OPTIMIZATION OF SOLAR PANEL SYSTEMS FOR CHARGING ELECTRIC VEHICLES AT HOME IN MALAYSIA

PUTERI AFIQAH SYAMIMI BINTI MOHD ZUKI

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

VERIFICATION

‘ I/ We hereby declared that I/ We had read through this thesis and in my/ our opinion that this final year project II is adequate in terms of scope and quality which fulfill the requirements for the award of Bachelor of Technology Management (Technology Innovation)’

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Signature : ……………………...................

Name of Supervisor : Madam Adilah Binti Mohd Din

Date : ……………………...................

Signature : ……………………...................

Name of Panel : Dr. Hasan Bin Saleh

Date : ……………………...................

OPTIMIZATION OF SOLAR PANEL SYSTEMS FOR CHARGING ELECTRIC VEHICLES AT HOME IN MALAYSIA

PUTERI AFIQAH SYAMIMI BINTI MOHD ZUKI

The final year project II is submitted in partial fulfilment of the requirements for the awards of Bachelor of Technology Management (Technology Innovation)

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Faculty of Technology Management & Technopreneurship
Universiti Teknikal Malaysia Melaka

FEBRUARY 2025

DECLARATION

"I admit that this report is the result of my own, except certain explanations and passages where every of it is cited with sources clearly."

Signature : ……………………

Name : Puteri Afiqah Syamimi

Date : 8/2/2025

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DEDICATION

I would like to dedicate the appreciation to my family members who supported me spiritually, supervisor and panel who guided me throughout the journey of research.

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ACKNOWLEDGEMENT

I wish to convey my heartfelt and genuine appreciation to my supervisor, Madam Adilah Binti Mohd Din, for her understanding, outstanding mentorship regarding my report-writing abilities, and priceless counsel that assisted me and furnished me with essential information. She dedicated her valuable time to help and direct me whenever I faced challenges during this project until I completed this report. Additionally, she consistently provided various recommendations to enhance my work and periodically reviewed my progress to ensure I was aligned with other peers under her mentorship. I value her patient guidance, advice, support, and openness to help me acquire more knowledge. Additionally, I am grateful to Dr. Hasan Bin Saleh for his insightful feedback and valuable recommendations during my final year project presentations in projects I and II.

Furthermore, I would like to express my gratitude to Universiti Teknikal Malaysia Melaka (UTeM) for affording me the invaluable opportunity to conduct this research project. Through this project, I acquired numerous new insights and gained knowledge that could be beneficial later.

Moreover, I want to convey my appreciation to my family and friends, who consistently back me from starting a project until its completion. Due to their assistance, I will complete the report with moral and financial backing. This also gives me the drive and enthusiasm to complete what I began.

Lastly, I want to express my appreciation to the participants who generously contributed their time to assist me in the completion of the survey questionnaire. I am also grateful to my parents and friends for their emotional support, inspiration, and encouragement, which were instrumental in my successful completion of this project.

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ABSTRACT

This research examines the optimization of solar panel system for charging electric vehicles (EVs) at home in Malaysia, addressing the growing need for renewable energy alternatives. The study highlights four primary influencing factors: ownership of electric vehicles, electric trading, charging variables, and battery storage. A quantitative method was employed, surveying 384 participants using structured questionnaires. Data analysis included descriptive statistics, Pearson correlation, and methods of multiple regression. The findings validated the importance of all four factors, with battery storage and charging variables exerting the greatest influence. These results highlight the necessity for effective energy storage and carefully planned charging systems to enhance solar energy use. The study recommended to promote solar panel usage for EVs charging, focus on improvements in battery storage, financial assistance to address cost challenges, and methods to boost the cost-efficiency of photovoltaic (PV) systems.

ABSTRAK

Penyelidikan ini mengkaji pengoptimuman sistem panel solar untuk mengecas kenderaan elektrik (EV) di rumah di Malaysia, menangani keperluan yang semakin meningkat untuk alternatif tenaga boleh diperbaharui. Kajian itu menyerlahkan empat faktor pengaruh utama: pemilikan kenderaan elektrik, perdagangan elektrik, pembolehubah pengecasan dan storan bateri. Kaedah kuantitatif telah digunakan, meninjau 384 peserta menggunakan soal selidik berstruktur. Analisis data termasuk statistik deskriptif, korelasi Pearson, dan kaedah regresi berganda. Penemuan mengesahkan kepentingan keempat-empat faktor, dengan storan bateri dan pembolehubah pengecasan memberikan pengaruh terbesar. Keputusan ini menyerlahkan keperluan untuk penyimpanan tenaga yang berkesan dan sistem pengecasan yang dirancang dengan teliti untuk meningkatkan penggunaan tenaga solar. Kajian itu mengesyorkan untuk menggalakkan penggunaan panel solar untuk pengecasan EV, memberi tumpuan kepada penambahbaikan dalam storan bateri, bantuan kewangan untuk menangani cabaran kos dan kaedah untuk meningkatkan kecekapan kos sistem fotovoltaik (PV).

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LIST OF ABBREVIATIONS AND SYMBOLS

EV	=	Electric Vehicle
H0	=	Null Hypothesis
H1	=	Alternative Hypothesis
α	=	Alpha

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

The global transition to renewable energy is no longer just an option but a necessity, driven by growing concerns about energy security, environmental sustainability, and the rapid depletion of fossil fuels. In Malaysia, the use of solar panel systems for residential energy needs has been increasing, supported by government initiatives to encourage renewable energy adoption. Solar photovoltaic (PV) systems, which convert sunlight into electricity, have emerged as a practical and eco-friendly home solution (Liang J. et al., 2022). To make solar technology more accessible, the government has introduced programs like Solar@PETRA and Solar BOLEH! to reduce installation costs and promote widespread adoption. These efforts align with Malaysia's pledge to achieve net-zero greenhouse gas (GHG) emissions by 2050 under the Paris Agreement.

Table 1.1: Buildings Assessed for Rooftop solar PV

State in Malaysia	Number of Building
Selangor	1,037,577
Johor	762,027
Perak	521,844
Kedah	353,943
Penang	301,637
Pahang	282,363

State in Malaysia	Number of Building
Negeri Sembilan	271,358
Sarawak	263,127
Melaka	196,588
Sabah	159,023
Kuala Lumpur	150,182
Terengganu	101,573
Kelantan	90,207
Perlis	29,175
Labuan	11,219
Putrajaya	4,107

(Source: Malaysia Renewable Energy Roadmap, 2021)

Table 3.1 shows the latest data of rooftop solar PV in 2021 from SEDA. From the table, building that already have panel solar has been shown among the state in Malaysia. The total of number of buildings assessed for rooftop solar PV is 4,535,594 in Malaysia. The highest from all 14 states is Selangor which has 1,037,577 of buildings. The lowest is Putrajaya which 4,107 building.

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Solar PV technology, recognized as one of the fastest-growing renewable energy sources, offers significant potential for residential applications. Solar systems reduce reliance on the national grid and lower monthly utility bills by allowing households to generate their electricity. Research from Universiti Teknologi Malaysia indicates that rooftop solar systems can cut energy consumption from Tenaga Nasional Berhad (TNB) by up to 50%, offering environmental and economic benefits (BERNAMA, 2023). Grid-connected systems also provide a reliable energy source, particularly when optimized to meet peak electricity demands (Tanoto Y., 2023).

At the same time, electric vehicles (EVs) are gaining traction worldwide as a cleaner alternative to traditional vehicles. In Malaysia, adopting EVs is seen as a critical step toward reducing carbon emissions and decreasing reliance on fossil fuels. The transportation sector contributes significantly to GHG emissions, with road vehicles accounting for around 74.5% of the total (Dia H., 2023). Encouraging EVs adoption is vital for Malaysia to meet its environmental goals and integrating solar power into home EV charging systems presents an opportunity to maximize renewable energy use. Lessons from countries like Norway, China, and the United States show that financial incentives, supportive policies, and advancements in renewable energy can drive EV adoption effectively (Dia H., 2023).

Combining solar panels with home EV charging systems offers a win-win solution. This approach not only enhances the environmental benefits of EVs by reducing grid dependency but also helps households save on electricity costs. Such integration aligns with Sustainable Development Goal 7, which emphasizes access to affordable, reliable, and clean energy for all by 2030. By investing in renewable energy infrastructure and optimizing solar-powered EV charging systems, Malaysia can create a cleaner, more sustainable energy future while supporting its growing EV market (United Nations, 2022).

This study optimizes solar panel systems for home EV charging in Malaysia. This research aims to contribute to the nation's efforts to embrace renewable energy and achieve its sustainability goals by examining key factors and exploring strategies to enhance efficiency and performance.

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1.2 Problem Statement

Malaysia is moving toward sustainable energy solutions, with solar energy playing a key role in supporting the country's renewable energy goals. As electric vehicle (EV) ownership grows, there is increasing interest in combining solar power with residential EV charging systems. This approach could reduce reliance on conventional electricity, lower energy costs, and support the country's push for greener technologies. However, achieving an efficient and cost-effective setup for solar-powered home EV charging requires addressing several technical, financial, and infrastructure-related considerations.

In Malaysia, home EV charging solutions, like Level 1 and Level 2 chargers, are becoming increasingly popular because they are suitable for residential use. While Level 1 chargers are more affordable, they charge at a slower rate compared to Level 2 chargers, which enable quicker charging but require more elaborate infrastructure and larger installation expenses (Lee, 2023; Ahmad, 2024). Nonetheless, Level 3 fast chargers are often inappropriate for home use because of their complexity and high energy consumption. The location of the charger, the current electrical setup, and adherence to local utility regulations are key factors influencing installation requirements and expenses.

Besides, the expense of setting up a home EV charging system in Malaysia could range from $1,300 to $3,000, based on the type of charger and any additional components needed to meet both EV charging and household energy requirements. Careful planning is essential when incorporating solar panels into the system to ensure that the solar capacity and battery storage align with the household's energy use patterns and EV charging needs (Barman, P. et al. 2023). Inadequately designed systems can lead to energy waste, higher costs, or greater reliance on the electrical grid.

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This study aims to optimize solar panel systems for residential EV charging, focusing on achieving the perfect equilibrium between energy efficiency and cost savings. This research will optimize the benefits of solar energy for electric vehicle charging while providing valuable information to support Malaysian households in their shift to clean energy alternatives by analyzing different configurations of solar systems and home chargers.

1.3 Research Questions

The research question asked in this study is as follows:

i. What is the optimization factor of using solar panel systems for charging electric vehicles at home?
ii. What is the correlation between the factors influencing the optimization of solar panels and charging electric vehicles at home?
iii. What is the most significant factor contributing to the optimization of solar panel systems for charging electric vehicles at home?

1.4 Research Objectives

This study attempted to accomplish the main objectives as follows:

i. To clarify the optimization factor of using solar panel systems for charging electric vehicles at home.
ii. To analyze the correlation between the factors that influence the optimization of solar panels and charging electric vehicles at home.
iii. To identify the most significant factor in optimizing solar panel systems for charging electric vehicles at home.

1.5 Scope of Study

This research conduct to determine the optimization of solar panel systems for charging electric vehicles at home in Malaysia. The project aims to optimize solar panel systems for Malaysian households that want to charge electric vehicles (EVs) at home. The aim is to look at several variables that affect how practical and efficient it is to include solar panels in housing EV charging systems. This comprehensive strategy aims to identify the most practical and cost-effective solar panel configurations to enhance energy efficiency, reduce reliance on the grid, and support the sustainability of home-based EV charging systems in Malaysia.

1.6 Limitations of Study

There are several limitations on this study. First, the results may not apply to all households because energy use and EV charging habits vary from one home to another. Since this research focuses on Malaysia, the findings might not be relevant to other regions with different climates, energy systems, or economic situations. Additionally, the study relies on data from solar panel and electric vehicle owners, which could be affected by the availability and accuracy of the information provided. Lastly, as solar panels and electric vehicles are continually improving, the results of this study may need to be updated over time to stay relevant with new technologies.

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1.7 Significance of Study

The significance of the study is its potential to contribute to the sustainable growth of the EV market in Malaysia by providing insights into the optimal use of solar energy for home charging. By identifying the key factors that enhance the efficiency and cost-effectiveness of solar panel systems for EV charging, the research can help reduce reliance on conventional energy sources, lower electricity costs, and minimize environmental impacts. These insights align with Malaysia's goals for sustainable development and clean energy, particularly in support of SDG 7, which aims to ensure access to affordable, reliable, sustainable, and modern energy. By addressing the technical, economic, and behavioural aspects of solar panel optimization for EV charging, the study provides a comprehensive framework for enhancing energy sustainability and efficiency in the residential sector.

1.8 Summary

This chapter is an overview of the study, divided into several components. The research's background is briefly summarized in the first part, which also introduces the optimization of solar panel systems for charging electric vehicles at home. The second part is the problem statement. The next part formulates the study question and research objectives. this research also identifies the variables influencing the optimization of solar panel systems for charging electric vehicles at home. The research's scope and limitations of the study are then discussed. Finally, the significance of the study has been emphasized. This study is significant for researcher to fill up the gap on the factors influencing the optimization of solar panel systems for charging electric vehicles at home in Malaysia.

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CHAPTER 2

LITERATURE RIVIEW

2.1 Introduction

This chapter detail and explain about solar panels, solar panels for housing, electric vehicles, and electric car charging at home. Besides, this research was also providing the factors for optimizing solar panels, such as ownership of electric vehicles, electric trading, charging variables, and battery storage. A theoretical framework and hypothesis from the previous study at the end of this chapter has been developed.

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2.2 Solar Panel

Numerous studies have been conducted on residential rooftop photovoltaic systems' economic viability and optimization. The viability of grid-connected residential rooftop photovoltaic systems in Turkey was examined by Duman and Güler (2020), who concentrated on metrics such as the profitability index, internal rate of return, and discounted payback duration. From the customer's standpoint, optimizing solar panel systems requires making difficult decisions. Insights into estimating a solar photovoltaic array and household electricity load were provided by Vaz (2020), who emphasized the intricacy of customer choices and the possible deterrent impact of having many alternatives.

2.2.1 Solar Panel for Housing

Research on the economic feasibility of residential rooftop photovoltaic systems has been conducted in several different areas. The viability of grid-connected residential rooftop PV systems in Turkey was examined by Duman and Güler (2020), who concentrated on metrics like the profitability index, internal rate of return, and discounted payback duration.

The focus of current research has been on optimizing solar panel systems for home use. Researchers Hoarau and Perez (2018) stressed that control generation should be controlled by biosocial solar power consumption. Boosted Solar generation must be integrated into the grid. (Munkhammar & Fachrizal, 2020) addressed the inverse relationship between home load and PV power generation by discussing enhanced solar self-consumption in residential structures through smart car charging. (Van der Meer et al., 2020) looked at the effects of seasonal variations on solar energy forecasts, which is relevant for increasing renewable energy capacity in Malaysia. (Luthander et al., 2020) analysed solar self-consumption, highlighting challenges and solutions for optimizing on-site renewable energy generation.

From the customer's standpoint, optimizing solar panel systems requires making difficult decisions. (Vaz, 2020) provided insights into modelling a domestic electricity demand and solar photovoltaic array, emphasizing the intricacy of customer choices and the possible turn-off effect brought on by an abundance of alternatives. Optimizing solar panels for home EV charging is a topic that (Gillingham et al., 2016 and Hardman & Tal, 2021) addressed to lower grid dependency and increase clean energy consumption.

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2.3 Electric Vehicle

Numerous studies have been conducted on integrating and optimizing home charging schemes for electric cars (EVs). (Muratori, 2018) investigated the consequences of disorganized plug-in EV charging, emphasizing the necessity of coordinated methods to maximize solar energy utilization for EV charging. (Fachrizal & Munkhammar, 2020) addressed the difficulties caused by the inverse relationship between residential demand and PV power output by concentrating on the best EV charging schedules to reduce net load unpredictability and flatten the load profile.

2.3.1 Charging Electric Vehicles at Home

A critical research topic has been how charging procedures affect the amount of electricity used in homes. (Muratori, 2018) investigated the consequences of disorganized plug-in EV charging, emphasizing the necessity of coordinated methods to maximize solar energy utilization for EV charging. (Fachrizal & Munkhammar, 2020) addressed the difficulties caused by the inverse relationship between residential demand and PV power output by concentrating on the best EV charging schedules to reduce net load unpredictability and flatten the load profile.

Optimizing EV charging infrastructure requires an understanding of home vehicle factors. In their discussion, (Hardman & Tal, 2020) focused on variables including the efficiency of the second home vehicle, the electric driving range, and shifts in household vehicle ownership that may contribute to the discontinuation of plug-in electric cars (PEVs) in California. The relevance of consumer attitudes and views towards EVs, particularly household vehicle factors, has been highlighted by studies Plötz et al. (2019).

Numerous studies have been conducted on the advantages of intelligent charging solutions regarding economy and load control. The potential of innovative EV charging systems for peak load control and shaving was noted by (Burlig et al., 2020). To guide upcoming infrastructure expenditures, (Wang et al., 2018) examined changes in power consumption behaviours after the introduction of EVs and residential solar PV systems. To get pre- and post-treatment variations in power demand, (Ghanem & Smith, 2021) employed a Difference-in-Differences technique with data from smart meters. This allowed them to collect empirical information regarding the effects of combining solar panels and electric vehicles on home energy consumption.

Battery storage must be optimized for residential solar power systems to function well. Sim & Vijayagopal, (2020) examined the difficulties of balancing environmental effects and financial accessibility. They emphasized the significance of choosing the right storage components to reduce ownership costs.

2.4 Optimization Factors for Solar Panel

These optimization factors for solar panels are independent variables that identify ownership of electric vehicles, electric trading, charging variables, and battery storage.

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2.4.1 Ownership of Electric Vehicles

Electric vehicles are popular, but only some worldwide use them the most. Past researchers in the United States say that a significant survey result shows that just 10% of EV-owning households are single-vehicle households (Davis, 2019). This statistic highlights the common practice of multi-vehicle ownership among Malaysian EV owners, indicating that most EV families also own other cars.

Furthermore, the study's EV owners admitted to owning multiple registered vehicles, which suggests a common situation in which one EV is usually left at home to be charged. People use other automobiles at the same time (Davis, 2019). These findings add to the knowledge of the best ways to charge electric vehicles at home in Malaysia. They highlight the need to consider the ownership patterns of multiple vehicles when analysing the charging habits and energy use of EV owners in the country.

Moreover, emphasize that understanding customer attitudes and beliefs regarding electric cars, especially those about household vehicle characteristics, is critical to encouraging greater adoption (Plötz et al., 2019). Policymakers and other stakeholders in Malaysia may create focused plans for maximizing EV charging infrastructure at home by using the findings from this research and considering factors like vehicle economy, driving range, and variations in the number of household vehicles owned.

In conclusion, it is essential to consider multi-vehicle ownership patterns and a range of charging behaviours among EV owners in Malaysia when optimizing EV charging at home. This comprehensive approach may help remove barriers to EV adoption and improve the entire charging experience for Malaysian EV owners, which will eventually support the market's sustainable expansion for electric vehicles.

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2.4.2 Electric Trading

It is crucial to consider the dynamics of household electric trading. Investigate combining photovoltaic (PV) systems with electric vehicle (EV) charging in residential structures, especially at high latitudes and suggest efficient charging strategies to reduce net load variability (Munkhammar and Fachrizal, 2020). Their results are relevant to Malaysia because they show how smart charging may lower peak loads and boost PV self-consumption in two essential aspects of maximizing home energy usage.

Thoroughly analyze solar self-consumption in buildings, highlighting the difficulties and possible solutions to maximize the use of on-site renewable energy generation (Luthander et al., 2020). This is especially important for Malaysia, where rooftop solar PV systems are becoming increasingly common. Combining home energy use with EV charging might result in more effective energy management.

Furthermore, examine how the seasons, aggregation, and penetration affect the precision of probabilistic predictions for solar energy, electricity usage, and net load. Their findings are significant for Malaysia, as the country wants to enhance its capacity for renewable energy (van der Meer et al., 2020). More precise forecasting might allow for more efficient control of EV charging demands.

Lastly, examine the relationships between solar generation and electric mobility, emphasizing the benefits and difficulties of this integration. This assessment emphasizes how crucial it is for Malaysia to integrate PV systems with EV charging to create a sustainable and effective energy grid that can support the nation's expanding EV population.

In conclusion, studies furnish a strong start at understanding the specifics of domestic electricity trading concerning electric vehicle charging, and they provide Malaysia with essential suggestions for optimizing its energy infrastructure in preparation for the growing popularity of electric cars.

2.4.3 Charging Variables

The charging variable is critical in determining solar panel systems' overall performance and sustainability for home-charging electric vehicles (EVs). The relationship between household photovoltaic systems and electric vehicle charging is addressed, and the latest study findings have been compiled. These address charging optimization goals, including lowering peak loads, optimizing charging efficiency, and maximizing charging costs (Fachrizal, R. et al, 2020).

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Optimizing home charging for electric cars (EVs) in Malaysia requires careful consideration of the findings, highlighting the critical role of available and comfortable charging infrastructure. This demonstrates that giving up owning an EV strongly correlates with dissatisfaction with charging convenience, suggesting that home charging availability is essential to keeping EV adopters (Hardman & Tal, 2020).

The study also highlights the connection between a decreased chance of giving up EV ownership and having level 2 (220-volt) charging available at home (Hardman & Tal, 2020). Malaysia may greatly benefit from these findings, which come from worldwide research, as it works to improve its EV charging infrastructure to accommodate the growing number of EVs on its roadways. Additional studies confirm these findings, highlighting the charging experience as a critical component of EV adoption and use (Franke et al., 2020).

In conclusion, Malaysia may greatly benefit from these findings, which come from worldwide research, as it works to improve its EV charging infrastructure to accommodate the growing number of EVs on its roadways. By implementing measures that tackle these concerns, Malaysia may provide a more favourable environment for adopting and using EVs, hence improving sustainable transportation and reducing environmental effects.

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2.4.4 Battery Storage

Numerous research works have explored the challenges of balancing financial accessibility and environmental impact when optimizing battery storage for home solar systems. They highlighted the significance of choosing the appropriate storage components to reduce ownership costs by examining the ideal size of vehicle storage parts based on fuel cells, supercapacitors, and batteries (Sim & Vijayagopal, 2020)

Additionally, work cantered on minimizing total costs by optimizing the size of components for a fuel cell-powered vehicle, highlighting the need for effective component selection in energy systems (Sim & Vijayagopal, 2020). These studies highlight how crucial battery storage optimization is to improve the efficiency and financial sustainability of renewable energy systems and offer insightful information for anyone involved in making decisions about sustainable energy sources.

By utilizing the knowledge gained from this research on battery storage optimization, one can better understand the complex balance between environmental concerns and cost optimization in the context of home solar systems. Integrating renewable energy sources, such as solar power, with effective battery storage technologies offers impressive possibilities for sustainable energy management in Malaysia. This information may be essential in influencing strategies for optimizing the charging of electric vehicles at home.

2.5 Charging Electric Vehicle at Home

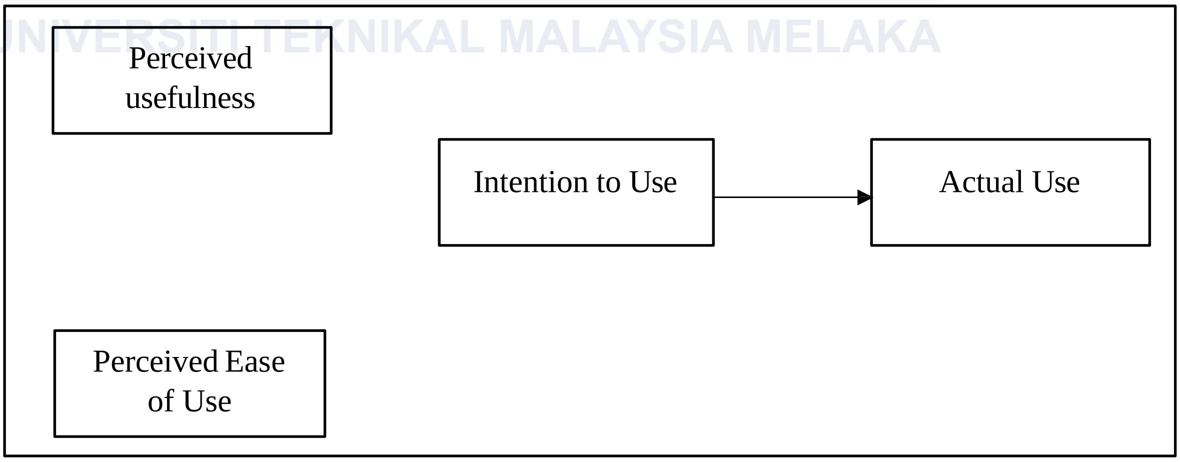
Solar panel optimization for home EV charging aims to optimize the use of renewable energy sources to improve transportation sustainability. Solar power, often known as photovoltaic (PV) systems, is essential for producing clean electricity for use in homes. By using sunshine and turning it into power, households may reduce their reliance on conventional grid electricity and carbon footprint (von Bonin et al., 2022).

Moreover, using solar panels to charge electric vehicles at home is a smart move toward encouraging environmentally friendly transportation options. This cooperative effort between solar energy generation and electric car charging aligns with the more significant objective of switching to more environmentally friendly modes of transportation. By optimizing solar panels for electric vehicle charging, households may help create a cleaner environment and lower greenhouse gas emissions (von Bonin et al., 2022).

Besides, when optimizing solar panels for home EV charging, energy efficiency, storage capacity, and charging infrastructure must be considered. By making the most of solar energy for EV charging, households may lower their power expenses and contribute significantly to the rapid growth of renewable energy in the transportation industry. This optimization procedure aims to encourage the integration of clean energy technology and improve the overall sustainability of home energy usage (von Bonin et al., 2022).

Furthermore, optimizing solar panels for home EV charging also highlights how homeowners may play an essential part in the shift to a more environmentally friendly energy supply. By using solar electricity for EV charging, homeowners may lessen their environmental impact and help mitigate climate change. In addition to helping individual homes save energy, this integrated strategy advances efforts to create a more durable and sustainable energy infrastructure (von Bonin et al., 2022).

2.6 Theory of Technology Acceptance Model (TAM)



(Source: Davis, 1989)

Figure 2.1: Theory of Technology Acceptance Model

Theory of Theory of Technology Acceptance Model (TAM) is the theoretical framework was created to forecast and comprehend how users would adopt new technologies, as shown in Figure 2.1. TAM is primarily concerned with two aspects: perceived utility and perceived ease of use. Perceived usefulness is the user's view of how a technology would improve performance. In contrast, perceived ease of use is the user's belief about how simple it is to utilize a specific technology (Marikyan, D. & Papagiannidis, S., 2023).

These two elements determine how users feel and want to utilize technology. According to TAM, adopting technology is a three-step process wherein outside stimuli cause cognitive reactions, which in turn cause emotional reactions that impact user behaviour (Davis, 1989). TAM offers providers significant advice to improve technology acceptance and implementation success by highlighting the significance of creating helpful and straightforward systems.

2.7 Proposed Research Framework

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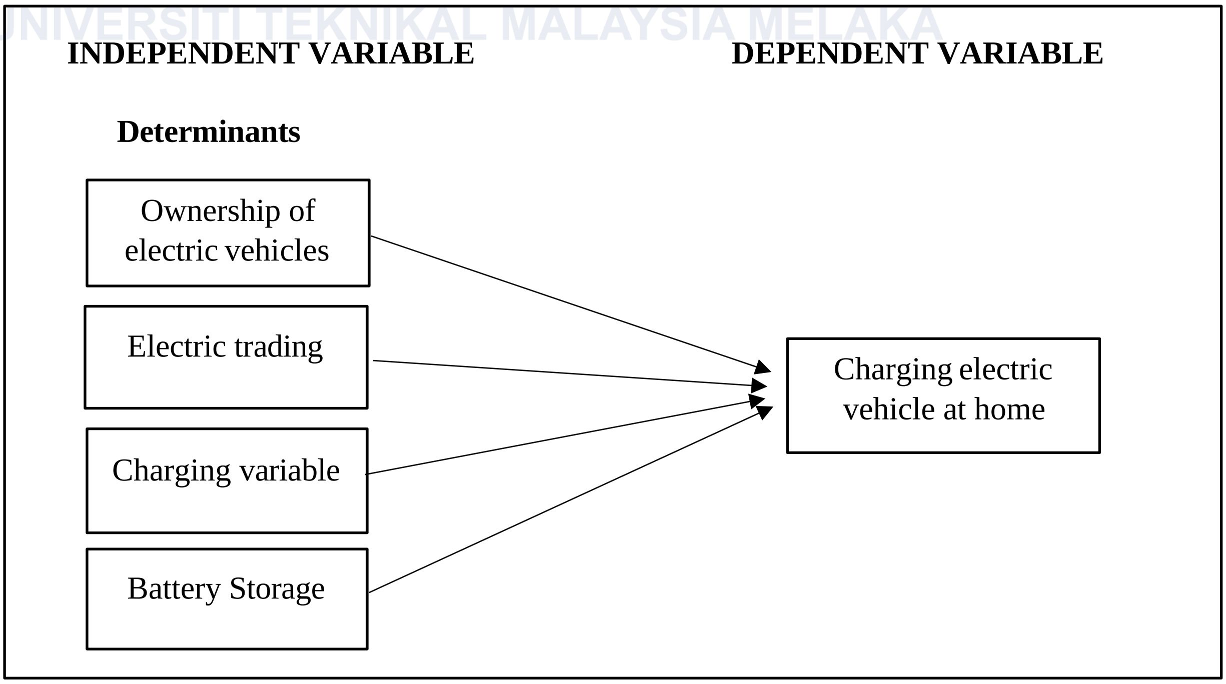

Figure 2.2: Theoretical Framework of Charging electric vehicle at home

This theoretical framework of the study is based on the Technology Acceptance Model (TAM), which aims to investigate the factors that panel solar for charging electric vehicles at home in Malaysia, as in Figure 2.2.

According to TAM that it focuses on understanding the factors that affect people's intentions to utilize technology rather than just the effects of that technology on performance. In this study, ownership of electric vehicles highlights that to promote increased EV adoption. It is critical to understand consumer attitudes and household car characteristics. With this knowledge, governments may better optimize the infrastructure for home EV charging by developing focused plans that consider factors like vehicle efficiency, driving range, and the number of family vehicles owned.

Furthermore, electric trading requires more accurate forecasting of solar energy and power use to improve the management of EV charging demands and meet Malaysia's renewable energy ambitions. Malaysia's increasing EV population will require a sustainable and functional energy infrastructure, which can only be achieved by successfully integrating PV systems with EV charging.

Besides, charging variable requires lower peak loads, increase charging efficiency, and cut expenses, the infrastructure for charging must be optimized. The availability of home charging, which increases its convenience and appeal, can significantly lower the chance that EV owners will give up on their cars. Malaysia can encourage the use of electric vehicles (EVs) and lessen their environmental impact by improving the infrastructure for charging them.

Lastly, battery storage requires optimization is essential in household solar systems to balance environmental effects and affordability. Selecting the appropriate storage components may lower the cost of ownership while enhancing the sustainability and efficiency of renewable energy systems. Incorporating efficient battery storage technology with renewable energy sources presents a substantial opportunity for sustainable energy management in Malaysia. These revelations can help develop home EV charging optimization strategies, which will help us move towards a more sustainable energy future.

2.8 Hypothesis of Study

The hypothesis of this study can be stated below:

Ownership of electric vehicles

H0: There is no significance relationship between ownership of electric vehicles and charging electric vehicle at home.

H1: There is significance relationship between ownership of electric vehicles and charging electric vehicle at home.

Electric trading

H0: There is no significance relationship between electric trading and charging electric vehicle at home.

H1: There is significance relationship between electric trading and charging electric vehicle at home.

Charging variables

H0: There is no significance relationship between charging variables and charging electric vehicle at home.

H1: There is significance relationship between charging variables and charging electric vehicle at home.

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<u>Battery storage</u>

H0: There is no significance relationship between battery storage and charging electric vehicle at home.

H1: There is significance relationship between battery storage and charging electric vehicle at home.

2.9 Summary

The study contributes a collection of studies identifying the factors influencing charging an electric car at home. In addition, this chapter covered the relevant theory, produced a theoretical framework, and concluded with a hypothesis.

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CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

This research methodology is the technique that is used for collecting sample data and solutions to the problem. In this chapter, the researcher explained the methods used to collect the data, define research questions, and test the hypothesis. This topic first discusses the research design and methodology choice. Then, the researcher continues with the data sources and sampling design. After that, the researcher continues with the research strategy, time horizon, specific canons, and data analysis method. This chapter aims to ensure that researchers have a better understanding and evaluate the result of the study.

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3.2 Research Design

The research design describes how the study will be carried out, including the methodology (qualitative, quantitative, or mixed techniques) and the reasons behind the choice of design (Huber S, 2024). The research strategy functions as the overarching framework for the study, including the methodology and techniques for collecting and interpreting data. In contrast, a research design offers a comprehensive and systematic strategy for the investigation, including the methods and approaches to be used at every phase.

In the context of the study on optimizing solar panel systems for charging electric vehicles at home in Malaysia, the research design provides a clear explanation for choosing a quantitative approach, as it enables the statistical analysis of data to identify patterns, correlations, and trends that are crucial for formulating evidence-based recommendations. Using a quantitative approach in this design is justified since it enables statistical analysis of the data to find trends, patterns, and correlations that are critical for developing recommendations supported by evidence (Kumar & Garg, 2020).

A research design is a specific plan for the study, while a research strategy is a general strategy (Huber S, 2024). A quantitative approach was used for this study to get objective, quantitative information that can be statistically analysed to provide reliable and applicable results. This method effectively determines consumers' involvement and what essential variables affect the uptake of solar panel systems for electric vehicle charging.

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3.3 Methodology Choice

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The chosen method's applicability for the given research issue should be made evident in the publication (Huber S, 2024). The method used in the research of choice is quantitative, which is very useful for tackling the research topic. This strategy works well because it allows gathering and evaluating quantitative data that may give a clear picture of customer optimizations, correlations, and the most significant aspects regarding the usage of solar panel systems for EV charging.

The quantitative method's capacity to provide objective, quantitative findings that can be extrapolated to a larger population shows its application. To ensure the validity and reliability of the results, this approach uses structured surveys to collect data from a representative sample of homes. Additionally, using practical statistical studies like regression and correlation analysis, the quantitative approach makes it possible to investigate the connections between different aspects impacting customer involvement and the adoption of solar panel systems.

The methodology's effectiveness in managing big datasets, essential for fully comprehending the variety of elements influencing Malaysian consumers' behavior, further supports the decision. The study can provide solid insights into how solar panel systems might be adjusted for greater customer acceptability and usage for EV charging at home by carefully analyzing the data gathered.

3.4 Data Sources

Various approaches to data collecting and analysis could be required depending on the data type, such as quantitative, qualitative, or a combination of both (Huber S, 2024). Quantitative data is the main emphasis of this study on solar panel system optimization for home electric vehicle charging in Malaysia. This method involves collecting quantitative data that can be statistically examined to find trends, correlations, and patterns regarding customer involvement and solar panel system adoption.

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The data sources used in the study are referred to as information sources. In this quantitative study, structured surveys will collect primary data from a representative sample of Malaysian households. The surveys will collect data on various topics, such as consumer preferences, satisfaction levels, adoption barriers, and perceived benefits of using solar panel systems for home EV charging.

Secondary data was gathered from published works, industry reports, and government publications in addition to primary data. These sources include benchmark data and valuable contextual information that may be utilized to support and corroborate the conclusions drawn from the primary data. The sources of the information utilized in the study are referred to as data sources. This may include primary data gathered through surveys or interviews and secondary data gleaned from databases or published literature (Huber S, 2024).

3.5 Sampling Design

Choosing the method for selecting the sample from the target population is part of the sampling design process. Determining the target population, sampling frame, elements, procedure, and size of the sample are all included in this (Huber S, 2024). The sampling design is essential in this study on optimizing solar panel systems for home electric vehicle charging in Malaysia to guarantee representative and reliable data collection. To guarantee that the sample size is sufficient to yield accurate and dependable findings while considering any non-responses and other sampling mistakes, statistical methods will be used to estimate the sample size. Cui et al. (2022) state that the study's extensive sample approach will allow for the precise capture of consumer participation levels, preferences, and barriers related to the usage of solar panel systems for EV charging at home.

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3.5.1 Target Population

The group of people the research seeks to analyze is the target population (Huber S, 2024). The intended target population for this study, which focuses on optimizing solar panel systems for home EV charging in Malaysia, includes Malaysian houses that have solar panel systems or not, EV users who have or interested to have it. This includes houses with differing geographic locations, economic holders, and current energy usage habits. The project is to collect complete data reflecting the attitudes, behaviors, and difficulties experienced by future and existing users of solar panel systems for electric vehicle (EV) charging in Malaysia by concentrating on this target demographic.

3.5.2 Sampling Frame

The sampling frame is the list of all the items from which the sample will be taken (Huber S, 2024). A thorough list of all the homes in Malaysia that have either installed solar panel systems or expressed interest in doing so will be included in the sample frame for this study on optimizing solar panel systems for home EV charging. Various sources, such as databases of solar panel installation businesses, government energy projects, and registers of homes participating in renewable energy programs, will be used to build this list. To optimize solar panel systems for home EV charging in Malaysia, the study intends to collect accurate and valid data by guaranteeing that the sample frame is inclusive and representative of the target population.

3.5.3 Sampling Element

Each home represents a single sampling element in the sampling frame, including those with installed solar panel systems or those who have shown interest in doing so. By concentrating on these homes, the research may collect accurate and comprehensive data about customer involvement, preferences, and barriers involving solar panel systems used for electric vehicle charging. This will enable the study to offer both local and general information.

3.5.4 Sampling Technique

The process used to choose a sample from the population is referred to as the sampling technique (Huber S, 2024). This study will use a stratified random sample approach to optimize solar panel systems for charging electric vehicles at home in Malaysia. This method separates the target population into subgroups or strata according to important factors, including geography, income, and existing energy use patterns. A random sample of homes has been chosen from each stratum.

Using a stratified method, the sample guaranteed being representative of the various demographic categories, allowing for a more thorough knowledge of customer involvement and preferences. To build focused strategies to optimize solar panel systems for EV charging, stratified random sampling is used to capture variances across various groups.

Theoretically, this approach can be compared to the shortened search strategy with an underline employed in literature reviews. The latter seeks to incorporate all pertinent information while guaranteeing thorough topic coverage (Kumar & Garg, 2020). The project intends to produce trustworthy and generalizable data that may successfully guide practice and policy in the context of solar energy adoption in Malaysia by utilizing a structured and systematic sampling approach.

3.5.5 Sampling Size

To ensure the validity of our study approach, we use accepted guidelines to estimate sample size. We use a method that considers population size, confidence level, and margin of error, as demonstrated by the pioneering research of Krejcie & Morgan (1970) in their article "Determining Sample Size for Research Activities," released in Educational and Psychological Measurement. Using this approach, we obtain accurate population parameter estimations for our solar panel system optimization research for home electric vehicle charging in Malaysia.

A total of 384 respondents will be randomly chosen to participate in a study about Malaysian households' use of solar panels, electric vehicles (EVs) and they interested. The study aims to learn more about how EVs and solar panels are being adopted, used, and perceived in household areas.

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Besides, right now more than 16,000 domestic users have benefited from the NEM program, and the government is planning to expand the use of the solar panel program to increase its maximum potential (BERNAMA, 2024). Besides, according to one estimate provided by the Zero Emissions Vehicle Association (ZEVA,2024), Malaysia reported that in 2023, there would be 13,257 electric vehicle registrations, meaning that overall, there will be 16,763 electric vehicle registrations on Malaysian roads (ZEVA,2024). With a 5% margin of error and a 95% confidence level, the sample size of 384 respondents has been established to guarantee the statistical validity and reliability of the survey results.

Table 3.1: Sample size for different sizes of population

Population Size	**Confidence = 95%**				**Confidence = 99%**			
	Margin of Error				**Margin of Error**			
	5.0%	**3.5%**	**2.5%**	**1.0%**	**5.0 %**	**3.5%**	**2.5%**	**1.0%**
10	10	10	10	10	10	10	10	10
20	19	20	20	20	19	20	20	20
30	28	29	29	30	29	29	30	30
50	44	47	48	50	47	48	49	50
75	63	69	72	74	67	71	73	75
100	80	89	94	99	87	93	96	99
150	108	126	137	148	122	135	142	149
200	132	160	177	148	154	174	186	198
250	152	190	215	244	182	211	229	246
300	169	217	251	291	207	246	270	295
400	196	265	318	384	250	309	348	391
500	217	306	377	475	285	365	421	485
600	234	340	432	565	315	416	490	579
700	248	370	481	653	341	462	554	672
800	260	396	526	739	363	503	615	763
1000	278	440	606	906	399	575	727	943
1200	291	474	674	1067	427	636	827	1119
1500	306	515	759	1297	460	712	959	1376

2000	322	563	869	1655	498	808	1141	1785
2500	333	597	952	1984	524	879	1288	2173
3500	346	641	1068	2565	558	977	1510	2890
5000	357	678	1176	3288	586	1066	1734	3842
7500	365	710	1275	4211	610	1147	1960	5165
10000	370	727	1332	4899	622	1193	2098	6239
25000	378	760	1448	6939	646	1285	2399	9972
50000	381	772	1491	8056	655	1318	2520	12455
75000	382	776	1560	8514	658	1330	2563	13583
100000	383	778	1513	8762	659	1336	2585	14227
250000	384	782	1527	9248	662	1347	2626	15555
500000	384	783	1532	9423	663	1350	2640	16055
1000000	384	783	1534	9512	663	1352	2647	16317
2500000	384	784	1536	9567	663	1353	2651	16478
10000000	384	784	1536	9594	663	1354	2653	16560
100000000	384	784	1537	9603	663	1354	2654	16584
300000000	384	784	1537	9603	663	1354	2654	16586

(Source: The Research Advisors, 2006)

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3.6 Research Strategy

A systematic literature review technique that drew from relevant literature sources (Cui et al., 2022) and Kitchenham and Charters's (2007) principles served as the foundation for the research strategy used in this study. This methodology included key phases, such as defining research inquiries, devising search tactics, setting inclusion and exclusion standards, evaluating study quality, obtaining data, and integrating conclusions (Cui et al., 2022). Under the topic Optimization of Solar Panel Systems for Charging Electric Vehicles at Home in Malaysia, the research strategy aimed to conduct a thorough literature assessment of previous studies on integrating solar panel systems with infrastructure for electric vehicle charging. This method was essential for comprehending the situation at the time, pointing out knowledge gaps, and developing suggestions for enhancing solar panel systems to facilitate electric car charging in homes. Through adherence to a methodical approach, the study aimed to guarantee thoroughness and accuracy in combining critical perspectives to accomplish the research goals efficiently.

3.6.1 Questioner Design

The data for this study will be gathered quantitatively through questionnaires with closed-ended questions by the researcher. The study was employing a closed-ended questionnaire due to the respondents' more rapid and straightforward responses. In addition, the survey was created in English and Malay, a suitable language for correspondence with the participants in Malaysia. The design of the questions based on the optimization factors for solar panel, as mentioned in the literature review, which will impact charging an electric vehicle at home. Additionally, the questionnaire for this study will be provided online.

The questionnaire design divided into three sections. The first set of questions asks about the respondents' gender, race, degree of education, monthly household income and so on. It assists to determine their demographic profile. It makes it easier to ascertain each person's background as you go through the survey. The second section comprises questions regarding the four determinants of optimization factors of using solar panel for charging an electric vehicle at home. Besides, the third section comprised questions regarding correlation factors between the factors that influence the optimization of solar panels and charging electric vehicle at home. The questionnaires contain questions regarding the four independent variables (ownership of electric vehicle, electric trading, charging variable and battery storage) and the dependent variable (charging an electric vehicle at home). To get the necessary data, respondents are requested to give responses on a five-point Likert scale to inquiries related to each variable. The Likert Scale has five points: 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree.

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3.6.2 Pilot Test

A pilot test has been conducted to verify the validity and reliability of the questionnaire for this study on solar panel system optimization for home charging of electric vehicles in Malaysia. Before conducting a full-scale data collection, a pilot test entails pre-testing the research equipment on a small sample to find and fix any problems (Huber S, 2024). To represent the variety of the target group, a representative sample of 30 participants has been chosen for this study. After completed the survey, participants give feedback on the questions' relevancy, simplicity, and challenges. After analyzing the pilot test data, the questionnaire revised to find recurring problems. This process improves the survey instrument, increasing its efficacy in gathering high-quality data and producing more valid and dependable study results.

3.7 Time Horizon

According to Huber (2024), the time horizon refers to the length of time that the study will take to complete, from data collection and analysis to reporting. Setting a specific time frame for the study is essential when examining how solar panel systems in Malaysia may be optimized for charging electric cars at home. Thus, establishing a clear timeframe guarantees thorough data collection, thorough analysis, and prompt distribution of results, all of which enhance the region's sustainable energy options.

3.8 Scientific Canons

The validity and reliability approaches were used in this research study since the validity and reliability of the research findings depend on both.

3.8.1 Reliability

Two primary forms of reliability are very crucial. First, internal consistency reliability measures how effectively a test's components function together to measure a single notion. Cronbach's alpha, which measures how effectively a group of questions measure the same underlying construct and assesses internal consistency, can be used to analyze this (Cronbach, 1951). For the sake of the study, this entails ensuring that the questionnaire's items consistently measure various aspects of solar panel system optimization. The test-retest reliability, which looks at whether a system consistently yields comparable findings over time, is the second kind. Assuring this reliability will boost the validity and repeatability of the study results (Lin et al., 2021).

Table 3.2: Cronbach's Alpha

Cronbach's alpha	**Internal consistency**
$\alpha \geq 0.9$	Excellent
$0.9 \geq \alpha \geq 0.8$	Good
$0.8 \geq \alpha \geq 0.7$	Acceptable
$0.7 \geq \alpha \geq 0.6$	Questionable
$0.6 \geq \alpha \geq 0.5$	Poor
$0.5 \geq \alpha$	Unacceptable

(Source: Lin et al., 2021)

A statistical technique for measuring internal consistency dependability is Cronbach's alpha. It examines how well a measuring method of elements functions together to reflect a single construct. Better accuracy is indicated by a higher Cronbach's alpha score, which shows that the questionnaire's individual questions consistently assess the overall construct under investigation (Cronbach, 1951). This guarantees that the information gathered is trustworthy and appropriately represents the concept being studied (Lin et al., 2021).

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3.8.2 Validity

A test's content validity is evaluated by looking at all the significant topics it must cover. To guarantee content validity, experts might, for instance, review the questionnaire questions in research to ensure they address every relevant aspect of the subject under investigation (Yudhistira et al., 2021).

Criterion-related validity, another name for empirical validity, examines the relationship between test results and other measures of the same concept. To prove empirical validity in the study and ensure that the questionnaire scores accurately reflect the essential components of the construct under investigation, researchers may compare the answers of thirty participants across different questionnaire sections (Yudhistira et al., 2021).

Table 3.3: R table of Pearson Product Moment

N	r	N	r	N	r	N	r
3	0.997	18	0.468	33	0.344	48	0.285
4	0.950	19	0.456	34	0.339	49	0.282
5	0.878	20	0.444	35	0.334	50	0.279
6	0.811	21	0.433	36	0.329	51	0.276
7	0.755	22	0.423	37	0.325	52	0.273
8	0.707	23	0.413	38	0.320	53	0.270
9	0.666	24	0.404	39	0.316	54	0.268
10	0.632	25	0.396	40	0.312	55	0.265
11	0.602	26	0.388	41	0.308	56	0.263
12	0.576	27	0.381	42	0.304	57	0.261
13	0.553	28	0.374	43	0.301	58	0.258
14	0.532	29	0.367	44	0.297	59	0.256
15	0.514	30	0.361	45	0.294	60	0.254
16	0.497	31	0.355	46	0.291	61	0.252
17	0.482	32	0.349	47	0.288	62	0.250

(Source: Duwi Priyatno, 2009)

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The Pearson Product Moment r Table is shown in Table 3.3 above. This table aims to determine the validity of each questionnaire item. The researcher determines the validity of the questionnaire by examining the significance value or by comparing each item's values with the r table product instance. Thirty participants will participate in pilot research in which the questionnaire will be pretested. The preceding table indicates that 0.361 is the crucial value for N = 30. Each questionnaire item's score must thus be more than or equal to 0.361. The validity of the questionnaire items is the sole conclusion the researcher may draw.

3.9 Data Analysis Method

The data analysis method refers to the specific techniques and processes used to examine the data that has been acquired (Huber S, 2024). Quantitative data analysis is a methodical way of examining data, where numerical information is gathered, and the researcher converts the received information into numerical form. The respondents were given questionnaires as part of this study. Once all the questionnaire data had been gathered from the survey, it was transformed into information using the SPSS software version 27. Therefore, the data was evaluated using descriptive statistics, Pearson correlation, and multiple regression analysis.

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3.9.1 Descriptive Analysis

Descriptive analysis is an essential tool in the research arsenal that offers a methodical way to arrange and summarize the collected information. Using descriptive analysis helps researchers investigating solar panel system optimization for home electric vehicle (EV) charging to gather helpful information from our survey data.

Descriptive analysis serves as the first window through which one can see and comprehend the characteristics of the people who have responded to the survey. Using statistical metrics like means, medians, frequencies, and percentages, we can obtain a thorough understanding of the demographic makeup of our sample. This breakdown establishes the foundation for further analysis while also helping identify critical demographic trends.

The descriptive analysis also helps the researcher identify trends and patterns in a dataset. Researchers can understand the general attitudes around satisfaction levels, advantages perceived, and difficulties encountered by utilizing central tendency measurements such as mean, median, and mode. Additionally, it may assess the variability in the data and gain a more detailed knowledge of respondent opinions by utilizing standard deviation to examine the dispersion of replies.

Descriptive analysis also gives us the ability to visualize the results. It may show the descriptive data in an understandable and comprehensible manner using graphs, charts, and visual aids like pie charts and histograms.

The study's foundation is descriptive analysis, even if it may investigate something other than complex statistical inference. It gives the researcher an extensive understanding of our dataset, allowing us to make wise decisions and direct further analysis. Descriptive analysis guides the researcher when navigating each phase of our research project.

3.9.2 Pearson Correlation Analysis

Examining the connection between two continuous variables using Pearson Correlation Analysis (Huber S, 2024). Furthermore, the research may have used keyword research analysis to find connections between terms and subjects in the literature. According to Cui et al. (2022), this study aids in identifying patterns of connection and correlation between various ideas. Pearson correlation uses a coefficient value called r to determine the direction and degree of the relationship between two continuous variables, such as adoption rates and satisfaction levels.

Table 3.4: Correlation Coefficient

Value of r	**Interpretation**
1.00	It is a perfect positive relationship between the two variables
0.50	It is a positive relationship between the two variables
0.00	It is no relationship between the two variables/ Perfect independence
-0.50	It is a negative relationship between the two variables
-1.00	It is a perfect negative relationship between the two variables

(Source: Creswell & Creswell, 2018)

From the table 3.5, a perfect positive correlation is represented by a r of +1.00, which means that whenever one variable rises, the other variable always rises by the same amount. A score of -1.00, on the other hand, indicates a perfect negative correlation, in which one measure consistently falls as the other rises. Values that fall between 0 and +0.50 or 0 and -0.50 indicate a moderate level of correlation, which can be either positive or negative. The stronger the association is, the closer the R-value is to +1 or -1. A r value of 0 indicates that there is no correlation and that the variables are totally independent of one another.

3.9.3 Multiple Regression Analysis

The study can investigate the invaluable function of multiple regression analysis, incorporating knowledge from academics like Salkind (2017) and Minium et al. (2018). Multiple regression analysis is a statistical method for examining the relationship between one dependent variable and two or more independent variables. It goes beyond basic linear regression by enabling researchers to evaluate the combined impact of several predictors on the outcome variable.

We use multiple regression analysis to quantify the individual contributions of each predictor variable to the total variance explained and determine which independent variables are significant predictors of the dependent variable. Comprehending the intricate elements that impact study results is essential.

General Equation:

$y = a + bx_1 + cx_2 + dx_3 + ex_4 + fx_5 + gx_6$ (3.1)

Where y = Dependent Variable

a, b, c, d, e, f, g = Unstandardized Coefficients

$x_1, x_2, x_3, x_4,$ = Independent Variables

By using their respective regression coefficients, this method predicts the value of the dependent variable Y based on the values of the independent variables X1, X2, X3, and X4. In this research, the dependent variable is charging electric vehicles at home, and the independent variable is ownership of electric vehicles, electric trading, charging variable and battery storage.

3.10 Summary

The chapter covered the methodology for the use of solar energy research. It stated that data on solar panel charging cars will be gathered through surveys conducted in houses. It uses statistics to identify patterns with a quantitative study. The sample process ensure that various Malaysian housing designs are represented. In this research, the main purpose of using survey strategy as research strategy is due to researcher wants to answer the ‘what’, ‘who’, ‘where’, ‘how much’ and ‘how many’ questions and to collect data quantitatively. The survey was conducted at Malaysia and 384 sets of questionnaires were distributed to household in Malaysia. The SPSS software version 27 has been used to analyze the data after all the questionnaires were collected back. Lastly, a more detailed of data analysis and the interpretation of the results have been discussed on the following chapter.

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CHAPTER 4

DATA ANALYSIS AND DISCUSSION

4.1 Introduction

This chapter offers an analysis and discussion of the results from the questionnaire. It begins with the outcomes of the pilot test, then continues with the response rate. The chapter provides an examination of demographic information, along with both descriptive and inferential statistics. Pearson Correlation Analysis will be employed for hypothesis testing, while Factor and Multiple Regression Analysis will be addressed as well. The findings will be displayed in graphs, and the chapter will conclude with a recap of the main points.

4.2 Pilot Test

In this study, a pilot test was carried out to pre-test the questionnaire on 30 participants before the publication of the actual questionnaire. The pilot test aims to verify if the participants understand the questions.

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4.2.1 Validity Test

Table 4.1: Validity test for pilot test

Items	Values	Critical Values	Validity
1	0.790	0.361	Valid
2	0.839	0.361	Valid
3	0.848	0.361	Valid
4	0.827	0.361	Valid
5	0.865	0.361	Valid
6	0.845	0.361	Valid
7	0.821	0.361	Valid
8	0.854	0.361	Valid
9	0.884	0.361	Valid
10	0.883	0.361	Valid
11	0.802	0.361	Valid
12	0.792	0.361	Valid
13	0.846	0.361	Valid
14	0.777	0.361	Valid
15	0.647	0.361	Valid
16	0.640	0.361	Valid
17	0.827	0.361	Valid
18	0.872	0.361	Valid
19	0.871	0.361	Valid
20	0.874	0.361	Valid
21	0.819	0.361	Valid
22	0.778	0.361	Valid
23	0.888	0.361	Valid
24	0.915	0.361	Valid
25	0.900	0.361	Valid
26	0.885	0.361	Valid
27	0.777	0.361	Valid

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Table 4.1 displays the validity assessment for 27 items in this questionnaire. In this study, researchers selected 30 participants to conduct this pilot test. Following this pilot test, it can be determined that every item in this questionnaire is valid. This is due to the r table for the Pearson correlation coefficient in the previous chapter, where the value of each item exceeds the critical value for N=30, which is 0.361. All items may be incorporated into the upcoming survey questionnaire to achieve this.

4.2.2 Reliability Test

In this research study, the reliability was measured by applying the Cronbach's alpha.

Table 4.2: Reliability statistics

Cronbach's Alpha	N of Items
0.982	27

Table 4.2 indicates that a total of 27 items will be assessed using the responses from 30 participants obtained from the pilot test, which resulted in an alpha value of 0.982. Consequently, this indicates that all the items employed for assessing these five variables in the survey questionnaire exhibited reasonable internal consistency and were esteemed as excellent.

4.3 Respondents Rate

Table 4.3: Response's rate

Criteria	Total	Percent (%)
Total response	436	100
Valid response	384	88.07
Invalid response	52	11.93

This research study has distributed 436 questionnaires online to participants who have panels or are interested in having them and who own electric vehicles or are interested in having them throughout Malaysia using an online survey. The researcher spent eight weeks distributing and collecting the questionnaire, beginning in the middle of November, and finishing in the middle of December 2024. Throughout the data collection phase, the researchers assisted friends, social media users, and random individuals they met in person in Malaysia to help distribute and gather the survey questionnaires. The total number of distributed questionnaires is 436 (100%) responses. The overall count of questionnaires collected was the same as the number of fully valid responses, which is 384 or 88.07%. However, the invalid questionnaires comprising 52 (11.93%) responses were excluded from the study.

4.4 Demographic Analysis

In this research study, demographic analysis was used to analyze the general information of the respondents. The analysis are consisting the basic frequently data from the sample which are gender, race, education level, monthly household income, state of residence, types of residence, home location, average monthly electricity usage, awareness of solar panel systems for home usage, have you installed solar panel at home, yes, who decide to install solar panels, types of solar panel owned or planned for installation, electric vehicle ownership, and types of electric vehicles charging level usage or planned.

4.4.1 Gender

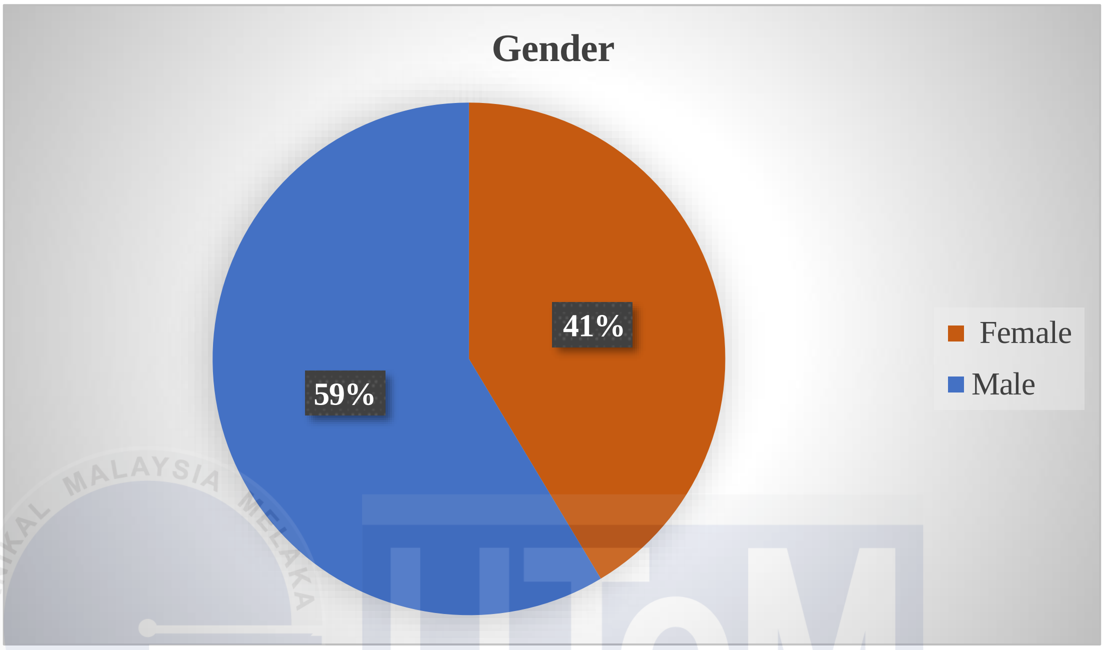

Figure 4.1: Gender

The gender of the respondents who participated in this survey was presented in figured 4.1. out of 384 respondents, most respondents were male that is 225 respondents, and it represents 59% of the total respondents. While the rest of the respondents were female, and it equates to 159 respondents (41%). Thus, this showed those male respondents have taken over the majority to involve in the survey.

4.4.2 Race

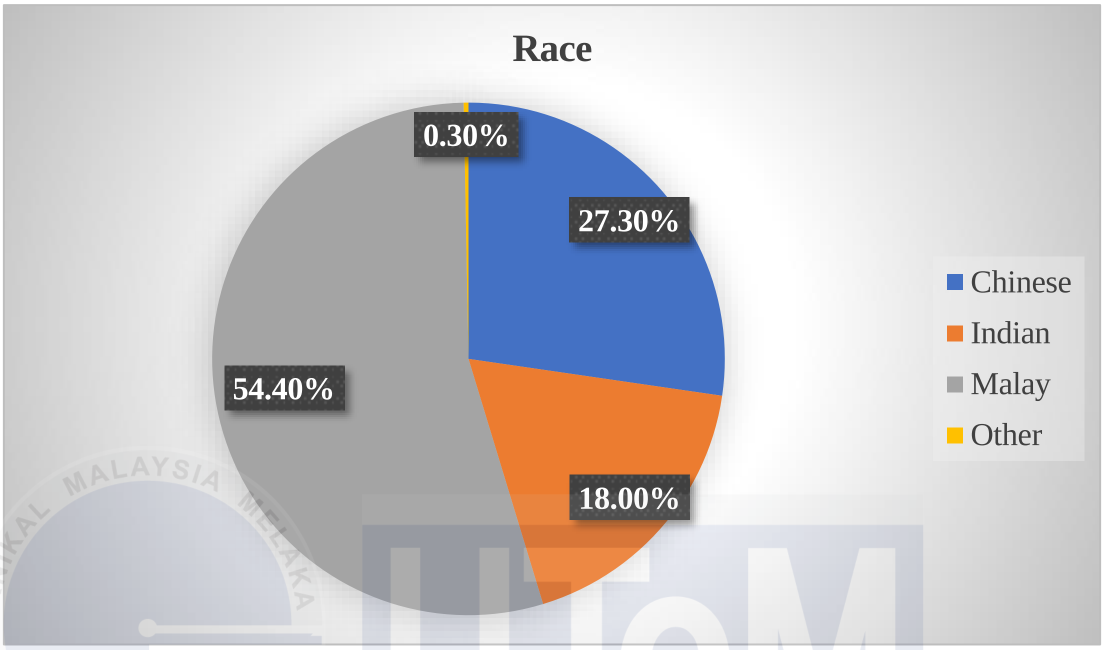

Figure 4.2: Race

Figure 4.2 displayed the four race groups of the respondents, which included Malay, Chinese, Indian, and others. There were 54.40% Malay respondents, 27.30% Chinese respondents while Indian respondents were amounted 27.30%. In addition, there were only 0.30% of respondents from others race (Siamese). The majorities of respondents were Malay and followed by Chinese, Indian and other race.

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4.4.3 Education Level

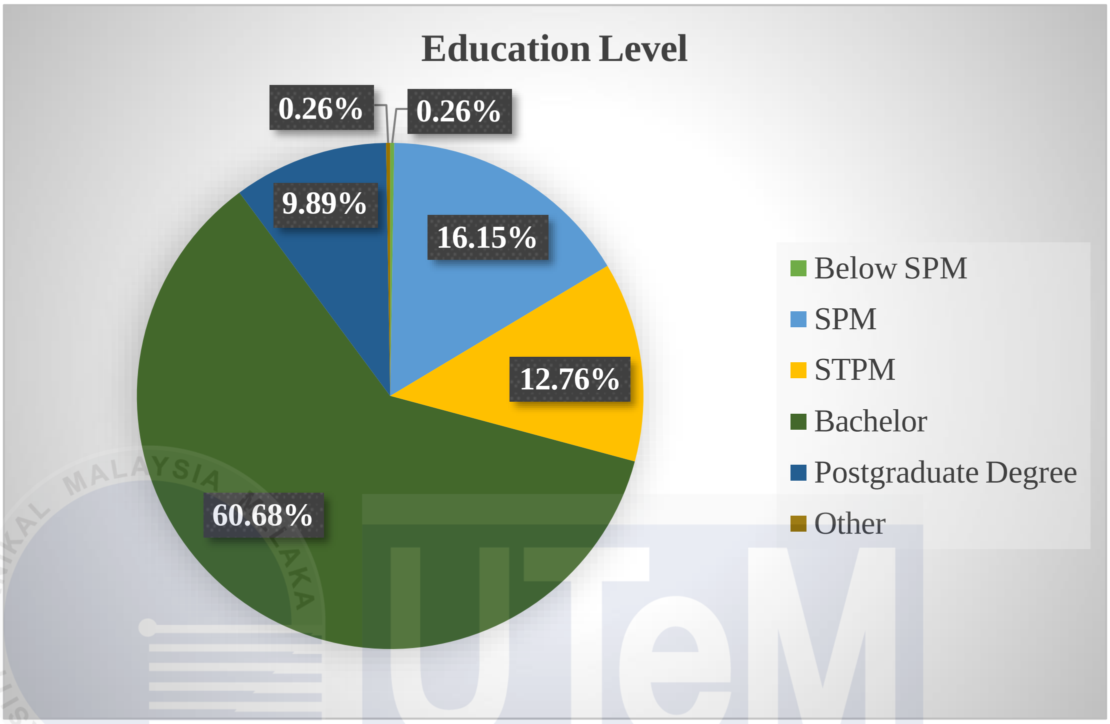

Figure 4.3: Education Level

As illustrated in figure 4.3, there were six categories of the respondent's highest education level who contributed to this research study which were below SPM, SPM, STPM/Diploma, Bachelor, Postgraduate degree (Master/PhD) and other. The highest proportions of education level among respondents are bachelor holder, which recorded 60.68%. It followed by SPM (16.1%) and STPM (12.76%). A smaller percentage holds a Postgraduate degree (9.89%), with the Below SPM and other (Master's degree) each one (0.26%) category comprising only a small portion of the sample. This indicates that the sample population is relatively well-education, with a strong presence of university graduates.

4.4.4 Monthly Household Income

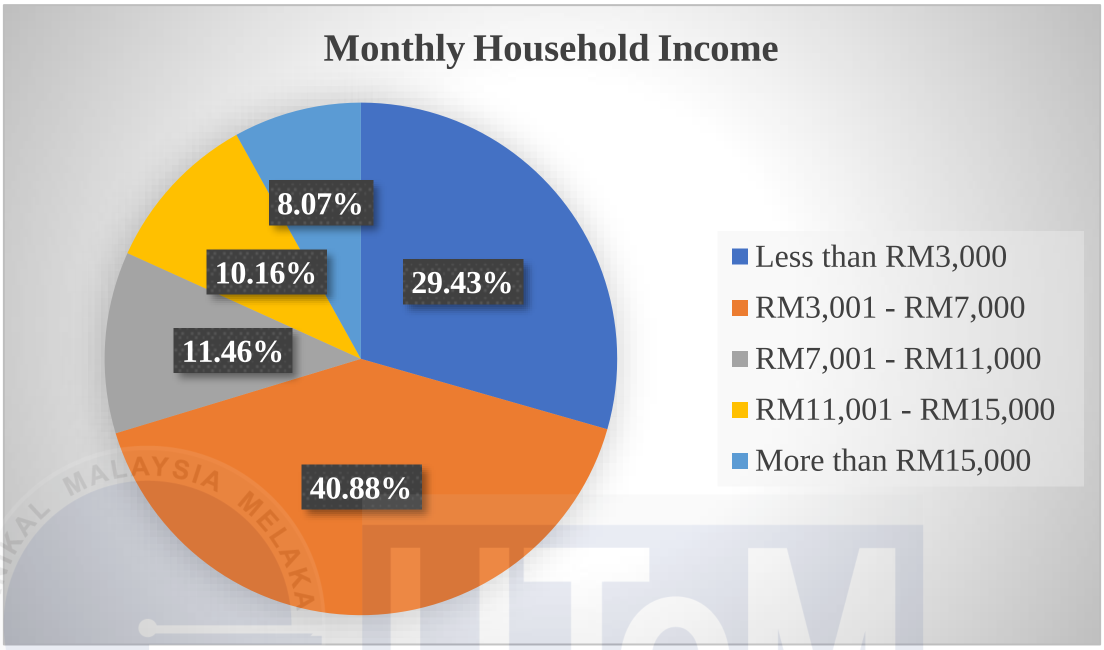

Figure 4.4: Monthly Household Income

Figure 4.4 above illustrated the analysis of monthly household income from sample. It been categorized into five ranges, which are less than RM3,000, RM3,001-RM7,000, RM7.001-RM11,000, RM11,001-RM15,000, and more than RM15,000. The highest proportion of respondents is 40.88% that monthly income RM3,001-RM7,000. Following this, 29.43% of respondents earned less than RM3,000 per month. Meanwhile, 11.46% of respondents earned RM7,001-RM11,000, and 10.16% earned between RM11,001 and RM15,000. The lowest proportion, 8.07% reporting income more than RM15,000.

4.4.5 Home Ownership Status

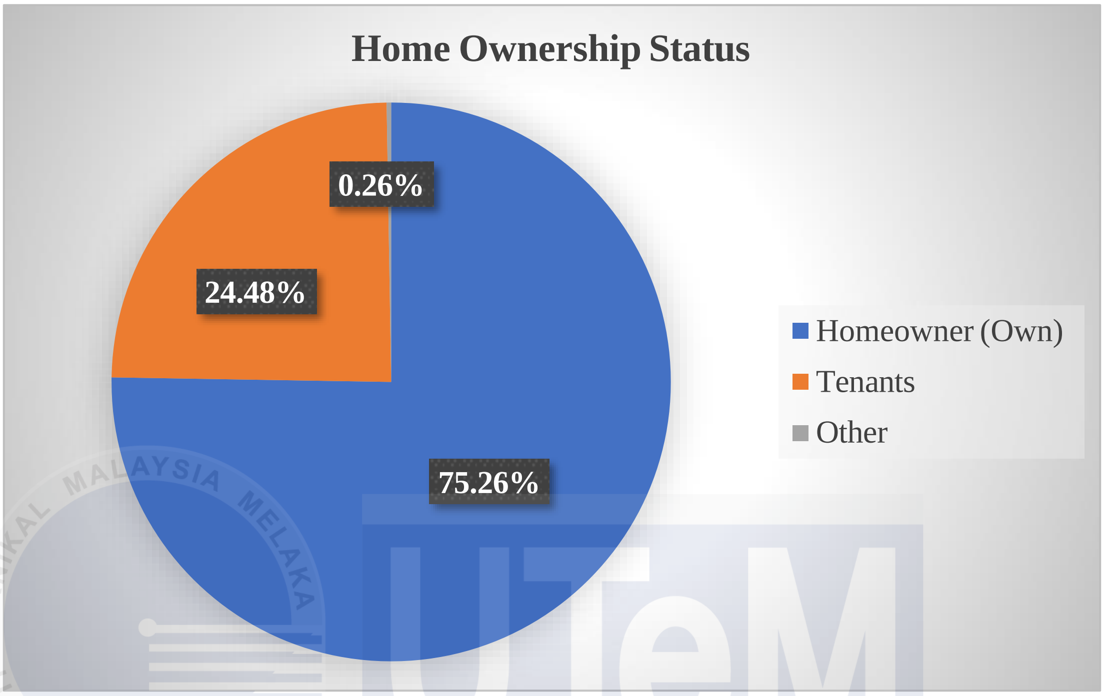

Figure 4.5: Home Ownership Status

Figure 4.5 shows, the home ownership status of the respondents, which were categorized as Homeowner (Own), Tenants, and other (stay with family). Most respondents were Homeowner (Own) with 75.26%, followed by 24.48% who were Tenants. Lastly, only 0.26% of respondents fell into the other (stay with family).

4.4.6 State of Residence

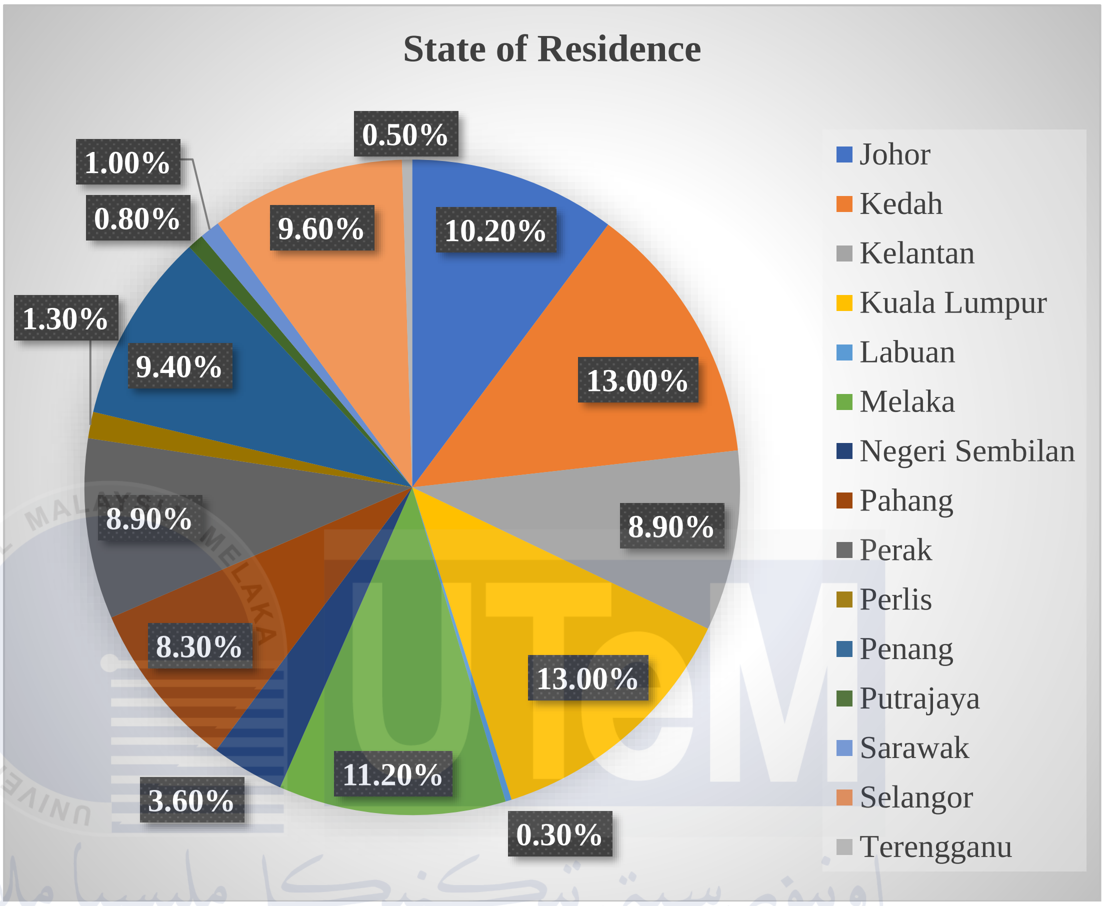

Figure 4.6: State of Residence

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Figure 4.6 illustrates the state of respondents, coverage a range of states in Malaysia. The highest state of respondents resided in Kedah and Kuala Lumpur, both at 13.00%, followed by Melaka with 11.20%. Johor accounted for 10.20% of respondents, while Selangor and Penang contributed 9.60% and 9.40% each. Besides, respondents from Kelantan and Perak each represented 8.90%. while Pahang considered for 8.30%. Lower percentages were recorded in Negeri Sembilan (3.60%), Perlis (1.30%), Sarawak (1.00%), Putrajaya (0.80%), Terengganu (0.50%), and Labuan (0.30%).

4.4.7 Types of Residence

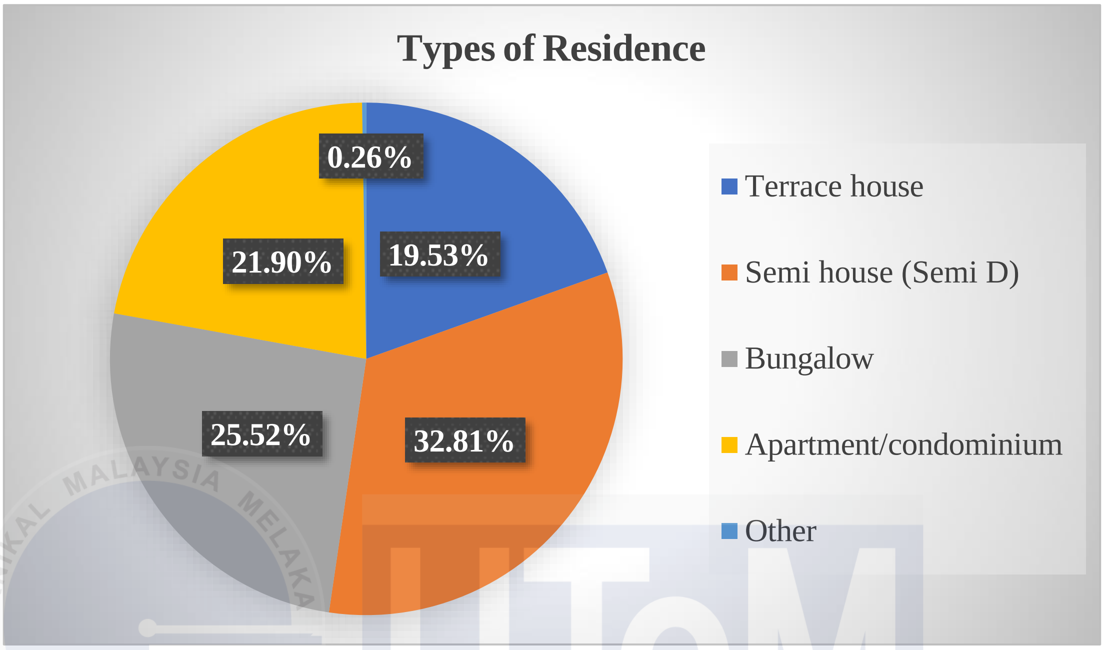

Figure 4.7: Types of Residence

Figure 4.7 presents the types of residences occupied by the respondents. The highest percentage of respondents, 32.81%, resided in Semi house (Semi D), followed by 25.52% respondents living in Bungalows. Additionally, 21.90% of respondents stayed in Apartment/Condominium, while 19.53% lived in Terrace houses, with only 0.26% resided in other (village house).

4.4.8 Home Location

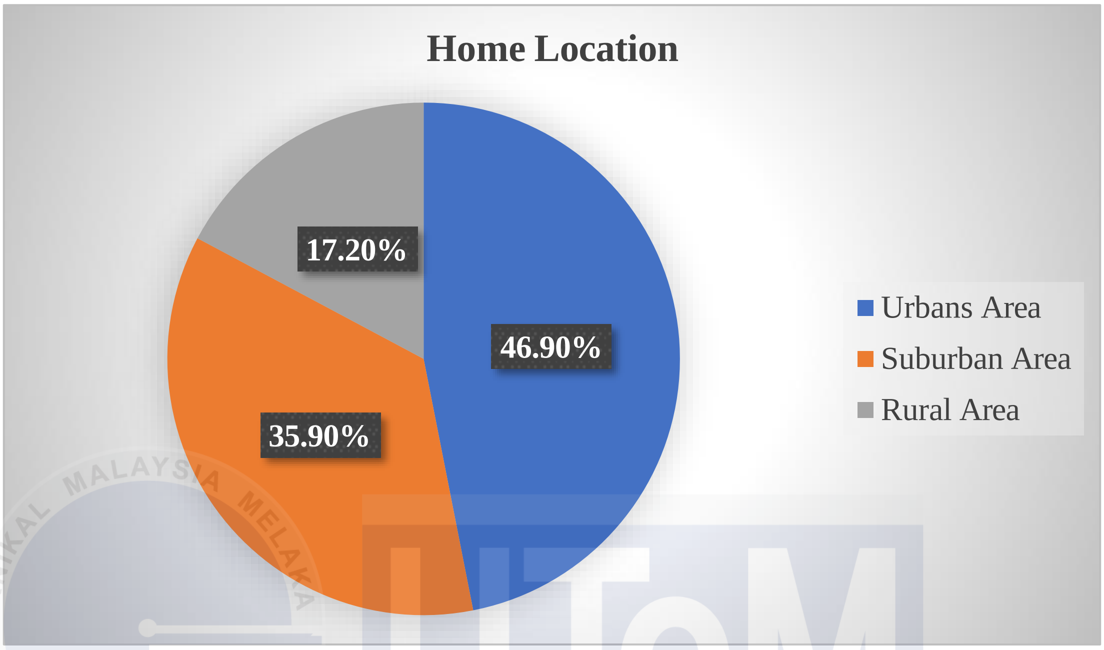

Figure 4.8: Home Location

Figure 4.8 presents the home locations of the respondents, categorized into Urban, Suburban, and Rural areas. The largest proportion of respondents, 46.90% respondents in Urban areas, followed by 35.90% in Suburban areas. Meanwhile, 17.20% of respondents lived in Rural areas.

4.4.9 Average Monthly Electricity Usage

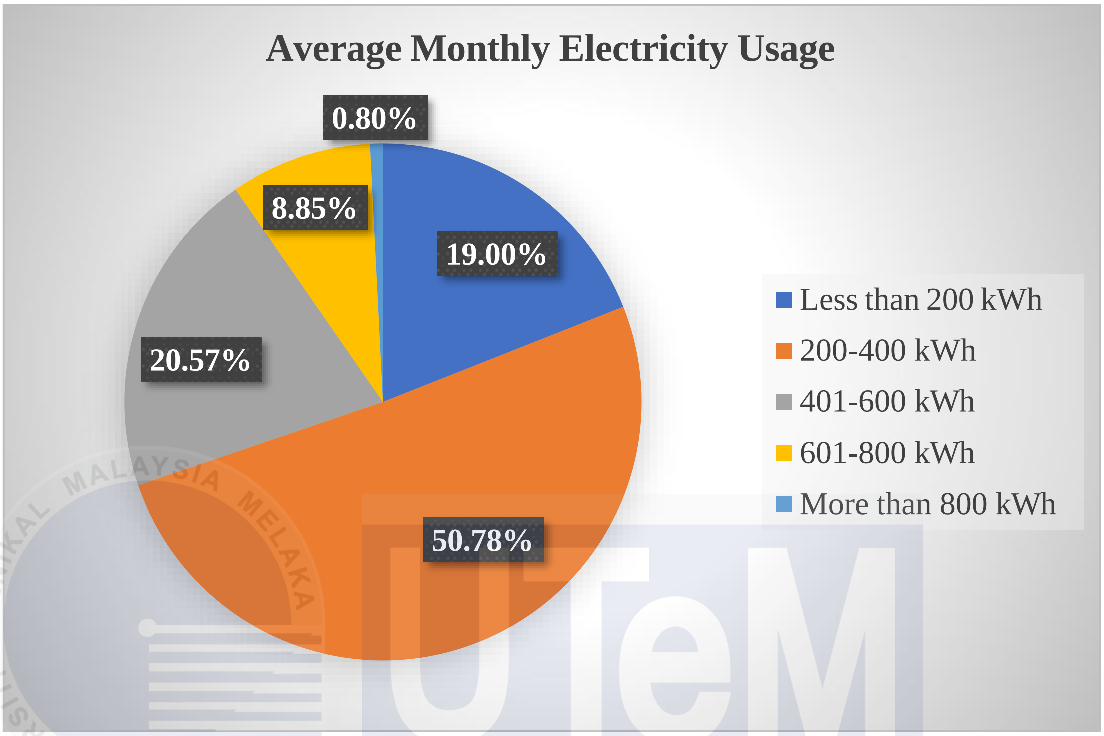

Figure 4.9: Average Monthly Electric Usage

Figure 4.9 illustrates the average monthly electricity usage among respondents. The majority is 50.78% reported using 200-400 kWh, followed by 20.57% who consumed 401-600 kWh. Additionally, 19.00% of respondents used less than 200 kWh, while 8.85% reported usage between 601-800 kWh. Only very small proportion, 0.80% of respondents consumed more than 800 kWh.

4.4.10 Awareness of Solar Panel Systems for Home Usage

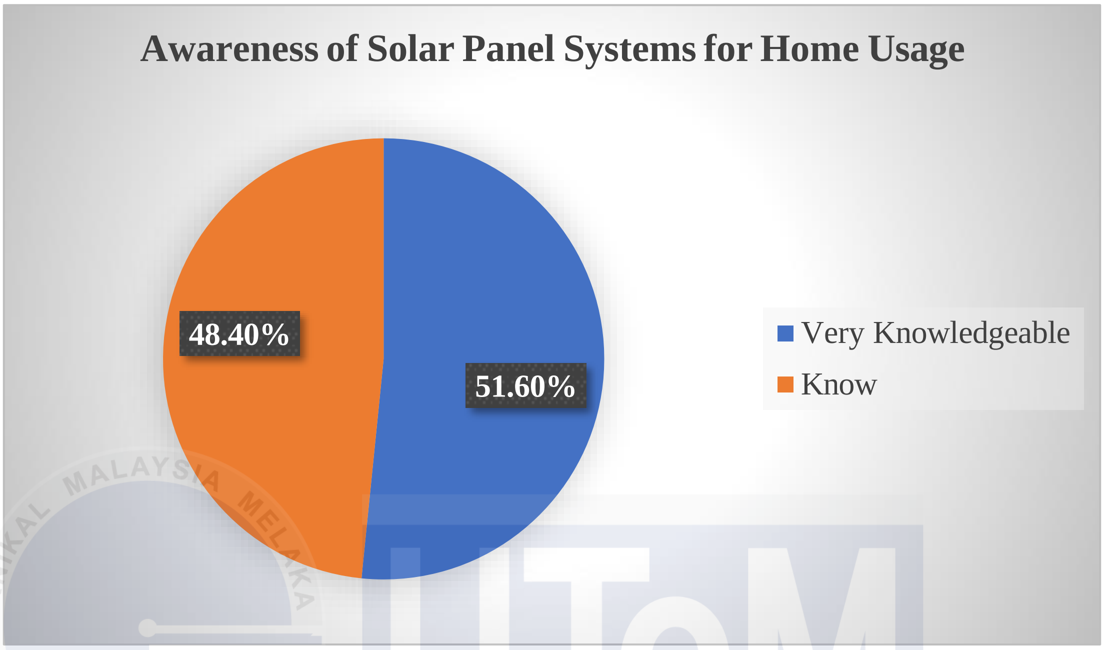

Figure 4.10: Awareness of Solar Panel Systems for Home Usage

Figure 4.10 shows the respondents awareness of solar panel systems for home usage. Most respondents, 51.60%, indicated they were very knowledgeable, while 48.40% reported that they had general knowledge which is known about awareness of solar panel systems for home usage.

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4.4.11 Have You Installed Solar Panel at Home?

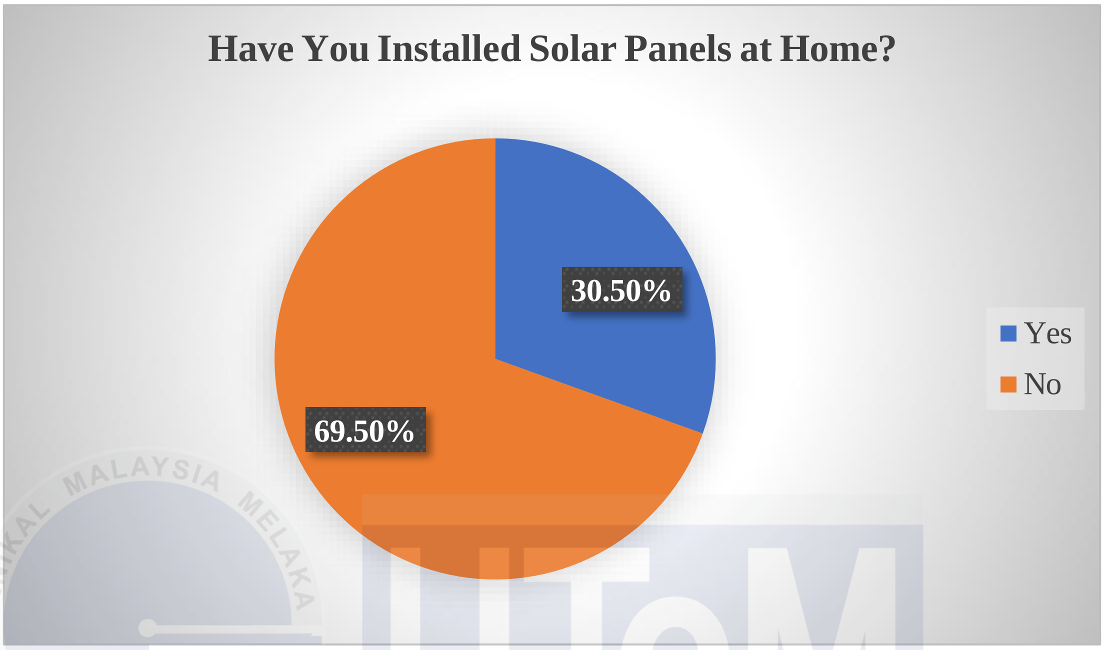

Figure 4.11: Have You Installed Solar Panel at Home

Figure 4.11 presents the respondents' responses regarding solar panel installation at home. Most respondents, 69.50%, reported that they had not installed solar panels while 30.50% indicated that they had installed them.

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4.4.12 If Yes, Who Decide to Install Solar Panels?

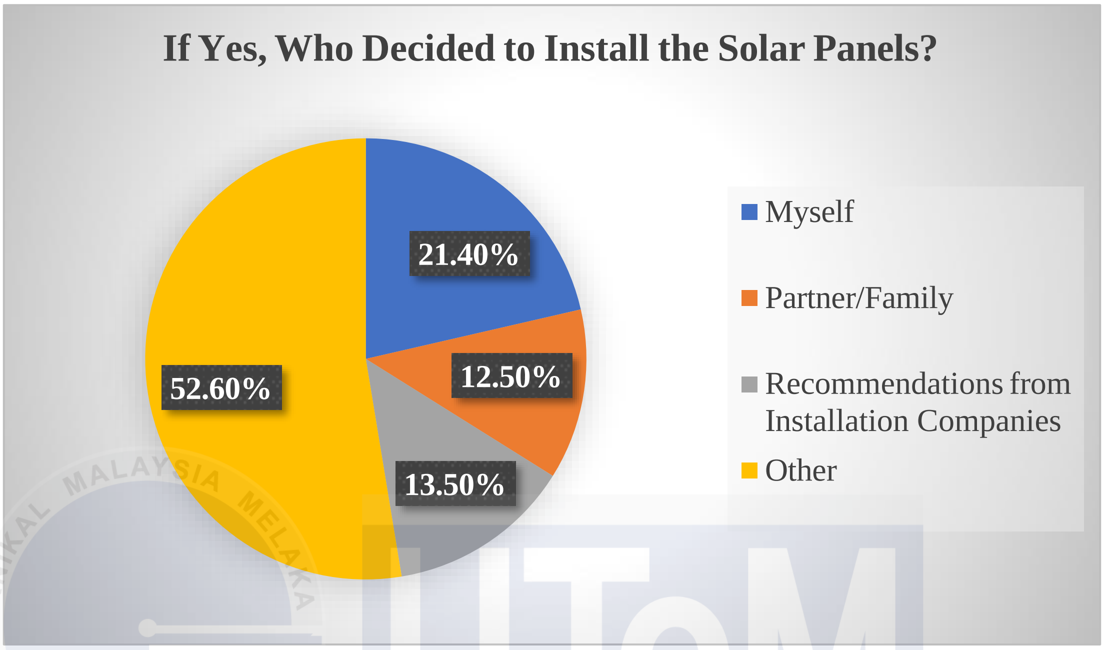

Figure 4.12: If Yes, Who Decide to Install Solar Panels?

Figure 4.12 illustrates the decision-making process among respondents if yes, who decided them to installed solar panels. The majority, 52.60%, stated that the decision was influences by other factors that not been specified. Meanwhile, 21.40% made the decision themselves, 13.50% were influenced by recommendations from installation companies, and 12.50% indicated that the decision was made by their partner of family.

4.4.13 Types of Solar Panel Owned or Planned for Installation

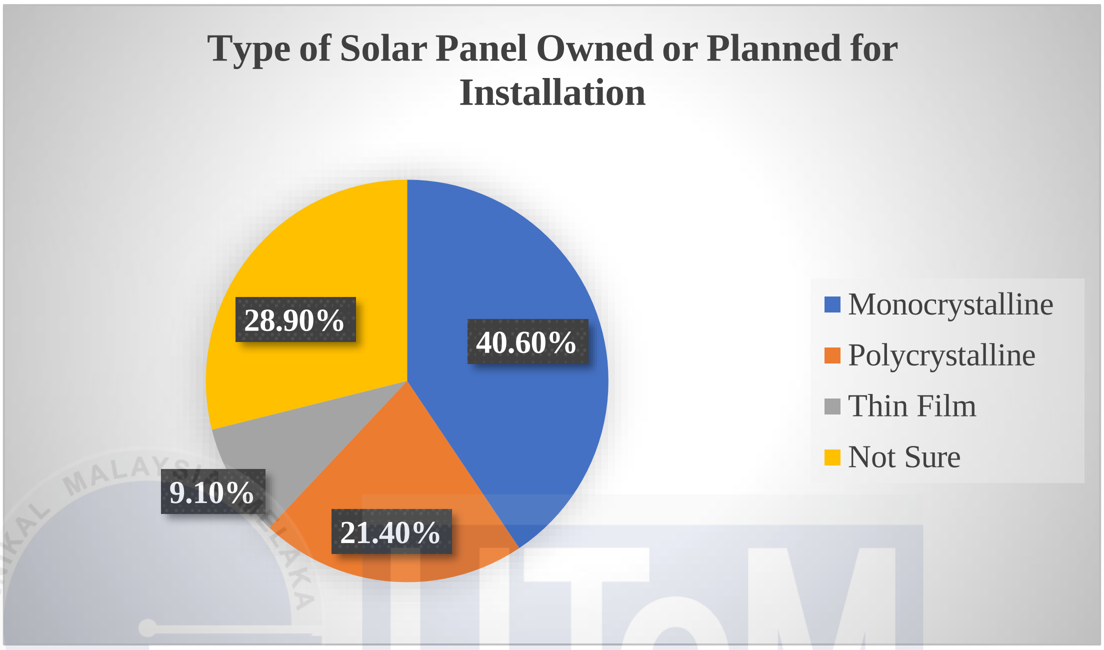

Figure 4.13: Types of Solar Panel Owned or Planned for Installation

Figure 4.13 presents the types of solar panel owned or planned for installation by respondents. The majority, 40.60% reported owning or panning to installed monocrystalline solar panels, followed by 28.90% who were not sure about the types of solar panel wanted to install. Besides, 21.40% opted for polycrystalline solar panels, and 9.10% choose thin-film panels.

4.4.14 Electric Vehicle (EV) Ownership

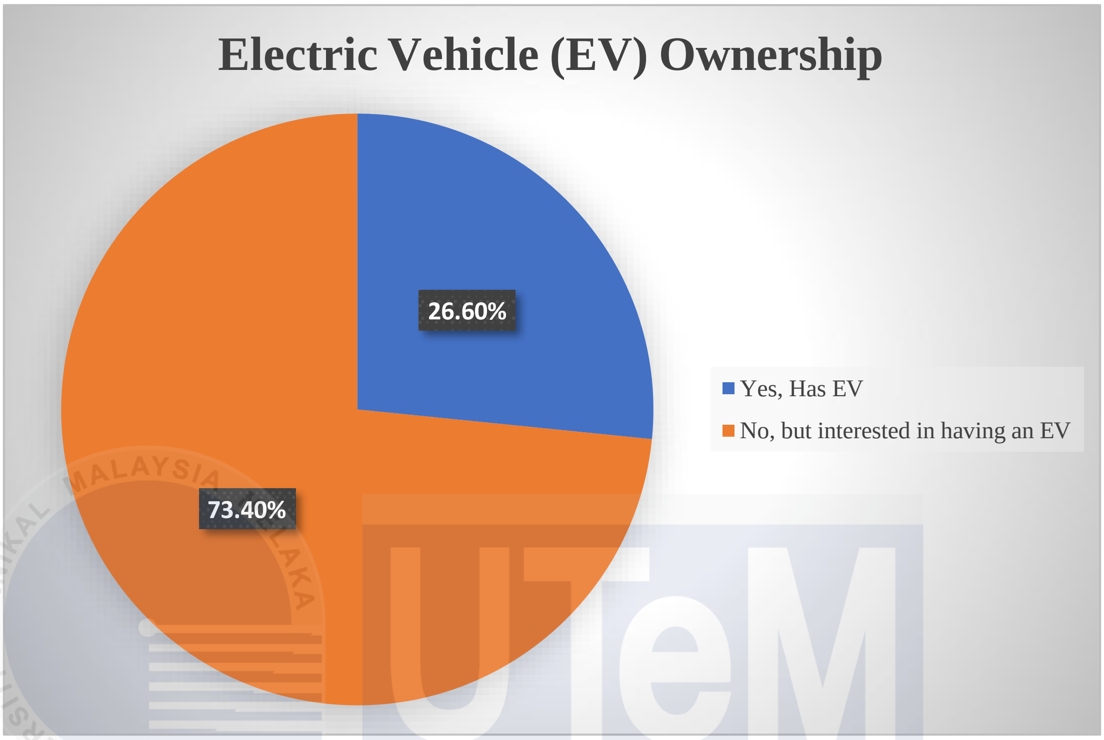

Figure 4.14: Electric Vehicle (EV) Ownership

Figure 4.14 illustrates the ownership status of electric vehicles (EVs) among respondents. Most respondents, 73.40% reported that they do not currently own an EV but are interested in having one. Besides, 26.60% of respondents indicated that they already own an EV.

4.4.15 Types of Electric Vehicles Charging Level Usage or Planned

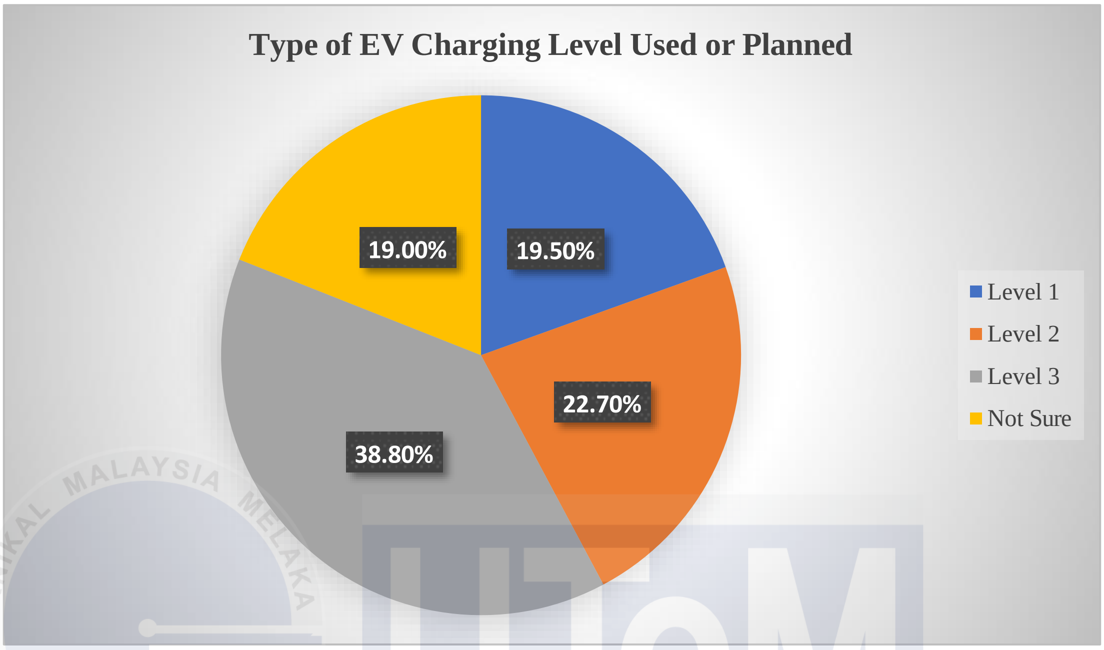

Figure 4.15: Types of Electric Vehicles Charging Level Usage or Planned

Figure 4.12 presents the types of electric vehicles charging level usage or planned by respondents. Most respondents 38.80% reported using or planned to use Level 3 charging, followed by 22.70% opting for Level 2 charging. Additionally, 19.50% of respondents selected Level 1 charging, while 19.00% were not sure about the type of charging level.

4.5 Descriptive Analysis

In this research, descriptive analysis gave the researcher insights into the respondents' views on the variables mentioned in this study by utilizing mean and standard deviation data.

Table 4.4: Descriptive statistics for twenty items

Independent Variable	**Factors**	**Mean**	**Standard Deviation**
Ownership of Electric Vehicles (IV1)	BA1	3.69	1.4777
	BA2	3.70	1.300
	BA3	3.58	1.425
	BA4	3.48	1.481
	BA5	3.54	1.482
Electric Trading (IV2)	BB1	3.58	1.429
	BB2	3.81	1.368
	BB3	3.66	1.429
	BB4	3.83	1.370
	BB5	3.52	1384
Charging Variable (IV3)	BC1	357	1.537
	BC2	3.43	1.416
	BC3	3.76	1.386
	BC4	3.64	1.420
	BC5	3.77	1.389
Battery Storage (IV4)	BD1	3.63	1.423
	BD2	3.65	1.338
	BD3	3.52	1.477
	BD4	3.55	1.503
	BD5	3.51	1.379
Charging EVs at Home (DV)	C1	3.76	1.471
	C2	3.70	1.317
	C3	3.65	1.476

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Independent Variable	Factors	Mean	Standard Deviation
Charging EVs at Home (DV)	C4	3.50	1.346
	C5	3.60	1.537
	C6	3.43	1.427
	C7	3.61	1.539

Table 4.4 present the mean and standard deviation of the independent variable which are ownership of electric vehicles (IV1), electric trading (IV2), charging variable (IV3), battery storage (IV4), and charging EVs at home (DV). All these determinants were measured based on a five-point Likert scale which from 1- strongly disagree until 5- strongly agree.

The result revealed that the mean score for every item in the ownership of electric vehicles (IV1), electric trading (IV2), charging variable (IV3), battery storage (IV4), and charging EVs at home (DV) were within the range of 3.00. It indicates that most of the respondents agreed with the questions in general. In addition, the standard deviation for statements IV1, IV2, IV3, IV4 and DV were closer to two. So, all the items in the standard deviation are more than 1.0, which indicates that the respondents, on average, were a little over 1 point away from the mean. This shows that while there is general agreement, there are also notable differences in individual opinions, as respondents' views on these factors vary by more than one point on average from the mean. This variability suggests that while most respondents align with the general trends, some still hold differing perspectives. Overall, the findings indicate that the respondents, as a group, are generally supportive of electric vehicle ownership (IV1), electric trading (IV2), charging infrastructure (IV3), and battery storage (IV4) and charging EVs at home (DV). Still, there is significant individual variation in how strongly they feel about these issues.

Table 4.5: Descriptive statistic for independent and dependent variables

Independent Variable	Mean	Standard Deviation
Ownership of Electric Vehicles (IV1)	3.597	1.348

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Independent Variable	Mean	Standard Deviation
Electric Trading (IV2)	3.682	1.354
Charging Variable (IV3)	3.635	1.346
Battery Storage (IV4)	3.571	1.363
Charging EVs at home (DV)	3.607	1.375

Table 4.5 shows the means and standard deviation for independent and dependent variables, namely ownership of electric vehicles (IV1), electric trading (IV2), charging variable (IV3), battery storage (IV4), and charging EVs at home (DV). the result revealed that all the mean below 4.0, the statistic revealed that the electric trading (IV2) scores the highest mean value of 3.682 whereas battery storage (IV4) scored the lowest mean value of 3.571. This mean that majority of respondents agreed that electric trading influencing the decision of using panel solar for charging EVs at home and battery storage on the other hand was less important for respondents when decision of using panel solar for charging EVs at home. In addition, most of the independent and dependent variables have scored the highest values of standard deviation, which was ranging from 1.3 to 1.4.

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4.6 Inferential Statistics

Inferential statistics were utilized in this study to analyze a random sample of data and make inferences about the entire population. Using these methods, the researcher may assess the kind and degree of correlations between independent and dependent variables as well as the likelihood of characteristics in the sample population. This direction correlation between the variables were determined using the techniques such as Person correlations that use to simulate the effects of multiple independent variables on the dependent variable were examine using regression analysis to improve the relationship comprehension and assess population related hypotheses and conclusion.

4.6.1 Pearson Correlation Coefficient

In this research study, Pearson correlation was utilized to measure the strength of the linear association between two numerical variables. The analysis of the data was conducted using bivariate correlation. Consequently, the item-item questionnaire that showed a strong correlation with the overall score suggests that the items were legitimate.

Table 4.6: Pearson correlation analysis

Determinants	Correlate Values	Significance
Ownership of Electric Vehicles (IV1)	0.985	0.000
Electric Trading (IV2)	0.966	0.000
Charging Variable (IV3)	0.988	0.000
Battery Storage (IV4)	0.993	0.000

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Based on this table 4.6. it has shown that the correlation between four independent variables such as ownership of electric vehicles, electric trading, charging variable, and battery storage dependent variable which was charging electric vehicle at home.

From the data in table 4.6, it was apparent that the relationship between variable can be considered as significance values in context. The value of correlation (R-value) can be represented into three values, which are (0.0 – 0.3 = weak), (0.4-0.6 = moderate) and (0.7+ and above = strong values). The table above send shown the correlation and relationship between independent variables and dependent variable are statistically significance strong values. As a result, the significance value (2-tailed) for all variables is p0.000. All the variable included independent variables and dependent variable are significant value, R=0.7+.

For the ownership of electric vehicles, the value of Pearson Correlation (r) is = 0.985 which are strong and positive significance. For electric trading, the value of Pearson Correlation (r) is = 0.966, which are strong and positive significance. Besides, charging variable value of Pearson Correlation (r) is = 0.988 and for battery storage the value of Pearson Correlation (r) is = 0.993 with are shows strong and positive significance. For dependent variable which is charging electric vehicles at home have a positive relationship, strong and significant value towards (ownership of electric vehicles r=0.985, electric trading r=0.966, charging variable r=0.988, and battery storage r=0.993, p0.000).

Therefore, based on the result above, all the variables were categorized under moderate and strong positive relationship in which significance value was 0.000. Hence, it can be concluded that all the null hypothesis (H0) were rejected, and alternative hypothesis (H1) were accepted.

4.6.2 Multiple Regression Analysis

In this research study, researchers were repeating coefficient multiple regression analysis of each variable. The purpose of conducting repeat test variable of multiple regression analysis was to find the significant relationship between dependent Y (charging electric vehicles at home) and independent variable X (ownership of electric vehicles, electric trading, charging variable, and battery storage).

Table 4.7: Model Summary

Model	**R**	**R Square**	**Adjust R square**	**Std. Error of the Estimate**
1	0.994	0.988	0.987	0.154

a. Predictors: (Constant), Charging Variable (IV3), and Battery Storage (IV4)

b. Dependent Variable: Charging Electric Vehicle at Home

Based on the table 4.9, the value of R was 0.994 and coefficient of determination R square is equal to 0.988 which showed that about 98.8% of the variation affected charging Electric Vehicle at home by variables of electric vehicles, electric trading, charging variable, and battery storage. Besides, the rest of 1.2% of the model is explained by other determinations which were able to affect the maximum of charging Electric Vehicle at home using panel solar.

Table 4.8: Repeat test variables for the coefficient multiple regression analysis

Variables	Unstandardized Coefficients (B)			Sig.		
	Test 1	Test 2	Test 3	Test 1	Test 2	Test 3
1 Constant	-0.016	-0.016	-0.015	0.498	0.492	0.510
IV1	0.075	0.075		0.140	0.106	
IV2	0.00			0.991		
IV3	0.257	0.256	0.380	0.000	0.000	0.000
IV4	0.678	0.678	0.370	0.000	0.000	0.000

Dependent Variable: Charging Electric Vehicle at Home

As the table 4.8 showed, there were three test variables for the Coefficients Multiple Regression Analysis. Throughout Test 1 and Test 2, researcher found that there were two variables such as ownership of electric vehicles (IV1) and electric trading (IV2) has no significance relationship on maximizing charging Electric Vehicle at home using panel solar. This is because the significance of both variables was greater than 0.05. Hence, researchers were repeated the test for Coefficients Multiple Regression Analysis until variables are significant at 0.000.

Based on the regression equation, researcher has calculated the statistical result:

Y = -0.015 + 0.310 (IV3) + 0.699 (IV4)

Where Y = Charging Electric Vehicle at Home

IV3 = Charging Variable

IV4 = Battery Storage

Based on the equation above, regression coefficient of charging variable was 0.310. It means every 1 unit of x would lead to increase 0.310 on charging Electric Vehicle at home. Besides, every 1 unit of x would lead to increase 0.699 battery storage that influence to charging Electric Vehicle at home.

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Among the four independent variables, battery storage has the strongest influence on the maximizing charging Electric Vehicle using panel solar at home where unstandardized beta equal to -0.015. Thus, battery storage was the most important predictor on maximizing charging Electric Vehicle using panel solar at home and followed by charging variable concern 0.310.

4.7 Summary

This chapter has examined the techniques employed to interpret the outcomes of the survey. Three types of data analysis methods, including demographic analysis, descriptive analysis, and inferential analysis, were utilized to evaluate the results of the data gathered in this chapter. In general, reliability analysis was conducted to assess if the instrument utilized in this study is dependable. In addition, descriptive analysis was utilized to assess the average and the standard deviation of each variable. Subsequently, Pearson correlation was employed to measure the intensity of the linear association between two numerical variables. Finally, the outcomes were produced for additional discussion.

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CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Introduction

In this chapter, researcher would discuss the major findings based on the results of that have been presented in previous chapter and draw the conclusion with the implication of this study. The research objectives have been answered in this chapter. Lastly, recommendation for this research also proposed for future researcher who interested in this field.

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5.2 Conclusion

In this section, researcher was discussed the findings from previous chapter and attempted to accomplish the three main research objectives that have been discussed previously. Hence, research objectives were achieved based on results of factors analysis, multi regression analysis and Pearson correlation. First, researcher has discussed the clarify the optimization factor of using solar panel systems for charging electric vehicles at home. Second, analyse the correlation between the factors that influence the optimization of solar panels and charging electric vehicles at home. Followed by discussing the most significant factor in optimizing solar panel systems for charging electric vehicles at home. Lastly, from the analysis, this research study has fulfilled the research objectives.

5.2.1 Objective 1: To clarify the optimization factor of using solar panel systems for charging electric vehicles at home.

In this research, following the execution of factor analysis for the independent variables by the researcher, all the determinants were grouped under four components which are ownership of Electric Vehicle at home, electric trading, charging variables, and battery storage. These factors were examined through statical analysis, such as Pearson Correlation and Multiple Regression, this to determine their significance and relationship with its dependent variable which is charging Electric Vehicle at home. These four components that consisted in this study are ownership of electric vehicles, electric trading, charging variable, and battery storage. Therefore, it can be concluded that all the four determinants were considered factorable and acceptable for further analysis because all these four determinations have a significant correlation $p<0.001$. it indicates that all four determinations influence to optimizing charging Electric Vehicle at home. In previous chapter researcher determine that battery storage and charging variables have accounted 98.7% of the variation in optimizing using panel solar for charging Electric Vehicles at home. It has been proved that battery storage and charging variables being the most impactful in charging Electric Vehicle at home.

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5.2.2 Objective 2: To analyze the correlation between the factors that influence the optimization of solar panels and charging electric vehicles at home.

In this research study, the results of Pearson correlation analysis in previous chapter have been discussed to determine the correlation between the factors that influence the optimization of solar panels and charging electric vehicles at home to find out whether the independent variables are strengthen or weaken each other. Hence, based on the findings in previous chapter, all the four determinants were significant and have moderate positive and strong positive relationship with optimization of solar panels and charging electric vehicles at home. Therefore, the null hypotheses of all variables were rejected.

First, ownership of electric vehicles has moderate positive relationship with charging electric vehicles at home. This finding was consistent with findings of past studies by Davis (2019), which found out that many EV owners, particularly in countries like the US, owner multiple vehicles, with only small percentage being single-vehicle households. This trend also seeing among Malaysia EV owners but in small percentages. Besides, Plotz et al. (2019) found that understanding vehicle ownership characteristics and their implications for home energy usage can aid in the development of better charging infrastructure. Such as need to tailored energy management strategy for optimal EV charging at home.

Second, electric trading was the significance determinant that influenced charging electric vehicles at home. This current finding was consistent with the outcome of Munkhammar and Fachrizal (2020) found that small charging strategy can reduce peak loads and increase the use of photovoltaic self-consumption, which are key for optimizing the use of home-generated solar energy. This is important in Malaysia were panel solar system in rooftop more common. By combining panel solar and EV charging household can maximize to renewable energy, leading to cost savings and enhanced energy efficiency. Besides, Luthander et al. (2020) found that further explored of solar self-consumption in buildings, identifying strategies to optimize the use of renewable energy. This is crucial in Malaysia to be more sustainable energy in practices. Besides, Van Der Mer et al. (2020) with concluded that importance of accurate the forecasting in optimizing the energy demands of EV charging by predicting solar energy availability and electricity usage patterns. As Malaysia seeks enhance its renewable energy but need to forecast in critical things like managing demands of EV charging, reducing grip dependency, and promoting energy independence.

Third, charging variables has strong positive relationship with charging Electric Vehicle at home. The present finding was supported previous researcher, Fachrizal et al. (2020) highlight the importance of optimizing charging schedules to lower peak loads and improve the charging efficiency. In Malaysia, encouraging the adoption of EVs and guaranteeing long-term use requires the provision of easily accessible and dependable charging alternatives. Besides, past researcher Hardman &

Tal (2020) found that supports the idea that making home charging convenient, especially with level 2 (220-volt) chargers, lowers the chance that EV owners would give up their vehicles. This has a direct connection to solar energy efficiency since simple and affordable charging infrastructure increases the likelihood that consumers will install solar charging systems. The study by Frankle et al. (2020) supports these findings even further, highlighting how important the charging experience is to EV adoption and the incorporation of solar power sources for home charging.

Lastly, the present finding was consistent with findings of past studies by Sim & Vijayagopal, (2020) examines how the size and effectiveness of battery storage systems can have a major impact on the performance of solar-powered EV charging stations, as well as how to balance the environmental impact and financial viability of storage components for solar energy systems, which stated that battery storage plays a critical role in charging electric vehicles at home. This is because majority customers considered battery storage should play a major role in store solutions can help reduce variations in solar energy generation, guaranteeing that power is accessible for EV charging even when there is little sunlight. Sim & Vijayagopal, (2020) highlight that important of choosing the appropriate storage components to save expenses and boost the overall effectiveness of renewable energy systems, since this has a direct bearing on how well solar panels are suited for EV charging.

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5.2.3 Objective 3: To identify the most significant factor in optimizing solar panel systems for charging electric vehicles at home.

In this research study, the findings of multiple regression analysis in previous chapter have been discussed to investigate on the most determinants that would affect the charging Electric Vehicle at home for maximizing using panel solar in Malaysia. After repeating test for the coefficient multiple regression analysis of each variable, the result revealed the battery storage were scored the highest regression coefficient among the other one. Therefore, it could be concluded that the battery storage was the most determinants which affect being a significant factor in optimizing solar panel system for charging electric vehicles at home in Malaysia.

The outcome aligned with earlier research by Sim & Vijayagopal, (2020), which proposed that battery storage have challenges of balancing When optimizing battery storage for residential solar systems, consider both the economic and environmental implications. To minimize ownership costs and optimize the utilization of solar energy, their research emphasized the need of choosing the right storage components, such as batteries, fuel cells, or supercapacitors. This study showed that, particularly for residential applications, optimizing battery storage is crucial to raising the effectiveness and long-term viability of solar-powered systems. Sim & Vijayagopal, (2020) highlight that reducing overall expenses for a fuel cell-powered vehicle by optimizing the size of storage components. The necessity of choosing energy system components wisely was also underlined by this study. Energy storage optimization is crucial for ensuring that extra energy produced during the day can be saved for later usage, which lessens dependency on grid electricity. Their results support the notion that improving the entire energy management system requires optimizing battery storage for domestic EV charging.

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5.3 Recommendation

An efficient way to promote sustainable energy use is to install solar panels for household charging of electric vehicles (EVs), which are becoming more and more popular. Though this research has identified battery storage as a critical component influencing system performance, there are still places for improvement. Research in the future should focus on analyzing how battery storage might improve reliability and efficiency. The best battery capacities, storage options, and consumption patterns that match the energy needs of homes and the demands of electric car charging might be the subject of future research. Additionally, to ensure systems that are both economical and effective, research into advancements in battery technology and how they may be integrated with solar panels should be undertaken.

Besides, the behavioral and financial barriers that affect householders' decisions to accept solar-powered charging are the next important subject for research. To identify practical strategies for increasing adoption, factors like perceived problems, budgetary constraints, a lack of knowledge, or accessibility issues must be considered.

Moreover, future research should examine regional performance, examining how solar-powered charging systems function in diverse locations while accounting for variations in local socioeconomic conditions, climate, and sunshine accessibility. For example, places with more sun exposure may achieve higher efficiency, while other regions may require tailored solutions to meet their unique needs.

Lastly, by concentrating on these factors, future studies can improve the availability, cost, and effectiveness of solar-powered EV charging solutions, helping more households transition to cleaner energy sources, and advancing global sustainability goals.

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APPENDIX 1

GANTT CHART FOR PSM I

		Mac			April				May				Jun			
No.	Task/ Weeks	11 - 16	18 - 22	25 - 29	1 - 4	15 - 19	22 - 26	27 - 30	6 - 10	13 - 12	20 - 24	27 - 29	4 - 6	24 - 25	26 - 27	28 - 29
1	Briefing PSM 1															
2	Topic proposal															
3	Topic Selection (Explanation of topic)															
4	Process information for chapter 1															
5	Construct chapter 1															
6	Process information for chapter 2							MID								
7	Construct chapter 2															
8	Revision and discussion with supervisor							TERM								
9	Process information for chapter 3															
10	Construct chapter 3							BREAK								
11	Revision by supervisor															
12	Presentation for PSM 1															
13	Edit PSM Report															
14	Submission of report PSM 1															

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APPENDIX 1I

GANTT CHART FOR PSM II

		October	November				December		January	
No.	Task/ Weeks	21 - 30	10 - 12	13 - 14	15 - 25	30	1 - 9	25 - 31	15 - 16	17 - 31
1	Send draft questionnaire					MID TERM BREAK				
2	Make a correction and send again									
3	Send again draft questionnaire to correct									
4	Proceed questionnaire in online platform									
5	Send final draft online									
6	Send filter question and proceed to collect respondent									
7	Finishing chapter 4 until 5 and send correction chapter 1 until 3									
8	Presentation for PSM 2									
9	Edit PSM Report									
10	Submission of full PSM 2									

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APPENDIX III

SURVEY QUESTIONNAIRE

OPTIMIZATION OF SOLAR PANEL SYSTEMS FOR CHARGING ELECTRIC VEHICLES AT HOME IN MALAYSIA

Assalamualaikum and hello everyone,

I am conducting research for my Final Year Project (FYP) titled "Optimization of Solar Panel Systems for Charging Electric Vehicles at Home in Malaysia." This study aims to identify the key factors that enhance the effective use of solar panel systems for charging electric vehicles (EVs) at home, with a focus on Malaysian homeowners who are either currently using solar panels or considering their installation.

As the demand for sustainable energy solutions continues to rise, it is increasingly important to understand how to maximize solar energy for EV charging. Your participation in this survey is invaluable, as your insights will help us identify the factors that impact the performance, cost-effectiveness, and reliability of home solar systems for EV charging. This research will benefit homeowners, inform policymakers, and contribute to environmental sustainability.

PENGOPTIMUMAN SISTEM PANEL SOLAR UNTUK MENGECAS KENDERAAN ELEKTRIK DI RUMAH DI MALAYSIA

Assalamualaikum dan hello semua,

Saya sedang menjalankan penyelidikan untuk Projek Tahun Akhir (FYP) saya bertajuk "Pengoptimuman Sistem Panel Suria untuk Mengecas Kenderaan Elektrik di Rumah di Malaysia." Kajian ini bertujuan untuk mengenal pasti faktor utama yang *meningkatkan keberkesanan penggunaan sistem panel solar untuk mengecas kenderaan elektrik (EV) di rumah, dengan tumpuan kepada pemilik rumah Malaysia yang sama ada sedang menggunakan panel solar atau mempertimbangkan pemasangannya.*

Memandangkan permintaan untuk penyelesaian tenaga mampan terus meningkat, semakin penting untuk memahami cara memaksimumkan tenaga suria untuk pengecasan EV. Penyertaan anda dalam tinjauan ini tidak ternilai, kerana pandangan anda akan membantu kami mengenal pasti faktor yang memberi kesan kepada prestasi, keberkesanan kos dan kebolehpercayaan sistem suria rumah untuk pengecasan EV. Penyelidikan ini akan memberi manfaat kepada pemilik rumah, memaklumkan penggubal dasar dan menyumbang kepada kelestarian alam sekitar.

Information/*Maklumat*:

1. Completion of this form will take you approximately 5-10 min/ *Pengisisan borang ini akan mengambil masa kira-kira 5-10 minit.*
2. The contents of this questionnaire will be kept strictly & for academic purpose only / *Kandungan soal selidik ini akan disimpan dengan ketat & untuk tujuan akademik sahaja.*

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Instruction/ Arahan:

There are **THREE (3) section** in this questionnaire. Answer All sections/ *Terdapat **TIGA (3) bahagian** dalam soal selidik ini. Jawab Semua bahagian.*

Inquiry/ *Pertanyaan*:

If you have any questions or concerns about answering this questionnaire, please do not hesitate to contact:

Jika anda mempunyai sebarang pertanyaan atau kebimbangan tentang menjawab soal selidik ini, sila jangan teragak-agak untuk menghubungi:

Puteri Afiqah Syamimi Binti Mohd Zuki Student (B062110058)	Madam Adilah Binti Mohd Din Supervisor

Faculty of Technology Management and Technopreneurship. Universiti Teknikal Malaysia Melaka Hang Tuah Jaya 76100 Durian Tunggal Melaka. Email: Contact:	Faculty of Technology Management and Technopreneurship. Universiti Teknikal Malaysia Melaka Hang Tuah Jaya 76100 Durian Tunggal Melaka. Email:

Thank you for your time and effort

SECTION A: DEMOGRAFIC/ *BAHAGIAN A: DEMOGRAFI*

This section relates to your background in brief. **Please tick** (/) for your answer.

Bahagian ini berkaitan dengan latar belakang anda secara ringkas. ***Sila tandakan*** *(/) untuk jawapan anda.*

1. Gender/ *Jantina***:**

1.	Male/ *Lelaki*		**2.**	Female/ *Perempuan*	

2. Race/ *Bangsa***:**

1.	Malay/ *Melayu*		**2.**	Chinese/ *Cina*	
3.	Indian/ *India*		**4.**	Other/ *Lain-lain* (Please state/ *Sila nyatakan*):	

3. Education Level/ *Tahap Pendidikan***:**

1.	Below SPM/ Bawah *SPM*		2.	SPM	
3.	STPM/Diploma		4.	Bachelor/ *Ijazah Sarjana Muda*	

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5.	Postgraduate degree/ *Ijazah Pascasiswazah* (Master/PhD)		6.	Other/ Lain-lain (Please state/ *Sila nyatakan*):	

4. Monthly Household Income/ *Pendapatan Isi Rumah Bulanan:*

1.	Less than RM3,000/ *Kurang daripada RM3,000*		2.	RM3,001 - RM7,000	
3.	RM7,001 - RM11,000		4.	RM11,001 - RM15,000	
5.	More than RM15,000/ *Lebih daripada RM15,000*				

5. Home Ownership Status/ *Status Pemilikan Rumah:*

1.	Homeowner (Own)/ *Pemilik Rumah (Memiliki)*		2.	Tenants/ *Penyewa*	
3.	Other/ *Lain-lain* (Please state/ *Sila nyatakan*):				

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6. State of Residence/ *Negeri Tempat Tinggal:*

1.	Johor		**2.**	Kedah	
3.	Kelantan		**4.**	Kuala Lumpur	
5.	Labuan		**6.**	Melaka	
7.	Negeri Sembilan		**8.**	Pahang	
9.	Perak		**10.**	Perlis	
11.	Penang		**12.**	Putrajaya	
13.	Sabah		**14.**	Sarawak	
15.	Selangor		**16.**	Terengganu	

7. Types of Residence/ *Jenis Rumah***:**

1.	Terrace house/ *Rumah Teres*		**2.**	Semi house (Semi D)/ *Rumah Berkembar (Semi-D)*	
3.	Bungalow/ *Banglo*		**4.**	Apartment/condominium/ *Apartmen/Kondominium*	
5.	Other/ *Lain-lain* (Please state/ *Sila nyatakan*):				

8. Home Location/ *Lokasi Rumah***:**

1.	Urbans Area/ *Kawasan Bandar*		2.	Suburban Area/ *Kawasan Pinggir Bandar*	
3.	Rural Area/ *Kawasan Luar Bandar*				

9. Average Monthly Electricity Usage/ *Purata Penggunaan Elektrik Bulanan***:**

1.	Less than 200 KWh/ *Kurang daripada 200 kWh*		2.	200-400 KWh	
3.	401-600 KWh		4.	601-800 KWh	
5.	More than 800 KWh / *Lebih daripada 800 KWh*				

10. Awareness of Solar Panel Systems for Home Use/ *Kesedaran Tentang Sistem Panel Solar untuk Penggunaan di Rumah:*

1.	Very Knowledgeable/ *Sangat tahu*		**2.**	Know/ *Tahu*	
3.	Do Not Know/ *Tak Tahu*				

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11. Have You Installed Solar Panels at Home? / *Telah Memasang Panel Solar di Rumah?*

1.	Yes/ *Ya*		2.	No/ *Tidak*	

12. If Yes, Who Decided to Install the Solar Panels? / *Jika Ya, Siapa yang Menentukan Keputusan untuk Memasang Panel Solar?*

1.	Myself/ *Diri sendiri*		**2.**	Partner/Family/ *Pasangan/Keluarga*	
3.	Recommendations from Installation Companies/ *Saranan dari Syarikat Pemasangan*		**4.**	Other/ *Lain-lain* (Please state/ *Sila nyatakan):*	

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13. Type of Solar Panel Owned or Planned for Installation/ *Jenis Panel Solar yang Dimiliki atau Dirancang untuk Dipasang:*

1.	Monocrystalline		**2.**	Polycrystalline	
3.	Thin Film		**4.**	Not Sure/ *Belum Pasti*	

14. Electric Vehicle (EV) Ownership/ *Pemilikan Kenderaan Elektrik (EV):*

21.	Yes, Has EV/ *Ya, memiliki EV*		2.	No, but interested in having an EV/ *Tidak, tetapi berminat untuk memiliki EV*	
3.	Not interested in having EV/ *Tidak berminat memiliki EV*				

15. Type of EV Charging Level Used or Planned/ *Jenis Pengecasan yang Digunakan atau Dirancang untuk EV:*

1.	Level 1/ *Tahap 1*		***2.***	Level 2/ *Tahap 2*	
3.	Level 3/ *Tahap 3*		***4.***	Not Sure/ *Belum Pasti*	

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SECTION B: ANALYSIS OF FACTORS TO OPTIMIZATION OF SOLAR PANELS FOR CHARGING EVs AT HOME / *ANALISIS FAKTOR-FAKTOR UNTUK PENGOPTIMUMAN PANEL SOLAR UNTUK PENGECASAN EV DI RUMAH.*

The following statements relate to factors to optimization of solar panels for charging EVs at home. **Please tick (/)** in the appropriate box to indicate the extent of your agreement with **EACH** statement.

Pernyataan berikut berkaitan dengan faktor-faktor untuk pengoptimuman panel solar untuk pengecasan EV di rumah. ***Sila tandakan (/)*** *dalam kotak yang berkenaan untuk menunjukkan sejauh mana persetujuan anda dengan* ***SETIAP*** *pernyataan.*

1	2	3	4	5
Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**

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	A. Ownership of Electric Vehicles/ *Pemilikan Kenderaan Elektrik*	**1**	**2**	**3**	**4**	**5**
1	An electric vehicle charged with solar power requires fewer charging stops than a gasoline vehicle. *Kenderaan elektrik yang dicas dengan tenaga solar memerlukan lebih sedikit perhentian pengecasan berbanding kenderaan petrol.*					
2	Charging EV with solar power at home provides a reliable and efficient energy source. *Mengecas EV di rumah dengan tenaga solar menyediakan sumber tenaga yang boleh dipercayai dan efisien.*					
3	Solar energy is a dependable option for charging EVs. *Tenaga suria ialah pilihan yang boleh dipercayai untuk mengecas EV.*					
4	Having solar-powered charging at home makes using an EV even more convenient. *Mempunyai pengecasan tenaga solar di rumah menjadikan penggunaan EV lebih mudah.*					
5	Using solar energy to power EV is a cost-effective solution in the long run. *Menggunakan tenaga solar untuk mengecas EV adalah penyelesaian yang menjimatkan kos dalam jangka masa panjang.*					

	B. Electric Trading/ *Penggunaan dan Kos Elektrik*	**1**	**2**	**3**	**4**	**5**
1	Charging EV at home with solar power is more economical than charging at a public station. *Mengecas EV di rumah dengan tenaga solar adalah lebih ekonomi berbanding pengecasan di stesen awam.*					
2	With a solar charging system at home, homeowners can reduce their dependence on public EV charging stations. *Dengan sistem pengecasan solar di rumah, pemilik rumah boleh mengurangkan pergantungan kepada stesen pengecasan EV awam. .*					
3	Solar-powered EV charging could greatly benefit rural areas. *Pengecasan EV berkuasa solar boleh memberi manfaat besar kepada kawasan luar bandar.*					
4	Government incentives for home solar systems encourage my adoption of EVs. *Insentif kerajaan untuk sistem solar di rumah menggalakkan saya untuk menggunakan EV.*					
5	Government grants for solar installations are beneficial for promoting EV adoption. *Geran kerajaan untuk pemasangan solar membantu mempromosikan penggunaan EV.*					

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	C. Charging Variable/ *Pemboleh Ubah Pengecasan*	**1**	**2**	**3**	**4**	**5**
1	Considering the benefits, I am willing for longer charging time at home with solar energy. *Mempertimbangkan faedahnya, saya bersedia untuk masa pengecasan yang lama di rumah dengan tenaga suria.*					
2	Solar charging systems should include energy flow controls to maximize efficiency and prevent overcharging. *Sistem pengecasan solar perlu mempunyai kawalan aliran tenaga untuk memaksimumkan kecekapan dan mengelakkan pengecasan berlebihan.*					
3	Safety measures are essential for a secure and reliable solar EV charging experience. *Langkah keselamatan adalah penting untuk pengalaman pengecasan EV yang selamat dan boleh dipercayai dengan tenaga solar.*					
4	Availability of EV maintenance services are important for users with solar charging systems. *Perkhidmatan penyelenggaraan EV yang tersedia adalah penting bagi pengguna dengan sistem pengecasan solar.*					
5	Charging EVs with solar energy can help reduce total charging time compared to grid energy. *Mengecas EV dengan tenaga solar boleh membantu mengurangkan jumlah masa pengecasan EV berbanding tenaga grid.*					

D. Battery Storage/ *Penyimpanan Bateri*		1	2	3	4	5
1	**EVs can be charged less often when using solar power than when using gasoline cars to refuel.** *EV boleh dicas kurang kerap apabila menggunakan tenaga solar berbanding apabila menggunakan kereta petrol untuk mengisi minyak.*					
2	**Lower maintenance costs for solar-charged EVs benefit homeowners with solar charging systems.** *Kos penyelenggaraan yang lebih rendah untuk pengecas EV dengan solar memberi manfaat kepada pemilik rumah dengan sistem pengecasan solar.*					
3	**Charging EVs with solar energy greatly reduces greenhouse gas emissions.** *Mengecas EV dengan tenaga solar mengurangkan pelepasan gas rumah kaca dengan ketara.*					
4	**Driving an EV charged by solar power helps minimize noise pollution.** *Memandu EV yang dicas dengan tenaga solar membantu mengurangkan pencemaran bunyi.*					
5	**Having a home battery storage system enhances the effectiveness of solar energy for EV charging.** *Mempunyai sistem penyimpanan bateri di rumah meningkatkan keberkesanan tenaga solar untuk pengecasan EV.*					

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SECTION C: FACTORS THAT INFLUENCE THE OPTIMIZATION OF SOLAR PANELS AND CHARGING EVs AT HOME. / *FAKTOR-FAKTOR YANG MEMPENGARUHI PENGOPTIMUMAN PANEL SOLAR DAN PENGECASAN EV DI RUMAH.*

The following statement relate to factor that influence to optimization of solar panels and charging EVs at home. **Please tick (/)** the appropriate box to indicate your degree of satisfaction where:

Kenyataan berikut berkaitan dengan faktor yang mempengaruhi pengoptimuman panel solar dan mengecas EV di rumah. ***Sila tandakan (/)*** *kotak yang sesuai untuk menunjukkan tahap kepuasan anda di mana:*

1	2	3	4	5
Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**

	Adoption of EVs and panel solar at home/ *Penggunaan EV dan Panel Solar di Rumah*	**1**	**2**	**3**	**4**	**5**
1	High-efficiency solar panels are essential to maximize EV charging at home. *Panel solar berkecekapan tinggi adalah penting untuk memaksimumkan pengecasan EV di rumah.*					
2	The time to fully charge EV depends directly on solar panel's efficiency. *Masa untuk mengecas EV sepenuhnya bergantung secara langsung pada kecekapan panel solar.*					
3	Installing high-efficiency solar panels helps reduce reliance on the grid for EV charging. *Pemasangan panel solar berkecekapan tinggi membantu mengurangkan kebergantungan kepada grid untuk pengecasan EV.*					
4	A home energy storage system (e.g., battery) is vital for efficient EV charging. *Sistem penyimpanan tenaga di rumah (contohnya, bateri) adalah penting untuk pengecasan EV yang efisien.*					
5	Storing solar energy during the day enhances EV charging efficiency at night. *Menyimpan tenaga solar pada waktu siang meningkatkan kecekapan pengecasan EV pada waktu malam.*					

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6	The initial cost of solar installation is a key consideration for optimal EV charging. *Kos awal pemasangan solar adalah pertimbangan penting untuk pengecasan EV yang optimum*					
7	Financial incentives like rebates and tax credits increase my interest in investing in solar for EV charging. Insentif kewangan seperti rebat dan potongan cukai meningkatkan minat saya untuk melabur dalam solar untuk pengecasan EV.					

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