

Progressive Research & Development on Solar Photovoltaic Technology

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ABSTRACT

The issues of climate change and the dwindling supply of fossil fuels, alternative energy sources have emerged to address these challenges. PV technologies, such as solar photovoltaics, are widely regarded as an environmentally friendly and renewable option. With an extensive collection of scientific resources and ongoing research and development, the field of inquiry has expanded considerably. In addition to cellular technologies, other components of the balance of the system include publications and patents. Therefore, the Research related to panels, electronics, and energy storage holds significant importance in the field. This article explores the subject matter in detail.

KEYWORDS: *Solar photovoltaics, Renewable energy, PV Cell Technologies, Solar cell, Emerging Technologies.*

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INTRODUCTION

Renewable energy refers to energy derived from sources that are naturally replenished on a human timescale. Unlike fossil fuels, which are finite and contribute to environmental degradation through emissions of greenhouse gases, renewable energy sources are considered more sustainable and environmentally friendly. Here are some key types of renewable energy:

Solar Energy:

Photovoltaic (PV) Solar Power: Solar cells convert sunlight into electricity. Solar panels, composed of multiple solar cells, are widely used for residential, commercial, and industrial applications. This

technology harnesses the sun's heat to generate electricity. Concentrated Solar Power systems use mirrors or lenses to focus sunlight onto a small area, creating high temperatures to produce steam and drive turbines.

Wind Energy: Wind energy is captured by wind turbines that convert the kinetic energy of the wind into electricity. Onshore and offshore wind farms are common installations.

Hydropower: Energy is generated by the movement of water, usually from dams or flowing rivers, turning turbines connected to generators. It's one of the oldest and most widely used renewable energy sources.



Fig.1 Renewable Energy system

Geothermal Energy: Heat from the Earth's interior is used to generate steam, which turns turbines connected to generators. Geothermal energy is harnessed in areas with geothermal activity, such as geysers or hot springs.

Biomass Energy: Organic materials, such as wood, crop residues, and organic waste, can be burned or converted into biofuels like biodiesel and ethanol. Biomass can be used for heating, electricity generation, or as a fuel source for vehicles.

Tidal and Wave Energy: Energy is generated by harnessing the movement of tides. Tidal turbines and tidal barrages are two common technologies. Energy is captured from the motion of ocean waves using various technologies such as oscillating water columns or point absorbers. Hydrogen, often produced using renewable energy, can be used in fuel cells to generate electricity with water vapor as the only byproduct.

Renewable energy technologies have been rapidly advancing, driven by increasing awareness of environmental issues and the need to transition away from fossil fuels. Government incentives, technological innovations, and economies of scale have contributed to the growing competitiveness of renewable energy sources in many regions. The adoption of renewable energy is seen as a crucial component of efforts to mitigate climate change, reduce air pollution, and achieve energy security. As technology continues to advance, it is expected that the share of renewable energy in the global energy mix will continue to grow.

A general overview of the progressive research and development trends in solar photovoltaic (PV) technology up to that point. Keep in mind that there may have been further advancements since then.

Efficiency Improvements: Researchers have been consistently working on enhancing the efficiency of solar cells. This involves developing new materials, improving manufacturing processes, and exploring novel cell architectures. Tandem solar cells, which combine different materials to capture a broader spectrum of sunlight, have shown promise in boosting efficiency.

Perovskite Solar Cells: Perovskite solar cells have gained attention due to their potential for high efficiency, low-cost production, and flexibility. Ongoing research is focused on addressing stability issues and scaling up production processes to make perovskite solar cells commercially viable.

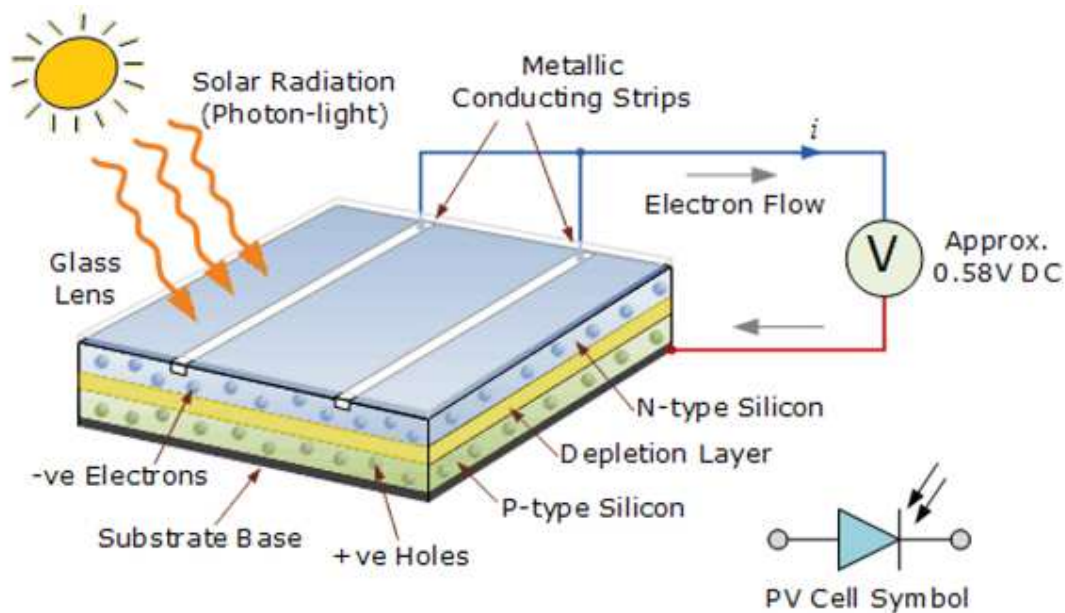


Fig.2 Construction of solar cell

Bifacial Solar Panels: Bifacial solar panels can capture sunlight from both the front and rear sides, increasing energy yield. Research is ongoing to optimize the design of bifacial panels and to understand their performance in different environmental conditions.

Advanced Manufacturing Techniques: Improving the manufacturing processes of solar panels is crucial for reducing production costs. Technologies like advanced robotics, machine learning, and automation are being integrated into manufacturing facilities to enhance efficiency and lower the overall cost of solar PV systems.

Energy Storage Integration: The integration of energy storage solutions, such as advanced batteries, with solar PV systems is a key area of research. This helps address the intermittent nature of solar energy production and enhances the reliability of solar power.

Transparent Solar Cells: Researchers are exploring the development of transparent solar cells that can be integrated into windows or other transparent surfaces. This technology could potentially enable the generation of solar power without obstructing light and visibility.

Smart Grid Integration: The development of smart grid technologies facilitates the efficient integration of solar power into existing electrical grids. This includes advanced monitoring and control systems to manage fluctuations in solar energy production and demand.

Environmental Impact Reduction: Researchers are working on reducing the environmental impact of solar PV technologies, including the development of more sustainable materials and recycling processes for solar panels.

Space-based Solar Power: Although still in the conceptual stage, space-based solar power involves capturing solar energy in space and transmitting it to Earth. Research in this area explores the feasibility, efficiency, and potential benefits of such a system.

It's essential to stay updated on the latest developments by referring to recent scientific publications, industry reports, and news from reputable sources in the field of solar photovoltaic technology.

Solar photovoltaics (PV) is a technology that converts sunlight directly into electricity. It's a key player in the renewable energy landscape and has seen significant advancements and widespread adoption in recent years. Here are key aspects of solar photovoltaics:

Photovoltaic Cells:

Solar cells, also known as photovoltaic cells, are the building blocks of solar panels. These cells are made of semiconductor materials, often silicon. When sunlight strikes these cells, it generates an electric current through the photovoltaic effect.

Solar Panels:

Solar panels consist of an array of interconnected solar cells. The panels are designed to capture and convert sunlight into electricity efficiently. They are the primary components of solar PV systems.

Types of Solar Panels:

Monocrystalline Solar Panels: These are made from single-crystal silicon, offering high efficiency and a sleek, uniform appearance.

Polycrystalline Solar Panels: Made from multiple silicon crystals, they are less expensive to produce but slightly less efficient than monocrystalline panels.

Thin-Film Solar Panels: These use thin layers of semiconductor material, offering flexibility and lower production costs but generally lower efficiency.

Solar PV System Components:

Inverters: Convert direct current (DC) generated by solar panels into alternating current (AC) used in homes and businesses.

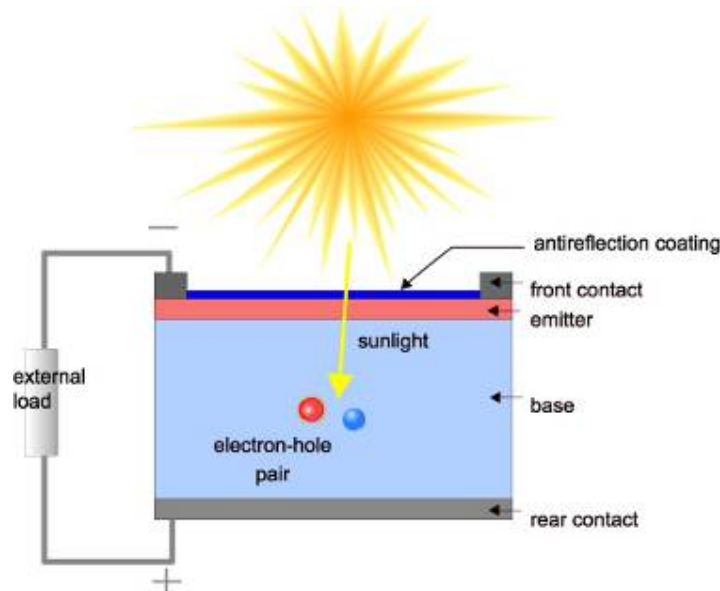


Fig.3 Solar PV cells

Mounting and Tracking Systems: Position solar panels optimally for sunlight exposure, maximizing energy production.

Balance of System (BOS) Components: Include wiring, switches, and other components that make up the rest of the solar PV system.

Grid-Connected and Off-Grid Systems:

Grid-Connected Systems: Most common, where solar PV systems are connected to the local electrical grid. Excess energy can be fed back into the grid, and electricity from the grid is used when solar generation is insufficient.

Off-Grid Systems: Used in remote locations without access to the grid. These systems typically include energy storage solutions, such as batteries, to provide power when the sun is not shining.

Solar Energy Storage:

Battery Storage: With advancements in energy storage technologies, solar PV systems can store excess energy for later use, providing a consistent power supply even when the sun is not shining.

Solar PV Efficiency: Ongoing research aims to improve the efficiency of solar cells, making them more cost-effective and increasing the amount of electricity generated per unit of sunlight.

Cost Trends: The cost of solar PV has been steadily decreasing due to advancements in technology, increased production scale, and improved manufacturing processes.

Integration with Other Technologies:

Solar PV is often integrated with other technologies, such as smart grids, to enhance overall energy efficiency and reliability.

Environmental Impact: Solar PV is considered a clean and sustainable energy source, producing electricity without emissions of greenhouse gases or air pollutants during operation.

As solar PV technology continues to evolve, it plays a crucial role in the global transition to a more sustainable and renewable energy future. Governments, businesses, and individuals are increasingly investing in solar PV systems as part of broader efforts to combat climate change and reduce dependence on fossil fuels.

Emerging technologies

Emerging technologies are technologies whose development, practical applications, or both are still largely unrealized. These technologies are generally new but also include older technologies finding new applications. Emerging technologies are often perceived as capable of changing the status. Emerging technologies are characterized by radical novelty (in application even if not in origins), relatively fast growth, coherence, prominent impact, and uncertainty and ambiguity. In other words, an emerging technology can be defined as "a radically novel and relatively fast growing technology characterised by a certain degree of coherence persisting over time and with the potential to exert a considerable impact on the socio-economic domain(s) which is observed in terms of the composition of actors, institutions and patterns of interactions among those, along with the associated knowledge production processes. Its most prominent impact, however, lies in the future and so in the emergence phase is still somewhat uncertain and ambiguous.

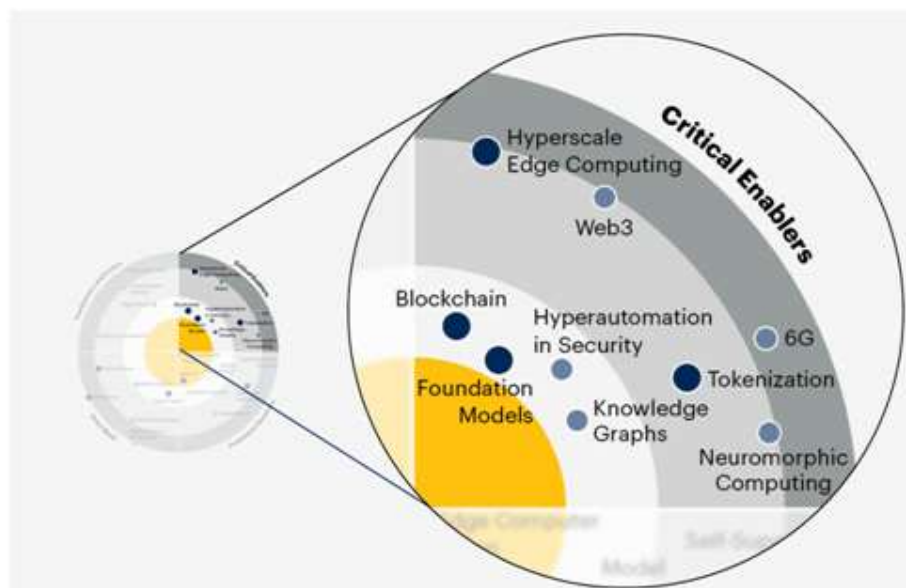


Fig.4 Emerging Technology

Emerging technologies include a variety of technologies such as educational technology, information technology, nanotechnology, biotechnology, robotics, and artificial intelligence. New technological fields may result from the technological convergence of different systems evolving towards similar goals. Convergence brings previously separate technologies such as voice (and telephony features), data (and productivity applications) and video together so that they share resources and interact with each other, creating new efficiencies.

Emerging technologies are those technical innovations which represent progressive developments within a field for competitive advantage; converging technologies represent previously distinct fields which are in some way moving towards stronger inter-connection and similar goals. However, the opinion on the degree of the impact, status and economic viability of several emerging and converging technologies varies.

CONCLUSION-

Annually, the global energy consumption is rising, and various technologies are being employed to generate power in order to meet this need. These days, environmental pollution is a major issue as well since fossil fuels are used more often to provide electricity. The past several decades have seen a significant advancement in solar photovoltaic technology, which can be crucial in meeting the world's enormous energy demand. An enormous number of PV systems built each year demonstrates.

Sunlight based PV innovation is filling quickly in past many years and can assume a significant part to accomplish the high energy request around the world. Colossal measure of PV frameworks introduced yearly shows the earnestness

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