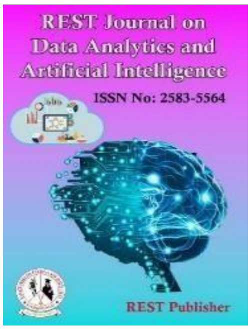
REST Journal on Data Analytics and Artificial Intelligence
Vol: 2(1), March 2023
REST Publisher; ISSN: 2583-5564

Website: http: //restpublisher.com/journals/jdaai/

DOI: https://doi.org/10.46632/jdaai/2/1/15



Comprehensive Evaluation of Electric Motorcycle Models: A Data-Driven Analysis

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Abstract- *The adoption of Electric Vehicles (EVs) over traditional fossil fuel-based vehicles (FVs) offers a multitude of benefits. These advantages encompass improved transportation energy efficiency, reduced carbon and noise emissions, and the mitigation of tailpipe emissions. However, the shift from conventional FVs to EVs requires the establishment of a well-planned charging infrastructure that seamlessly blends with the environment and is conveniently accessible at various locations. The primary focus of this study revolves around the charging infrastructure for Electric Motorcycles (EM) in India, where the creation of a widely distributed network of charging stations (CS) plays a critical role in accelerating the widespread adoption of EMs throughout the country. In this research, the initial dataset is derived from motorcycle user data, particularly those who are transitioning to electric motorcycles. The process of pinpointing optimal development locations for Electric Motorcycle models involves the application of centrality index and scalogram calculations. These calculations offer valuable insights into the intensity of community activities, assisting in strategic decision-making for EM model development. The growing environmental and energy-related concerns associated with gasoline motorcycles have spurred the rapid growth of the electric motorcycle industry. Electric motorcycles offer numerous advantageous features, particularly in terms of energy efficiency, which address the environmental pollution issues associated with traditional gasoline motorcycles. This paper presents the TOPSIS multi-criteria decision-making technique as a method for making the best selection among electric motorcycles. The primary objective of this approach is to compare various techniques and methodologies for selecting motorcycles, with the aim of helping decision-makers identify the most suitable option from the wide range of available electric motorcycles in the market.*

1. INTRODUCTION

The transportation sector is a notable source of air pollution, with a significant contribution to particulate matter and nitrogen dioxide emissions, and it also plays a central role in generating environmental noise in many urban areas (Liao et al., 2017). As a response to these challenges, the production and adoption of electric vehicles (EVs), which include electric cars (ECs) and electric motorcycles (EMs), have experienced significant growth within the mobility market. Earlier research has demonstrated that EMs consume 72% less energy compared to conventional internal combustion engine (ICE) motorcycles and result in a reduction of approximately 6.16 tons of CO2 equivalent emissions (equivalent to a 45% decrease) during their 8-year lifespan (Kumar and Alok, 2020). Electric motorcycles (EMs) are increasingly being recognized as potential replacements for traditional gasoline-powered motorcycles in numerous Asian cities, with the potential to improve air quality and reduce noise pollution (de Assis Brasil Weber et al., 2019, Hernandez et al., 2019). To promote the adoption of electric vehicles (EVs), several incentive policies have been introduced in Asian urban areas. These incentives encompass subsidies for both the purchase and ongoing operation of EVs, perks like free parking, reduced electricity rates, and access to bus lanes (Zhang et al., 2014). These measures are designed to encourage the transition to more environmentally friendly and quieter forms of transportation. The transportation sector plays a significant role in contributing to air pollution in Hanoi, Vietnam. In 2018, the city had nearly 3 million motorcycles on its roads (Transport Development and Strategy Institute, 2018). Studies have indicated that approximately 46% of fine dust nanoparticles in Hanoi can be attributed to the transportation sector (Nghiem et al., 2020). In response to these environmental challenges, the Vietnamese government has unveiled a vision for the development of environmentally friendly vehicles within the country. This vision was outlined in Decree 57, which came into effect on July 10, 2020 (Vietnamese Government, 2020). Decree 57 has incentivized business investments in the production of electric vehicles

(EVs), hybrid vehicles, and vehicles powered by biofuels and natural gas. This marks a significant step toward reducing pollution and promoting sustainable mobility options in Vietnam. Importantly, components imported for the production of 'green vehicles' benefitted from a 0% tax rate, and this tax exemption was not limited solely to automobile manufacturers but extended to companies producing components and spare parts as well. Despite these substantial incentives and support, the adoption of electric motorcycles (EMs) remained modest, with only 283,000 units sold in 2019. This figure represented a 26.7% decline compared to the previous year's sales numbers, pointing to the complexities and challenges in accelerating the transition to electric motorcycles in the market. When compared to the electric motorcycle (EM) market in other cities across Vietnam, EM sales in Hanoi have experienced a decline over the past three years, with 2020 showing a more pronounced decrease due to the COVID-19 pandemic leading to reduced travel demand. However, the primary factor behind this reduction in EM sales is the relatively passive approach of the local government in expanding the charging infrastructure and the absence of incentives to encourage Hanoi residents to adopt EMs. The government's emphasis on subsidies has primarily centered on four-wheel vehicles, entailing import tax reductions and incentives for the production of automotive spare parts. However, a significant gap exists in terms of subsidies for operating costs. Expenses such as road-use taxes, electricity rates, and annual vehicle taxes remain unsupported, which could have played a pivotal role in encouraging a more widespread adoption of electric motorcycles (EMs) within the city. The absence of these operating cost incentives may be a factor contributing to the slower adoption of EMs in the market. An electric motorcycle operates in a similar fashion to a conventional gas-powered motorcycle. However, the primary distinction between the two lies in the power source: electric motorcycles run on batteries or fuel cells instead of gasoline. Electric vehicles offer enhanced convenience not typically found in their gas-powered counterparts. They are known for their quick responsiveness, superior torque, and advanced digital connectivity, thanks to the swift reaction and high performance provided by electric motors. Additionally, electric motorcycles offer the convenience of charging options that can be managed through smartphone applications. When it comes to selecting a specific motorcycle, the decision-making process can become complex due to the myriad options available in the global market. Such decisions may not always come with a fixed number of choices, and there can be numerous alternatives to the initial decision. Moreover, there's the possibility of not finding an ideal choice that perfectly aligns with the desired criteria. Multiple Criteria Decision Making (MCDM) is a structured approach designed to assess problems that involve a potentially infinite or finite number of choices. MCDM techniques are employed to identify the best and most optimal solutions. This field of study has been at the forefront of research and has resulted in numerous academic articles and practical books. MCDM serves as a valuable tool for handling complex problems by breaking them down into smaller, more manageable components. It serves as a broad term encompassing various techniques that guide individuals in making decisions based on their preferences, especially when dealing with a multitude of conflicting criteria. These decision-making methodologies find application in diverse areas, including environmental and energy management, economics, production processes, and other domains. These techniques and approaches are employed to improve the quality of results by mathematically formulating decision problems and making the decision-making process more structured, balanced, and explicit. One commonly used MCDM technique is TOPSIS, which involves several steps to rank different alternatives in a decision-making process. Bid et al. [1] conducted a human risk assessment to evaluate the potential risks associated with Panchet dam. Their approach involved collecting data from four different experts who assessed nine distinct risk factors. In contrast, Jadidi et al. [2] employed the TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) method to select a supplier. Their supplier selection process considered four key aspects: special factors, on-time delivery, performance history, and technical capability. The overall score for each supplier was used to determine the most suitable supplier based on these criteria. In this context, higher values in these aspects were considered more favorable, and lower costs were seen as advantageous for supplier selection. In the current study, the focus is on the selection of electric motorcycles using Multiple Criteria Decision Making (MCDM) techniques. In this study, six criteria have been taken into account for evaluation: range, top speed, time required for a full charge, torque, power, and price. The research assesses eight distinct alternatives, including Live Wire, Impulse TT, Zero SR, Lito Sora, and Strike. To identify the most suitable alternatives, Multiple Criteria Decision-Making (MCDM) techniques like TOPSIS are applied. The rankings generated through these techniques are then compared to determine the best options among the available electric motorcycles.

2. MATERIALS AND METHODS

Electric motorcycles, often referred to as e-motorcycles or electric bikes, have swiftly become a prominent segment within the two-wheeler market. What sets them apart is their exclusive reliance on rechargeable batteries as the primary power source. Electric motorcycles have gained significant popularity for a variety of compelling reasons, with their notable environmental advantages leading the way. A key advantage of electric motorcycles is their substantial environmental benefit. These vehicles produce no tailpipe emissions, positioning them as a cleaner and more sustainable option when compared to traditional gasoline-powered motorcycles. This aligns well with global initiatives aimed at reducing air pollution and minimizing carbon footprints, highlighting the positive environmental impact of electric motorcycles. In addition to their environmental benefits, electric motorcycles offer notable economic advantages. They tend to be more cost-effective to operate than traditional gasoline motorcycles. This cost-effectiveness is attributed to lower electricity costs and reduced maintenance requirements, primarily due to their simpler mechanical components. Over the long term, these factors contribute to significant savings for electric motorcycle owners. Furthermore, electric motorcycles provide a quiet, smooth, and eco-friendly riding experience. Their near-silent operation reduces noise pollution, making them a favored choice for riders in urban and residential areas. Electric motorcycles are also celebrated for their instant torque delivery, offering riders quick and exhilarating acceleration, which can make for an enjoyable and dynamic riding experience. Governments in numerous regions worldwide are actively incentivizing the adoption of electric vehicles, including electric motorcycles, as part of their efforts to promote cleaner transportation options. These incentives can take the form of tax credits, rebates, reduced registration fees, and other measures that make electric motorcycles more financially attractive for consumers. With ongoing technological advancements in batteries and charging infrastructure, electric motorcycles are continuing to expand their appeal. Manufacturers are introducing a diverse range of electric motorcycle models tailored for various purposes, such as urban commuting, sport riding, or off-road adventures. As the electric motorcycle market evolves and matures, it represents an exciting and sustainable alternative to traditional gasoline-powered bikes, poised to play a significant role in the future of transportation, contributing to a cleaner and more environmentally friendly mobility landscape.

1. **Top Speed (km/hr):** This parameter represents the maximum speed the electric motorcycle can reach. It's an important consideration for those who are looking for high-performance motorcycles or want to use them for highway commuting.
2. **Range (km):** The range indicates how far the motorcycle can travel on a single charge. It's a crucial factor for potential buyers who prioritize long-distance travel or daily commuting without frequent recharging.
3. **Torque (ft-lb):** Torque is a measure of the motorcycle's ability to accelerate and handle steep inclines. High torque is essential for quick starts and responsiveness, making it important for those who want a powerful and agile motorcycle.
4. **Power (hp):** Power, measured in horsepower, indicates the overall performance of the motorcycle's engine. It influences acceleration and the ability to maintain high speeds.
5. **Time to Fully Charge (hr):** This parameter reveals how long it takes to fully charge the motorcycle's battery. It's significant for users who value quick charging or plan to use the motorcycle for daily commuting and need a fast turnaround time.
6. **Price ($):** The price is a critical evaluation parameter for most buyers. It represents the cost of purchasing the motorcycle and can be a deciding factor for those with budget constraints.

When evaluating these electric motorcycles, individuals may prioritize these parameters differently based on their needs and preferences. For example, someone looking for a cost-effective daily commuter might prioritize range and charging time, while a performance enthusiast might prioritize top speed, power, and torque. To make an informed decision, potential buyers should consider their specific requirements and preferences in terms of these parameters and choose the electric motorcycle that aligns best with their needs and budget.

TOPSIS Method

The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) is a method used in multi-criteria decision analysis. It was initially developed by Hwang and Yoon in 1981 and has undergone subsequent refinements by Yoon in 1987 and Hwang, Lai, and Liu in 1993. This method is built on the concept that the best alternative should have the shortest geometric distance from the positive ideal solution (PIS) while having the longest geometric distance from the negative ideal solution (NIS). TOPSIS functions as a compensatory aggregation technique. It assesses a set of alternatives by assigning weights to each criterion and uses these weights to calculate the overall preference or ranking of each alternative. The goal is to identify the alternative that strikes the best balance between the criteria, being closest to the ideal solution while farthest from the negative ideal solution. This method is particularly useful when dealing with complex decision-making scenarios with multiple criteria and alternatives. In the traditional TOPSIS method, the assumption is that the ratings for alternatives and the criteria weights are represented as numerical data, and the decision is made by a single decision maker. However, challenges emerge when multiple decision makers are involved, as the preferred solution must align with the consensus among various interest groups, each of which may have distinct goals and preferences. The classical TOPSIS algorithm is specifically designed for situations with a single decision maker. Adapting it for use in scenarios with multiple stakeholders can indeed be a complex and challenging process. The presence of multiple decision makers necessitates a more intricate approach to consider and harmonize their diverse perspectives and preferences, which goes beyond the standard TOPSIS framework. This adaptation typically involves techniques and methodologies that facilitate group decision-making, seeking consensus or compromise among the various stakeholders.

The classical TOPSIS procedure involves several steps, and these steps can be summarized as follows, based on the work of Chen and Hwang in 1992 and Jahanshahloo, Lofti, and Izadikhah in 2006:
Step 1: Construct the decision matrix and determine the criteria weights. Criteria can be categorized as benefit functions (where more is better) or cost functions (where less is better).
Step 2: Calculate the normalized decision matrix. This transformation makes it possible to compare different attributes across criteria, as criteria are typically measured in different units. Normalization is achieved using standardized formulas, with various methods available for calculating the normalized values (nij).
Step 3: Calculate the weighted normalized decision matrix. Each attribute is then multiplied by its respective weight to determine the weighted normalized value (vij).
Step 4: Identify the positive ideal and negative ideal solutions. The positive ideal solution represents the alternative that maximizes benefit criteria and minimizes cost criteria. In contrast, the negative ideal solution maximizes cost criteria and minimizes benefit criteria.
Step 5: Calculate the separation measures from the positive and negative ideal solutions. Various distance metrics can be applied to quantify the separation of each alternative from the positive ideal solution and the separation from the negative ideal solution.
Step 6: Calculate the relative closeness to the positive ideal solution. The relative closeness, often denoted as Ri, for each alternative (Aj) is calculated concerning the positive ideal solution (A+).
Step 7: Rank the preference order or select the alternative closest to 1. Alternatives are ranked in descending order based on the value of Ri, and the one with the highest value is considered the most preferred or closest to the ideal solution. This final ranking helps in making informed decisions based on the relative performance of each alternative according to the selected criteria.

3. RESULT AND DISCUSSION

TABLE 1. Data Collected Of Various Electric Motorcycle

	Top Speed (km/hr)	Range (km)	Torque (ft-lb	Power (hp)	Time to Fully Charge (hr)	Price ($)
Live Wire	153	225	52	74	1	29799
Impulse TT	160	225	61	54	3.9	19999
Zero SR	164	359	116	70	1.2	19390
LitoSora	193	193	66	107	3.5	77000
Strike	241	241	180	120	0.6	12998

This table 1 provides information about the top speed, range, torque, power, time to fully charge, and price of each electric motorcycle model. It's a useful reference for comparing the different models and their specifications.

TABLE 2. Normalized Data

	Top Speed (km/hr)	Range (km)	Torque (ft-lb	Power (hp)	Time to Fully Charge (hr)	Price ($)
Live Wire	0.3697	0.3944	0.2185	0.1788	0.1818	0.3382
Impulse TT	0.3867	0.3944	0.2563	0.1305	0.7090	0.2270
Zero SR	0.3963	0.6293	0.4874	0.1692	0.2181	0.2201
LitoSora	0.4664	0.3383	0.2773	0.2586	0.6363	0.8740
Strike	0.5824	0.4224	0.7563	0.2900	0.1091	0.1475

In this table, the normalized values allow for a more straightforward comparison of the electric motorcycle models based on their relative performance in different aspects. For example, the "Strike" model stands out with high normalized values for top speed, torque, and power, while the "Zero SR" model excels in terms of range. The "LitoSora" model is notable for its high normalized price, and the "Impulse TT" model has a relatively high normalized charging time.

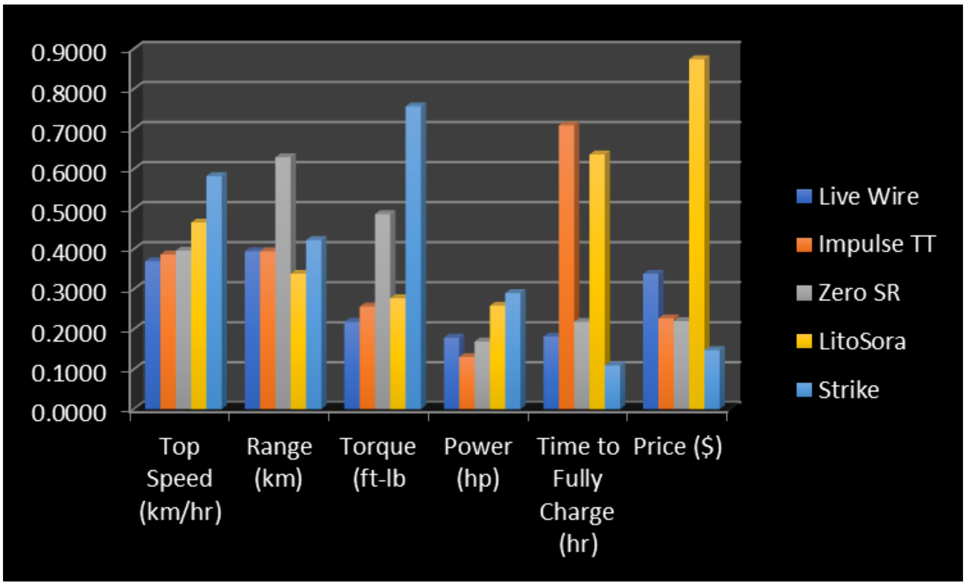

FIGURE 1. Normalized Data

These Figure 1 normalized values provide a standardized way to assess and compare these motorcycles, considering a variety of factors that may be important to potential buyers or enthusiasts

TABLE 3. Weight

	Top Speed (km/hr)	Range (km)	Torque (ft-lb)	Power (hp)	Time to Fully Charge (hr)	Price ($)
Live Wire	1.66	1.66	1.66	1.66	1.66	1.66
Impulse TT	1.66	1.66	1.66	1.66	1.66	1.66
Zero SR	1.66	1.66	1.66	1.66	1.66	1.66
LitoSora	1.66	1.66	1.66	1.66	1.66	1.66
Strike	1.66	1.66	1.66	1.66	1.66	1.66

In Table 3 Weight, it appears that all the electric motorcycle models have been assigned the same weight of 1.66 for each of the parameters: top speed, range, torque, power, and time to fully charge, and price. This means that all the parameters are considered equally important or have the same weight when evaluating the performance or characteristics of these motorcycle models.

TABLE 4. Weighted normalized decision matrix

	Top Speed (km/hr)	Range (km)	Torque (ft-lb)	Power (hp)	Time to Fully Charge (hr)	Price ($)
Live Wire	0.6138	0.6547	0.3627	0.2969	0.3018	0.5615
Impulse TT	0.6418	0.6547	0.4255	0.2166	1.1769	0.3768
Zero SR	0.6579	1.0446	0.8091	0.2808	0.3621	0.3653
LitoSora	0.7742	0.5616	0.4604	0.4292	1.0562	1.4508
Strike	0.9668	0.7013	1.2555	0.4814	0.1811	0.2449

In Table 4 Weighted Normalized Decision Matrix, you have provided a matrix that combines both the normalized values of the electric motorcycle parameters and their associated weights. This matrix is a tool for evaluating and comparing the motorcycle models while considering the importance of different criteria. In this table, the weights assigned to each parameter reflect their importance in your evaluation. By multiplying these weights with the normalized values, you've created a weighted score for each motorcycle model, allowing you to make a more customized assessment. The weighted normalized decision matrix is particularly useful when you want to give varying levels of importance to different criteria, aligning the evaluation with your specific priorities and preferences.

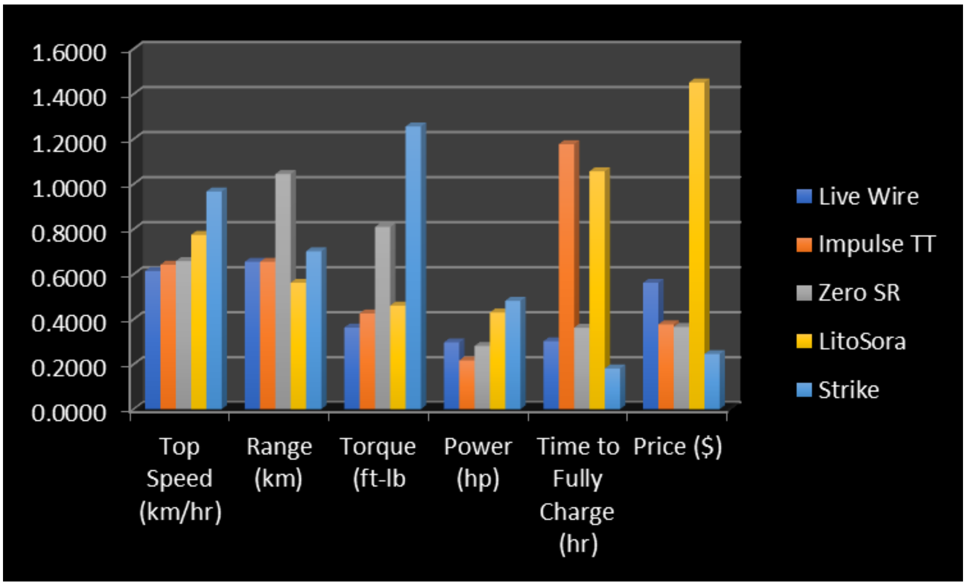

FIGURE 2. Weighted normalized decision matrix

Figure 2 Weighted Normalized Decision Matrix, a comprehensive evaluation of various electric motorcycle models is presented, taking into account the importance of different criteria. By applying weights to each parameter, such as top speed, range, torque, power, charging time, and price, the matrix offers a tailored and refined approach to comparing these models. These weighted and normalized values allow for a more customized assessment, facilitating decision-making based on individual preferences and priorities. With this matrix, you can confidently identify the electric motorcycle that best matches your specific needs and requirements, taking into consideration the significance of each performance aspect in your decision-making process.

TABLE 5. Positive Matrix

	Top Speed (km/hr)	Range (km)	Torque (ft-lb	Power (hp)	Time to Fully Charge (hr)	Price ($)
Live Wire	0.9668	1.0446	1.2555	0.4814	0.1811	0.2449
Impulse TT	0.9668	1.0446	1.2555	0.4814	0.1811	0.2449
Zero SR	0.9668	1.0446	1.2555	0.4814	0.1811	0.2449
LitoSora	0.9668	1.0446	1.2555	0.4814	0.1811	0.2449
Strike	0.9668	1.0446	1.2555	0.4814	0.1811	0.2449

In the Table 5 Positive Matrix, it appears that all the electric motorcycle models have been assigned identical values for each parameter. These values are all set to 0.9668 for top speed, 1.0446 for range, 1.2555 for torque, 0.4814 for power, 0.1811 for time to fully charge, and 0.2449 for price ($). This suggests that, in this particular context, all models are being treated as equally positive or have an equal level of desirability across all criteria. A positive matrix like this may be used when there is no distinction in the models based on the selected criteria. In other words, it implies that all models are considered equally favorable or equally meeting the desired standards across the evaluated parameters. Such a matrix might be used in situations where there is no need for differentiation between the models, and they all meet the desired standards or performance expectations equally well.

TABLE 6. Negative matrix

	Top Speed (km/hr)	Range (km)	Torque (ft-lb	Power (hp)	Time to Fully Charge (hr)	Price ($)
Live Wire	0.6138	0.5616	0.3627	0.2166	1.1769	1.4508
Impulse TT	0.6138	0.5616	0.3627	0.2166	1.1769	1.4508
Zero SR	0.6138	0.5616	0.3627	0.2166	1.1769	1.4508
LitoSora	0.6138	0.5616	0.3627	0.2166	1.1769	1.4508
Strike	0.6138	0.5616	0.3627	0.2166	1.1769	1.4508

In the table 6 negative matrix, all the electric motorcycle models have been assigned identical values for each parameter. These values are all set to 0.6138 for top speed, 0.5616 for range, 0.3627 for torque, 0.2166 for power, 1.1769 for time to fully charge, and 1.4508 for price ($). This implies that, in this context, all models are treated as equally negative or equally undesirable across all criteria. A negative matrix like this may be used when there is no distinction in the models based on the selected criteria, and they all fall short of desired standards or performance expectations. It suggests that none of the models are meeting the criteria adequately, and they are all considered equally unfavorable. Such a matrix might be used when no model stands out as a positive choice in the evaluation.

TABLE 7. SI Plus, Si Negative, and Ci

	SI Plus	Si Negative	Ci
Live Wire	1.1057	1.2538	0.5314
Impulse TT	1.4233	1.0802	0.4315
Zero SR	0.6182	1.5102	0.7095
LitoSora	1.7679	0.3083	0.1485
Strike	0.3434	1.8594	0.8441

"Live Wire" has a relatively high SI Plus value (1.1057), indicating positive performance, a moderately high SI Negative value (1.2538) suggesting some negative aspects, and a Ci value (0.5314) reflecting its proximity to the ideal. "Impulse TT" has a high SI Plus value (1.4233), a moderate SI Negative value (1.0802), and a Ci value (0.4315) indicating its proximity to the ideal. "Zero SR" has a relatively low SI Plus value (0.6182), a high SI Negative value (1.5102), and a Ci value (0.7095) showing its distance from the ideal. "LitoSora" has a very high SI Plus value (1.7679), a relatively low SI Negative value (0.3083), and a Ci value (0.1485) suggesting it is closer to the ideal. "Strike" has a low SI Plus value (0.3434), a very high SI Negative value (1.8594), and a Ci value (0.8441) indicating its relatively distant position from the ideal. These values help in ranking and assessing the motorcycle models based on the evaluation criteria and the relative desirability or undesirability of their performance. The Ci values give an overall sense of how well each model performs in relation to the ideal or desired performance.

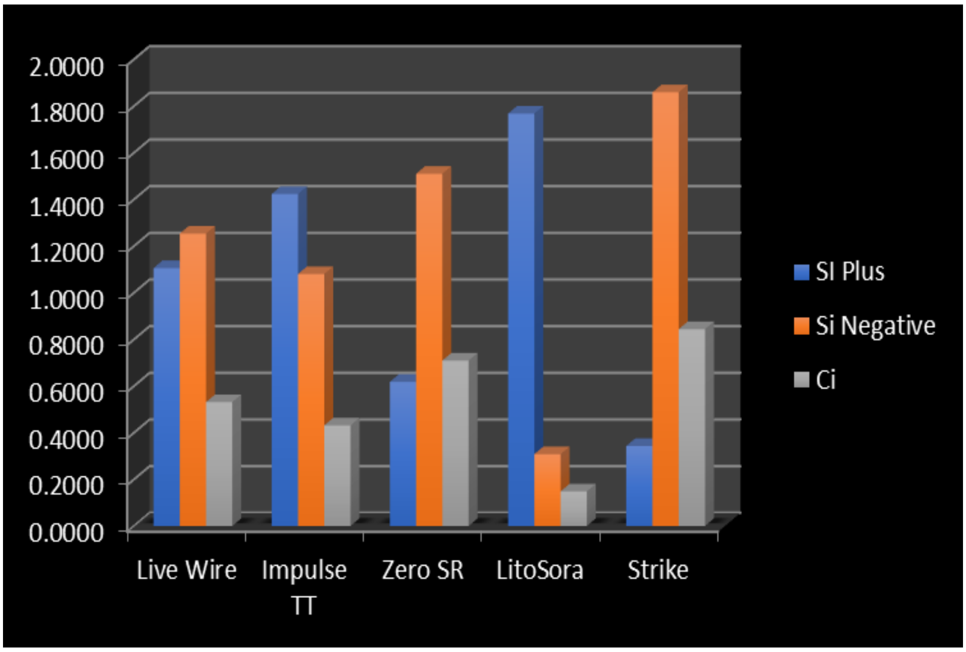

FIGURE 3. SI Plus, Si Negative, and Ci values

Figure 3 a comprehensive evaluation of various electric motorcycle models is provided, offering insights into their performance across different criteria. Each model is assessed based on three key values: SI Plus, SI Negative, and Ci. "Live Wire" and "Impulse TT" display positive performance aspects, with moderately high SI Negative values, suggesting areas for improvement, and Ci values indicating their proximity to the ideal. "Zero SR" falls short in SI Plus but excels in SI Negative, signifying its relatively distant position from the ideal, as confirmed by its Ci value. "LitoSora" stands out with a remarkably high SI Plus and a notably low SI Negative, reflecting its favorable performance and close proximity to the ideal. In contrast, "Strike" exhibits lower SI Plus and an exceptionally high SI Negative, indicating its relatively undesirable performance. The Ci values offer an overall gauge of each model's adherence to the desired standards. These values provide valuable guidance for ranking and assessing these electric motorcycle models, helping individuals make informed decisions tailored to their specific needs and preferences.

TABLE 8. Rank

	Rank
Live Wire	**3**
Impulse TT	**4**
Zero SR	**2**
LitoSora	**5**
Strike	**1**

In the table 8 rank, a concise and informative ranking of the electric motorcycle models is presented, offering a straightforward hierarchy of their performance or desirability based on the evaluation criteria. "Strike" secures the top position with a rank of 1, signifying it as the most coveted or top-performing model among the options. "Zero SR" follows closely as the second-best model with a rank of 2, and "Live Wire" takes the third spot with a rank of 3. "Impulse TT" is ranked fourth, while "LitoSora" brings up the rear as the fifth and final model in the ranking. This ranked order simplifies the decision-making process, providing potential buyers or enthusiasts with a clear reference point to identify the most suitable electric motorcycle model based on their specific preferences and requirements.

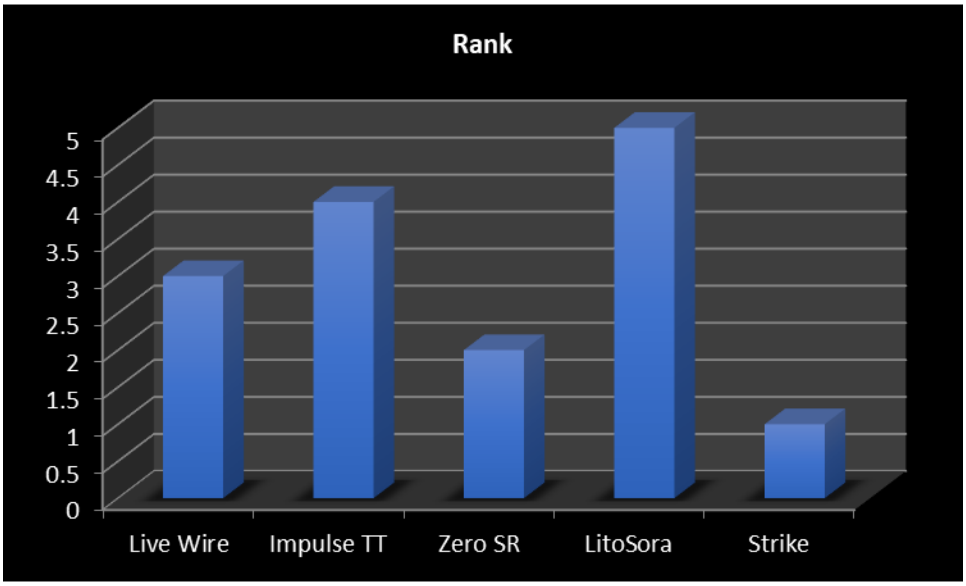

FIGURE 4. Ranking

This figure 4 ranking provides a clear hierarchy of the electric motorcycle models, making it easier for individuals to identify which model is considered the most favorable or suitable based on the evaluation criteria.

4. CONCLUSION

This research focuses on evaluating the ranking performance of the well-established Multiple Criteria Decision Making (MCDM) method TOPSIS for the selection of electric motorcycles. In this particular problem, the study involves five alternative electric motorcycle models and six criteria for evaluation. To assess the effectiveness of the TOPSIS method in ranking these alternatives, two performance tests are conducted. After conducting these performance tests, it is determined that the best alternative, according to the TOPSIS method, is the "Strike" model. This suggests that, based on the selected criteria and the methodology employed, the "Strike" electric motorcycle is the most preferable choice among the available alternatives. In conclusion, the presented tables and data provide a comprehensive evaluation of various electric motorcycle models, considering multiple criteria and parameters. These criteria encompass factors such as top speed, range, torque, power, charging time, and price, which are essential for assessing the performance and desirability of these vehicles. Through the use of normalization, weighting, and ranking, a thorough analysis is achieved, offering a well-rounded understanding of the strengths and weaknesses of each model. The normalized data in Table 2 allows for a fair and consistent comparison of the motorcycles, while Tables 3 and 4 introduce the concepts of weight and weighting for more customized assessments. The weighted normalized decision matrix in Table 4 empowers potential buyers to evaluate models based on their unique priorities. Additionally, Tables 5 and 6 present positive and negative matrices to highlight the desirability or lack thereof across criteria, helping individuals to recognize models that excel or fall short of expectations. The Si Plus, Si Negative, and Ci values in Table 7 offer a comprehensive assessment, considering both positive and negative aspects, culminating in the Ci values which indicate proximity to the ideal. Lastly, Table 8 ranks the models based on their overall performance or desirability, simplifying the decision-making process for those seeking to make an informed choice. This extensive analysis equips consumers with valuable insights for selecting the electric motorcycle that best aligns with their unique needs and preferences. As the electric motorcycle market continues to evolve, these evaluation techniques will prove invaluable in aiding individuals in making informed and tailored decisions when choosing an electric motorcycle that suits their specific requirements.

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