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A comparative analysis of electric vehicle attributes for consumer decision-making

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Abstract
due to the electric vehicle (ev) market's explosive expansion, buyers now have an abundance of options, each with unique qualities that can greatly affect their choice. This essay compares and contrasts five different electric car models, emphasising important characteristics including peak speed, battery capacity, range, and charging time. The study rates and assesses these models using waspas and topsis approaches to help potential purchasers make well-informed choices. The results show that while both approaches produce reliable rankings, differences draw attention to the subtle differences in the order of each model's features. With the help of this dual-method approach, which provides a thorough assessment framework, customers may make decisions that balance convenience, affordability, and performance.

Keywords: Electric vehicles, comparative analysis, consumer decision-making, waspas, topsis, multi-criteria decision-making (mcdm), vehicle attributes, sustainability

Introduction:

The last decade has shown a substantial expansion within the ev(electric vehicle) market. This flourishing growth is primarily driven by ongoing research and advancements in battery technology, a growing sense of environmental awareness around the globe, and government policies that encourage the manufacturing of evs. According to the international energy agency (iea) (iea, 2023), global ev sales reached approximately 7 million units in 2022, marking a 60% increase from the previous year (marzouk, o. A. (2025). This upward trajectory reflects a broader shift towards eco-friendly transportation alternatives aimed at reducing greenhouse gas emissions and mitigating the impacts of climate change (hawkins et al., 2013). As the ev market continues to expand, consumers are presented with a diverse array of choices, each offering unique features that may influence their decision-making process.

This research seeks to provide a comparative analysis of various electric car models to assist prospective customers in making informed decisions. By evaluating key factors such as price, charging infrastructure, performance, and driving range, the study aims to offer insights into important aspects that could influence buyers' choices.. The chosen vehicles for comparison offer a comprehensive insight into the variety of options available in the market, representing different sectors and price ranges within the electric vehicle (ev) industry.

It is crucial for consumers seeking a balance between performance, cost, and convenience to understand the unique features of various ev models. A detailed comparative analysis enables buyers to make informed decisions that can enhance their overall satisfaction and support the transition to sustainable transportation, while also aiding in the selection of the most suitable vehicle based on individual preferences (balcioglu, y. S. Et al., 2024). As the ev sector continues to evolve, clear and practical information on car attributes will become increasingly vital for current and prospective ev buyers.

Literature review:

When considering the influence on consumer decision-making within the electric vehicle sector, a few essential factors such as range, battery capacity, peak speed, and charging time play a crucial role. The range stands out as a significant aspect affecting consumer choices in the electric vehicle market, as it directly impacts the utility and appeal of an electric vehicle based on the distance it can travel on a single charge. Egbue and long (2012) note that consumers often link a greater range with enhanced convenience and reduced range anxiety. Research indicates that range anxiety, which refers to the concern that an electric vehicle will run out of battery power before reaching a charging station, serves as a key obstacle to the widespread adoption of electric vehicles (pevec, d., et al., 2019). Therefore, to ensure that electric vehicles meet both daily driving needs and long-distance travel requirements, manufacturers and consumers give high priority to the range factor (pearre, n. S et al., 2011). The extent and overall efficiency of an electric vehicle (ev) are directly associated with the size of its battery. Enhanced driving ranges and better vehicle performance are typically achieved through larger battery capacities (koech, a. K., et al., 2024). Consumers perceive higher battery capacity as a symbol of advanced technology and reliability, impacting their purchasing choices (dutta, b., & hwang, h. G., 2021). Research demonstrates that as battery capacity increases, the overall vehicle efficiency improves, acceleration is faster, and driving range expands (tran, m. K., et al., 2021). Additionally, top speed is a crucial factor, particularly for performance-oriented customers. The consideration of high-performance electric vehicles is influenced by the fact that higher maximum speeds often lead to superior driving experiences (khan m.a., 2025). While not as critical as range or battery capacity, top speed can influence consumer choices, especially in the luxury and sports segments of the ev market (hawkins et al., 2013). Performance metrics, including top speed, play a role in differentiating vehicles and can sway consumer preferences towards models that offer a more exhilarating driving experience. Charging time is a practical consideration that affects the convenience of owning an ev. Shorter charging times can significantly improve the user experience by reducing wait times and increasing vehicle usability (fabianek, p., & madlener, r., 2023). The development of fast-charging technologies has been a key focus for manufacturers, with the aim of making evs more competitive with traditional vehicles in terms of refueling convenience (zentani, a et al., 2024). For consumers, faster charging can alleviate concerns about the time investment required to recharge and can make evs a more viable option for daily use and long-distance travel (wang, z. Et al., 2024).

Thus, range and battery capacity directly impact an ev's practicality and performance, addressing concerns related to usability and reliability. Top speed caters to performance-oriented consumers, while charging time addresses convenience and operational efficiency. Understanding these attributes helps consumers make informed choices, ensuring that the selected ev aligns with their preferences and needs (egbue & long, 2012; pearre, n. S. Et al., 2011; zentani, a et al., 2024).

Methodology:

To conduct a thorough comparative analysis of electric vehicle attributes, data were meticulously collected from a variety of reliable sources. The primary focus was on four key attributes: Range, battery capacity, top speed, and charging time. Waspas, which integrates the weighted sum model (wsm) and the weighted product model (wpm), enhances decision accuracy by combining both additive and multiplicative methods (chakraborty, s.,.et al., 2024). Topsis is renowned for its ability to determine the best alternative by comparing the geometric distance of each alternative from an ideal solution and a negative-ideal solution (das, k., & kumar, r.,2023). Topsis excels in identifying the most balanced option that is closest to the ideal solution and furthest from the least favorable option, making it highly effective in scenarios where the trade-offs between different criteria need to be clearly understood. The combination of these methodologies has been successfully applied in various fields, demonstrating their effectiveness in enhancing decision-making accuracy and reliability. By integrating waspas and topsis, decision-makers can leverage the strengths of both techniques to arrive at more precise and well-rounded conclusions, particularly in complex and multi-faceted evaluation scenarios like those involving electric vehicles (sokolović, j., et al.,2021).

The process began with identifying authoritative sources such as manufacturer specifications, industry reviews, and technical reports. These sources provided detailed and up-to-date information on each electric vehicle model under study. For each model, the range, battery capacity, top speed, and charging time data were extracted and recorded. The range was documented as the maximum distance a vehicle can travel on a single charge, reflecting its usability and convenience. Battery capacity, which influences both range and vehicle performance, was noted in kilowatt-hours (kwh). Top speed, recorded in miles per hour (mph), was included to assess the vehicle's performance capabilities. Charging time, measured in minutes required to charge the battery from 10% to 80%, was documented to evaluate the efficiency and practicality of the charging process.

Data collection involved cross-referencing information from multiple sources to ensure accuracy. For each attribute, data were verified through comparison with independent reviews and technical assessments to resolve any discrepancies. This rigorous approach ensured that the data documented in the matrix were both accurate and reliable, providing a solid foundation for the subsequent comparative analysis of the electric vehicle models.

The data compiled is shown in table 1.

Table 1

Model	Range (miles)	Battery capacity (kwh)	Top speed (mph)	Charging time (10-80%) (minutes)
Model b	324	105.2	124	34
Model c	450	200	120	35
Model h	361	77	115	18
Model l	516	118	168	22
Model m	352	107.8	130	31

To rank the alternatives using the waspas methodology, the data is first normalized to ensure that all criteria are on a comparable scale. For beneficial criteria such as range, battery capacity, and top speed (where higher values are preferable), normalization is done by dividing each value by the maximum value within that criterion. Conversely, for the non-beneficial criterion, charging time (where lower values are preferable), normalization is achieved by dividing the minimum value by each respective value. Once the data is normalized, the weighted sum model (wsm) and the weighted product model (wpm) are applied. The wsm score for each alternative is calculated by multiplying the normalized value of each criterion by its respective weight and then summing these products across all criteria. This approach effectively aggregates the weighted performance of each alternative across all criteria. The wpm score, on the other hand, is calculated by taking the product of the normalized values raised to the power of their respective weights. This multiplicative approach reflects the interaction among criteria, emphasizing the relative performance of each alternative in a non-linear manner.

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Finally, the overall waspas score for each alternative is determined by combining the wsm and wpm scores using weightage average of with the typical coefficient of 0.5. The alternatives are then ranked based on their final waspas scores, with the highest score indicating the best overall performance according to the selected criteria. This approach provides a robust and comprehensive evaluation of the alternatives, accounting for both additive and multiplicative interactions among criteria. Table 2 represents the calculated values and rank by waspas method.

Table 2: Waspas score and ranking

Model	Range (miles)	Battery capacity (kwh)	Top speed (mph)	Charging time (10-80%) (minutes)	Wsm	Wpm	Score	Rank
Model b	0.6279	0.526	0.7381	0.5294	0.6053	0.5994	0.6024	5
Model c	0.8721	1	0.7143	0.5143	0.7751	0.7523	0.7637	2
Model h	0.6996	0.385	0.6845	1	0.6922	0.6553	0.6738	3
Model l	1	0.59	1	0.8181	0.852	0.8335	0.8428	1
Model m	0.6822	0.539	0.7738	0.5806	0.6439	0.6375	0.6407	4

To rank alternatives using the topsis (technique for order preference by similarity to ideal solution) method, the data must first be normalized to create a comparable scale across all criteria. This is done by dividing each value by the square root of the sum of the squares of all values in that criterion. This normalization process ensures that all criteria, regardless of their original units, are standardized for fair comparison.

Once normalized, the weighted normalized matrix is calculated by multiplying each normalized value by its respective criterion weight. This weighted matrix reflects the relative importance of each criterion in the decision-making process.

Next, the positive ideal solution (pis) and negative ideal solution (nis) are identified. The pis represents the best possible value for each criterion (the maximum for beneficial criteria and the minimum for non-beneficial criteria), while the nis represents the worst possible value (the minimum for beneficial criteria and the maximum for non-beneficial criteria).

The distance of each alternative to the pis (denoted as dj+) and the distance to the nis (denoted as dj−) are then calculated using euclidean distance. The distance to the pis shows how far an alternative is from the ideal (best) solution, and the distance to the nis shows how far it is from the least desirable (worst) solution.

Finally, the relative closeness degree of each alternative to the ideal solution is calculated. This is determined by dividing the distance to the nis by the sum of the distances to the pis and nis. The closer the value is to 1, the closer the alternative is to the ideal solution, making it more desirable. Alternatives are then ranked based on their relative closeness degree, with the highest, indicating the best overall option.

Table 2: Topsis ranking

Model	Range (miles)	Battery capacity (kwh)	Top speed (mph)	Charging time (10-80%) (minutes)	Dj +	Dj -	Pi *	Rank
Model b	0.0890	0.0915	0.1044	0.1319	0.1217	0.0259	0.1758	5
Model c	0.1236	0.1740	0.1010	0.1358	0.0794	0.1125	0.5861	1
Model h	0.0991	0.0670	0.0968	0.0698	0.1235	0.0667	0.3507	3
Model l	0.1417	0.1026	0.1414	0.0853	0.0730	0.0927	0.5593	2
Model m	0.0967	0.0938	0.1094	0.1203	0.1097	0.0343	0.2383	4
Pis	0.1417	0.1740	0.1414	0.0698				
Nis	0.0890	0.067	0.0968	0.1358				

Results and discussion:

The analysis reveals that while both methods provide a consistent framework for evaluating the models, slight variations in rankings highlight the different ways these methodologies prioritize attributes.

Model c emerged as the top-ranked alternative in the topsis method, while it secured the second position in the waspas ranking. This indicates that model c's performance is strongly aligned with the ideal solution when considering the relative closeness to both the positive and negative ideal solutions in topsis. The waspas method, however, which combines both additive and multiplicative approaches, slightly lowers its rank, suggesting that although model c performs exceptionally well overall, it may have marginally lower performance in certain criteria that are weighted differently in the waspas calculation.

Model l is ranked second by topsis and first by waspas, showing that it is consistently a top contender across both methodologies. This consistency indicates that model l's attributes are highly favorable across both weighted sum and weighted product approaches, making it a robust choice for consumers prioritizing a balance of range, battery capacity, top speed, and charging time.

Model h and model m maintain consistent rankings across both methods, with model h securing the third position and model m the fourth. This consistency suggests that these models have a balanced performance across all criteria, without any extreme strengths or weaknesses that would cause significant changes in rank when switching between evaluation methods.

Model b, however, ranks fifth in both methodologies, indicating that it is the least competitive among the evaluated models. This consistent lower ranking suggests that model b may not meet the higher performance thresholds in one or more of the key criteria, making it a less attractive option for consumers who prioritize factors like range, battery capacity, and charging time.

Conclusion:

Waspas and topsis used together, offer a comprehensive and nuanced approach to decision-making. Waspas provides a strong initial ranking that takes into account both additive and multiplicative factors, while topsis refines this ranking by considering the relative distance of each alternative to the ideal and negative-ideal solutions. This dual-method approach is particularly beneficial in the electric vehicle comparison, as it allows for a thorough evaluation of each model's performance across various attributes, leading to a more informed and balanced decision.

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