

The Canal Top Solar Power Generation Project

Samruddhi Nilesh Kalaskar¹, Vaishnavi Mane², Sanika Khude³, Sujata Shinde⁴

⁵Prof. V. B. Chakrasali

^{1,2,3,4}*Department of civil engineering TSSMS,*

SPPU TSSM PVPIT College Bavdhan Pune

⁵*Guidance, Department of civil engineering TSSMS,*

SPPU TSSM PVPIT College Bavdhan Pune

I. INTRODUCTION

“The Canal Top Solar Power Generation Project”

Due to the increase in world population, development in industrial activities, and enhancement in living standards, the human demand for electricity will grow in the future years. Traditional fossil fuels such as oil and coal cause carbon dioxide emissions and global warming. Thus, it is necessary to explore appropriate alternative sources for electricity generation that are environmentally benign and sustainable. Solar energy is one of the most attractive sources of energy for electricity generation. Typically, solar energy harnessed in the daytime needs to be stored (thermally or electrically) for utilization in the night. Utilizing energy storage units typically result in increased investment and maintenance cost and increasing the levelled cost of generation of electricity. Recent advances in solar energy research and development have helped make solar energy systems more affordable for commercial utilization.

Research continues in order to decrease the constraints (which are mainly technical) and cost of those systems which are typically employed in solar power plants. Based on a recent International Energy Agency (IEA) report, the share of fossil fuels in the global energy consumption is equal to 82%, however, it is anticipated that this share will be reduced down to 75% by 2035 by developing new renewable energy sources or adding improvements to the present renewable energy systems. The energy received by the earth from the sun in 1 day can provide the whole world's energy requirements for more than 20 years since this is the rate of the solar energy that falls to the earth's surface: 120×10^5 watts. Developing solar energy

infrastructures can enhance the level of energy security since it is an import-independent energy source. In addition, using solar energy results in minimal environmental impacts.

Renewable energy sources are environmentally friendly (He rez et al., 2018), one of which is by increasing power generation by using distributed charging stations based on renewable energy sources (Torreglosa et al., 2016). Within increasing public awareness of environmental protection and strengthening continued government support, more and more home users have installed small scale distributed renewable energy power generation systems such as solar power and wind energy (Zatsarinna et al., 2020) (Sun et al., 2020). Therefore, it is highly expected that future markets will see high growth of this technology with different types of distributed generation (Wang et al., 2020). Moreover, the generation of electricity from renewable energy sources integrated into a smart grid system can be one of the best choices for future energy security. Smart network system overcomes resource breakdown and modern information technology for communication and 3 improves power distribution efficiency.

However, this renewable energy is likely to be produced not only at the industrial level (for example, on a large-scale state or private company) but also at the household or individual level (Strielkowski et al., 2019). Human Activities contribute to climate change and, consequently, environmentally friendly energy generation is needed. For this, finally, we explore the possibility of utilizing solar energy (Strušnik et al., 2020), because it can be used to overcome dependence on non-renewable resources (Sahu & Raheman,

2020). Renewable and alternative energy has great potential benefits to replace dependence on fossil fuels, bringing progress into the mainstream slowly in most developing countries (Vaka et al., 2020). A study conducted by JX Sun, JN Wang, WX Yu, ZH Wang, and YH Wang shows that the proposed algorithm is applied for household electrical load sorting with solar panels, with high accuracy and reliability (Sun et al., 2020). In general, previous research related to renewable energy and solar panels has only examined one research topic, such as one country (Pantua et al., 2020), one affiliation (Preston et al., 2020), and one field (Ioannidis & Koutsoyiannis, 2020). The creation and management of records by individuals or organizations is growing rapidly, especially the change from print to electronic, and the smallest fraction of records or metadata (Wicaksono & Nurpratama, 2017).

Unfortunately, although it displays a broad image map visualized from year to year with details from several published studies on a global scale, there is not much literature on renewable energy and solar panels. The strong positive relationship regarding affiliation, scholars, and the impact of scientific studies has also not been explicitly discussed by any publication. This study aims to study the position of literature in the field of renewable energy and solar panels by researchers at the global level published internationally and indexed by Scopus using bibliometric position. We monitor an increasing number of scientific documents related to renewable energy and solar panels published and indexed by Scopus from 1989 to 2020. Energy is one of the most important factors affecting and shaping our daily life. Basic life necessities such as water and food are also obtained and transported by energy. Therefore, having high-quality and uninterrupted energy is a basic need, for reasons such as rising fuel prices, energy requirements, pollution, and greenhouse gases; the use of environmentally friendly renewable energy sources is increasing rapidly. Due to the high potential of renewable energy in our country, renewable energy systems are also increasingly popular (Demiroren & Yilmaz, 2010).

Therefore, the use of renewable energy to supply electricity has grown in recent years, especially wind and solar. Electrical energy has been universally accepted as one of the most important aspects of

electrical energy for human development and economic growth (Vishnupriyan & Manoharan, 2018). To match the ever-increasing demand for power, the concept of renewable-based power generation is being implemented, and a lot of research is being done on the same (Balasubrahmanyam & Gupta, 2020). Solar energy is one of the cheapest, pollution-free, inexhaustible renewable energy resources. It is used to provide heating, hot water, electricity, and even cooling to residential, commercial, and industrial centers (Zoghi et al., 2017). Solar energy is considered a reliable, promising, and profitable energy source. It has various advantages such as being pollution-free, having a long life, being low maintenance, etc. (Gupta et al., 2016). Solar energy is used in at least 4 different ways in our daily lives, and these range from heating water to generating electricity (Husain et al., 2018).

1.1 Need of Present Study

In the present era of rapid industrialization and urbanization, the global demand for energy is continuously increasing. Most of this demand is still being met by conventional fossil fuels such as coal, oil, and natural gas, which are finite in nature and cause severe environmental pollution. To achieve sustainable development, there is an urgent necessity to shift towards renewable and eco-friendly sources of energy. Among various renewable energy options, solar power has emerged as one of the most reliable, clean, and abundant sources. However, the conventional ground-mounted solar power systems require vast tracts of land, which often compete with agricultural, residential, and ecological needs.

To overcome this challenge, the Canal Top Solar Power Generation concept has been introduced as an innovative and sustainable solution.

The present study on canal-top solar power generation is needed for the following reasons:

1) Optimal Utilization of Available Resources

India has an extensive network of irrigation canals that can be effectively used for solar installations. By utilizing the space above canals, solar panels can be installed without acquiring additional land. This reduces the cost of land acquisition, prevents deforestation, and ensures that fertile agricultural land remains available for cultivation.

2) Conservation of Water Resources

Water scarcity is one of the major problems faced by many regions of India. When solar panels are installed above canals, they provide shade to the flowing water, thereby reducing the rate of evaporation. Studies show that canal-top solar installations can reduce water loss by 20–30%, ensuring more water availability for irrigation and domestic use.

3) Improvement in Solar Panel Efficiency

The presence of water beneath the solar panels helps maintain a lower ambient temperature around the panels. This natural cooling effect prevents overheating of the photovoltaic cells, resulting in higher.

4) Environmental Protection and Climate Benefits

Canal top solar power generation produces clean and renewable electricity without emitting greenhouse gases or other pollutants. It helps in reducing dependence on fossil fuels and contributes significantly to carbon footprint reduction, thus supporting national and global efforts to combat climate change.

5) Socio-Economic Development

The implementation of canal-top solar projects promotes rural employment and technical skill development. It provides opportunities for local people in construction, maintenance, and monitoring activities. Moreover, it can support irrigation needs by ensuring a reliable energy supply for pump operation, enhancing agricultural productivity and farmers' income.

6) Alignment with National Energy Goals

India has set ambitious targets to achieve a large share of renewable energy in its total power generation capacity. Projects like canal-top solar power generation align with national missions such as the Jawaharlal Nehru National Solar Mission (JNNSM) and the National Action Plan on Climate Change (NAPCC). These projects demonstrate the country's commitment to sustainable and innovative energy solutions.

7) Replication and Scalability Potential

Studying the performance, benefits, and challenges of canal-top solar systems will help in developing standard models for large-scale implementation. The findings of such studies can be replicated across other canal networks in India and abroad, making it a scalable and globally relevant technology.

II. LITERATUREREVIEW

A literature review is an account of what has been published on a topic by accredited scholars and researchers. In writing the literature review, our purpose is to convey what knowledge and ideas have been established on the above-mentioned topic and what their strengths and weaknesses are.

Gupta (2024) aimed to compare solar power technology and cost trends in India, the USA, and Japan. The study concluded that decreasing PV costs make solar projects highly feasible in India.

Ghadge (2023), in his paper "Review on Solar Energy Resources and PV Systems," presented an overview of solar energy development, technologies, and their applications in India and worldwide. The study emphasizes India's progress under the National Solar Energy Mission–2020 and the use of solar pumps for irrigation and electricity generation. The author reviewed several research works on solar photovoltaic (PV) systems, highlighting advancements in solar harvesting techniques, hybrid PV systems, and solar thermal power. The paper also discusses the challenges, such as high installation cost, lack of investor support, and dependency on imported components. Ghadge concludes that with continuous technological improvements and government support, solar energy can significantly reduce dependence on conventional fuels and meet India's growing power needs sustainably.

Hanaji (2022), in her paper "The Concept of Canal Top Solar Power Plant," discussed the innovative approach of installing solar panels over irrigation canals to generate renewable energy while conserving land and water. The study highlights that India faces challenges in producing solar energy due to limited barren land and high population density, especially in urban areas. The canal-top solar system proposed by Gujarat effectively utilizes existing canal infrastructure, preventing water evaporation and improving panel efficiency through cooling effects. The paper also notes that canal-top solar projects support India's National Solar Mission by promoting clean energy generation and reducing dependency on fossil fuels. Overall, the study concludes that canal-top solar power plants are a sustainable and space-efficient solution for meeting India's growing energy demand. Bhadke and Gulhane (2022) aimed to identify challenges and policy gaps in India's solar energy

sector. They found that financial limitations, land issues, and lack of awareness hinder growth and recommended stronger government support.

Vishwakarma, Chandrabhushan; Dwivedi, Ananya; Yadav, Devendra (2022). The authors discussed India's growing energy demand and the significance of renewable energy in achieving sustainability. The paper emphasized that installing PV systems on canal tops is a practical solution to land scarcity issues faced by conventional solar plants. It highlighted the geographical suitability of India for solar installations due to high solar irradiation. The study reviewed several canal-top solar power projects, their operational principles, benefits, and implementation challenges.

Alhejjietal. (2021) aimed to evaluate energy generation and water-saving potential from canal-top PV systems in arid regions. The study confirmed that these systems efficiently generate clean energy while significantly reducing water loss.

Mudit & Garg, Rahul Dev (2021): The authors used remote sensing, GIS (Geographic Information System), and cloud data to assess solar potential over the Ganga canal in Roorkee Tehsil, India. Satellite images from Google Earth were analysed using QGIS software to calculate the usable canal area for PV installation.

Global Horizontal Irradiance (GHI) data from NREL (USA) and MNRE (India) were used to determine solar potential and converted into tilted GHI for higher accuracy. Buffer analysis revealed that 83% of towns and 46% of villages near the canal could benefit from canal-top solar energy.

Yadav and Mishra (2020), in their paper "Status of Conventional Energy Sources and Solar Energy in India: A Review," discussed India's growing energy demand and the shift from conventional to renewable sources. The study highlights that conventional fuels like coal and oil cause pollution and contribute to greenhouse gas emissions. To overcome energy scarcity, India is promoting solar energy due to its vast sunlight availability. In 2019–20, renewable sources contributed 23.90% of total power generation, with solar energy sharing 9.80%. The paper concludes that solar energy has great potential to meet future energy needs sustainably.

Sairam and Aravindhan (2020), in their paper "Canal Top Solar Panels: A Unique Nexus of Energy, Water, and Land," discussed an innovative approach to solar

energy generation that utilizes the space above irrigation canals for installing solar panels. The study highlights how canal-top solar systems save valuable land resources, reduce water evaporation, and generate clean electricity simultaneously. By shading canals, these systems lower water temperature and minimize loss due to evaporation while also improving solar panel efficiency through natural cooling.

The author emphasizes that India, with its vast canal network and abundant sunlight, has great potential for such projects. They also note that canal-top systems contribute to sustainable development by addressing the energy-water-land nexus and reducing greenhouse gas emissions. Overall, the paper concludes that canal-top solar projects are a practical and eco-friendly solution to meet India's growing energy demands while conserving natural resources.

Baradei and Al Sadeq (2020), in their paper "Effect of Solar Canals on Evaporation, Water Quality, and Power Production: An Optimization Study," analysed how solar canals can serve as an integrated solution for energy generation, water conservation, and environmental protection. The study developed a mathematical model and optimization system to determine the best canal coverage that minimizes evaporation, maintains water quality, and maximizes power output. The research found that covering 33% to 50% of a canal with solar panels achieved optimal results. The authors also examined water quality parameters such as dissolved oxygen, pH, and nutrients, showing that partial canal coverage helps maintain ecological balance while reducing water loss and enhancing solar power efficiency. Overall, the study demonstrates that solar canal systems are an effective and sustainable approach to address energy and water scarcity simultaneously.

Naz (2019) aimed to study solar energy generation across different Indian states. The paper compared statewide installations and found that Rajasthan and Gujarat lead due to high solar potential and supportive policies.

Nair and Morkhade (2018) focused on analysing the feasibility of a hybrid canal-top solar-hydro system. Their objective was to utilize existing hydro infrastructure along with PV panels to improve power reliability and reduce cost, showing positive results for hybrid generation.

Aryal (2018) aimed to review solar energy as a clean renewable source, discussing its global importance and seasonal variations affecting generation efficiency.

Sajimon and Chacko (2017) aimed to design reflectors for canal-top solar power plants to enhance solar radiation on panels and reduce water evaporation. Their study showed that adding reflectors between PV rows improves energy output and supports sustainable water use.

Gaikwad, O. D., & Deshpande, U. L. (2017). The paper discussed the increasing global energy demand and dependence on fossil fuels. The authors proposed the use of floating and canal-top PV systems as alternative renewable solutions, especially in developing countries like India. These systems not only generate electricity but also reduce water evaporation from canals, helping in water conservation. The paper also highlighted the benefits of solar power as a sustainable and environment-friendly energy source, particularly for rural and urban areas in India.

III. PROBLEM STATEMENT

Conventional solar power plants occupy large areas of land, often leading to land scarcity and land-use conflicts in agricultural and populated regions. Open irrigation canals also experience high water losses due to evaporation, especially in hot climatic conditions. While installing solar panels over canals can help address these issues, it presents several technical, structural, and maintenance challenges that need to be managed carefully. Additionally, the rising demand for renewable and sustainable energy sources, driven by the depletion of fossil fuels, further emphasizes the importance of innovative solutions like canal-top solar power generation.

IV. AIM & OBJECTIVE

A. Aim:

To produce clean electricity while conserving land and water resources, reducing evaporation losses, and enhancing the efficiency of solar panels through the natural cooling effect of flowing water. It also risks promoting green technology, reducing carbon emissions, and supporting the nation's transition

toward sustainable and environment-friendly energy solutions.

B. Objective:

- 1) To evaluate the technical and economic feasibility of installing solar panel over canals.
- 2) To reduce water evaporation losses from canal surfaces by providing shade through solar panel installations.

V. MATERIALS & METHODOLOGY

A. Materials

1. Esp-32
2. Flowmeter
3. Turbidity Sensor
4. Servomotor
5. Batteries
6. Water pump 12v
7. DC motor
8. INA 219 current sensor
9. Foamboard
10. Metal base
11. Solar panel
12. Solar charge module

B. Methodology

Working and benefits of solar power plant

What is a solar power plant? Solar energy is the energy that is available from the sun in abundance. Solar power is the conversion of sunlight into electricity. As electricity plays a key role in our day-to-day life, we need it in abundance. As sunlight is clean and is available for free, solar power is created from it. A solar power plant is basically a system that supplies electricity to wide areas. The solar power tower. The system has many sun-tracking mirrors installed that help in tracking sunlight into a central receiver. In the solar thermal power system, the radiation of the sun heats the thermal oil that flows inside the receivers to a temperature of 400 degrees Celsius so that the downstream heat exchanger can generate steam. The steam is then pressurized into the turbine that drives the generator. Thus, the heat collected by the receiver is used as electricity for performing various activities and purposes. The method of this will, however, be explained in detail below. Solar power plants that have been around for some time now help in supplying energy. They act as a source of energy that is totally

pollution-free and environmentally friendly. The traditional solar plants that were used before were solar thermal plants. However, the solar power plants can be made very easily in a few years, as they are made from readily available materials. These solar power plants are huge and hence require lots of space. Thus, the perfect place for their setup would be deserts and other barren, unoccupied lands. Apart from the solar power plant that makes use of tracking mirrors, we have the photovoltaic cells that help in converting the sunlight into electricity directly. These cells are made of semiconductors, i.e., crystalline silicon, which is cheap and works effectively. On the whole, solar power plants are being built in all the developing countries even though the installation charges are expensive.

How Solar Power Plant works?



Figure1.WorkingSolarPower Plant

Electricity can be generated in two ways with the help of solar energy or the sun's energy. It can be generated firstly with the help of photovoltaic electricity and secondly with solar thermal electricity. Photovoltaic electricity is a method that uses photovoltaic cells to capture direct sunlight. The photovoltaic cells are nothing but solar cells. The solar thermal electricity, on the other hand, makes use of a solar collector that has a mirror for reflecting sunlight into the receiver that heats up the liquid, and the heated liquid produces steam, which is used to produce electricity.

Working of Photovoltaic Plant:

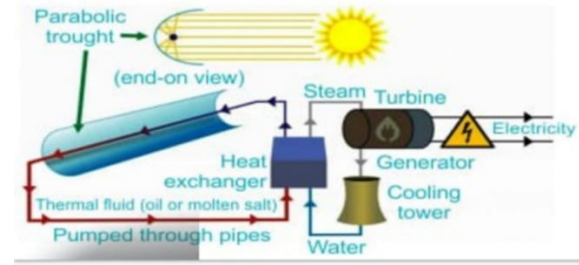


Figure2.WorkingofPhotovoltaic Plant

A solar photovoltaic (PV) system is like any other electrical power generation system in terms of the output, except for the fact that the source of the power is solar radiation. The conversion of solar radiation to electrical power is based on the photovoltaic principles.

However, the principles of operation of the connected load and interfacing with other electrical systems remain the same. Though a solar PV array produces power when exposed to sunlight, several other components are required to properly conduct, control, convert, distribute, and transform the energy produced by the array. Solar power generating systems supplied for this project shall be utilized for powering various office loads like computers, lighting loads, fans, etc. for specified hours of sunshine operation. This system is designed to generate energy in an eco-friendly manner with the source from solar radiation, which is available in abundance.

The system designed is for a 20.00 kWp solar power generation grid-connecting system. The system does not have any storage for standby power. The solar PV array will have 80 units of 250Wp crystalline solar modules. These modules will be connected in a series/parallel combination through optimizers to the desired string configuration as per the design parameters of the PCU. The PCU is of 17KVA capacity with a three-phase AC output. Grid power supply is provided to support the loads and to reduce the grid power consumption when solar power is available.

Types of solar power plant:

We have been talking about what a solar power plant is. Now, after knowing what exactly it is, in easier terms it can be stated that it is a method that makes use

of the energy of the sun for providing electricity for the working of different appliances.

As mentioned before, there are basically three main types of solar power plants, namely – Photovoltaic Solar Energy Plant:

This as mentioned before makes use of photovoltaic cells or solar cells as it is called for generating power. It is used for house wiring and powering electrical appliances.

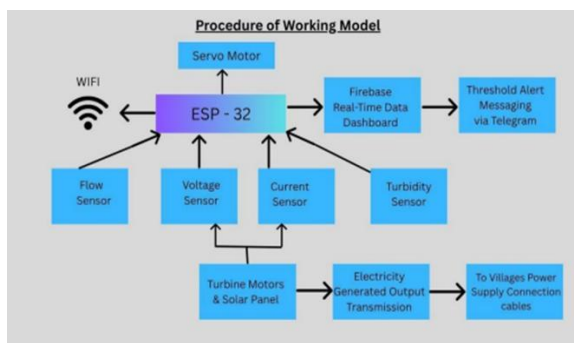
Thermal Energy Solar Power Plant:

This can be used for heating water and drying clothes. Also, this system is used for heating houses during cold days.

Concentrating Solar Power Plant:

This type of solar power plant is very similar to the photovoltaic one. However, the only difference is it makes use of mirrors and lenses for trapping sunlight. The trapped sunlight will then be directed to the photovoltaic cells that will convert into heat energy. These plants are used by big companies and industry

VI. FLOWCHART OF PROJECT



Working of model:

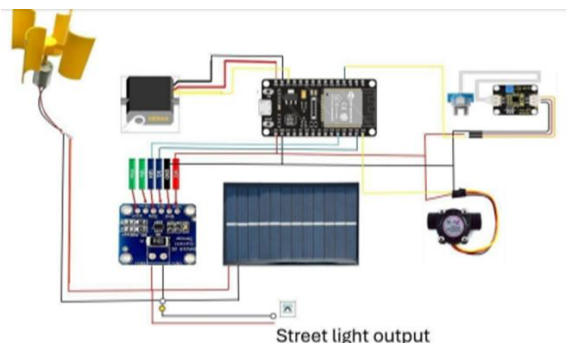


Figure3. Working of model

VII. EXPERIMENTAL OR THEORETICAL WORK

The canal-top solar project is an innovative, experimental renewable energy initiative, pioneered in India, that installs solar panels directly over irrigation canals. It provides a dual benefit: generating electricity while reducing canal water evaporation and avoiding the need for large land acquisitions.

VIII. RESULT AND DISCUSSION

eliminates the need for land acquisition and provides cooler operating temperatures, which boosts panel efficiency by 2–5%

- **Energy Generation:** The project produces over 16 million units (kWh) of clean energy annually, which is used for irrigation pumping stations.
- **Water Conservation:** It saves roughly 90 million liters of water annually from evaporation. **Land Savings:** It saves approximately 25 acres of land for a 10 MW plant, avoiding the need for large-scale land acquisition.
- **Increased Efficiency:** The cooling effect of the water beneath the panels increases their power generation efficiency by roughly 2–5%.
- **Environmental Benefits:** The panels shade the water, reducing algae growth and improving water quality.

IX. FINALIZATION OF CONCLUSION

A novel concept that effectively uses land and conserves water is the canal top solar power plant. It offers a more effective administrative framework for irrigation, smart city, and smart village initiatives. Additionally, the public-private partnership (PPP) form can be used to construct it. Canal top projects are anticipated to take up an increasing share of the country's solar targets as a result of falling cost trends. The development of solar power plants in India could be accelerated and made more affordable using large capacity canal top solar parks.

ACKNOWLEDGEMENT

Research or study on a project is of great importance in one's life because this is an overall application of the knowledge of one's mind. So, we are now satisfied with our step of completing the research on our project i.e "The Canal Top Solar Power Generation Project"

We are thankful to our respected Principal Prof. R. S. Pawar and also our Head of Department, DR.D.B. Jasutkar for permitting us to work on this project and for encouraging us throughout this operation. We are very grateful to our project guide, Prof. V. S. Chakrasali for being there with us in every step for completing this project and for showing the path of new ideas which helped us grow in every possible way we could. Her readiness for consultation at all times, her technical comments and inputs, her concern and assistance have been helpful We are also thankful to the teaching and non-teaching staff of our department for supporting us by direct or in direct means. Lastly, we are very grateful to our Parents and friends who have encouraged us throughout this project.