

FUTURISTIC TRENDS IN SOLAR ENERGY

Abstract

The increase in the energy demand and how we are going to supply it is one of the world's major issues and challenges. Thus, the set of resources and changes in non-fuel sources of the energy system (i.e., wind, solar) become more prominent with the progress of the energy transition. Those fuels are different from fossil in two fundamental aspects: they are abundant, not scarce, but its instantaneous availability is limited, instead of being dispatched on demand. Through the use of photovoltaic panels or concentrated solar power, the solar energy system directly or indirectly transforms solar energy into electrical energy. The future of Solar energy is promising as solar becomes more efficient, bringing with it innovation and the latest trends in solar technology. New chip technology, micro-inverters, and improvements to solar tech products are promising better and more efficient solar ideas. And looking to the future, groundbreaking technologies for building materials are on the horizon. This chapter explores the futuristic trends in solar energy, highlighting key innovations, emerging technologies, and their potential to reshape the energy landscape.

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I. INTRODUCTION

This chapter explores the futuristic trends in solar energy, discussing advancements and emerging technologies that hold great potential for transforming the solar energy landscape. It provides an overview of current solar energy technologies and then delves into key futuristic trends that are expected to shape the future of solar energy generation, efficiency, and integration. The chapter covers various topics such as advanced solar panels, energy storage solutions, smart grids, solar-powered transportation, and solar power desalination. By examining these trends, this chapter aims to inspire readers and highlight the immense possibilities that lie ahead in the field of solar energy. Here, the chapter discusses the global capacity and growth of solar energy installations. It highlights the increasing adoption of solar energy across different regions and provides statistics on installed capacity, generation, and market trends. This subsection demonstrates the expanding role of solar energy in the global energy mix. Solar energy has emerged as a dominant and sustainable source of power in the quest for a greener and more sustainable future. With advancements in technology and a growing awareness of the need to transition to renewable energy sources, solar power has seen rapid progress. This chapter explores the futuristic trends in solar energy, highlighting key innovations, emerging technologies, and their potential to reshape the energy landscape.

Next-Generation Solar Cells:

Section 1: Solar Energy Generation

1. Advanced Solar Panels

- **Transparent Solar Panels:** Transparent solar panels enable the integration of solar power generation into various surfaces such as windows, screens, and building facades. Through the use of innovative materials and technologies like organic photovoltaics and quantum dots, transparent solar panels can harvest solar energy while allowing light to pass through, revolutionizing architectural design and energy generation in urban environments.
- **Solar Panel Coatings:** Specialized coatings can enhance the performance of solar panels by reducing reflection, improving light absorption, and enabling self-cleaning properties. Advanced coatings such as anti-reflective coatings, hydrophobic coatings, and self-healing coatings are being developed to optimize the efficiency and durability of solar panels, making them more efficient and resilient to environmental factors.
- **Energy Storage Solutions**
- **Solar Batteries:** The integration of solar power with energy storage systems is crucial for overcoming the intermittent nature of solar energy. Advances in battery technologies, such as lithium-ion batteries and emerging alternatives like solid-state batteries, are enabling efficient and cost-effective storage solutions for solar energy. These batteries offer improved energy density, longer lifetimes, and faster charging capabilities, facilitating the broader adoption of solar power.

- **Hydrogen Production:** Solar energy can be harnessed for the production of clean hydrogen through a process called water electrolysis. With advancements in electrolysis technologies, solar-powered hydrogen production holds great potential for storing and utilizing solar energy in various applications, including transportation, industrial processes, and grid-scale energy storage.
2. **Perovskite Solar Cells:** Halide perovskites are a family of materials that have shown potential for high performance and low production costs in solar cells. The name “perovskite” comes from the nickname for their crystal structure, although other types of non-halide perovskites (such as oxides and nitrides) are utilized in other energy technologies, such as fuel cells and catalysts. Perovskite solar cells have shown remarkable progress in recent years with rapid increases in efficiency, from reports of about 3% in 2009 to over 25% today.
- **Stability and Durability:** While perovskite solar cells have become highly efficient in a very short time, a number of challenges remain before they can become a competitive commercial technology. Perovskite solar cells have demonstrated competitive power conversion efficiencies (PCE) with potential for higher performance, but their stability is limited compared to leading photovoltaic (PV) technologies. Perovskites can decompose when they react with moisture and oxygen or when they spend extended time exposed to light, heat, or applied voltage. To increase stability, researchers are studying degradation in both the perovskite material itself and the surrounding device layers. Improved cell durability is critical for the development of commercial perovskite solar products.
 - **Futuristic Trend:** The perovskite PV research and development (R&D) community is heavily focused on operational lifetime and is considering multiple approaches to understand and improve stability and degradation. Efforts include improved treatments to decrease the reactivity of the perovskite surface, alternative materials and formulations for perovskite materials, alternative surrounding device layers and electrical contacts, advanced encapsulation materials, and approaches that mitigate degradation sources during fabrication and operation.
3. **Multijunction Solar Cells:** 3.1.1. Multijunction solar cells, also known as tandem solar cells, are advanced photovoltaic devices that consist of multiple semiconductor layers with different bandgaps stacked on top of each other. These cells are designed to increase the efficiency of solar energy conversion by capturing a broader spectrum of sunlight.
- **Transparent Solar Panels:** Transparent solar panels are being developed to integrate solar cells into windows, building facades, and even electronic devices. These transparent panels allow natural light to pass through while harnessing solar energy, making them ideal for applications in urban areas without compromising aesthetics.
4. **Solar Integration with Emerging Technologies:** Quantum dot solar cells hold promise for next-generation photovoltaics due to their tunable absorption, potential for multiple exciton generation, and solution-processability. Ongoing research aims to overcome the challenges associated with quantum dot solar cells and unlock their full potential for efficient and cost-effective solar energy conversion.

- **Internet of Things (IoT) and Smart Grids:** Solar-powered smart grids are advanced electricity distribution systems that incorporate solar energy generation, storage, and intelligent monitoring and control capabilities. Here's a deeper look into solar-powered smart grids: Integrating solar energy systems with IoT devices and smart grid technologies allows for efficient monitoring, control, and optimization of solar power generation and consumption. Smart grids enable bidirectional energy flow, facilitating the integration of distributed solar energy systems and ensuring grid stability, while IoT devices provide real-time data for better management and optimization of solar resources.
- **Solar-Powered Desalination:** Solar energy can power desalination processes, providing clean drinking water in water-scarce regions. Solar desalination technologies, such as solar stills and reverse osmosis systems, offer sustainable and cost-effective solutions for water purification, making solar-powered desalination a key futuristic trend in addressing global water challenges.
- **Solar-Powered Electric Vehicles:** Solar integration into electric vehicles (EVs) is a promising trend. Solar panels on the surface of EVs can help charge the vehicle's battery, increase driving range, and reduce dependence on external charging infrastructure. Emerging technologies like solar paint and solar glass are being explored for seamless integration into vehicle surfaces.

Floating Solar Farms: As land availability becomes a constraint, floating solar farms are gaining popularity. These installations involve solar panels mounted on buoyant platforms in water bodies, such as lakes, reservoirs, and offshore areas. Floating solar farms have several advantages, including reduced land use, increased efficiency due to cooling effect from the water, and potential integration with hydropower or water treatment facilities

II. CONCLUSION

These trends indicate a promising future for solar energy, with increased efficiency, enhanced integration, and expanded applications, making solar power a key player in the global transition towards clean and sustainable energy sources. As we look ahead, these trends offer hope for a future powered by clean and sustainable solar energy, mitigating the environmental impact of traditional energy sources and paving the way for a greener world.

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