International Journal of Advance and Applied Research
Peer Reviewed | International Open Access Journal
ISSN: 2347-7075 | Impact Factor – 8.141 | Website: https://ijaar.co.in/
Volume-13, Issue-6 | July – August 2026

Original Article

Solar Technology: Concept, Evolution and Future Perspective

Chawale Kartik
Assistant Professor, Department of Physics,
Shri Mahatma Basweshwar Mahavidyalaya, Latur, Maharashtra, India

Manuscript ID: IJAAR-130623
ISSN: 2347-7075
Impact Factor – 8.141

Volume - 13
Issue - 6
July – August 2026
Pp. 169 - 173

Submitted: 10 August 2026
Revised: 19 August 2026
Accepted: 25 August 2026
Published: 31 August 2026

***Corresponding Author:* Chawale Kartik**

Quick Response Code:

Website: https://ijaar.co.in/

DOI: 10.5281/zenodo.22318498

DOI Link: https://doi.org/10.5281/zenodo.22318498

Introduction:

Solar energy is currently being gathered and converted into electricity using modern technology. These methods are frequently used as renewable substitutes for traditional non-hydro technologies and have previously been shown to be effective. Theoretically, if solar energy collection and supply technology were widely accessible, solar energy might sufficiently meet the world's energy needs. Approximately 5×10^4 EJ of the over four million exajoules ($1EJ=10^{18}$ J) of solar energy that reach Earth each year are reportedly easily harvestable. Despite this huge po tential and increase in awareness, the contribution of solar energy to the global energy supply is still negligible. Another major prospect with regard to solar research is associated with the current drive toward reducing global carbon emissions, which has been a major global environmental, social, and economic issue in recent years. Consequently, the use of solar technology would greatly reduce and ameliorate problems related to unemployment, climate change, energy security, etc. Because it doesn't require fuel for transportation, it is also expected to play a significant role in the transportation sector in the future. A strong foundation for the exploitation of this renewable energy source has been established by policies, investments, and support (such as research funding) from numerous governmental and non-governmental organizations for solar technologies. This makes solar cell technology sustainable, economically feasible, and capable of reducing greenhouse gas emissions, making it the perfect energy source while avoiding environmental and energy-related drawbacks (Miranda *et al*., 2019). In the realm of photovoltaics, thin film solar cells are attractive options due to their low material consumption and increasing efficiencies. α-silicon (α-Si), copper indium gallium selenide (CIGS), and star absorber materials like cadmium telluride (CdTe) are the three most well-known thin film technologies that have been thoroughly researched and are currently undergoing intense investigation. First generation solar cells, sometimes referred to as standard inorganic silicon modules, are the most used solar technology in most residential and commercial sectors. Currently, the carrier-selective layer technique has given crystalline silicon wafers based on a superior float zone a competitive edge over conventional solar cells (Wu *et al*., 2016). Furthermore, based on the matrix of interdigitated back contact and heterojunction technologies, the aforementioned architecture achieved a power conversion efficiency of 26.6%, which is close to the theoretical limit power

International Journal of Advance and Applied Research
Peer Reviewed | International Open Access Journal
ISSN: 2347-7075 | Impact Factor – 8.141 | Website: https://ijaar.co.in/
Volume-13, Issue-6 | July – August 2026

conversion efficiency (PCE) of 29.1% for a silicon solar cell. Despite its intriguing features and high scalability for commercial and industrial usage, the technology's manufacturing prices have stopped, making solar panels expensive. The module efficiencies of CIGS and CdTe technologies nearly match those of crystalline solar cells, with documented efficiencies of 21.4% and 21.6%, respectively, even though crystalline silicon solar cells now hold a larger than 55% market share. Parallel with the emerging materials utilized in thin film technology, most focus is on perovskite solar technology and organic solar cell, as well as dye sensitized solar cells. These plastic single junction based devices exhibits efficiencies of 25.5%, 16-18.1% and 13%, respectively (Nair *et al*., 2020). These are third generation solar cells also known as plastic solar cells. Similarly, exfoliated tungsten telluride (WTe) flake (CiGSe) based multilayer thin films have been reported with a PCE of 10.87%. Furthermore, the structural manipulations of the active materials for these cells have garnered immense momentum due to their ease of production, flexibility, and simple fabrication methodologies. In an effort to match the electrical conducting properties of chemically doped polyacetylene, a significant scientific contribution has been made to the field of application-specific properties of π-conjugated polymers (i.e., design, modeling, and fabrication). The aforementioned optoelectronics, sensors, internet of things (IoT), energy storage photodetectors, memory devices, field effects transistors (FETs), nonlinear optical devices, electrochromic, light emitting diodes (LEDs) and photovoltaics (Moliton *et al*., 2004).

How to cite this article:

Chawale Kartik. (2026). Solar Technology: Concept, Evolution and Future Perspective. International Journal of Advance and Applied Research, 13(6), 169 – 173. https://doi.org/10.5281/zenodo.22318498

Evolution of Solar Technology:

The evolution of solar technology has been marked by significant milestone, driven by advances in materials science, manufacturing techniques and an increasing emphasis on renewable energy sources. The journey of solar technology began with the discovery of the photovoltaic effect by Alexandre Edmond Becquerel in 1839 (Oktik, 2022). This principle, which allows sunlight to generate an electric current laid the groundwork for future developments. These early solar cells were primarily used in space application, such as powering satellites, where cost was less of a concern. This periods marked the beginning of the first generation solar cell, characterized by silicon based technology. Despite being expensive and relatively inefficient these cells demonstrated the potential of solar energy and set the stage for further research and developments. Off-grid power systems, navigation aids, and remote telecommunications were among the first commercial uses. The creation of thin-film solar cells was a major breakthrough in lowering production costs and boosting adaptability. Second-generation solar cells, which first appeared in the 1980s, used substances like copper indium gallium selenide (CIGS) and cadmium telluride (CdTe). These thin-film technology increased the range of uses for solar panels by making them lightweight and flexible. Technological developments in manufacturing reduced production costs and increased the accessibility of solar energy. Third-generation solar cells, which include high-efficiency multijunction cells, organic photovoltaics (OPVs), and perovskite solar cells, first appeared in the 2000s. In lab settings, multi-junction cells which employ several layers of semiconductor materials to catch a wider spectrum of sunlight achieved efficiencies higher than 40%. Space and concentrated solar power applications are the main uses for these cells. Research into solar fuels and artificial photosynthesis aims to convert solar energy into chemical fuels, such as hydrogen, and mimic natural photosynthesis processes, offering potential solutions for energy storage and transportation (Basher et al., 2023). The ongoing search for more effective, economical, and adaptable energy solutions is reflected in the development of solar technology. Every stage has expanded on earlier advancements, which has accelerated the development and uptake of solar energy globally.

Benefits of Solar Energy Technologies:

It is common knowledge that nothing can match the sun's energy potential. Solar energy is more than capable of meeting the world's electricity needs because it is theoretically sufficiently abundant. It is not required to take into account the possibility that solar energy may ultimately run out because it is both sustainable and renewable. The catastrophic potential of global warming highlights its detrimental effects on the climate, environment (including plants and animals), and human health. Power plants, particularly those that burn coal, are a major source of greenhouse gasses (GHG), which account for around 25% of all emissions caused by human activity. Hence, GHG emissions associated with the generation of solar power (including manufacturing, installation, operation, and maintenance) are minimal (Sen, 2004). With an emission ratio of 18:9.5:1, the range of CO2 emissions per kilowatt-h produced by coal, natural gas, and solar is projected to be 0.64~1.63, 0.27~0.91, and 0.03~0.09 kg, respectively. Thus, among other things, this comparison reaffirms how much more environmentally friendly solar power is. As a result, solar energy has emerged as one of the most practical ways to address the present global warming dilemma, which might have costly consequences if it continues unchecked. In order to achieve sustainable development, it will eventually be advantageous for the environment, economy, and society to mitigate global warming by replacing coal and gas-based power sources with solar electricity. Solar energy is considered to be a non-polluting, reliable, and clean source of energy. Unlike other energy sources, its use is not accom panied by the release of harmful gases (e.g., oxides of C/N/S and/or volatile organic compounds (VOCs)) and particles (e.g., soot, carbon black, metals, and particulate matter (PM)). Such fossil fuel emissions from gas-fired power plants have been indicted with regard to causing neurological damage, heart attacks, breathing problems, cancer, etc (Machol, 2013). Solar power technologies are thought to be more labor-intensive than fossil fuel technologies, which are mostly capital-intensive and mechanized. One benefit of this idea is that solar technologies ought to increase employment prospects. Compared to fossil fuels, solar energy can typically generate more jobs per unit of electricity produced. Additionally, local solar energy projects would retain money in the local economy, saving a significant sum of money that is currently spent on

International Journal of Advance and Applied Research
Peer Reviewed | International Open Access Journal
ISSN: 2347-7075 | Impact Factor – 8.141 | Website: https://ijaar.co.in/
Volume-13, Issue-6 | July – August 2026

importing fossil fuels from other places. Due to tax benefits, the elimination of electricity costs, higher property prices, and great durability, solar power is advantageous from an economic standpoint. Solar power systems are incredibly inexpensive to operate, but they do require an initial investment for installation. The financial demand for solar power is comparatively steady over extended periods of time, in contrast to the price of fossil fuels, which are subject to significant price fluctuations. Furthermore, solar panels are long-lasting (no wear and tear) and require very little maintenance because they have no (mechanically) moving parts. Furthermore, solar panels' installation versatility is justified by the ease with which they may be mounted on building walls and roof tops. Furthermore, solar power systems are less prone to large-scale failure because they are distributed and composed of numerous individual solar arrays. Therefore, if any section of arrays were found to be faulty, the rest could continue to operate. However, additional solar modules could also be added over time to improve the energy generation capacity.

Future Prospects:

Because solar energy is better to other renewable energy sources in terms of availability, cost effectiveness, accessibility, capacity, and efficiency, it is one of the greatest possibilities to satisfy future energy demand. The flow of solar energy into and between various components of a photosynthetic organism has been successfully quantified in detail for the first time. The outcome is a preliminary investigation that may eventually aid in the creation of technologies that employ solar energy significantly more effectively than is currently feasible. Researchers from the Graphene Flagship demonstrated that employing few-layer MoS_2 flakes as an active buffer interface layer can greatly extend the lifespan of perovskite solar cells. Furthermore, researchers in Hong Kong claimed to have created perovskite-silicon tandem solar cells with the best power conversion efficiency in the world 25.5%. It is important to note that when perovskite solar cells were first introduced in 2009, their efficiency was only 3.8%. As a result, semi-transparent perovskite solar cells have been developed that are excellent options for solar windows since they exhibit high power conversion efficiency and transmit visible light while blocking infrared radiation (Kim *et al*., 2016). In order to capture a wider variety of solar energy, a team of researchers at the Massachusetts Institute of Technology in the United States has created a new solar cell that combines two distinct layers of sunlight-absorbing material (Chirumamilla *et al*., 2016). Researchers have discovered that a heat-resistant gadget composed of layers of aluminum and tungsten can absorb solar radiation and transform it into electrical power. The dye-sensitized solar cells were treated with a green polymer made from biowaste.

Conclusion:

Around the world, solar energy technologies are now widely used and well-established. In order to overcome the present constraints in the solar industry, billions of US dollars have been invested, and much more is anticipated in the near future. Many new large-scale solar power projects, such as CSP, are now being constructed or coming online in both developed and developing nations. Despite being more costly than PV technology, CSP has been shown to be appropriate for areas without regular clouds or haze. The total cost of producing solar power is still high, even if the cost of solar technology has rapidly decreased in recent years. Innovative strategies are still required to lessen the financial burden of various policy incentives, as demonstrated by the incentives and rebates that are essential for the growth of the solar energy market. Nonetheless, the solar sector ought to concentrate more on the advancement and caliber of its technology. Researchers should also concentrate on making solar energy more competitive with conventional and alternative renewable energy sources.

References:

1. Basher, M. K., Nur-E-Alam, M., Rahman, M. M., Alameh, K., & Hinckley, S. (2023). Aesthetically appealing building integrated photovoltaic systems for net-zero energy buildings. Current status, challenges, and future developments—a review. *Buildings*, *13*(4), 863.
2. Chirumamilla, M., Roberts, A. S., Ding, F., Wang, D., Kristensen, P. K., Bozhevolnyi, S. I., & Pedersen, K. (2016). Multilayer tungsten-alumina-based broadband light absorbers for high-temperature applications. *Optical Materials Express*, *6*(8), 2704-2714.
3. Kim, H., Kim, H. S., Ha, J., Park, N. G., & Yoo, S. (2016). Empowering semi-transparent solar cells with thermal-mirror functionality. *Advanced Energy Materials*, *6*(14), 1502466.
4. Machol, B., & Rizk, S. (2013). Economic value of US fossil fuel electricity health impacts. *Environment international*, *52*, 75-80.
5. Miranda, J., Ponce, P., Molina, A., & Wright, P. (2019). Sensing, smart and sustainable technologies for Agri-Food 4.0. *Computers in Industry*, *108*, 21-36.
6. Moliton, A., & Hiorns, R. C. (2004). Review of electronic and optical properties of semiconducting π-conjugated polymers: applications in optoelectronics. *Polymer International*, *53*(10), 1397-1412.
7. Nair, S., Patel, S. B., & Gohel, J. V. (2020). Recent trends in efficiency-stability improvement in perovskite solar cells. *Materials Today Energy*, *17*, 100449.
8. Oktik, Ş. (2022). The holy triangle of science, technology and industry for photovoltaic solar energy conversion. In *Renewable Energy Based Solutions* (pp. 51-80). Cham: Springer International Publishing.
9. Şen, Z. (2004). Solar energy in progress and future research trends. *Progress in energy and combustion science*, *30*(4), 367-416.
10. Wu, Y., Yang, X., Chen, W., Yue, Y., Cai, M., Xie, F., ... & Han, L. (2016). Perovskite solar cells with 18.21% efficiency and area over 1 cm2 fabricated by heterojunction engineering. *Nature Energy*, *1*(11), 16148.