*Grenze International Journal of Engineering and Technology, Jan Issue*

# Solar Power Generation Technique and its Challenges - A Comprehensive Review

Himanshu Kitey[1], Dr. Pankaj Chandankhde[2], Dr. Kapil Jajulwar[3], Dr. Mohammad Shahnawaz Shaikh[4] and Dr. Pragati M. Fatinge[5]
[1]M. Tech Communication Engineering/ Department of Electronics and Telecommunication Engineering, G H Raisoni College of Engineering, Nagpur, Nagpur, India
Email: himanshu.kitey.mtechcom@ghrce.raisoni.net
[2-4]Department of Electronics and Telecommunication Engineering, G H Raisoni College of Engineering, Nagpur, India
Email: {pankaj.chandankhede, kapil.jajulwar, mohammadshahnawaz.shaikh}@raisoni.net
[5]Department of Computer Science and Engineering, G H Raisoni Institute of Engineering and Technology, Nagpur
Email: pragati.fatinge@raisoni.net

***Abstract*— In the contemporary world, energy stands as an essential driving force behind socio-economic development. However, with the alarming levels of environmental pollution, there has been a growing focus on renewable energy sources. These sustainable alternatives are gaining increasing attention, particularly as the depletion of fossil fuels becomes more ap-parent. Natural components such as sunlight, wind, and rainfall are used to generate renewable energy. Among these non-traditional renewable sources, solar energy emerges as a prominent contender for power generation.**

**Solar power generation has gained recognition as a promising and environmentally sustain-able renewable energy source to meet growing global energy demands while minimizing cli-mate change consequences. This paper extensively examines solar power generation techniques, encompassing Photovoltaic (PV) Systems and Solar Thermal Technologies. The paper explores the present state of solar power generation technology, outlines its advantages, and researches the various challenges obstructing its widespread adoption. Furthermore, the study offers insights into potential solutions and outlines future directions for advancing solar power generation techniques.**

***Index Terms*— Photovoltaic (PV) System, Solar Thermal Technologies, Renewable Energy, Socio-economic, Solar Power.**

## I. INTRODUCTION

The introduction section offers an overview of the significance of solar power as a renewable energy source and its capability to mitigate greenhouse gas radiations. It contextualizes the paper by emphasizing the growing global demand for energy and the imperative shift towards sustainable energy options. The escalating volatility of fossil fuel prices underscores the increasing importance of renewable energy, especially in the educational sector, where engineering and technology students must understand and respect renewable energy technologies.

Solar energy, among the most widely embraced renewable energy sources, holds a permanent position. Solar energy, a rich and direct source of energy, is offered. The process of creating energy using solar power involves

*Grenze ID: 01.GIJET.10.1.122*

capturing solar radiation and converting it into either usable heat or electrical power. Electromagnetic waves from the sun have the potential to create 178 billion megawatts, which is equivalent to 20,000 times the energy of the entire planet. A part of solar energy powers life-sustaining natural processes such as evaporation, rainfall, and photosynthesis. Over time, humans have been required to harness this boundless energy source but have thus far managed to harness only a fraction of its potential. This extensive research has been dedicated to improving the efficiency of solar panels, aiming to maximize their energy conversion capabilities.

### *A. Photovoltaic (PV) Systems*

The radiation from the sun can be converted into useful electricity using a photovoltaic system. It consists of solar array, inverter, network meter, grid connection and wires. This causes the electrons in the substrate material of a solar panel to become more active when photons of light impact the panel. In the next process, these electrons leave the panel to generate direct current (DC) energy. These photons have different amounts of energy depending on the wavelengths that make up the solar spectrum, [1].

An inverter is often used to convert direct current (DC) electricity into alternating current (AC) power, which makes it more instantly usable for customers. Additionally, most contemporary electric products can only operate on AC power. PV systems can be divided into many groups based on different criteria, including grid-connected vs. standalone systems, etc. The size of photovoltaic systems varies greatly; they can be as little as portable or rooftop devices or as large as manufacturing facilities utilized by utilities.

### *B. Solar Thermal Technologies*

Thermal energy, or heat, is produced by sun radiation using solar thermal technology. Mirrors and lenses are the main tools used by flat or parabolic collectors (low, medium, and high temperature collectors) to concentrate sunlight in solar thermal technology. Solar thermal technologies depend on the sun's thermal energy to create heat, which may then be used for several applications. This contrasts with photovoltaic (PV) systems, which directly turn sunlight into electricity, [9]. Solar thermal solutions come in a variety of Flavors, each with its own strategy to capturing and harnessing solar heat. Here are several examples:

a) *Concentrated Solar Power (CSP):* Concentrating Solar Power (CSP) is a technique that generates high temperatures by focusing sunlight into a small area using mirrors or lenses. The steam produced by the concentrated solar energy is then used to power a turbine that is connected to a generator to finally produce electricity. CSP systems are intended to capture solar energy on a larger scale than standard solar water heating or photovoltaic systems.
b) *Solar Water Heating:* Solar Water Heaters usage solar radiation to heat water. This system operates based on the thermosiphon concept and is specifically designed to provide hot water without requiring costly energy use. This technology involves using solar collectors to heat water for domestic, industrial, or commercial use, such as hot water supply or space heating. This method is very efficient in producing hot water, resulting in significant electricity savings. Additionally, it is environmentally beneficial.
c) *Solar Air Heating*: Solar Air Heating is a renewable energy technique that uses sunlight to heat air for a variety of purposes such as space heating and industrial processes. In contrast to solar water heating, which concentrates on heating water, solar air heating systems gather and use solar energy to directly heat air. Solar collectors are often used in these systems to absorb sunlight and convert thermal energy to air.

## II. SOLAR PHOTOVOLTAIC (PV) PROCESS

A photovoltaic (PV) panel, commonly known as a solar panel, comprises PV cells that absorb sunlight and transform solar energy into electrical energy. These cells, composed of a semiconductor material i.e., gallium and arsenide capable of transmitting energy, such as silicon, are interconnected to form a module. This process relies on the interaction between photons – the particles of sunlight and semiconductor materials found within the solar cells. The creation of an electric current results from this contact, [1]. Photovoltaic (PV) systems usually consist of the following main components:

a) *Solar Panels:* The cell consists of each a N-type and a P-type semiconductor material and a PN junction diode sandwiched in between. This layer is responsible for trapping solar energy which converts into electricity. The N-type layer is also known as the first layer or the emitter layer. The P-type layer is the base layer and the intermediate layer between the two is the PN junction diode. The surface of the cell is covered by an anti-reflective material which traps the light energy and avoids any loss of energy. The bottom layer, the last one may completely be covered by the material in which the conductor is made up of. An external DC supply is generated when photons hit a semiconductor's surface, which causes the semiconductor to absorb them and release electron-hole pairs, [4].

b) *Inverter:* A solar energy system is not complete without an inverter, which is one of the most important components. This electronic equipment is responsible for converting direct current (DC) electricity generated by solar panels into alternating current (AC) power, which is then utilized by the electrical grid. When it comes down to it, an inverter is a device that swiftly changes the direction of a DC input to convert it from DC to AC, [11]. Consequently, a direct current (DC) input will result in an alternating current (AC) output. In addition, a clean sine wave that produces a repeating pattern and has a changeable voltage may be generated and sent into the electrical grid through the utilization of filters and other instruments.

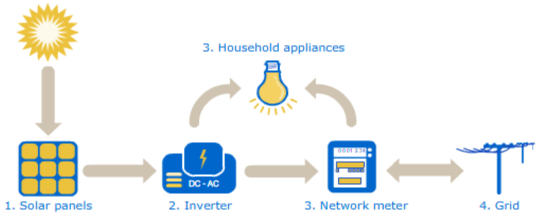


Figure 1. The Solar Photovoltaic (PV) System

c) *Balance of System (BOS) Components*: A grid-connected system needs balancing equipment that allows you to safely transfer electricity to your loads while also meeting your power provider's grid connection criteria. A solar battery bank is necessary for off-grid installations to store the power generated by the PV panels. In the event of a power outage, solar batteries provide an optional backup for grid-connected systems, [7]. The voltage and current from the solar panels into the solar battery are regulated by a solar charge controller. A BMS (Battery Management System) protects your solar batteries from undercharging and overcharging while also assisting in the optimization of performance and efficiency. A sophisticated BMS extends the life of Li-ion and LiFePO4 (LFP) solar batteries while ensuring peak performance. High-quality wire and cables of the appropriate gauge are necessary to connect all your components, [12].

## III. Concentrating Solar Power

In thermal power plants, mirrors reflect the sun's rays and turn them into heat that is raised to a very high level to make electricity. After that, the heat is sent through a normal engine. There are two parts to the plants: one collects solar energy and turns it into heat, and the other uses that heat to make power, [9]. Three different types of technology are used by CSP technology: Power Tower Systems, Dish Engine Systems, and Trough Systems.

a) *Trough Systems:* Figure illustrates the enormous, U-shaped (Parabolic) reflectors (focusing mirrors) seen in trough systems, which have oil-filled pipelines flowing through their focal point. The oil within is heated to as much as 750°F by the sunlight that is focused on the pipes by the mirrored reflectors that are directed toward the sun. During the heating process, the oil is utilized to boil water, creating steam that powers conventional steam turbines and generators, [6].

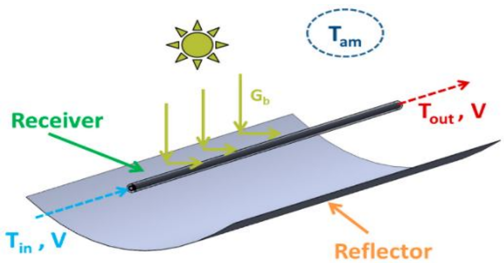


Figure 2. Solar Trough System

b) *Power Tower Systems:* Power tower systems, often referred to as central receivers, employ a multitude of flat, heliostat mirrors to monitor and concentrate the sun's beams onto a receiver. The receiver, seen in the illustration, is situated at the summit of a lofty tower where concentrated sunlight heats a liquid to temperatures reaching up to 1,050°F, such as molten salt. The hot liquid can be stored for future use or immediately used to produce steam, which is essential for generating power. Due to its high heat retention capacity, molten salt may be stored for extended periods of time prior to being converted into energy. This suggests that electricity may be generated during gloomy days, even several hours after sunset or during peak demand periods, [9].

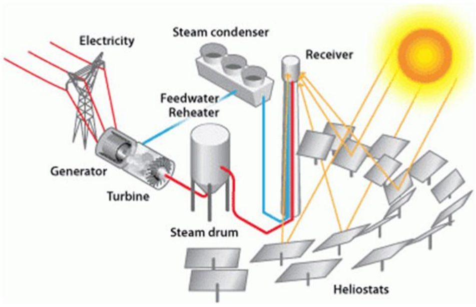


Figure 3. Power Tower Systems

c) *Dish Engine Systems:* Dish Engine Systems use mirrored dishes, which are around 10 times larger than a typical backyard satellite dish, to focus and redirect sunlight onto a receiver. The receiver is positioned at the focal point of the dish, as seen in the diagram. The dish assembly tracks the sun's movement across the sky to optimize solar energy capture. The receiver is integrated into a high-performance "external" combustion engine, [6]. The engine's four piston cylinders are encircled by slender tubes containing hydrogen or helium gas, which connect to them. When focused sunlight hits the receiver, it elevates the temperature of the gas in the tubes to exceedingly high levels, resulting in the expansion of hot gas within the cylinders. The pistons are driven by the expanding gas. The pistons rotate the crankshaft, which in turn powers an electric generator. Consequently, we obtain an alternating current (AC) power supply.

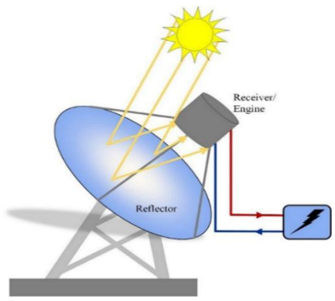


Figure 4. Dish Engine Systems

## IV. Solar Water Heating

A solar water heating system is a device that uses the sun's energy to help heat water. The collector panel, which is part of a solar water heating system, is hit by the sun's rays. A black surface (absorber) inside the collection absorbs the sun's rays and sends the heat energy to the water that flows through it. The hot water is stored in a tank that keeps the heat in. The thermos-siphon device moves water from the tank to the collection and back to the tank on its own. Based on the collection method, solar water heaters can be put into two groups: A solar water heater is made up of a collector that gathers solar energy and an insulated storage tank that holds hot water. The hot water that has been saved can be utilized at any moment.

A flat plate collector is made up of an absorber plate that has an absorbent coating on its sun-facing surface, also known as selective coating. A grid of metallic tubes and sheets makes up the absorber. The tubes carry water. The sun radiation that falls on the sheet is absorbed and transferred to water. To protect the absorber plate from the elements, it is housed in a top open box. To limit heat losses, the area between the absorber's back and sides and the box is filled with insulation. A high transmittance glass plate covers the box's front.

Using circulating pumps, this heat is subsequently transmitted to a water tank. Thermal regulators only enable this exchange to occur when the collector is hotter than the tank water. Hot water rises uphill in this process due to its low density, and cold water with a higher density moves lower due to gravity head. Collectors are typically connected in a series-parallel fashion. It aids in obtaining a huge quantity of hot water. During the summer season, the effectiveness of these collectors is at its peak at midday. Furthermore, the solar water system performs effectively in other seasons. When there is insufficient sunshine, the water in the tanks is pre-heated, and a backup system delivers the water to the required temperature. As a result, the solar water heater operates continuously and creates hot water all year, [10].

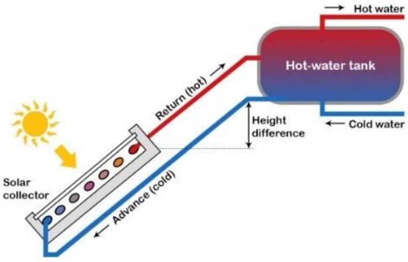


Figure 5. Solar Water Heating

V. SOLAR AIR HEATING

A Solar Air Heater is a unique solar system that heats the air with sunlight. It has windows that let sunshine in and warm the air inside. After that, this warm air can be sent into a room right away or saved for later use. Two main parts of a solar air heater are the screens that catch sunlight and the diffusers that let air flow through them. There may be a fan in some devices to move the warm air around, but in others, fresh air flows naturally.

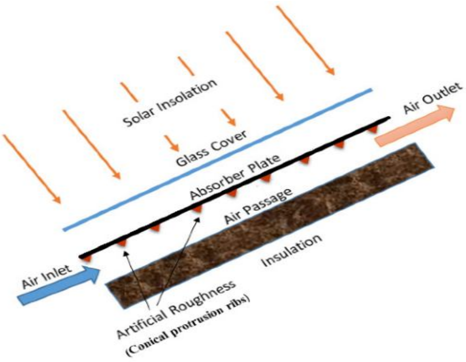


Figure 6. Solar Air Heating

Unglazed air collectors are like heaters that use outside air, not the air inside a building. Transpired solar collectors are mounted on walls to catch sunlight from lower angles during winter and even sunlight reflecting off snow. They work best when the air flows through them at rates of 4 to 8 cubic feet per minute per square foot of collector area. Transpired solar collectors have lots of tiny holes on their surfaces. These holes capture heat from the sun and pull it into an air space behind the panels. This warm air is then taken into the building's ventilation system through outlets on top of the collector. The warm air is distributed inside the building as needed. Using transpired solar collectors can cut the need for conventional heating by 10% to 50%. They can also catch heat escaping from the building, bringing it back into the ventilation system, [11].

a) *Non-Porous Type Solar Air Heater:* Non-porous solar air heaters are distinguished by the fact that the air does not pass through the area that is located below the absorber plate. Another possibility is that it will flow above or behind the plate. When the absorber plate is in contact with the transparent cover, air is allowed to travel through it directly. However, the hot air that is traveling above the absorber causes the cover to absorb a significant amount of the heat, which results in a significant amount of heat being lost to the surrounding environment. Since it is inefficient, this air heater is not recommended. The most common type of non-porous material that has an air passage beneath the absorber is designed with a plate that is positioned parallel to the absorber plate. This creates a passageway that has a high aspect ratio between the absorber and the insulation. A more efficient heat collection and retention system is provided by this design. In a different kind of air heater that is not porous, the absorber plate is cooled by an air stream that is flowing on both sides of the plate. Even additional enhancements to the solar air heater's efficiency are brought forth by this design.

b) *Porous-Type Solar Air Heater:* A Porous type of solar air heater is a clever device that uses tiny holes or openings in its absorber plate. When sunlight hits the plate, the air flowing through these small holes gets heated up. This heated air is then sent into the area or room that needs to be warmed up. It's like having a smart and eco-friendly heater that works with the power of the sun. The tiny holes in the absorber plate allow air to pass through and get heated, making it an efficient way to capture solar energy for heating purposes. These types of solar air heaters are simple to use and can help save on energy costs while being gentle on the environment. With the porous type of solar air heater, we can enjoy a cozy and warm space without relying solely on electricity or other traditional heating methods.

## VI. Solar Energy In India

The Ministry of New & Renewable Energy (MNRE) has published the Scheme-wise Cumulative Physical Progress report for August 2023, providing information on the accomplishments in the renewable energy industry for the current fiscal year. Significant progress has been achieved in the domain of installed renewable energy capacity, [1]. In the current fiscal year, Wind Power has increased by 1306.95 MW, resulting in a total accomplishment of 43,940.08 MW as of July 31, 2023. At the same time, Solar Power has seen a significant rise of 4364.65 MW, bringing the total accomplishment to an amazing 71,145.01 MW. During the fiscal year, Small Hydro Power has increased its power generation capacity by 38.45 MW, resulting in a total cumulative capacity of 4982.75 MW.

The Worldwide Solar Alliance (ISA) is a treaty-based worldwide international association with the goal of attracting more than one trillion dollars' worth of investment by the year 2030, which is necessary for the widespread implementation of solar energy, [13]. The International Solar Alliance (ISA) was created on November 30, 2015, when Prime Minister Narendra Modi and President Francois Hollande of France came together to form the organization. The organization's goal is to increase solar energy utilization and lower solar power production costs by combining the need for solar financing, technology, innovation, R&D, and capacity building.

## VII. Benefits Of Solar Energy

Solar energy is a natural source that is both clean and renewable. The earth is constantly supplied by the sun. The rising usage of solar energy has reduced the need for alternative energy sources, which is excellent news for both the ecosystem and the environment.

Maintaining solar energy systems is minimal, typically involving biannual cleaning. However, it is crucial to emphasize that cleaning should be performed by a qualified professional. The system also incorporates inverters that are replaced every 5-10 years, which means that maintenance and repair work, aside from the original expenditures, is quite low, [8].

Solar energy is a limitless supply of power that is safer than traditional energy sources, regardless of how it is used, maintained, or repaired. It can be used anywhere on the planet, making it constantly available. Because you meet all your energy demands with solar energy, you are relieved of the high cost of your power bill. The amount you can save on your bill is determined by your needs.

Solar energy may be used for several purposes. Using solar energy, anything may generate electricity or heat (solar heat). It can offer energy to locations that do not have it, be used in factories to produce clean water, be used for home activities, and be used in space satellites.

The industry's growth has expanded because of the rising usage of solar energy, and it is predicted to continue to develop in the future. Overall, solar panels may help you conserve power and reduce large electricity bills by utilizing solely nature's energy supply, the sun.

## VIII. Challenges Of Solar Power Generation

The paper discusses various challenges faced by solar power generation, [5] including:

a) *Intermittency and Variability:* Addressing the issues related to solar energy's intermittency due to day-night cycles, weather conditions, and seasonal variations.

b) *Energy Storage:* The need for effective energy storage systems to offset the consequences of intermittency and enable reliable power supply is being investigated.

c) *Land Use and Environmental Impact:* Analyzing the environmental consequences and land needs of large-scale solar systems. The scarcity of land to install big terrestrial solar systems is one of the problems of solar energy in India, which solves the possibility for greater R&D and innovation to boost installation tenfold.

d) *Material Supply Chain and Recycling:* Investigating supply chain difficulties and the recycling of PV panels and other solar components. Domestic manufacturing Due to a lack of infrastructure, trained personnel, and expensive manufacturing costs, India's photovoltaic cell and module industries are severely weak.
e) *Grid Integration:* Addressing technical and regulatory challenges in integrating solar power into existing energy grids.
f) *Waste Management:* It must be considered the absence of solar waste management is a key solar difficulty in India that is impeding the expansion of the solar sector. Solar waste in India is expected to increase by 1.8 million tons by 2050. Currently, e-waste restrictions are not necessary in India, resulting in a considerable volume of solar energy waste each year.
g) *Financial Mechanism:* There will be no disruption. Innovative financing options for developing large-scale solar farms are another essential component of India's solar energy challenge, since they may provide larger quantities at lower interest rates for a longer period. Some government measures, like as the National Clean Energy and Environment Fund and the sale of green Masala Bonds, have helped to alleviate the problem to some extent.
h) *Low Rates:* Because the Government of India offers one of the lowest solar rates, some developers are unable to buy solar panels, lowering the quality of solar panels. This is yet another key aspect of India's solar challenge that must be solved.

## IX. SOLUTION AND FUTURE DIRECTIONS

People are looking for other energy sources as thermal energy supplies dwindle. India has increased solar energy output to meet rising energy needs. Many sections of the country are developing solar thermal power plants to generate energy like conventional power plants. India is a leader in solar power energy generation. Solar energy might meet industrial, commercial, and household energy demands, [2].

Indian solar installations are among the biggest, with more coming. Gujarat dominates global solar power. Indian officials aim to build solar villages with massive power plants in various locations. The Jawaharlal Nehru National Solar Mission seeks to make India a solar powerhouse Rajasthan, Andhra Pradesh, Madhya Pradesh, Punjab, Maharashtra, and Haryana are strategically positioned and have tremendous solar energy potential for power generation. Energy from solar parks is planned. The Indian Ministry of Defense needs solar power for building sites above 100 square meters. Tax incentives will encourage solar energy in such constructions, [3].

The transition from traditional to non-traditional solar energy will address the problem of non-renewable energy resource overconsumption. It is a renewable energy source that is abundant in India and should be exploited appropriately to meet the country's increasing energy demands, [14].

## X. RESULT & ANALYSIS

Over the years, solar power production has witnessed considerable technological and infrastructural developments, with numerous approaches being created to collect solar power. Concentrated Solar Power (CSP) and Photovoltaic (PV) Systems are two of the most notable solar power-producing approaches. These strategies have shown significant promise in terms of supplying sustainable and renewable energy, helping to the worldwide move toward cleaner energy sources and decreased dependence on fossil fuels.

Despite improvements, solar power production still confronts various problems that must be solved to achieve universal acceptance and optimum efficiency. Among these difficulties are High Initial Costs, Intermittency and Storage, Land Usage and Environmental Impact, Efficiency Limitations and Technological Constraints, Policy, and Regulatory Hurdles.

During the first half of 2023, India's solar generation increased by 26%, which resulted in an increase of 12 TWh. This growth was more than the average growth of the world, which was 16%. With twelve percent of the total additions made throughout the world in the first half of 2023, India provided almost as much additional solar production as the European Union. Solar energy was responsible for the generation of 5.5% of the world's power during the first half of 2023, representing a 16% increase (+104 TWh) in comparison to the same time in the previous year. According to the research, India's solar growth of 26% (+12 TWh) was higher than the average for the whole world. This growth was responsible for half of the country's demand uptick over the same time.

Global efforts are being undertaken to overcome these issues, with an emphasis on R&D, technical innovation, and legislative changes to make solar energy more accessible and cost-effective. Furthermore, the sector is focusing on developments in energy storage technology, increases in solar panel efficiency, and the development of more sustainable production procedures.

## XI. Conclusion

The report finishes by describing the present state of solar power generation, emphasizing its potential advantages, and emphasizing the significance of overcoming hurdles to achieve a sustainable energy future. In physical terms, solar energy, a renewable energy source, is readily available in most regions worldwide.

However, its theoretical potential far exceeds the current total primary energy supply in these areas. Sun energy and technology may assist in addressing energy availability in rural locations, and distant communities can aid in long-term energy security recovery.

This study intends to contribute to the current efforts to promote solar energy as a critical component of the global energy mix by examining present solar power generating systems and resolving the accompanying problems.

## References


[1] Chinedu Okoye and Ugo Iduma Igariwey, "Solar PV Power Generation: Key Insights & Imperatives". International Journal of Energy and Environmental Research.7, No.3, pp.31-41, December 2019 Published by ECRTD-UK ISSN 2055-0197(Print), ISSN 2055-0200(Online).

[2] Kalbande, Kamlesh, Swapna Choudhary, Anushka Singru, Ishika Mukherjee, and Prachi Bakshi. "Multi-Way Controlled Feedback Oriented Smart System for Agricultural Application using Internet of Things." In 2021 5th International Conference on Trends in Electronics and Informatics (ICOEI), pp. 96-101. IEEE, 2021.

[3] Saeed Samadi, Student Member, IEEE, "Reliability Evaluation of Generation Systems with Solar Power", Department of Electrical and Computer Engineering Texas A&M University College Station, TX, U.S.A. 978-1-4799-3561-1/14 ©2014 IEEE.

[4] Keskar Vinaya N, "Electricity Generation Using Solar Power", International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181 Vol. 2 Issue 2, February 2013.

[5] Arun Kumar Singh Tomar, K. K. Gautam, "A Review of Solar Energy – Challenges, Economics & Policies in India", International Journal of Science and Research (IJSR) ISSN (Online): 2319- 7064 Index Copernicus Value (2015).

[6] Kalbande, Vednath P., Pramod V. Walke, Sachin Untawale, and Man Mohan. "Performance Evaluation of Novel Heat Pipe-Assisted Thermal Storage System with Parabolic Trough Solar Collector Using Nanofluid." Energy Technology 10, no. 9 (2022): 2200118.

[7] Deshmukh, Akshay Narendra, and Vinod K. Chandrakar. "Design and Performance Analysis of Grid-Connected Solar Photovoltaic System with Performance Forecasting Approach (PFA)." Journal of The Institution of Engineers (India): Series B 103, no. 5 (2022): 1521-1532.

[8] Padwad, Dipali, and Hari Kumar Naidu. "A Review of Electrical Boat Vehicle Solar Generation for Energy Sustainability and Development." In 2022 10th International Conference on Emerging Trends in Engineering and Technology-Signal and Information Processing (ICETET-SIP-22), pp. 1-6. IEEE, 2022.

[9] Khobragade, Prashant, Payal Ghutke, Vednath P. Kalbande, and Neha Purohit. "Advancement in Internet of Things (IoT) based Solar Collector for Thermal Energy Storage System Devices: A Review." In 2022 2nd International Conference on Power Electronics & IoT Applications in Renewable Energy and its Control (PARC), pp. 1-5. IEEE, 2022.

[10] Khedikar, Isha P., A. R. Tembhurkar, Kuldeep R. Dabhekar, and B. J. Godboley. "Effect of turbidity on survival of Escherichia coli, feacal coliform and total coliform in grey water by using solar disinfection (SODIS)." In Journal of Physics: Conference Series, vol. 1913, no. 1, p. 012068. IOP Publishing, 2021.

[11] Zade, Nikhil, and Kapil Jajulwar. "Performance Analysis of Paper cup machine Using Capacitive sensor for industry automation." In 2021 12th International Conference on Computing Communication and Networking Technologies (ICCCNT), pp. 1-4. IEEE, 2021.

[12] Kolhe, Mukul, Roshan Paturkar, Umesh Sahu, Sofia Pillai, and Abhijit Titarmare. "Analytic for Temperature and Humidity–Cloud based Forecasting and Dashboard." In 2020 4th International Conference on Intelligent Computing and Control Systems (ICICCS), pp. 674-679. IEEE, 2020.

[13] Kumari, Kriti, Pankaj H. Chandankhede, and Abhijit S. Titarmare. "Design of human activity recognition system using body sensor networks." In 2021 6th international conference on communication and electronics systems (ICCES), pp. 1011-1016. IEEE, 2021.

[14] Choudhary, Swapna, Kamlesh Kalbande, and Nitin Dhote. "IoT based Multi-point Pesticide Spraying Machine." In 2021 6th International Conference on Inventive Computation Technologies (ICICT), pp. 432-436. IEEE, 2021.