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Detection and Evaluation of Solar Panel Energy Through Light Intensity Level

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Abstract: Solar energy can only be produced in the presence of the sun. The only source of power at night is what was generated during the day and stored in batteries. The light intensity of the available solar irradiation is also impacted by environmental problems like weather changes and orientation. Therefore, the goal of this study is to assess the energy of solar panels by measuring the amount of available light intensity. To improve the efficiency of solar panels, the amount of light generated in three different orientations is evaluated to determine which ones take in the most sunlight. The developed device is equipped with LDRs, LEDs and a temperature sensor. Each direction has its own LCD set up to record and display data on voltage, current, temperature, and energy produced. The findings indicate that a voltage divider could be used to calculate current and voltage and that LEDs light up when the system reaches a predetermined threshold value. The energy of a solar panel is higher when it receives higher light intensity. According to measurements, the LDR oriented toward the east receives the most solar irradiation and the temperature sensed is higher at peak hours. To summarize, the objectives are successfully achieved in this project.

Keywords: Energy, LDR, Light Intensity

1. Introduction

Solar energy is one of the renewable energies widely commercialized in recent decades to replace conventional energy. It is rich in resources and can strike solar radiation through any corner of the earth. The potential of solar energy for economic growth is higher as people now are more educated and getting ready for solar, plus it can reduce the consumption of conventional power. Research has proven that solar energy can help reduce monthly electrical bills. Hence, it requires low maintenance because there are no moving parts in solar panels and it can operate in 20 to 30 years of usage before a new replacement is needed [1].

However, this energy only can be generated in the presence of the sun. No electricity will be generated when night comes. At night, the supply only comes from the energy that is stored in batteries

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during the day [2]. Also, environmental crises such as changes in weather and orientations affect the intensity of the available solar irradiation. The temperature also affects the energy generated due to lousy weather such as foggy and stormy days. Thus, the energy output of solar panels from light intensity detection in advance could help correctly set up the solar panels and ensure that these panels operate at their full potential.

This project focused on investigation of the amount of energy generated by a solar panel depending on the amount of irradiation in different direction using a light intensity detector. The detector is capable to measure various parameters for eight hours, and using all the data collected from the LDR to observe and investigate the amount of energy generated by a solar panel.

2. Methodology

2.1 Block Diagram

Figure 1 shows the block diagram for a light intensity detector. A DC power supply powers the microcontroller, and the input is the temperature sensors and three sets of photoresistors. The output for this system is the LEDs to investigate the threshold values for each level. It represents a different light intensity level with three different colors for each LED set: green, yellow, and red. Each set of LDR is placed on a different direction to analyze which direction gets higher solar irradiation. The output parameters such as color of LED, energy, current, voltage and temperature are displays on LCD.

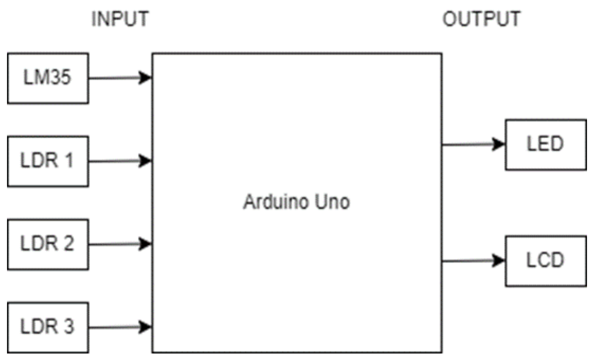

Figure 1: The block diagram of light intensity detector

2.2 Simulation

The level of light intensity and the threshold values in the simulation are set up by observing the level of light glow on the torch light (LDR) as shown in Table 1. The values will not be the same as the experimental prototype as prototype will consider the real environment. Hence, the threshold value for the prototype is set by testing the LED in a dark room. The prototype's threshold value is determined by observing the sensitivity to temperature and light changes in an array of LEDs. The LDR is then gradually exposed to a flash light in an effort to detect any color shift from red to yellow or green when subjected to exceptionally bright light. The threshold value is then determined for each level and implemented in the Arduino code based on the results of the observations. Once the LDR is weatherproofed, testing can be done in the field under actual sun conditions.

Table 1: The level of light intensity and threshold value on LDR

LED Color	Level of Light Intensity	Threshold Value	
		Simulation	Prototype
Green	High	>400	>140
Yellow	Moderate	400	140
Red	Red	200	80

The software simulation of a light intensity detector is displayed in Figure 2. The LDR 1 is positioned to the left, LDR 2 to the right, and LDR 3 to the bottom of the Arduino Uno board.

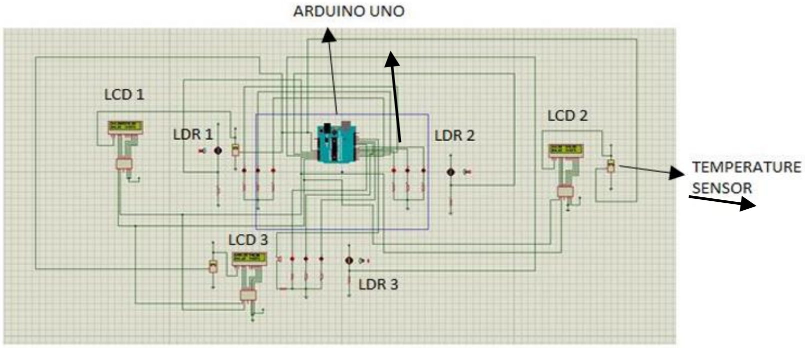

Figure 2: The simulation of the light intensity detector

2.3 Experimental Setup

The prototype light intensity detector's full connection is shown in Figure 3. It is placed in the same three-dimensional configuration as the simulation and is supplied by the same 5V source. Checking the functionality of the LCD is the first step in troubleshooting this detector. After that, the Arduino board is loaded with code, and the threshold values for each level of light intensity are established by considering the ambient temperature. Next, the phone flashes are used to observe the LEDs' color changes, a crucial step in the testing process. The LCDs are also checked to make sure they are printing out the four parameters (power, voltage, current, and temperature).

Figure 3: The connection for the light intensity detector

3. Result and discussion

3.1 Simulation result

Light intensity detector for the LDRs is depicted in Figure 4. The parameters of the simulated detector's output are shown on the screen. The LDR's red LED will turn on to signal the presence or absence of light when the device is in a dark environment. A red LED indicates a weak light source where the LED's color adjusts when the LDR is activated. Until the light reaches the required level of brightness, the yellow LED will remain ON. This indicates that the LDR is subjected to a small amount of light source. Meanwhile, the LED green is lights up when it receives larger quantity of light intensity that received from the LDR. The data are also displayed in the LCD and the temperature can be determined by altering the voltage value on the LM35 sensor.

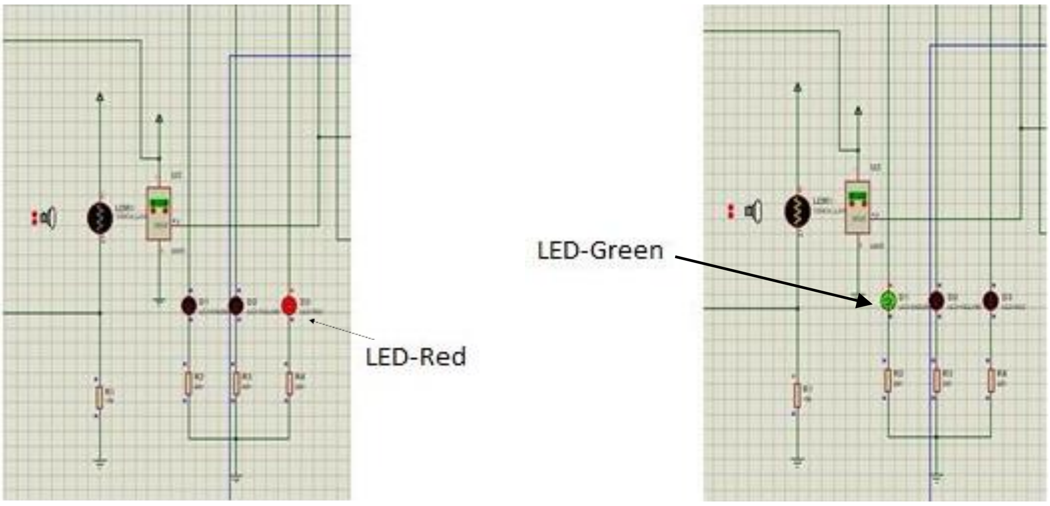

Figure 4: The changes of LED color at low and highest light intensity level

3.2 Experimental Result

The experiment for the light intensity prototype is conducted for three days to collect the exact results. This detector is mounted in three direction where LDR 1 is looking west, LDR 2 facing east and LDR 3 facing south. The parameter measured are the energy, current voltage, temperature and output power to fulfil the objectives. The testing is conducted on sunny days and measured for eight hours commencing from 10:00 to 17:00 on afternoon with one-hour interval. As seen in Figure 5, the LED's efficacy is evaluated by testing the LDR in the dark at normal temperature. The red LEDs on the LDRs are ON and active because there are currently no light sources present. Meanwhile in Figure 6, it shows the LED green is lights up when it receives highest light intensity. The LCD displays the value of temperature, current, voltage and energy received on that time.

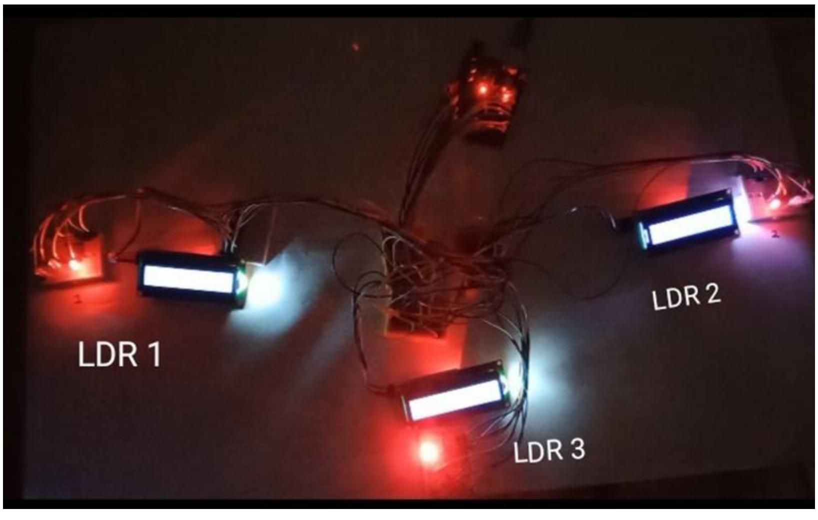

Figure 5: The Red LED glow when low light intensity

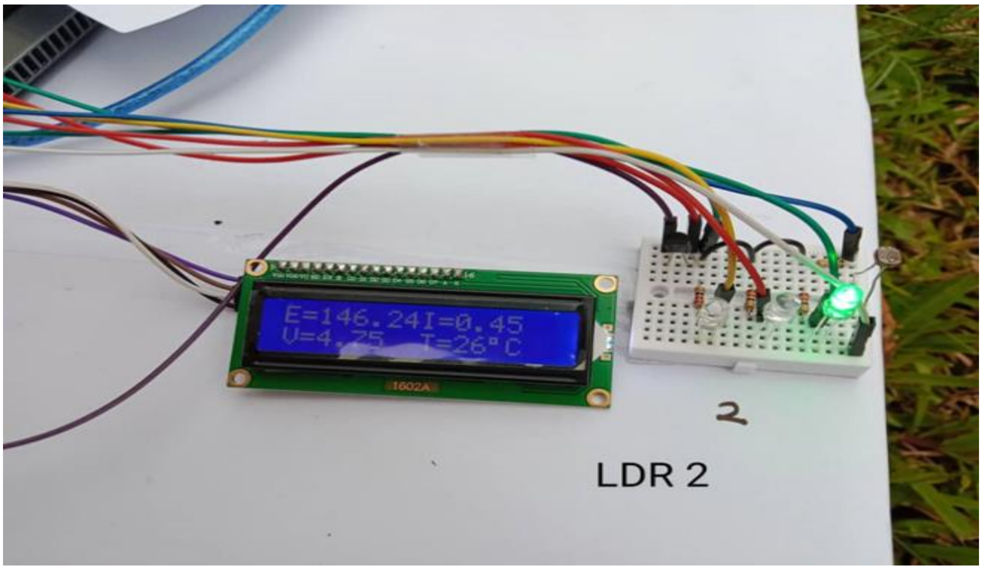

Figure 6: The Green LED glow when low light intensity

3.2 Discussion

(a) Temperature versus Time

The temperature comparison over three days is depicted in Figure 7. T_D1, T_D2 and T_D3 represent the temperature on Day 1, Day 2 and Day 3. In general, solar energy production is highest between the hours of 11:00 and 16:00. The greatest temperature recorded during the day was between 13:00 and 14:00, as seen in the accompanying bar chart. This is the time of day when the sun's rays are at their strongest, and hence the solar panels are most effective. The solar panel's current output grows exponentially but the voltage output decreases linearly as the temperature of the panel rises. Early morning and late evening are cooler than the rest of the day because that's when the sun rises and sets.

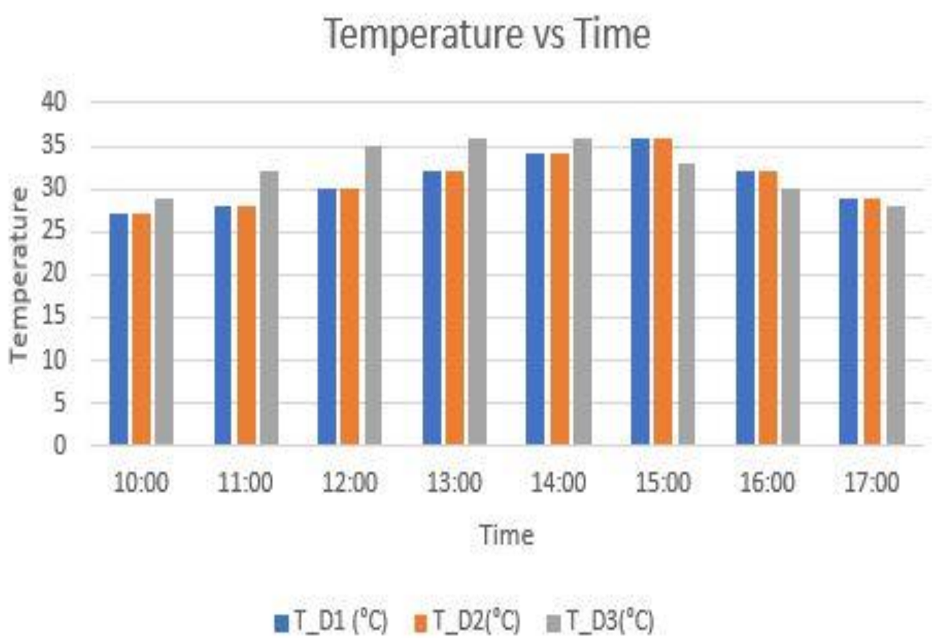

Figure 7: The bar chart for temperature versus time

(b) Energy versus Time

To visualize the dissimilarities in the LDR's energy output, a bar chart is used to compare the relevant data. Starting on Day 1 and continuing through Day 3, LDR 1 and LDR 2 are exposed with more light intensity than LDR 3. The midday hours of 13:00 to 14:00 have the highest energy output. Since the sun rises in the east and sets in the west, the LDR 2 which facing the east receives the highest light intensity among the three detectors. In conclusion, the higher the light intensity strikes on LDR, the higher energy generated on a solar panel. Figure 8, Figure 9 and Figure 10 below show the results of energy versus time for three days where E_LDR1, E-LDR2 and E_LDR3 represent the energy on each LDR.

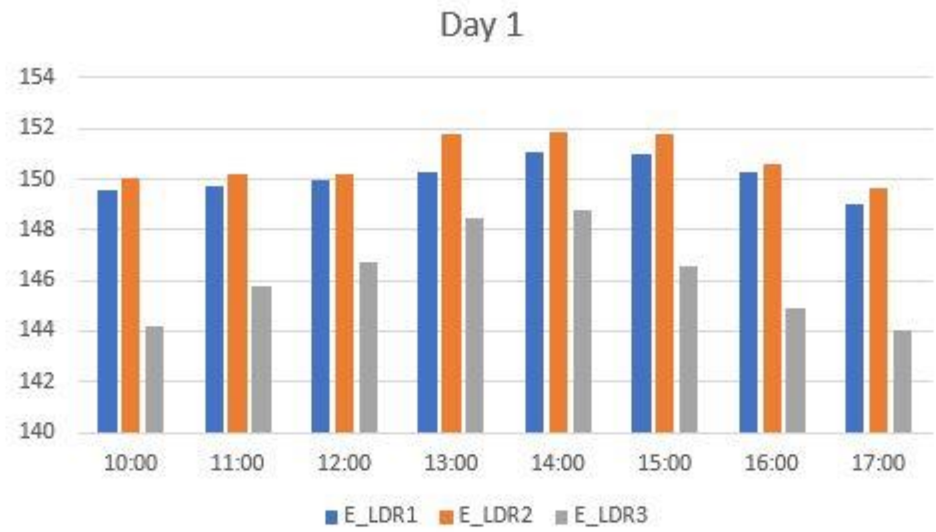

Figure 8: The bar chart for energy versus time on Day 1

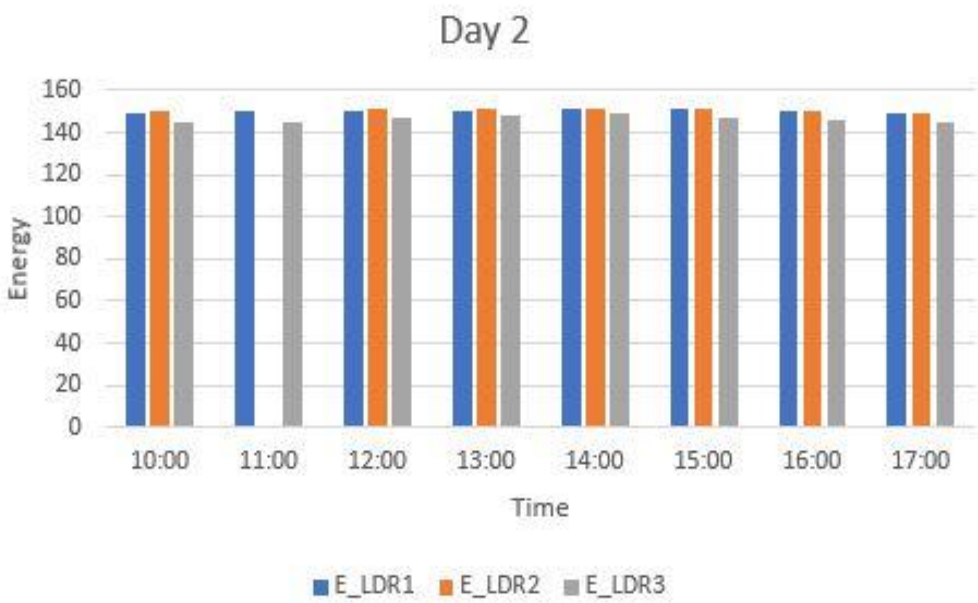

Figure 9: The bar chart for energy versus time on Day 2

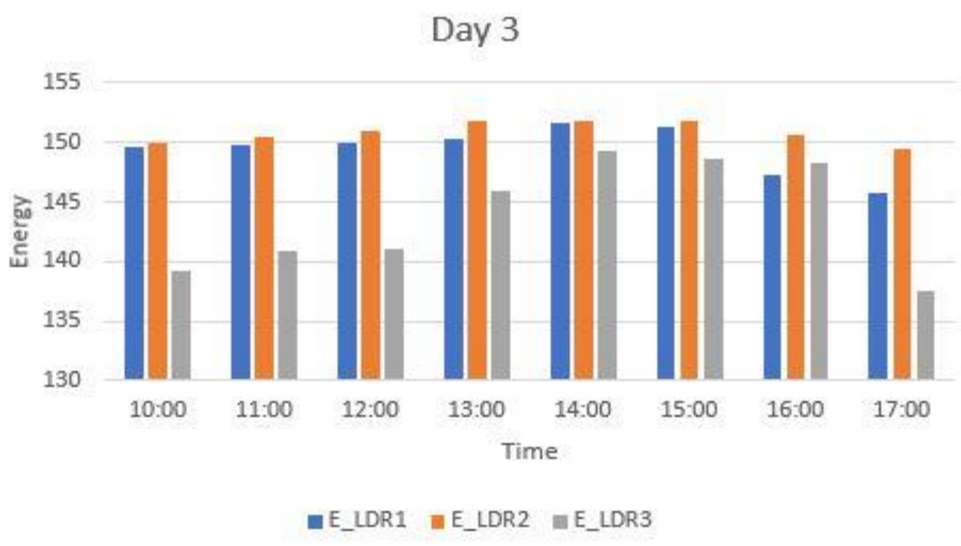

Figure 10: The bar chart for energy versus time on Day 3

(c) Power versus energy

From 10:00 until 17:00, the relation of energy and power are depicted in a combination charts at one-hour intervals. Figures 11, 12, and 13 depict the three-day power and energy measurements for LDR 1, LDR 2, and LDR 3. Only data for Days 2 and 3 are visible from a distance for power in Figure 12, as the values of LDR 1 for Days 1 and 2 are fairly similar. Hence, it overlaps and only shown for one line only. It is due to the difficulty of the first day's distance.

It can be observed from the charts for LDR 1, LDR 2, and LDR 3 that the LDRs receive the most energy on Day 3. The output power increases throughout the day until 14:00, at which point it begins to decrease until 15:00. At 14:00 in the afternoon, LDR 1 and LDR 2 attain the daily peak power of 151.65kWh and 151.85kWh, respectively, with respective power outputs of 2.39W and 2.40W. The largest amount of energy received on LDR 3 is 149.25kWh with a power output of 2.28W. The value indicates that LDR 3 receives the least amount of light among the LDRs.

Increasing the solar panel's input energy results in a higher current and higher output power. This statement is supported by a research study that as sun irradiance strikes the solar panel surface, the amount of power generated also increases. High surface temperatures on photovoltaic modules create more resistance for the electronics, reducing the output and thus the efficiency of the solar panel.

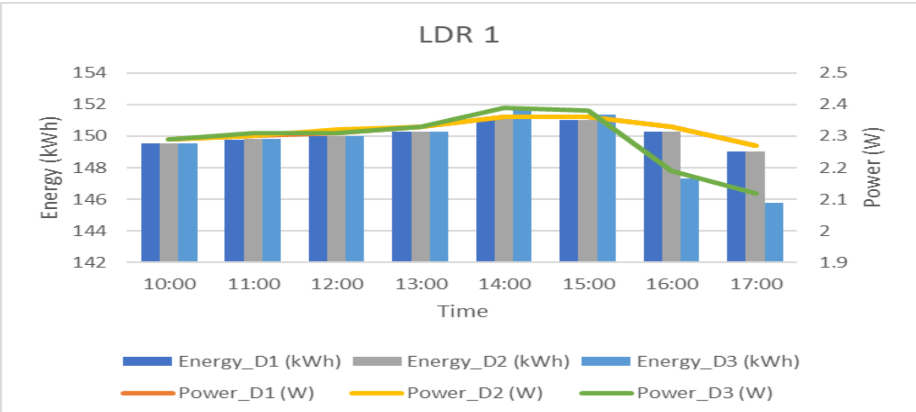

Figure 11: The combination chart of LDR 1 for three days

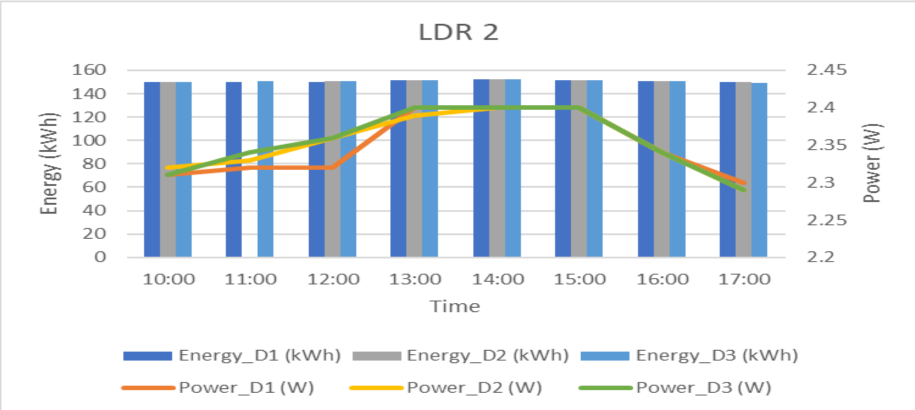

Figure 12: The combination chart of LDR 2 for three days

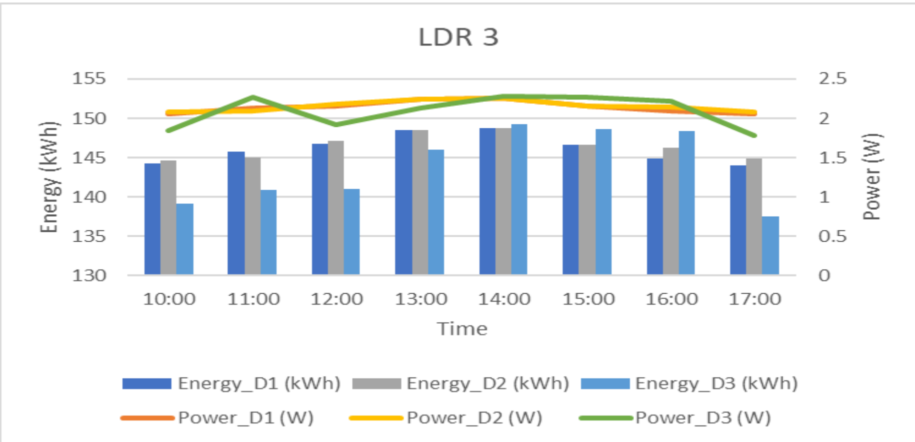

Figure 13: The combination chart of LDR 3 for three days

Conclusion

In conclusion, a solar energy detector is a good technology as engineers will know the amount of solar irradiation and which direction a solar panel can generate the maximum solar energy. Construction of a light intensity detector system is to detect the level of irradiation. There are a lot of different aspects that need to be taken into consideration, such as the weather, the direction that the sunlight is coming from, and the influence that shading has on the solar panel. According to the results of this project, the LDR 2 that was installed facing east receives a higher light intensity than the LDR 3 that was installed facing south. It indicates that the way this project is being headed was chosen in error orientation because usually, south direction will receive the highest solar energy. However, it also depends on the location of the place installed. The parameter of current, voltage and temperature based on LDR performance was analyzed under different light intensity level. This measurement employs the sensors and equations in order to provide a precise value for the output.

Acknowledgement

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References

[1] L. Richardson, “How long do solar panels last? Solar panel lifespan explained,” *EnergySage*, pp. 6–8, 2020.

[2] J. Bruce, “What Is The Biggest Problem With Solar Energy ? Renogy Solar Products Make It Easy,” S. Website, 2022.