The output of the solar cell is affected by changes in these two variables, namely ambient temperature and solar radiation.

The quality of the power is poor, and the supply is quite erratic. "Poor Power Quality" has a detrimental impact on all areas of the economy, causing the nation to lose a significant amount of money every year in both visible and invisible ways. Even though most electrical equipment can operate without issue with voltage variations of up to 6%, out-of-tolerance voltage issues can still happen and are typically categorized as sags, brownouts, surges, and so many energy crises. We employ environmentally friendly renewable energy sources to alleviate these challenges, and solar energy is one simple way to produce electricity [1]. Electrical energy is the most adaptable type of energy, capable of being transformed into and used in a variety of ways, just as any other kind of energy could be transformed into and stored as electric energy. Although fossil fuels are the primary source of electricity, they are being extinguished at an alarming rate because of their irreversible nature. In the modern era, all nations concur that electric energy is crucial to their nation's economic success. Electric energy has become a valuable resource due to the fast industrialization, expansion of technology, and needs of the modern world. Its output is increasing as people live better, more comfortable lives [2].

Sunlight is directly converted into power by solar PV systems. The output of the solar cell is primarily influenced by two variables, namely ambient temperature and solar radiation. The output of the solar cell is affected by changes in these two variables and can either rise or fall. The mathematical equations describing and specifying the physical properties of the PV cell are necessary for the modeling. Seven solar panels totaling 75 panels are connected in series in our system [4]. Additionally, we use a DC battery to store the DC, which is subsequently transformed into AC using an inverter. We use a boost converter, often known as a step-up converter. A boost converter is a DC-to-DC power converter that boosts the input voltage. A form of switched-mode power supply (SMPS), it elevates the DC voltage level by using at least two semiconductors (a diode and a transistor) and at least one energy storage component. Any acceptable DC source, including batteries, solar panels, rectifiers, and DC generators, can provide energy for the boost converter. DC to DC conversion is the process of converting one DC voltage to another DC voltage. Additionally, we can attach a load (single phase load), such as a lamp or fan. We created a Simulink model of a 20 kW PV system using this information [4].

Energy crises are getting worse every day as a result of the ongoing loss of fossil fuels and rising electrical demand. A good way to generate power is to use sustainable and environmentally friendly resources to produce energy. To meet the energy demand at the domestic level, renewable energy sources (RES), particularly solar photovoltaic systems, are a simple source of power. The performance of PV systems is greatly influenced by the weather. Due to changes in the environment, its output is extremely unpredictable. By using...
an MPPT charge controller, maximum power output can be increased [5].

The following are the main purposes of our research.

- Importance of standalone PV systems for building energy management.
- Effect of temperature and irradiance on permanence parameters.
- Performance analysis of solar system using MPPT along with DC to DC converter.

A cheap, clean, and abundant energy source that is also good for the environment is solar electricity. Today, several solar energy approaches are being developed, and solar cells are receiving more respect as a result of the quick development of technology and its applications to meet the energy needs of the modern world. The solar cell is a device that harnesses the power of solar radiation to create electricity using the photovoltaic effect [6]. Fig.1 depicts the solar system's schematic diagram.

![Solar system schematic diagram](image)

**Figure 1.** Solar system schematic diagram.

### 2. Literature Review

Both Solar energy is converted into electrical energy in a single step. The PV is a dual-layer device with an n-type free electron layer. It is created by doping silicon with elements from the fifth group, such as phosphorous, which has five electrons in its valence shell. With the silicon atom, phosphorus forms four bonds, leaving one phosphorous electron free to create the n-type part [7]. The third group elements such as boron, which form three bonds with silicon atoms and one partial bond with an electron shortage known as a hole, are used to dope silicon to create the other layer, which is p-type. When solar irradiance, which consists of packets of energy, reaches a PV model, electrons begin to move and produce electrical energy; however, only those electrons whose energy exceeds the permitted energy gap cause them to move. This material is known as P-type. There are three main types of PV system

1. Stand-alone PV System.
2. Grid Connected PV System.
3. Hybrid PV System.

#### 2.1. Stand Alone PV System

Remote Area Power System (RAPS) is another name for a standalone PV system. It is a system that is not connected to the power grid or where doing so would be economically unviable. It serves to completely meet the electricity demand. Vehicles, water pumps, and other equipment all use it. For unforeseen weather changes like gloomy days and nighttime, we must reserve energy [8]. The block diagram for a solo PV system is shown in Fig. 2.

![Block diagram of a solo PV system](image)

**Figure 2.** Stand alone PV system.

A PV cell converts solar energy into electrical energy. The modules that make up a PV array are composed of cells. Each PV cell produces 2W of power. To obtain the necessary high voltage or current, they are connected in series or parallel, accordingly. A PV array is a type of generator that is made up of various modules and cells [9].

PV array refers to the arrangement of solar cells in a single array (in series or parallel). We made use of the PV array Simulink block. The models include seven arrays and a total of 75 solar panels. Three panels are attached to each of the 25 parallel threads. These monocrystalline panels have a 275-watt power rating.

The PV array's specifications are displayed in Table 1. Fig. 3 shows the solar cell's fundamental circuit. Additionally, the terms \( I_L \) for light current, \( I_D \) for diode current, \( R_{sh} \) for shunt resistor, and \( R_s \) for series resistor are used in this diagram.

![Fundamental circuit of a solar cell](image)

**Table 1.** Parameter of PV arrays.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parallel strings</td>
<td>4</td>
</tr>
<tr>
<td>Series connected modules per string</td>
<td>3</td>
</tr>
<tr>
<td>Module</td>
<td>User defined</td>
</tr>
<tr>
<td>Maximum Power (W)</td>
<td>275.44</td>
</tr>
<tr>
<td>Open circuit voltage ( V_{oc} )</td>
<td>383</td>
</tr>
<tr>
<td>Voltage at maximum power point ( V_{mp} )</td>
<td>51.3</td>
</tr>
<tr>
<td>Temperature to efficient of ( V_{oc} ) (°C)</td>
<td>-0.51</td>
</tr>
<tr>
<td>Cells per module (Ncell)</td>
<td>60</td>
</tr>
<tr>
<td>Short circuit current ( I_{sc} ) (A)</td>
<td>9.31</td>
</tr>
<tr>
<td>Current at maximum power point ( I_{mp} ) (A)</td>
<td>8.60</td>
</tr>
<tr>
<td>Temperature to efficient of ( I_{sc} ) (°C)</td>
<td>0.029</td>
</tr>
<tr>
<td>T cell (°C)</td>
<td>45.24</td>
</tr>
</tbody>
</table>
3. Methodology

It is a tool that operates based on the photovoltaic effect; as a result, it is also referred to as a photovoltaic cell. It is distinct from a solar thermal device since it converts light energy into electrical energy. It typically consists of semiconductor material, such as silicon, and transforms light current directly into DC electricity. It excites the electron by absorbing light energy, which may subsequently be extracted into an electric circuit by an applied electric field that is built into the device. Because there is a greater emphasis on using renewable energy sources to provide electricity. The ease of use of solar energy, especially at the domestic level, has expanded its popularity. The structure of their electron energy level allows for the conversion of solar energy into electrical energy. The valance band and conduction band are the two main forms of energy bands.

It comprises the charge controller algorithms to maximize the power from the PV panel under specific circumstances. Irradiance and temperature variations cause it to fluctuate. And the maximum power point is the voltage at which maximum power is produced. To determine the best power to produce the best voltage for delivering the maximum current to the battery, it compares the output of the panel to the battery voltage. It functions effectively in the following situations.

1. The MPPT can extract more current in case if the battery is deeply discharged. So MPPT will extract the current to charge the battery.
2. When the weather is cold, this is because at cold temperatures MPPT extracts max power.

The MPPT algorithm is used to adjust the impedance of the solar array to changes in circumstances, such as temperature and irradiance, to get the most power possible from the PV array. By utilizing various algorithms, research is being done to extract the maximum power possible from the PV panel [10]. The techniques utilized make it possible to obtain the maximum voltage on the PV curve. Types of algorithms are as follows.

1. Perturb and observe
2. Incremental conductance
3. Fractional open circuit voltage

3.1. Perturb and Observe Method

It is the MPPT algorithm that is most frequently employed. We employed a solar tracker with a perturb and observe technique in the suggested model. Within the stated search space limit, it performs perturbation and observation while tracking the power to the maximum power point. In the MPPT perturb and observe method, as shown in Fig. 4, the voltage level is monitored while the voltage value is perturbed to the maximum power point [10, 11]. Up until the maximum power is reached, the process of perturbation and observation is constant.

We have created a model of a 20kW solar PV system for the proposed project. This system uses 75 PV panels, each of which is 275W. There are seven combinations of series and parallel panel arrays. These seven arrays are coupled to a charge controller and a DC-to-DC converter.

With a maximum power point Tracking system MPPT controls and monitors the system's maximum power output using the perturb and observe method. Regulating the DC output level to a maximum power point is beneficial.

A group of 24 batteries with a total capacity of 600 amp hours and a 2-volt rating. Three sets of inverters convert the battery bank's DC output from batteries into AC once it has been charged by charge controllers [12]. Three AC inverters each handle a portion of the 15kW total load that is connected to the solar system. The model was created in Matlab Simulink as depicted in the Fig. 5.

Fig. 5 shows the connections between 7 arrays and 7 DC to DC converters. This also has batteries linked for backup power storage. Inverters convert DC-to-AC to help with building AC loads.
Results

Irradiance and temperature are the two variables used to base the results and analysis. We simultaneously employed various light temperature and intensity values. Table 2 provides various irradiance and temperature values.

<table>
<thead>
<tr>
<th>Irradiance</th>
<th>Temperature</th>
<th>Power output</th>
</tr>
</thead>
<tbody>
<tr>
<td>300</td>
<td>32</td>
<td>2500</td>
</tr>
<tr>
<td>500</td>
<td>35</td>
<td>3800</td>
</tr>
<tr>
<td>800</td>
<td>38</td>
<td>6000</td>
</tr>
<tr>
<td>1000</td>
<td>40</td>
<td>7500</td>
</tr>
</tbody>
</table>

4.1. Graphical Representation

Fig. 6 displays the energy generated by PV array 1. When the irradiance value is maintained at 300 and the temperature is 32 degrees Celsius, the PV array 1 generates 580 W of power. The outcomes for PV arrays 1, 2, and 3 are identical.
is 35 degrees Celsius, the PV array 1 generates 800 watts of power. The outcomes for PV arrays 1, 2, and 3 are identical.

**Figure 9.** Power-time 4×3 array.

Fig. 10 displays the energy generated by PV array 5. When the irradiance value is maintained at 500 and the temperature is 35 degrees Celsius, the PV array 5 generates a power of 655 watts. The output from PV arrays 5 through 7 will be the same.

**Figure 10.** Power-time 3×3 array.

Fig. 11 shows the power output after DC-to-DC conversion and MPPT charge controller.

**Figure 11.** Power-time pout MPPT.

Fig. 12 displays the energy generated by PV array 1. When the irradiance value is maintained at 800 and the temperature is 38 degrees Celsius, the PV array 1 generates 1146 watts of power. The outcomes for PV arrays 1, 2, and 3 are identical.

**Figure 12.** Power-time 4×3 array.

Fig. 13 displays the energy generated by PV array 5. When the irradiance value is maintained at 800 and the temperature is 38 degrees Celsius, the PV array 5 generates power of 908 watts. Results from PV arrays 5, 6, and 7 will be the same.
Fig. 13. Power-time 3×3 array.

Fig. 14 shows the power output after DC-to-DC conversion and MPPT charge controller.

Fig. 14. Power-time pout MPPT.

Fig. 15 displays the energy generated by PV array 1. When the value of irradiance is fixed at 1000 and the temperature is 40 degrees Celsius, the PV array 1 generates power of 1382 watts. The outcomes for PV arrays 1, 2, and 3 are identical.

Fig. 15. Power-time 4×3 array.

Fig. 16 displays the energy generated by PV array 5. When the irradiance value is maintained at 1000 and the temperature is 40 degrees Celsius, the PV array 5 generates 1080 watts of power. The output from PV arrays 5 through 7 will be the same.

Fig. 16. Power-time 3×3 array.

Fig. 17 shows the power output after DC-to-DC conversion and MPPT charge controller.

Fig. 17.
4.2. State of Charge Level

The state of charge level is defined as "the level of charge on the battery about its capacity" and is expressed in percentage points. The charge level with the load connected is shown in Fig. 18.

Fig. 18. State of charge-time.

Fig. 19 shows the charge level when the load is disconnected.

Fig. 19. State of charge-time.

The output power (shown in Fig. 20) when the battery is separated from the load. When the load is connected, the output power has a higher value.

Fig. 20. Power-time.

Fig. 21 shows the current after the battery when the load is disconnected and the circuit is opened.
Fig. 21 shows the output power when the load is connected. When the load is connected so the output power will be less.

Fig. 22 shows the output current when the switch is closed, and the load is connected.

The DC voltage shown in Fig. 24 is constant regardless of whether the load is attached or unplugged since the battery voltage was set to a constant value to ensure that it would do so.

Fig. 23 shows the voltage value after inverter 1.
energy storage system is utilized to increase the dispatch ability and stability of erratic PV electricity. Here, the storage device is primarily a nickel metal hydride battery since, due to its low cost and wide availability, it is more practical to employ in high-power applications like solar and wind systems. By taking into account the charging and discharging equations based on the equivalent circuit, nickel metal hydride batteries are modeled.

We have created a model of a 20 kW solar PV system for the suggested project. In this system, there are 75 PV panels with 275W apiece. Seven combinations of series and parallel panel arrays are present. These seven arrays are coupled to a charge controller and a DC-to-DC converter.

With a maximum power point Tracking system, MPPT controls and monitors the system's maximum power output using the perturb and observe method. Regulating the DC output level to a maximum power point is beneficial. A group of 24 batteries with a total capacity of 600 amp hours and a 2-volt rating. This battery bank is charged by a charge controller, and then three sets of inverters convert the batteries' DC output to AC. Three AC inverters each handle a portion of the 15kW total load that is connected to the solar system.

The outcome demonstrates how temperature and irradiance variations affect the system's output power. Both characteristics have a significant impact on the power output. The outcomes of the simulation demonstrate how effective MPPT controllers are. The output power has been enhanced to the highest level possible using MPPT and the perturb and observe method. The battery supplies extra power when load power demand exceeds PV generation, and the battery should store excess power when PV generation exceeds load power demand.

References


According to the findings, power production also varies when irradiance and temperature are changed at the same time. After entering several irradiance and temperature values 300, 500, 800, and 1000 for irradiance, and 32, 35, 38, and 40 degrees Celsius for temperature, we draw our conclusions on the outcome. Then, we noticed that the power output of PV panels significantly varies from Fig. 6 to Fig. 17.

5. Conclusion

In this work, a standalone photovoltaic (PV) system that uses a storage device as a backup source has been modeled. The

Figure 25. Voltage-time.

Fig. 26 shows the AC properties of the Simulink model.

Figure 26. AC output-time.

