Designs of Automatic Solar Panel Cleaner Prototype Controlled by The Arduino

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ABSTRACT

This paper has designed a prototype of an automatic solar panel cleaner with Arduino to increase the efficiency of the Photovoltaic system. The structure of a prototype solar panel cleaner is designed and constructed using aluminum profiles size 70 x 30 cm. The solar panel cleaner is controlled by Arduino, a microcontroller board designed to be easy to use. The solar panel cleaner has been tested to clean 80-watt Mono-Crystalline solar panels for 6 months. The results showed that when the solar panel washing machine is set to work at the initial temperature of 42 degrees Celsius, We found that the output power of the panels that install the automatic solar panel washers has a higher power value than not installed and the efficiency of the panels that install the automatic solar panel cleaners with the values of 0.679%. The total average power output (kW) is 4.603 kWh.

Keywords: *Solar Panel Cleaner, Module Temperature, Arduino*

.1 Introduction

Renewable energy is obtained from natural sources. These resources can be used to produce energy, again and again, e.g. solar energy, wind energy, tidal energy, etc. Non-renewable resources cannot be replaced once they are used, such as coal, oil, gas, etc. these energy resources are limited and would be exhausted within a prescribed period of time. [1]

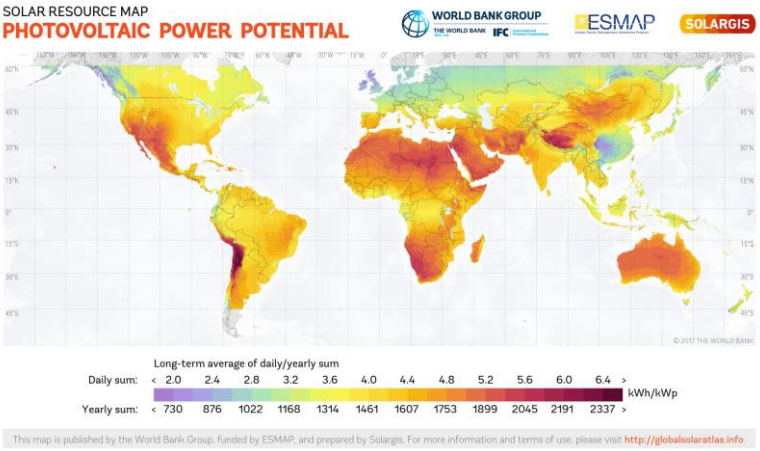

Figure 1 The Global photovoltaic power potential [2]

Solar energy is the largest natural energy source. There are many around the world. It is also an energy that is never consumed. It is clean and pollution free energy is everywhere. Solar energy is another important energy that humans use as an alternative energy [3]. At the same time, utilization may still be limited, as sunlight is only during the daytime and the solar irradiation is unpredictable because it depends on the weather and the changing seasons [4-5]. Therefore, when using solar energy, consideration must be given to the efficiency that the PV system can produce the most energy. The amount of power harvesting depend on solar irradiance and module temperature. Figure 1 shows The Global photovoltaic power potential.

The efficiency of a solar panel means the power output that can be measured per unit, cross-sectional area. The efficiency of a solar panel means that one area of measurement that has more power, it will be more efficient and more worth the investment. The efficiency of a solar panel will have many variables, including solar cell type, panel structure, panel material, mounting and installation, temperature, dust, and shadow covering]6-8[. Figure 2 shows the Sankey diagram on the energy output of a photovoltaic system [9]. The Efficiency loss of solar modules due to panel temperature is shown in figure 3.

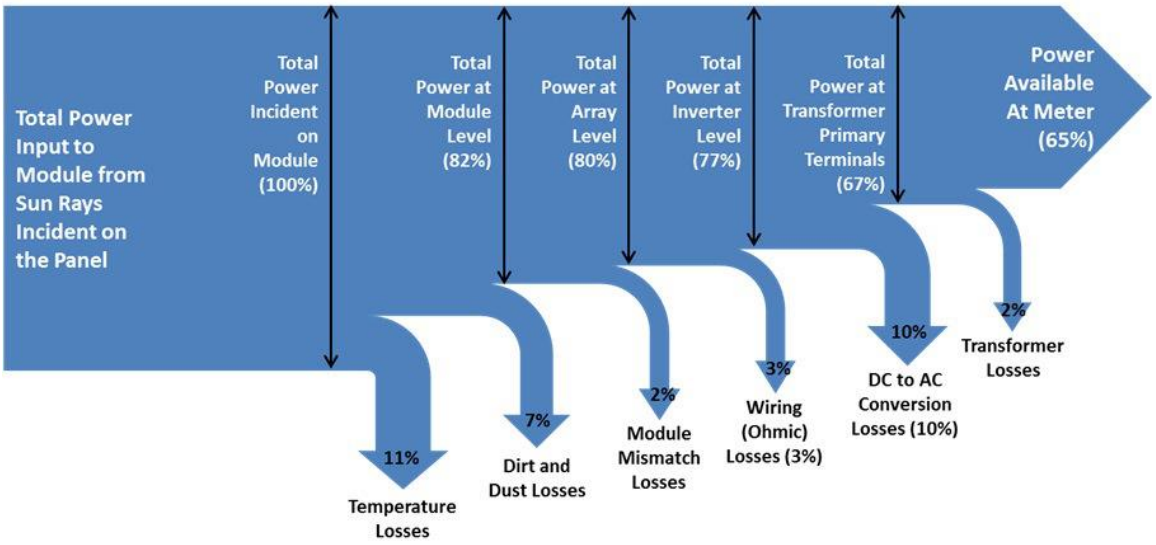

Figure 2 The Sankey diagram on the energy output of a photovoltaic system [9].

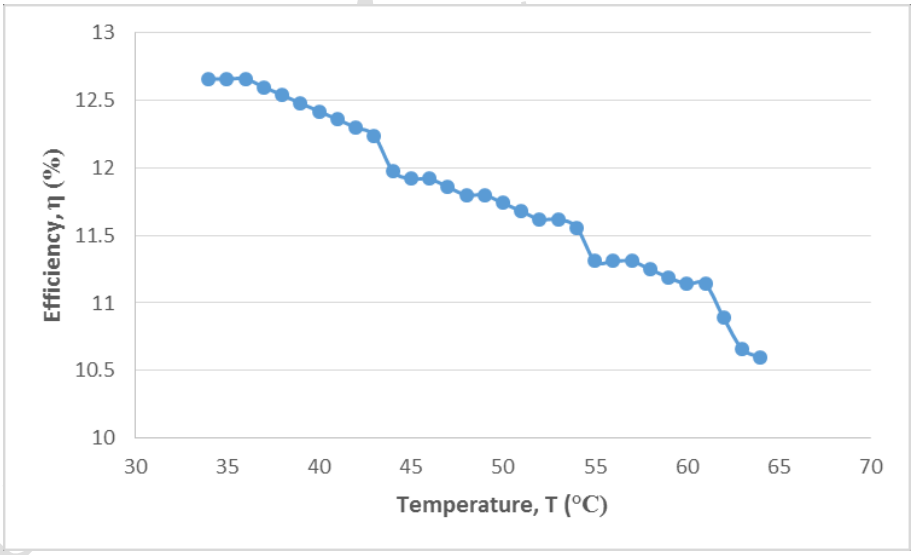

Figure 3 The Efficiency loss of solar modules due to panel temperature [10].

Therefore, this research has studied and constructed automatic solar panel cleaner. To test the use of solar panel cleaners and reduce the temperature of the solar panels, which increases the efficiency of the solar cell system. It also helps to reduce the cost of hiring workers to clean the solar panels of solar power operators as well.

.2 Methodology and Design Analysis

2.1 Structural design

Figure 4 shows the 80 Watt Monocrystalline silicon solar panel. Design the structure of the solar panel washers. The structure of the solar panel shown as figure 5.

Figure 4 The 80 W of Monocrystalline Silicon Solar Cells

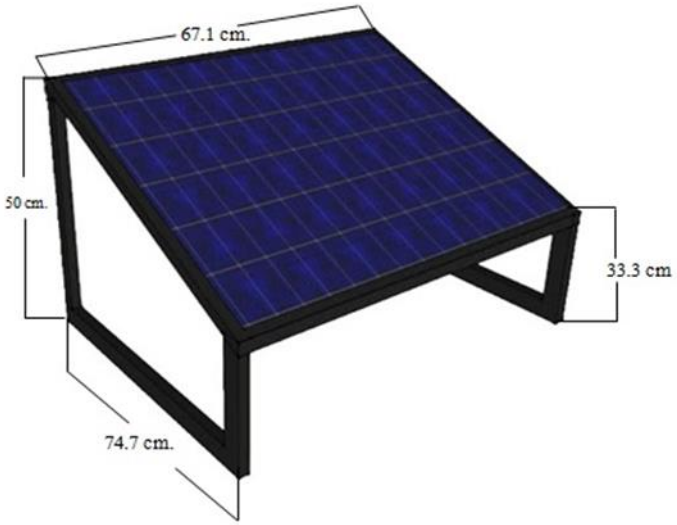

Figure 5 Structural of 80 W of Monocrystalline Silicon Solar Cells

The solar panel washers are constructed. Figure 6 shows the prototype automatic solar panel cleaner.

Figure 6 Prototype automatic solar panel cleaner

Controller

Nowadays, microcontrollers are being used more widely, with embedded microcontrollers in many types of electrical appliances such as automatic washing machines, electric ovens, microwaves, air conditioners with temperature control and much more. Arduino is a microcontroller platform that is very popular because it is an open platform, both hardware and software. It is easy to use, uncomplicated and has low cost to build circuits. Therefore, this research uses Arduino to control automatic panel washers [11,12]. Arduino board as shows in figure 7.

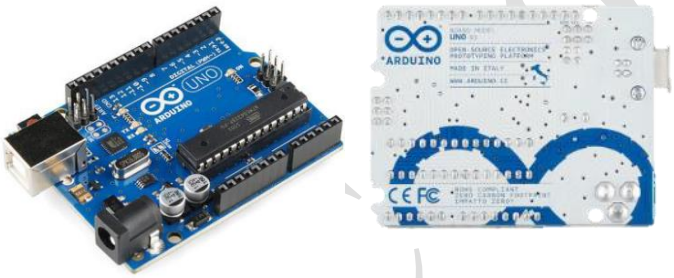

Figure 7 Arduino board. [13]

2.2 Solar panel installation and test results collection

In the testing of automatic solar panel cleaner controlled by Arduino. The first step is to find the temperature that causes the output power to decrease. By installing the solar panel at the angle of 13 degrees according to the location in Bangkok to get the highest solar energy [14]. As of 1 December 2018, the output power of the cell panel changes with the increasing temperature of the cell panel as shown in the figure 8.

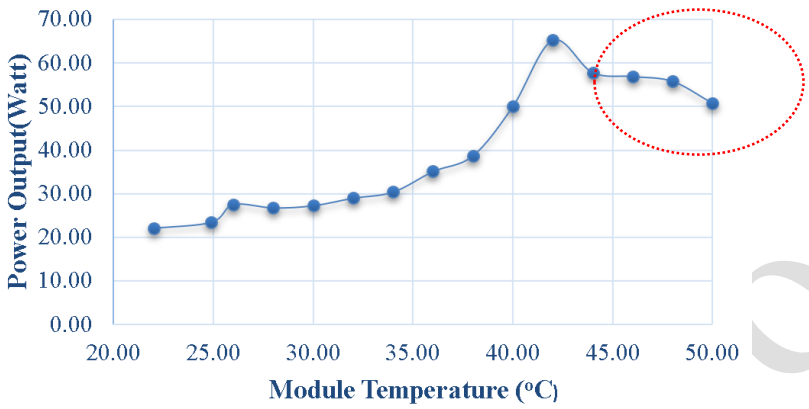

Figure 8 The output power of the solar panel.

From Figure 8, it can be observed that the electrical power value will decrease when the temperature is higher than 42 °C. Step 2: set the temperature for the panel washers to operate at a temperature of 42 °C and record the test results of the electrical power increase for 6 months from December 2018-May 2019.

.23 Solar Cell Efficiency

In order to observe the behavior of the solar module based on the increased of its module temperature, the generated voltage and current of the solar module will be measured respectively with its temperature.

The efficiency of a solar cell is determined as the fraction of incident power which is converted to electricity and is defined as:

$$P_{max} = V_{oc} * I_{sc}FF = V_{max} * I_{max} \quad (1)$$

The efficiency of the solar panel will be calculated using equation (2)

$$\eta = \frac{V_{oc} * I_{sc} * FF}{P_{in}} = \frac{P_{max}}{E * A_c} \quad (2)$$

The input power for efficiency calculations is 1 kW/m^2 or 100 mW/cm^2. Thus, the input power for a 156 × 156 mm^2 cell is 24.3 W.

There is another important parameter that is used to determine solar cell performance. It is referred to as Fill Factor. The equation or formula of solar cell fill factor is as follows:

$$FF = \frac{P_{max}}{V_{oc} * I_{oc}} = \frac{\eta * A_c * E}{V_{oc} * I_{oc}} \quad (3)$$

Where: V_{oc} is the open-circuit voltage

I_{sc} is the short-circuit current

FF is the fill factor

η is the efficiency (%)

P_{max} is maximum output power

P_{in} is input power

E is incident radiation flux

A_c is the area of a collector (m^2)

Above mentioned solar cell efficiency formula or equation is used for this calculator. As mentioned University, solar cell efficiency is the ratio of electrical output power (in Watt) to the incident energy which is in the form of sunlight. Incident energy is known as irradiance or radiation flux (in Watt/m^2). The surface area of the solar cell on which light falls is known as the collector area. [14]

The global formula to estimate the electricity generated in output of a photovoltaic system is:

$$E = A * r * H * PR \quad (4)$$

Where: E = Energy (kWh)

A = Total solar panel Area (m^2)

r = solar panel yield or efficiency (%)

H = Annual average solar radiation on tilted panels

PR = Performance ratio, coefficient for losses

r is the yield of the solar panel given by the ratio: electrical power (in kWp) of one solar panel divided by the area of one panel [15].

3. Results and Discussion

When installing the solar panel cleaner that operating at an initial temperature of 42 °C, then the test results are daily recorded. By choosing a sunny day, 10 Dec 2018, to record the results as an example. The results of the experiment were recorded from 06.00 am -18.00 pm, the change of electric power compared with the solar panel which is not equipped with the cleaner, as shown in figure 9. Figure 10 shows the calculation of the changing efficiency of solar panels when installing automatic panel cleaner. After that, the experimental results are collected for power output and energy values for 6 months as shown in Table 1.

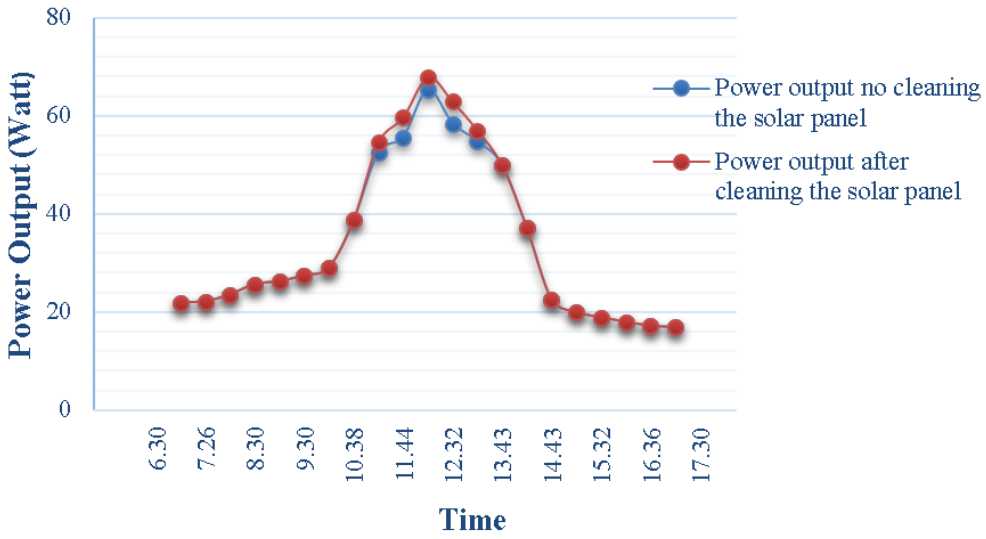

Figure 9 The PV power output

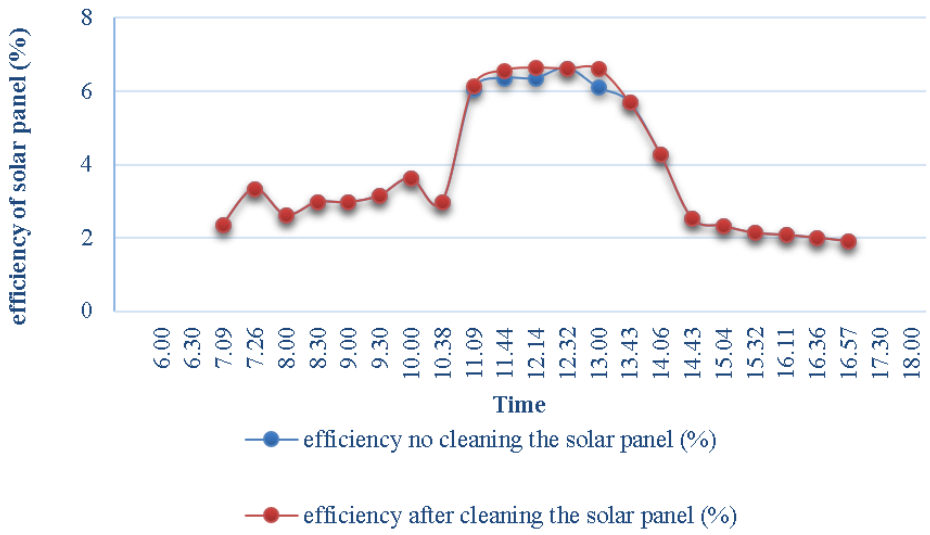

Figure 10 The efficiency of solar panels

Table 1 The Comparisons of PV power output

Month	Average Power Output (kW)	
	No cleaning the solar panel	after cleaning the solar panel
December	8.190	8.878
January	8.820	9.114
February	9.240	10.080
March	11.592	12.327
April	12.572	13.310
May	11.358	12.665
Total	61.772	66.374

From Table 1, it can be seen that when we install the automatic panel cleaners, the results show that the electrical power of the panels that install the automatic panel cleaners has higher power and electrical energy value than the panels that are not installed.

4. Conclusions

From designing and constructing automatic solar panel washers with Arduino, testing with solar panel type 80 W Mono-Crystalline. By using the case study area in Bangkok and collected test results for 6 months from December-November. We found that the output power of the panels that install the automatic solar panel washers has a higher power value than not installed and the efficiency of the panels that install the automatic solar panel cleaners with the values of 0.679%. The total average power output (kW) is 4.603 kWh. It can be seen that the electrical energy does not increase much because the electrical power produced by the solar cell does not only depend on the temperature but also depends on the intensity of sunlight in each period.

Acknowledgement

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References

[1] Saurabh Kumar Rajput.)2017(. **SOLAR ENERGY Fundamentals, Economic and Energy Analysis**. First Edition. Northern India: NITRA**.**

[2] The Global photovoltaic power potential., Available online: https://globalsolaratlas.info/. (accessed on 20 October 2019).

[3] Backus, C.E. (1976). **Solar Cell**. The Institute of Electrical and Electronics Engineer, Inc., New York.

[4] Garcia, M.C.A. and J.L. Balenzategui.(2004). "Estimation of photovoltaic module yearly temperature and performance based on nominal operation cell temperature calculations." **Renewable Energy**, 29: 1997-2010.

[5] Promphak Dawan ,Songkiate Kittisontirak, Kobsak Sriprapha, Rangson Muanglua, Wisut Titiroongruang and Surasak Niemcharoen.(2018). **"**Comparison of Performance of 1D5P with 2 input and 1 input Model in Forecasting of Power Output for Photovoltaic Systems". **IEECON 2018**, Krabi, Thailand: Page:261-263.

[6] **Solar panel efficiency**., Available online: https://solarsmileknowledge.com/solar-cell. (accessed on 22 October 2019).

[7] **Loss in the system**). Available online: https://solarsmileknowledge.com/system. (accessed on 15 October 2019).

[8] Promphak Dawan**,** kamonwan Buewichien,pornpimol Tiampan,Kaweepoj Worranetsuttikol and Terapong Boonraksa .(2019) **"**Comparison the Power output of 80 W Monocrystalline Silicon Solar Cell installed on land and installed on the Floating photovoltaic". **15th Conference on Energy Network of Thailand**. 21-23/May/2019.Greenery resort Kho Yai Nakhon Ratchasima Thailand: Pages157-161.

[9] **The sankey-diagrams of Solar panel efficiency**., Available online: http://www.sankey-diagrams.com/tag/solar/. (accessed on 25 October 2019).

[10] Li Wah Thong ,Sharmeeni Murugan, Poh Kiat Ng and Cha Chee Sun.(2016).“Analysis of Photovoltaic Panel Temperature Effects on its Efficiency” **2nd International Conference on Electrical Engineering and Electronics Communication System**. 18-19/November/ 2016.Ho Chi Minh, Vietnam.

[11] Prajin Palangsantikul. (2010). **C Programming for Arduino**. Edition no 1. Bangkok : Appsofttech.

[12] Prapas Suwannapet .(2017) **Learn and try out the basic Arduino**. Edition no 1. Chaiyaphum :Prapas Suwannapet.

[13] Weerapong Sangsawang at all.(2018). **DESIGN OF AUTOMATIC SOLAR PANEL CLEANING PROTOTYPE CONTROLLED BY THE ARDUINO**. BACHELOR OF ENGINEERING (ELECTRICAL ENGINEERING). Faculty of engineering .BangkokThonburi University.

[14] Kanjanasid Wetchakan(2017). **Performance Analysis of 50 kWp Floating PV System**. Master of Engineering in Electrical Engineering. Faculty of Engineering. Rajamangala University of Technology Thanyaburi.

[15] **The calculate solar energy and power of pv systems** .,Available online: https://photovoltaic-software.com/principle-ressources/how-calculate-solar-energy-power-pv-systems. (accessed on 19 October 2019).

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