblers along the federative units of the national territory, as well as the incentive to the installation of workshops specialized in the sector because with such prerequisites being met, success in the future has its probability increased. Such a thought change has a greater social and environmental potential than previously used diesel vehicles, but still, under current conditions, it is not yet economically attractive.

V. AUTHOR'S CONTRIBUTION

Conceptualization: Barboza, Meiriño
Methodology: Barboza, Tavares
Investigation: Barboza, Tavares
Discussion of results: Meiriño, Fortes
Writing – Original Draft: Meiriño, Barboza
Writing – Review and Editing: Meiriño, Fortes
Resources: Tavares, Barboza
Supervision: Fortes.
Approval of the final text: Meiriño, Fortes.

Data Availability Statement

Some or all data, models, or codes that support the findings of this study are available from the corresponding author upon reasonable request.

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VII. APPENDIX

This appendix shows Table II cited in item III.

Table II – Analysis of diesel vehicles

Model	Year	Vehicle Weight (tons)	Traction Capacity (tone)	Gross Weight (tons)	Top Speed (km/h)	Consumption (km/l)	Total Distance Travelled (km)	Average Distance Travelled (km/day)	Operational Days (days)
M.Benz ATEGO 1719	2018	4.91	11.09	16	117	3.7	7,873	106.39	74
M.Benz L1318	2010	4.89	9.01	13.9	117	2.91	5,742	92.61	62
M.Benz ATEGO 3026	2017	7.58	21.42	29	120	2.6	6,761	169.03	40
VW 13.180	2008	4.87	8.35	13.2	113	3.56	6,977	93.03	75
M.Benz L1318	2010	4.89	9.01	13.9	117	1.08	5,711	93.62	61
VW 24.280	2015	6.64	16.36	23	116	2.8	6,417	87.9	73
M.Benz ATEGO 3026	2017	7.58	21.42	29	120	2.67	5,719	129.98	44
M.Benz ATEGO 3026	2017	7.58	21.42	29	120	2.75	6,732	192.34	35
VW 17.190	2012	4.97	11.03	16	113	1.94	8,204	110.86	74
M.Benz L1318	2010	4.89	9.01	13.9	117	3.96	6,224	91.53	68
VW 24.250	2012	7.12	17.58	24.7	114	5.31	8,266	116.42	71
VW 17.230	2017	6.27	10.83	17.1	110	1.49	6,461	88.51	73
VW 17.230	2017	6.27	10.83	17.1	110	3.18	9,126	125.01	73