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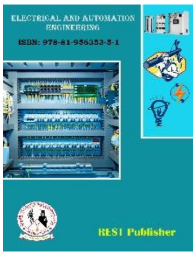

Assessment of Battery Electric Vehicles using the EDAS Method: A Comprehensive Evaluation of Performance and Sustainability

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Abstract. The global shift toward environmentally sustainable transportation has accelerated the development and adoption of Battery Electric Vehicles (BEVs). This paper presents a comprehensive evaluation of BEVs using the Estimation Based on Distance from Average Solution (EDAS) method, a multi-criteria decision-making (MCDM) approach that facilitates an objective and systematic comparison across multiple performance parameters. The assessment considers critical technical and user-centric criteria, including battery capacity, driving range, top speed, acceleration (0–100 km/h), charging time, and overall environmental impact. Eight popular BEV models—Kia EV6, Mahindra XUV400 EV, Hyundai Kona Electric, BMW i7, Jaguar I-Pace, Mercedes-Benz EQS, Audi e-tron GT, and Porsche Taycan—were analyzed using the EDAS method to determine their relative performance scores. The analysis revealed that the Kia EV6 ranks highest, demonstrating a well-balanced profile across all key performance indicators. Conversely, the Hyundai Kona Electric recorded the lowest overall performance score due to trade-offs in range, speed, and acceleration metrics. The results offer practical implications for potential consumers, manufacturers, and policymakers by identifying optimal BEV models and highlighting areas for further technological improvement. This research contributes to the growing body of knowledge on sustainable mobility solutions and provides a data-driven framework for comparative vehicle assessment.

Keywords: Battery Electric Vehicle (BEV), EDAS Method, Multi-Criteria Decision Making (MCDM), Electric Vehicle Assessment, Sustainable Transportation, Performance Evaluation.

1. INTRODUCTION

Increasing focus on environmental protection, sustainability and health concerns is driving the urgent need for cleaner technologies to replace combustion vehicles. BEVs offer a compelling solution that holds great promise. By thoroughly evaluating various aspects of BEVs, such as their performance, environmental implications, and economic feasibility, we can lay the foundation for a sustainable transportation future. By improving the efficiency of BEVs and striving for their widespread adoption, we can significantly reduce the negative environmental and health impacts associated with fossil fuel-powered vehicles **[1]. A** new approach in vehicle transport is required due to rising pollutants in the air, fossil fuel usage, and associated problems. We may move to a low-carbon including oil-dependent transportation solution by increasing the efficiency of current cars, investigating biofuels, and adopting electric power systems that include battery electric vehicles (BEVs). We obtain crucial insights that direct us towards a more sustainable, healthier future for transportation via thorough examination and examination **[2]**. In an era of remarkable technological progress and intensive environmental appraisal it is important to thoroughly evaluate BEVs. This assessment includes a detailed analysis of multiple aspects such as key performance indicators, range, charging infrastructure, cost efficiency and environmental impact. Considering the aspects carefully and objectively provides valuable insights that inform decision-making processes and ultimately lead to a cleaner and more sustainable future. Critical assessments and comprehend analysis provide an understanding of the capabilities and limitations of these vehicles **[3]**. In the context of continuous energy transition, battery electric vehicles (BEVs) are making a significant contribution to reducing the impact of the transport sector. Assessing the reliability and effect of BEVs using electrolytic hydrogen is crucial to inform policy choices and make the necessary changes to keep temperatures below set targets. By evaluating their efficiency, reliability, and environmental benefits we can accelerate towards an environment-friendly and carbon-free transport system **[4].** Decision-makers may make well-informed decisions that are in line with objectives for sustainability by thoroughly evaluating environmental consequences and expenses over the course of their full life cycle. These analyses offer a trustworthy and transparent framework to create policies and making investments in a more environmentally friendly transportation system **[5]**. These evaluations influence the development of technological advances, infrastructure, and policy initiatives aimed at speeding up the acceptance of BEVs. The ultimate objective is to make BEVs a practical and appealing alternative for customers, resulting in broad decarbonization of the automotive sector and a healthier future for mobility **[6].** When analysing battery-electric vehicles (BEVs), attention is given to issues including low battery life, a limited driving range, and lengthy recharging periods. Scientists and companies are striving to enhance the efficacy of BEVs and allay these worries by developing and testing new battery technologies. By giving consumers dependable and useful electric vehicle options, these present studies hope to speed up the adoption of BEVs **[7].** This assessment enables the promotion of a sustainable mode of transport and the reduction of greenhouse gas emissions across the full life cycle of EVs, encompassing their manufacture. To encourage the use of BEVs, or battery electric vehicles, and to enhance their environmental performance all through the duration of their full life cycle, more study and focus in this area is required **[8].** Large urban areas like Sydney, with average driving speeds of about 34 km/h are ideal for maximising the vehicle's range, are most appropriate for regular city travel with BEVs. However, without having access to outside charging alternatives, they might not be appropriate for lengthy, high-speed journeys. The study has ramifications for both policy makers and automakers, offering useful insights into elements that may remove perceived obstacles to the widespread use of BEVs and their expansion in the future **[9].** Scientists & consumers can develop effective mitigation methods by gaining insightful information about possible problems. This analysis encourages the safe and economic incorporation of BEVs with the electrical grid, providing a smooth and ideal transition to a less polluting and more effective transportation industry **[10].** The impacts of battery electric cars (EVs) on the environment are constantly questioned. According to the study, the primary causes are the creation of EVs, notably the battery, and the power applied for charging them. Promoting environmentally friendly and sustainable transportation needs an understanding of and sensitivity to these impacts **[11].** Because they save energy and reduce emissions, battery electric cars (BEVs) are viewed equally competitive alternative for fuel cell vehicles (FCVs). On examining the transient power properties of FCVs, several simulation and modelling research works have been conducted. A lot of study has also been done on the fuel-cycle analyses, GHG emissions, and energy use related to different transportation fuels. These evaluations help us get a thorough understanding of the environmental effects and performance of BEVs, enabling us to make wise decisions as we move towards low-emission and sustainable transportation systems **[12].** Battery electric vehicle (BEV) adoption on a large scale is commonly acknowledged as a viable solution to address important sustainability concerns in the transportation industry. These difficulties include the sector's involvement in anthropogenic climate change, urban air pollution, and dependence on not renewable fossil fuels. A 2010 estimate placed the no. of early deaths caused by fine particulate matter (PM 2.5) and ozone layer (O3) pollution at 3.3 million globally. The use of BEVs in place of conventional automobiles results in large exhaust emissions, minimising the negative health consequences of air pollution while reducing the transportation industry's environmental footprint. This analysis emphasises how quickly we must switch to BEVs in order to create safer, healthier, and increasingly affordable urban settings **[13].** Due to growing “petrol prices and environmental concerns”, interest in battery electric cars (BEVs) and hybrids electric vehicles (HEVs) has increased. In order to achieve outstanding results in terms of power density and energy efficiency throughout both the acceleration and braking phases, its renewable energy storage systems (RESS) design is crucial **[14].** For planning and policy purposes, it is crucial to comprehend the effects of vehicle-to-grid, or V2G, energy storage. In order to meet reductions in emissions and renewable usage targets, V2G-based systems ought to be included into policies that promote energy conservation and methods for acquiring resources. By contrasting the effects of “stationary power storage (SES) systems” and “V2G-based systems” on many areas relating to electricity and light public transit performance, this study intends to offer insightful information **[15].**

2. METHODOLOGY

EDAS METHOD: The average solution methodology was applied by Keshavars Korabai and colleagues (2015) to offer the EDAS (estimation determined by distance from typical solution) method, which evaluates alternatives. It compares the alternatives using two metrics: the +ve separation from the mean (PDA) & the negative distances from the mean (NDA). When there are competing criteria, this strategy is most useful **[16].** The EDAS technique offers an effective and dependable framework for making knowledgeable judgements based on many criteria when used to evaluate battery electric vehicles (or BEVs) or similar circumstances. It assesses the attractiveness of alternatives by considering how far they are from the typical solution. Because the mean answer is established via arithmetic mean, the EDAS approach is highly helpful in tackling stochastic situations **[17].** Collaboration between different partners and stakeholders is essential to attaining effective outcomes while evaluating the deployment and uptake of battery electric vehicles (BEVs) or projects connected to them **[18].** Here we are presenting the "EDAS (Estimation Based upon Distance from Average Solution)" approach as a multi-attribute choice-making (MADM) tool. It was initially used for inventory categorization and concentrated on assessing positive and negative deviations from the mean solution. In the years that followed, the EDAS technique was expanded to include fuzzy and intuitive hazy environment in supplier selection and, separately, the mark of solid waste disposal sites **[19].** The shifts in perspective occurs at the same time as battery electric vehicles (BEVs) are being adopted and assessed as possible tools for cutting carbon emissions and advancing sustainable development **[20].** A novel strategy in the area of multi-criteria decision making (MCDM) is the estimates on the basis of distance from average solution (EDAS) technique. This approach specialises on stock ABC grouping, a crucial element of inventory management. The EDAS system provides efficient choices in inventory classification by employing a compromise strategy that takes multiple variables into account **[21].** The use of the IVPF-EDAS technique in the evaluation of battery electric cars (BEVs) can offer a thorough and efficient way for comparing and assessing BEVs based on a variety of criteria and uncertainties. It facilitates decision-making and aids in choosing the best BEV while considering a variety of ambiguous and unclear aspects, including performance, cost, and user desire **[22].** Trapezoidal bipolar fuzzy sets are used in the TrBF-EDAS approach to solve multi-criteria group decision-making issues that take linguistic ambiguity into account. The performance, price, and environmental effect of battery-electric cars (BEVs) may be assessed using this technique by getting a range of viewpoints. It gives decision makers a solid foundation for choosing the best BEV solution based on their preferences **[23].** Making decisions becomes more difficult as the socioeconomic environment grows more complicated. The examination of electric cars with batteries (BEVs), where various elements including cost, performance, and environmental effect must be taken into consideration, is where this complexity is most clearly shown. In these circumstances, depending only on an analysis expert might compromise the process's precision and understanding **[24].** The revised EDAS technique contains a weighting methodology to efficiently incorporate expert opinions and takes into account several indications to identify significant risk issues for battery electric automobiles (BEVs). By thoroughly evaluating risks and incorporating subjective and objective weights, it enhances decision-making **[25].** Some important terms related to the Battery Electric Vehicle are discussed down under.

Battery Capacity: When it pertains to battery electric vehicles (BEVs), battery capacity is a crucial factor. It shows how much energy a car's battery can hold, which has an immediate effect on the vehicle's efficiency and range. Longer driving distances between recharges are made possible by larger batteries, providing BEV drivers much more convenience and freedom. Additionally, improvements in general reliability and acceptability of BEVs as potential alternatives to traditional internal combustion engine cars have been made possible by changes in battery technology and capacity increases.

Range: Range is an important consideration when evaluating battery electric vehicles (BEVs). This indicates the distance a BEV can travel on a single charge. Improvements in battery technology have led to increased ranges, addressing concerns about reduced driving range. A longer range enhances the practicality and versatility of BEVs, making them more suitable for a variety of driving needs. Ongoing advances in battery technology are expected to further enhance the range of BEVs, offering drivers greater flexibility and confidence in electric driving.

Top Speed: High speed is a crucial feature to consider. This shows the top speed the BEV is capable of. BEVs can travel at high speeds that, while not as high as some traditional gasoline-powered cars, are nonetheless fast enough for daily driving. Instead of being designed for high-speed performance, BEVs are primarily concerned with sustainability and efficiency. But as electric vehicle technology develops, BEVs' top speeds become even faster, giving drivers a choice between quick travel and environmentally benign transportation.

Maximum power (performance): In batteries electric vehicles (BEVs), maximum power—the maximum electrical output generated by their electric motors—is a crucial performance component. It establishes a vehicle's capacity for acceleration and overall efficiency while driving. BEVs provide a distinctive driving experience by delivering quick torque and gradual acceleration. The technology of electric vehicles is always evolving, increasing maximum power, and enhancing driving efficiency.

Quick Charge Time: Fast charge times are critical for battery electric vehicles (BEVs) as they enable faster battery charging and improve driver comfort.

Acceleration: For Battery electric cars (BEVs), acceleration is a critical performance component that affects their capacity to swiftly and effectively attain targeted speeds.

Full charge time: Full charge time is the amount of time necessary to fully charge a Battery Electric Vehicle’s (BEV) battery from empty to its full potential. It has an influence on how practical and convenient it is to use BEVs for regular transportation demands, thus it is a crucial issue to take into consideration.

Curb weight: When a Battery Electric Vehicle (BEV) is empty and set up for use, its curb weight is the total of the weight of the vehicle's frame, battery pack, electric drivetrain, and other elements. This is an important factor since it has a direct effect on the vehicle's overall performance, power efficiency, and handling attributes. Furthermore, a BEV's range, acceleration, and load-carrying the capacity are all influenced by its curb weight.

3. RESULT AND DISCUSSION

Table 1. Assessment of Battery Electric Vehicle

	ASSESSMENT OF BATTERY ELECTRIC VEHICLE							
	'Battery capacity'	**'Range'**	**'Top speed'**	**'Maximum power (performance)'**	**'Quick charge time'**	**'Acceleration'**	**'Full charge time'**	**'Curb weight'**
Kia EV6	77	708	192	321	20	4	6.00	1945
Mahindra XUV400 EV	39	456	150	148	50	8	6.50	1578
Hyundai Kona Electric	39	452	154	134	47	10	6.83	1535
BMW i7	102	625	239	536	30	5	12.00	2715
Jaguar I-Pace	90	470	200	394	30	5	8.00	2208
Mercedes-Benz EQS	108	857	210	516	30	4	11.50	2585
Audi e-tron GT	93	500	245	523	33	4	9.50	2350
Porsche Taycan	79	395	240	483	22	5	9.00	2125
Average	79	558	204	382	33	6	8.67	2130

Table 1 contains the Dataset of “Kia EV6, Mahindra XUV400 EV, Hyundai Kona Electric, BMW i7, Jaguar I-Pace, Mercedes-Benz EQS, Audi e-tron GT, Porsche Taycan”; The parameters are “Battery capacity, Range, Top speed, Maximum power (performance), Quick charge time, Acceleration, Full charge time, Curb weight.”

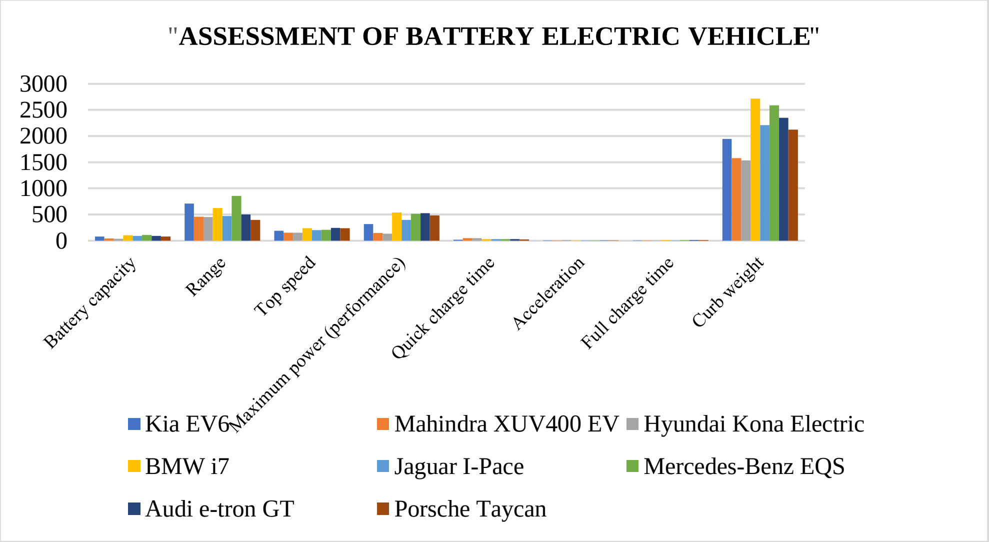

FIGURE 1. Assessment of Battery Electric Vehicle

Figure 1 indicates the statistical measurement of each Individual Parameters.

TABLE 2. Positive Distance away from Average

"Positive Distance from Average (PDA)"								
	'Battery capacity'	'Range'	'Top speed'	'Maximum power (performance)'	'Quick charge time'	'Acceleration'	'Full charge time'	'Curb weight'
Kia EV6	0.0000	0.2691	0.0000	0.0000	0.3893	0.3750	0.3077	0.0869
Mahindra XUV400 EV	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2500	0.2592
Hyundai Kona Electric	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2115	0.2794
BMW i7	0.2953	0.1203	0.1730	0.4047	0.0840	0.1607	0.0000	0.0000
Jaguar I-Pace	0.1463	0.0000	0.0000	0.0325	0.0840	0.1429	0.0769	0.0000
Mercedes-Benz EQS	0.3730	0.5362	0.0307	0.3520	0.0840	0.2321	0.0000	0.0000
Audi e-tron GT	0.1896	0.0000	0.2025	0.3696	0.0000	0.2679	0.0000	0.0000
Porsche Taycan	0.0088	0.0000	0.1779	0.2642	0.3282	0.0357	0.0000	0.0024

Table 2 denotes the "Positive Distance away from Average" of the Dataset; "Kia EV6, Mahindra XUV400 EV, Hyundai Kona Electric, BMW i7, Jaguar I-Pace, Mercedes-Benz EQS, Audi e-tron GT, Porsche Taycan"; The parameters are "Battery capacity, Range, Top speed, Maximum power (performance), Quick charge time, Acceleration, Full charge time, Curb weight."

TABLE 3. Negative Distance away from Average

"Negative Distance from Average (NDA)"								
	'Battery capacity'	'Range'	'Top speed'	'Maximum power (performance)'	'Quick charge time'	'Acceleration'	'Full charge time'	'Curb weight'
Kia EV6	0.0142	0.0000	0.0577	0.1606	0.0000	0.0000	0.0000	0
Mahindra XUV400 EV	0.4982	0.1826	0.2638	0.6137	0.5267	0.4821	0.0000	0
Hyundai Kona Electric	0.5007	0.1898	0.2442	0.6488	0.4351	0.7321	0.0000	0
BMW i7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3846	0.2746
Jaguar I-Pace	0.0000	0.1575	0.0184	0.0000	0.0000	0.0000	0.0000	0.0366
Mercedes-Benz EQS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3269	0.2135
Audi e-tron GT	0.0000	0.1037	0.0000	0.0000	0.0076	0.0000	0.0962	0.1032
Porsche Taycan	0.0000	0.2920	0.0000	0.0000	0.0000	0.0000	0.0385	0

Table 3 denotes the "Negative Distance away from Average" of the Dataset; "Kia EV6, Mahindra XUV400 EV, Hyundai Kona Electric, BMW i7, Jaguar I-Pace, Mercedes-Benz EQS, Audi e-tron GT, Porsche Taycan"; The parameters are "Battery capacity, Range, Top speed, Maximum power (performance), Quick charge time, Acceleration, Full charge time, Curb weight."

TABLE 4. Weightage of the Parameters

Weightages of the Parameters								
Kia EV6	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
Mahindra XUV400 EV	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
Hyundai Kona Electric	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
BMW i7	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
Jaguar I-Pace	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
Mercedes-Benz EQS	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
Audi e-tron GT	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
Porsche Taycan	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125

Table 4 provides the weights utilized for the analysis, where equal weights are assigned to all parameter.

TABLE 5. Weighted PDA & SPi

"Weighted PDA"									"SPi"
Kia EV6	0.0000	0.0336	0.0000	0.0000	0.0487	0.0469	0.0385	0.0109	0.1785
Mahindra XUV400 EV	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0313	0.0324	0.0636
Hyundai Kona Electric	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0264	0.0349	0.0614
BMW i7	0.0369	0.0150	0.0216	0.0506	0.0105	0.0201	0.0000	0.0000	0.1548
Jaguar I-Pace	0.0183	0.0000	0.0000	0.0041	0.0105	0.0179	0.0096	0.0000	0.0603
Mercedes-Benz EQS	0.0466	0.0670	0.0038	0.0440	0.0105	0.0290	0.0000	0.0000	0.2010
Audi e-tron GT	0.0237	0.0000	0.0253	0.0462	0.0000	0.0335	0.0000	0.0000	0.1287
Porsche Taycan	0.0011	0.0000	0.0222	0.0330	0.0410	0.0045	0.0000	0.0003	0.1022

TABLE 6. Weighted NDA & SNi

Weighted NDA									SNi
Kia EV6	0.0018	0.0000	0.0072	0.0201	0.0000	0.0000	0.0000	0.0000	0.0290
Mahindra XUV400 EV	0.0623	0.0228	0.0330	0.0767	0.0658	0.0603	0.0000	0.0000	0.3209
Hyundai Kona Electric	0.0626	0.0237	0.0305	0.0811	0.0544	0.0915	0.0000	0.0000	0.3438
BMW i7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0481	0.0343	0.0824
Jaguar I-Pace	0.0000	0.0197	0.0023	0.0000	0.0000	0.0000	0.0000	0.0046	0.0266
Mercedes-Benz EQS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0409	0.0267	0.0676
Audi e-tron GT	0.0000	0.0130	0.0000	0.0000	0.0010	0.0000	0.0120	0.0129	0.0388
Porsche Taycan	0.0000	0.0365	0.0000	0.0000	0.0000	0.0000	0.0048	0.0000	0.0413

TABLE 7. SPi VS SNi

	SPi	SNi
Kia EV6	0.8880	0.9155
Mahindra XUV400 EV	0.3167	0.0667
Hyundai Kona Electric	0.3053	0.0000
BMW i7	0.7699	0.7604
Jaguar I-Pace	0.3001	0.9228
Mercedes-Benz EQS	1.0000	0.8035
Audi e-tron GT	0.6402	0.8870
Porsche Taycan	0.5082	0.8799

Table 5 shows the Weighted PDA & the SPi of the Parameters. Table 6 and 7 show the Weighted PDA & the SPi of the Parameters, and the SPi vs SNi respectively.

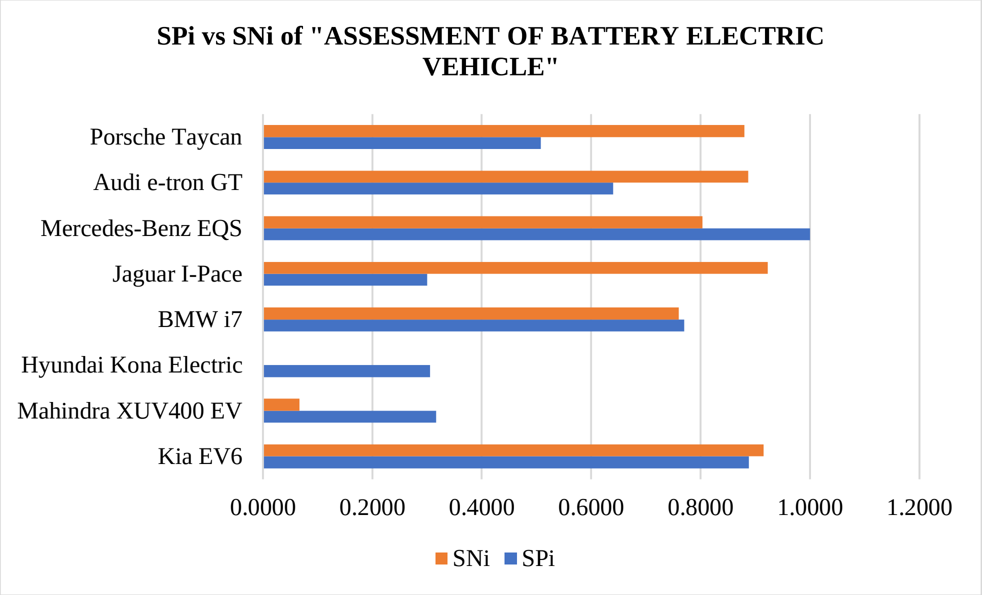

Figure 2. Graphical representation of SPi vs SNi for each case

TABLE 8. ASi (AVERAGE)

ASi	
Kia EV6	0.9018
Mahindra XUV400 EV	0.1917
Hyundai Kona Electric	0.1526
BMW i7	0.7651
Jaguar I-Pace	0.6114
Mercedes-Benz EQS	0.9018
Audi e-tron GT	0.7636
Porsche Taycan	0.6941

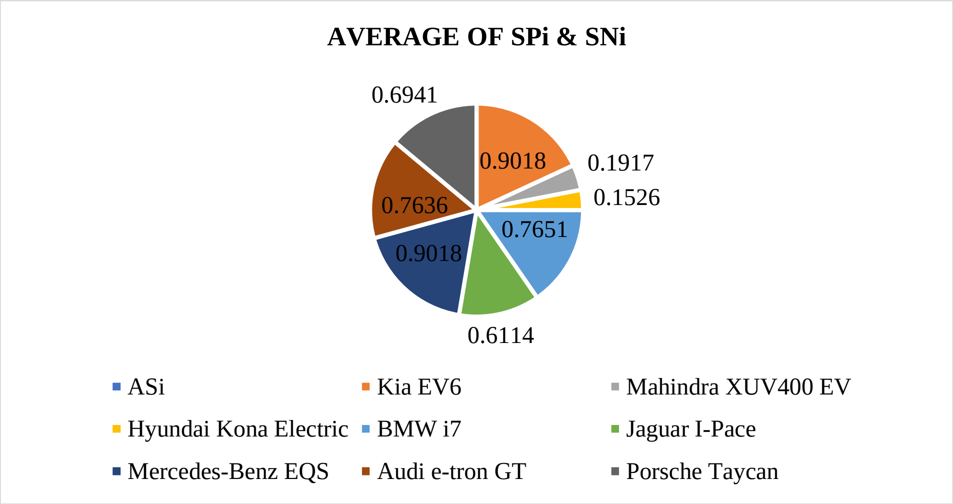

FIGURE 3. AVERAGE OF SPi & SNi

Figure 3 shows the Average of the Si for each of the parameters. Here the Kia EV6 and recedes-Benz EQS have equal averages.

TABLE 9. Rank of the Assessment of Battery Electric Vehicle

RANK	
'Kia EV6'	1
'Mahindra XUV400 EV'	7
'Hyundai Kona Electric'	8
'BMW i7'	3
'Jaguar I-Pace'	6
'Mercedes-Benz EQS'	2
'Audi e-tron GT'	4
'Porsche Taycan'	5

Table 9 shows the Ranks of the Assessment of Battery Electric Vehicle. Here the Kia EV6 is placed on the top and the Hyundai Kona Electric placed on the bottom rank.

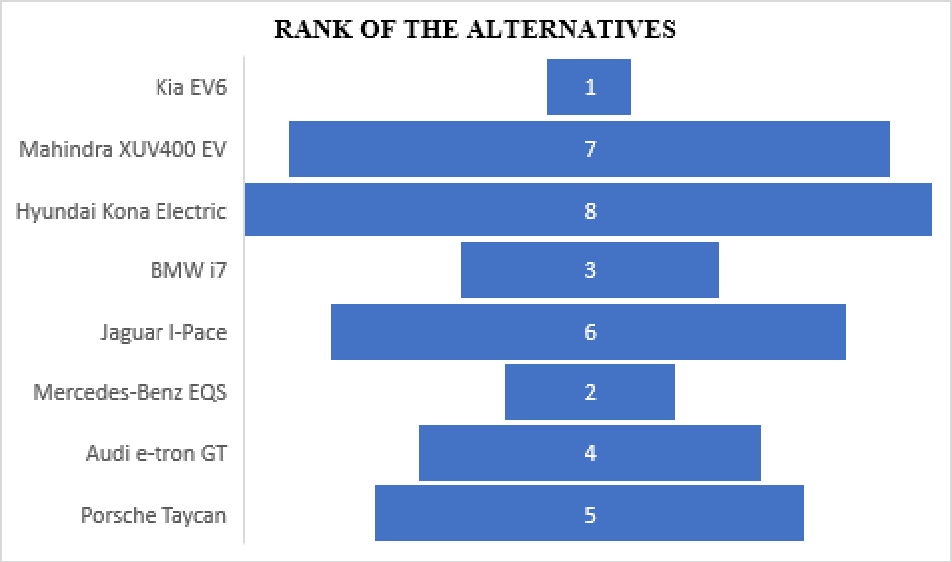

Figure 4. Rank of the alternatives

Figure 4 shows the "Rank of the alternatives of "Kia EV6, Mahindra XUV400 EV, Hyundai Kona Electric, BMW i7, Jaguar I-Pace, Mercedes-Benz EQS, Audi e-tron GT, Porsche Taycan"; The parameters are "Battery capacity, Range, Top speed, Maximum power (performance), Quick charge time, Acceleration, Full charge time, Curb weight." Here the Kia EV6 is placed on the Top and the Hyundai Kona Electric is placed at the bottom due to their difference in their Advantages and Disadvantages.

4. CONCLUSION

Important insights that guide our decision-making and eventually help us move towards a cleaner, more sustainable future by carefully and impartially studying these factors. We embark on an insightful voyage into the world of BEV assessment, where thorough assessment & complex analyses will shape our knowledge of these vehicles' possibilities and limits. This study informs customers, producers, and policymakers on the advantages and difficulties of BEVs in also adding to the body of knowledge regarding electric cars. Researchers will identify places for progress, establish strategies for the best deployment, and aid in the shift to a low-carbon transportation sector through assessing factors including range, charging infrastructure, cost-effectiveness, and environmental impact. Additionally, the results of these evaluations have an extensive effect on future technological advancements, legislation systems, and investment choices in the quest of clean and sustainable transportation. The study has ramifications for both policy makers and automakers, offering useful insights into elements that may remove perceived obstacles to the widespread use of BEVs and their expansion in the future. Scientists & consumers can develop effective mitigation methods by gaining insightful information about possible problems. This analysis encourages the safe and economic incorporation of BEVs with the electrical grid, providing a smooth and ideal transition to a less polluting and more effective transportation industry. EDAS technique contains a weighting methodology to efficiently incorporate expert opinions and considers several indications to identify significant risk issues for battery electric automobiles (BEVs). By thoroughly evaluating risks and incorporating subjective and objective weights, it enhances decision-making. Kia EV6 is placed on the Top and the Hyundai Kona Electric is placed at the bottom in the Assessment of Battery Electric Vehicle using EDAS Method.

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