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A STUDY OF ELECTRICAL VEHICLE SELECTION USING BY TOPSIS METHOD

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Abstract- In the current climate, India's worry over air pollution has grown significantly. Numerous Indian towns are among the most polluted in the world, according to a recent survey. Transport and industrial sectors are the two main sources of air pollution. The industrial sector is responsible for 51% of this air pollution, and the transportation sector is responsible for 27%. 2 million Indians die prematurely each year as a result of air pollution. Electric Vehicles (EVs) can be a gift in reducing GHG emissions to reduce air pollution. Electric vehicles provide several benefits, including less pollution and lower costs for purchasing fuel. Even Nevertheless, there are many dangers to the development of electric vehicles in India. Government efforts to encourage their use, as well as the increased sales and large increase in the number of e-vehicles, are also brought to light. The goal of this research work is to propose an integrated method for choosing and ranking the best electric vehicle alternatives using the Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS Method) and a multi-criteria decision-making tool (MCDM). The TOPSIS approach is utilized to calculate the weight coefficients of the criteria, and the decision to choose one set of EVs over another is assessed. Five workable options have been selected as a sample for the investigation. This study offers a natural preference for thorough selection criteria and evaluates the best choice among the various electric automobiles.

***KEYWORDS*:** Multi-criteria decision-making (MCDM), TOPSIS method, Government Policies**,** Electric Vehicles, Pollution, barriers

1. INTRODUCTION

A vehicle is referred to as an EV if it uses an electric motor to supply all or some of the mechanical power required to move it. Battery Electric Vehicles (BEV), Fuel Cell Electric Vehicles (FCEV), and Hybrid Electric Vehicles are the three different types of EVs now available (HEV). EVs powered by batteries conserve energy electrochemically. The additional expenditures for the Vehicle to Grid (V2G) installation are negligible because these cars must be linked to the grid. The term "plug-in hybrid electric vehicle" (PHEV) refers to a new generation of automobiles that combine the advantages of high-performance battery vehicles with conventional vehicles. The advancement of electric vehicles has changed in recent years. Optimization of intelligent hybrid electric vehicle parking using renewable energy sources. Forecasts have been made on the growth rate of battery-electric vehicles in a city. Several multi-criteria decision-making techniques have been utilized with various target functions, such as cost reduction or air pollution minimization, to enhance the usage of EVs. (Farivar, F. et al 2014).

Automobiles are a substantial source of hydrocarbons, nitrogen dioxide, lead, carbon monoxide, sulfur dioxide, and

particulate matter pollution. India's massive automobile sector, the fourth largest in the world, is the cause of a significant portion of vehicular pollution. India's electric car population is growing at a pace of 37.5%. Additionally, the government is giving electric vehicles and charging stations more attention [20]. The best location for charging stations has been suggested in order to maximize their efficiency and supply the necessary amount of electricity [21].

1.1 WORKING PRINCIPLE OF EVS

The electric vehicle's operating system, in which the battery supplies electricity to the controller, which in turn powers the e-motor. Electricity is the basis of the e-operation. Car's Power for the electric motor is provided by the battery pack. As a result, the wheels revolve as the transmission system is rotated by the e-motor using energy from the rechargeable battery. Additionally, the car's accelerator pedal is connected to a potentiometer, which communicates to the controller how much power should be sent to the electric motor.

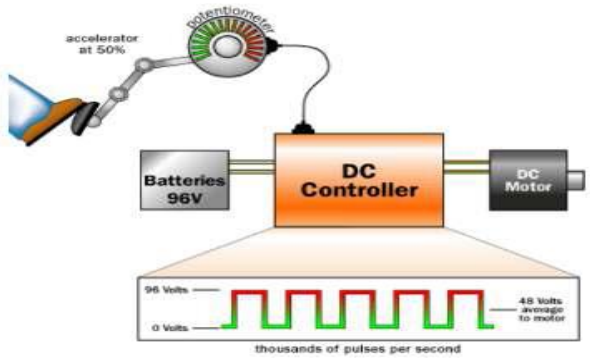


Figure.1.1: Principle of Electric Car

1.2 ELECTRIC VEHICLE POLICY IN INDIA

The National Electric Mobility Mission Plan (NEMMP) 2020 was created in 2012, and as part of it, an incentive program called Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) was introduced in 2015. FAME aims to lower the price of hybrid and electric vehicles and promote the market adoption of these vehicles. The retail price of passenger automobiles is subsidized under the FAME program. These subsidies are between INR 11,000 and 24,000 for mild hybrids, between INR 59,000 and 71,000 for strong hybrids, and between INR 60,000 and INR 1, 34,000 for electric cars. Additionally, there are subsidies for buses, light-commercial vehicles, two-wheelers, and three-wheelers. The FAME scheme's subsidy is not the only incentive program that influences the hybrid and electric car industry in India. The National Capital Territory of Delhi (NCT of Delhi) and various state governments in India, including the Central Government of India, offer tax benefits that give hybrid and electric vehicles a leg up over other types of vehicles. The government has doubled the import tariff on electric vehicles to promote make in India, according to recent declarations made by finance minister Nirmala Sitharaman during the presentation of the union budget 2020.

1.2 INDIA'S POSITION ON ELECTRIC VEHICLE

Controlling Pollution: The International Council for Clean Transportation (ICCT) estimates that in India in 2015, air pollution from vehicle exhaust emissions contributed to 74,000 premature deaths. Additionally, India is home to many of the world's most polluted cities. New Delhi, as an illustration.

The Reduction of Climate Change: India's ranking on the global vulnerability ladder dropped from the 14th position in 2017 to the fifth position in 2018 according to the German watch Climate Risk Index 2020, which was published in December 2019. This gives India even more justification to prioritize the development of electric automobiles and vehicles in its effort to reduce its dependency on fossil fuels.

Alternatives to Sustainable Energy: By switching to electric vehicles, India will be able to lessen its reliance on foreign oil, overcome its energy crisis, and transition to clean, renewable energy sources.

2. LITERATURE REVIEW

Iclodean, C et al. (2017) In this paper author represent Battery controlled Electric Vehicles are beginning to assume a critical part in the present auto industry. There are many kinds of batteries tracked down in the development of the present Electric Vehicles, being difficult to conclude which one satisfies best every one of the main qualities, This study presents the independence of an Electric Vehicle that uses four distinct kinds of batteries: Lithium Particle (Li-Particle), Liquid Salt (Na-NiCl2), Nickel Metal Hydride (Ni-MH) and Lithium Sulphur (Li-S), every one of them having a similar electric energy stockpiling limit. The oddity of this logical work is the execution of four unique sorts of batteries for Electric Vehicles on a similar model to assess the vehicle's independence and the productivity of these battery types on a driving cycle, progressively, digitized by virtual experience.

Farzad, Tahriri et al. (2008) The work addresses the efficient distinguishing proof of the significant standards for the supplier determination process. Furthermore, the outcomes show the utilization of improvement of a multi-measures choice model for assessment and determination of suppliers with the proposed AHP model in steel-producing organizations in India which by scoring the presentation of providers can lessen the time taken to choose a seller

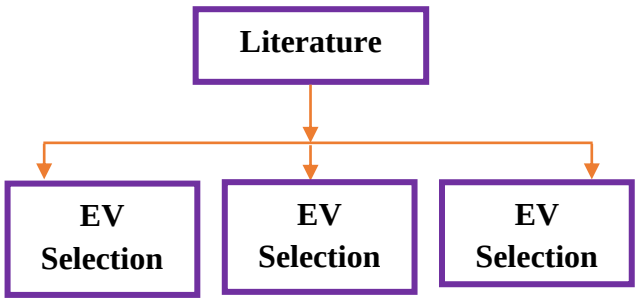


Figure.2.1: Road Map of Literature Review

2.1 SUPPLIER SELECTION BARRIERS

Grimier, L.P et al. (2018) The diffusion of EVs in India relies upon a few genuine and saw obstructions. As noted beforehand, these hindrances were distinguished through an exhaustive writing survey, including an investigation of important internet-based content, recently distributed examinations, and collaborations with partners, like EV producers, strategy creators, specialized specialists, purchasers and clients, and related establishments. In particular, a literature survey review was played out, this approach brought about the ID of 17 barriers applicable to EV diffusion in India. Then, the boundaries were arranged into five classes: specialized, strategy, monetary, framework, and social. Quite, a past report concerning sustainable power improvement in India grouped the recognized boundaries into six categories. In any case, the on-going review doesn't think about the regulatory idea of obstructions, as EVs are new to the Indian market and the vehicle business is presently shown to privately owned businesses.

2.2 SUPPLIER SELECTION DRIVERS

Choosing the right electric vehicle to fit a specific vehicle isn't clear all of the time. There are such countless factors to consider and it very well may be hard to tell where to begin. Given the cost of batteries and electric engines, to find the most efficient arrangement, you ought to search for a powertrain that will fit the required vehicle exhibitions as close as possible. In this research work, we will outline 10 fundamental drivers that we want to reply to before trying to track down the right engine for your venture. Essentially, we want to decide the most requested necessities of your vehicle as well as assess what different street conditions will mean for the execution of the powertrain.

- Vehicle characteristics
- Driving cycles
- Vehicle configuration (electric, hybrid)
- Maximal torque

- Maximal power
- Battery Capacity
- Battery Voltage
- Cost

2.3 EV SELECTION PROCESS

In the current review, the focal inspiration for supporting the dynamic cycle is the choice of the most ideal electric vehicle that anyone could hope to find in the Indian car market. We focused on choosing the most reasonable vehicle for a buyer, given the different rules or buyer inclinations while picking an electric vehicle. At first, a few models that influence the presentation of EVs are shortlisted from past academic literature. These days, the car market offers a wide assortment of variations, including different execution measures. These variations incorporate style, variety, quality, sizes, and exhibitions. Essentially, there are different measures that buyers considered while choosing a reasonable vehicle, which incorporates battery limit, seating capacity, driving range, cost, torque, acceleration, charging time, charging foundation, and so on. Consequently, it is hard for the buyer to measure the performance of elective variations/models and pick the most appropriate vehicle for their expected use [16].

3. PROBLEM STATEMENT

India makes up about 18% of the world's transport-related carbon emissions. One of the most practical alternative options to overcome problems is the electric vehicle (EV). Many automakers are introducing EVs and broadening their product lines. Promoting EVs is advantageous for both customers and the country as it can help reduce pollution and reliance on fossil fuels. People's level of awareness of EVs is substantially more influenced by their education than by any other factor. The difference between domestic oil output and consumption is growing. About 70% of the oil required annually is imported by India. Investigating the drivers behind the need for sustainable and greener alternatives is thus urgently necessary. In India, switching from internal combustion engines to electric vehicles is a significant problem. Planning and research are both necessary for this. To handle range anxiety, charging infrastructure must be properly constructed. Although the idea of electric vehicles has been around for a while, it has attracted a lot of attention in the past ten years due to the growing carbon footprint and other environmental effects of fuel-based vehicles. **There are the few important factors about the electrical vehicle selection is given below.**

(A) To learn about consumer awareness of electric cars.
(B) Should be aware of how electric vehicles affect the environment.
(C) To realize how consumers see utilizing a traditional vehicle for transportation.
(D) Fully comprehend the elements involved in buying an electric vehicle.
(E) To comprehend the customer's actions when switching out a vehicle.

4. OBJECTIVE OF THE RESEARCH

A significant strategy for lowering greenhouse gas emissions is the usage of electric automobiles. Electric cars not only decline dependence on fossil fuels but also decrease the effects of ozone-depleting compounds and encourage the widespread use of renewable energy sources. The use of electric vehicles has the potential to reduce carbon emissions and encourage the use of greener energy. Government agencies and public bodies (GAPBs) have highlighted the necessity of adopting electric vehicles through supplier selection due to growing carbon-neutral pressure and market rivalry from the transportation industry. As a result, GAPBs must carefully analyse a set of appropriate criteria and a thorough framework for choosing electrical vehicle, then make a decision on which provider of electric vehicles best meets their actual

requirements in terms of economic, social, environmental, and technological issues. The main objective of our research work is to provide GAPBs with information about electric vehicle selection (EVSS) utilizing an MCDM framework. The TOPSIS approach is suggested, and based on a review of the literature and the opinions of experts, 5 important criteria and 5 alternatives from the economic, social, environmental, and technological aspects are determined as the criteria. A case study is initiated and examined to verify the suitability and viability of the suggested framework. The research supports methodical decision-making for GAPBs and aids in understanding the factors for choosing electric vehicles. The major goal of the research is to accelerate the adoption of electric and hybrid vehicles by providing upfront incentives on EV purchases and by developing the necessary EV charging infrastructure.

5. RESEARCH METHODOLOGY

The overall assurance to change from contamination prompting traditional vehicles that sudden spike in demand for petroleum products, to electric vehicles which are without contamination and capable with an electric power supply drawn from sustainable assets, is at last expanding. The rising interest for e-vehicles, their deals, and their significant expansion in numbers, government strategies to advance their use are likewise brought into the spotlight. India's promising e-vehicle plan for 2030 and the means taken to promote electro mobility are likewise surveyed. In comparison to gasoline engines, the cost of fuel is almost completely reduced, and current developments make it easier to charge electric cars. DC fast charging is currently the fastest way to charge electric automobiles. In order to drive carbon-free, EV owners can also combine solar panels and home charging stations. However, it's getting simpler than ever to charge an EV at a public station even without a charging station at home.

5.1 TOPSIS METHOD

The TOPSIS (A Technique for order preference by similarity to an ideal solution) was first developed by Hwang & Yoon (1981). In this technique, two counterfeit alternatives are characterized as positive-ideal and negative-ideal solutions. The positive ideal arrangement (PIS) is an answer that expands the benefit criteria and minimizes the cost criteria, though the negative ideal arrangement (NIS) maximizes the cost criteria and minimizes the benefit criteria. In this research work, for doing the presentation assessment and positioning of the best choices of electric vehicles, a coordinated TOPSIS strategy has been proposed. The schematic chart of the means engaged with the proposed strategy is introduced in Fig. 1. The technique manages the determination of models utilizing TOPSIS and figuring out the best choices utilizing this strategy.

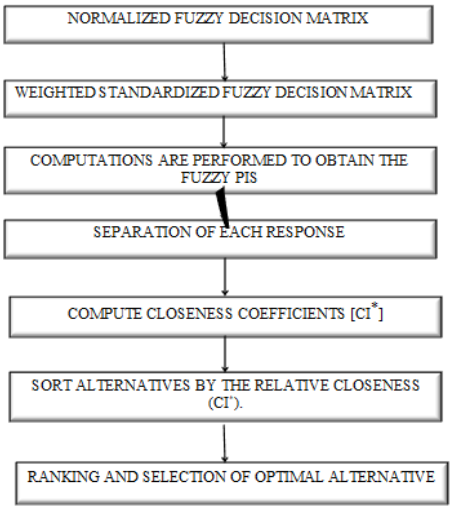


Figure 5.1: Phase of TOPSIS Method

6. Analysis

6.1 DATA COLLECTION

The study's goal is to rate and prioritise key criteria and options for electric vehicles. First, six criteria have been identified based on buyers' preferences when choosing an electric vehicle from the extensive literature review. As was previously mentioned, the TOPSIS approach was used to prioritise these criteria. The market then offers a variety of electric vehicle alternatives. The TOPSIS approach has been used to rank each possibility. Each criterion was scored, and inputs from professionals in the field were used to create the pair-wise comparison matrix**.**

6.2 SAMPLE SELECTION

In order to lessen biases and more accurately generalize the results of this study, a diverse group of specialists was chosen for the sample. People who are already interested in importing electric automobiles for personal usage from India make up the sample population. These people are regarded as technophiles and were well-informed about technological factors when choosing an electric vehicle. 35 people have been contacted to take part in our case study. However, fifteen people declined our invitation because they were short on time or had other obligations. Finally, 20 people with strong ties to technological advancements in the automobile industries took part in our study. These people work in a range of fields, including consulting, research, and the private, public, and semi-public spheres as well as non-governmental organizations (NGOs).

Table 5.1 Alternatives of electric vehicles available.

Alternatives	Criteria				
	Driving Range	Battery Capacity(KWh)	Price(Lakh Rs.	Seating Capacity	Charging Time(Hrs.)
Mahendra E Verito (P1)	140	18.55	10.17	5	11.3
Tata Tigor EV Xm (P2)	213	21.5	14.46	5	11.5
Tata Nexon EV Prime 2020 (P3)	312	30.2	14.99	5	8.5
MGZS EV (P4)	340	44.5	22.58	5	16
Hyundai Kona Electric (P5)	452	39.2	23.84	5	6.1

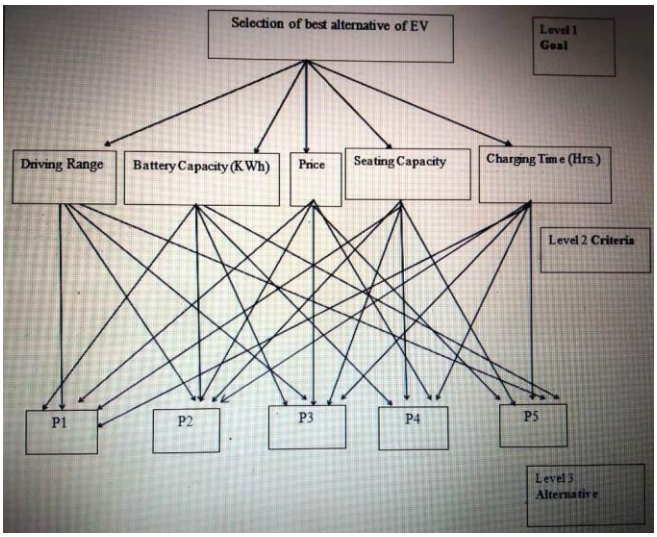


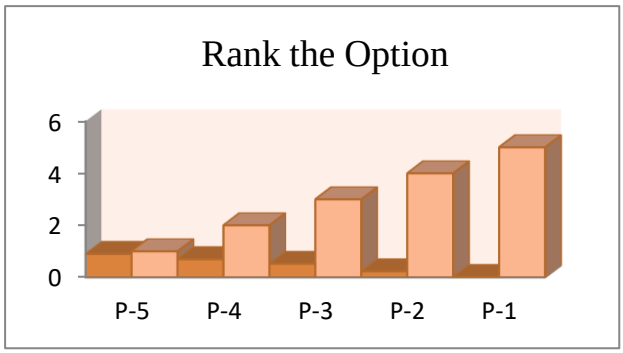
Figure 5.2: Electric vehicle selection criteria in a hierarchical structure

Table 5.2: Ideal best and ideal worst calculations

Attributes	s+	s-	s+ + s-	Ci
P-1	0.619	0.01	0.629	0.016
P-2	0.177	0.0529	0.2299	0.230
P-3	0.11	0.118	0.228	0.518
P-4	0.071	0.164	0.235	0.698
P-5	0.022	0.22	0.242	0.9

Table 5.3: Rank the options

Attributes	Ci	Rank
P-5	0.9	1
P-4	0.698	2
P-3	0.518	3
P-2	0.230	4
P-1	0.016	5



6. CONCLUSION

The majority of buyers are still having trouble deciding which electric vehicle best suits their needs based on a variety of performance metrics, including driving range, battery capacity, and other factors. This research work uses TOPSIS to rank several electric vehicle options now on the market and to prioritise key performance criteria. The TOPSIS technique enables researchers to record both concrete and abstract criteria of challenging real-world issues. Six criteria in total were found in the literature, and phase 1 of the ranking method took into account six choices. TOPSIS was used to determine the weights assigned to each criterion, and the results suggest that experts prioritised driving range over price as the most important criteria. The MCDM approach has been used in phase 2 to rank the numerous EV segment choices according to various performance parameters. The study's findings indicate that the Hyundai Kona received the greatest performance rating and was thus chosen as the finest option out of all those considered. Tata Tigor excels when pricing is taken into account when deciding to buy a car for someone seeking a bargain. This study contributes by outlining a genuine preference for a broad range of selection criteria and evaluating how to choose the finest electric car out of those that are on the market. For EV makers, this study can help focus on consumer purchasing habits and optimise crucial performance metrics for electric cars. This research work can serve as a manual for EV engineers who want to include consumer preferences in their designs. Assessing their benchmarks might also be beneficial for low-performing EVs. The journal article finishes on a hopeful note, predicting that in the far future, proposals for electro mobility and renewable energy production will result in a pollution-free atmosphere.

7 .LIMITATIONS AND FUTURE WORK

This study contributes by outlining a genuine preference for a wide range of selection criteria and by analysing how to choose the best electric vehicle out of those that are on the market. To improve key performance indicators for electric vehicles, manufacturers may find it advantageous to concentrate on client purchasing preferences. Also, this work can serve as a template for EV engineers to use when incorporating user preferences into EV design. It can also be useful for low-performing EVs to evaluate their standards. The policy-makers may use it as a stepping stone to concentrate on significant EV selection criteria and customer preferences. The government can also consider constructing more infrastructures to promote EVs in more efficient ways. Governments at the federal, state, and local levels should concentrate on incentives and subsidies to encourage the use of EVs across the nation. At the same time, institutional and programmatic support is crucial at the national level for allocating resources to the development and use of EVs. The findings in this study cannot be applied to other parts of India. Future research should examine customers from various parts of India to generalize the results. The methodology utilized in this study can also serve as a model for its replication in other countries.

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