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Effect of dynamic weather conditions on solar energy systems

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Abstract - The different PV cell technologies on the market have forced a comparison of their performance and viability in real-world weather situations. The influence of dynamic changes in irradiance and temperature on the performance of several PV cell technologies was examined in this article. In this study discuss the Effect of dynamic weather conditions on solar energy systems.

Keywords - Dynamic weather, conditions, solar energy

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1. INTRODUCTION

The most abundant and most environmentally friendly renewable energy source is solar power. For example, modern technology may be used to generate power, provide light, and heat water for both home as well as commercial and industrial purposes.[1]

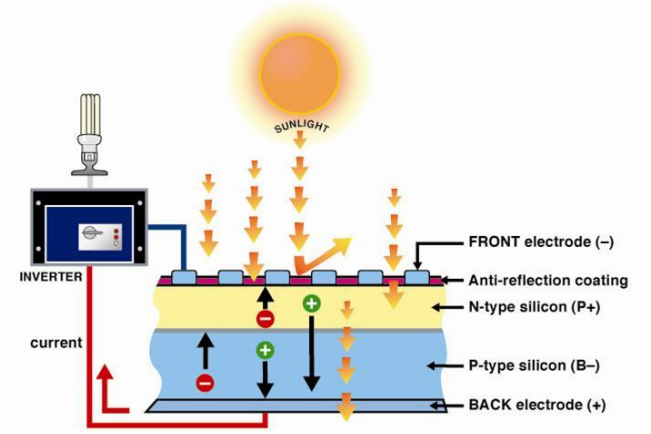
Our electrical needs can also be met by solar power. Direct conversion of solar radiation to direct current power is made possible by solar photovoltaic (SPV) cells. You can utilise this power right away, or you can save some of it in the battery. We'll learn all about solar power in this essay. Let's see step by step:

- **Solar Photovoltaic (SPV) Cell:**

Photovoltaic cells, often known as solar cells, are devices that use the photoelectric effect to convert light into electrical current. There are several uses for SPVs, including powering remote telecommunication systems, railway signalling, street lighting, and household lights.[2]

P-type silicon is in direct contact with n-type silicon and electrons are diffused from the n-type silicon to the p-type silicon. There are holes in the p-type material that take electrons. It is because the n-type material has a high concentration of electrons that the electrons from the n-type material may migrate to the p-n junction, where they are paired up with holes. This forms an electric field on both sides of the p-n junction. In this way, a diode-like structure emerges, which facilitates the passage of charge. This is the flow of electrons and holes that is regulated by this current. There are no mobile charge carriers in the depletion zone or space charge region, which is where drift current occurs.

As a result, when the sun is not shining, the solar cell acts like a reverse biassed diode. When exposed to light, the solar cell undergoes forward biassing, causing current to flow from the anode to the cathode in a single direction, much like a diode. When a solar panel is connected to a battery, its rated voltage is lower than its open-circuit voltage. In direct sunlight, a 12-volt panel may produce up to 20 volts. The voltage reduces to 14-15 volts when the battery is attached. Solar photovoltaic (SPV) cells are manufactured using materials such as silicon, which is now the most extensively utilised. When light strikes the cell's semiconductor material, some of it is absorbed. In other words, the semiconductor receives the light's energy in this manner.[3]



All solar PV cells have electric fields that direct electrons produced by light absorption. We may take advantage of this flow of electrons by making metal connections on the top and bottom of the SPV cell. The maximum output of a solar cell is determined by its voltage. Photovoltaic (SPV) technology transforms light into electricity. Using solar panels, the sun's rays are transformed into direct current (DC) power. An inverter must be used to convert the DC power back to its original form. The inverter converts 240-volt DC power into 120-volt AC electricity, which is used by most household equipment.

- **Solar Panel:**

A solar panel is made up of an array of individual solar cells. The solar panel converts solar energy into electrical energy. Ohmic substance is used in the solar panel's interconnections and external terminals. Because of this, the n-type material generates electrons, which are then transmitted to a battery wire by way of electrode. Conductors in the battery conduct electrons to the p-type material. The electrons and holes merge here. This means that the solar panel acts as a second battery when linked to the battery, and both systems are connected in series much as two batteries connected serially.[4]

The solar panel's output is measured in watts or kilo watts, which are the units of measurement for its power. There are a variety of output ratings for solar panels, ranging from 5 watts to 100 watts. In other words, before making a decision on a solar panel, you need to know how much electricity the load will require. Calculating the amount of electricity needed is done in watts or kilowatt hours. Average power is typically equivalent to 20% of peak power. As a result, a solar array with a peak output power of 1 kilowatt produces energy at a rate of 4.8 kilowatt hours per day. Over the course of 24 hours, that works up to 20% of a kW.

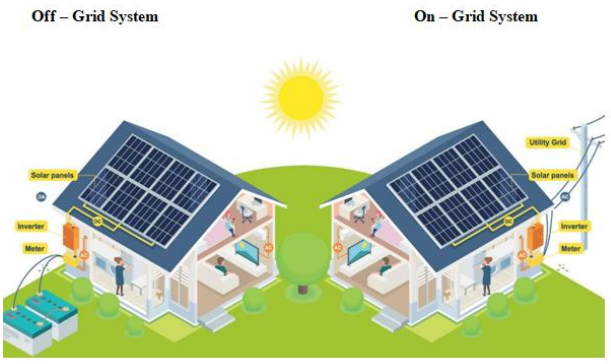
The efficiency of a solar panel is affected by a variety of variables, including the climate, sky conditions, panel orientation, sunlight intensity and duration, and the connections to the panel. One ampere of electricity may be drawn from an ordinary 12-volt, 15-watt solar panel. A solar panel may expect to survive around 25 years if it is properly cared for. The placement of solar panels on the roof must be planned. Typically, it is positioned at a 45-degree angle to the east. The panel may also be rotated to follow the sun's path from east to west using a solar tracking system. In addition, the wires must be properly connected. High-quality cable with adequate gauge to carry electricity will enable optimum battery charging. Charge current may drop if the cable is too long. As a result, solar panels are often installed at a height of 10-20 feet above the ground. It is suggested that you clean your solar panel properly once a month. There are two parts to this: surface cleaning to eliminate dust and moisture, and terminal cleaning and reconnection.[5]

2. SOLAR ENERGY SYSTEM COMPONENTS

Energy generated by the sun is regarded to be environmentally friendly. Solar energy is a good alternative for homeowners looking to lower their utility expenses while also promoting clean, sustainable energy. It requires less upkeep and has a long lifespan with fewer mechanical losses, making it ideal for long-term operations (no moving parts are present).[6]

Solar energy system is divided into two types:

1. Off – Grid System
2. On – Grid System



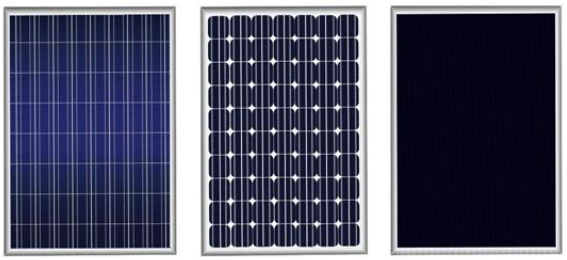
Basic components of solar power system (off-grid and on-grid) are as follows:

1. Solar panel: Solar panels are an essential component of a solar energy system since they convert sunlight to electricity. The individual solar cells that make up a solar panel. The photovoltaic

effect converts sunlight into direct current electricity when it touches these cells. Solar panels' output power is measured in watts.[7]

Common types of solar panels are as follows:

- **Polycrystalline solar panel** – Because they are multi-crystalline, they take up a lot of room. It is the most widely utilised solar installation technique, despite its lower efficiency and lower cost when compared to monocrystalline cells.
- **Monocrystalline solar panel** – Single-crystal cells are more efficient than polycrystalline cells since they are composed of a single piece of silicon. They take up less space but cost a little more.
- **Thin film solar panel** – They may be turned into flexible panels despite their thinness. They take up a lot more room and aren't very efficient.



New-generation solar panels, including those with perovskites, are on the verge of commercialization.

Passivated Emitter and Rear Cell or Passivated Emitter and Rear Contact (PERC): Monocrystalline and polycrystalline solar cells both employ PERC technology. Conventional silicon wafers are used to absorb light on the top surface of these solar cells. It is the inclusion of a dielectric passivation layer on the backside of the PERC solar cell that makes the difference between the two.[8]

2. **Array Junction Box:** Solar modules and inverters are connected via an array junction box.

Array junction box performs following functions:

- In order to link the output of many solar string lines in parallel, an array junction box is needed.
- For the purpose of protecting the panel against reverse current, each string has a blocking diode
- This function also provides protection against overcurrent and overvoltage.

3. Inverter*:* The solar energy system's inverter is sometimes referred to as its "heart." Solar panels create DC (Direct current) output, which is converted into AC (Alternating current) supply by this converter device.

The inverter, which converts DC to AC, is critical to the operation of most of the equipment in our home.

Aside from power conversion, inverters are useful for synchronising the generated electricity with the appliances. An inverter with or without a transformer is used to do this.[9]

Inverters are classified as follows:

Off -grid inverter – These inverters are completely independent of the electrical grid and do not need to be connected to it.

Grid inverter– Connected to the electrical grid, this sort of inverter is the most typical for domestic usage.

Grid inverters are further classified as:

String inverter: Due to their reasonable price and long-lasting technology, string inverters are in high demand. A single string inverter is constructed by connecting many strings together. It has a downside that if a single thread is destroyed or comes into direct sunlight, the entire converter may suffer.

Micro-inverter: When space is at a premium and the cost of a string-type inverter is prohibitive, this form of inverter is a better option because it's more expensive. There are independent inverters for each of the solar panels, which convert DC to AC energy. The remaining panels' functioning is unaffected even if one panel is broken or shadowed.

Central inverter: Unlike string inverters, which require a small inverter for each area of the plant, central inverters have a wide capacity range. When it comes to large-scale applications, they are most commonly employed.

Hybrid inverter– An off-grid and on-grid combination is known as a hybrid inverter. They may choose between solar power, battery backup, and grid connectivity for power distribution, which gives them a lot of options.

4. Solar racking and mounting (module support): Rooftop, ground-mounted, or individual

pole-mounted arrays are all viable options for mounting solar panels.[10]

To put a solar panel in any of the locations listed above, you'll need the right kind of support. Additionally, the solar panel mounting support aids in ensuring that the solar panels are positioned at an angle that maximises their exposure to the solar radiation.

Mounting support is of two types:

1. **Fixed mounts**– The advantages of a fixed mounting system include lower costs and the ability to remain in place. This type of installation is less effective when the sun's angle changes.
2. **Track mounts:** Using these mounts, the angle of the sun may be adjusted to suit the needs of the user. Track mounts are able to follow the sun's path throughout the day, resulting in the best possible results. They're more expensive than a fixed-mount system, but they're also more efficient. However, track mounts are better suited for bigger ground-mounted plants because of the additional maintenance they need.

5. Cabling system: These are the solar cables that depict the solar installation's veins and arteries. As the electricity is transferred from solar panels to the loads via an inverter, they are responsible for this task. [11]

In order to avoid overheating the system and maintain a reasonable cost, it's critical to choose the right solar cable. Size of solar cable is determined by the amount of power generated by the solar panels and the distance between solar panels and loads.

Solar cables are classified into two types:

- **AC cable** – Solar power inverters are connected to the grid through these connections, which subsequently distribute AC power to the grid or load.

- **DC cable** – The DC power generated by solar panels is sent to the inverter through these lines. They must be properly insulated because these wires will be exposed to the weather.

6. Distribution box: Electricity delivery systems include a distribution box or distributional panel(board).[12] It is commonly of two types:

- **DC Distribution Board (DCDB):** The DCDB connects the solar panel's output power to the inverter's input. Additionally, the DC distribution box can be equipped with surge protection devices to guard against system failure.
- **AC Distribution Board (ACDB):** Using an energy metre, ACDB transfers electricity from a solar inverter to the AC load system. A backup power supply (ACDB) is included to separate the solar system from the grid in the event of a power outage or other malfunction.

There is no better source of renewable energy than the sun, and it is free. It has the potential to outperform many traditional sources of energy at a lower cost if handled properly. However, relying only on solar power has significant drawbacks. The weather is the most important factor. What is the effect of snow on solar panels, and what is the effect of cloud cover? Many prospective solar panel purchasers have these questions on their minds. Such doubts are addressed here.

3. HOW VARYING WEATHER CONDITIONS CAN AFFECT THE PERFORMANCE OF YOUR SOLAR PV CELLS

- **Cloudy Environment**

Solar panels in overcast weather are less productive than on bright days since they rely on solar radiation to work. The amount of cloud cover affects the output of a solar panel on a cloudy day. Cirrocumulus or thin sheet-like clouds, for example, may not harm solar panels. When it's overcast, even the most efficient solar panels lose 10 to 25 percent of their efficiency. Instead of seeming horrible, rainy days may really be rather pleasant. The panels' output might be impaired if they become dirty over time. The dirt may be washed away by rainwater, which reduces the need for upkeep.[13]

- **Snowy Environment**

PV cells can be adversely affected by a high covering of snow, however even with a thin layer of snow, some sunlight can still reach the panels. The construction of a new roof is often done in such a way that snow just rolls off of it. The increased quantity of solar energy created by a snow-covered home is unexpected because of the snow's reflecting characteristics. Because of this, more radiation penetrates solar panels throughout the winter.

- **Extreme Temperatures**

It's a frequent belief that greater temperatures will make solar panels more efficient. This is not the case. Temperatures lower than 80 degrees Fahrenheit are better for solar panels. When the temperature goes above a specific level, the voltage drops. To put it another way, solar panels are more efficient when it's chilly and sunny outside.

- **Windy Environment**

Unfortunately, even though current panels can withstand gusts of up to 90 mph, poorly built panels may have a lower wind resistance than the more modern ones. Even if the system fails, the panels are rarely the limiting issue. Problems with the racking system or the roof on which the solar panels are installed are frequently to blame. In windy situations, the panels may also be damaged by dust and other flying debris. The vast majority of solar panels, on the other hand, are built to resist even the most extreme weather conditions.[14]

- **Lightning**

Damage or destruction of solar panels and inverters can occur as a result of lightning striking them. Direct lightning hits, for example, have the potential to melt the panels. Indirect lightning strikes, which are more common than direct strikes, can harm several components of the system. Lightning insurance may be a good idea if you reside in a region prone to lightning strikes. To keep the solar power plant safe from lightning, Genus has installed a lightning arrestor.

Despite adverse weather conditions, solar panels are becoming more durable and productive because to technological advancements. Clients must first learn about their own location before making any judgments about which panel to select.

4. CONCLUSION

Solar energy is the most plentiful renewable energy source accessible, and in most places of the world, its theoretical potential is much in excess of the present primary energy supply in such locations, physically speaking.. Energy availability in rural and isolated areas, long-term energy security, and greenhouse gas abatement are all possible outcomes of solar energy technology. In the last decade, the market for solar energy harvesting technology has grown dramatically, with grid-connected distributed PV systems and solar hot water systems in particular seeing impressive growth. In recent years, centralised utility-scale PV applications have developed significantly, while off-grid applications have become the main form of PV in developing countries. A increasing number of new installations, as well as projects in the planning phases, are feeding the need for bigger solar thermal technologies, were first emerged in the early 1980s. Even if the costs of solar energy technologies continue to decline, solar energy's lowest levelized cost may still be more than conventional power generation's maximum levelized cost. As of right now, the largest hurdle to broad adoption of solar energy is a lack of available resources. Financial, technological, and institutional hurdles continue to impede the growth of solar energy technologies. Solar energy production has increased as a result of tax and regulatory incentives.

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