

STUDYING THE IMPACT OF EXTERNAL FACTORS ON THE OPERATION OF SOLAR PANELS

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Abstract. *In this article, opinions and observations are presented on the impact of internal and external factors in the operation of solar panels. In the relentless pursuit of sustainable energy sources, solar power has emerged as a frontrunner, harnessing the sun's inexhaustible energy to meet the world's growing demand for electricity. The effectiveness of solar panels, however, is not solely dependent on the intensity of sunlight. A myriad of internal and external factors come into play, shaping the efficiency and overall performance of these photovoltaic wonders. At the core of every solar panel lies the solar cell, the elemental unit responsible for converting sunlight into electricity. The type of solar cell technology employed significantly impacts a panel's efficiency. Traditional silicon-based cells, while widely used, have limitations in terms of flexibility and cost. Emerging technologies, such as thin-film and organic solar cells, aim to address these drawbacks, offering potential advancements in efficiency, cost-effectiveness, and adaptability.*

Key words: *solar panels, internal factors, external factors, operation process, solar energy, photovoltaic cells, silicon technology, environmental impact, geographic location, solar irradiance, temperature management.*

INTRODUCTION.

The quality and purity of materials used in manufacturing solar panels play a pivotal role in their efficiency. Impurities and defects in the materials can hinder the movement of electrons, reducing the overall performance of the solar cells. Continuous advancements in material science are aimed at improving the purity of silicon, enhancing the conductivity of materials, and exploring alternative materials with superior photovoltaic properties [1, 164].

Solar cells are a set of individual silicon chambers that generate electricity from solar energy. There are several different advantages to using solar resources:

✓ First and foremost, it is environmentally friendly. Unlike the energy sources currently being used, which cause significant harm to the environment, replacing them is impractical. Solar energy, on the other hand, is absolutely safe for the environment in terms of production and utilization.

✓ Unlike other energy sources, solar energy is inexhaustible. The installation and utilization of solar panels provide an excellent solution. According to NASA research, the sun will continue to radiate its light for another 6.5 billion years.

✓ Solar energy has a very high potential. The amount of energy that can be harnessed for use far exceeds the demand. It is 20 times more than required, making it possible for future generations to effortlessly benefit from this energy without wasting it.

✓ Solar rays reach every point on Earth's surface, not limited to countries located near the equator. Even countries in the Northern Hemisphere can easily benefit from solar energy. Currently, Germany leads in the utilization of this energy among countries.

✓ It is inexhaustible. There is no depletion of resources in the production and utilization of solar energy.

✓ It is cost-effective. It requires minimal expenses for utilization.

Solar panels, while designed to be durable, are not immune to the accumulation of dust and pollutants on their surfaces [2, 318]. Over time, this layer of debris can obstruct sunlight, reducing the efficiency of the panels. Regular cleaning is a simple yet essential maintenance practice to ensure optimal performance. Additionally, advancements in self-cleaning technologies and anti-soiling coatings are being explored to mitigate the impact of dust and pollutants.

The maintenance of solar panels goes beyond cleaning. Regular inspections are crucial to identify and address potential issues such as faulty connections, damaged modules, or wear and tear. Proper maintenance not only ensures consistent performance but also extends the lifespan of the solar installation. As solar technology evolves, efforts are being made to enhance the durability and longevity of panels, making them a more sustainable and cost-effective investment.

Solar panels generate electricity when exposed to sunlight, making them most productive during daylight hours. However, to meet the energy demands during the night or on cloudy days, an effective energy storage solution is necessary. Energy storage systems, such as batteries, store excess electricity generated during peak sunlight hours for later use. Advances in energy storage technologies complement solar panels, providing a more reliable and continuous power supply [3, 83].

RESEARCH METHODOLOGY.

The integration of solar panels with smart grids represents a significant advancement in the utilization of solar energy. Smart grids allow for real-time monitoring of energy production and consumption, enabling better management of electricity flow. This integration enhances grid

stability, facilitates demand response strategies, and promotes the seamless incorporation of solar power into existing energy infrastructures.

Community solar projects are gaining popularity as a means of making solar energy accessible to a broader audience. These initiatives involve shared solar installations that multiple individuals or entities can contribute to and benefit from. Community solar projects promote inclusivity, allowing those without suitable rooftops or financial means to participate in the clean energy transition [4, 638]. The widespread adoption of solar panels is often influenced by government incentives and policies. Subsidies, tax credits, and feed-in tariffs encourage individuals and businesses to invest in solar technology. Progressive policies aimed at promoting renewable energy contribute to the growth of the solar industry, fostering a more sustainable energy landscape.

The landscape of solar panel technology is dynamic, with continuous research and innovation pushing the boundaries of efficiency and sustainability. Breakthroughs in materials science, quantum dot technology, and novel designs hold the promise of further enhancing the performance of solar panels. Research initiatives also focus on developing solar panels with increased flexibility, transparency, and integration capabilities, expanding their applications across various industries [5, 132].

The process of working solar panels extends far beyond the fundamental principles of photovoltaics. From internal mechanisms and external influences to maintenance practices, energy storage, and innovative applications, the journey of solar energy is marked by a constant pursuit of efficiency, reliability, and accessibility. As we navigate the evolving landscape of solar technology, the synergy of these elements propels us toward a future where clean, renewable energy is not just an option but a mainstream reality. The intricate dance of photons, materials, and engineering ingenuity is not only illuminating our present but shaping a sustainable and bright future for generations to come.

The design and architecture of solar panels also influence their efficiency. Factors such as the arrangement of solar cells, the type of connection between cells, and the overall panel design impact how efficiently sunlight is captured and converted into electricity. Innovations in panel design, such as bifacial panels that can capture sunlight from both sides, are continuously pushing the boundaries of efficiency.

Perhaps the most apparent external factor is solar irradiance, the amount of sunlight reaching the Earth's surface. Different regions experience varying levels of solar irradiance, influenced by factors like latitude, altitude, and local weather patterns. For instance, locations near

the equator receive more consistent and intense sunlight throughout the year compared to regions at higher latitudes. Understanding a specific geographic location's solar potential is crucial in optimizing the installation and performance of solar panels [6, 136].

Solar panels are most effective when operating at lower temperatures. However, ironically, they generate heat while converting sunlight into electricity. Excessive heat can reduce the efficiency of solar cells, a phenomenon known as the temperature coefficient. This makes effective heat management essential for maintaining optimal performance. Advances in cooling technologies, such as integrated cooling systems and smart panel designs, aim to mitigate the impact of elevated temperatures on solar panel efficiency.

Shading is a critical external factor that can significantly diminish the output of solar panels. Even a small amount of shading, caused by objects like nearby buildings, trees, or debris, can lead to a drop in efficiency. This is due to the interconnected nature of solar cells, where shading on one cell affects the performance of the entire array. Proper site selection, the use of anti-reflective coatings, and innovative shading solutions contribute to minimizing the impact of obstructions.

The accumulation of dust and pollutants on the surface of solar panels can obstruct sunlight, reducing their efficiency. Regular maintenance, including cleaning, is essential to ensure optimal performance. In areas with high levels of air pollution, the deposition of particulate matter on the panels can be a persistent challenge. Research into self-cleaning and anti-soiling technologies is ongoing to address this issue and reduce the maintenance requirements of solar installations.

ANALYSIS AND RESULTS.

The journey of sunlight to electricity through solar panels is a complex dance influenced by a myriad of internal and external factors. From the microscopic intricacies of solar cell technology to the macroscopic considerations of geographic location and environmental conditions, each element plays a crucial role in shaping the efficiency and effectiveness of solar panels. As technological advancements continue to push the boundaries of solar energy, a holistic approach that considers both internal innovations in materials and design, as well as external factors like solar irradiance and environmental challenges, is essential. The synergy between these elements holds the key to unlocking the full potential of solar power and establishing it as a sustainable cornerstone in our global energy landscape.

In an era where sustainable energy solutions are paramount, solar panels have emerged as a beacon of hope, harnessing the sun's inexhaustible energy to power our world. The process by

which solar panels operate is a captivating journey that involves intricate technology, harnessing the power of photons, and transforming sunlight into a clean and renewable source of electricity.

The process begins with the sun, our celestial powerhouse, emitting photons – particles of light. Solar panels are equipped with photovoltaic cells, usually made of silicon, which have the remarkable ability to absorb these photons. When a photon strikes a solar cell, it excites electrons, knocking them loose from their atoms in a process known as the photoelectric effect.

As photons bombard the solar cells, they impart energy to the electrons, causing them to break free from their atomic bonds. This creates electron-hole pairs, where the negatively charged electrons are set loose, leaving behind positively charged holes in their stead. The liberated electrons now have the potential to move and generate an electric current.

The movement of electrons, triggered by the energized photons, constitutes an electric current. This flow of electrons is harnessed by the structure of the solar panel, typically made up of multiple interconnected cells. The electric current generated by each cell combines to form a direct current (DC), the primary type of electricity produced by solar panels.

While solar panels produce direct current, most of our electrical appliances and the grid itself operate on alternating current. This necessitates the role of an inverter, a crucial component in the solar panel system. The inverter converts the DC produced by the solar panels into AC, making it compatible with household appliances and the broader electrical grid.

The transformed AC electricity is now ready for consumption. For residential solar installations, the electricity can either be used directly to power appliances or be fed back into the electrical grid, earning credits through net metering. In larger utility-scale solar installations, the electricity generated can contribute to powering communities, cities, and even entire regions [7, 153].

At the heart of every solar panel are photovoltaic cells, and the choice of cell technology significantly impacts the panel's efficiency. Silicon-based cells, both monocrystalline and polycrystalline, are the most common due to their stability and efficiency. Emerging technologies, such as thin-film and organic solar cells, offer exciting possibilities for improved efficiency and cost-effectiveness.

Solar cells are not standalone entities; they are organized into modules that collectively form a solar panel. These modules are encapsulated in protective layers, typically made of tempered glass, to shield the cells from environmental factors like weather, dust, and debris. The encapsulation process ensures the durability and longevity of the solar panel, allowing it to withstand the rigors of the elements.

The efficiency of solar panels is intricately linked to the intensity of sunlight, which varies depending on geographic location, time of day, and weather conditions. Regions closer to the equator receive more direct sunlight, optimizing the performance of solar panels. Understanding solar irradiance patterns is crucial for effective site selection and system design.

Temperature plays a dual role in the efficiency of solar panels. While the photoelectric effect benefits from the warmth of sunlight, excessive heat can have adverse effects on the overall performance of solar cells. The temperature coefficient, a measure of this impact, is an essential consideration in optimizing the efficiency of solar panels. Cooling technologies and smart design strategies help mitigate the challenges posed by elevated temperatures.

✓ Solar panels use a special type of cell called a photovoltaic cell to generate electricity by converting photons into electrons through a specific process. These cells are typically found in calculators and small gadgets. When these cells are connected together, forming a bank, they are collectively referred to as a solar panel.

✓ Photovoltaic cells are made of semiconducting materials, often silicon. The semiconducting material absorbs sunlight. When this happens, the photons from the sunlight release some of the electrons in the semiconducting material, allowing them to move freely, creating an electric current.

✓ Each cell contains an electric field that helps direct the flow of electrons. When these electrons encounter a metal contact on the photovoltaic element, they can create an electric current, providing a means to power devices or be stored for later use.

Silicon crystals are structured in a tetrahedral shape, with each silicon atom holding fourteen electrons. Two of these tetrahedra are complete and symmetrical, containing eight and sixteen electrons respectively. The third tetrahedron, which holds the remaining four electrons, is only half-filled. To complete the third tetrahedron, silicon electrons form bonds with nearby atoms, creating the crystalline structure [8, 195].

DISCUSSION.

Naturally, silicon is not a good conductor due to the absence of free electrons. To facilitate the movement of electrons, especially in solar panels, a specific, impure form of silicon is used, known as amorphous silicon. By introducing other atoms to silicon atoms, a varying quantity of free electrons is generated. These electrons do not form strong bonds, allowing them to move freely when exposed to sunlight. Silicon is naturally very brittle and reflective. Therefore, an anti-reflective coating is applied to solar cells to minimize reflection and enhance light absorption. To

protect silicon from external elements, a glass cover is often placed on top, providing additional durability and shielding.

Even a small amount of shading can cast a significant shadow on the performance of solar panels. Trees, buildings, and other obstructions can lead to a reduction in energy production. This emphasizes the importance of strategic placement and regular maintenance to minimize shading effects and ensure continuous efficiency.

Solar panels are a rapidly evolving source of renewable energy that has become highly beneficial for the environment. The process of converting solar rays into electrical energy has significantly improved over the past several decades and is now highly efficient. While solar energy has been utilized for many years in small devices like calculators, nowadays, many are discussing using these panels to power homes and businesses [9, 80].

Due to its abundance, solar energy is currently one of the most promising renewable energy sources. Sunlight can produce approximately 1000 watts of energy per square meter of the Earth's surface. Accumulating this energy, we need not worry about the depletion of the sun in our lifetime. Solar photovoltaic systems harness solar radiation to generate electrical energy, making it feasible for powering your home or office, thus reducing your carbon footprint and minimizing environmental impact.

Solar energy is generated through the use of solar panels. Solar energy panels can operate by harnessing the solar energy obtained from the sun. Each solar energy panel contains various silicon cells or solar batteries, which are the building blocks of solar panels. Solar energy is absorbed by these solar cells. The solar energy obtained from the sun is converted into electrical energy through the operation of solar panels.

CONCLUSION.

The process of solar panels transforming sunlight into electricity is a symphony of physics, materials science, and engineering ingenuity. From the moment photons dance on the surface of photovoltaic cells to the delivery of electricity to our homes and communities, the journey is a testament to human innovation and the untapped potential of renewable energy. As we continue to refine solar panel technologies, exploring new materials, design innovations, and addressing external variables, we move closer to a future where solar power plays an even more significant role in our global energy landscape. The intricate dance of internal mechanisms and external influences is steering us towards a brighter, more sustainable future, one sunbeam at a time.

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