International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.141
Peer Reviewed Bi-Monthly
Vol. 6 No. 18 March - April - 2025

Solar Energy Resources and PV System: A Comprehensive Overview

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DOI - 10.5281/zenodo.14784834

Abstract:

Solar energy is a vital renewable energy source with the potential to address the growing global energy demand and mitigate climate change. This paper provides a comprehensive overview of solar energy resources, including their availability and characteristics, and delves into the intricacies of photovoltaic (PV) systems, from their basic principles to advanced applications. We explore the different types of PV systems, their components, performance analysis, and the challenges and opportunities associated with their widespread deployment.

Keywords: Solar energy, renewable energy, global energy demand, climate change, photovoltaic (PV) systems, PV system types, PV components, PV performance analysis, PV deployment, solar resources, solar availability, solar characteristics

Introduction:

The increasing global energy consumption, coupled with the detrimental effects of fossil fuels on the environment, has necessitated a shift towards sustainable and clean energy sources. Solar energy, derived from the sun's radiation, offers a promising solution. This paper examines the abundance and characteristics of solar resources and provides a detailed analysis of PV systems, which convert sunlight directly into electricity.

[1] Daning Hao et al. The introduction of a variety of electrical uses has greatly enhanced many important facets of civilization, including housing, transportation, and healthcare, and power production for electricity applications has been a prominent area of research. Self-powered photovoltaic (PV) technologies have promise for solving power supply issues in applications, reducing traditional energy loads, and reducing pollutants in the environment. Solar energy harvesting (SEH) solutions for PV self-powered applications are reviewed in this paper. First, possibilities of PV self-powered applications and PV power generation are examined. Second, a system design study is provided for PV self-powered applications. Third, there is a thorough discussion of the essential elements for PV self-powered applications, such as power management (PM) systems and maximum power point tracking (MPPT) strategies. Additionally, a summary of several PV self-powered applications and energy collecting uses is provided. Lastly, several suggestions are made for additional study. Solar radiation analysis, PV system design, and hybrid energy system design, such as hybrid PV-wind and hybrid PV-wave systems, are covered in this study. Deep decarbonization is now possible with multi-energy renewable systems. We propose a cost-effective two-phase decarbonization approach to attain deep

decarbonization, which consists of implementing a carbon emission cap after increasing the use of renewable energy sources to reduce dependency on fossil fuels

[2]. technology for solar energy, Sumedha Weliwaththage, R.G., et al., 2020: Solar energy and developments in solar energy technology are the main topics of this study. This paper examines the shortcomings of both the new solar energy harvesting method—the solar cell and its material—and the solar energy technology. It discussed more efficient power generation through the use of solar energy

[3].Mohd Rizwan et.al [4] – A review paper on electricity generation from solar energy 2017: In this paper authors explained Solar energy, derived from sunlight, is a clean, abundant, and renewable resource capable of meeting global energy demands. Directly converting sunlight into electricity via photovoltaic cells offers a cost-effective and environmentally friendly alternative to fossil fuels. This article explores solar energy's potential, discussing its working principles, various panel types, diverse applications (industrial, commercial, and residential), and future trends, emphasizing its benefits and promoting wider adoption. With decreasing costs and technological advancements, solar energy is poised to play a crucial role in a sustainable future.

Humans require more energy to provide better living conditions as their population increases and economic and technical advancements quicken. In contrast, conventional fossil fuels are contributing to several environmental problems, including as acid rain, air pollution, climate change, and global warming. To solve the political, economic, and environmental issues associated with electricity generation, renewable energy technology must be developed. When it comes to assessing the new energy source's economic viability, the rise of these energies in recent years has caught the interest of academics, policymakers, and corporate executives [5]–[9].

Types of PV Technologies:

Examining the panorama of PV innovation requires looking at a variety of developed PV technologies. They mostly use cost-effective poly-Si, efficiency-focused mono-Si, mono PERC, and clever half-cut solar cells that are intended to increase efficiency.

Monocrystalline Silicon (Mono-Si) Solar Cells:

Mono-Si is a cutting-edge PV technology that achieves remarkable energy conversion efficiency by using single-crystal ingots. Sun et al. [10] developed a forensic algorithm to differentiate between computer-generated and natural photos and investigated the conversion efficiency of monocrystalline silicon solar cells using statistical distribution law. Additionally, electrochemical etching is presented for the creation of porous silicon. The study's authors used processing methodologies, mathematical methods, statistical methods, and experimental procedures to validate statistical methods and provide references for similar research [10]. Boulmrharj and associates [11] studied Morocco's shift to renewable energy sources (RES), especially solar power, in an effort to cut back on imports of electricity and fossil fuels. In El Jadida, Morocco, three silicon-based grid-connected photovoltaic systems were compared in Mediterranean climates. Polycrystalline silicon and monocrystalline silicon systems outperformed micromorph tandem systems in terms of final yield, performance ratio, and capacity factor [11].

Polycrystalline Silicon (Poly-Si) Solar Cells:

Poly-Si uses several silicon crystals to provide a viable alternative to solar energy production, using economic efficiency, without sacrificing its potential.

Tariq et al. [12] studied the mechanical behavior of the sunny elements in polycrystalline silicon (PSSC) in photoelectric modules. Using the final element method (FE), they used the Voronoi transaction scheme and the homogenized scheme of the average field to predict a homogenized response. This study compared heterogeneous and homogeneous modeling and studied the deterioration of stiffness caused by existing microfissories. Homogenized Fe solutions are progressive failures of solar elements in effective and computer-effective ways [12]. The accumulation of dust in photoelectric modules can cause significant loss of culture. Researchers collected and analyzed five seats of dust in Northern Albatin, Oman. In total, 5 g/m2 contamination of single crystal modules reduced power by 12%, 6%, 6%, 3%, 4%, and 4%, respectively. The fractures of the polycrystalline module were 5%, 4%, 4%, 1%, 2%, and 2%. This study includes regular beach purification intervals for polycrystalline and single crystal modules from 10 to 15 days respectively [13].

Monocrystalline Passivated Emitter and Rear Cell (Mono-PERC):

Monopark leads to a new stage of improving light capture through the reflective rear, increasing efficiency due to advanced design. Es et al. [14] predicted that the concept of passive emitter and rear cells (Perc) will dominate the PVS industry in the future. Pilot lines, such as the PV Gunam line, connect laboratory concepts with mass products. The authors focus on standard sunny elements of PERC with the basis of P-type and posterior passivation AL2O3 and demonstrate how to use analysis of losses in industrial environments [14]. Lunardi et al. [15] We conducted an environmental analysis by comparing the monocrystalline solar modules Al-BSF and PERC. Using the methods of assessing the life cycle (LCA), they calculated global warming, human toxicity, EU freshwater trimal, ecotoxicity, the potential of abiotic exhaustion and the time of payback of energy. Compared to AL-BSF, PERC technology slightly improves environmental impact, while metallurgical levels of electronic and modernized silicon reduce the impact [15].

Half-Cut Solar Cells:

The effectiveness dynamics of the solar element were redesigned using semi-visible solar elements that justify the usual approach, significantly reducing the loss of shading. Researchers have uncovered potential pathways that minimize loss-related losses by increasing the efficiency of the output product and dividing cells in half to optimize the compounds. Shukir et al. [16] Vedat Kiray et al. [11] discusses obstacles to self-generated energy in a home, such as locations in shade above the roof, slopes, resistance, and exposure. Solar energy monitoring systems increase efficiency, but are not aesthetically pleasant. The article offers a double sun tracking system and an aesthetic arbor to solve these problems. A design study examined the dimensions of a mobile platform / roof and calculated the annual energy collected by pvpanels using a simulation program known as "PV Performance Tool" [17]. Table 1 presents a comparative analysis of different studies classified according to their contexts: computer research, field research and experimental research. These research settings serve in order to emphasize the focus of each study.

Structural Considerations for Solar Panel Installations:

Structural considerations are required to safely and effectively integrate solar panel installations into the building. Engineers carefully evaluate load charge and architecture compatibility, optimize solar panel placement and maximize energy capture. Eltayeb et al. [18] proposes a study on the design of a 3 kW hybrid tree with wind and solar capacity of 1 kW and 2 KW, respectively, and aims to install it in Badeswaram, Andhra Pradesh. Optimal energy production was carried out using a two -axis monitoring system. The AU Thors explored various conceptions and applications of global energy trees, by examining the PV and current characteristics of the tensions of solar panels and the characteristics of the energy of wind turbines. Optimising the structure ensures that wood can withstand adhering loads, resulting in a significant increase in power production compared to fixed solar panels. Choi et al. [19] [20] We carry out extensive testing and digital modeling, analyze the load capacity carrying the structure of the solar panel, and focus on post systems installed on the base connection. This study determined the progress of non-wired communications capabilities to improve sustainability. The findings demonstrated that developing dependable structures for paneled solar poles installed to connect column-base connections requires a thorough structural evaluation of the connection.

Energy Performance and Efficiency in Solar-Powered Buildings:

Solar energy productivity and solar energy building effectiveness demonstrate the important benefits of solar panel integration. Deymi et al. [22] studied thematic research in St. Petersburg, Russia on an integrated system based on solar winds in zero energy buildings. The system aims to fill hourly electricity, heating and cooling using absorbed cold wind turbines, solar loops of parabolic grooves, and energy storage of compressed air. The feasibility assessment has shown that the solar system can cover 61% of the annual charges; The required electrical load is supported by almost 99% of the energy storage system. The system helps reduce 13,859 kg / year following CO2 emissions and reaches extreme efficiency and monthly energy consumption in December. Economic analysis shows current positive net values after 17, 14 and 12 years, with interest rates of 5%, 3%and 1%, respectively. Sulaiman et al. [23] studied the possibility of using low-GWP refrigerants to replace normal refrigerants. This model evaluates performance according to exceptional and energy compression cycles with a variety of refrigerants. The prototype unit with PV panels and battery storage provides cooling air to the connected canopy. R290 and R600A demonstrate potential as suitable replacements, indicating improved COP and energy efficiency compared to R134A. Temiz et al. [24] I have developed a complete solar energy system with a heat pump from the floor source for autonomous use of cases providing power, heating, cooling and water temperature households. The system included various orientations of PV guidelines, anion-exchanged membrane electrolyzers, vertical heat pumps with hydrogen-based underground storage, and fuel elements for proton metabolism. This study evaluated the system in five world cities and determined the PV capacity required for a 20-year-old building in Ottawa, Canada, achieving energy efficiency and total energy of 10.49% and 18% and 76% respectively. Woo et al. [25] evaluated the ideal size design of the hybrid solar hydrogen energy system in AFine, Turkey, providing continuous and reliable food for energyless energy. Searching for sufficient number of photoelectric panels, stacks of fuel elements, storage volume, corresponding models and size of electrical linens was important to meet the needs of the energy house. Nominally optimal electrolyzer had a significant impact on the efficiency of the system. Abu-Hamdeh et al. [28] associated the energy competence of paraffin / graphene wax and nanofluides of paraffin wax / graphene in solar collectors with flat plate for the building of heating systems. The results showed that both graphene -based undergraduates showed increased thermal conductivity compared to paraffin. The effectiveness of the solar manifold was also improved using graphene -based undergrowth. In addition to structural limitations, operational limitations for liquid solar collector operations were significant [29]

Conclusion:

Solar energy is a critical component of the global transition to a sustainable energy future. PV systems offer a clean and efficient way to harness solar energy and have a wide range of applications. Addressing the challenges related to intermittency, energy storage, and grid integration is essential for realizing the full potential of solar energy. Continued research and development in PV technologies, coupled with supportive policies, will pave the way for widespread deployment of solar energy and contribute to a cleaner and more sustainable energy future.

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