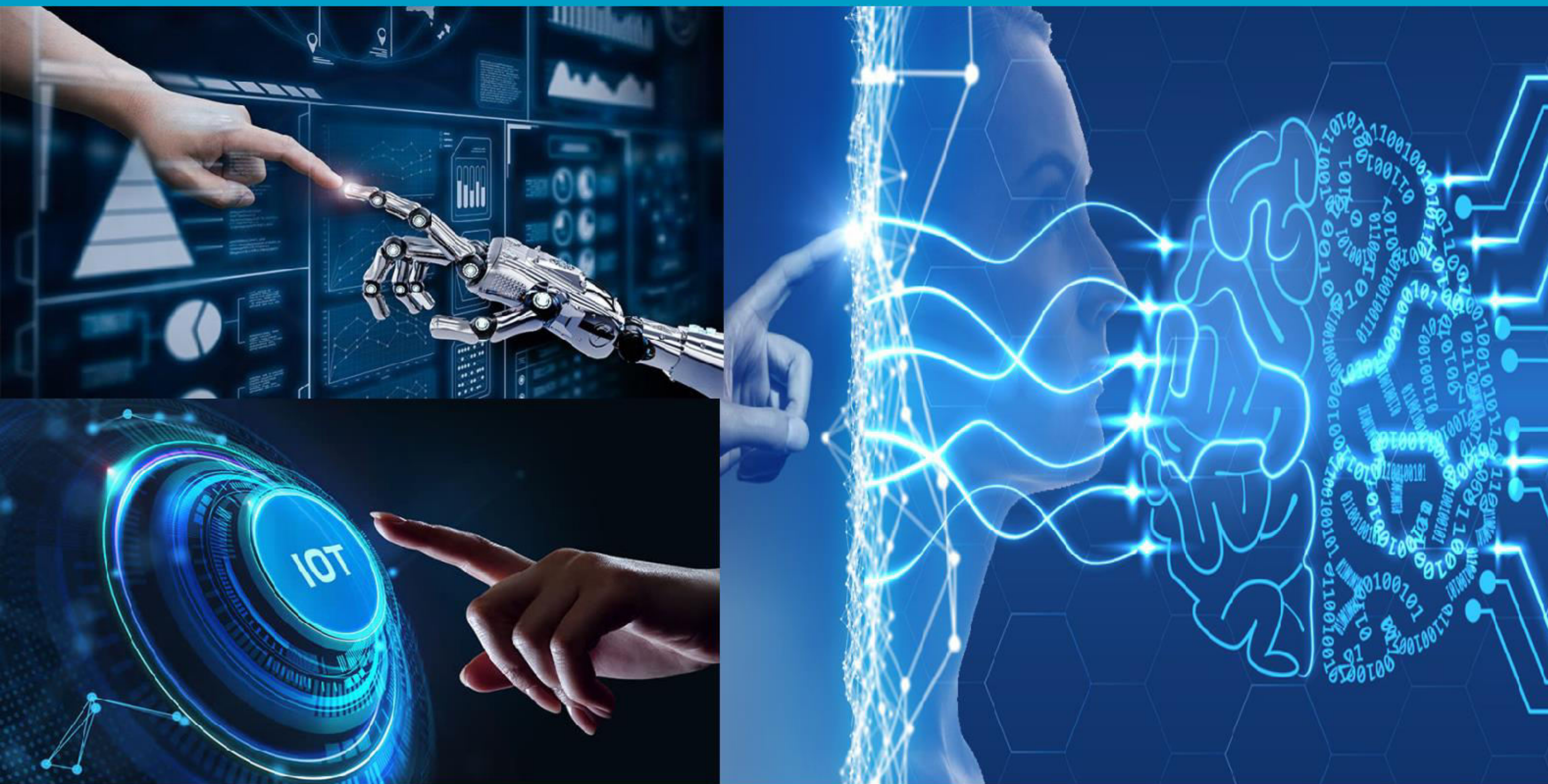
IJMRSETM

e-ISSN: 2395 - 7639



INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH

IN SCIENCE, ENGINEERING, TECHNOLOGY AND MANAGEMENT

Volume 11, Issue 1, January 2024

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 7.580

+91 99405 72462 +9163819 07438 ijmrsetm@gmail.com www.ijmrsetm.com

| ISSN: 2395-7639 | www.ijmrsetm.com | Impact Factor: 7.580| A Monthly Double-Blind Peer Reviewed Journal |

| Volume 11, Issue 1, January 2024 |

Design & Development of Opto-Mechatronic Solar Concentration System for Improving PV Generation Efficiency

Mr.Devman D.Gore [1], Mr.Shekhar G.Pawar [2] , Yogesh A. Jadhav [3] ,Mr.Nandu S.Gaikwad[4]

Matoshri Institute of Technology, Dhanore, Yeola, India[1]

Matoshri Institute of Technology, Dhanore, Yeola, India[2]

Matoshri Institute of Technology, Dhanore, Yeola, India[3]

Matoshri Institute of Technology, Dhanore, Yeola, India[4]

ABSTRACT The focus of this research is to design a ground-mounted photovoltaic system at optimal tilt angle and interrow space to meet high demand of electrical energy. The Department of Electrical Engineering and Technology, GC University Faisalabad has been considered to perform the simulation test. This study is conducted using Meteonorm software for solar resource assessment. Furthermore, HelioScope software is used for modeling of a ground-mounted photovoltaic system, study of PV system's performance in terms of annual generation, system losses and performance ratio and analysis of photovoltaic module's performance, current-voltage and power-voltage curves for different irradiance levels. From SLD, it is seen that 11 strings are connected to each inverter and inverters output power are combined by using 20.0 A circuit interconnects. The performance of photovoltaic systems is impacted by tilt angle and interrow spacing. From simulation results of all cases, it is concluded that the PV system installed at 15° tilt angle with 4 feet interrow spacing are more efficient than the other installed PV systems, because total collector irradiance is maximum (1725.0 kWh/m^2) as compared to other tilt angles. At 15° tilt angle, the annual production of photovoltaic system is 2.265 GWh and performance ratio of PV system is 82.0%. It is envisioned that this work will provide the guidance to energy system designers, planners and investors to formulate strategies for the installation of photovoltaic energy systems in Pakistan and all over the world.

I.INTRODUCTION

Concentrator photovoltaic (CPV) systems combine large, light-collecting apertures with high efficiency semiconductor photovoltaic (PV) materials to convert solar photons directly into electricity. III-V multijunction PV cells provide efficiencies surpassing 40%, but only when illuminated with high solar flux (up to 500x)1-3. These cells are significantly more expensive than crystalline silicon or thin film solar cells, however, optical concentration results in a dramatic reduction in the cell's physical area. Combining small-area, high-efficiency PV cells with inexpensive concentrator optics can potentially decrease costs as well as reducing the system footprint.All CPV optics collect direct insolation while high flux systems actively tracking the sun's daily position. Large aperture concentrators are typically difficult to mount for tracking due to their considerable physical weight and volume, and due to wind-loading forces on the extended surface. Nevertheless, most CPV systems rely on bulky optics such as parabolic dishes or imaging lenses4,5. These elements produce de-magnified images of the sun and can yield high levels of concentration (>1000x), but produce non-uniform flux distributions and require very accurate alignment6. To minimize overall CPV system cost, our goal was to identify a manufacturable optical system that can provide high collection efficiency and 100-500x concentration with a thin physical footprint. The planar geometry lends well to a tilt/roll tracking approach with concentrators mounted into louvered strips, like those of Venetian blinds. Trough Systems

Trough systems use large, U-shaped (parabolic) reflectors (focusing mirrors) that have oil-filled pipes running along their center, or focal point, as shown in Figure 1. The mirrored reflectors are tilted toward the sun, and focus sunlight on the pipes to heat the oil inside to as much as 750°F. The hot oil is then used to boil water, which makes steam to run conventional steam turbines and generators.

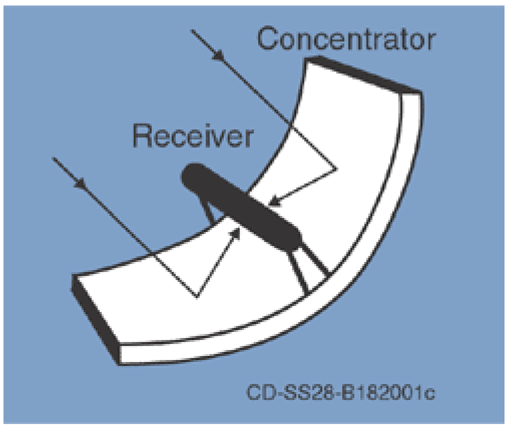


Figure 1: Parabolic Trough System Schematic Diagram   Figure 2: Parabolic trough system.

Figure: 3 SEGS IX Parabolic Trough 360° - Interactive Panorama. Source: Argonne National Laboratory

Figure: 4 Nevada Solar One Parabolic Trough - 360° Interactive Panorama. Source: Argonne National Laboratory

Power Tower Systems

Power tower systems also called central receivers, use many large, flat heliostats (mirrors) to track the sun and focus its rays onto a receiver. As shown in Figure 3, the receiver sits on top of a tall tower in which concentrated sunlight heats a fluid, such as molten salt, as hot as 1,050°F. The hot fluid can be used immediately to make steam for electricity generation or stored for later use. Molten salt retains heat efficiently, so it can be stored for days before being converted into electricity. That means electricity can be produced during periods of peak need on cloudy days or even several hours after sunset.

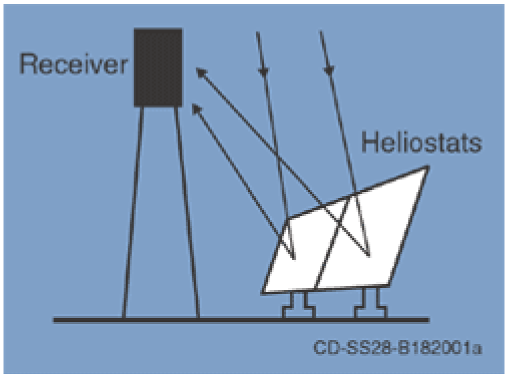


Figure 5: Power Tower Schematic Diagram

Figure 6: Power tower system

Figure.7. Solar Sierra Suntower Power Tower Facility - Interactive Panorama.
Source: Argonne National Laboratory

II.LITERATURE REVIEW

Opeyeolu Timothy et. all (2021) From the results of water sprayed solar algorithm, there is a considerable improvement in power generated by the solar panel with a significant increase in efficiency by 16.65 %. It is very important to ensure that solar panels do not exceed their operating temperature to improve the light absorption.

Linus Idoko et. all (2018) The efficiency and power output of a PV module decrease at the peak of sunlight due to energy loss as heat energy and this reduces the module power output. Multi-concept cooling technique, a concept that involves three types of passive cooling, namely conductive cooling, air passive cooling and water passive cooling has the potential to tackle this challenge. D. T. Cotfas et. all (2019) The electricity demand has greatly increased in recent years due to economy and population growth in developing countries, a gradual rise in comfort levels in well-developed countries, the demand for more goods and services, and the increase in the number of electric vehicles for public transportation and electric cars. India's energy demand will increase the global one with 30% and only a part of the Chinese industry will increase the electricity demand with 20% by 2040, according to the International Energy Agency.

Bhubaneswari Paridaa et. all (2011) A review of major solar photovoltaic technologies comprising of PV power generation, Hybrid PV generation, various light absorbing materials, performance and reliability of PV system, sizing, distribution and control is presented.

Dharmendra thakur et. all (2016) The temperature of the solar cell has a huge impact on the efficiency of photovoltaic system. With the increase in surface temperature of solar cells or panels their efficiency decreases quite dramatically. The

| ISSN: 2395-7639 | www.ijmrsetm.com | Impact Factor: 7.580| A Monthly Double-Blind Peer Reviewed Journal |

| Volume 11, Issue 1, January 2024 |

solar system is one of the most important alternative sources of energy. But the problem is that the PV cell is not 100% consumable. To increase the efficiency of the PV cell we need to find the alternative which will boost the efficiency of the solar panel.

III.METHODOLOGY OF PROPOSED SURVEY

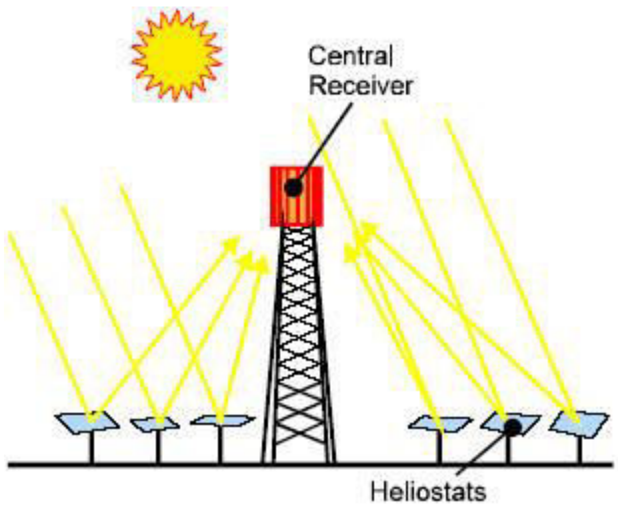


Figure : 8 Basic Layout

Power tower or central receiver systems utilize sun-tracking mirrors called heliostats to focus sunlight onto a receiver at the top of a tower. A heat transfer fluid heated in the receiver up to around 600ºC is used to generate steam, which, in turn, is used in a conventional turbine-generator to produce electricity.Early power towers, such as the Solar One plant, utilized steam as the heat transfer fluid; current designs use molten nitrate salt because of its superior heat transfer and energy storage capabilities. Some other designs use air as heat transfer medium because of its high temperature and its good handability.The world's largest CSP plant in operation is the 392 MW Ivanpah solar plant in California which employs power tower technology.

Objective WORK

Design & Development of an Electro-Optical, Moving Mirror Type Solar Concentration System Using Proprietary Control Algorithm for High PV Generation Efficiency.Use of Modified Perturb & Observer (P&O) Algorithm for Stabilization of Maxima During Power Generation.Hybridization of Control Algorithm with Artificial Intelligence to Optimize Control of Mirror Movement, thereby increasing Power Efficiency.Fusion of Sensor Technology With Machine Learning To Preempt Solar Influx Changes To Reduce Oscillating Mirror Movements & Reduce Overhead Power requirements.Integration of Real Time Clock With Time & Date Synchronization For Preemption of Time of Day Wise & Weather Wise (Time of Year) Wise Solar Position Changes.

Proposed MPPT Algorithm

In comparison to the current DP P&O approach, the proposed enhanced DP P&O MPPT method speeds up tracking by doing away with the requirement for extra power samples to establish the tracking direction. Rather than collecting more samples, the suggested approach uses a half sine wave solar radiation model to forecast the tracking direction while accounting for the timing of irradiation incidence.The suggested approach consists of two primary steps: monitoring MPP and figuring out the power differential between subsequent samples. Based on the variations in solar radiation, the entire

| ISSN: 2395-7639 | www.ijmrsetm.com | Impact Factor: 7.580| A Monthly Double-Blind Peer Reviewed Journal |

| Volume 11, Issue 1, January 2024 |

twelve-hour period is split into three time intervals (T1, T2, and T3): phases that are growing, peaking, and dropping. T1 denotes the moment in the day when solar radiation starts to rise and reach its maximum, while T3 denotes the moment in the day when it starts to fall. T2 is the period of time that corresponds to the approximate maximum of solar radiation. Forecasts of solar radiation are used to establish the precise length of these phases. T1 might run from 6 AM to 11 AM, T2 from 11 AM to 2 PM, and T3 from 2 PM to 6 PM, for example, on a clear day. This strategy makes it possible for the suggested method to forecast the tracking direction without the need for extra samples, which makes the MPPT process quicker and more effective.

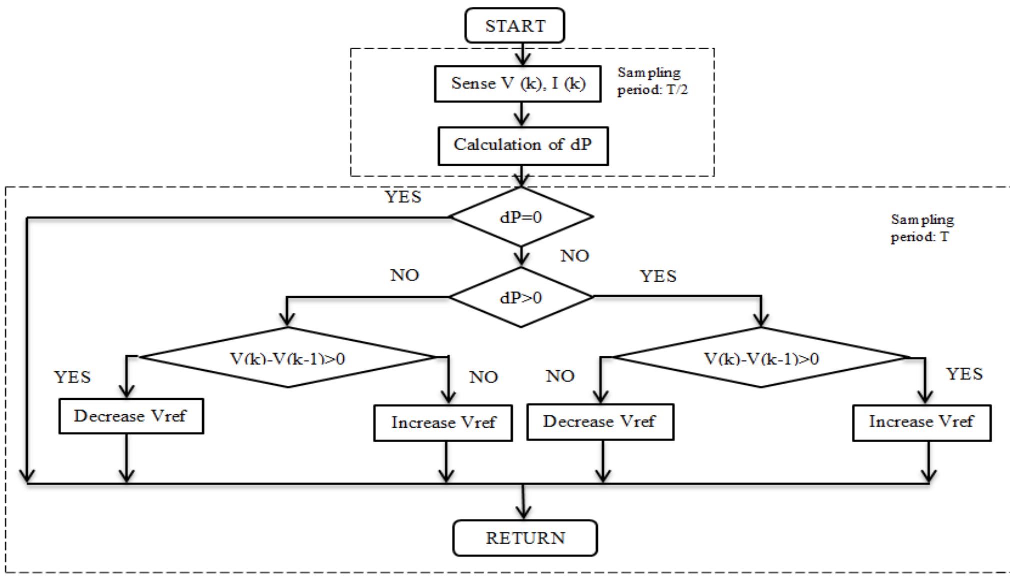


Figure 9: The flowchart of the DP P&O method

SIMULATION RESULTS

To examine the precision and efficacy of the suggested approach, a PV system comprises PV modules, a DC-DC boost converter, a resistive load, and a control system. These components are then taken into account and modelled using MATLAB/SIMULINK software. To compare the performance of the suggested enhanced DP P&O MPPT technique with that of the DP P&O MPPT method, simulation models have been run and examined.

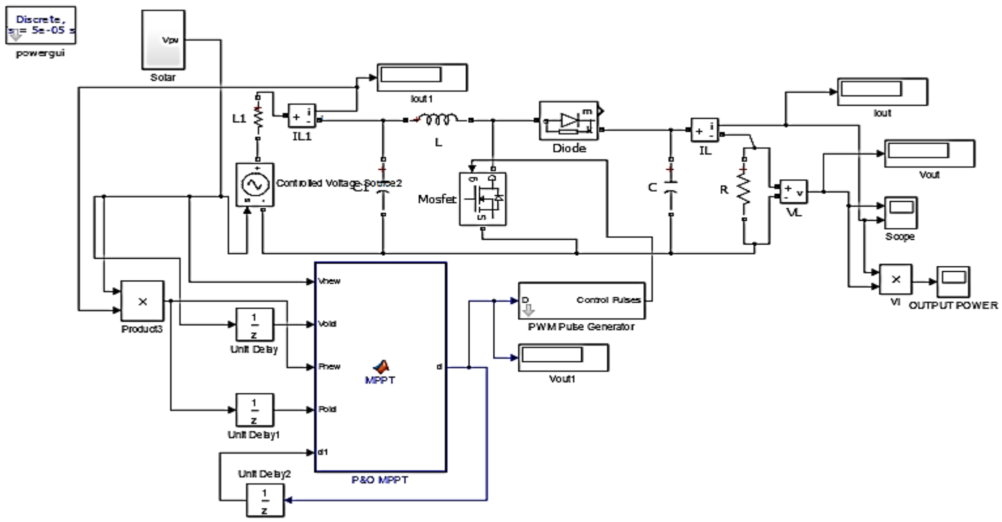


Figure 10: Simulink model of DP P&O method

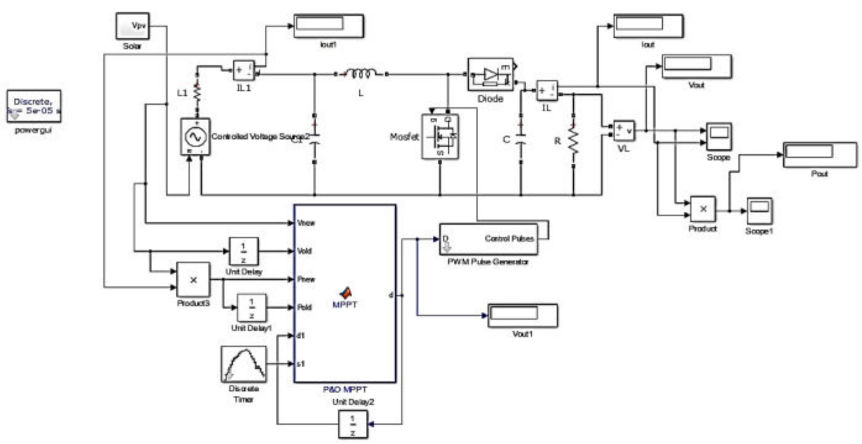


Figure 11. Simulink model of improved DP P&O method

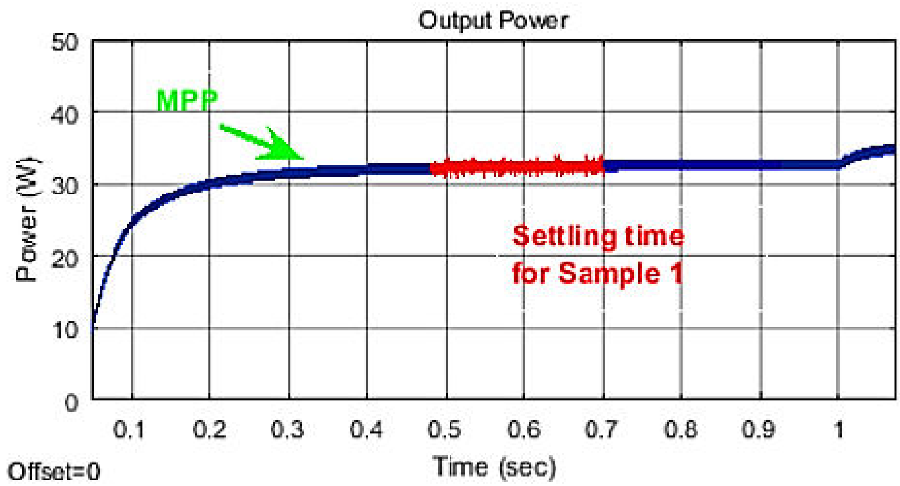


Figure 12 Tracking trajectories of Improved DP P&O method

This chapter provides an explanation of the suggested enhanced DP P&O MPPT approach. A detailed discussion is held on the sun irradiation and forecast analytical model. MATLAB is used to simulate both the current DP P&O and enhanced DP P&O MPPT methods. Analysis is done on how the solar PV system's current and suggested MPPT regulation techniques respond. It can be deduced from the simulation results that the suggested enhanced DP P&O MPPT approach outperforms the current MPPT technique in terms of speed.

IV.CONCLUSION

The Big Scheffler with a size of 9.7 m2 and a cylindrical receiver is evaluated having the potentials of achieving a maximum thermal efficiency between 48 to 50% for a steam pressure range up to 3 bar, although reasonable efficiency up to 5 bar could be achieved. Steam temperature would be in the range of 140 to 150°C. The steam generating capacity was measured as 3.85 kg/ h and heat gain as 2.45 kW. Among the various measures tested to improve efficiency, the best was found to be feed water preheating, by which the efficiency can be improved up to 54%, a 4% gain over normal conditions. This is determined as the best condition for the Big Scheffler dish. In the solar noon period, the thermal efficiency showed stable efficiency. A conical receiver showed a reasonable efficiency of 48% with the tilt condition only whereby the focal area is improved. At solar noon, the efficiency reached a maximum value at 51%.

V. FUTURE WORK

1. The experimentation work involved in testing of possible improvement measures one by one separately to know their individual effects. It is feasible to combine more than one concept into one integrated Scheffler dish with selected receiver and still further scope to improve thermal efficiency.

2. The integrated system concept is tested during the experimental work, but it can be brought closer to reality as a combined system for commercial use.

3. To Develop Guidelines to use wind speed weighted directional HLC average for choice of Scheffler receiver shape and geometry for reducing HLC at specific location.

4. Three application-oriented projects have been identified to utilise the enhanced capability of the Scheffler system to generate steam at high temperatures, especially in the case of the Small Scheffler.

REFERENCES

[1.] Opeyeolu Timothy Laseindea Moyahabo Dominic Ramere "Efficiency Improvement in polycrystalline solar panel using thermal control water spraying cooling" Procedia Computer Science 2021.

[2.] Linus Idoko, Olimpo Anaya-Lara, Alasdair McDonald "Enhancing PV modules efficiency and power output using multi-concept cooling technique" Energy Reports 2018.

[3.] D. T. Cotfas and P. A. Cotfas "Multiconcept Methods to Enhance Photovoltaic System Efficiency" International Journal of Photoenergy 2019.

[4.] Bhubaneswari Paridaa, S. Iniyanb, Ranko Goicc "A review of solar photovoltaic technologies" Renewable and Sustainable Energy Reviews 2011.

[5.] Dharmendra thakur, Amit arnav, Abhishek datta, E.V.V Ramanamurthy "A Review on Immersion System to increase the efficiency of Solar Panels" International Journal of Advanced Research 2016.

[6.] Dinesh Rana, Gourav Kumar, Atma Ram Gupta "Increasing the Output Power and Efficiency of Solar Panel by Using Concentrator Photovoltaic (CPV) and Low Cost Solar Tracker" CICT 2018.

[7.] Sourav Diwania, Sanjay Agrawal, Anwar S. Siddiqui, Sonveer Singh "Photovoltaic–thermal (PV/T) technology: a comprehensive review on applications and its advancement" International Journal of Energy and Environmental Engineering 2020.

[8.] Gan Huang, Kai Wang and Christos N. Markides "Efficiency limits of concentrating spectral-splitting hybrid photovoltaic-thermal (PV-T) solar collectors and systems" Science & Applications 2021.

[9.] Gregory M Wilson, Mowafak Al-Jassim, Wyatt K Metzger "The 2020 photovoltaic technologies roadmap" Journal of Physics D: Applied Physics 2020.

[10.] King, R.R,, "Multijunction cells: Record breakers," Nature Photonics 2, 284-286 (2008).

[11.] King, R.R., Law, D.C., Edmondson, K.M., Fetzer, C.M., Kinsey, G.S., Yoon, H., Sherif, R.A. and Karam, N. H, "40% efficient metamorphic GaInP/GaInAs/Ge multijunction solar cells," Appl. Phys. Lett. 90, 183516 (2007).

[12.] Guter, W., Schöne, J., Philipps, S.P., Steiner, M., Siefer, G., Wekkeli, A., Welser, E., Oliva, E., Bett, A.W., and Dimroth, F., "Current-matched triple-junction solar cell reaching 41.1% conversion efficiency under concentrated sunlight," Appl. Phys. Lett. 94, 223504 (2009).

INTERNATIONAL JOURNAL
OF MULTIDISCIPLINARY RESEARCH
IN SCIENCE, ENGINEERING, TECHNOLOGY AND MANAGEMENT

+91 99405 72462 +91 63819 07438 ijmrsetm@gmail.com

www.ijmrsetm.com