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DEFINITION OF CRITERIA AND CHARACTERIZATION OF THE ALTERNATIVES OF THE THEORETICAL MODEL TO SUPPORT THE AHP GREEN MOVING CAR (GMC)

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ABSTRACT

Urban planning requires results in terms of sustainable mobility. To be sustainable, this planning requires broad participation of the various actors and organizations, however the lay population does not always seem to have the technical knowledge to subsidize the choices of motor vehicles (for example: fossil fuel vehicles versus electric vehicles), making them more aware of the impacts of local action on sustainable development on a global scale. Therefore, the general objective of this preliminary study was: To define criteria with attributes for an AHP model that was named Green Moving Car (GMC) and to characterize alternatives to be tested (fossil fuel vehicles versus electric vehicles). This preliminary research, of an exploratory, descriptive nature and of a qualitative and quantitative nature, was carried out through two steps: (1) Scope Review and (2) Documentary Research. The results allowed the decomposition of the problem into four key dimensions based on the scientific literature: (1) Propelling energy; (2) Infrastructure and services; (3) Environmental Sustainability; (4) Economic Sustainability, and characterize the alternatives in detail: (a) Electric Car; (b) Fossil-powered car. The results of the present stage (definition of criteria and characterization of alternatives) contribute to the future formulation and testing of the AHP Green Moving Car (GMC) model, which is a promising tool to educate the lay population about conscious choices regarding motor vehicles today.

Keywords: Urban planning, Sustainable mobility, Electrification, Decarbonization, AHP model, Education.

INTRODUCTION

The depletion of natural resources and increasing environmental degradation, including the desertification of biomes, uncontrolled droughts, soil degradation, freshwater scarcity, and biodiversity loss, make it imperative to rigorously analyze these climate issues, which are among the great challenges facing humanity. Climate change, according to the 2030 Agenda (2015, s.p.), "[...] It is one of the greatest challenges of our time and its

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negative effects undermine the ability of all countries to achieve sustainable development." Therefore, it becomes essential to (re)educate oneself for the challenges of sustainability in the twenty-first century.

In this scenario, sustainable mobility and electric vehicles play an essential role, requiring urban planning that involves participatory decisions. At this point, the education of the lay population regarding conscious choices regarding energy can be relevant to achieve sustainable mobility in urban terms. As Santos, Araújo, Santos and Silva (2021) point out, electric mobility technology is resurfacing and consolidating in several nations due to its ability to use energy named clean and, therefore, more sustainable. Its purpose is to replace vehicles that emit polluting gases, an issue of great concern due to the worsening of the greenhouse effect, global warming and negative impacts on public health. In Brazil, according to the IEA (2021), fossil fuels are responsible for more than 60% of carbon dioxide (CO^2) emissions.

In documentary terms, in the Brazilian context, a bill was approved in February 2020 by the Constitution and Justice Commission (CCJ) that provides for the replacement of fossil fuel-powered vehicles from 2030. From that date on, only vehicles that use biofuels or electricity will be allowed to be sold. In addition, the bill establishes that, as of 2040, the use of any motor vehicle powered by internal combustion may be prohibited, as provided for in Senate Bill No. 304/2017.

The need arises to investigate how to justify the choice of electric vehicles in a conscious way by the lay population, with the aim of contributing to the reduction of greenhouse gas emissions. To address this issue, one of the most renowned methods of decision support will be used, known as Analytic Hierarchy Process (AHP), that is, a hierarchical analysis method that focuses on choices between peer-to-pair comparisons (Saaty, 1991), calibrated by a group of experts. Thus, this method allowed a structured and careful analysis of available alternatives: (a) electric car or (b) fossil fuel-powered, aiming to promote an informed and effective choice in relation to sustainable mobility.

To this end, the questions that underpin the problem were: What are the criteria for the best choice of motor vehicles aiming at sustainable mobility in urban areas? What are the characteristics of the alternatives? Therefore, the general objective of the study in the preliminary phase was: Creation of a theoretical model with the definition of criteria with attributes for an AHP model that was named Green Moving Car (GMC) and characterization of alternatives to be tested (fossil fuel vehicles versus electric vehicles). The specific objectives were: (a) to characterize the interface between urban planning and sustainable mobility (b) to qualify aspects related to electric vehicles and combustion, highlighting pros

and cons of electric vehicles today.

The exploratory, descriptive research of a qualitative and quantitative nature, for this purpose, was carried out through two steps: (1) Scoping Review; (2) Documentary research; with future steps to be unfolded in the present study: (3) AHP modeling; (4) Testing of the Green Moving Car (GMC) Model. The work is organized into four sections in addition to this introductory section.

URBAN PLANNING AND SUSTAINABLE MOBILITY

URBAN PLANNING AND SUSTAINABLE MOBILITY REQUIRES EDUCATION

Although sustainable development is a theme that originated in the Brundtland Report in 1987 according to the World Commission on Environment and Development (CMMAD, 1991) Currently, sustainable development, at the global level, is governed by the 2030 Agenda created by the United Nations (UN) in 2015, notably by the 17 Sustainable Development Goals (SDGs), and SDG 11 is related to sustainable cities and communities, and SDG 12 with responsible production and consumption (Brazil, UN, 2015). Therefore, urban planning must be intertwined with these guidelines. Even Sianes (2021) addresses the transdisciplinary role that sustainability assumes in contemporary times. Thus, SDG 4 deals specifically with quality education, and at this point it is necessary to assume that with the paradigmatic change to a green economy, it requires formal and non-formal education centered on the debate on sustainability, and this includes issues of daily life such as behavioral changes in the face of urban mobility alternatives.

In a broader way, and in dialogue with urban mobility, the importance of education for sustainability in the twenty-first century leads us to reflect on issues such as: the shape of the city since they do not conform in the same way, being living organisms. This theme was part of emblematic research such as that of Lynch (1999) and this demands not only a vision for architecture, but the planning of strategies aimed at urbanism to provide decision-makers.

In addition to understanding the urban and the conformation of city design, decision-making in urban planning and sustainable mobility, in a democratic way, by going through choices that must be conscious and lead to changes in the behavior of as many actors and organizations as possible, it becomes essential that the lay public understands that all actions in the present impact the future both individually, and collective. In this sense, in technical terms of planning, it is necessary to understand that planning is an action in the present that aims at results in the future, thus presenting levels and scope, namely: (a) Strategy, long-term; (b) Tactical management, medium-term; (c) Operational, short-term

(Chiavenato, 2000).

In turn, as the urban locus of event of a significant part of human life, it is full of transversalities regarding infrastructural, political, social, economic, environmental, and cultural issues, among other dimensions that are amalgamated. In this sense, planning the urban has been a complex task that requires both a generalist and a specific view, depending on the problems to be faced. In conceptual terms, mobility differs from accessibility, since accessibility is the physical and financial connection between certain points of a transport network. Mobility, on the other hand, implies the "how" the displacements will be made. This argument is directly linked to the notions of the transport cycle and mobility management. The transport cycle is composed of cyclical phases evidencing the cause and effect relationship between: "(a) change in land use and occupation; (b) it generates movements; (c) demand for transportation; (d) provision of transportation; (e) increased accessibility; (f) change in the value of the land" (Campos, n.d.). Furthermore, Balassiano (2012) explains that mobility management is understood as:

> (...) Strategies adopted based on the concept of Mobility Management have been used since the 1970s in the United States and in countries that are part of the European Union. In general terms, this concept assumes that the rationalization of the use of private cars associated with the improvement of the quality and supply of public transport options and the incentive to non-motorized transport, are viable alternatives for mobility to be sustainable in large urban centers (Balassiano, 2012, p.6).

In this sense, it is observed that the greater provision of accessibility is directly linked to urban planning because it implies changes in accessibility standards that can generate changes in land use. According to Balassiano (2012), mobility management with the incentive of collective public transport is at the top of the strategies to mitigate sustainable mobility problems. However, it is noted that at first the change in behavior regarding the choice of private motor vehicles for public transport in developing countries such as Brazil seems to be less likely, since this would imply the provision of greater infrastructure and adequate services in the short term. Thus, the focus of this work is on a first type of conscious choice involving two alternatives related to the use of motor vehicles: (a) fossil fuel-powered (b) electric car, as this seems to be more feasible in the short term.

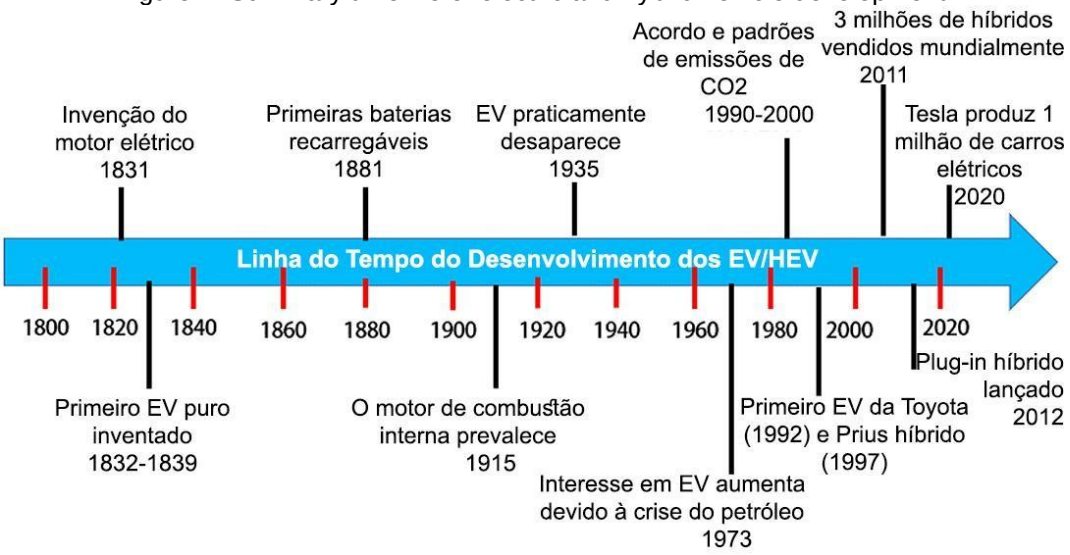
ELECTRIC VERSUS COMBUSTION VEHICLES

The transport matrix for private motor vehicles is still focused on fossil fuels in most countries, including underdeveloped countries and developing countries, such as Brazil. It is observed that electric vehicles have spread intensely worldwide in the most current contexts, especially in recent years, including in Brazil. However, in historical terms, it is

emphasized that the search for the association between electricity and means of transport is not recent, and the objectives of integration between such technologies date back to the nineteenth century, going through several transformations over time until the present day, both in terms of the batteries used and the types of vehicles, which, as pointed out by Swarnkar et al. (2023), included everything from electric carriages, locomotives, tricycles, vehicles for lunar use, to the most well-known electric vehicles today, which in addition to electric cars, include public and collective transport models, among others.

Continuing the understandings and understanding a brief history that briefly covers the evolution of the development and technologies related to electric vehicles, Chen et al. (2020) present a timeline, translated here in Figure 1, which addresses such vehicles (Electric Vehicles - EV) and Hybrid Vehicles (HEV) that correspond to those that combine electric and combustion engines, and, in addition, emphasizing the growing number of these means of transport, considering both the number of models available and the number of sales, corroborating the idea of the relevance of the theme today. Discussing such historical analysis, it is emphasized that the variations in sales and interest in such vehicles over time, that is, the existence of moments of growth and decrease, consist of another relevant aspect, which tends to raise doubts as to the probabilities and limitations of the perpetuation of the trade of related vehicles in future contexts.

Figure 1. Summary timeline of electric and hybrid vehicle development



Source: Chen *et al*. (2020, p. 2).

In the early days of the production of electric motors and then of the first electric vehicles and their promising popularization in the nineteenth century, taking into account the characteristics of easy use and silent engine compared to combustion vehicles (Reddy et al., 2024), being used as taxis in large global metropolises. However, even with the

apparent initial advantages, the means of transport with electric motors ended up being overtaken by those made up of combustion engines in the following years.

The strengthening of combustion vehicles to the detriment of electric ones occurred, in that context, not only due to the mass production of gasoline vehicles, but also due to the characteristics of these models, which include facilities for refueling at gas stations, which occurs extremely quickly and, moreover, at the cost and characteristics of fossil fuels at the time (Reddy et al., 2024).

Therefore, a large part of the success of the combustion engine is linked to the availability and accessibility of oil at different moments in history, and this resource is a relevant condition for consumers in the choice of vehicles. The aforementioned statement is proven by the return of interest in electric vehicles in times of oil crises and also encompassing the growing concern with sustainability and the quality of the environment, that is, they have since constituted a new paradigm for society, bringing such models back to the fore, in a way correlated with the development of technological innovations (Chen et al., 2020; Reddy et al., 2024). Looking at the present day, the significant increase in the fleet of electric vehicles has, globally, raised the question of whether they are likely to take hold definitively or not. To this end, it is vital to carefully analyze the panorama and characterize these means of transport, both from a commercial and user perspective, as well as from an environmental perspective.

The main advantages of electric vehicles can be described by resuming the research of Swarnkar et al. (2023), who point out, in addition to the characteristic regarding the reduction of the emission of polluting gases with regard directly to the circulation of vehicles, that these also "[...] can capture energy during braking through regeneration, and EVs are more efficient in terms of having a complex internal combustion engine." (Swarnkar et al., 2023, p. 3), that is, contributing to an optimized use, added to the characteristic of being silent, perceived since the precursors of these vehicles and, likewise, the promising reduction in the cost of fueling/loading such means of transport and the presence of government incentives, in a wide range of countries, aimed at fostering the use and development of automotive technologies designed with a sustainable bias (Chen et al., 2020).

However, the technical challenges for use are also addressed by Chen et al. (2020), and include not only aspects related to the availability of charging points and autonomy of the aforementioned vehicles before requiring a new recharge, but also a look at commercial aspects, since, in many places, as is the case in Brazil so far, the cost of these EVs remains high, as well as the durability of components such as batteries, whose quality and

maintenance is indispensable for effective operation and user service, is questioned. In summary, Chart 1 presents, in a qualitative and comparative way, the positive and negative points inherent to vehicles (especially cars) in the current context.

Table 1. Pros and Cons of Electric Vehicles Today

Pros	Cons
Increased efficiency of the propulsion system	Limited charging infrastructure
Improved acceleration and power transmission compared to combustion engine technology	The production and initial cost of the vehicle is high
Recharging the battery system	Highly flammable
Noise-free motor operation	Battery cost and battery degradation

Adapted from: Reddy *et al*. (2024, p. 20).

In Chart 1 it is evident that there are a series of attributes that can be organized according to the relationship with propelling energy, infrastructure and services, environmental sustainability and economic sustainability, which allows the adoption of the AHP Method.

METHODOLOGY

This research is exploratory and descriptive, qualitative and quantitative in nature, and is exploratory because it promotes familiarization with the theme. Gil (2019) explains that this type of research is relevant to advance theoretical, conceptual and methodological knowledge on a given theme.

The specific theme of this research is about conscious choice between electric vehicles and fossil fuel vehicles, in the context of urban planning and sustainable mobility and having as a differential the use of AHP to support decision-making on the subject. This, in order to create an instrument for the education of the lay public. The step-by-step methodological approach undertaken in this preliminary research is described in Chart 2 with respective supports:

Table 2. Methodological steps

Steps	Brackets
1. Scoping Review	Google Scholar (2024) and CAPES Periodicals Platform
2. Desk research	Brazilian Legislation and Bills

Source: Prepared by the authors, (2024).

In Stage 1, the bibliographic research was conducted in the CAPES Periodicals platform, using the descriptors "Urban Planning", "Sustainable Mobility", "Electric Vehicles", "Reduction of Gas Emissions", "Analytic Hierarchy Process Model", "AHP" and "Multicriteria Decision", in combination with Boolean operators (AND, OR and NOT). In addition, to

present a brief history of the subject, the descriptor "History" was used, combined only with the aforementioned descriptor "Electric Vehicles", using only the Boolean AND. Only peer-reviewed articles were considered, filtering in the areas of engineering and multidisciplinary knowledge, with open access, in a time frame from 2018 to 2024. In total, 15 articles (n=15) were found that were selected and elected to support the scoping review.

Concomitantly, in Stage 2, the documentary research was also conducted according to Gil's (2019) proposal, and, in turn, encompasses sources "[...] mainly primary, that is, those that have not yet undergone any analytical treatment." (Gil, 2019, p. 70), in this work represented by national legislation and bills, as well as by the data analyzed and by the 2030 Agenda.

Based on the results found in these first two stages, as mentioned in the introductory section, in future studies the Saaty scale (1991) will be applied by a group of experts, who answered the anonymous form, voluntarily (Future - Stage 3). As well as the future testing of this model (Futura - Stage 4) with the lay public, also anonymously and voluntarily as a pilot.

RESULTS AND DISCUSSIONS

In terms of results, it is emphasized that in the face of the pressing challenges imposed by environmental degradation and climate change, the transition to sustainable mobility emerges as a crucial strategy to mitigate the adverse impacts of polluting gas emissions. It is reinforced that the conscious choice of clean technologies is therefore essential for the reduction of carbon dioxide levels and for the promotion of a healthier quality of life in urban areas. Below it is demonstrated how the theoretical model was created from the methodology used, which is the mix between scoping review and document analysis (see Chart 4).

Table 4. Theoretical model from the definition of the criteria and attributes of the decision tree

Question	**What are the criteria for the best choice of motor vehicles aiming at sustainable mobility in urban areas?**			
Dimensions	**Propulsive energy**	**Infrastructure**	**Environmental Sustainability**	**Economic Sustainability**
Attributes (Description)	**Efficiency of the drivetrain** (range per charge/refuelling in km)	**Need to recharge/ Supply** (in number of km)	**Noise emission** (generates a lot of environmental noise pollution / does not generate environmental noise pollution)	**Initial cost of acquiring the vehicle** (in Brazilian currency - R$)
	Propellant energy density level (higher to lower density level in comparison)	**Existence of infrastructure for recharging/refueling in the urban environment**	**Environmental degradation** (generates environmental pollution/does not generate environmental	**Cost of propellant energy to maintain** (in Brazilian currency - R$)

		(existence of stations and/or electric stations)	pollution)	
	Acceleration and power transmission (in seconds)		**Risk of being flammable** (very - no possibility)	

Source: Based on Reddy *et al*. (2024, p. 20).

The implementation of electric or fossil fuel-powered vehicles, supported by recent legislation and the scientific evidence of the AHP Green Moving Car (GMC) Model, represents a significant step towards building a more sustainable, less polluting and more conscious future. Although Reddy et al. (2024) have treated the decarbonization of the sector by comparing different energy sources, other studies have provided the basis for the creation of the theoretical model, such as the one by Chen et al. (2020) add up when dealing with lubricants for electric and hybrid vehicles, or even the one by Beté et al. (2020) dealt with sustainable vehicles for urban mobility in cities and offer relevant clues regarding the efficiency of the propulsion system. Tischer & Polette (2019) were incisive in bringing cities that are references in sustainable urban mobility, allowing the visualization of criteria in practice, including drawing attention to the power of externalities when what is in perspective is urban transport planning. Taking into account the specificities of Brazil, since the methodology used Brazilian legislation, there is a study by Guimarães & Lucas (2019) that allowed us to verify cultural aspects regarding the definition of criteria, as the authors dealt with equity in the planning of urban public transport in Brazil. Another work identified in the scoping review was by Dos Santos et al. (2021) who deals with the impact of electromobility on energy infrastructure issues in Brazil, which illuminates the nuances of the attributes of the theoretical model.

The theoretical model as a significant part of an AHP model that will be weighed and tested in the future on the subject becomes evident when paying attention to the work of Bhadane et al. (2022). These authors sought to integrate a framework related to inclusive city planning using the AHP method. A curious fact was related to geomorphology, as the authors applied it to a semi-urban city. Thus, creating and testing a pilot AHP model (which will be the two future stages of this research) to support conscious choices regarding clean transport technologies in favor of sustainable mobility in urban areas aiming at a future use for the education of the lay public requires providing the lay public with the minimum of information about the alternatives, as shown in Table 5:

Table 5. Characterization of the alternatives for the Theoretical Model

Alternatives	Characterization of the alternatives for the theoretical model
Electric car	It offers higher efficiency of the propulsion system than conventional fuels. It has improved acceleration and power transmission compared to combustion engine technology. The system is recharged by batteries at an electric station. The engine running without noise. However, the initial cost of acquisition is higher, as the cost of producing the vehicle is high. Another counterpoint is that the vehicle is highly flammable, with battery cost and battery degradation being an economic sustainability issue, accompanied by lower energy density.
Fossil-powered car	It offers lower efficiency of the propulsion system and has worse acceleration and power transmission compared to electric motor technology. The system is recharged by fossil fuels at gas stations. The engine operation has noise. The initial cost of acquisition is lower, as the cost of producing the vehicle is generally lower compared to the electric vehicle. The vehicle is not highly flammable, and the cost of the combustion engine is lower than the electrical system, and its degradation is more avoidable than the electric car battery, in addition, the use of fossil fuels confers greater energy density than electric cars.

Source: Elaborated, adapted and based on Reddy *et al*. (2024, p. 20).

Although the characterization was based on Reddy et al. (2024), other studies have contributed decisively, such as that of da Silva (2023), which aimed to understand the influences of electric mobility on the reduction of pollutants in the atmosphere, and evoked the role that fossil fuel-powered vehicles have played in the greenhouse effect. Thus, based on the definition of the criteria and characterization of the alternatives of the theoretical model, it will be possible to advance in the next two stages of the study, which are: weighing and testing of the GMC, making it indeed a promising tool for education.

FINAL CONSIDERATIONS

During all stages of the present work, the relevance of the theme of electric vehicles is perceived linked to the increasing demand for the adoption of sustainable strategies and technologies. Therefore, the potential of integrating these vehicles is evidenced in order to promote sustainable mobility strategies, contributing directly to urban spaces and their respective planning and management.

Historically, the fluctuations perceived in the market regarding the choice between combustion vehicles, with alternative or electric fuels, correspond to factors that raise doubts in consumers in general regarding the choice of the vehicle to be purchased. The promotion of debates, discussions and awareness of the positive and negative aspects of each choice, covering the technical and commercial specificities, are ways to foster the most appropriate choices considering the consumer's profile.

In view of this, it is considered that the creation of the theoretical model and the subsequent weighing and testing of the AHP Green Moving Car (GMC) as a grounded and conscious aid for the choice based on established criteria and with a multidimensional character will be a promising strategy to avoid inductions to error based on various disseminated information that, often do not consider the specificities of each consumer and

the specificities present in each dimension in the context in which it is inserted.

In summary, such hierarchical analyses are able to take into account the intersections present in the reality experienced by each user and corroborate the search for decisions that not only tend to contribute to better experiences from the consumer's perspective, but also stimulate sustainability in urbanism. However, for this to happen, they need to have these first stages of creating the theoretical model based on scoping review and document analysis (secondary data) very solidified before future studies involving primary data collection with human beings, such as questionnaires and uses of AHP's own software, such as Superdecisions or Expert Choice.

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REFERENCES

1. Balassiano, R. (2012). Mobilidade urbana no âmbito da economia verde. Coleção de Estudos sobre Diretrizes para uma Economia Verde no Brasil. Ambev, BNDES, JSL, Light, Shell, Tetra Pak. Available at: https://l1nk.dev/s3p7R. Accessed on: June 21, 2024.

2. Bhadane, P., Menon, R., Jain, R. K., Joshi, D., & Ravikar, A. A. (2022). Integrated framework for inclusive town planning using fuzzy analytic hierarchy method for a semi-urban town. Civil Engineering Journal, 8(12), 2768-2778.

3. Beté, T., Conti, D., Mizutani, M., & de Oliveira, C. (2020). Veículos sustentáveis para a mobilidade urbana nas cidades futuro. International Journal of Professional Business Review (JPBReview), 5(2), 163-178. Available at: http://www.openaccessojs.com/JBReview/article/view/169.

4. Brasil. (2015). ONU Agenda 2030 para o Desenvolvimento Sustentável. Translated by the United Nations Information Centre for Brazil (UNIC Rio). Last edition on October 13, 2015. Available at: https://brasil.un.org/pt-br/91863-agenda-2030-para-o-desenvolvimento-sustentável. Accessed on: July 17, 2024.

5. Brasil. (2017). Projeto de Lei do Senado nº 304/2017. Institui a política de substituição dos automóveis movidos a combustíveis fósseis e altera a Lei nº 9.503, de 23 de setembro de 1997 (Código de Trânsito Brasileiro). Brasília, DF: Senado Federal.

6. Campos, V. B. G. (n.d.). Planejamento de transportes: conceitos e modelos de análise. Apostila. Instituto Militar de Engenharia (IME).

7. Chen, Y., Jha, S., Raut, A., Zhang, W., & Liang, H. (2020). Performance characteristics of lubricants in electric and hybrid vehicles: A review of current and future needs. Frontiers in Mechanical Engineering, 6, 571464.

8. Chiavenato, I. (2000). Administração: teoria, processo e prática (3rd ed.). São Paulo: Makron Books.

9. CMMAD. (1991). Nosso futuro comum (2nd ed.). Rio de Janeiro: Editora da Fundação Getúlio Vargas.

10. Da Silva, M. B. (2023). Influência da mobilidade elétrica na redução da emissão de poluentes. Brazilian Journal of Development, 9(5), 17109-17115.

11. Dos Santos, G. R., Araujo, K. K. M., Dos Santos, P. A., & Silva, G. R. P. (2021). O impacto da eletromobilidade: veículos elétricos, meio ambiente e a infraestrutura energética do Brasil. South American Development Society Journal, 7(21), 238-253.

12. Gil, A. C. (2019). Métodos e técnicas de pesquisa social (7th ed.). Rio de Janeiro: Grupo GEN.

13. Guimarães, T., & Lucas, K. (2019). O papel da equidade no planejamento de transporte coletivo urbano no Brasil. Transportes, 27(4), 76-92.

14. IEA. (2021). E4 Perfil do País: Eficiência Energética no Brasil. Available at: https://www.iea.org/articles/e4-country-profile-energy-efficiency-in-brazil. Accessed on: July 20, 2024.

15. Lynch, K. (1999). A boa forma da cidade. Lisboa: Edições 70.

16. Reddy, V. J., Hariram, N. P., Maity, R., Ghazali, M. F., & Kumarasamy, S. (2024). Sustainable vehicles for decarbonizing the transport sector: A comparison of biofuel, electric, fuel cell and solar-powered vehicles. World Electric Vehicle Journal, 15(3), 93.

17. Sianes, A. (2021). Academic research on the 2030 Agenda: Challenges of a transdisciplinary field of study. Global Policy, 12(3), 286-297.

18. Swarnkar, R., Ramachandran, H., Ali, S. H. M., & Jabbar, R. (2023). A systematic literature review of state of health and state of charge estimation methods for batteries used in electric vehicle applications. World Electric Vehicle Journal, 14(9), 247.

19. Tischer, V., & Polette, M. (2019). Sistema de avaliação de cidades de referência em transportes e mobilidade urbana sustentável. Cadernos Metrópole, 21(45), 481-509.