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Maximizing Solar Energy Harvest for A Campus Charging Station: A Comparative Study of Two Solar Panel Types

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Abstract:

The rising reliance on mobile devices among students highlights the need for sustainable and accessible powering solutions in educational settings. This study proposes a solar-powered charging station for Politeknik Kota Kinabalu, aiming to reduce carbon emissions and promote green energy on campus. The primary objective is to compare the performance of monocrystalline and polycrystalline solar panels in generating sufficient power to charge a mobile device battery. Two phases of experimentation were conducted, i.e. laboratory testing under artificial lighting and on-site testing under natural sunlight. Both solar panel types were configured in series and parallel arrangements. Voltage, current and irradiance were measured using multimeters and solar meters, with a 10kΩ rheostat included to simulate varying resistance conditions. Findings revealed that the parallel configuration provided the most stable current output and performed best in both laboratory and real-world conditions. Even under relatively low irradiance, the battery showed consistent power restoration. This study concludes that a solar-powered charging station using a parallel configuration of either panel type is a feasible solution for campus use. Further research is needed to optimise the design for varying climatic conditions and to support broader implementation in sustainable campus infrastructure.

Keywords: mobile charging, monocrystalline, solar panel, polycrytalline.

Introduction

This project proposes a feasible and sustainable solution for mobile device charging by introducing a solar-powered campus charging station in Politeknik Kota Kinabalu. Recognizing that students spend a significant portion of their day on campus, providing a convenient and eco-friendly way to charge their phones aligns well with both student needs and environmental goals. By strategically locating these stations across the campus is expected to reduce reliance on the campus electricity supply and promote the use of green energy, thereby contributing to Malaysia's sustainability objectives. While past researches have largely focused on rooftops solar installations for purposes such as lighting [1],[2], display boards [2], and performance comparisons of different panel types [3],[4], there has been little emphasis in developing autonomous mobile phone charging stations. Moreover, limited recent research has explored the use of monocrystalline [3] and polycrystalline [4] solar panels for mobile phone charging. Significantly, a research gap exists in the exploration of utilizing solar panels for an autonomous mobile phone charging structure. This project addresses that gap by proposing a unique, campus-oriented solar charging solution that reflects the sustainability values upheld by many educational institutions.

Research Methodology

The methodological procedures of this study began with aligning the work of this project against the main objective of the study as illustrated in a flow chart style shown by Figure 1. The first step involved conducting a laboratory experiment to evaluate the parameters of monocrystalline and polycrystalline solar panels that could produce an output voltage of 12V, considering various design configurations and number of panels. The setup is as shown in Figure 2(left). The configurations included series and parallel connections, as connecting identical panels in these ways typically doubles the voltage and amperage outputs, respectively, of a single solar panel [5]. In the laboratory setup, both types of solar panels were tested individually as single units, in series, and in parallel. Four 75-watt lamps, placed at a consistent distance of 30 cm from the panels, served as the artificial light source. The experiment began with a single lamp before progressing to two, three and four lamps in subsequent stages. A 10kΩ rheostat was integrated into the circuit allowing for resistance varying. A multimeter was employed for precise measurements of voltages and currents. The experiment was systematically tested and data for each panel configuration was recorded. The experiment also explored their responses to varying resistance.

Following the lab testing, an on-site experiment was conducted as shown in Figure 2(right). This setup included both panel types, a solar charging circuit, a 10kΩ rheostat, and measurement instruments such as a multimeter and a solar meter, were arranged to evaluate the charging performance of a connected battery. Initially, the panels were exposed to direct sunlight with the rheostat set to 1.42kΩ. The value of 1.42 kΩ was identified as the optimal resistance for achieving maximum system charging. This value was determined through a controlled laboratory experiment in which the solar panel was exposed to one, two, three, and four 75W lamps, simulating irradiance levels of 25%, 50%, 75%, and 100%, respectively. Nonetheless, the experimental setup remained exposed to sunlight from 8 am to 1 pm, with readings recorded hourly. This procedure was repeated for different configurations, including series connection, and parallel connection. The solar charging circuit facilitated the conversion of sunlight into electrical energy, with the rheostat enabling the adjustment of variable

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resistance to influence charging conditions. The multimeter measured voltage across the panels and the generated current, while the battery's charging status was monitored under different configurations and

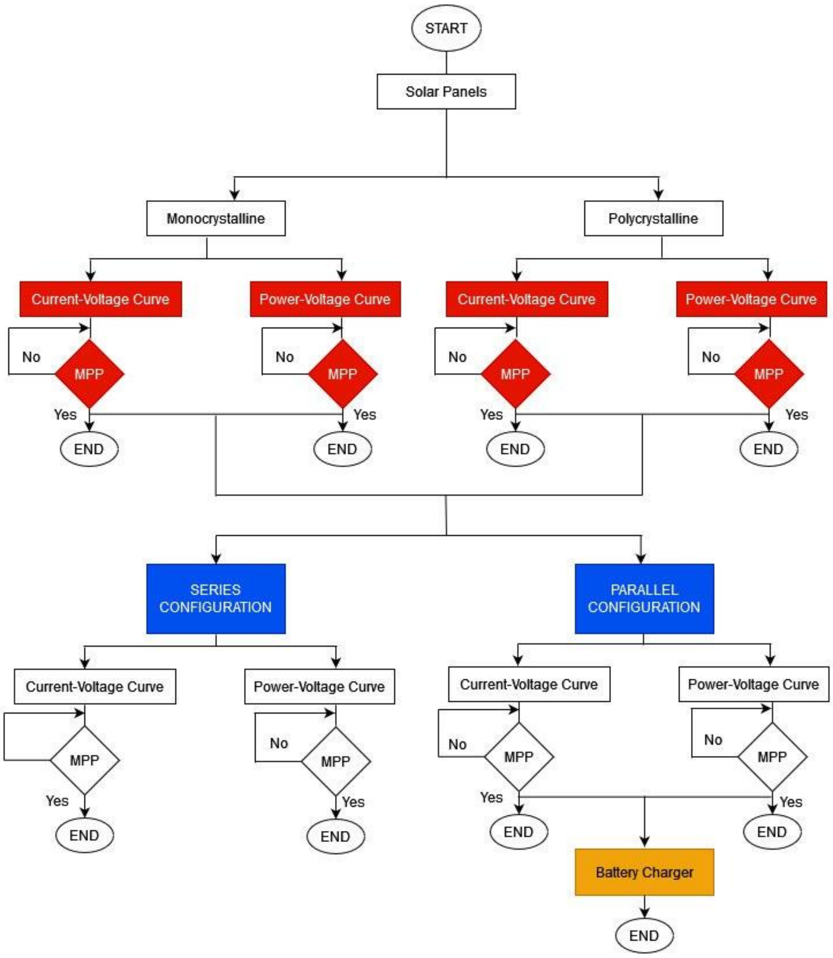

Figure 1: Chart of the objective attainment through planned methodology

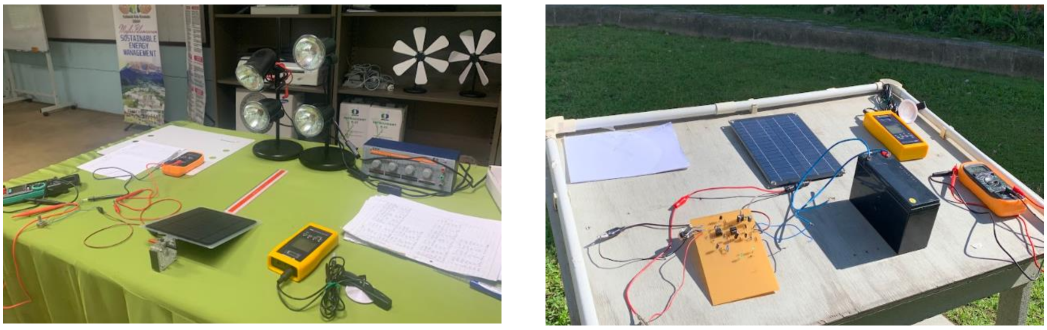

Figure 2: Experimental setup (left) laboratory experiment (right) on-site experiment

resistance levels. Figure 3 shows the location of the experiment and the weather on the day of the experiment.

In Figure 4, the laboratory experiment results for monocrystalline and polycrystalline solar panel series vs parallel connection IR curves are presented across irradiance levels from 25% to 100%. It was evident that the parallel connection consistently outperformed the series connection in terms of current generation. Higher irradiance improves solar panel performance, and parallel configurations are better at maintaining high current output, which is critical for battery charger requiring stable current supply. Irrespective of irradiance levels, the analysis indicated that the parallel configuration generated the highest current compared to series connection. Additionally, a noteworthy trend was observed where the highest current was consistently achieved at a resistance level of 1.42kΩ for each irradiance tier for both connections. Therefore, the parallel connection was chosen as the solar panel configuration for the on-site experiment.

Figure 3: (left) Geographical location of the on-site experiment;(right) the ambient temperature on the day of the experiment

Analysis and Discussion

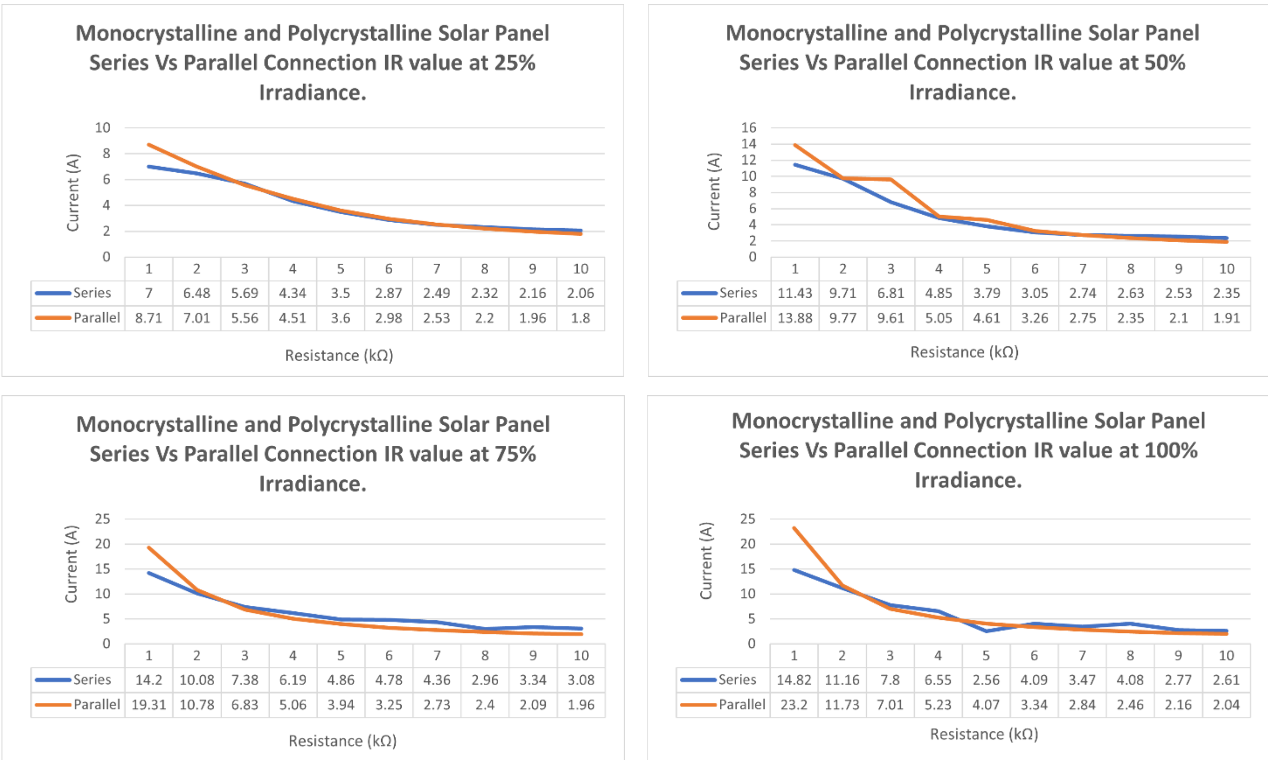

Figure 4: Series vs parallel connection IR curve at 25%, 50%, 75% and 100% irradiance

In the final analysis (Figure 5), concerning the parallel connection configuration, it was observed that the battery attained an increase of 1V from its initial value of 5.03V during the testing phase at the site. It is noteworthy to mention that the irradiance (measured in W/m2) was relatively low throughout this experiment, and this had a discernible impact on the charging characteristics of the battery despite the average ambient temperature being 33°C. This phenomenon aligns with the findings presented in [6], supporting the assertion that variations in irradiance levels play a crucial role in influencing the charging performance of batteries. The diminished irradiance levels during the experiment underscore the importance of considering environmental factors, such as solar irradiance, in assessing and interpreting the outcomes of parallel connections in solar panel systems.

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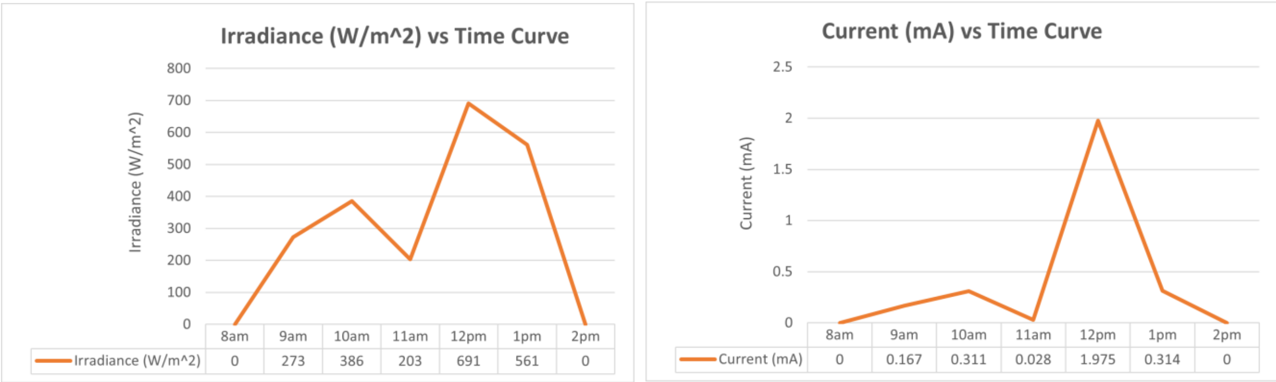

Figure 5: Irradiance (W/m^2) and current measurement vs time curve

Conclusion and Recommendation

This study presented a comparison between monocrystalline and polycrystalline solar panels as viable solutions for generating and storing clean energy in a campus charging station. Both laboratory experiments and on-site experiments were conducted to assess the performance of different solar panel configurations. The findings demonstrated that the selected configuration (parallel) was capable of effectively charging the system battery. While the results are promising, the study was limited by its use of idealized climatic conditions. Additionally, it relied on simplified models of the campus charging station, which may not fully reflect real-world scenarios. Therefore, further studies and development are recommended, particularly in advancing solar energy harvesting technologies and exploring their integration into broader, environmentally sustainable infrastructure.

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