

# Potential and Future Directions of solar energy: A Review

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## ABSTRACT

The global energy crisis is accompanied by serious environmental issues such as contamination, climate change, and the impact of greenhouse gases. Using alternate energy sources is essential because conventional energy sources such as fossil fuels contribute significantly to the problem. Green renewable energy sources and environmentally conscious energy production techniques are currently driving growth in the generation of electricity. Solar power is one of the largest, most effective, and environmentally friendly renewable energy sources used to generate electricity. The potential, advantages, and restrictions of solar energy technologies are highlighted in this article. This also emphasizes the future possibilities of solar energy technologies.

*Key words: Solar energy, Benefits, Limitations, Future scope*

## Introduction

An ability to work is called energy. This has the potential to be measured in a number of different ways, including mechanical, chemical, thermal, radiant, electrical, and nuclear energy. Based on their method of generation and availability, it is broadly divided into two groups: (i) Renewable energy, (ii) Non-Renewable energy. These renewable resources are widely available. However, they vary and none of them can be exhausted because the fundamental law of natural phenomena allows for their regeneration. There are many types of energy, including solar, wind, biomass, geothermal, tidal, and ocean power. Nature accumulates nonrenewable re-

sources over a long period of time. Once this is exhausted, it cannot be regenerated on a human time scale. Limited supply of fossil fuels such as coal, petroleum, natural gas, and so on are examples of nonrenewable sources. These nonrenewable resources are used to meet our energy needs. According to the current state of energy sources, nonrenewable energy sources are constrained and depreciating, causing them to run out completely in the coming years. As a result, there is a need for additional alternative energy sources that can meet current energy demand while also being environmentally friendly. Renewable energy sources are used to solve the problems caused by the energy crisis because they are environmentally friendly and practically limit-

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less.

Nowadays, population growth has increased the technological challenges in energy management and solid waste management. The reduction of renewable energy sources such as hydropower immediately lowers people's standard of living (Esmailion, Ahmadi and Dashti, . Meanwhile, the sun provides almost 4 million exajoules (1 EJ = 1018J) solar 2021) energy to the earth annually. In contrast, it is claimed that  $5 \times 10^4$  exajoules solar energy are simple to acquire (Kabir *et al.*, 2018). This amount of energy is equivalent to the 3 trillion barrels of oil that can be extracted from the world's reserves. Many research studies have recently focused on developing new technologies for harvesting and generate electricity from solar energy in order to develop renewable alternatives (Esmailion, Ahmadi, Hoseinzadeh *et al.*, 2021). Thus, the collection and use of solar power, including light or heat, as well as the technologies (both passive and active) necessary to do so, are collectively referred as solar energy.

The sun's energy is more than enough to meet all of human needs on its own. The sun's powerful energy output is complemented by its adaptability. Solar energy can be converted into solar fuel, electricity, and heat. For instance, photosynthesis can convert solar energy into solar fuel. Further, solar energy has a main benefit over other traditional sources of electricity in that it can be produced using the smallest photovoltaic (PV) solar cells. This allow sunlight to be directly converted into solar energy. Furthermore, when compared to traditional energy production technology, solar energy requires significantly less manpower. A significant amount of research has been done to combine the sun's energy process through the development of solar cells, panels, and modules with high converting forms. When compared to the cost of various fossil fuels and oils the most advantageous aspect of solar energy is that it is easily accessible and free to the general public. Additionally, residential solar generators deserve more subsidies than utility-scale generators.

A further important field for solar research is the use of alternative fuels to address global carbon emissions and climate change. This has been (Mathur *et al.*, 2022) predicted that its application in the transport sector will grow significantly in the future because it doesn't require the transportation of fuel. The use of this renewable energy system in the transportation sector has been made possible by policies, investments, and research funding from

various governmental and non-governmental organizations. The solar energy technologies are discussed in this article in terms of their potential, prospects, limitations, and policies. This will lead to a better understanding of solar energy and its potential to meet projected energy needs.

### Potential of solar energy technologies

In comparison to other renewable energy sources, biomass, geothermal, and solar can produce enough heat energy for power generation. Solar energy has the greatest potential for use globally of the three because biomass is rare in nature and geothermal energy is only found in a few locations. The amount of solar radiation that enters the Earth's atmosphere is influenced by a variety of factors, including latitude, daytime variation, weather, and geographical differences.

Approximately  $342 \text{ W/m}^2$  of solar energy is typically received by Earth's atmosphere, with approximately 30% dispersed back into space, leaving approximately  $239 \text{ W/m}^2$  that can be harvested and captured. The annual effective solar radiation ranges from  $60$  to  $250 \text{ W/m}^2$  around the world. Active solar energy technology can be classified into two broad categories: photovoltaic technology and solar thermal technology. A classification of the most recent solar energy technologies is shown in Figure 1 (Kabir *et al.*, 2018). Further, active solar energy technology can be classified into two broad categories as photovoltaic technology and solar thermal technology.

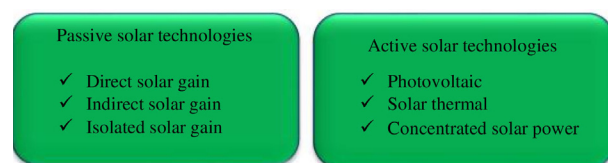


Fig. 1. Solar energy technologies

### Photovoltaic technology

One of the most popular methods for directly converting solar radiation into electricity is PV technology. The solar PV system is expanding quickly and could outperform with other systems.

Some of their distinguishing qualities include the fact that they operate quietly, don't produce any pollution, and can function even in extreme weather with little assistance from humans during operation and maintenance. Nowadays, PV system involving the use of semiconductors ((Mohanty, 2016 & Jeon *et*

al., 2013) new thin film cells (Green *et al.*, 2014) to convert sunlight directly into electrical energy. In particular, hybrid perovskite solar cells has a promising achievement in increasing efficiency up to 18% (Alharbi and Kais, 2015).

### Solar thermal technology

Solar thermal technology converts solar energy to thermal energy for use in domestic and commercial applications such as drying process, water heating process, air conditioning, cooking, and other related activities (N'TSOUKPOE *et al.*, 2023). Meanwhile, concentrated solar thermal and power technologies are used to generate electricity and meet such heating requirements (Palacios *et al.*, 2020). Solar energy is focused using high-magnification mirrors in the latter before being converted into heat energy to power a steam turbine (Tambunan *et al.*, 2020).

### Benefits of solar energy technologies

Solar energy is a significant renewable and sustainable energy resource due to the sun's ability to produce energy. Solar power plants emit very little greenhouse gas (0.03-0.09kg) when compared to coal-fired power plants (0.27 to 0.91kg) (Jerez *et al.*, 2015). Furthermore, solar energy is environmentally friendly because it emits no harmful gases, such as organic chemicals, or particles, such as metals and carbon (Wang *et al.*, 2021). In addition, unlike fossil fuel power plants, there is limited access to water while the plant is operational (Zhang *et al.*, 2022).

### Limitations of solar energy technologies

Domestic solar system use may be limited by substantial initial expenses for installation, protracted payback cycles, and low revenue (Aziz *et al.*, 2023); however, government subsidies may increase this use. Other disadvantages include lower domestic solar panel efficiencies (10-20%), inefficient batteries and inverters; however, more efficient (>20%) solar panels are available at higher prices (Soomar *et al.*, 2022) basic technical skills (Pouran *et al.*, 2022).

### Future prospects of solar technology

The potential solutions for providing the global energy demand include solar energy, which is one of the most promising ones. In addition, this is superior to alternate energy sources in terms of practicality, economy, capability, and potency (Maka and Alabid, 2022). The advancement of research in photosynthetic organism measurement will ultimately

lead to the utilization of solar energy innovations, such as the invention of buffered interface layers, perovskite-silicon conjunction PV cells, and demi transparent perovskite PV cells (Enriquez *et al.*, 2019). This contribution introduces future trends in the study of solar energy technology. As a result, solar energy has emerged as one of the most viable solutions for addressing current environmental emergencies. If ignored, the potential consequences could be very costly. Thereby, minimizing the impact of global warming by shifting to solar energy will ultimately benefit the environment, economy, and society as a whole in order to achieve sustainable development.

### Conclusion

Around the entire globe, solar energy innovations are now widely recognized and extensively utilized. In order to overcome the current constraints in the solar industry, billions of dollars have already been invested in order to achieve environmentally friendly power plants, and much more is anticipated in the near future (Kabir *et al.*, 2018). Fortunately, PV technologies are making a greater contribution to solar energy production. However, off-grid solar system evaluation could enhance solar power generation. The overall cost of solar energy production remains high, but increased domestic awareness, improved government subsidies, and government initiatives could stimulate the solar energy market.

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