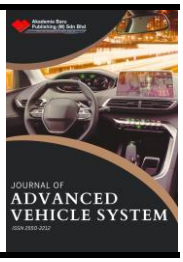
Penerbit Akademia Baru

Journal of Advanced Vehicle System

Journal homepage:
http://www.akademiabaru.com/submit/index.php/javs/index
ISSN: 2550-2212



Trends Towards the Demand of Electric Vehicles based on the Distribution of Electric Vehicle Charging Stations in Malaysia

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ABSTRACT

Despite their inception in the early 20th century, electric vehicles have recently garnered significant attention. However, only 5% of vehicles on the world's roads are powered by electricity or electric hybrid systems. Meanwhile, vehicles relying on the internal combustion engine (ICE) are already considered outdated due to their low efficiency, heavy fuel consumption, and emission of harmful pollutants. Despite these drawbacks, ICE vehicles remain popular in today's society due to their ease of use and lower upfront costs compared to electric vehicles. The lagging electricity infrastructure has also made it difficult for the general public to access EVs. Therefore, this study aims to analyze the demand trends for EVs in the global market. This study will also collect data from various international and local administrative bodies. Furthermore, this study seeks to forecast the development of the EV sector, particularly by the year 2030. Thus, this study aims to examine the distribution of electric vehicle charging stations (EVCSs) and establish a correlation between EV demand and charging station (CS) distribution using the Pearson Correlation method. This research is vital for Malaysia, as it prepares the nation to navigate the evolving development of the EV sector. Addressing this issue has become one of the yardsticks for Malaysia in following the increasingly rapid trend of modernization in line with the circulation of technology and the country's mission by the year 2030.

Keywords:
EV demand trends; electric vehicles; EV demand and EVCS distribution; electric vehicle charging stations; Malaysia

Received: 23 January 2024 **Revised: 1 February 2024** **Accepted: 26 February 2024** **Published: 30 March 2024**

1. Introduction

Electric vehicles (EVs) refer to vehicles used for transportation on the road that operate on electricity rather than traditional fossil fuels. As the world moves towards a greener future, EVs are gaining popularity because it is better for the environment and getting more advanced technologically [1]. According to a report from the International Energy Agency [2], EVs also refer to battery electric vehicles (BEVs) which use battery packs to store the electrical energy that works to drive the motor. It is common knowledge that today's society is used to using petrol or diesel vehicles as the main fuel in their vehicle service. As time progresses and in alignment with the country's vision, EVs are increasingly capturing global attention. According to the Electric Vehicle Association of Malaysia (EVAM), Malaysia is one of the best countries for the EV industry because Malaysia has expertise suitable for investment and export [3]. According to Tengku Zafrul, Malaysia has aimed to have EVs and hybrids which contribute at least 15 percent of the total industry volume (TIV) by the

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year 2030 and this coincides with the Low Carbon Mobility Development Plan 2021-2030 that he previously introduced [4].

Based on the study, the trend towards the demand for EVs in Malaysia has become a topic of concern among various stakeholders because the scarcity of EVs, particularly in Malaysia, has raised questions and drawn attention nowadays. In line with the country's mission and vision to move in step with the latest technological advances that are growing day by day, EVs are also one of the country's contributions to the community to move towards a society that is in step with the development of technology. According to Benotsmane *et al.,* [5], human life will become easier with the help of tools or robots in human life. This coincides with developments in the automotive field such as EVs. In addition, the prediction future sales of EV are assured to be significant, offering an environmentally friendly alternative for transportation needs [6]. As mentioned in Liu *et al.,* [7], the strategic allocation of electric vehicle charging stations (EVCS) along transportation routes is essential. Owing to that, Malaysia faces significant challenges due to its heavy dependence on fossil fuels and inadequate EVCS [8].

Hence, the establishment of charging stations (CSs) along routes is imperative, as it can reduce range anxiety among EV users [9]. Additionally, the installation of CSs can significantly boost the adoption of EVs among Malaysians [10]. Therefore, this study was conducted to analyze the demand for EVs in Malaysia in 2030 based on statistical data. This study also aims to identify the location distribution of EVCSs in Malaysia as well as examine the relationship between the demand for EVs in Malaysia and the distribution of EVCS in Malaysia. Section 2 outlines the methodology utilized in this study, while Section 3 highlights the statistical methods employed. The distribution of EV charging stations is examined in Section 4, and finally, Section 5 concludes the study's conclusions.

2. Methodology

This study uses a quantitative research approach, employing trend analysis and the Pearson correlation method. In this study, data collection is sourced from the official website of the International Energy Agency (IEA). This choice is made due to the website's reputation for offering extensive and precise data on EVs from various global publishing sources. The initial data gathering process will prioritize the official IEA website. The website offers access to global EV car stock and sales data spanning from 2010 to 2020, which can be downloaded in Excel format. Additionally, information regarding passenger and commercial vehicles produced and assembled in Malaysia from 2010 to September 2021 can be obtained from the Malaysia Automotive Association (MAA) website [11]. Finally, data regarding the installation of publicly accessible chargers, which expanded sevenfold in the last 10 years, and the total registered EVs in Europe can be accessed from the IEA website and downloaded into an Excel spreadsheet. Since this study focuses on an overall data analysis, only data from the Global section, which includes global EV stock and sales, will be evaluated. Furthermore, the Pearson correlation method is employed to examine the relationship between two variables measured on the same interval scale or ratio. Researchers often choose the correlation method to analyze the relationship between two variables due to the valuable insights it provides.

3. Statistical Method

Correlation analysis is a statistical method utilized to determine and quantify the strength of the relationship between variables. Two types of correlations are often used by researchers in analyzing statistical analysis, namely Pearson's Correlation and Spearman's Rank Correlation. In this study, the Pearson correlation method is selected to establish a correlation relationship. Pearson's correlation

is a correlation method involving two variables which are dependent and independent. The data used in this Pearson correlation method is sourced from a reliable platform, specifically from the Malaysian Transport Company. The calculation using the Pearson correlation method can be formulated as Eq. (1) below [12]

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}} \quad (1)$$

r = correlation value
x = value of variable x
y = value of variable y
n = number of data points

r = +/-0.5 strong correlation value
r = +/-0.3 mild correlation value
r = +/-0.1 low correlation value

Table 1
Pearson correlation calculation results using Excel

Year	Data of EVCS	Data of EV Sales	EV Sales X EVCS	$(\text{Data of EVCS})^2$	$(\text{Data of EV Sales})^2$
2015	6,000	700	4,200,000	36,000,000	490,000
2016	8,000	1,590	12,720,000	64,000,000	2,528,100
2017	1,100	2,250	2,475,000	1,210,000	5,062,500
2018	1,400	3,800	5,320,000	1,960,000	14,440,000
2019	1,700	6,400	10,880,000	2,890,000	40,960,000
2020	2,200	8,500	18,700,000	4,840,000	72,250,000
2021	2,800	19,400	54,320,000	7,840,000	376,360,000
	23,200	42,640	108,615,000	118,740,000	512,090,600
n	7				
r	1.056929546				

Table 2
The strength level of the correlation coefficient value

Size of Correlation Coefficient (r)	Correlation Strength
0.91 until 1.00 or -0.91 until -1.00	Very strong
0.71 until 0.90 or -0.71 until -0.90	Strong
0.51 until 0.70 or -0.51 until -0.70	Medium/ Mild
0.31 until 0.50 or -0.31 until -0.50	Low
0.1 until 0.30 or -0.1 until -0.30	Very Low
0.00	No correlation

According to Table 2, the interpretation of the relationship between 0.91 to 1.00 indicates a very strong correlation. If the value of the coefficient (r) is 0.71 to 0.90 indicates a strong relationship between the two variables. Likewise, if the coefficient is between 0.51 to 0.70, the relationship is considered moderate. Next, if the value of the coefficient (r) is between 0.31 to 0.50, the relationship indicates a weak relationship, and if the value of the coefficient is 0 suggests no correlation between the two variables. Based on research conducted by various generations of researchers, the trend status and demand for EVs have consistently increased each year, especially since 2015. According to a global study that has been done by Rietmann *et al.,* [13], more than 10 million EV units will be

sold by 2030. This trend is evident as nearly 10 million EV units were sold in 2020 alone as illustrated in Figure 1 and Figure 2. Analysis from previous researchers also predicts a systematic increase in the trend and demand for EVs by 2030.

Based on the Pearson correlation analysis conducted for this research, the results indicate a very strong correlation between EV sales and EVCS in Malaysia. The correlation value obtained is 1.06 for the data spanning from 2015 to 2021, as presented in Table 1.

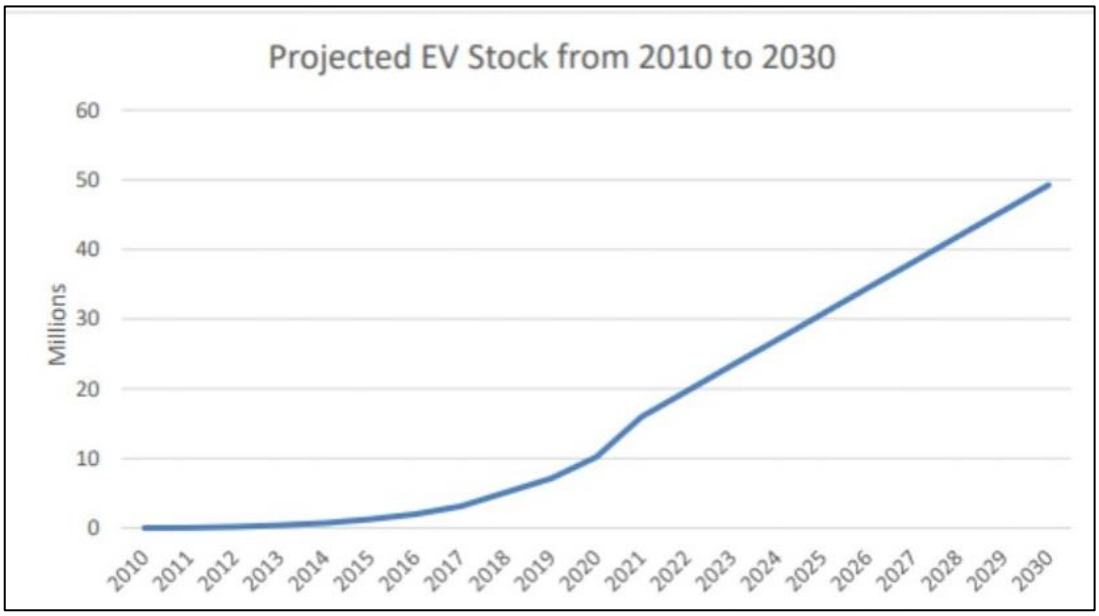

Fig. 1. Projected EV stock: 2010 – 2030 [14]

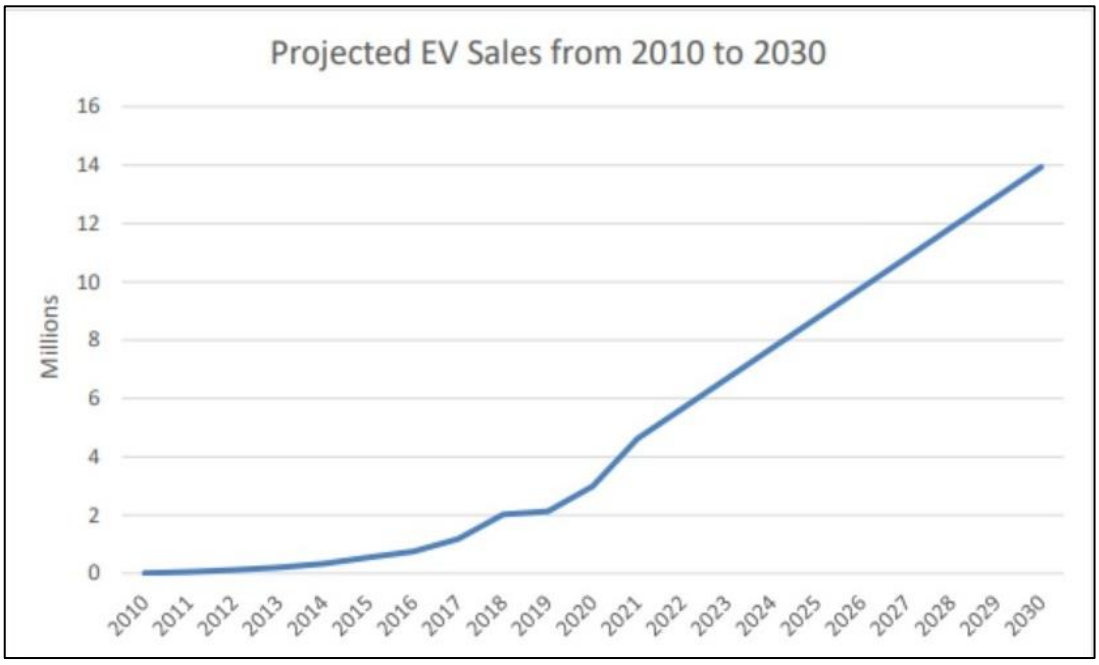

Fig. 2. Projected EV sales: 2010 – 2030 [14]

4. The Distribution of EV Charging Stations

The data obtained related to the distribution of EVCS is more geared towards foreign countries that are famous for the EV automotive sector, such as China, the United States, and others. According

to the International Energy Agency [2], starting from the previous year, China exhibited significant growth in the construction and utilization of EVCS, including both fast and slow chargers. In 2021, China will have approximately 680,000 charging units accessible to all communities, marking a notable 35% increase from the previous year [15]. Notably, the correlation between EV demand and electric charging remained steady from 2015 to 2021 in China [2]. However, it is important to acknowledge that this data is confined to select foreign countries, as comprehensive data from regions like Malaysia or on a global scale is not available through the website or related profiles. Consequently, researchers extrapolated data on EVCS distribution based solely on projected figures from these countries.

5. Conclusion

In conclusion, the market and trend of electric vehicles in the future is seen to be more increased. It shows that accessible charger had the highest influence in term of increasing the EV production and the study can be imply in Malaysia and increase the global market share. Projections suggest a robust upward trajectory for EV adoption, particularly evident by 2030. This point is further proven when the government has also given incentives to EV users among them in terms of financing rates, charging usage and so on. The statistical data compared in this study is among the comprehensive literature where references are taken from various sources to show that EV stock and sales are relatively standing with the aspects discussed in this study. It is necessary to do more research into an efficient micro-scale EV charging station prediction technique using pertinent real-world or simulated data. Such infrastructure plays a pivotal role in attracting new EV buyers, making insights into EV charging trends indispensable for policymakers, suppliers, and manufacturers alike. This finding might serve as a starting point for future research to evaluate and construct a better model to describe the desire to utilise EV in Malaysia.

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