Progress in Engineering Application and Technology Vol. 3 No. 1 (2022) 147-155
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PEAT

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/peat
e-ISSN : 2773-5303

Development of pH Meter with Solar Panel as Battery Replacement of Lithium Button Cell

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DOI: https://doi.org/10.30880/peat.2022.03.01.017
Received 17 January 2022; Accepted 11 April 2022; Available online 25 June 2022

Abstract: It has been highly crucial for the cost of solar energy devices due to the limiting quantity of renewable energy supplies. Solar energy has a considerable advantage over other traditional power generators in that even the tiniest photovoltaic (PV) solar cells can convert sunlight instantly into solar energy. The manufacture of lithium-ion batteries has resulted in greenhouse gas emissions, which negatively influence the environment. Compared to solar panels, which store solar energy to recharge the power, the use of lithium batteries on pH meter devices can create pollution in terms of disposal. This project aims to establish a digital pH meter device with a solar panel and conduct a test to determine the device's effectiveness. Comparison between a solar panel and lithium battery are in the category of durability, which is that lithium battery needs to be replaced once the energy depleted. The device was tested for different weeks and days, but data taken is for a day in 2 hours, 30 minutes and 10 minutes. The output, Watt-hr, varies according to the operational hours applied on the solar panel. The efficiency of the solar panel depends on the area of the solar panel and the maximum power output of the solar panel. The recommendation for this device is to attach a DC voltage booster. Have the battery be connected with a solar panel to execute the pH meter's long run life cycle as the solar panel will act as a storage energy system and transmit the light into electrical energy.

Keywords: Solar panel, lithium-ion batteries,

1. Introduction

Renewable energy (RE) is a problem that professionals and the public are becoming highly concerned about. Renewable energy sources (RES) research has increased in these recent years. RES can play a critical role in addressing fossil fuel limitations and global warming worries. Fossil fuels, nuclear energy, and renewable energy sources such as sun, wind, biomass, geothermal, and hydropower are the three primary energy sources. These resources are used to recreate the energy and are thus generally applicable in tackling energy challenges. The public's opinion toward renewable energy and willingness to spend for it was examined in a recent study of villages in Western Greece. Sustainable

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energy alternatives are renewable energy resources, and their environmental friendliness makes them essential [1]. Sustainable energy sources have minimal adverse effects on the environment, global warming, and air quality.

Furthermore, renewable energy is sourced from infinite resources, and it is a long-term investment. Solar photovoltaic (PV) energy generation contributes significantly to renewable energy generation. During the energy generation phase, PV module-based power generation produces no pollution, noise, or vibration, making it an environmentally friendly way of manufacturing. PV systems have no waste while generating electricity, resulting in zero greenhouse gases (GHG) emissions, and they can reduce pollutants such as GHG in general by utilizing solar energy. Solar energy is one of the ways to meet global energy demands while also reducing carbon emissions [2].

The three major external stress elements affecting deterioration are temperature, state of charge (SoC), and capacity. In general, the temperature is the most critical stress factor, with deviations from the usual 25.00 °C leading to quick failure. Solar irradiation and module temperature have an impact on PV module output. According to Dunlop and Halton, shade, rain, and dust, all have an effect. The majority of these adjustments are transitory or modifiable on some dates. Degradation is the loss of output due to physical deterioration or damage to the PV cell, and the effects are permanent. It refers to the impact of this process that will eventually demand the replacement of a PV cell to return to its initial operation condition. Degradation is measured by mean efficiency or performance ratio changes over time [3].

A pH meter is an electrical instrument that measures the pH of aqueous solutions or the number of hydrogen ions in them. A pH meter is a gadget that determines how acidic or basic a solution is. On a scale of 0 to 14, the level of acidity and alkalinity is measured. A solution with pH value below seven is classified as acidic, whereas one with a pH more than seven is classified as basic. The hydroxyl ion concentration (OH^-) and hydrogen ion concentration (H^+) are both represented on the scale.

Instead of employing a lithium-ion cell, a solar panel with a photovoltaic system (PV) is used to design a pH meter for this project. The PV systems convert solar into electrical energy and store it in a battery, allowing power to be used in various situations. Because solar photovoltaic systems are largely environmentally beneficial and do not cause pollution, they can help prevent issues like pollution, global warming, and ozone layer degradation (Manimekalai et al., 2013). Solar batteries also have advantages in that the energy is easy to recognize and can be delivered in large quantities [4].

Solar cells are the components needed to capture solar energy. In a series of solar panels, a portable battery charger was required. According to Fitria [4] research on portable battery chargers, certain mobile phone manufacturers employ portable chargers. Another researcher explained how portable chargers attached to a jacket are manufactured. According to the findings, an additional innovation in the adaptation of solar panels to a moveable battery charger with direct charge technique or kept in the battery initially is needed [5]. The voltage stabilizer and current amplifier are two elements that help sustain the energy from the solar panel conserved and flowing to the product [5].

2. Materials and Methods

2.1 Materials

2.1.1Mini solar panel

In the solar panel business, a photovoltaic module is a structure made up of photovoltaic cells. The solar panel captures and converts sunlight energy into direct voltage. A solar panel collects photovoltaic cells that convert sunlight into electricity. First, they capture sunlight as a source of energy for their Photovoltaic Cells, which produce electricity in the same way as traditional solar panels do. The accumulated energy is then transferred to the semiconductor, which develops an electromagnetic current and results in watts of voltage and current (W). The specification of the solar panel is the dimensions, area, maximum current, and voltage output. The dimensions are 0.068 m in length and 0.037 m width, and the area is 0.00252 m^2. The maximum current and voltage output are 0.06 A and 5 V; respectively while the power is 0.3 W. This solar panel can be used on smaller products such as light up an LED.

Figure 1: Mini solar panel

2.1.2 Digital pH meter

A digital pH meter is an electronic instrument that measures and records the pH of substances or liquids with precision. In a liquid state, measuring pH allows you to evaluate and determine acidity and alkalinity. The device's dimensions are 153 mm in length, 29 mm in width, and 16 mm in thickness or breadth. Temperatures suitable for use range from 0.00 °C to 60.00 °C, and to avoid disturbance in pH calibration process, the temperature was checked for the device to be functioned.

Figure 2: Digital pH meter

2.1.2 Solution for calibration of portable pH meter

Two buffer solutions are used to calibrate the electrodes on a pH meter. When an electrode is exposed for an extended period or is used frequently, it is necessary to calibrate it. The solution was made up of 250 mL distilled water and buffer solution 6.86. The pH meter was submerged in the beaker and the button was switched on. Button CALC was held for 5 seconds after the digit had been fixed. Before the calibration step was done, the screen displayed the value of 6.86 and had to wait until the value stopped and 'end' flashed on the screen.

Figure 3: Buffer solution

2.1.2 Lithium cell battery

The output voltage of the lithium battery utilized by the pH meter is 1.5 V. The battery has a diameter of 0.01143 m, which is 0.45 inch, and a depth of 0.0052 m, 0.203 inch. The battery can resist a maximum temperature of 60.00 °C and has a capacity of 150 mAh. The LR44 lithium battery indicates the battery size, and the battery's shape indicates that it is a coin cell battery.

Figure 4: Lithium cell battery

2.1.4 Solder

Soldering is the process of melting solder around a connection between two or more electronic components. When solder cools, it forms a strong electrical connection between the elements [6]. A soldering iron is a portable device that connects to a 120 V electrical outlet and heats up to melt lead. Output temperature from welder soldering is from 200.00 to 450.00 °C and the output power produced is approximately for 60 W. The soldering input voltage is at 140 V to 220 V. The ways to solder started with the electronic components need to be soldered were cleaned, a little solder wire then applied on the heated iron tip to avoid oxidation during the process. The iron tip was rubbed onto the surface on the components required to be soldered.

Figure 5: Solder apparatus

2.2 Methods

Figure 5 shows the steps in developing and testing the effectiveness of solar panel attached on pH meter.

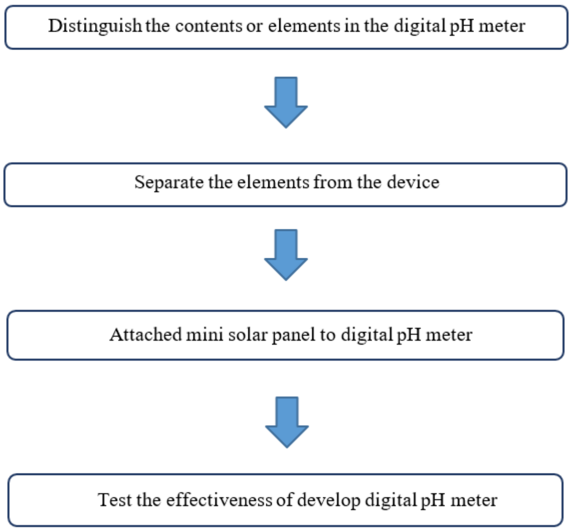

Figure 5: Flowchart of steps

2.2.1 Distinguish the elements related to digital pH meter

In this project, the components required were listed in the materials section, such as the solar panel, the electrode to determine the functionality of the pH meter, buffer solution and soldering materials.

2.1.2 Separate the elements from the device

Elements that been included is lithium battery, which connected on top of the pH meter

2.2.3 Attached mini solar panel to the digital pH meter

The wire linked to the solar panel has negative and positive poles inscribed on the back. According to the pole arrangement, the wires are connected to the motherboard of the digital pH meter. The pH meter will be tested in a beaker of water after the attachment procedure is completed.

2.2.4 Test the function of the developed digital pH meter

To test the functionality of the digital pH meter, a beaker or bowl of distilled water is prepared, the set of digital pH meter includes a solution to cleanse the electrode. The electrode must be rinsed with distilled water and wiped with filter paper. The pH meter electrode was submerged in the fluid to be tested after pushing the ON button. Gradually mix the liquid, remove the device from the solution, and wait 30 seconds for the pH meter reading to stabilize. Finish the test by cleaning the electrode with water, wiping it with filter paper, and turning it off using the OFF button.

3. Results and Discussion

In this section, the discussion is about the efficiency and durability of the solar panel. The solar irradiance at Pagoh, Johor were discussed in the form of a graph.

3.1 Efficiency

Equation 1 shows the formula of efficiency for the solar panel. According to the formula, the data for maximum power output, which is 0.3 W and area of panel that is 0.00252 m^2, the efficiency of solar panel is 11.90 %.

$$P_{max} = V_{oc} I_{sc} FF$$

$$\text{Efficiency} = \frac{\text{Pmax}}{(\text{Area x}\frac{1000\text{W}}{m2})} \text{ x } 100\% \qquad Eq. 1$$

3.2 Estimated load requirements for pH meter

Since the power of the solar panel is the same, Table 1 indicates the predicted power consumption by the pH meter based on times applied and operation hours. The power output for two hours of operation per day was around 0.6 Wh, whereas the power output for half an hour was 0.15 Wh. The pH meter with solar panel was also tested for around 10 minutes, or 0.167 of the 0.05 Wh operation hours. The data in the table was tested on various days over the course of one day.

Table 1: Estimated power required pH meter

Appliances	Times applied (day)	Operation hours	Watts – hour (Wh)
	1	2	0.6
pH meter	1	0.5	0.15
	1	0.167	0.05

3.3 Solar energy received and temperature at Pagoh, Johor

In the year 2020, Figure 6 depicts a graph of monthly solar energy received along with temperature. CLRSKY SFC SW DWN refers for Clear Sky Surface Shortwave Downward Irradiance and TS is for earth skin temperature in degrees Celsius. TS has an annual value of 28.39 °C, while radiance has a value of 6.64 kWh/m^2/day. The greatest earth skin temperature is 29.39 °C in April and May, and the lowest is 27.64 °C in January. From January 1, 2020, to December 31, 2020, data was collected in NASA's database.

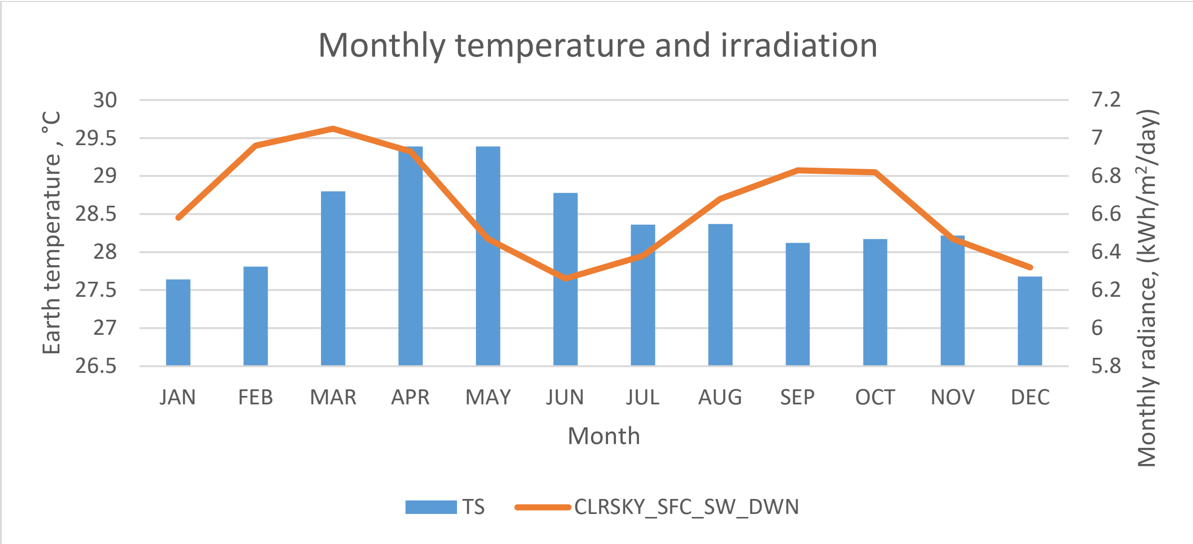

Figure 6: Graph of monthly temperature and irradiation

Figure 7 shows the graph of temperature against month in 2020. The graph shows that January and December have the same temperature, which is 30.00 °C. Starting in March until June, the temperature increased to 32.00 °C while declining in July with 31.00 °C. From August to October, the temperature is constant at 32.00 °C while in November, the temperature drops to 31.00 °C and continue to drop to 30.00 °C in December.

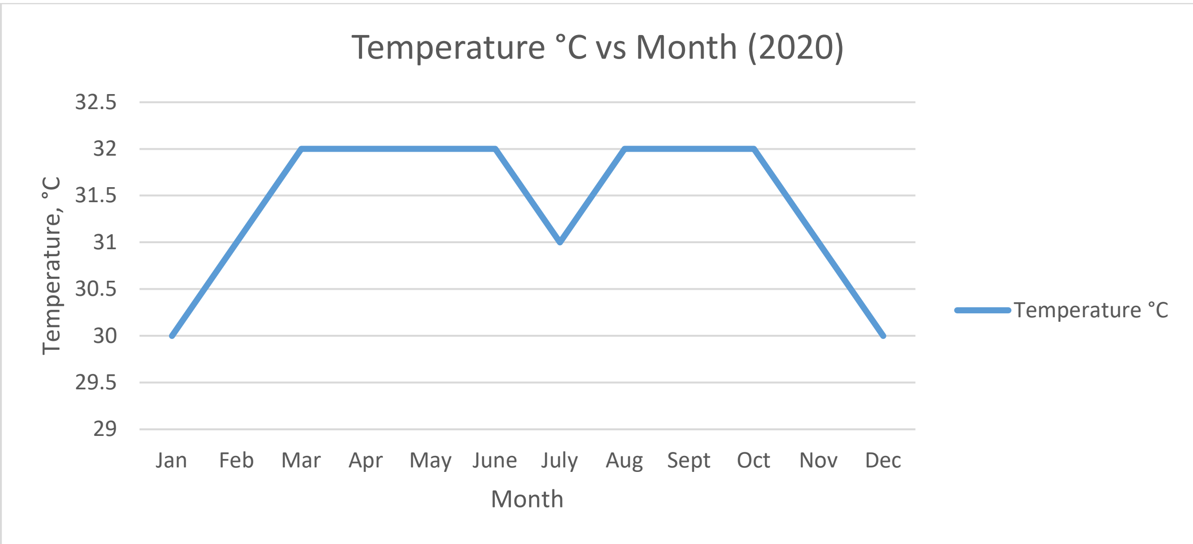

Figure 7: Graph of temperature against month in Pagoh, Johor

3.4 Economic feasibility of solar panel

The formula for calculating the levelized cost of energy for solar panels is shown in Equation 2. The cost of a solar panel in this project is RM 9.44, which was factored into Equation 2. With a 20-year deterioration period, the levelized cost of electricity for solar panels is RM 1.573 per Watt-hour.

$$LCE = \frac{\sum_{k=1}^{n} \frac{I_c + M_c + F_c}{(1+d)^c}}{\sum_{k=1}^{n} \frac{E_a}{(1+d)^c}} \qquad Eq.\ 2$$

Table 2: Parameters in the study

Parameters	Unit	Value
Max Current Output	A	0.06
Max Voltage Output	V	5
Power	W	0.3
Area of solar panel	m^2	0.00252
Efficiency	%	11.9
Cost of solar panel	RM	9.44
Life of solar panel	years	20

The parameters utilized in this study are listed in Table 2. The area of a solar panel is 0.00252 m^2 according to the specifications determined using the area formula. The maximum current and voltage outputs are 0.06 A and 5 V, respectively. The efficiency of solar panels has been determined and is 11.9 percent, while the life of solar panels is 20 years, according to prior research. For one solar panel, the cost was RM 9.44.

3.5 Discussions

The pH meter that is attached to the solar panel, on the other hand, must be used outside or in an area that is accessible to sunlight because it immediately captures the rays and converts them into electrical energy. This is one of the solar panel's limitations, as a pH meter with lithium can be used even in a closed space.

It will be tough to build a perfect overall performance of the develop pH meter in this project, but a fully functional prototype must be available. This development needed a lot of work and had a lot of parameters that had to be met in order for it to function properly. Consider the energy required to make solar panels function as energy sources. Solar panel longevity is also important to consider as it determines the operational duration of solar panel. Solar panel can be used as an energy source for the pH meter as long as there is sunlight, but if it is in a closed space or in the shadow, the pH meter cannot be used because it is connected directly to the pH meter and cannot recharge.

Regarding the restriction of the pH meter with solar panel that is dependent on sunshine, it is suggested that the solar panel be attached to the pH meter's lithium battery to assist in its recharge. It is because working with a pH meter in a dark or difficult-to-reach position is challenging. When the battery's capacity is depleted, a new lithium-cell coin battery is required, and the solar panel will serve as a charger to recharge the battery. Because the solar panel and pH meter are not suitable in size, the pH meter must be modified to include a gap for the solar panel to be within the range of the sunlight.

4. Conclusion

The conclusion for this project concludes the purpose of this project and the relation of the lithium cell battery and the solar panel with environmental aspects whether it bring benefits or more drawbacks towards the environment. It is certified that solar panel is environmentally friendly according to the research and the widespread used in industry and as an assist from the diminished natural sources issues. The development of digital pH meter probably can bring benefits to the environment by having using of natural sources such as sunlight as energy and have a long degradation period that makes solar panels have a long lifecycle. The efficiency of solar panel is influenced by the natural factors such as temperature and solar irradiation received on a location. The area of solar panel is also included in the factors that affect the efficiency of solar panel.

Acknowledgement

The authors would like to thank the Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia for its support.

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