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Advance Solar Design for Electric Vehicle Storage in Universiti Pendidikan Sultan Idris

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Abstract: The global transition towards sustainable energy systems demands educational institutions like Universiti Pendidikan Sultan Idris (UPSI) to optimize renewable energy especially Solar technologies. However, a significant challenge emerges when only 85% of photovoltaic power generated can be effectively utilized resulting in a 15% energy surplus that remains underexploited. This inefficiency reflects technological limitations and management strategies that require deep investigation thereby driving this study to propose the development electric storage for 50 electric vehicle (EV) charging stations in the UPSI campus as an innovative solution for leveraging this solar energy surplus.

Keywords: Solar design, electric vehicle, energy, design and technology

1. Introduction

The quantity of sunlight that reaches the Earth's surface in just one and a half hours is sufficient to supply all of the world's energy needs for a full year. By using two primary techniques to transform sunlight into electrical energy-photovoltaic (PV) panels and solar concentrator mirrors-solar technology plays a significant role (Tang et al., 2023). In addition to being used immediately to create electricity, the energy generated can also be stored for later use in thermal storage devices or batteries (Soumya et al., 2021). In addition to discussing the integration of electrical grid systems and the soft costs of solar energy, this article offers a thorough explanation of solar radiation, photovoltaic technology, and concentrated solar power systems. Additionally, you will receive guidance on how to use solar energy in everyday life and how the solar energy sector is growing. Find out more about how the U.S. Department of Energy's Solar Energy Technologies Office spearheads cutting-edge research and development to hasten the global adoption of solar technology.

The main forms of solar energy that reach Earth are heat and light, but a lot of it is wasted because to cloud absorption, reflection, and dispersion. According to Kannan & Vakeesan (2016), the world's energy needs may be met by free and plentiful solar energy. Asian nations have the most potential to utilise this resource due to their longer yearly sunshine length. However, a significant amount of solar radiation is still unexplored. Solar energy provides a sustainable substitute for the world's growing reliance on fossil fuels, assisting in averting future energy crises. In order to maximise energy utilisation and successfully meet future demands, research efforts are still concentrated on increasing the efficiency of the solar industry.

Globally, the use of large-scale solar (LSS) photovoltaic systems including standalone systems-is growing, and nations like Malaysia are actively promoting their use. Asa result of this trend, PV panels, inverters, transformers, and storage technologies have advanced, improving the efficiency and performance of LSS (Thadani & Go, 2023). To stabilise the system and guarantee its long-term viability, solar power plants depend on a wide range of auxiliary

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equipment, including inverters, controllers, transformers, cables, and energy storage devices. UPSI's solar panel project, led by Vice Chancellor, is a collaborative effort between UPSI Holdings Sdn Bhd, Tenaga Nasional Berhad (TNB), and strategic partner Synergy Generated Sdn Bhd (SGSB). This initiative supports the university's commitment to the Sustainable Development Goals (SDGs) and aligns with UPSI's strategy to develop a smart, sustainable, and environmentally friendly campus. The project is expected to save RM13.5 million and reduce carbon emissions by 56.000 tons over a 20-year concession. Additionally, it will foster research opportunities, technology transfer, and create job prospects for UPSI graduates in the renewable energy sector (Sadeq et al., 2021). The integration of renewable energy generation with electric vehicles (EVs) has now become one of the latest trends in optimizing the use of Renewable Energy Sources (RES).

This approach helps meet energy needs, enhances the stability of the electrical grid, and supports sustainability. Energy management for EV charging supported by photovoltaic (PV) systems in the context of Industrial Microgrids (IMG) is highlighted as a solution to provide EV load reduction services and optimize electricity costs during the charging process (Sang & Bekhet, 2015). Solar Energy 101, solar radiation refers to the light or electromagnetic radiation emitted by the sun (Murat et al., 2020). Although all areas on Earth receive sunlight throughout the year, the amount of solar radiation received at a specific location varies depending on certain factors. Solar technology works by capturing this radiation and converting it into a usable form of energy.

2. Literature Review

The global transition towards sustainable energy systems demands educational institutions like UPSI to optimize renewable energy technologies. However, a significant challenge emerges when only 85% of photovoltaic power generated can be effectively utilized resulting in a 15% energy surplus that remains underexploited. This inefficiency reflects technological limitations and management strategies that require deep investigation thereby driving this study to propose the development of 50 electric vehicle (EV) charging stations on the UPSI campus as an innovative solution for leveraging this solar energy surplus. This proposal aligns with Malaysia's green technology aspirations and sustainable energy transition strategies. The strategic location of UPSI in Tanjung Malim is near the North-South Expressway offers a unique opportunity to utilize solar energy surplus through supportive infrastructure development for EV users subsequently positioning UPSI as a primary exemplar in renewable energy integration and sustainable mobility within educational institutions.

The issue of solar energy surplus carries profound implications for campus energy management strategies. According to Altassan (2023), educational institutions face significant challenges in optimizing solar energy utilization focusing primarily on developing efficient and sustainable infrastructure. Furthermore, failure to fully exploit solar energy potential can result in substantial economic losses particularly in the context of Malaysian educational institutions. Additionally, the lack of infrastructure to store or utilize solar energy surplus remains a primary barrier to realizing the full potential of photovoltaic technology thus emphasizing the need for advanced and flexible energy storage systems to support campus energy ecosystem transformation (Hassan et al., 2023). The proposed research strategically addresses this knowledge gap by conceptualizing an innovative approach to solar energy surplus through comprehensive EV charging infrastructure development.

Technical challenges in implementing this proposal involve several complex factors requiring in-depth analysis. According to Chachuli et al. (2021), primary obstacles in integrating solar energy systems with EV charging infrastructure include grid stability issues, infrastructure costs and technical maintenance requirements. Moreover, there is a need to develop more intelligent energy management models to address fluctuations in solar energy generation and EV charging demand. Therefore, this research will conduct a comprehensive investigation into these intricate challenges by developing a detailed framework critically analyzing the complex relationship between solar energy generation dynamics and evolving electric mobility technology.

The stated problem is not merely a technical issue but reflects the transformative potential in energy management paradigms within educational institutions. According to Fossatti et al. (2024), educational institutions play a crucial role in managing green technology transformation focusing on optimizing renewable energy resources. Furthermore, Malaysia stands at the threshold of a green technology revolution with educational institutions serving as primary change drivers (Veza et al., 2022). Through a strategic approach and commitment to innovation, UPSI has the opportunity to become a leading model in solar energy optimization and green technology ecosystem expansion in Malaysia. By addressing solar energy challenges methodically, this research aims to generate a sophisticated and replicable sustainable energy utilization model potentially offering transformative insights for educational institutions nationwide. In conclusion, the initiative to develop 50 electric vehicle charging stations on the UPSI campus not only offers an innovative solution to address underutilized solar energy surplus but also supports the agenda of transitioning towards renewable energy and sustainable mobility in Malaysia. By considering the technical challenges that must be addressed including grid stability and infrastructure costs, this study potentially generates a more efficient and competitive energy management model. Through a strategic and comprehensive approach, UPSI can become a leading example of green technology integration in educational institutions consequently contributing to sustainable energy ecosystem development that benefits society and the nation as a whole.

The Malaysian government has shown strong dedication to the development of renewable energy (RE) by introducing the National Energy Transition Roadmap (NETR) in July this year. This plan aims to transform the country's approach to energy consumption, while also opening new business opportunities in the green energy sector. NETR is structured in several phases, with phase 1 focusing on 10 key ideas and six strategic approaches to accelerate the transition to clean energy sources such as renewable energy and hydrogen technology. The Minister of Economy stated that by 2050, this plan has the potential to attract investments worth between RM435 billion and RM1.85 trillion (Cantarero, 2020).

According to Hadjukiewich & Pera (2020), among the business opportunities identified in the NETR include the construction of large-scale solar plants in ASEAN, the installation of solar panels on residential rooftops, the establishment of designated areas for RE development, and the development of mega solar parks. In fact, the government's target is to ensure that 70% of the country's energy comes from renewable sources by 2050, as outlined in the RE Development Strategic Plan and Trade Policy. This step not only supports new economic growth but also attracts the attention of international investors. Verdant Solar Sdn. Bhd welcomes this plan, describing it as a viable and progressive approach to energy and economic policy. CEO of Verdant Solar, praised the government's efforts in creating an environment that facilitates the transition to clean energy while making the sector more profitable. According to Ghosn et al. (2024), the implementation of the NETR strategy can stimulate the widespread adoption of RE technology, promote an innovative competitive market, reduce energy costs, and generate job opportunities in the green energy sector. This government commitment also sends a strong signal to domestic and international investors that Malaysia is serious about moving towards a sustainable energy future.

2.1 Demand for Solar Energy in Malaysia: Encouraging Trends and Growth

Since its establishment in 2015, Verdant Solar has adhered to its mission of providing world-class solar solutions and superior customer service. In recent years, the solar energy market in Malaysia has shown impressive growth. In 2022, the residential solar sector recorded a 56% increase in installations compared to the previous year, reflecting a growing awareness among households of the benefits of solar energy. Several factors have contributed to this growth, including the decrease in installation costs, more flexible financing options, government policy support, and increased awareness of the environmental benefits offered by renewable energy (RE). With this development, on August 16, 2024, solar energy consumption in Malaysia exceeded the total consumption in 2022 by 5%, indicating consistent and stable growth. He stated, this growth reflects the increasing recognition of the economic and environmental advantages of solar energy, thereby indicating that Malaysia is moving towards a greener and more sustainable future. This is a positive sign for the development of the solar energy solutions market in the country (Hannan et al., 2018).

The increase in demand in the solar market in Malaysia, the government's initiative that has set guidelines to support the development of this sector, while emphasizing the importance of taking immediate action to expand solar usage without waiting for a perfect plan. From an industry perspective, this is a good start. According to Teoh et al. (2020), there will always be challenges in balancing the demands of the private sector, national interests, and the needs of the people. However, with a balanced approach, we are on the right track. Yap also emphasized that the current administration shows a strong commitment to the development of solar energy, including efforts to enhance promotion and provide a conducive environment for the public to install solar panels. This step, according to him, signifies Putrajaya's commitment to ensuring the success of the clean energy plan for Malaysia's future.

2.2 Promoting the Acceptance of Solar Power: Verdant Solar's Efforts

Towards Sustainability Verdant Solar continues to be committed to expanding access to solar photovoltaic (PV) systems, making them more accessible to homeowners and businesses in Malaysia. According to Ghosn et al. (2024), the company strives to accelerate the adoption of clean energy by offering solutions that not only reduce electricity bills but also help customers lower their carbon footprint. In addition, the company is also taking proactive steps to achieve the goal of becoming a carbon-neutral organization. One of the latest initiatives is participation in the Green Electricity Tariff (GET) program, which allows Verdant Solar to offset 80% of their office electricity usage with renewable energy (RE).

According to Sarker et al. (2023), solar's dedication to sustainability but also becomes part of their corporate responsibility strategy. By participating in the GET program, we are not only reducing our environmental impact but also setting a positive example for customers and the energy industry as a whole. However, efforts to raise awareness about the benefits of solar energy still need to be intensified. Although the government has taken steps to promote the use of solar energy among homeowners and businesses, the potential for solar PV installation in Malaysia has not yet been fully realized. The statistics showing that out of four million terrace houses in Malaysia, fewer than 30.000 houses are equipped with solar PV systems. Through its commitment to sustainability, dedication to raising awareness, and provision of sustainable solutions, Verdant Solar hopes to play a significant role in accelerating Malaysia's transition towards green energy.

2.3 Electric Vehicle (EV) in UPSI

According to the former 9th prime minister, the establishment of an Automatic Training and Research Center at UPSI known as the Center of Advanced Automotive Research and Training (CAART). This proposal meets the needs in terms of the development of a trained, educated workforce and also has research in the latest automotive fields such as hybrid, autonomous, electric vehicles and so on. In fact, UPSI is also equipped with lecture rooms, accommodation facilities and technological laboratories, CAART which allows focus on studies, skills training, human resources and maintenance related to the latest automotive technology.

In accordance with its strategic location, which is located in the High-Tech Automotive Valley (AHTV) region, the Ministry of Higher Education is confident that UPSI is the best choice to implement this desire. UPSI management with four representatives of Hunan Automative Engineering Vocational College (HAEVC) led by Deputy President of HAEVC, to discuss and establish cooperation on satellite campus programs and automation-related training aimed at the field of Technical and Vocational Education and Training (TVET). They also discussed the main discussion to make FTV a leader in the production of skilled energy based on Green Energy in the field of automation. The aim is to become one of the critical needs of the country's automotive industry, especially in the Automotive High Tech Valley (AHTV), Proton City.

2.4 UPSI Solar System

Universiti Pendidikan Sultan Idris (UPSI) signed a renewable energy supply agreement (SARE) with Tenaga Nasional Berhad (TNB) together with its strategic partner Synergy Generated Sdn. Bhd (SGSB) to build solar photovoltaic (PV) system panels at the Sultan Azlan Shah campus. They introduced a new module which is infrastructure construction equipped with solar PV panels rated at 3.2 MWp (Megawatt Peak). The collaboration between UPSI Holdings and SGSB will create initiatives to support the Sustainable Development Goals (SDGs). This objective coincides with the development of a smart, digital, sustainable and environmentally friendly campus. The production of the solar system aims to utilize solar energy to reduce the cost of electricity bills which exceed RM 12 million per year at the Sultan Azlan Shah Campus, UPSI. This initiative to emphasize UPSI's rating in the UI Green Metric World University Ranking related to green initiatives. In fact, can generate side income. However, the use of solar systems at UPSI only makes use of solar energy resources at a rate of only 85% of the total solar energy (Ibrahim et al., 2024). Surplus solar energy of 15% is not subject to energy sources beyond what is obtained. Solar energy that exceeds consumption to produce EV charging points.

2.5 Construction of Changer EV Station

Proton City also emphasizes the use of solar systems. The establishment of the solar system implemented in Proton City is due to the area being located on the right side of the North-South Highway, between Tanjung Malim and Slim River. This area also has a Proton factory that produces models such as Persona, Gen2, and Preve. The factory is located on an area of 517.12 hectares, which is five times larger than the Proton factory in Shah Alam, with a production capacity of 150.000 cars per year. Proton City is an Automated High Technology Center (AHTV) which is the state government's desire in the long term to attract more revenue for the development of new facilities to support the automotive industry and increase the competitiveness of Tanjung Malim as the nation's automotive hub. The strategic position of Proton City which is located on the North-South highway, between Tanjung Malim and Slim River is also one of the main factors for the construction of the EV Station charger. The highway is the main highway for road users who want to move from south to north and so on. If there is an EV Station changer service built in Proton City, it will provide facilities for solar car users to charge solar energy due to the lack of energy charging points in Malaysia. This to some extent will make Proton City a place that is often visited by people in Peninsular Malaysia.

2.6 The Solar Design

Fig. 1 shows the integration of the Solar system with the charging system for the EV (electric vehicle). The solar panels that install at Sultan Azlan Shah Campus (KSAS) of Universiti Pendidikan Sultan Idris (UPSI) directly turn sunlight into electrical power is also called photovoltaic (PV) panels. A module is a collection of electrically connected panels that are bundled into a frame and referred to as solar panels. In essence, the semiconductor material in the panel absorbs a portion of the light that strikes it. This indicates that the semiconductor receives the energy of the light that was absorbed and electrons are free to move after being knocked loose by the energy. Electrons formed by light absorption are forced to flow in a certain direction by one or more electric fields in photovoltaic solar panels. When extraction of current happens for external use, placing metal contacts on top and bottom of the PV cell can draw the current off.

The DC electricity form the solar panels is sent to inverter and converts DC electricity into alternating current (AC). Once converted, this type of electricity can power lights, appliances and any other devices at Universiti Pendidikan Sultan Idris Campus. Solar panels work best in sunny areas which is make sense to install it at parking area and roof in campus. The best thing is when using solar as generating electricity it still generates on cloudy days. Excess energy can be stored in batteries or can called it energy storage. Electrical Vehicle (EV) charger station can be installed by using the electricity that stored in the storage. This makes solar energy more reliable and sustainable power source especially at UPSI Campus. As a conclusion in this part, solar panel can provide clean and renewable way to generate electricity around the campus.

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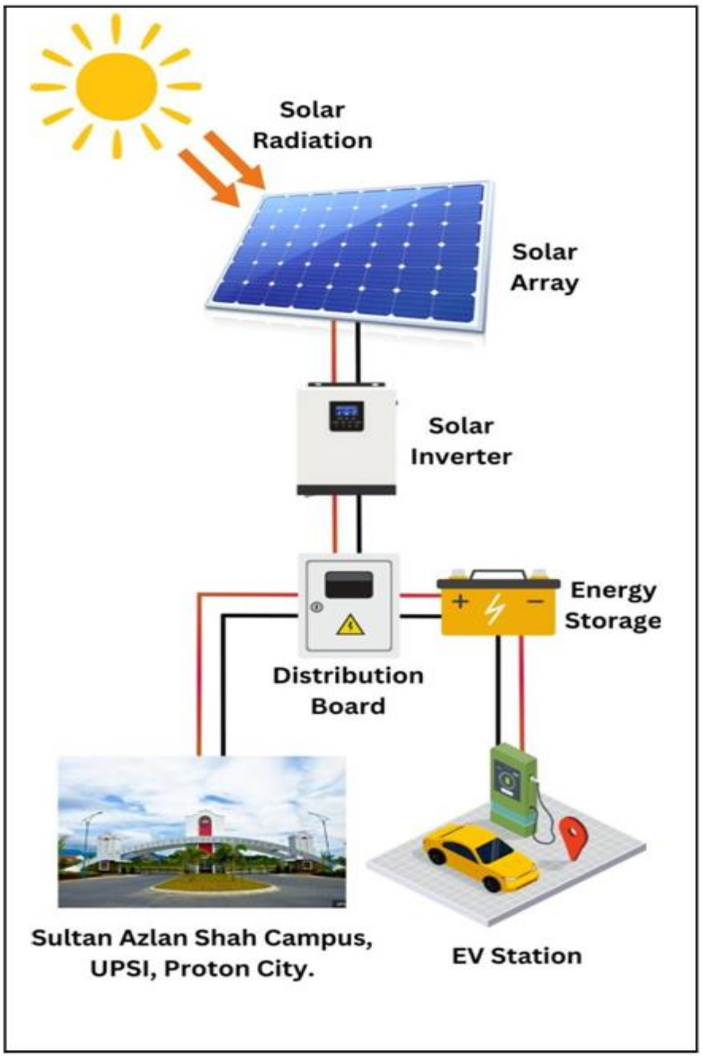

Fig. 1: The integration of the solar system for the EV station

3. Results and Discussion

The data in Fig. 2 shows how much solar energy was used at the Sultan Azlan Shah Campus (KSAS) of Universiti Pendidikan Sultan Idris (UPSI) during the month of July. The data shows the average power consumptions is around 20000kwh per month. Fig. 2 shows Power Consumption over time in July 2025.

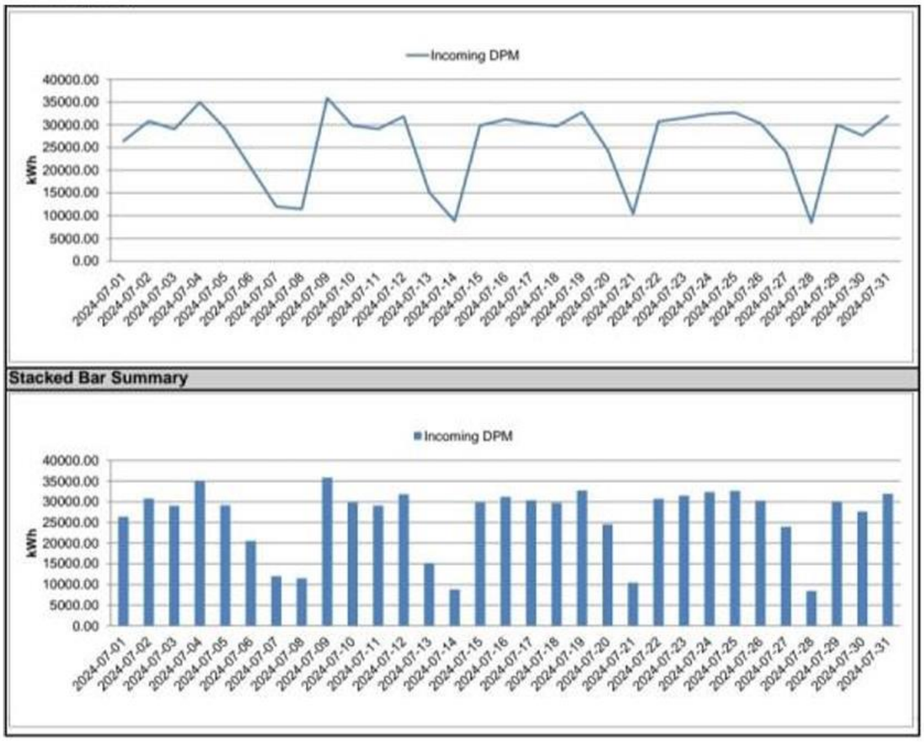

Fig. 2: Power consumption over time in July 2024

The In the first week, from July 1 to July 7, total energy usage reached 186,505.16 kWh. Notably, the highest usage day was July 4, with a reading of 34,958.08 kWh, whereas the lowest occurred on July 7, with 12,037.25 kWh. During this period, there were three days of increased usage (July 2, July 3, and July 4) and three days of decreased usage (July 5, July 6, and July 7). Moving into the second week, from July 8 to July 14, the total usage recorded was 147,258.09 kWh. The highest consumption occurred on July 9 at 35,870.59 kWh, while the lowest was on July 8, with 11,501.44 kWh. Here, we observe three days of increase (July 8, July 9, and July 10) and three days of decrease (July 11, July 12, and July 13). In the third week, from July 15 to July 21, total usage amounted to 181,481.59 kWh. Specifically, the highest day was July 18 with 29,692.42 kWh, and the lowest was July 21 with 10,441.73 kWh. Throughout this week, there were three days of increased usage (July 15, July 16, and July 18) and three days of decreased usage (July 17, July 19, and July 21). The fourth week, from July 22 to July 28, recorded energy usage of 193,598.27 kWh. Here, the highest day was July 24, with 32,361.22 kWh, contrasting with the lowest on July 28, at 8,460.54 kWh. Similar to previous weeks, there were three days of increase (July 22, July 23, and July 24) and three days of decrease (July 25, July 27, and July 28).
Finally, in the fifth week, spanning July 29 to July 31, total usage was 104,508.69 kWh. Notably, the highest usage day was July 31, at 31,936.77 kWh, while the lowest was July 30, with 27,652.35 kWh. This week demonstrated a single day of increase (July 31) and one day of decrease (July 30).

Universiti Pendidikan Sultan Idris (UPSI) has made significant strides in renewable energy through its large-scale solar photovoltaic (PV) installation at the Sultan Azlan Shah Campus. This project, backed by the Vice Chancellor UPSI and involving partnerships with Tenaga Nasional Berhad (TNB) and Synergy Generated Sdn Bhd, aligns with the university's commitment to sustainable development and carbon footprint reduction. Over a 20-year concession, the project is anticipated to save RM13.5 million in energy costs and reduce carbon emissions by 56,000 tons. The system currently uses 85% of generated solar energy to meet campus needs, with surplus energy suggesting an opportunity to establish an EV Charging Station to utilize the additional energy. This excess can support UPSI's broader goals of energy management, technological advancement, and contributions to the green economy. The analysis of solar usage data from July to September demonstrates UPSI’s fluctuating energy consumption patterns, largely impacted by operational activities, weather conditions, and semester schedules. Given these fluctuations, UPSI's solar initiative proves effective, though there is room to optimize usage further. To support the growing trend of electric vehicle (EV) adoption and capitalize on the surplus solar energy, UPSI could install EV Charging Stations on its Sultan Azlan Shah Campus. A minimum of 50 charging points would provide ample capacity for students, faculty, and visitors. The suggested locations for EV charging stations include near the Main Entrance and Parking Areas. This would make the stations easily accessible for users entering the campus. Ideal parking lots close to administrative buildings or high-traffic areas would increase convenience. Strategically positioned EV charging stations, leveraging the surplus solar energy generated on campus, would support UPSI's green goals, encourage EV usage, and enhance the university’s reputation as a leader in renewable energy adoption. The following figure is a proposed plan for the EV Charging Station construction area at the Sultan Azlan Shah Campus.

Fig. 3: The proposed plan for the EV charging station construction area at the Sultan Azlan Shah Campus

4. Conclusion

Overall, this proposed location corresponds to the location of Tanjung Malim between the north and south highways. Therefore, the proposed 50 EV Charging Points at the Sultan Azlan Shah Campus will be an add value to the EV ecosystem in Malaysia.

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