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Study and evaluation of energy on the house by standalone photovoltaic systems of half-cell and full cell types

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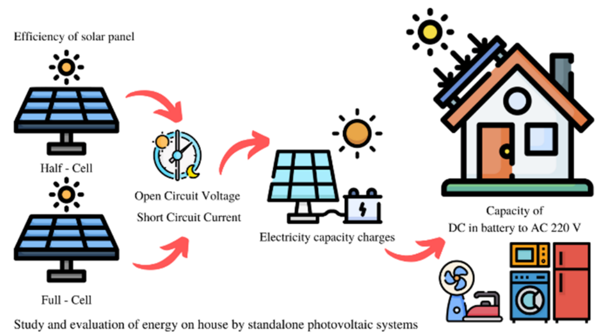
Abstract

This research aimed to investigate the effectiveness and performance of standalone photovoltaic systems of the half-cell and full-cell types. In Phetchabun province, it requires 8 hours of sunlight per day between the hours of 8:00 A.M. and 4:00 P.M.. Open circuit voltage, short circuit current, DC, and AC power are continually recorded for 62 days in July and August 2020. According to the results of the solar panel efficiency test, the full and haft cell solar panels' actual efficiencies are 89.13 and 89.04% of the manufacturer's maximum power, respectively. The power generating efficiency of full-cell and half-cell types of panels was considerably different at 95% confidence. The power of 307.5 and 307.9 W for full and half-cell solar panels. By using two 345 W solar panels connected in parallel, it can produce an average voltage and current of 25.40 V and 21.62 Ah respectively, and when charged to a 100 Ah 24 V battery for 8 hours it can use electrical appliances including 350, 450, 550, and 650 W.



Keywords: Solar energy; Renewable Energy; Solar panel

1. Introduction

With Thailand's economic expansion, industrial demand, air conditioning consumption, increase in the number of electric vehicles, and overall development, the country's electrical energy consumption has been rising steadily. Thailand's energy consumption in 2021 totaled 190,483 GWh, with conventional fossil fuel power plants providing virtually all of it [1]. Thailand has created regulations to lessen its reliance on fossil fuels for the generation of electricity and boost the usage of renewable energy sources because it is cognizant of the need for energy security. Due to the present electrical energy consumption rate's rapid rise and the inability of large-scale power plants to meet the demand, renewable energy has attracted a lot of attention in recent years. As a result of Thailand's tropical location and plentiful solar power resources, which include sun irradiation of 17 – 20 MJm^{-2} per day, solar energy is one of the renewable energy sources that has had a quick growth in terms of capacity [2]. In accordance with the Alternative Energy Development Strategy (AEDP) and the Electricity Development Plan (PDP), the country's master plan for renewable energy, the government also supports the generation of solar power. The government is increasing its aim for electricity capacity to 70,410 MW [3, 4] in this AEDP that was created in accordance with the PDP, with installed renewable energy capacity set at 19,635 MW in 2036. With a planned installed capacity of 6,000 MW, solar energy is the greatest anticipated renewable energy source for electricity generation in the plan. In the past, utility-scale installations have provided the majority of solar systems invested in in Thailand [5]. However, as the cost of solar systems has been on the decline, prosumers have become more prevalent in various markets, particularly the industrial and residential ones. Because of this, solar systems at all sizes of the solar system, such as in homes, buildings, and industries, contribute significantly to raising the generation of renewable energy.

A solar cell, also known as a photovoltaic cell, is an electrical device that uses the photovoltaic effect, a natural physical and chemical phenomenon, to convert light energy directly into electricity [6]. A device whose electrical properties, such as current, voltage, or resistance, change when exposed to light is a type of photoelectric cell. The foundation of photovoltaic modules, sometimes referred to as solar panels, are solar cells. Whether the source of light is natural or artificial, solar cells are referred to be photovoltaic. The foundation of photovoltaic modules, sometimes referred to as solar panels, are solar cells. There are several crystalline or thin-film PV modules that power a solar PV system. Typically, solar cells are called for the semiconducting component that makes them up. For these materials to absorb sunlight, they need to have specific properties. While some cells are tailored for usage in space, others are made to handle sunlight that reaches the Earth's surface. To take use of diverse absorption and charge separation techniques, solar cells can be constructed using just one layer of light-absorbing material (single-junction) or using numerous physical configurations (multi-junctions) [7].

There are three generations of solar cells: first, second, and third. The first-generation cells, also known as conventional, traditional, or wafer-based cells, are constructed of crystalline silicon, the PV technology that is most widely used commercially and contains components like polycrystalline and monocrystalline silicon. The second generation of solar cells are thin film solar cells, which may be used in small standalone power systems, integrated photovoltaic buildings, utility-scale photovoltaic power plants, and amorphous silicon, CdTe, and CIGS cells. Many of the thin-film technologies that are sometimes referred to as emerging photovoltaics are included in the third generation of solar cells, however the majority of them are still in the research or development stages and have not yet been used commercially. Both inorganic and organic materials are frequently used in manufacturing.

Half cut cells are a modification of the already available commercial modules with the goal of resolving their flaws and improving upon them. The idea, as the name implies, is the straightforward laser cutting of a solar cell into two halves in order to decrease total power losses and improve efficiency [8]. In comparison to normal modules, it offers several benefits, but it also has manufacturing disadvantages of its own. The role it will play in the development of solar energy may be better understood by a full comparison of the parameters affected by the two technologies in the following section. Reduce the resistive power loss in PV modules by using cells that have been cut in half. The typical full-size cells are divided in half using a laser in a direction perpendicular to the busbars to create the halved cells. The cells are then joined and placed into a PV module. Some major PV manufacturers have already used this technique in their commercially available PV modules. Therefore, the evaluation of half-cell versus full-cell solar panel efficiency results will be the main focus of this research.

2. Materials and Methods

Evaluation of efficiency of solar panel type

For the study of the evaluation of half-cell versus full-cell solar panel efficiency, both of type solar panel with a power output of 345 W and a voltage of 36 V. There was chosen to be mounted at a 15-degree south angle as in Fig. 1. Solar panels are the main device for converting solar energy into electrical energy. It requires 8 h of exposure every day during the daytime hours of 8:00 AM to 4:00 PM from July – August 2020 at Phetchabun province. Collect electrical data of the system by installing an electric meter that is the current value, voltage value and electric power value both on the DC and AC sides and then record the data every 15 minutes into the Data Logger and using independent samples T-test statistic for correlation analysis.

Electricity capacity charges to storage in battery.

In a 24 V system, the solar panels are connected in parallel to acquire the greatest amount of current, and the power generated by the solar panels is collected by batteries. It was created with the intention of installing an automated voltage regulator between the solar panel and the battery to improve charging and discharging stability and to regulate the voltage from DC 36 to DC 24 V so that it could be used with 24 V batteries. Record the voltage and charging current every 15 minutes.

Stored electricity from an inverter to electrical equipment.

Through a voltage converter, DC from the batteries will be fed to AC equipment. Alternative current 220 V 50 Hz, allowing 621 W items to be powered at 90% efficiency. The highest capacity for electricity generation per day is 8 h. Record percentage of voltage battery and the amount of energy charge in a battery every 15 minutes.

3. Results and Discussion

The result of efficiency of solar panel

The results of the solar panel efficiency test revealed that the average open-circuit voltage of full and haft cell type of solar panels were 37.5 and 38.4 V, respectively, and the average short circuit current of full and haft cell type for the solar panel values were 8.2 and 8 A, respectively as show in Fig. 2 [9], That means a full and half-cell solar panel has a power of 307.5 and 307.9 W, respectively (Fig. 3) [10, 11]. And when compared to the data of solar cells from manufacturers, the characteristics of solar panels are as follows.

Maximum Power (Pmax)	345 W ± 2.5%
Maximum Power Voltage (Vmp)	37.7 V
Maximum Power Circuit (Imp)	9.15 A
Open Circuit Voltage (Voc)	46.4 V ± 3%
Short Circuit Current (Isc)	9.62 A ± 4%
Maximum System Voltage	IEC1500 W

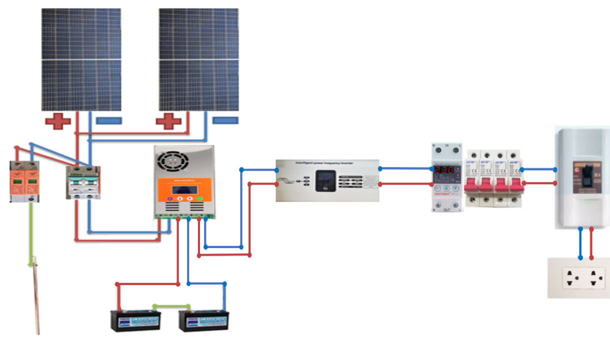


Fig. 1 The diagram of workflow for off-grid solar power generation.

We found that the full and haft cell solar panels have differences between the manufacturers' power efficiency and true measurement, with 10.83 and 10.96%, respectively. This indicates that full and haft cell solar panels' actual efficiency is 89.13 and 89.04% of the manufacturer's maximum power, respectively [12, 13].

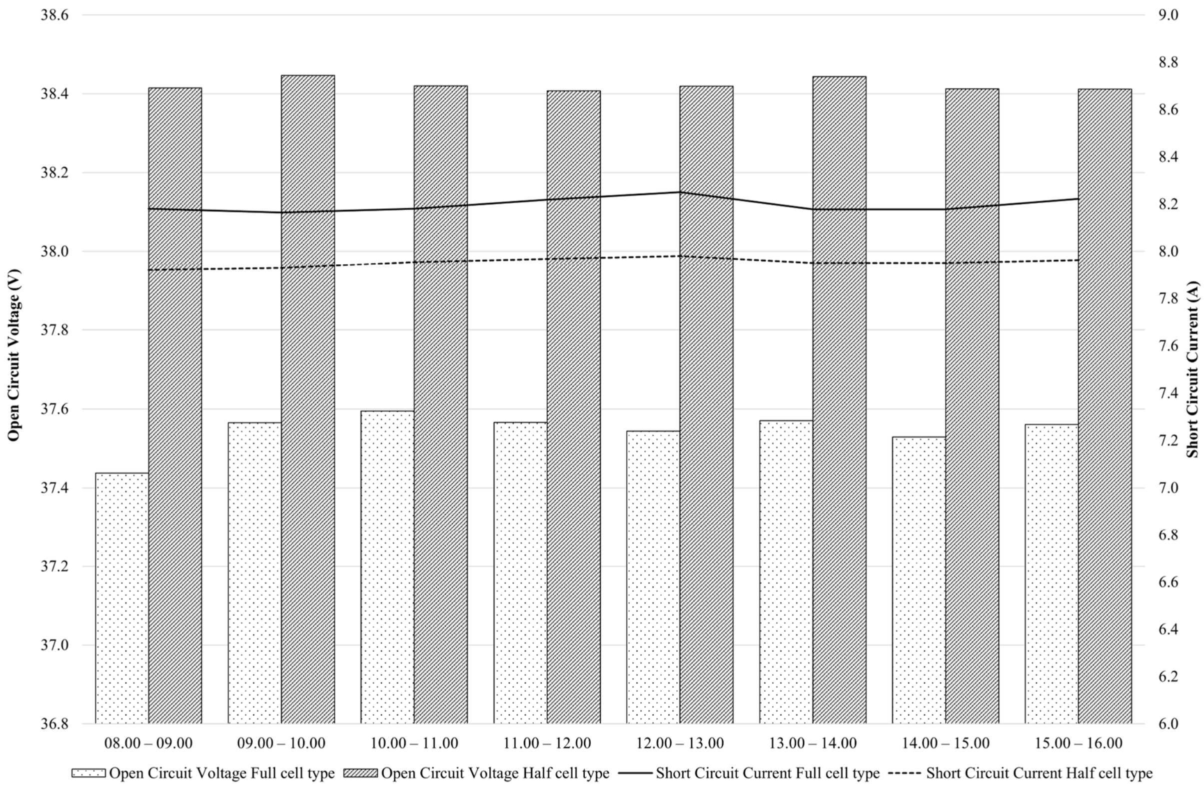


Fig. 2 The result of efficiency for two types of solar panel.

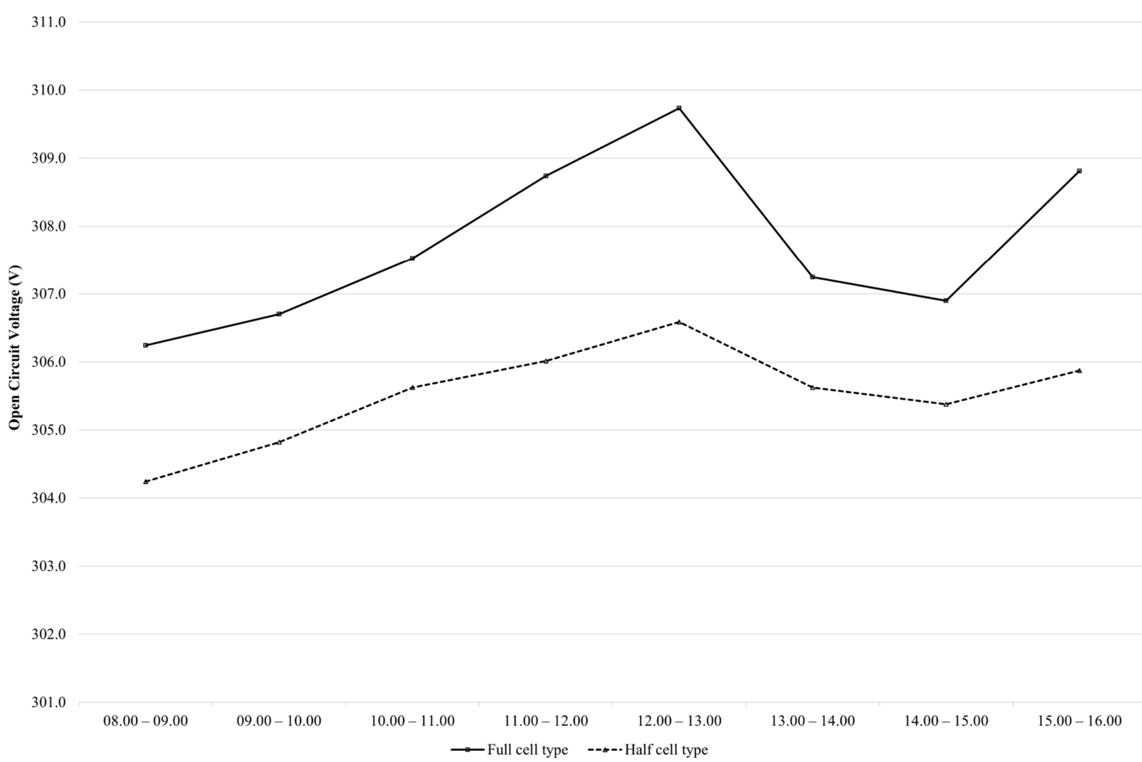
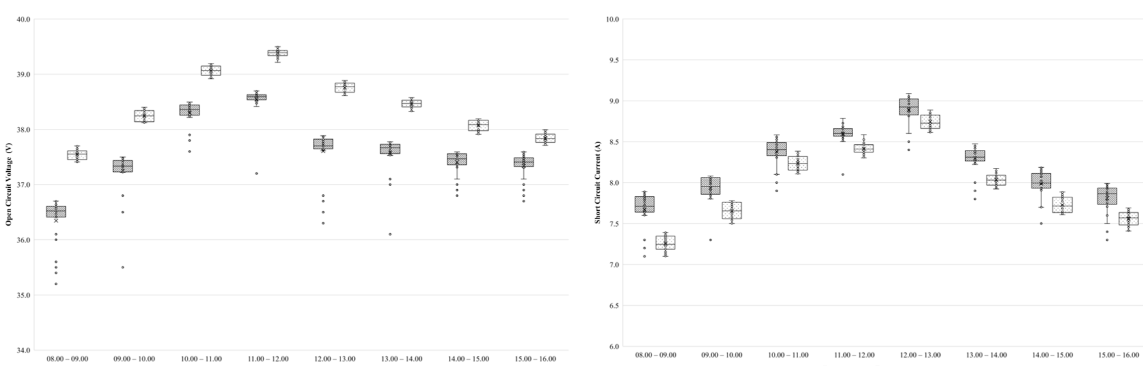


Fig. 3 The result of maximum power for two types of solar panel.

Fig. 4 show that Voc and Isc values have anomalous values. Solar panels, particularly full-cell solar panels when utilizing time series analysis however the unusual pattern was discovered to be inconsistent. When plotted in a time series, this happens practically every time and at the time of the outlier, there was little or no value found.

Table 1 shows a statistical analysis of the difference in performance between the two types of panels using paired samples z-test analysis with two-way assumptions of 95% confidence. Full and half-cell solar panels are not different, according to the null hypothesis (H0). Full and half-cell solar panels are distinct, according to alternative hypothesis (H1).

The result form Table 1 show the probability (P) obtained from the analyses of both types of solar cells is less than the statistical significance level (P(Sig.) < 0.05), as shown in Table 1. This means that the Voc and Isc values of the two types of solar panels differed at a significant level of 0.05, rejecting the null hypothesis (H0) and accepting the alternative hypothesis (H1). The two panels' power generating efficiency was significantly different. Guo *et al.* [14] investigated theoretically and experimentally the differences between modules made with halved and full-size solar cells, and the results show that using halved cell modules instead of full-size cell modules is even more advantageous for solar cells with high short circuit current density (high efficiency) and the superiority of half-cut solar cells over standard solar cells, in terms of output, manufacturing efficiency, and loss reduction, making them a practical commercial substitute for standard cells [15]. The experiment's findings are generally in agreement, showing that half-cell modules operate better in partial shade circumstances, produce more power due to optical gain, and have less electrical losses in cell connections. Due to the increased cell spacing, the modules short-circuit current increased to around 3%, and the Fill Factor increased to 1.48%.



a) Open Circuit Voltage b) Short Circuit Current

Fig. 4 Time series of average Voc (a) and Isc (b) in different time periods.

Table 1 The result of paired samples z-test analysis for two types of solar panels.

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Voc	full - half	–0.88	0.38	0.023	–0.92	–0.83	–37.1	255	0
Isc	full - half	0.24	0.16	0.010	0.22	0.26	24.0	255	0

The results of electricity capacity charges to storage in battery.

The voltage and current obtained from two 345 W solar panels connected in parallel are measured in this experiment. The average voltage and charging current were determined to be 25.40 V. and 21.62 Ah, respectively. However, when looking at Fig. 5, the time period was discovered to be 11 A.M. – 2 PM. In contrast to the charging current, which is the largest at this time, the average voltage is the lowest. Despite this, there was some anomaly in both results [16].

The result of stored electricity from an inverter to electrical equipment.

Using a 100 Ah 24 V battery, a 3 kW inverter was used to test the inverter's operation for 8 h, converting direct power to alternating current 350, 450, 550, and 650 W, respectively. Then calculate the proportion of battery voltage and the amount of energy charge each size of electrical appliance (Ah). The average percentage lift time of voltage battery when measured at electrical load 350, 450, 550, and 650 W was 25, 25, 24.7, and 24, respectively [17]. The average of the power delivered to electrical appliances was 1.59, 2.04, 2.5, and 2.95 Ah, respectively (Table 2). When using the four sizes of the device in comparison to the size of the battery utilized, the total current may be used for eight hours in all four sizes [18].

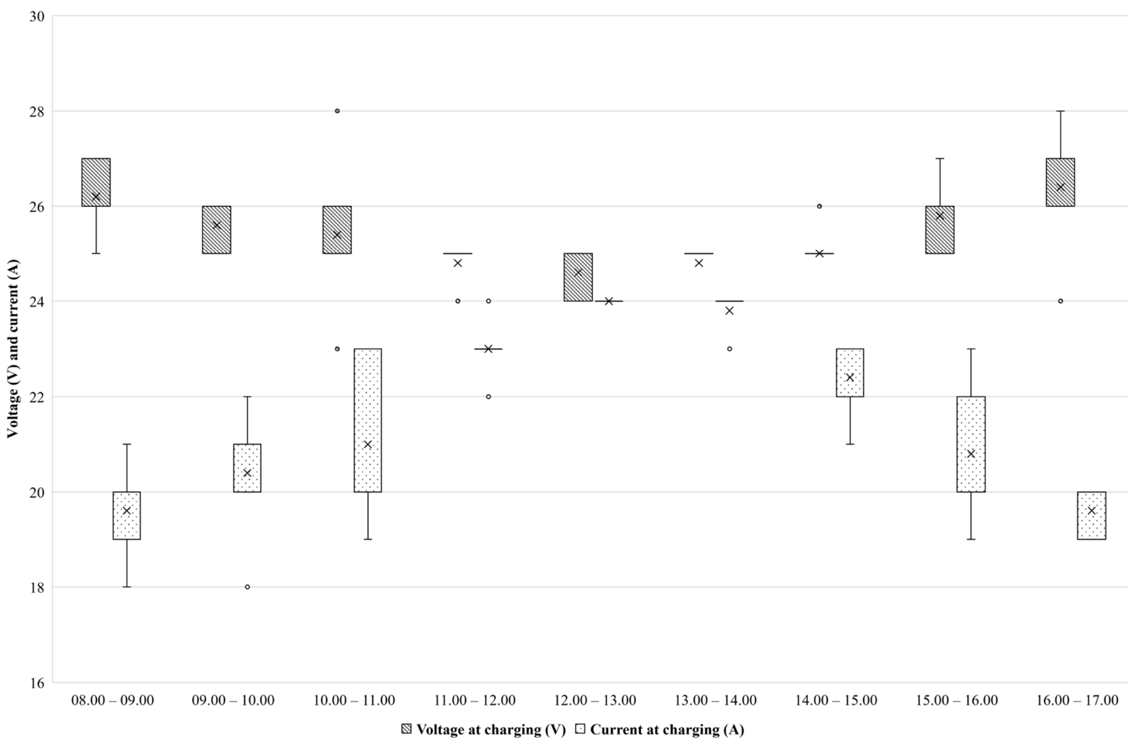


Fig. 5 The result of average voltage and current on charging in different time periods.

Table 2 The result of percentage of voltage battery and supply current when measured at difference electrical load.

Electric load AC (W)	Supply current to electric load (Ah)	Voltage of battery (%)
350 (50.72%)	1.59	25
450 (65.21%)	2.04	25
550 (79.71%)	2.50	24.70
650 (94.20%)	2.95	24

4. Conclusion

The solar panel with a power output of 345 W and a voltage of 36 V, both half-cell and full cell type. It requires 8 h of sunlight every day during the daytime hours of 8:00 A.M. to 4:00 P.M. from July – August 2020 at Phetchabun province. The results of the solar panel efficiency test revealed that full and haft cell solar panels' actual efficiency is 89.13 and 89.04% of the manufacturer's maximum power, respectively. And both type panels' power generating efficiency was significantly different at 95% of confident. The average voltage and current obtained from two 345 W solar panels connected in parallel were 25.40 V and 21.62 Ah, respectively. When using the alternating current 350, 450, 550, and 650 W for the device in comparison to the size of the battery 100 Ah 24 V with two solar panels, the total current may be used for eight hours in all loads.

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