icast2021d

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Submission date: 19-Jun-2023 10:53PM (UTC+0700)
Submission ID: 2119127566
File name: Prosiding_ICAST2021d.pdf (531K)
Word count: 2041
Character count: 10130

Experimental Investigation of the Angle Inclination Variation Effects in Photovoltaic Array Prototype Modules

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Keywords: Photovoltaic, Angle Inclination, Power Output.

Abstract: In this paper, the performance of photovoltaic with three arrays is investigated experimentally. The angle of inclination 0°, 15°, 30° and 45° were tested in order to find the maximum power output. Determining the effect of the angle of inclination combined with the placement of the cardinal directions is observed as well. The test was carried out for seven and a half hours starting in the morning at 08.30 until in the evening at 16.00 of local time in good weather conditions. As a result, 15° of the angle inclinations provide the best value of power 43.4 watt in average and the influence of the angle of inclination and direction of the placement, it is obtained that the angle of 30 with the north direction gives the best power output of 55.1 watts.

1 INTRODUCTION

Indonesia, a country in the Asian region, to be precise in Southeast Asia, is known as a tropical country, of course, has a high level of sun exposure throughout the year. However, the use of its exposure is still not the main commodity that can be used optimally. Many other tropical countries are also facing the problems like this (Young,1989, Erdil,2008 and Mints, 2007). The PV system, which is part of new and renewable energy, has often been discussed, starting from the technical level of its implementation to its economic value and even to the institutional level (Soteris, 2003, Kwok, 2009, Martins, 2008 and Lu, 2015). Photovoltaic modules can produce electricity and heat simultaneously so that they are categorized as attractive technologies for use in buildings (Good, 2015, Pearce, 2009 and Ruther, 2008). The installation of the PV module is influenced by azimuth and shading, which are basically design parameters to get maximum results (Yoon, 2011 and Zondag, 2008).

Based on this, we try to do an experiment to take advantage of the natural resources we have. The purpose of this study is to find the effect of the angle of inclination 0°, 15°, 30° and 45° and the effect of the angle of inclination combined with the placement of the cardinal directions on the maximum output power of photovoltaic. As a result, the output power of photovoltaic 43.4 watt is produced on tilt angle of 15°. Concerning the combination between tilt angle and direction obtained the tilt angle 30° and North side providing best output power.

2 RESEARCH METHOD

2.1 Experimental Apparatus

The experimental apparatus used in this study shows in figure 1. It consists of three array polycrystalline type solar panels, solar charge controller, dry battery with a voltage of 12 V and a capacity of 100 Ah and inverter.

2.2 Experimental Method

In research, the angles of 0°, 15°, 30° and 45° and the cardinal directions of the north, south, east, and west

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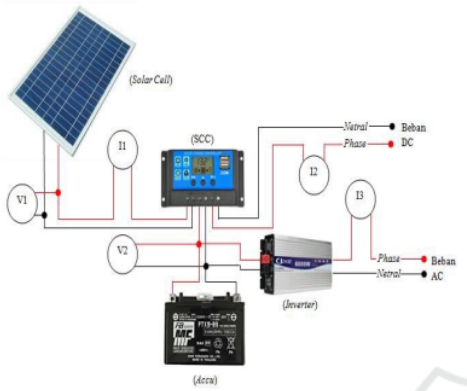
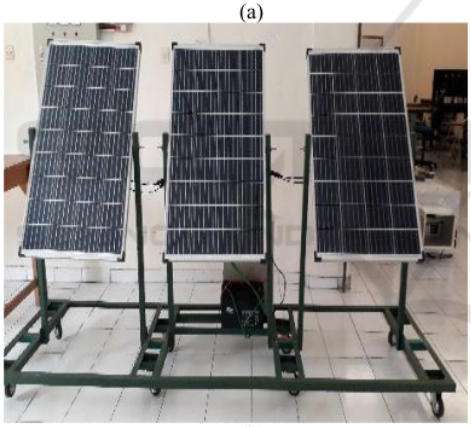
Wirajati, I., Ardita, I., Santosa, I. and Madrini, I.
Experimental Investigation of the Angle Inclination Variation Effects in Photovoltaic Array Prototype Modules.
DOI: 10.5220/0010962800003260
In *Proceedings of the 4th International Conference on Applied Science and Technology on Engineering Science (iCAST-ES 2021)*, pages 1231-1234
ISBN: 978-989-758-615-6; ISSN: 2975-8246

for the placement of the solar panel system in obtaining maximum output power of photovoltaic. This test is carried out using 1 polycrystalline type solar panel (poly-crystalline) with a capacity of 100 Wp.



(a)



(b)

Figure 1: Schematic & experimental apparatus: (a) design of experiment, (b) experiment apparatus.

The location and place for data collection in this research was carried out at the Bali State Polytechnic within March - August 2020.

Experimental data was carried out in 3 weeks, where the angle of inclination was changed each week. In the first week

The position of the solar panel module is in 0° position then continuing to other angle position.

The data obtained by conducting direct tests on the solar panel system, data can be retrieved after the system works normally, then it is done for five days, on the first day the angle is 0 ° for seven and a half hours. On the next day the angles in each panel are different, with the same duration of time. Recording data is taken during sunny weather.

Data collection was carried out by following the test procedure as follows:

1. Prepare testing and measuring tools that will be used for data collection such as: stopwatch, multi meter, ampere pliers, hygrometer, thermo couple, solar power meter, protractor.
2. Ensuring all equipment are work properly.
3. Placing the modul in a place that is exposed to direct sunlight.
4. Setting the module with the desired angle.
5. Taking measurements of voltage (V), current (I), temperature (T) and observed in every 30 minutes starting at 08.30 am to 16.00 pm local time
6. Then recording begins.

The above steps are repeated at each angle to be studied.

3 RESULTS AND DISCUSSION

3.1 The Effect of the Angle of Inclination on the Current Output

The effect of the angle of inclination on the direct current (DC) released by photovoltaic, starting from 08:30 am to 16:00 pm at local time, with a combination of 0°, 15°, 30° and 45° is be shown on figure 2.

The graph can explain that the trends of the current increase to the maximum limit and decreases in line with the increasing time. The maximum value of the current shown by all the PV tilt angle combinations is at 10:30 pm at local time. The maximum current value generated is at a tilt angle of 0° with a current of 5.7 A.

3.2 The Effect of the Angel of Inclination on the Voltage Output

Figure 3 informed the effect of the angle of inclination on the voltage released by photovoltaic, with a combination angle of inclination of 0°, 15°, 30° and 45° from 08:30 am to 16:00 pm at local time.

Based on the graph can explain that the trends of the voltage increase to the maximum limit and decreases gradually with the increasing time. The maximum value of the voltage reached 81.7 volt at 13.30 pm and given by 15°.

There is another trend that can be seen from figure 3 when modules in horizontal position (0°). It's

shown almost flat. Since repeated experiment held twice, the tendency is still the same. The closest opinion is the pseudo motion of sun around earth may cause this.

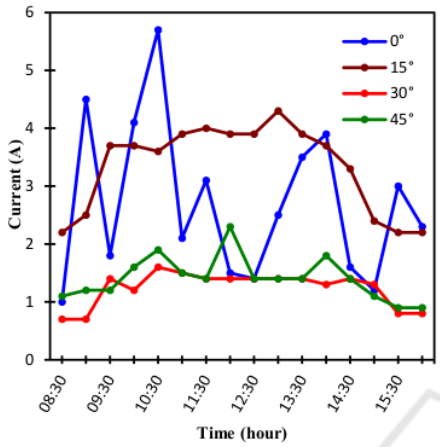


Figure 2: Current output in variation of angle inclination.

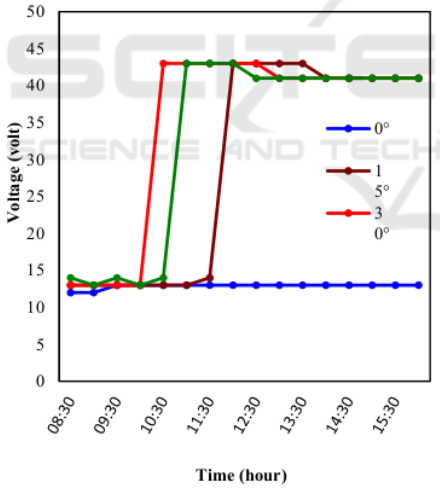


Figure 3: Voltage output in variation of angle inclination.

3.3 Power Value of Variation Angle Inclination

Figure 4 shows the power value of each position from module. Four angles inclination are selected from 0° to 45° to determine the characteristics of the position they are placed in.

From the graph it can be concluded that the slope angle of 15° gives the greatest value, which means that this position is the best for module to be applied to give maximum results.

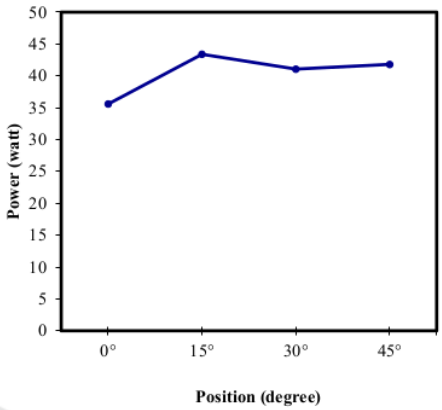


Figure 4: Power value of variation angle inclination.

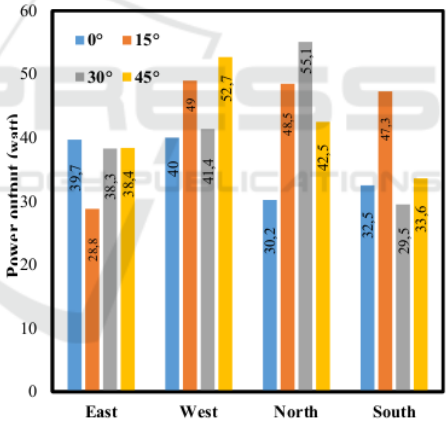


Figure 5: The effect of the angle of inclination and direction of placement on the module power output.

3.4 Comparison of Output Power

The graph above shows the amount of power generated from the combination of the tilt angle and the direction of the module placement. Data collection starts at 08.30 until 16.00 WIB, which is carried out from June to mid-August 2020. From the graph, it can be seen that the angle of 30 with the north direction gives the best power output of 55.1 watts. This can be caused by the apparent movement

of the sun, which usually occurs in July and August, where the sun tends to rise from the north.

4 CONCLUSIONS

From this research it can be concluded that by positioning the tilt angle on the PV panel gives a significant effect where angle 15° is the position that gives the maximum value. In the future, the effect of the angle of inclination will be combined with the placement of the cardinal directions in order to determine the effect. From observing the influence of the angle of inclination and direction of the placement, it is obtained that the angle of 30 with the north direction gives the best power output of 55.1 watts.

ACKNOWLEDGEMENTS

This research was supported by the *Direktorat Riset dan Pengabdian kepada Masyarakat* (DRPM) - Ministry of Research and Technology-BRIN, Indonesian Government, No. SPKK : 133/SP2H/AMD/LT/DRPM/2020 and (SP DIPA-042.06.1.401516/2020) for the in cash contribution. The authors wish to acknowledge the contributions of Mechanical Engineering Department -Bali State Polytechnic for the in-kind contributions. Also Center for Research and Community Service (P3M) for all administrative support.

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