Rapid Adaptation of Renewable Energy – A Review on Solar Energy, Types and Overview

S.P.Meena

Associate Professor, Department of H&S (Physics), Sri Indu college of Engineering and Technology, Hyderabad.

E-mail: meena.palanisamy@gmail.com

Abstract

Renewable energy is derived from the sources that can be renewed naturally. The majority of renewable energy sources obtained from sunlight, wind, water currents, and geothermal heat, are sustainable. Solar energy, wind energy, hydropower, geothermal energy, and other forms of renewable energy utilize a variety of methods to generate renewable resources. The sun has the potential to meet the entire world's energy requirements. Solar energy has the capacity to be efficiently and economically converted into electricity by remaining as a renewable energy source. This article will explain about the solar energy, its overview, evolution, different forms, advantages, and disadvantages.

Keywords: Renewable energy, solar energy, photovoltaic energy, concentrated solar power, and passive solar water heater

1. Introduction

Renewable energy is produced by natural processes that are constantly renewed. The renewable energy comes from the sun directly or from the heat produced deep beneath the earth in one of its many forms. Over a large geographic region, there are different sources of renewable energy and great opportunities for energy efficiency. Rapid advancements in renewable energy and energy efficiency would have a positive impact on the economy and energy security [1]. Wind and solar energy are becoming considerably more affordable. The first known application of renewable energy dates back more than a thousand of years, when conventional biomass was used to fuel fossil fires. The second-oldest renewable energy source is wind energy, which is used to propel ships across ocean.

One of the commonly used renewable energy sources is solar energy. Solar energy is the energy that the sun provides through solar radiation. A variety of methods, including solar heating, solar photovoltaic, and solar thermal power can be used to capture the radiant light and heat from the sun. It is a primary source of sustainable energy, and depending on how it is turned into solar power, its methods are classified as passive or active [2]. It is tempting to use solar energy as a source of power due to its high volume.

Utilizing concentrated solar power, photovoltaic systems, and solar water heating remain as the examples of active solar approaches. It actively transforms solar energy into another type of energy, mostly heat or electricity by using a mechanical and electrical equipment [3]. A building's construction toward the sun, the use of materials with advantageous thermal mass or light-diffusing qualities, and the creation of naturally ventilated rooms are all examples of passive solar approaches. These technologies don't rely on any extra hardware. It will benefit from the local weather by reflecting heat in the summer and using it to heat structures in the winter.

Augustine Mouchot successfully developed a solar steam engine in 1878 at the Universal Exposition in Paris. An early adopter of solar energy from the United States, Frank Shuman created a modest demonstration solar engine in 1897 that used black pipes and had a lower boiling point than the water to operate a solar steam engine. In Maadi, Egypt, between 1912 and 1913, he also constructed the world's first solarthermal power station. In the year 2020, Solar remains as the most affordable type of power. A power purchase agreement has been recently made in April 2021 for a solar energy plant in Al-Faisaliah, Saudi Arabia. The project recorded the lowest cost in solar PV power production across the globe.

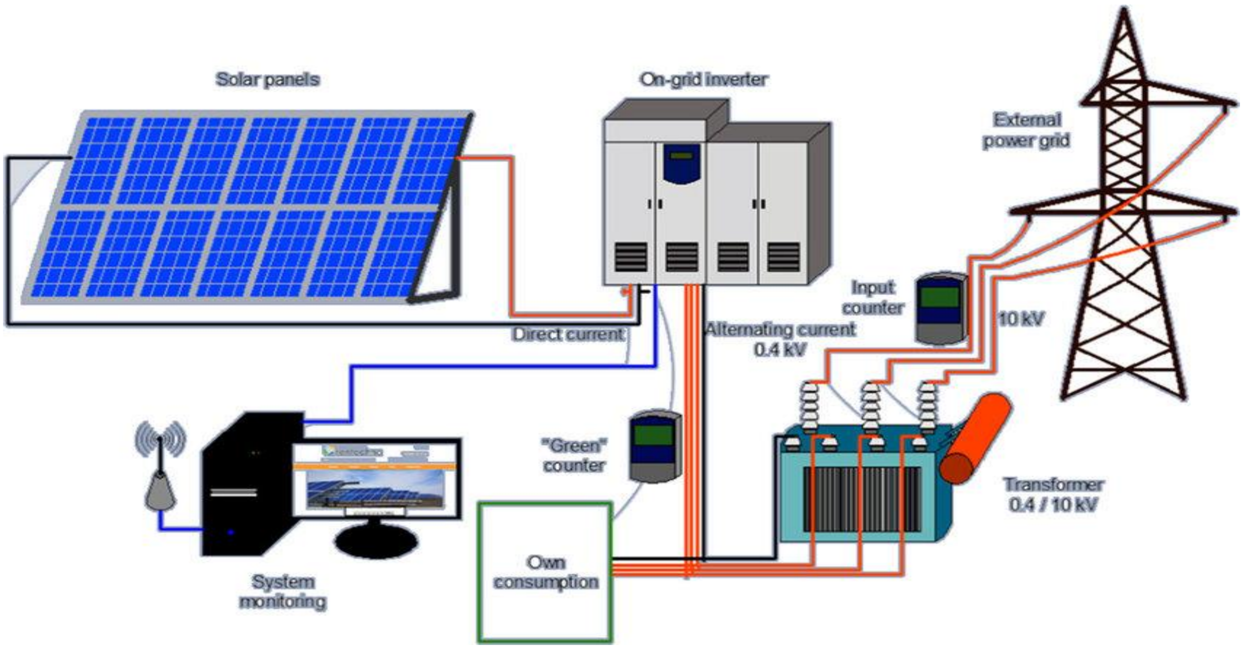

Figure 1. Structure of Solar power plant [4]

2. Types of Solar Energy

The sun, the primary source of energy, is changing the way people think about and utilize energy. Solar energy has the potential to solve both climate change and rising energy costs. Solar energy methods are classified into four broad categories. They are

Solar Photovoltaic Plants

The most popular type of solar system that uses sunlight to generate energy is a solar photovoltaic system. It absorbs sunlight using semiconductor materials. It operates in a similar manner to how heat from the sun's radiation causes the electrons to become free to move. These electrons create energy when they move through semiconductor materials [5]. The majority of the visible spectrum of light as well as a portion of the infrared and ultraviolet light spectra are absorbed and turned into electricity by modern solar photovoltaic plants.

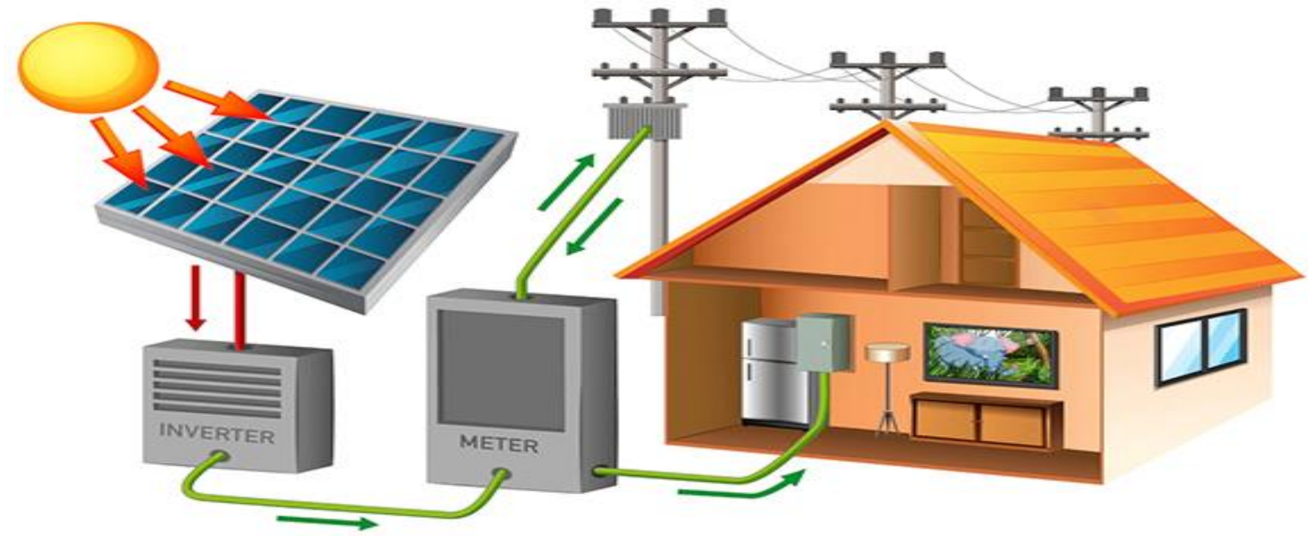

Figure 2: Solar Photovoltaic plants structure [6]

2.1 Solar Water Heating System

Solar water heating systems utilize the energy from the sun to warm or boil water. The shallow locations allow sunlight to readily reach the ground, heating it and producing warm water. The solar collector and the water storage tank are the two main components of the design. Through tiny water-carrying tubes, the collectors and storage tank are connected. As the heat from the sun is absorbed by the flat-plate collector, it warms the water that is travelling through the pipes. The storage tank holds the heated water [5].

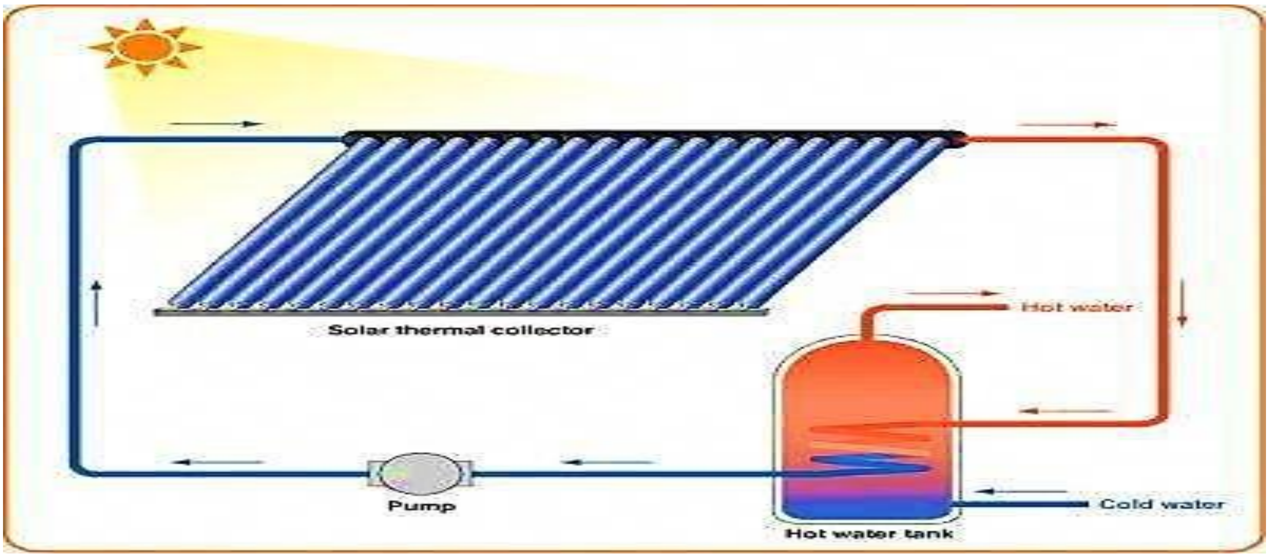

Figure 3. Solar Water Heating System Structure [7]

2.2 Concentrated Solar Power

Concentrated solar power is the most widely used type of solar energy. In particular, it refers to a huge set up, which provide the grid with power. It makes use of mirrors and lenses to focus a wide region of sunlight onto the solar receiver. They produce enough energy to run a few specific enterprises or a small settlement. A convectional generator is used to direct this heat energy. The focus of the first section is on gathering solar energy and turning it into heat. The second section focuses on producing electricity from heat energy [5].

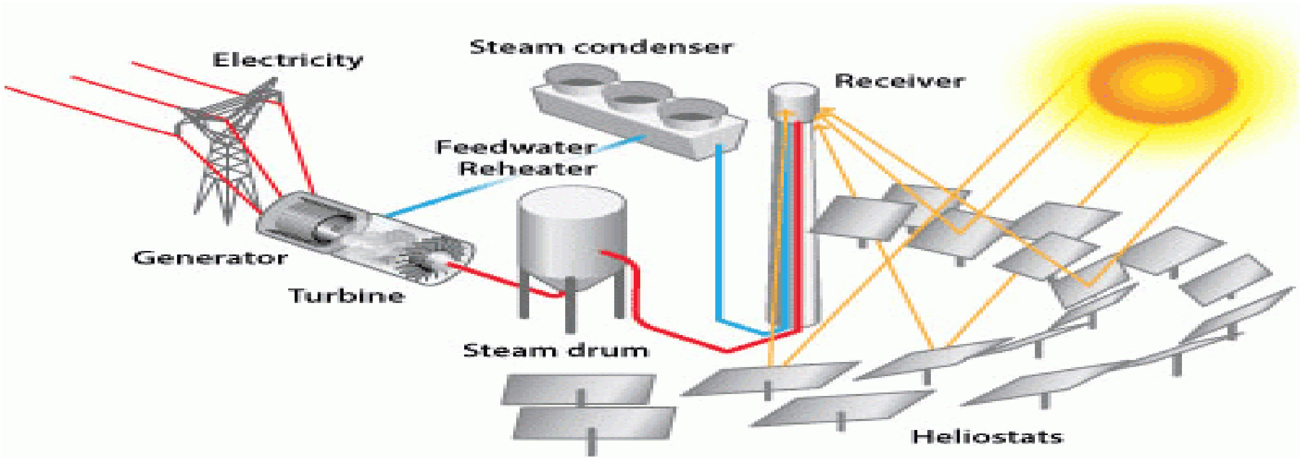

Figure 4. Concentrated Solar Power structure [8]

2.3 Technical Passive Solar Heating

Based on the same concept, passive solar heating is often referred to as "daylighting”. The energy requirements of the home can be met by using solar technologies, such as sunny walls, roofs, and floor that absorb the heat of the sun. These devices function by absorbing heat during day, when the sun sets and the air becomes colder and gradually release the heat. Therefore, a building with smart design, effective ventilation, and solar technology will never face the heating problems during winter [5].

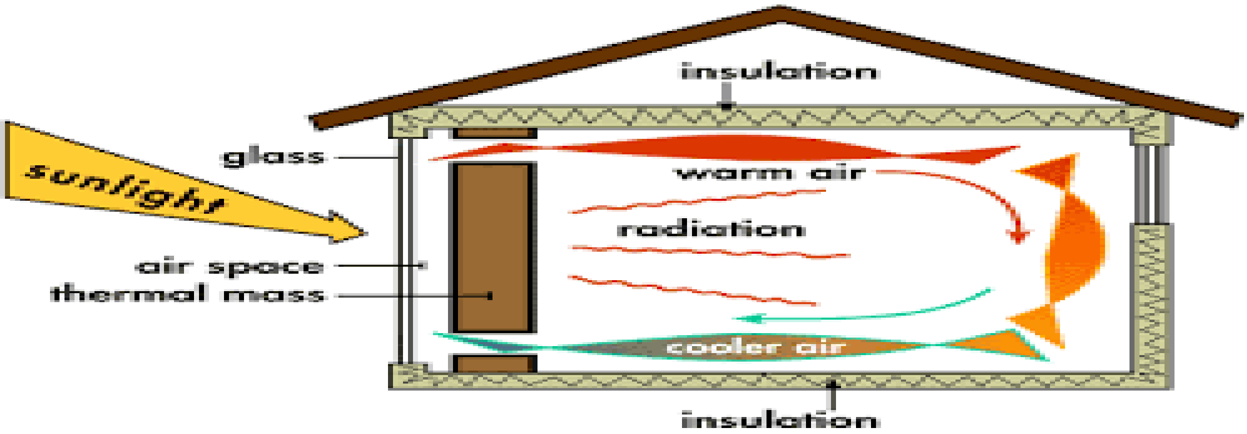

Figure 5. Passive solar Heating Structure [9]

3. Literature Survey

Pierangelo Metrangolo et al [10], revealed the XB's potential to offer significant advantages in producing stable PSCs. The majority of the described cases have the traits of enhanced crystallization and stability, decreased surface state, and the potential for the formation of organized structures and layers. The range of perovskite compositions, device topologies, and the susceptibility of the present materials to outside influences make these discoveries extremely interesting. In order to fully utilize the benefits of combining the XB and HOIHPs, which are considered as the fast expanding study domains require a strong grasp of atomic and molecular level processes. It is know that the XP in HOIHPs has a promising future.

A layer of in-situ p-type SiCx and an interfacial oxide formed in hot HNO_3 were used as the passivating contacts as illustrated by the F-J Haug et al [11] investigation into the quick thermal processing of p-type silicon. Starting at 450°C, the firing process generates a sizable number of shallow mass defects in the beneath FZ silicon, which transition into the defect curing phase for firing temperature of 800°C and higher. Additionally, recombination bulk defects may now be distinguished using formalism by injecting a small current throughout the interfacial oxide. An ideal firing temperature within 800 and 830° C with the use of a dwell period of 3s is determined by the fabrication method and the type of c-Si substrates. This temperature range was altered by utilising various interfacial oxides, and it can be modified for Cz wafers, which are more appropriate to industry applications.

Gang Kou et al. [12] developed creative methods for enhancing the effectiveness of solar power projects. The most important element that increases the model efficacy is its dynamic nature. The solar panels should be positioned, according to this text, so that they may catch the sun at various periods during daytime. While completely facing the sun, the solar panel will perform in the most effective level. This programme calculates the ideal angle of inclination at which the degree angle of the solar panel should be placed in order to maximize the energy efficiency. Considering the research results, it is highly preferred to develop flexible and structural solar panels, which can adjust its position in response to the angle of the sun throughout the day. This will increase the electrical energy production.

For the solar PV cell, Tamen Thapa Sarkar et al. [13] proposed an SMC-based MPPT controller with adaptive control gain. The primary goal of the proposed controller is to maintain the operating point at maximum power under a variety of environmental conditions. It is resistant to changes in temperature and irradiation. To achieve optimum power, it also offers superior tracking and complete disturbance rejection. Rapid changes in temperature and irradiance have an adverse effect on P & O MPPT regulating approach. The outcomes for both MPPT methods show that the SMC-MPPT control technique is superior to the P & O MPPT controller.

Author Chenyu Zhou et al. [14] evaluated the characterization and application of typical solar energy devices, including DSSC, organic-inorganic hybrid solar cells, and photoelectrochemical water splitting cells, as well as the deposition processes of ultrathin TiO_2 films. Techniques built on the synchrotron are appropriate for in-situ research, which has to be done during the film growing process. It is also important to comprehend the flaws in TiO_2 layers affect the conversion of solar energy. In a photoelectrochemical cell, the TiO_2 coating layer comes into direct contact with the aqueous electrolyte, making it crucial to examine the surface chemistry at the TiO2 liquid interface using the extensive information gained from research on TiO_2 single crystals. The findings demonstrated the ideal shape of extremely thin films for applications involving solar energy conversion.

The author of this article [15] highlighted that several nations and areas have passed laws supporting the industry for dispersed and readily available PV power generation. PV self-powered systems are a potential area for research due to the widespread dispersion of solar radiation and its quick decline in the cost of PV power generation. The requirements for the architecture of PV systems vary by area. In PC self-powered applications, choosing the right PV system topology for various application scenarios is essential. For PV self-powered systems to operate well, MPPT, PM, and fusing solar energy with wind, mechanical energy, and some other energy sources are crucial.

In this article [16], solar power plants in four US electrical systems regions—California, New England, New York, and the Southwest—will be compared and analysed. the proportion of energy resources that were produced both before and after extensive use of solar plants. The decrease of fossil fuels is impacted by the plots with 100% solar power. The research demonstrates that there is a considerable difference with in energy balance in the region with the largest solar output, especially California and the southwest, when comparing the discrepancies among net demand and generation before and after the huge integration of solar plants. By expanding the penetration of solar energy, the effects are amplified. It is more likely that the energy peaks will rise when solar energy penetration is taken into account.

The GIS-based multi-criteria decision-making process used to locate the ideal solar PV farm locations in the East Shewa zone of Ethiopia is described by Abayneh Gerbo et al. in their study [17]. The entire area that may be used for solar farm sites is around 1129 km2, and it is evenly spread, with the northern, northwestern, and central regions having the highest potential. According to the suitability research, 53 possible solar PV farm areas in the study site may be used to produce an expected 2.2 TW of solar electricity in total. The current analysis will help government organisations and innovators who are building solar PV farm locations. Additionally, the current study offers a systematic framework for identifying and prioritising the variables that affect the choice of locations for solar farms. This would promote solar energy investment and create new employment and sustainable growth that benefits the entire nation, not just the affected regions.

The benefits of a combined wind-PV solar offshore energy system on the Western Iberian Peninsula were examined by X. Costoya et al. [18] in the context of climate change from 2000 to 2040. The stability of the resource, the complexity of offshore resource, economic variables, and risk factors are the combined source of energy utilising a Delphi technique used to eight indices under four categories. utilising a multi-model ensemble made up of 35 simulations using data from EURO-CORDEX. The fundamental problem with wind energy—its inability to produce steady amounts of electricity—is addressed in the current research by combining the two renewable energy sources using PV solar energy. The evolution of offshore wind and PV solar systems begins with this analysis.

To get around the current methods, S. Gopalakrishnan et al. [19] proposed using hybrid power generation systems to create up to 1 kW of electricity. Depending on the weather, solar panels generate power. The energy will continually recuperate in a windmill. The place for creating high electric power is determined throughout the analysis procedure. It can deliver to far-off locations that the government cannot access. Both the cost and transmission losses will be decreased. It doesn't generate any emissions or toxic waste products, making it extremely safe for the environment. Overall, it is a good, dependable, and cost-effective alternative for producing power.

Table 1. Survey Table on Rapid Adaptation of Renewable Energy – Solar Energy

Pierangelo Metrangolo et al [10]	**Technique:** Hybrid organic–inorganic halide perovskites (HOIHPs) **Application:** X-Band **Functions:** *Enhanced stability and crystallization. *Possibility of building orderly structures and layers. *Slight decrease of surfaces trap states.
F-J Haug et al [11]	**Technique:** Rapid Thermal Annealing **Application:** SiCx layer **Functions:** *A bulk defect forms between 450 and 700^{o} C, not away from one of the band edges. *When the temperature reached 800^{o} C or above, the bulk fault gradually improved. *Optimal temperature range for optimal carrier lifetime is between 800 and 830^{o} C.
Gang Kou et al [12]	**Technique:** Spherical Fuzzy methodology, Hybrid Decision-Making Methodology. **Application:** Group Decision-Making (GDM), Spherical Fuzzy Numbers. **Functions:** *The most important TRIZ-based component, Dynamicity, increases the efficiency of solar-based projects. *Designing solar panels to receive sunlight vertically at various periods.

	*Solar panels on flexible constructions can adjust their position to match the position of the sun.
Tamen Thapa Sarkar et al [13]	**Technique:** Maximum Power Point Tracking (MPPT) charge controller **Application:** Sliding Mode Controller (SMC) **Functions:** *Prevents oscillation around an operational point, a problem. *Perturbation and Observation (P & O) approaches are compared with SMC to assess the robustness of SMC.
Chenyu Zhou et al [14]	**Technique:** Deposition techniques. **Application:** Ultrathin layer of TiO_2 **Functions:** *Enhancing their stability and promoting electron transport. *TiO2 coating on polymer-based solar cells lowers interface recombination rate and makes charge extraction easier. *When the shell or coatings are thicker, the open circuit voltage (VoC) and fill factor (FF) of dye-sensitized solar cells with TiO2 coating or shell both rises.
Daning Hao et al [15]	**Technique:** Solar Energy Harvesting (SHE) technology. **Application:** Photovoltaic (PV) self-powered application. **Functions:** *Designing PV system architectures for various applications-plays a significant part in PV self-powered application. * Rapid decrease of PV power generating prices. *For PV self-powered products to operate well, additional energy sources are required.
Esteban A. Soto et al [16]	**Technique:** Renewable Energy Systems or Photovoltaic (PV) Systems **Application:** Grid Disturbances **Functions:** *Differences in the energy balance and peak power can be found statistically.

	*Energy imbalances are evident in certain areas with the highest solar output. *Both solar generating capacity and potential grid energy imbalances are on the rise.
Abayneh Gerbo et al [17]	**Technique:** GIS-based approach, Analytical Hierarchical process **Application:** Solar Photovoltaic (PV) farms. **Functions:** *Analyses of 2.2TW solar PV electric power put into grid systems suggest that zones. *With an area of 1129 cm2 are excellent for the establishment of big PV solar farms. *Useful to businesses and government organizations working to develop, produce, and market unconventional solar energy sources in the area.
X. Costoya et al [18]	**Technique:** Delphi method **Application:** Solar Photovoltaic (PV) power, Wind energy **Functions:** *The total amount of renewable energy resources is increased. *Geographical and temporal variability is decreased. *An offshore wind PV-solar energy is larger than 800 KM m-2 in the summer. The range around 900 to 1000 KM m-2 in the winter.
S. Gopalakrishnan et al [19]	**Technique:** Design Hybrid Energy System **Application:** Solar photovoltaic system, Wind turbine **Functions:** Power generation with a hybrid system is efficient. *It uses windmills to continually recover energy and solar panels to generate electricity from the environment. *Lessen transmission expenses and losses. *Costs fall as production rises.

4. Conclusion

The term "renewable energy" refers to alternative sources of energy that are ecologically benign since they are replenished by Earth's natural processes, such as sunlight from the sun and wind from the air. Thus, solar energy seems to be the pure, clean, and sustainable form of energy. In order to safeguard people, animals, and ecosystems from climate change, solar energy plays a significant role in lowering greenhouse gas emissions. Additionally, it can lower water usage and enhance air quality. This research study is concentrated on one form of solar energy, including its types, a summary, and potential future advances.

5. Future Enhancements

By 2026, the world's electricity capacity is expected to increase abruptly and the main source of energy will come from renewable sources, with solar PV panels and other technologies. It is expected that the number of renewable energy generation capacity will increase by 50% in the year 2026, compared to the period from 2015 to 2020. Solar PV continues to be the engine driving development in renewable electricity, with capacity gains of 17% in 2021, which will reach a new high of approximately 160 GW. Onshore wind gains are expected to increase more quickly than they increased from 2015 to 2020. Total offshore wind capacity will be tripled by 2026. [20].

Researchers have discovered a novel method for turning solar energy into electricity. This was accomplished by integrating native photosystems using electrodes for the conversion of light to electrical energy. This will be ideal for water-intensive enterprises, which implement either water or land floating panels and floating solar farms, which are an easy and economical alternative to ground-mounted systems. By 2030, the Space Solar Power Systems (SSPS) program of the Japanese Space Agency (JAXA) will transfer electricity from solar panels in space. Additionally, there will be a lot of solar energy-related technologies in the future [21].

References

[1] https://en.wikipedia.org/wiki/Renewable_energy

[2] https://en.wikipedia.org/wiki/Solar_energy

[3] https://www.solarschools.net/knowledge-bank/renewable-energy/solar/energy#:~:text=Solar%20energy%20is%20a%20renewable%20source%20of%20energy%20that%20is,buildings%20and%20generating%20electrical%20energy.

[4] https://www.researchgate.net/figure/Schematic-diagram-of-a-solar-power-plant_fig2_341937464

[5] https://noviron.com/solar-energy/types-of-solar-energy/

[6] https://www.lsp-international.com/1500vdc-application-in-the-photovoltaic-system/

[7] https://greenlivingideas.com/2014/09/15/clean-technologies-cooling-heating-home/amp/

[8] https://www.energy.gov/eere/solar/power-tower-system-concentrating-solar-thermal-power-basics

[9] http://www.iklimnet.com/save/passive_solar_heating.html

[10] Metrangolo, Pierangelo, Laura Canil, Antonio Abate, Giancarlo Terraneo, and Gabriella Cavallo. "Halogen bonding in perovskite solar cells: a new tool for improving solar energy conversion." *Angewandte Chemie International Edition* 61, no. 11 (2022): e202114793.

[11] Haug, F-J., S. Libraro, M. Lehmann, A. Morisset, A. Ingenito, and C. Ballif. "Impact of rapid thermal processing on bulk and surface recombination mechanisms in FZ silicon with fired passivating contacts." *Solar Energy Materials and Solar Cells* 238 (2022): 111647.

[12] Kou, Gang, Serhat Yüksel, and Hasan Dinçer. "Inventive problem-solving map of innovative carbon emission strategies for solar energy-based transportation investment projects." *Applied Energy* 311 (2022): 118680.

[13] Sarkar, Tamen Thapa, and Chitralekha Mahanta. "Gain Tuned Sliding Mode Control Based Maximum Power Point Tracking for Solar PV systems." *IFAC-PapersOnLine* 55, no. 1 (2022): 417-422.

[14] Zhou, Chenyu, Zhaoyi Xi, Dario J. Stacchiola, and Mingzhao Liu. "Application of ultrathin TiO2 layers in solar energy conversion devices." *Energy Science & Engineering* 10, no. 5 (2022): 1614-1629.

[15] Hao, Daning, Lingfei Qi, Alaeldin M. Tairab, Ammar Ahmed, Ali Azam, Dabing Luo, Yajia Pan, Zutao Zhang, and Jinyue Yan. "Solar energy harvesting technologies for PV self-powered applications: A comprehensive review." *Renewable Energy* (2022).

[16] Soto, Esteban A., Lisa B. Bosman, Ebisa Wollega, and Walter D. Leon-Salas. "Analysis of Grid Disturbances Caused by Massive Integration of Utility Level Solar Power Systems." *Eng* 3, no. 2 (2022): 236-253.

[17] Gerbo, Abayneh, Karuturi Venkata Suryabhagavan, and Tarun Kumar Raghuvanshi. "GIS-based approach for modeling grid-connected solar power potential sites: a case study of East Shewa Zone, Ethiopia." *Geology, Ecology, and Landscapes* 6, no. 3 (2022): 159-173

[18] Costoya, X., M. Decastro, D. Carvalho, B. Arguilé-Pérez, and M. Gómez-Gesteira. "Combining offshore wind and solar photovoltaic energy to stabilize energy supply under climate change scenarios: A case study on the western Iberian Peninsula." *Renewable and Sustainable Energy Reviews* 157 (2022): 112037.

[19] Gopalakrishnan, S., and R. Sasikumar. "Hybrid Power Generation Using-Vertical Axis Wind Turbine and Solar Panel."

[20] https://www.iea.org/news/renewable-electricity-growth-is-accelerating-faster-than-ever-worldwide-supporting-the-emergence-of-the-new-global-energy-economy

[21] https://www.livemint.com/Industry/lGM9f97bTxoboIZebYtq9N/10-technologies-shaping-the-future-of-solar-power.html

Author's Biography

S.P.Meena is working as an Associate Professor in Department of Humanities and Science (Physics) of Sriindu College of Engineering & Technology, Hyderabad, Telengana. She did her Ph.D in Bharathiar University, Coimbatore. She has published research papers in various International and National Research Journals. She has more than 10 years of Teaching Experience. Her area of interest includes thin films and nanotechnology.