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Green Transportation: A Foresight Study of Electric Vehicles Adoption in Malaysia

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Abstract

Electric vehicle is one of the most important innovations that have revolutionized the industry especially in automotive industry and nowadays, electric vehicles have become popular worldwide. The purpose of this research is to identify the key drivers for the electric vehicles adoption in Malaysia and study the future scenario of electric vehicles in Malaysia. The study uses STEEPV analysis to identify issues, challenges, and trends of electric vehicles based on social, technological, environmental, economic, political, and value aspects. The research had been conducted among Malaysian consumers; the research had collected 251 responses from respondent with a response rate of 65.36%. Impact-uncertainty analysis can help to determine future scenario based on the highest impact-uncertainty level to study the future scenario. For this study, top drivers are availability of charging infrastructure and purchasing and maintenance cost of electric vehicle and scenarios derived from these top drivers are high availability of charging infrastructure, low availability of charging infrastructure, high purchasing and maintenance cost of electric vehicle and low purchasing and maintenance cost of electric vehicle. This scenario can help dealers, government, and all Malaysian have a better understanding about electric vehicle. The best scenario for study is mature adoption for adopting electric vehicle in Malaysia to develop the better world for future and the worst scenario is absence of electric vehicle so that the future stakeholders should be avoided this scenario happened in Malaysia after 10 years.

1. Introduction

Electric Vehicle (EV) is the turning point of the automotive sector which bringing the huge impact to the industry, economic, and the environment. All the sustainability projects by the private sector are more focused on the environmental impact and those automakers have started green-transportation vehicles research and development projects to ensure the zero emissions during the transportation (International Energy Agency, 2022). Hence, the automakers had invested in EV sector and undergo the Environmental, Social, and Governance (ESG) practices to educate the next generation accept the EV in their daily life and reduce the production line of internal combustion engine vehicle (ICEV) in the industry (Patrick,2023). With the ESG project to educate the Z-Generation (Z-Gen), the adoption level of EV among the Malaysian become the priority to the industry, social, and government to understand the acceptance level of EV in Malaysia.

1.1 Research Background

The acceptance level of EV in Malaysia the indicator to indicate the popularity of EV in Malaysia. A positive signal shows to the Malaysian EV market has ready to accept the usage of EV in their daily life and up to 10,000 units of EVs had been registered in Road Transportation Department (JPJ) and those records can help the automotive dealers in Malaysia such as Sime Darby Motors, Great Wall Motor Sdn. Bhd to import various types of EV to Malaysia to continue fulfilling the needs to the Malaysian market and match to actual needs to the potential EV users to increase the adoption level in EV sectors by Malaysians (Chan, 2023).

The technology level of EV production is the indicator to increase the adoption of EV to the locals. Self-developed products or services are the pride for the nations and technological level can decide the status between the country and the competitiveness in the EV industry. There have various types of EV in the world such as Battery Electric Vehicles (BEVs), Plug-in Hybrid Electric Vehicles (PHEVs), Hybrid Electric Vehicles (HEVs), and Fuel Cell Electric Vehicles (FCEVs) and each EVs can shows each advantage and technological level to the global when introducing to the international (U.S. Department of Transportation, 2022). All kind of EV brings the positive environmental impact since its had introduced to the market. The key characteristic become saviour to the environment which is EV did not produce any toxic gases during the cursing while the ICEV is the "environment killer" and it can produce billions of tons of toxic gases in a year, but EV can help to cut down the air pollution by give up the fossil fuel to undergo combustion for generate power and it powered by the electricity (José, 2023).

1.2 Problem Statements

Nowadays, the innovation of automotive sector has become a serious case especially for developed countries. The new product of innovation in automotive is electric vehicles (EV) and it became the ideal personal transportation tools. However, the real situation in Malaysia shows the charging network coverage cannot cover the whole Malaysia and those basic infrastructure will affect the willingness for buying the electric vehicles (Veza, 2022). Most of the potential buyers worries about the fears of the battery draining while driving the car especially in Malaysia which the charging stations of the technology for fast charging to the EV cannot be set up in the short time. Government can push the adoption of EV on the road, but the policies are not friendly for EV users. This is because the EV policies in Malaysia are not plan well and most of the policies related to EV only for short term policies and those policies required to review again after those policies expired.

Additionally, the ideal scenario for EV is not provided by Malaysia due to the demand of the EVs for Malaysia road users. As mentioned before, Malaysia did not provide the clear policies and planning for friendly use by EV users, so the ideal scenario can be imaging with full of charging stations and list up the standard for the EVs and oil powered road users to make sure all the road users can be fair when they on the road. Rules and regulations by government is a part of the adoption and acceptation of EV by Malaysia road users, the private sector should be taking the role to speed up the technology progress in EV and the battery technology (International Energy Agency, 2022).

Most of the financial sectors offer their package to potential EV owners but the most reason cause the EV cannot be adopted or accepted by the younger generation or another potential buyer in Malaysia is the price of the EV. Based on the data of Zigwheels, the cheapest EV in Malaysia is Ora Good Cat by Great Wall Motor (GWM) with the price RM 139,800 and the price is higher than petrol powered vehicles. Even though the technology used in EV is very advanced, it still requires a competitive price to the mid-range income potential buyer, or it will become the toy for the rich people to show their level of wealth by purchasing the EV.

Therefore, to achieve the research objectives the issues, trends and challenges related to EV adoption in Malaysia is determined. Furthermore, the key drivers for the adoption of EV in Malaysia also determined. Consequently, the future scenario for the adoption of EV in Malaysia is identified.

1.3 Scope of the Study

Foresight study for this research is to overview the changing of the Malaysia road user's behaviour in 10 years from 2023 to 2033. The biggest component in Malaysia transportation is the private vehicles which are cars and motorcycles due to the planning and policies by government are not suitable for this globalization era and EVs are the future star which will replace the internal combustion vehicles and reducing the emissions of carbon when using EVs. The focus for this research is related to the adoption EVs in Malaysia Road users and the future trend for the Malaysian to select their vehicles.

1.4 Significance of the Study

This research focus to three aspect which are society, industry and policy makers to identify the challenges based on three aspects above. EV become the trend to the international automakers and those automakers require to evaluate the local's behaviour before to run a new product to the market (Chris, 2022). However, in Malaysia has facing the unclear goals for implement the EV to the Malaysia market and cause most of the citizens do not try the EV in their daily life (Joycelyn, 2021). So that the study will discuss about the policies for the EV automakers, this study can bring the policymakers aware to the current international trend and undergo the changing based on policy bases to make sure that Malaysia can follow the real scenario in the transformation of transportation. The policymakers can revise the outdated rules and regulations and provide the funding to the Malaysia R&D team to make sure Malaysia have the ability to produce a local EV product.

In the society aspect, the study can help to develop a vision for the community and learns the basic rights of EV users and how EVs to contribute to Malaysia society in many aspects such as in environmental, social and so on. The learning process can the community understands that the EV can through technological innovation, reduce all the uncertain risks and increase the range and quality of EVs. Besides, the rights for all the EV users also can be protected if the society have been educated that the rights of EV users and ICE-powered vehicles are the same, and society should respect the rights of EVs like do as not to occupy the public charging point for EVs.
In industrial aspect, this study brings awareness for any changes to the customer's behaviour and the technology changes. Customer behaviour can be easily changing uncertain issues, and the industry should analyse this to identify their business plan to follow up on the customers' behaviour and make the product meet the actual customer's needs, The technology changes in the EV can be rapid because EV is the latest trend for all automakers to hit the highest technology in the world, so the local automotive industry should have a clear understanding of the technology level in EVs and not only retain outdated information, with the learning of the research, the industry can focus on the R&D to develop the self-development of EV and undergo technology transfer to get the latest technology from another side of the Earth to ensure the progress for self-development in EV at the positive way, and the Malaysian will adopt to the EV with the proud of the nation brand.

2. Research Methodology

This chapter describes the research methodology used when conducting this foresight study titled "green transportation: Foresight Study of Electric Vehicles Adoption for Malaysia Transportation." According to Saunders *et al.* (2019), research methodology involves the planning phase's strategy to study a whole research project. Besides that, research methodology can be a guideline for the researchers using the appropriate tools to analyse the data collection. Applying STEEPV analysis is used in foresight research, which requires analysing quantitative data from primary and secondary data. STEEPV framework requires following the core factors, which are social, technological, environmental, economic, political, and value which are essential tools to have a wide range of vision with the following factors to visualise the prediction for the foreseeable future study of electric vehicles adoptions for Malaysia's transportation system (Austin, 2021).

2.1 Research Design

To foresight the future of the adoption of the EV in Malaysia, mixed research is the most relevant. The foresight study is to make more accurate predictions for the research by using mixed research, which combines qualitative and quantitative methods in the investigation process for the truth of the research. Qualitative research focuses on analysing and measuring the current information between the variables (Babbie, 2009). Quantitative research focuses more on the numerical data from a group of respondents to explain the study (Babbie, 2009). The foresight study considers mic research, which is the process of investigation for the data collection from articles, books, journals, and online or physical resources can be considered qualitative research. Quantitative research resources can be identified from survey questionnaires, interviews, or reviewing the past statistical data using computer applications such as SPSS.

The foresight study uses the STEEPV technique as qualitative research to analyse and interpret the information based on six factors social, technological, environmental, economic, political, and value, to analyse the significance of foresight research by predicting the future of Malaysia. A survey questionnaire is mandatory to identify the adoption level of EVs on Malaysia's road system with their sincere responses.

2.2 Data Collection

Data collections are collecting information from many sources by two data resources, primary and secondary data, to strengthen the study's credibility for future research. primary data by using questionnaires, surveys, and interviews to understand the opinions of the third party to solve the research problem (Benedictine University Library, 2023). Secondary data resources are collected from bibliographic, journals, magazines, newspapers, articles, theses, and other resources more economically than primary data, then the resourced had been used to construct the STEEPV analysis. For the data collected from the survey, the researcher used the SPSS to analyse it and conduct the impact-uncertainty analysis to imaginate the four scenarios for the study.

In the data questionnaire design, the researcher used a closed-ended questionnaire and Ten Likert scales for the demographic background as Part A, the issue of EV adoption in Malaysia and the uncertainty drivers toward the adoption in Malaysia of EV as Part B and C used Five Likert scales with ranking from one to ten to represent the issues and uncertainty level by the respondents. There have 45 questions including demographic and the drivers for adopting EV in Malaysia. To determine the questions asked in survey, the researcher use the 12 key drivers after the merging of issues, trends, and uncertainty.

2.3 Research Process

The first step in this foresight study is horizon scanning which focuses on the early detection of weak signals as indicators of potential change which in this study in the use of unmanned convenience store. STEEPV will then be used to identify the key drivers and issues. Then, a set of questionnaires will be distributed to users who are using the service in unmanned convenience stores.

2.4 Foresight Process

Foresight uses various methodologies and tools, including horizon scanning for emerging change in any situation, analysing the global trend and simulating multiple scenarios to match the research to generate an excellent idea and vision for the future (OECD, N.D.). A foresight study is required for the institution to identify the trend of EV adoption to ensure Malaysian citizens always follow the trend, especially in the vehicle technology sectors Malaysians are putting more effort into the Malaysia road usage system. The foresight process focuses on the long-term foreseeable future in the range of 10-15 years to support the decision maker's vision and mission for the future of Malaysia. Foresight involves horizon scanning and the STEEPV method to analyse the information from multiple resources to identify the drivers for the adoption of EVs in Malaysia.

2.4.1 Horizon Scanning

Horizon scanning is a systematic process to collect and analyse information from various recourses to identify the latest trends, potential threats, and future views for developments in specific industries or sectors. Monitoring and examining the wide range of information resources can identify the trends to show an early signal to analyse the potential risks and threats for specific industries or sectors. With the prediction of the future, multiple scenarios can develop by identifying the trends to explore the different outcomes and scenarios (European Foresight Platform, n.d.). The early signal can quickly provide industries or sectors with the responsibility for decision-making by adopting to emerging trends and challenges.

2.4.2 STEEPV Method

STEEPV is a framework to assess the factors from multiple resources, which are for Social (S), Technological (T), Environmental (E), Economical (E), Political (P), and Value (V) to evaluate the future perspective based on those driving factors (Nazarko & Kuźmicz, 2017). STEEPV is a brainstorming process to discover the key terms or issues that may happen in the future and shows the multiple scenarios to the researcher. In this research, STEEPV plays an essential role in identifying the factors that the adoption of EVs for Malaysian, especially Gen-Z Road users. The result of the STEEPV analysis can help the researcher have the vision to create a survey questionnaire for the potential respondents in Malaysia.

2.5 Population and Sampling

The target population in the research is the all the Malaysian. The overall population in Malaysia are 32.8 million. The sample size is 384 people (Krejcie and Morgan, 1970).

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2.6 Research Instrument

Questionnaire has been four sections: Section A, Section B, Section C and Section D. Section A is about the demographic respondents, Section B is about the important of key factors/drivers toward the EV adoption in Malaysia. Section C is about the impact of key factors/drivers toward the EV adoption in Malaysia. Section D is about the uncertainty of key factors/drivers toward the adoption of EV in Malaysia. The instrument was designed in the Likert scale style. The answer to the question given by the respondents with a five-scale ranging from one to five to represent the issues and uncertainty level by the respondents.

Table 1 *Structure in questionnaire*

Section	Items
A	Demographic Background
B	The important of key factors/drivers toward the EV adoption in Malaysia
C	The impact of key factors/drivers toward the EV adoption in Malaysia
D	The level of uncertainty of key factors/drivers toward the adoption of EV in Malaysia

2.7 Data Analysis

2.7.1 Descriptive Analysis

Descriptive analysis uses current or historical data to identify the relationship between the study and the future trend for the forecast study (Cote, 2021). The raw data received from various databases. Microsoft Excel and Google Sheets become the first stage to arrange the data from the survey questionnaire and export to the professional statistical system, Statistical Package for Social Science (SPSS), to analyse a large amount of data from the Microsoft Excel and Google Sheets to show the result of a study in a readable format.

2.7.2 Impact-uncertainty analysis

Impact-Uncertainly analysis is used to determine the level of uncertainty and impact of the drivers found through STEEPV analysis on the adoption of EV among the Malaysian. The key drivers will be used to develop future scenario of EV adoption in Malaysia.

2.7.3 Reliability analysis

Reliability analysis measures the consistency of raw data from various resources using SPSS for accurate study calculations. This study focuses on using Cronbach's alpha to measure the internal consistency and reliability of the study to determine whether the data collected had been measured with the same characteristics as the study (Frost, n.d.).

3. Literature Review

This chapter focused on the issues and the key drivers of the adoption of EVs in Malaysia. STEEPV analysis is a method to analyse all the issues and drivers to let the researcher identify the future scenarios for EV adoption in Malaysia. STEEPV can assist in the literature review to help the researcher to have a basic understanding of the study, which is in EV adoption in Malaysia to construct frameworks of the report and the questionnaires to study further. In this chapter, the readers can have an overview of the situation of EV adoption with reference from the previous research or secondary data, which had tabulated in a STEEPV analysis format.

3.1 Overview of the EV Industry

The EV industry history has been around for a long time, but it started popping up in these few years due to the commercial success of Elon Musk, the Tesla founder and Toyota Prius. Without the innovation of Tesla, especially in EV automotive sector, most of the automakers still focusing on the internal combustion engine by using fossil fuel ignite the car because internal combustion engine is a mature technology since 1860 by creation of Étienne Lenoir during to speed up the process of Industry revolution (Martins & Siluk, 2022). The oil crisis and environmental awareness became the turning point for emerging EVs in the 20th century to reduce the financial burden. However, the range of EVs still suffers users due to the shorter driving range, and the internal combustion engine cannot be replaced at that time (EVBox, 2023). With the innovation of scientists to solve the driving range problem, the product of the transition period was produced, and the significant product was Toyota Prius, by using hybrid technology in 1997 Japan and get great success in the worldwide automotive market (EVBox, 2023). The game changer shifts the automakers to another high by involving the EV, which is the success of Tesla with the sports EV; Tesla Roadster pushed all the automakers involved in EV R&D (EVBox, 2023). In Asia, the rise of China also with EV policy planning and financial incentives to those automakers investing in EV sectors.

3.2 The Trend of EV Adoption

Adoption is a process of accepting, integrating and publicising a new product or service to the public (Rogers, 2003). In the EV sector, adoption level can be the guideline for the researcher to identify the public acceptance of the new type of technology and replace the internal combustion engine to follow the global trend, which is more focused on environment-friendly transportation to reduce the combustion of fossil fuel by internal combustion engines (Ellsmoor, 2019).

Environmental awareness for the public has become a strong factor in adopting the EV as a transportation tool due the EV can make the environment sustainable because of the reduction of gas emissions and climate change in the environment if using the EV compared to the internal combustion engine vehicles (Okada *et al.*, 2019). Technology advancement is an adding point for the public to adopt and follow the EV to accept the EV in their daily life. The electric motor is the key for the EV, and it identified the efficiency of the EV with the driving range because the motor is quiet than an internal combustion engine and generates huge house power in a short time due to the innovation of technology enhancement in the motor (Shrink That Footprint, 2023). Besides, the coverage of public infrastructure for EV charging points can help to push the general trends to EVs because of the ability to charge points which are invested by the government or cooperate in developing a complete charging point network for reducing the range anxiety to the EV users and let the potential buyers feel the confidence to the EV network (Peng,2022). Affordable price is the key point to making the EV trendy in society. The head of EV, Tesla, also started to lower the price of EVs and the benefit of competition, especially in China which was happening the price war to find potential buyers to buy the EVs at a reasonable price and lower price affect the comparison to adopt the EV by following the trend or continue to use internal combustion engine vehicles. However, most potential buyers will prioritise the price (Singhi, 2023). The change in consumer behaviour is the most easily affected by the trends of EV adoption due to many reasons; the previous research shows the Malaysian are slowly favourable to the EV (Manca *et al.*, 2020).

3.3 EV adoption in Malaysia

Malaysia has been involved in EV since 1996 as a joint venture with Tenaga Nasional (TNB) and Frazer-Nash Research to develop a local EV to strengthen the name ofand form Perusahaan Otomobil Elektrik (POEM), but the ways for POEM was more focused to the sports industry and the first EV by POEM was Eleksuria which is golf cart powered by electric during the Tun Dr Mahathir bin Mohamad century but POEM faded into obscurity in mid-2000 (Foong, 2022). the ambitious project that shows that Malaysia was able to take part in heavy industry, especially for EVs, but due to the policy and management at that particular time, the POEM project had stopped, and Malaysia lost the opportunity to enter the EV sector in 2000 (Foong, 2022).

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3.4 Advantage of EV adoption in Malaysia

Table 2 *Advantages of EV adoption in Malaysia*

Advantages	Explanation
Reduce air pollution	Adopting EVs can lower the rate of greenhouse effects, such as the emission of fossil fuel combustion can be neglected due to not involving internal combustion engines.
Reduce noise pollution	EV does not involve the combustion process, and it does not have any noise pollution during the driving process.
Reduce the wastage of non-renewable resources and rate of illness to the human	EVs are run with zero tailpipe emission because they EV did not use fossil fuel to generate power, and they can reduce air pollution and lead to a reducing the rate of asthma and even lung cancer.
Prioritize the rights of EV users by bringing the income to the developers.	The development of EV-friendly cities that protect the rights of EV users can attract more EV users or potential buyers who tend to use EVs for trips or commutes, and the investment in charging points is the opportunity to bring much revenue during the charging process.
Cheaper price to own an EV	The Government of dealers offers lots of financial and tax relief while purchasing the EV.
Lower fuel cost	The energy cost for EVs is lower than that of internal combustion engines because the electricity rate is cheaper than petrol or diesel and some residential industries are using solar to generate energy.
Improvement of driving performance	The motor's efficiency is higher than the internal combustion engine because the motor's response is immediate. In contrast, the engine has latency at the turbo or time of combustion in the chamber.

3.5 Challenges of EV adoption in Malaysia

Table 3 *Challenges of EV adoption in Malaysia*

Challenges	Explanation
The lack of charging points for EV.	Become a burden due to the limited charging points. Most EV users feel range anxiety during their journey, and if they are out of battery, they need to find alternative transportation quickly and trail the EV to the nearest EV charging point (Woodward *et al.*, 2020).
Security risks for EV users.	EVs cannot help users to reduce the risk of accidents due to the limitations of technology during human error interrupting driving (The Sun Daily, 2022).
Leakage of chemical substances during the production of EV	This causes pollution, and it is irreversible to the environment, and some of the substances are rare earth elements (REE), lithium, nickel, cobalt, and graphite very hard to mine and bring the effect during the mining process (EVBox, 2023).
The cost of maintaining an EV is very high.	EV is an emerging technology. It mostly can be uncertainties such as the price of the battery if any problem with the battery replacement, and it is very expensive, around $10,000 to $12,000 in the United States (EVBox, 2023).

3.6 STEEPV Analysis

STEEPV analysis is a method to analyse secondary data from various resources such as articles, newspapers, journals, websites to identify the issues, trends and challenges based on social, technological, economic, environmental, political, and values.

Table 4 *Output of STEEPV*

Factors	Total
Social	15
Technological	32
Economic	17
Environmental	12
Political	10
Value	5
Total	91

3.7 Merged Issues, Challenges, and Trends

Table 5 *Table of driver to merged issues, and challenges*

No.	Drivers
1	Range and Battery Efficiency
2	Product Differentiation and design
3	Technological innovation and features
4	Charging Infrastructure Availability
5	Purchasing and Maintenance Cost
6	Government Action and Incentives
7	Emissions Reduction
8	Public Environmental Awareness
9	Resource Use
10	Recyclability of EV Components
11	Policy on Green Technology and Energy Security
12	Social-Cultural Acceptance

Table 5 shoes 12 key terms were merged from a total 91 issues and drivers related to EV adoption in Malaysia. After the merging of key terms of issues and drivers which will be included in the questionnaires for the purpose of collecting data.

For driver 1 focus about the battery management, in this case, battery is directly proportional to the range of the EV because due to the capacity of the battery and the user's behaviour, the range of the EV can be adjusted during the journey (Wei *et al.*, 2022).

The driver 2 explain about the type of EV and design, the type and design always different due to the behaviour changes for the consumer and the changes are uncertain and easily to be affected by external factors (Tao *et al.*, 2022).

Driver 3 describes about the technology innovation, as the emerging technology in the world, those EV still very new to the consumers and did not have enough brand reputation compared to the traditional automotive market, so, the technology part become the crucial part of all EV producers by using their own new technology to show the strength of the EV and provides a lot of features to the consumers who want to adopt it (David, 2023).

Driver 4 is the charging network; the network can be the bottleneck when the basic infrastructure for EV did not cover every area, and this become the saviour for all EV during the journey on the road to charge the EV before out of battery (Bowtie, 2023).

Driver 5 explains the initial cost and the running cost for affording an EV in the market, due to the technology of EV did not as mature as internal combustion engines (ICE), the initial cost and running cost always affected by many external factors and those costs are unavoidable when driving on the road, if adopts the EV, this becomes the consideration for the potential EV users (Andrew, 2023).

Driver 6 is the government action, government act an important role such as providing the subsidy, reduce the tax and those can be the factors affect the public adoption to EV (IEA, 2021).

Driver 7 is emissions released by the EV, EV can be a part of green transportation and it can minimise the pollution such as air pollution during the journey because it did not have any tailpipe emissions and did not cause air pollution (EPA, 2023).

Driver 8 is public environmental awareness, the term of "green transportation" can uses on EV due the limited pollution by the EV, for those public wanting to adopt the EV, they will consider the ways to increase the awareness of protecting the environment by using the EV and become the role models in their area (Zhang *et al.*,2022).

Driver 9 explain the resource use during the construction of EV and power source for EV, the development of EV requires a lot of resource via R&D or joint venture with third parties and those resources should be shares internally at the automakers, besides the power source for EV will consider about the raw material for generating the power such as coal, natural gas, hydropower, solar to ensure that the power sources are environmentally friendly (World Nuclear Association, 2021).

Driver 10 is the recyclability rate of the EV because recycle can be a part of green environment and the rate of recyclability are directly proportional to how the environmentally friendly during the selection of materials to develop an EV (Andrew, 2023).

Driver 11 focusses on the environmentally friendly policy, the policy is designed to ensure that the environment can be assisted by the technology enhancement, the green technology can ensure the limitations of emit harmful gases to the environment and using the sustainable energy (KeTTHA, 2017).

Lastly, the social-cultural acceptance of EV can be the trouble or strength to adopt the EV, when the social-layers tends to adopt new technologies, it may easily to adopt the EV in the area and vice versa (Xia,2022).

4. Result

4.1 Pilot Test

The researchers selected 30 respondents to undergo a pilot test to check the reliability of questionnaire survey by using SPSS application. Three parts of the questionnaire survey tested which were the level of importance, the level of impact, and the level of uncertainty and all the results presented by Cronbach's Alpha Value. The results show for all the of levels are higher than 0.90, each part of Cronbach's Alpha Value is 0.957 (Level of Importance), 0.960 (Level of Impact) and 0.958 (Level of Uncertainty) prove that the questionnaire survey was acceptable and the data collection for the actual study can proceed by using the Rule of Thumb Cronbach Alpha (Hair *et al.*, 2010).

4.2 Demographic Analysis

There are 251 valid respondents involved in this study out of 384 sample size respondents. First, the majority of respondents were female at 144 (57.4%) respondents while male respondents were 107 (42.6%). Secondly, the majority of respondents were between 18 to 25 years old which are 171 respondents (68.1%). Next is the age 34 and above old with a frequency of 47 (18.7%), and then followed by 33 respondents (13.1%) from 26 to 33 years old Therefore, the majority of respondents were aged between 18 to 25 years old. Thirdly, the majority of respondents were bachelor's degree which are 161 respondents (64.1%), next is high school and below are 33 respondents (13.1%) and followed by master's degree or higher are 29 respondents (11.6%) and last but not least is diploma which are 28 respondents (11.2%). Next, the majority of respondents came from rural areas which are 108 respondents (43.0%), next were coming from suburban areas which are 89 respondents (35.5%) and last but not least were coming from urban areas which are 54 respondents (21.5%). Next is ownership status, 137 respondents (54.6%) have their own cars and 114 respondents (45.4%) did not have their own cars. In the power source of vehicles, 129 respondents (51.4%) use petrol/diesel, 7 respondents (2.8%) use hybrid, 1 respondent (0.4%) use electric and rest of the 114 respondents (45.4%) did not have vehicles.

Firstly, the majority of the respondents 232 respondents (92.4%) familiar to Malaysia traffic condition which rated the familiarity from 5 to 10 marks while 9 respondents (7.6%) lack of familiar with Malaysia traffic conditions. For the knowledge about the EV, more than half of the respondents (163 respondents) are familiar with EV which is 64.9% of respondents and rated the familiarity from 5 to 10 marks and 88 of respondents (35.1%) are not familiar with EV and rate the familiarity from 4 to 0.

4.3 Impact-Uncertainty Analysis

Impact-uncertainty analysis is conducted to identify the top two drivers with high impact and high uncertainty values. These two drivers will then be used to develop the scenario analysis. The mean of impact and uncertainty variables are shown in Table 6. The top drivers are D4 availability of charging infrastructure which is the highest impact mean value (4.24) and D5 purchasing and maintenance cost of EV which is the highest uncertainty mean value (3.57). The top leading drivers on level of impact and uncertainty plotted at Fig. 1 to show the relationship

between the D4 availability of charging infrastructure which is the highest impact mean value and D5 purchasing and maintenance cost of EV which is the highest uncertainty mean value.

Table 6 *Mean score of impact and uncertainty drivers*

No.	Driver	Uncertainty (X)	Impact (Y)
1.	Reliability of the EV's range and battery efficiency	3.56	4.12
2.	Product differentiation and design of EV compared to internal combustion engine vehicle (ICEV)	3.43	3.89
3.	Technological innovation and features of EV	3.56	4.12
4.	Availability of charging infrastructure	3.52	4.24
5.	Purchasing and maintenance cost of EV	3.57	4.18
6.	Government incentives for EV	3.49	3.93
7.	The potential of EV to reduce carbon emissions	3.25	3.85
8.	Knowledge and awareness of the impact of transportation on the environment	3.27	3.8
9.	Sustainable resource use during travel	3.24	3.86
10.	Recyclability rate of EV components at the end-of-life	3.28	3.8
11.	Government policy on green technology and energy security	3.36	3.9
12.	Social-cultural factors such as social image/identity and lifestyle	3.16	3.59

Table 7 *Mean of 6 leading drivers on level of impact and uncertainty*

No.	Driver	Uncertainty (X)	Impact (Y)
4	Availability of charging infrastructure	3.52	4.24
1	Reliability of the EV's range and battery efficiency	3.52	4.12
3	Technological innovation and features of EV	3.56	4.12
5	Purchasing and maintenance cost of EV	3.57	4.18
11	Government policy on green technology and energy security	3.36	3.9
7	The potential of EV to reduce carbon emissions	3.25	3.85

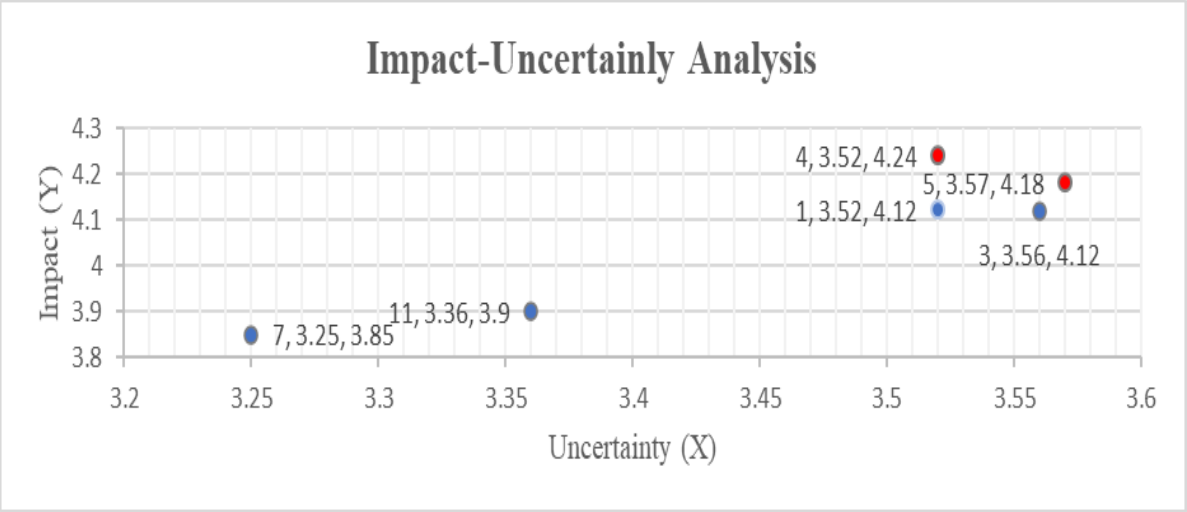

Fig. 1 *Mean Score of impact-uncertainty drivers*

5. Discussion, Recommendation and Conclusion

This chapter will discuss and conclude the findings for this study. According to chapter 4, there have two drivers had been selected by using impact-uncertainly analysis and these drivers will used in scenario building. The purpose for developing a scenario building is analysing the outcome which affected by the two main drivers to study the future trend of EV adoption in Malaysia in the coming 10 years, therefore, the scenario building will generate four scenarios in the end of the chapter.

5.1 Discussion based on the First Research Objective

The first objective for this research is to identify are the issues, trends and challenges related to EV adoption in Malaysia. For these issues, trends and challenges, there were 12 merged drivers had been identified by using STEEPV and analyse the highest impact and uncertainty level by using impact-uncertainly analysis and the top two drivers are availability of charging infrastructure and purchasing and maintenance cost of EV.

5.2 Future Scenario of EV Adoption in Malaysia

Fig. 2 shows the four possible future scenarios that indicated in future, the data is getting from impact-uncertainty in chapter 4. Moreover, the four alternatives scenario were developed from two selected drivers which is “purchasing and maintenance cost of EV” and “Low availability of Charging Infrastructure.”

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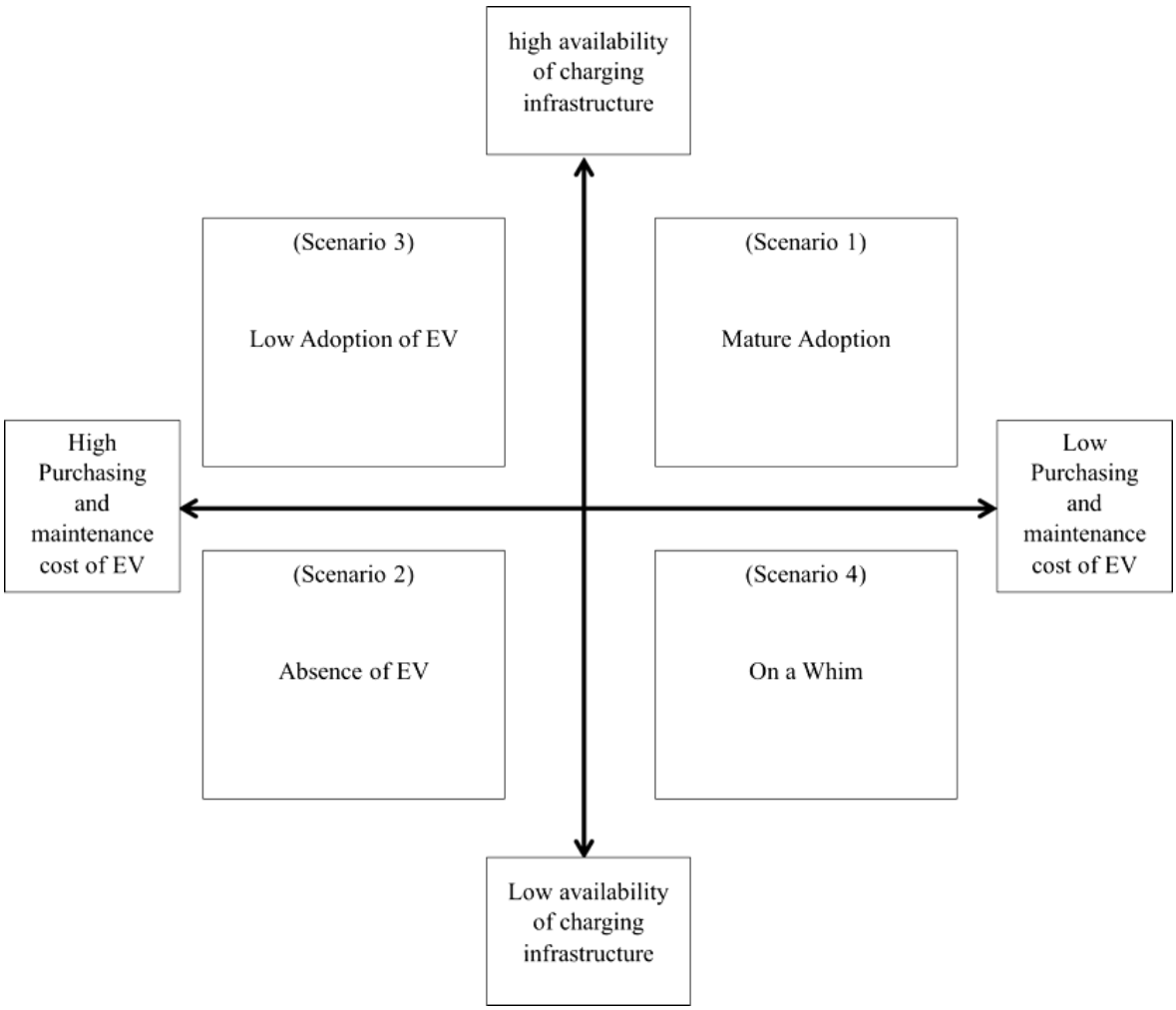

Fig. 2 *Future Scenario of EV adoption in Malaysia*

5.2.1 Scenario 1: Mature Adoption

In the first scenario, mature adoption occurred when there was a high availability of charging infrastructure and low purchasing and maintenance cost of EV. This situation is the best situation for consumers having the chance to purchase EV for their daily routine and replace the ICE vehicles. In Malaysia have a complicated petrol/diesel station in every area whatever in rural or city but in this scenario shows that the charging infrastructure also covered to whole Malaysia as same as petrol/diesel station. This is an important element to increase the adoption of EV in the Malaysia when the facility is covered to whole Malaysia, the range anxiety can be reduced when charging station have provided (Energy5, 2023).

As mentioned before, lower price of purchasing and maintenance cost of EV can help to increase the adoption of EV in Malaysia and the users can use the EV as usual such like the ICE vehicles that can ensure the convenience during the journey (Muzir *et al.*, 2022). The customer behaviour shifts to adopt the EV with complicated charging network, and this is benefits to users and the environment (Hiroko and Brad, 2023).

If this scenario happened in todays or the future world, it can be the best strategic to eliminate the carbon emissions released by the ICE vehicles and meet the SDG 7 and SDG 13 (SK, 2020). In this case focus on carbon and reducing the carbon can achieve the SDG 13: Climate Action for a low carbon future and this will create the green culture to the Earth which supported by all stakeholders (SK, 2020). The green culture in EV sector through the green energy while changing in the public charging station such as solar to generate the energy at all the charging stations. (Chargev, 2019).

5.2.2 Scenario 2: Absence of EV

In the second scenario, absence of EV occurred when there was a low availability of charging infrastructure and high purchasing and maintenance cost of EV. This situation shows the Malaysian totally did not interest into EV due to the price and facilities did not fulfil the basic needs for an EV. When the price of EV is higher than ICE vehicles, the consumers still stand at ICE vehicle market and did not giving a chance for EV. The core element of

EV, charging infrastructure also did not been fulfil by the government or private sectors and the consumers will thinks about the accessible of charging are not very convenient and not friendly to the EV. So, the EV will not be the first choice for those who want to buy the vehicle.

If this scenario happened in today's world, it would become the serious cases to Malaysia even the global. As mentioned before, Malaysia would like to meet the achievement of carbon neutral in 2050 and EV is the best choice for Malaysia to achieve it (Andrew, 2023). In this scenario the vehicle users did not want to use EV as they are daily routine and continues to use the ICE vehicles is not every affected to Malaysia because Malaysia is the oil producer so that Malaysia users did not feel the expensive petrol price compared to those non-oil producers, but it will produce the high carbon emission during driving (BHP, n.d.).

5.2.3 Scenario 3: Low Adoption of EV

In the third scenario, low adoption of EV occurred when there was a high availability of charging infrastructure and high purchasing and maintenance cost of EV. This situation shows that the Malaysia did not have the clear understanding to adopt the EV in Malaysia when the price is very expensive during purchasing and maintenance even though the charging infrastructure are available, the supply for the charging infrastructure become over supply in Malaysia.

As the premium products in scenario, EV will focus on niche market which is focusing on the T20 range in Malaysia because only them can afford to purchase and maintain the expensive EV in Malaysia (The Star, 2023). Those T20 owners can use the charging infrastructure worry free about the battery life during the journey because with high availability of charging infrastructure along the road and the adoption level cannot penetrate to the B40 and M40 lifestyle so that the charging infrastructure always available and seen like the infrastructure serves to those potential T20 owners only (Yukiko, 2023).

When the increasing of available charging infrastructure at public also brings the criminal to the users because most of the public charging stations are remote manage by the providers with limited security features such as streetlight, emergency alarm but those are not secure to protect the users during charging (Channaiah, 2023). So that the adoption of EV is very low in Malaysia at the future even though Malaysia has enough charging infrastructure and still cannot increase the EV rate.

5.2.4 Scenario 4: "On a Whim"

In the fourth scenario, "on a whim" occurred when there was a low availability of charging infrastructure and low purchasing and maintenance cost of EV. For this situation with low cost of purchasing and maintenance of EV, Malaysian will purchase EV hassle-free to in the short period but after the cooling down phase, the consumers adoption will decline and only the clients with loyal to the brand will continue to support the EV.

With the lower price for purchasing and maintaining the EV, all segments in Malaysia mostly can afford the EV by full payment of cash or apply the car loan but is just a short honeymoon phase to enjoy the EV in Malaysia. When they are facing problems with low availability of charging infrastructure, the feeling will go down and reject to use the EV due to the poor availability of charging infrastructure in Malaysia (Robert, 2023). The EV can charge at home but due to the residential power rate is quite low compared to commercial power rate, the EV charging speed will be affected and very slow when charging in house (Cyber Switching, 2023). So, when the EV users facing the challenges in public charging, they will not adopt the EV until the charging infrastructure had been covered to all Malaysia.

5.3 Limitation of the Study

For this research, there are many limitations encountered during the process of research. The first limitation is lack of information regarding the true experience for the EV users from the data collection process. In the survey questionnaire result, only one respondent (0.4%) is using the EV in his/her daily life, but the researcher has a clear vision for the EV users with 1 respondent only. This is because the usage of EV in Malaysia have yet to begin in the Malaysian daily life and cause a lot of respondents did not have the experience to use the EV or very understand to the EV. Future more, the answers options in demographics and the drivers are very limited. The demographics section did not have a very clear option in the Main sources of information about electric vehicles (EV) if they did not have the selection in the survey, the only answer is "others" option. For the driver section, most of the respondents are very confused about how to rank the uncertainty level to answer the question in section drivers even the researcher provides various types of languages to assist the respondent.

5.4 Recommendations

The adoption of EV has been penetrating developed countries such as China, United States, United Kingdom, and so on but in Malaysia the researcher discovered that EV still is the new market for Malaysian and a lots of vehicles users are more tends to ICE vehicles for their journey. To increase the adoption level of EV in Malaysia,

all the sectors should collaboration to reduce the cost and increase the facilities so that Malaysia still has the chances to adopt the EV in the future and this research can made recommend for any future research regarding the EV in Malaysia.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *P.H.J., and W.N.K.W.A.;* ***data collection:*** *P.H.J.* ***analysis and interpretation of results*** *P.H.J., and W.N.K.W.A.;* ***draft manuscript preparation:*** *P.H.J., and W.N.K.W.A. All authors reviewed the results and approved the final version of the manuscript.*

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