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Harvesting of Photon Energy through PV on Building Envelope and Windows Canopy

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Abstract. It often does not occur to us that there is a space or point in the construction of a house or residence that has the potential to develop new and renewable energy sources (EBT) that produce additional electrical energy. The position of the window canopies and building walls has the potential to place solar panels (PV) according to the canopy design without requiring additional installation costs. This position is known as passive energy. The advantage is that it is easier to maintain compared to PV panels installed on the roof of the house. Although this position is not optimal to get sunlight, at least there will be photon energy captured by placing PV in the path of the sun's shadow. This means that the solar thermal value that PV does not like will decrease, while what is needed for PV semiconductors is photon light. Therefore, this study aims to increase profits in terms of construction management of exterior walls and building canopies, especially window roofs. The observation results show that The position of placing the PV panels in one direction of the sun's shadow, which is on the west side of the building gives better advantages to PV on the building envelope compare with window canopy. The PV output power generated on the building envelope is about 6 Watt, while the window canopies are only around 4 Watt. Need further investigation on different site of the building.

Keywords**:** passive solar house**,** building envelope**,** window canopy, photon energy, sun shading

1. Introduction

In the future, the walls and windows of buildings or residences will not only serve as protection from cold and hot air and air circulation passageways, but can also double as an additional energy source to harvest photon energy for photovoltaic (PV) panels from sunlight. The layout of the PV panels on the front wall of the residence, precisely on the balcony, is the main attraction of the design apart from being a relaxing place for residents of a house or apartment. Its uniqueness is that only by attaching PV panels to the side walls of the balcony or on the elevation of the balcony roof, you can get energy from sunlight. This also adds to the aesthetics of the building exterior. Relaxed residential models using balconies are often found in urban and rural marginal communities as a characteristic of traditional houses. This particularity has become a potential development area for harvesting solar energy for the generation of new and renewable energy (EBT) that is available for all time (sustainability energy).

In building interiors, research by Mustofa et al., [1] in his latest study shows the output power characteristics of mini PV modules that utilize LED residential light bulbs as a source of new electrical energy generation as well as a lighting source. Initially, Mustofa et al., [2], Piarah et al., [3], and Piarah et al., [4] continuously investigated the use of incandescent, xenon, and halogen bulbs as photon energy providers in PV and thermoelectric generator. Unfortunately, as a source of electrical energy for residential needs, the power is still relatively small, so it needs to be combined with other similar energy sources.

Research conducted by Freitas et al., [5], Kim et al., [6] and Eum et al., [7] provides a form of scientific work that can support increasing electrical energy simply by installing PV panels on balcony walls. This study of PV building exteriors that utilize sunlight during the day is quite interesting when combined with the use of light bulbs in PV building interiors at night. Even though the PV panels do not get perfect exposure to solar light following the direction of the sun because they are attached to the balcony wall of a building or residence, the light from the sun's shadow in the morning, afternoon and evening is enough to provide electron excitation energy in the PV panel as an electric current generator. The layout design of the PV balcony and building envelope is as shown in Figure 1. Research on the intensive use of building walls was carried out by [8]. They introduced a framework for model optimization and building sizes suitable for simulated PV integration. Still rarely do it experimentally.

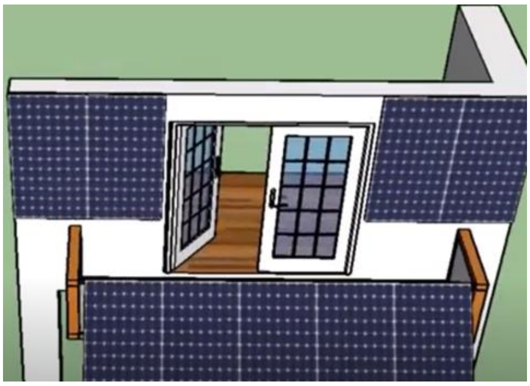


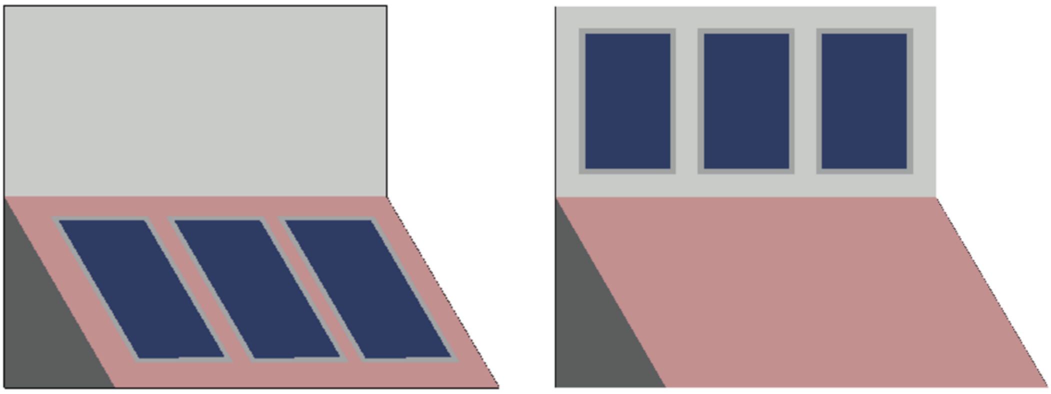
Figure 1. PV balcony [7].

The use of light bulbs and the sun in this study is called passive solar panel system (PSPS) because the PV panels are permanently attached to the inner and outer walls according to the direction of the largest portion of the light coming. Therefore, to be able to take advantage of the harvest of the photon energy captured by the light bulb and the sun, it is necessary to store energy called a battery, so that it is efficient as a source of operational energy for other electrical devices. The work system for generating electricity from the Light Bulb and Solar Power Plant can be abbreviated as PLTCBS. The placement of PV panels as part of construction management in residential buildings needs to be promoted, especially in two-story residential buildings made of cement or wood. The position on the balcony is easier to control, maintain and replace PV panels or their supporting components than if they are placed on the roof.

In line with the argumentation of the research results above, this research will focus on how much PSPS power is on the window canopies and the building envelope as energy sustainability on the residential building for PLTCBS which can be used to harvest solar energy using PV.

2. Materials and Methods

The place of observation and data collection was carried out in the Mechanical Engineering Department building, Tadulako University, precisely on the roof canopy, windows and envelope of the building as shown in Figure 2. The solar panels used consisted of solar cells made of semiconductor materials to convert solar energy into electrical energy with 2 specifications; different dimensions, but the same What power (50 Wp) as in Tables 1a and 1b. The two PV panels are installed in parallel on the envelope building and/or window canopies simultaneously, where sunlight passes from east to west. This model will make it easier to maintain solar panels compared to PV installed on the roof of the house. In addition, it will add to the aesthetics of the building if the wall or canopy construction materials are made of solar panels that are specially designed according to the dimensions of the holder. This would be an interesting future research.



(a) (b)

Figure 2. Position of PV panels on (a) window canopies and (b) building envelope.

Furthermore, the PV panel will be assembled with a wattmeter, diode component, Solar Charge Controller (SCC), load and battery as shown in Figure 3 below. Data on voltage, electric current, PV surface temperature and solar irradiance will be recorded every 10 minutes from 09am to 04pm. The surface temperature of the PV is measured with a digital infrared thermometer and the amount of irradiance that strikes the PV panel is also recorded using a Solar Power Meter.

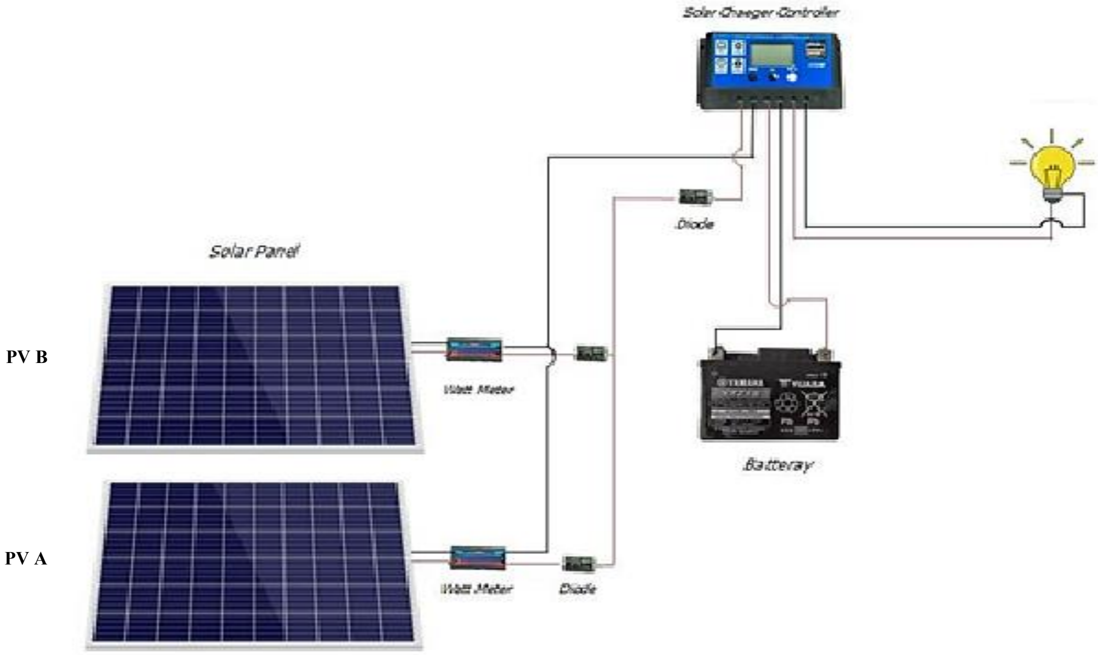


Figure 3. The experiment set up of the PV A and B panels in parallel.

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The advantage of polycrystalline PV is the ability to capture photon light even if the weather is rather cloudy or the sun's irradiance is rather low, so it can be more effectively used in positions that are not exposed to direct solar heat. This means that only the shadow of the sun's path will give the effect of converting electrical energy even though it is not as big as if under the sun.

Table 1a. Specifications A; PV panel 50 Wp dimensions 700x510x30 mm.

Parameter	Unit	Polycrystalline
Rated max power	Pmax	50 W
Curret at Pmax	Imp	2.85 A
Voltage at Pmax	Vmp	17.6 V
Open circuit voltage	Voc	22.5 V
Short- circuit current	Isc	3.04 A
Max system voltage	VDC	700 V
Dimension	Mm	700 × 510 × 30

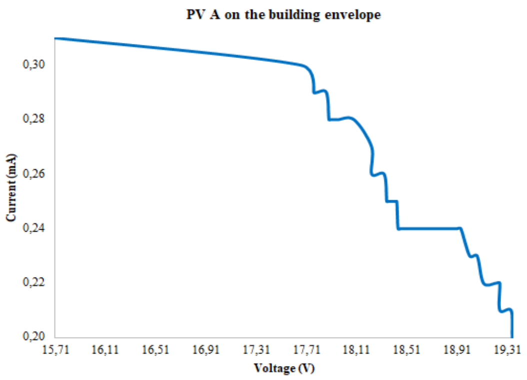
Table 1b. Specifications B; PV panel 50 Wp dimensions 770x540x30 mm.

Parameter	Unit	Polycrystalline
Rated max power	Pmax	50 W
Curret at Pmax	Imp	2.86 A
Voltage at Pmax	Vmp	17.6 V
Open circuit voltage	Voc	21 V
Short- circuit current	Isc	3.2 A
Max system voltage	VDC	1000 V
Dimension	Mm	770 × 540 × 30

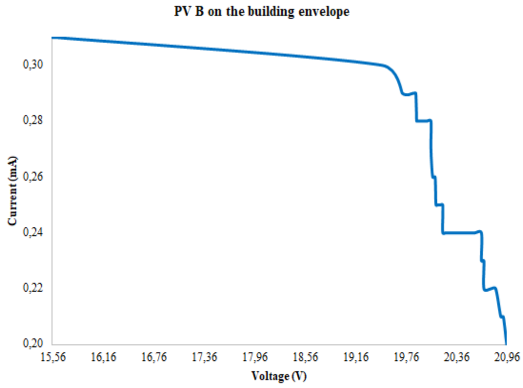
3. Results and Discussion

The test results show that the placement of solar panels in a place that is not exposed to direct sunlight (building envelope and window canopy) is able to harvest photon energy that generates electrical energy. Observations also prove that although the commercial power of PV is the same (50 Wp), but different I_{sc} and VDC and the dimensions will affect the PV performance. This can be seen in PV A in Figure 4 (c) which has a smaller output power than PV B in Figure 4 (d). This trend occurred during the observation hours before 12 noon.

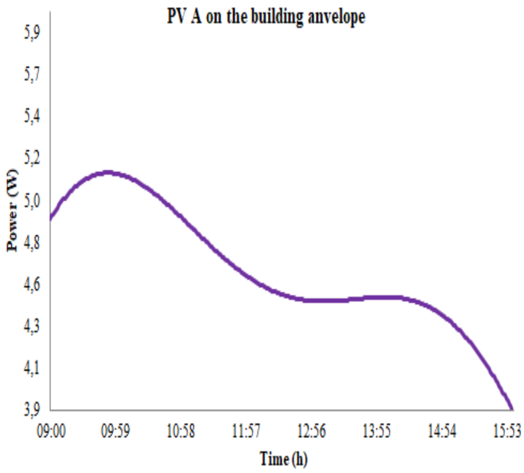
3.1. The performance of PV on the building envelope



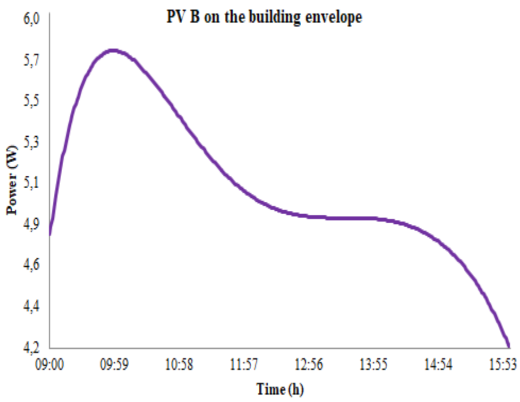
(a) I-V PV A on the building envelope



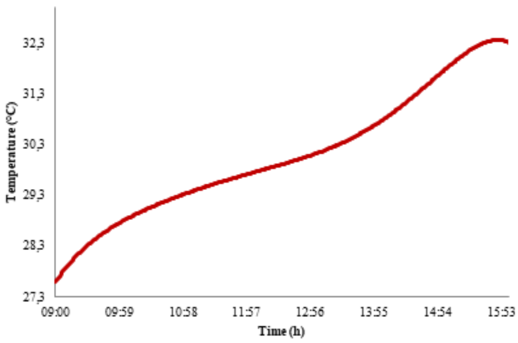
(b) I-V PV B on the building envelope



(c) Power of PV A on the building envelope



(d) Power of PV B on the building envelope



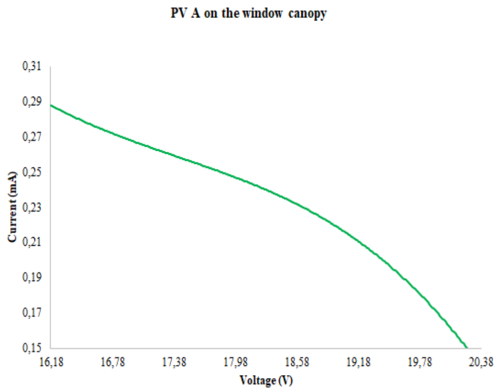
(e) Top surfaces PV temperature on the building envelope

Figure 4. The performance of PV on the building envelope.

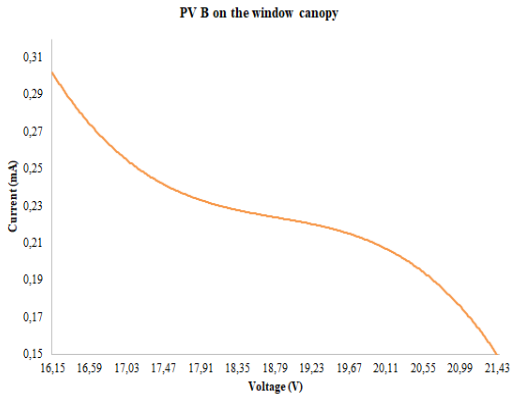
Figure 4 (e) shows the temperature of the top surface of the PV attached to the walls of the building whose maximum number is 32.3°C. This value is in the safe category to maintain solar panel efficiency below 50°C [9].

3.2. The performance of PV on the window canopy

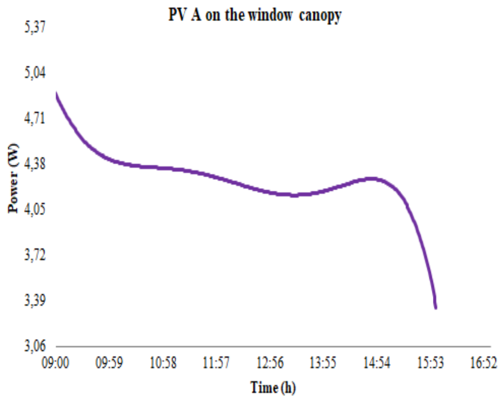
In contrast to the position of the PV on the building envelope, the current-voltage characteristics during the test showed an unstable trend in the window canopy. This is also seen in the output power of the panels on the window canopy which is slightly lower than that of the building, as shown in Figures 5 (c) and (d). This difference is probably due to a much greater increase in the top surface temperature of the panel in the window canopy, Figure 5(e). The increase in the surface temperature of the PV increases along with the sunset time, so that the panel position on the west side of the building tends to get more radiation.



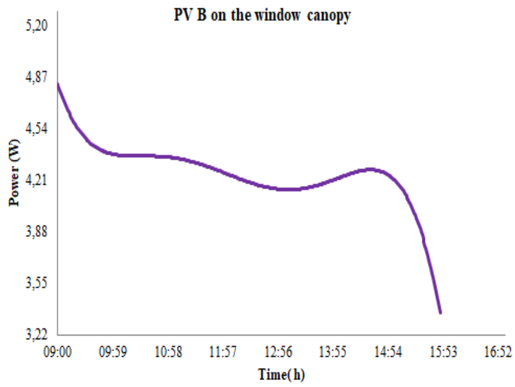
(a) I-V PV A on the window canopy



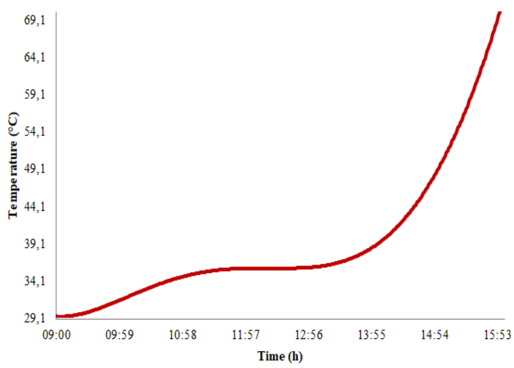
(b) I-V PV B on the window canopy



(c) Power of PV A on the window canopy



(d) Power of PV B on the window canopy



(e) Top surfaces PV temperature on the window canopy

Figure 5. The performance of PV on the window canopy.

4. Conclusions

The conclusions that can be drawn from this test are:

a. Polycrystalline PV panels are able to harvest photons in the shade that is not exposed to direct sunlight as long as it is not cloudy.
b. Placement of PV panels on building envelope provides a better conversion of photon light to electrical power than in window canopy.
c. The position of placing the PV panels in one direction of the sun's shadow, which is on the west side of the building gives better advantages to PV on the building envelope.
d. Even though the commercial power of PV is the same, the output power can be different according to other different parameters such as I_{sc} and VDC unit.

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