Solar Panel Performance Assessment

(A Day-Long Study of Voltage Output)

Introduction

Solar energy is a rapidly growing source of renewable energy that offers numerous benefits over traditional fossil fuel-based energy sources. One of the key advantages of solar energy is that it is a clean and sustainable source of energy that can be harnessed using solar panels. However, to make the most of solar energy, it is essential to understand how solar panels perform under different conditions.

Measuring the voltage output of a solar panel over time is an important way to assess its performance. This exercise involved collecting voltage values from a solar panel that was stationed outside for 24 hours. The purpose of this exercise was to gain insights into the performance of the solar panel over the course of a day.

By collecting data on the voltage output of the solar panel over a 24-hour period, it is possible to identify any patterns or trends that emerge over time. This information can be used to optimize the placement and orientation of the solar panel to maximize its efficiency and power output.

The data collected in this exercise was stored in a .csv file format on a memory card. The voltage values were recorded using a custom-made voltage sensor that was connected to an Arduino Uno microcontroller. The voltage sensor was connected to the outputs of the solar panel to measure its voltage output.

This documentation presents the results of the exercise and provides insights into the performance of the solar panel over the course of a day. By analyzing the data collected, it is possible to gain a better understanding of the behavior of the solar panel and to identify opportunities for improving its performance.

Overall, the findings of this exercise have important implications for the use of solar energy as a renewable energy source. By optimizing the placement and orientation of solar panels, it is possible to maximize their efficiency and power output, thereby making solar energy an even more attractive option for meeting our energy needs.

Methodology

Equipment

A custom-made voltage sensor was used to collect voltage values from the solar panel. The voltage sensor was connected to an Arduino Uno microcontroller, which was used to record the voltage values. The voltage sensor was connected to the outputs of the solar panel to measure its voltage output.

Data Collection

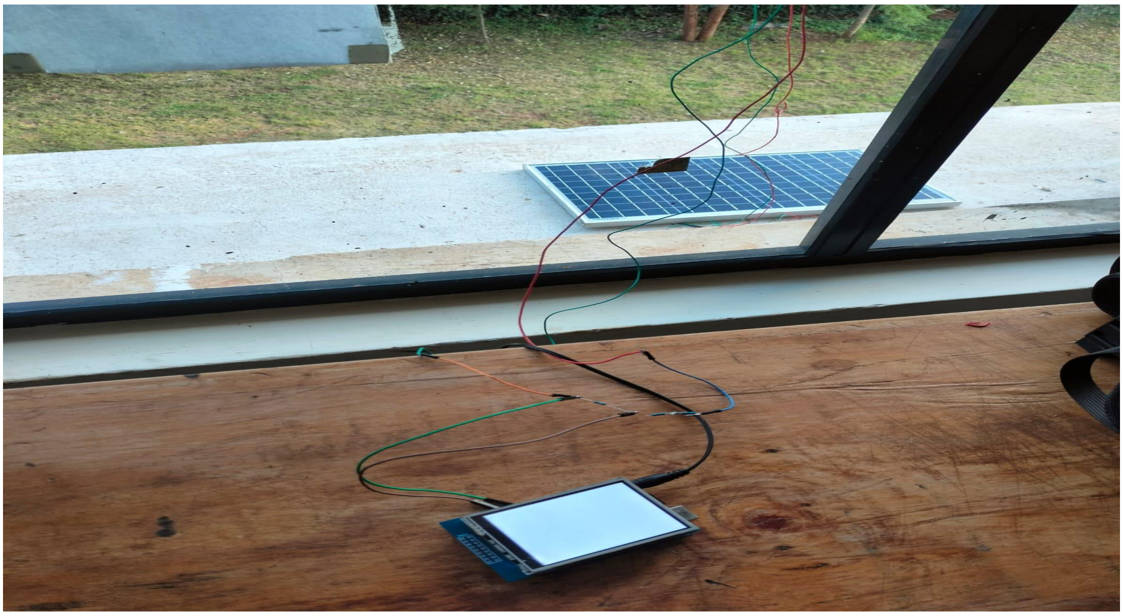
The Arduino Uno was programmed to record the voltage values at a specified sampling rate. The data was collected continuously for 24 hours and was stored on a memory card in .csv format. The memory card was connected to the Arduino Uno during the data collection period.

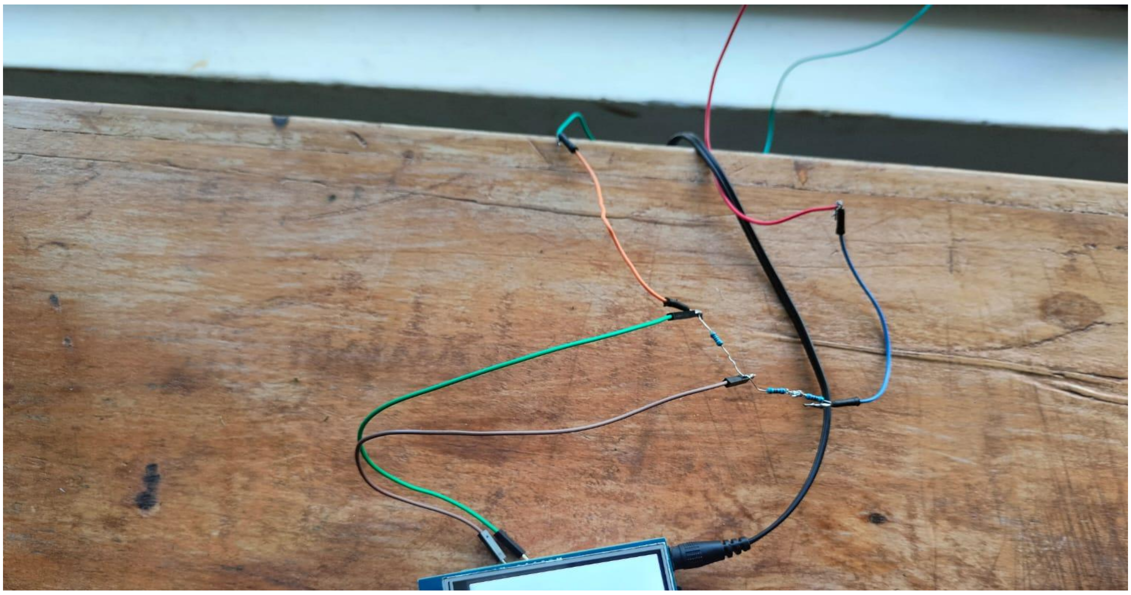
Location

The solar panel was stationed outside in an open area to ensure that it received direct sunlight for the entire 24-hour period. The location was chosen to minimize any shading or obstruction that could affect the voltage output of the solar panel.

Sampling Rate

The voltage values were recorded at a sampling rate of 15mins. This sampling rate was chosen to ensure that sufficient data was collected over the 24-hour period.





Custom Voltage Sensor

Arduino Code

```
// inclduing the necessary libraries to be used in the code
#include <SPI.h>
#include <SD.h>
File myFile;

float voltage_value;
char myString[10];
int recTime = 0;
char comma = ',';
String sendStr = "";

// the setup function
void setup() {
  Serial.begin(9600);
  while (!Serial) {
  }
  Serial.print("Initializing SD card...");
  setUpSD();
  writeSD("TIME , START");
}

// the loop function
void loop() {
  readVoltage();
  Serial.print("Voltage: ");
  Serial.println(voltage_value);
  dtostrf(voltage_value, 5, 2, myString);
  int ftime = recTime*15;
  sendStr.concat(ftime);
  sendStr.concat(comma);
  sendStr.concat(myString);
  Serial.println(sendStr);
  writeSD(sendStr);
  sendStr = "";
  recTime += 1;
}

// function to read voltage  using the custom made voltage sensor
void readVoltage(){
  float sensorValue = analogRead(A0);
  voltage_value = ((sensorValue * 5)/1024) * 11.25;
  delay(900000);
```

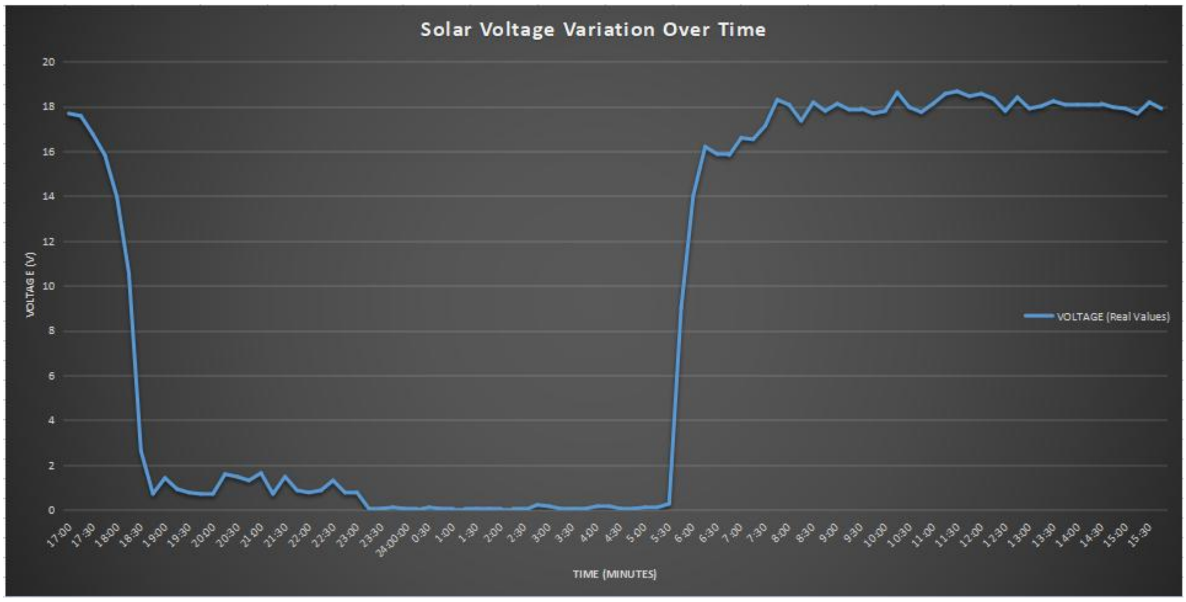
```
}

// function to setup the SD card including initialization
void setUpSD(){
  Serial.print("Initializing SD card...");
  if (!SD.begin(10)) {
    Serial.println("initialization failed!");
    while (1);
  }
  Serial.println("initialization done.");
}

// function to write the voltage value to the csv file located in the memory card
void writeSD(String voltage){
  myFile = SD.open("SOLAR.csv", FILE_WRITE);

  if (myFile) {
    Serial.print("Writing ...");
    myFile.println(voltage);
    myFile.close();
    Serial.println("done.");
  } else {
    Serial.println("error opening");
  }
}
```

Analysis



1. **Solar Panel Performance**: The low voltage readings during the evening and early morning hours indicate that the solar panel's power generation capability is significantly reduced or nearly inactive during these periods. This is expected as there is limited or no sunlight available for the solar panel to convert into electrical energy.

2. **Daytime Performance**: The high voltage readings during the daytime indicate that the solar panel is operating optimally and generating a sufficient amount of electricity. The voltage exceeding 17V suggests that the solar panel is efficiently converting sunlight into electrical energy.

3. **Sunlight Dependency**: The significant variation in voltage between daytime and nighttime highlights the dependence of solar panel performance on sunlight availability. Solar panels rely on sunlight to generate electricity, and their output is directly affected by the intensity and duration of sunlight exposure.

4. **Time-dependent Energy Generation**: The voltage data pattern suggests that the solar panel system is most productive during daylight hours. Therefore, if the objective is to maximize energy generation, it is crucial to ensure that the solar panel is positioned and oriented to receive maximum sunlight during the day.

Battery Storage Consideration: The observation of low voltage during the nighttime hours indicates that the solar panel system may not be directly powering the load during these periods. It is possible that energy generated during the day is stored in batteries for use during nighttime or low-light conditions. This highlights the importance of an effective energy storage system, such as batteries, to provide continuous power supply even when sunlight is unavailable.

Conclusions

In conclusion, the analysis of the voltage data reveals the time-dependent nature of solar panel performance. The solar panel system demonstrates low voltage readings during the evening and early morning, indicating limited power generation due to minimal or no sunlight. Conversely, the voltage rises significantly during the daytime, indicating optimal solar panel performance and efficient conversion of sunlight into electrical energy. This observation emphasizes the need for careful positioning, orientation, and energy storage considerations to maximize the solar panel system's overall efficiency and effectiveness.

Future Work

While this exercise provides valuable insights into the performance of the solar panel over a 24-hour period, there are several opportunities for future work. One potential area of future work is to collect data over a longer period of time, such as several days or even weeks. This would provide a more comprehensive understanding of the performance of the solar panel over time, and could help to identify any long-term trends or patterns.

Another area of future work is to investigate the impact of different environmental factors on the performance of the solar panel. For example, it would be interesting to study how variations in temperature, humidity, and cloud cover affect the voltage output of the solar panel.

Finally, it may be valuable to compare the performance of the solar panel studied in this exercise with other types of solar panels, or to investigate the impact of different types of solar panels on overall energy production. This could help to identify the most effective solar panel types for different environments and applications, and could inform future decision-making around renewable energy adoption.

Overall, these areas of future work could provide valuable insights into the performance and optimization of solar panels, and could contribute to the ongoing effort to maximize the efficiency and sustainability of renewable energy sources.