Solar Energy Application: A Decade Review

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Abstract

Since there have been tremendous increases in all of those technology and population, the need for energy is growing at such an alarming pace on a global scale. To fulfil the increasing need for energy in the future, it is crucial to develop renewable energy sources that are reliable, affordable, and unbreakable. As a way of reducing the long-term impacts of the energy shortage, solar energy offers many potentials and is easily available for free, along with other renewable energy sources. Because of the enormous demand of energy and the restricted availability for the primary valuable medium of energy generation (fossil fuel), the solar (PV) business is increasing at a constant rate around the globe. There are other non-cheaper sources. It is now cost-effective after years of intensive study that was done to hasten its development, and as a result, it has become a tool that can be used to improve the economic condition of developing nations and to support the lives of a large number of people who are living in poverty. When comparing to another types of non-conventional energy generating mediums, the solar (PV) sector is head and shoulders above the competition in terms of availability, cost-effectiveness, accessibility, capacity, and efficiency. This makes it a clear frontrunner for meeting the growing energy demand in next following years. This study will discuss recent advancements in solar energy in the previous decade and cover the many techniques that are utilized for the use of solar trackers, designing of solar cells and Solar cells in a variety of applications.

Keywords: - Solar Energy, Solar tracker, solar dryer, solar lamp, floating solar PV cell, etc.

1. Introduction

The major crucial challenge facing humanity in the twenty first century is finding ways to head off an impending energy catastrophe. The bulk of the world's population, which is still mostly impoverished, has long had increasing energy demands that have been the subject of continuous research. This has been done to prevent polluting our ecosystems, using up resources that will be needed by coming generations, and putting an undue amount of stress on regions of the world with abundant energy resources. The rapid population expansion and attempts made by the most densely populated regions of the world to progress their economies have resulted in an unprecedented increase in demand, which must be overcome in order to achieve this aim. The world's population has expanded by approximately 2 billion people in the span of only one generation, with a significant portion of that growth coming from emerging nations. Additionally, it is good to know that the demand for energy rises at a pace that is directly proportionate to the expansion of the economy. The number of regions in developing nations that do not have access to electricity has not greatly decreased, despite the fact that several initiatives, policies, and expenditures have been made to increase generating capacity. One of the primary reasons why residents in non-electrified villages are still economically disadvantaged is that they do not have access to a reliable source of electrical power. As a result, it is of the utmost importance to construct the necessary infrastructure and set up the essential resources for decentralized energy production in order to fulfill the requirements of the global energy market[1]. Although it is not a brand-new idea, renewable energy is quickly being recognized as a viable option to fossil fuels and other types of energy sources that are harmful to the environment[2]. It is possible for non-conventional energy mediums like bio gas, wind energy, sun, hydroelectricity, and geothermal to offer continual energy supply by making use of domestic mediums that are consistently accessible. It is becoming more probable that we will make the switch to renewable energy[3] systems as the price of fossil fuels continues to climb and the price of non-conventional energy mediums continues to fall. Sun energy and air power systems have, over the course of the previous three decades, seen continuous improvements in their performance characteristics and have seen explosive development in terms of sales[4]. The costs of both the initial investment and the electricity generated by such systems have seen considerable reductions in recent years. These changes have created market possibilities to both innovate and capitalize on developing markets in order to advance renewable energy solutions. This is particularly true when additional assistance is provided by both the government and the sentiment of the general public. The advancement and employment of non-conventional energy[5] sources can contribute to an increase in the diversity of energy supply sectors, a contribution to the long-term security of energy supplies, a decrease in both local and global air emissions, and the availability of financially appealing solutions to satisfy specific energy service requirements. It is also becoming more vital to make use of non-conventional energy mediums[6][7] in order to slow down the consequences of climate change. Solar technologies provide a great deal of potential as a sustainable energy medium due to their output efficiencies[8] are always improving and they will be used in settings of wide range. Solar power is helpful for many reasons, particularly for developing nations, due to the inherent properties that make it a valuable utility. One of the main causes is that the majority of emerging nations are located in areas with excellent access here to sun's rays. The bulk of non - renewable energy or energy resources now available can only be used through mistreating the environment, which worsens civilization. Second, as the globe becomes less dependent on fossil fuels, the demand for solar technology increases. This, in turn, causes the essential research to advance more quickly and its costs to decline. In wealthy nations' residential regions, solar power[9] is gaining popularity as the third option. This is because solar power systems can be deployed both in urban and rural settings, and they are also cheaply priced. Last but not least, when it comes to photovoltaics and considering renewable energy for buildings, active solar designs do quite well[8]. These designs are at the cutting edge of photovoltaics and may be used in conjunction with solar panels to reach the highest levels of comfort and sustainability. The table 1 that follows displays diverse research on solar energy and technologies.

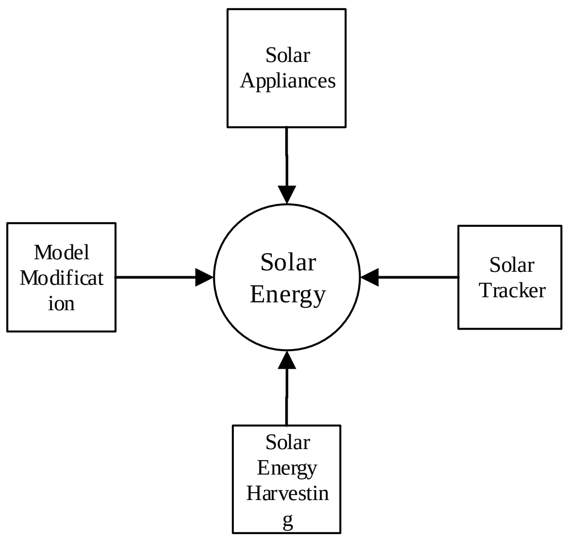

Fig: 1 Type of Problem Discus in the Literature Review

2. Solar Tracker

Sun tracking systems with their applications in such a wide range of human endeavors have been the subject of a significant number of published studies. Both uniaxial and biaxial classifications of solar trackers are possible, based on the architecture of the solar tracker system (PV trackers)[10]. Solar trackers that only have one axis of rotation revolve on a horizontal plane while following the sun using a variety of different algorithms. In this case, the daytime fluctuation in the height of the Sun is not taken into account by uni - axial solar trackers. The latitude of the location where the tracker is placed is used to determine the angle at which the solar panel should be positioned. Due to the fact that they adjust for the Sun's fluctuating height throughout the day and year, biaxial solar trackers have an edge over their uniaxial counterparts. Numerous automatic biaxial solar trackers that function based on a variety of algorithms are already on the market. The bulk of the time, automatic solar trackers' [10]algorithms are dependent on the readings from responsive sensors, which identify the direction of the sun's peak intensity of radiation. A further possibility is to base the algorithms on the Sun's known ascent across the sky as it moves in the Earth-related coordinate system. These algorithms are used by the trackers to determine the intended placement of the solar panel. This guarantees that the solar battery's surface receives light from the sun in a direction parallel to a panel. If the weather takes a turn for the worse, turning bright skies into fluctuating cloudiness and rain, a solar panel that has been mounted in a horizontal position will generate more electricity. Many types of the solar tracker are available.

2.1 *Uni Axial Solar Tracker*:- This type of tracker performs the function of one axis of rotation. The implementation of single-axis trackers can take many different forms, including polar aligned uni-axis trackers, inclined uni-axis trackers, vertical uni-axis trackers, and horizontal uni-axis trackers.

2.2 *Dual Axial Solar Tracker:-* Dual-axial trackers are distinguished by the fact that they include two degrees of freedom that double as axes of rotation. There are many typical ways that dual-axis[10] trackers may be implemented. They are characterized according to the direction of their circular path about the surface of the earth. Two common applications of this technology are azimuth-altitude dual-axial trackers and tip-tilt dual-axis trackers. Because of their capacity to watch the sun in both a perpendicular and a horizontal plane, dual-axis trackers make it possible to harvest the maximum amount of solar energy possible.

3. Solar Applications

3.1. *Solar lamp:* - A solar lamp, also known as a solar illumination or solar torch, is a lighting system consisting of a LED light, solar cells, a battery, a charge controller, and sometimes a converter.. The light runs on solar-charged batteries (solar photovoltaic panels).The LTSHE project package consists of solar panels with a capacity of 20W, batteries, four light-emitting diodes (LED) lights, and an HP-based charging mechanism. It is estimated that the system will function for a max of 60 hours when it does not receive solar radiation. According to the government standard, the least amount of illumination flux that must be produced from every LED is approx. 374 lumens, and 124 lumens produced per watt. Each LTSHE must have four LEDs and be able to maintain its position for a minimum of ten hours each day. Additionally, there must be an automated dimmer control for the bulb. Load profile consisting of one USB connection and a 3W LED.

3.2. *Solar Dryer*: - Utilizing a solar device collector allows the solar radiation to be immediately turned into either heat or electricity. On the other hand, photovoltaic (PV) panels are typically employed for nothing other than the generation of electricity. Conventional solar thermal collectors, on the other hand, are designed to convert sunlight directly into heat. Commercial solar photovoltaic modules have an efficiency of roughly 17% when it comes to converting solar radiation into electricity. This implies that the efficiency only transforms the value of solar photons that collide directly onto the modules into power. A rise in the average temperature of the cells results from the higher proportion of energy that is not utilized being taken by the cells and transformed into heat there. On the other hand, as the temperature of the photovoltaic cell rises, so does the efficiency of the PV module and the panel both increase, resulting in less power being generated. Thermal solar collector[11] systems, as opposed to PV modules (with the same area dimension), may produce heat more effectively. This is despite the fact that solar thermal -collector systems take up more space.

3.3 *Solar energy powered Road and Rail Transportation:* - Due to its flexible access, which can be done by putting solar panels in the own accessible places of road and rail transportation, solar power production is the most ideal and promising solution to provide a more sustainable power supply. This makes solar power generation the most viable option among variable renewable power generations. In order to make the most of the space they have on their properties, numerous organizations that maintain roads and railroads have photovoltaic panels and are operating their individual solar power production. When it comes to vehicular mobility, the most widespread approach is to include solar power production in electric vehicle charging stations. These stations can already be found in many different areas. In situations like these, recharging an electric vehicle using solar power results in an even greater reduction in the vehicle's total carbon emissions. The Byron Bay Railway Company in Australia has introduced an electric train that is operated on solar panels placed on top. On the roofs of the trains are unique curved solar panels that have been fit and placed. 16000 solar modules, each having a 245 watt rating, are installed on the roof of a 3.6 km on long train tunnel in Belgium. The train lines that pass through it are being used to generate renewable energy in the form of power, making this solar tunnel the first of its kind in the whole globe. The solar array has a total surface area of 50,000 square meters and generates 3,300-megawatt hours (MWh) of power annually. The energy that was generated by the solar power production that was built has been utilized to power not just the lighting, signals, and stations along the Belgian rail network, but it has also been used to power the electric trains that operate on that network. It is anticipated that the installation of solar panels on the tops of train tunnels in Belgium would result in a yearly reduction of carbon emissions of 2,400 tones. When it comes to vehicular mobility, the most widespread approach is to include solar power production in electric vehicle charging stations. These stations can already be found in many different areas. In situations like these, recharging an electric vehicle using solar power results in an even greater reduction in the vehicle's total carbon emissions. In Shanghai, an electric car charging station with integrated solar power generating underwent testing in 2017.The station had 1002 solar modules and has the capacity to generate around 500 kWh of power on a daily basis. This electric vehicle charging point has the capacity to offer charging services for more than 400 electric vehicles in a single day.

4. Designing of solar panel

4.1. *Floating Solar panel*: **-** The aim of the Floating Solar Panel project is to make a PV panel activity that can be deployed in the water conditions of the ocean. Floating units are used as support for the panel, which helps to keep it dry and protected from the ocean. The solar array is made of many different photovoltaic cells which are all attached in series to provide the desired voltage for every individual module. In the form of a direct current distribution, the electrical power that is produced by the solar array is sent out to the world through an electrical distribution network, beginning in the ocean and ending on the beach. In conditions of shadow or absence of sunshine, it also serves as a storage facility for the energy that is produced. The solar photovoltaic system that is floating is going to make advantage of the water for cooling. A mechanics for the thermo-electric producer is provided by the significant temperature differences between the two sides, one of which is hot due to exposure to direct sunlight and the other of which is cold due to shading provided by solar cells and cooling provided by water. In order to create more power, the TEG is placed in the area between the solar panels. This is an additional source of knowledge.

4.2. *Plating Method for Silicon Heterojunctions Solar Cell Metallization*: **-** Plating onto a patterned seed layer is one of the metallization methods used in silicon heterojunction solar cells. We don't need pricey consumables or processing stages with our methods. Indium tin oxide is followed by such a blanket metal layer, including such Al is first deposited in the complete area as a dielectric or as the first step of indium tin oxide (ITO). First, SiN2, SiO2, or Al2O3 are deposited upon this ITO front surface of a precursor for a SHJ solar module. A full-area PVD metal coating covers the back. The dielectric and metal layers would be deposited on a production line by adding additional targets to the same tool that is used to deposit the ITO layer. Laser Forward NiV transfers are used to deposit a seed layer onto the front side of a cheap polyethylene foil. The secondary laser procedure will be needed to ignite the main layer with all the di-electric layers, dependent upon durability or thickness. Then, the front side is plated with Cu and Ag. The cathodic potential is applied to the rear-side metal during plating to distribute the plating current. The second approach is placing a conductive covering film on the front and rear of a SHJ precursor's surface on an ITO substrate. Metals that can passivate themselves, like aluminum or titanium, are good candidates for use as conductive masks. Because of its very high conductivity, aluminum is a material that performs well in our efforts to produce bifacial solar cells.

5. Solar Energy Harvesting

An ultra-compact solar energy-collecting integrated circuit that only uses a single chip and has on-chip photodiodes is shown. This proposed device makes use of an on chip charge pump that collect power from a built-in PV cell and produce a significant load voltage and keeping a hold up explanation. Miniaturizing such systems too as much feasible, resulting in a strict size and energy bottleneck, is the best way to ensure the least invasiveness for implanted devices. Miniaturization should be done to the greatest extent possible. The solar energy harvesting device that we have demonstrated can achieve high efficiency without requiring extra pads or packaging expenses, making it a good fit for applications that call for affordable, very small, and reliable surgically implanted implants. The creation of a customizable charge pump consisting closed loop MPP tracking (MPPT) capabilities is the following effort.

Table.1:- Significant work on Solar energy and Technology

S.no	Name of Journal/Conference	Title of the paper	Authors	Year of publication	No.of paper review	Goals	Findings
1	IEEE JOURNAL OF PHOTOVOLTAICS	Energy Payback Time (EPBT) and Energy Return on Energy Invested (EROI) of Perovskite Tandem Photovoltaic Solar Cells[12]	Adam B. Philips et al.	2018	37	Two-terminal tandem solar cells with lead-based PK top cells copper indium gallium selenide, copper zinc tin selenide, and monocrystalline silicon bottom cells are examined for life-cycle energy consumption.	As tandem PV technologies evolve, high-efficiency long-lifetime devices may have an EBPT of 27 days (0.9 months) and an EROI of 105.
2	2017 7th International Conference on Power Electronics Systems and Applications - Smart Mobility, Power Transfer & Security (PESA)	Concentrating Solar Thermal Heat Storage Using Metal Hydrides[11]	David N. Harries et al.	2012	63	This research examines the current state of solar thermal heat storage devices based on metal hydrides, which, despite technological hurdles.	The research examines metal hydride-based solar thermal heat storage devices despite technological obstacles.
3	IEEE JOURNAL OF PHOTOVOLTAICS	Harvesting Roadway Solar Energy—Performance of the Installed Infrastructure Integrated PV Bike Path[13]	Aditya Shekhar et al.	2018	35	That study discusses operational issues and performance factors using first-year recorded values.	Monocrystalline yielded the most at low temperatures. SR technique may provide location-specific yearly outputs of 150 kWh/m2.
4	CSEE JOURNAL OF POWER AND ENERGY SYSTEMS	A Perspective on Solar Energy-powered Road and Rail Transportation in China[14]	Limin Jia et al.	2020	94	This study examined solar power generation & transportation integration.	Lastly, it's clear that a collaborative approach can not only help to create quite low-carbon, green, and sustainable transport services, as well as help a lot with accommodating renewable power for energy changes.
5	IEEE ACCESS	Comprehensive Review on Renewable Energy Sources in Egypt—Current Status, Grid Codes and Future Vision[15]	Hussein Abubakr et al.	2022	146	The current developments in RESs, including photovoltaic (PV) cell, solar chimneys (SC), large scale solar plant (CSP), and wind power, are discussed in this study.	The current developments in RESs, including photovoltaic (PV) cell, solar chimneys (SC), large scale solar plant (CSP), and wind power, are discussed in this study.

6	IEEE TRANSACTIONS ON SUSTAINABLE ENERGY	Optimal Offering Strategy for Concentrating Solar Power Plants in Joint Energy, Reserve and Regulation Markets[16]	Guannan He et al.	2016	22	This study proposes a general modelling technique for the optimum CSP plant proposal strategy in integrated 24-hour energy, backup, or regulatory markets that is stochastic to market price variability and resilient to solar energy variability.	The model aids in managing the CSP plant inside the energy market and assesses how it may include renewable energy sources and boost flexibility economically. A multi-stage proposal choice framework for all day and current markets may be the subject of future research.
7	IEEE ACCESS	Piezoelectric Energy Harvester With Shape Memory Alloy Actuator Using Solar Energy[17]	A. Rami Reddy et al.	2015	39	In accordance with predictions of solar irradiance and battery backup level, this paper presents Practical Power-Aware Method for Sun Sensors, a ground-breaking algorithm that modifies device duty cycles to maximize energy harvesting.	PPAASS needs modest computing power, making it suitable for IoT devices with limited resources. Because a gadget with far more processing power can execute the first three phases. Therefore, the sensor gadget only conducts final-stage arithmetic.
8	IEEE JOURNAL OF PHOTOVOLTAICS	PPAASS: Practical Power-Aware Duty Cycle Algorithm for Solar Energy Harvesting Sensors[18]	Ivan Garcia et al.	2022	16	We use a computer-controlled simulation model to develop maps of a solar cell's genuine performance for a variety of light spectrum contents.	A simplified set of comparable yearly spectra for a site is being produced to speed up energy yield measurement and permit concentrator operation.
9	2017 7th International Conference on Power Electronics Systems and Applications - Smart Mobility, Power Transfer & Security (PESA)	Floating Solar Cell Power Generation, Power Flow Design and its Connection and Distribution[19]	Sai Fai Hui et al.	2017	6	The purpose of this article is to talk about the project that involves the production of solar electricity using sea water.	The design of photovoltaic cells, the connections, the distribution of electricity, the protection, the influence on the environment, and the management of shore side energy are addressed.
10	IEEE JOURNAL OF PHOTOVOLTAICS	Impact of Irradiance Data on the Energy Yield Modeling of Dual-Junction Solar Module Stacks for One-Sun Applications[20]	Jayanth N. Murthy et al.	2021	56	They investigate how the power demand of the two-terminal III-V/Si tandem devices is influenced by the precision of the irradiance data.	Yield assessments for silicon-based tandem solar cells compare technologies, particularly silicon single-junction devices.

11	IEEE JOURNAL OF PHOTOVOLTAICS	Global Progress Toward Renewable Electricity: Tracking the Role of Solar[21]	Nancy M. Haegel et al.	2021	11	This quarterly publication gathers data from a variety of sources and organizes it for IEEE JPV users as a useful reference.	Users of IEEE JPV may refer to this quarterly publication, which gathers data from a variety of sources and presents it logically.
12	IEEE ACCESS	Feasibility Analysis of Solar Technology Implementation in Restructured Power Sector With Reduced Carbon Footprints[22]	Iram Akhtar et al.	2021	47	This article examines the state, technology, accessibility, policies, important contributions, future potentials, and trends of solar energy and coal-based generation in the Indian power industry.	This article shows that Singrauli has strong solar power production capability, thus localities with comparable metrological qualities may build a solar energy-based power generating system.
13	IEEE JOURNAL OF PHOTOVOLTAICS	Up converter Silicon Solar Cell Devices for Efficient Utilization of Sub-Band-Gap Photons Under Concentrated Solar Radiation[23]	Stefan Fischer et al.	2014	17	Under broad-band sub-band-gap stimulation, we measured the external quantum efficiency of up conversion solar cell devices.	This research found that UC increases short-circuit current density at low wide solar radiation concentrations.
14	IEEE JOURNAL OF PHOTOVOLTAICS	Four-Junction Wafer-Bonded Concentrator Solar Cells[24]	Frank Dimroth et al.	2016	35	This study presents the first working Ge and GaSb solar cells developed by Fraunhofer ISE.	Wafer bonding may combine III-V compound elements with significant lattice misfit, resulting in material choices that have the best properties of materials for multijunction cells.
15	CSEE JOURNAL OF POWER AND ENERGY SYSTEMS	Simultaneous Optimization of Renewable Energy and Energy Storage Capacity with the Hierarchical Control[25]	Zhaodi Shi et al.	2022	36	This study re-formulates this sub-model as a consensus issue to reduce the system's overall investment expenses.	For multi-objective and high-dimensional systems, the proposed technique improves computation accuracy, and hierarchical distributed control is far more efficient than single-level control.
16	IEEE TRANSACTIONS ON BIOMEDICAL CIRCUITS AND SYSTEMS	A Single-Chip Solar Energy Harvesting IC Using Integrated Photodiodes for Biomedical	Zhiyuan Chen et al.	2017	19	This paper describes a single-chip solar power generation IC with an on-chip solar cell for biomedical implantable devices..	Solar energy harvesting device works well for low-cost ultra-compact resilient subdermal implant applications

		Implant Applications[26]					without pads or packaging.
17	IEEE TRANSACTIONS ON VERY LARGE SCALE INTEGRATION (VLSI) SYSTEMS	Accuracy Improvement of Energy Prediction for Solar-Energy-Powered Embedded Systems[27]	Qiang Liu et al.	2016	27	To strengthen solar-energy-powered systems, this research provides artificial neural network-based solar energy forecast accuracy improvements.	This research presents neural network-based methods to improve solar power prediction in energy extracting embedded devices.
18	IEEE Transactions on Sustainable Energy	Adaptive Residual Compensation Ensemble Models for Improving Solar Energy Generation Forecasting[28]	Heng-Yi Su et al.	2020	10	This paper provides a new supervised learning methodology towards solar power production predictions.	This paper proposes an enhanced ensemble approach towards solar power forecasting using ARC & NSGA-II.
19	IEEE JOURNAL OF PHOTOVOLTAICS,	Novel Plating Processes for Silicon Heterojunction Solar Cell Metallization Using a Structured Seed Layer[29]	Markus Glatthaar et al.	2017	16	We discuss plating onto a structured seed layer metallization strategies for silicon heterojunction solar cells.	This substantial process reduction would make it possible to put the process sequence into industrial production using already accessible production tools.
20	Proceedings of the IEEE	Review of Solar Thermal Storage Techniques and Associated Heat Transfer Technologies[30]	Luisa F. Cabeza et al.	2012	55	The technologies for solar thermal storage and related heat transmission that help and improve these systems	This study describes the primary storage techniques utilized in commercial power plants and analyses the literature on materials and heat transfer difficulties and solutions.
21	IEEE ACCESS	Increasing Self-Sufficiency of Energy Community by Common Thermal Energy Storage[31]	Elahe Doroudchi et al.	2022	40	This research contrasts distributed thermal energy storage provided by each home with specific electric heat energy storage, which uses community solar PV output to create thermal energy via heat storage.	Our case study found that developing an energy community with neighbors and pooling thermal storage may benefit building owners financially.
22	IEEE JOURNAL OF PHOTOVOLTAICS	Gallium Phosphide Window Layer for Silicon Solar Cells[32]	Markus Feifel et al.	2016	32	The advancement of gallium phosphide (GaP) heteroepitaxial nucleation on silicon is discussed in this work.	To maximize the potential of this solar cell design, the nucleation process has to be further enhanced.

23	IEEE ACCESS	Advanced Fuzzy-Based Smart Energy Auditing Scheme for Smart Building Environment with Solar Integrated Systems[33]	Iram Akhtar et al.	2021	24	The auditing approach based on fuzzy logic is thought to provide the best outcomes for residential properties in this article.	In smart buildings with integrated solar energy systems, fuzzy logic reduces energy consumption and improves efficiency.
24	IEEE ACCESS	Planning Solar in Energy-Managed Cellular Networks[34]	Mathieu D. Amours et al.	2018	38	This article examined how adding a solar harvesting system to power a cellular network base station affects energy management under varied demand.	We demonstrate that, even when the unit cost of solar electricity is lower than the grid, deploying solar equipment anywhere is not always the wisest course of action.
25	2020 10th International Conference on Power and Energy Systems	Research on Energy Storage Configuration Method Based on Wind and Solar Volatility[35]	Shi Xuewei et al.	2020	6	This study examines the features of wind and solar power generation's 15- to 10-minute fluctuations as well as the energy storage system's control strategy.	An analysis of an energy storage system architecture, mitigating wind power variations & monitoring expected production as well as research on energy storage capacity allocation technologies were both conducted in this study.
26	2020 47th IEEE Photovoltaic Specialists Conference (PVSC)	The Impact of Cracked Solar Cells on Solar Panel Energy Delivery[36]	Andrew M. Gabor et al.	2020	7	We come to the conclusion that evaluations of the deterioration resulting from field exposure and expedited testing should include values lower than 1-Sun as well.	We have demonstrated that a less sunny northern location has a greater influence on system energy delivery than just a sunnier southern position.
27	2017 International Renewable and Sustainable Ene rgy Conference (IRSEC)	Improvement of Energy Efficiency of solar Hybrid Water Collector[37]	Khaled Touafek et al.	2017	13	It is done in an effort to focus sun fluxes and improve their thermal and electrical performance.	The hybrid PVT collectors' two mounted reflectors made it possible to concentrate solar radiation, which increased the yield's energy efficiency.
28	2018 6th International Renewable and Sustainable Ene rgy Conference (IRSEC)	Electrification of Rural and Arid Areas by Solar Energy Applications[38]	Brahim Hachim et al.	2018	6	We want to demonstrate a solar-powered rural electricity concept.	Additionally, the SOLEIL Inno-PV project is financed by the Moroccan Research Institute in Solar Energy & New Energies (IRESEN).

29	2018 2nd International Conference on Green Energy and Applications	Study and Design of Energy-Saving Solar Lamp for Rural Area in Indonesia[39]	Naftalin Winanti et al.	2018	8	This study would also demonstrate how the government's LTSHE equipment standard does not apply in certain areas of Indonesia with low solar irradiation, in this example, the North Sumatera region.	This study would also demonstrate how the government's LTSHE equipment standard does not apply in certain areas of Indonesia with low solar irradiation, in this example, the North Sumatera region.
30	Journal of Solar Energy Engineering	Design and Implementation of Hybrid Automatic Solar-Tracking System[40]	Tarequl Karim et al.	2013	14	This research provides a microcontroller-based energy-efficient hybrid automated sun-tracking system to analyze solar energy conversion efficiency improvement.	Showed an efficient mechanism for monitoring the sun's rays.
31	2019 Ural Symposium on Biomedical Engineering, Radio electronics and Information Technology (USBEREIT)	Performance Comparison of Dual Axis Solar Tracker with Static Solar System in Ural Region of Russia[10]	Adven Masih et al.	2019	18	To analyze the solar power potential of Russian Federation's Ural area, this research compares the performance of Dual Axis Solar Tracker (DAST) and Static Solar System (SSS), a fixed-axis solar system.	Studied on the performance assessment of two different solar power system variants: fixed and dual axis systems.
32	The 9th International Renewable Energy Congress (IREC 2018)	Simple Design and Implementation of Solar tracking System Two Axis with Four Sensors for Baghdad city[41]	Falah I. Mustafa et al.	2018	10	An autonomous dual-axis sun tracking system using LDR with DC actuators on a mechanical framework with gear box is designed and developed in this study.	This work designs and implements a two-axis solar tracker for motor satellite dishes to properly monitor the sun and utilize LDR sensors to measure sunlight quantity.
33	2013 IEEE 39th Photovoltaic Specialists Conference (PVSC)	Increased Energy Production of First Solar Horizontal Single-Axis Tracking PV Systems without Backtracking[42]	Lauren Ngan et al.	2013	5	Using First Solar modules in several PV systems, T-T generates 1.7%–2.5percentage points more energy annually than (Backtracking).	In kW- to MW-scale Photovoltaic system, T-T with First Solar panels generates 1.7%–2.5% more power annually than similar BT systems.
34	The 11th International Renewable Energy Congress (IREC 2020)	Performance analysis of solar heat generation system for multi-purpose applications[43]	Mohammed Abdunnabi et al.	2020	17	This research simulates multifunctional solar central heat production system thermal performance.	The simulation shows that now the solar system may offer approximately 90% of space heating energy & 60% for desalination.
35	2016 International Conference on	Design of a GPS-Based Solar Tracker System for	Dian Artanto et al.	2016	10	Vertical solar still offers better condensation but less evaporation than	The solar tracker-controlled solar cell captured more sun

	Smart Green Technology in Electrical and Information Syst ems (ICSGTEIS)	a Vertical Solar Still[44]				horizontal solar still.	energy than the horizontally oriented solar cell.
36	2014 International Conference on Intelligent Green Building and Smart Grid (IGBSG)	Smart Controller Design for Solar-Grid Hybrid System[4]	Krishna Neupane et al.	2014	9	This work provides a digital signal processing-based smart controller for cost-effective solar-grid coupled system operation.	This method is designed for areas in which solar energy is solely utilized to charge the battery and is actively dumped during grid operation.
37	2018 2nd IEEE International Conference on Power Electronics, Intelligent Control and Energy Syst ems (ICPEICES)	An Efficient Solar Energy Harvesting System for Wireless Sensor Nodes[45]	Himanshu Sharma et al.	2018	11	This study proposes a solar-powered battery-charging system using MPPT for WSN nodes.	The efficiency of our solar energy collecting technology is 96%.
38	2019 IEEE International Conference on Automatic Control and Intelligent Systems (I2CACIS 2019)	An Automated Intelligent Solar Tracking Control System With Adaptive Algorithm for Different Weather Conditions[46]	Nurzhigit Kuttybay et al.	2019	20	In order to increase solar energy production, the research investigated an advanced AI solar tracking control system.	Proposed approach generates 18% more energy in overcast conditions than biaxial solar tracker.
39	2017 IEEE PES Asia-Pacific Power and Energy Engineering Conference (APPEEC)	Power & Energy Optimization in Solar Photovoltaic and Concentrated Solar Power Systems[47]	Anupam Sharma et al.	2017	65	This article investigates techniques to optimize solar power and energy to decrease carbon footprint.	Site selection should also include climate & radiation from the sun to maximize solar PV and CSP power and energy.
40	2020 International Seminar on Intelligent Technology and Its Applications (ISITIA)	Hybrid PV-T Solar Collector using Amorphous Type of Solar Cells for Solar Dryer[48]	Elieser Tarigan	2020	15	A tiny solar dryer is built and tested using amorphous PV-T collectors.	At 50°C, amorphous photovoltaic thermal works well as a sun dryer collectors.
41	2018 IEEE 61st International Midwest Symposium on Circuits and Systems (M WSCAS)	New Design for Solar Panel Tracking System Based on Solar Calculations[49]	Zuhal ER et al.	2018	10	The tracker design was developed utilizing a controller, according to the innovative technique of this study.	This study would be applicable and practical for the application of producing electricity from panel to charge batteries.

42	2017 7th International Conference on Power Systems (ICPS)	Modeling of Solar Photovoltaic module using system identification[50]	Rohan S. Kulkarni et al.	2017	9	This paper shows that by application of system identification technique.	This paper show that the dynamics of a solar PV array system can be identified with a black-box model.
43	International Conference on Intelligent Computing and Control Systems ICICCS 2017	Solar-Wind Hybrid Energy System Using MPPT[51]	Ligade Gitanjali Vasant et al.	2017	13	MPPT in a Solar-Wind Hybrid System is intended to improve both stability and efficiency.	The issue with energy production from separate energy sources may be resolved by the hybrid system, which also uses MPPT to boost productivity and durability.
44	2017 15-th International Conference on Electrical Machines, Drives and Power Systems (ELMA)	Solar Potential For Building Integrated Solar Collectors: Application in Bulgaria,Romania &France[52]	Gilles Notton et al.	2017	8	This research paper is used to calculate the solar energy on various planes for a photovoltaic or thermal conversion.	Represent two cases Case 1:- This paper will consist now to transform this collected solar energy into electrical production via photovoltaic modules and/or to convert it in thermal energy with flat plate solar collector. Case 2:-The ambient temperature will have a high influence on the performance and the gaps of production between the meteorological stations will be more significant because important differences exist from the temperature point of view between the stations
45	2017 8th Annual Industrial Automation and Electromechanical Engineering Conference (IEMECON)	Grid-Tie Rooftop Solar System Using Enhanced Utilization of Solar Energy[53]	Debadyoti Ghosh et al.	2017	7	In this study, we demonstrate the functioning of a dual-axis sun - tracking system that is based on to an ARDUINO.	The study demonstrates how stepper motors operate in accordance with the signal produced by a light sensor circuit for maximal luminosity.
46	2020 IEEE International Conference on Power	Evaluation of Integrated Dual-DC Boost Converter as	Debjit Rana et al.	2020	8	The IDDBC architecture have assessed as EMS for an independent dc-based distribution	The IDDBC architecture have assessed as EMS for an independent dc-

	Electronics, Drives and Energy Systems (PEDES)	Energy Management System for Standalone Solar-Battery Applications[54]				network in this paper.	based distribution network in this paper.
47	2016 IEEE Advanced Information Management, Communicates, Electronic and Automation Con trol Conference (IMCEC)	Research and Design of Control System of the Solar Panel Tracking[55]	Xing Zhikun	2016	6	In this research, the potential for adopting the IDDBC chopper architecture as power management system for connecting freestanding dc loads to solar-battery hybrid systems has been assessed.	Using an SCM as the primary component, its solar-tracking concept as well as its algorithms are used to construct a control system for solar-tracking of solar panels.
48	IEEE South eastCon 2018	Design and performance analysis of three photovoltaic systems to improve solar energy collection[56]	Rocio Alba-Flores et al.	2018	12	The design, improvement, and characterisation of a low-cost, small-scale solar tracking system are discussed in this paper.	The findings indicated that the solar tracker system was successful in generating a greater amount of electricity.
49	2018 National Power Engineering Conference (NPEC)	Performance of Rooftop Solar PV System with Crystalline Solar Cells[57]	Karthik Atluri et al.	2018	20	This paper is investigating the simulated performance of 5 kW rooftop solar PV system with crystalline solar cells.	This study, it is observed that, these modules perform better with a 17.5 % of capacity factor.
50	2017 International Conference on Electrical and Computing Technologies and Applications (ICECTA)	Performance Evaluation of Solar Tracking Systems for Power Generation Based on Simulation Analysis: Solar Island Concept[58]	Nada Al Safarini et al.	2017	11	Under this study, the idea of a floated solar tracking platform is introduced, and an investigation of other advancements throughout the globe that are conceptually comparable is carried out.	When compared to such a fixed PV solar system, the evaluation of a solar PV system and a CSP solar system indicated a rise in power output of 14.8% and 15.03%, correspondingly, when compared to the fixed PV solar system.

6. Result and discussions

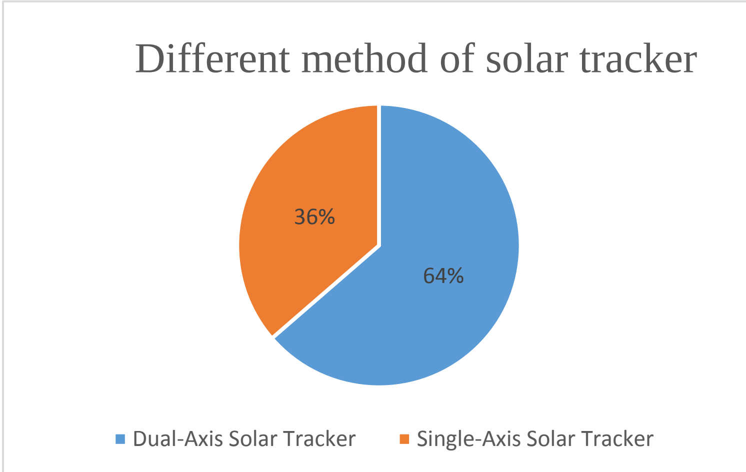

Fig. 2 Pie Chart of the Different Solar tracker techniques

This figure illustrates the different solar racking techniques. The number of publications that have been written about solar tracker variations is shown below in this chart. I have chosen fifty publications on solar energy at random, and among these fifty papers, there are several papers based on solar tracker technology. This slice of pie will demonstrate how the solar tracker has implemented a variety of strategies, such as a single-axis solar tracker and a dual-axis solar tracker. This pie chart illustrates that 36 percent of the papers will work on the single-axis solar tracker technique, while 64 percent of the papers will work on the dual-axis solar tracker technique.

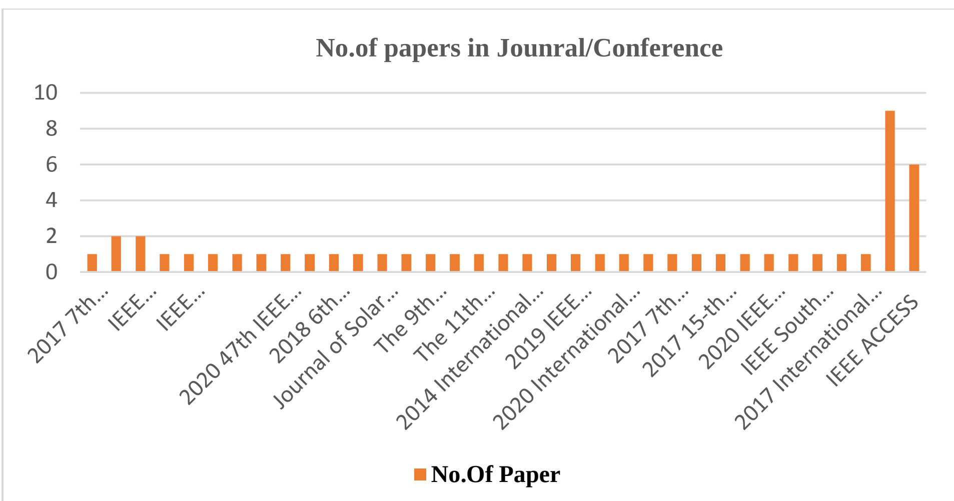

Fig: 3 Graph between the No.of papers published in Journal/Conference

This figure illustrates the correlation between the number of papers published in journals and those presented in conferences. I chose 50 papers on solar energy at random and read each one. This 50-paper presentation was given at the IEEE Access, 2017 International Conference, and IEEE Access Conference. And additional individual papers were presented at the 2017 7th International Conference, IEEE Transaction, Proceedings of the IEEE, and 2020 47th IEEE Conference, Journal of Solar Energy, 9th International Conference, 11th International Conference, and 2019 IEEE International Conference. This graph will display the highest total number of articles taken from IEEE transactions, 2017 International conferences, and IEEE access. The research presented in these journal articles and conference papers focuses on solar energy harvesting methods, solar energy conversion techniques, and solar energy usage strategies.

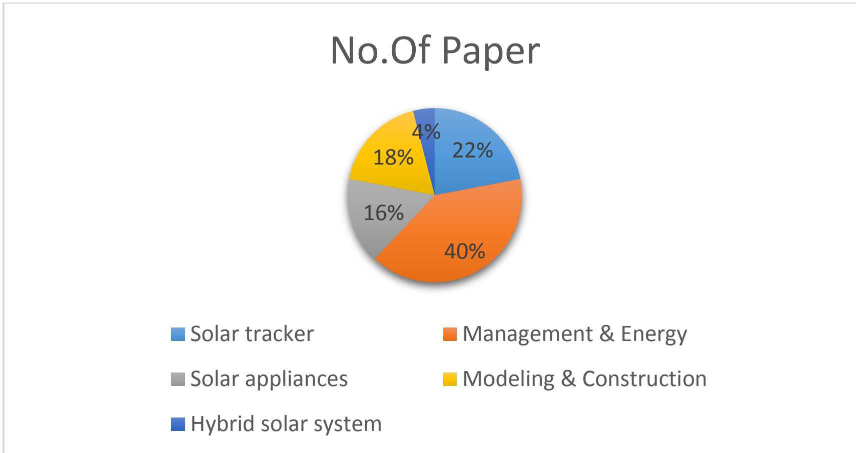

Fig 4 Pie chart of the No. of paper for different techniques

This figure illustrates the No. of papers for different techniques. This chart displays the highest and lowest possible numbers of paper-based different techniques. A pie chart will be used to display the number of articles that each represent a different strategy for making use of solar energy. The management and energy industry has the most papers, while the hybrid system of solar and wind energy has the fewest articles. The biggest number of papers is based on the management and energy sector.

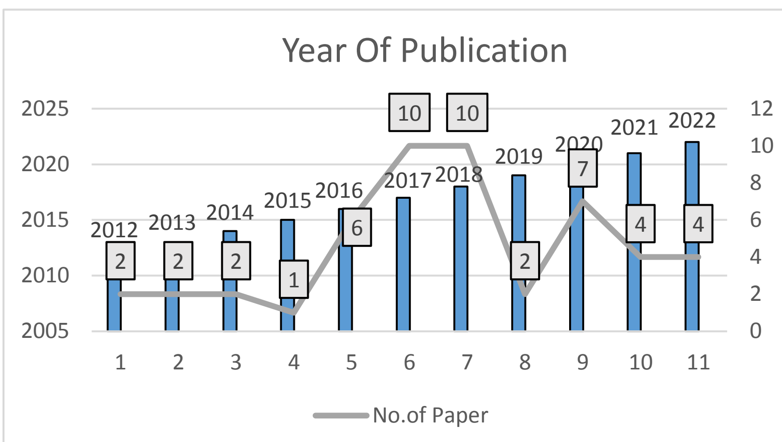

Fig 5 Graph in between No.of paper publication in the year

This figure will illustrates the No. of papers published in the year. This graph will display the total number of articles that were published during the year. This graph depicts the largest number of articles that were published in 2017, 2018, and this year, with the majority of those publications focusing on solar tracking technologies and solar energy harvesting. The number of articles that are published at a high pace in 2021 and 2022 is unlikely. The number of publications that were published between 2012 and 2014 was quite low. The number of articles published in this year, 2015 is relatively low according to this graph.

7. Conclusion

A review of solar energy for the futuristic world that includes the fundamentals of photovoltaic (PV) technology, the energy situation of the world, and emerging trends, and highlights the extraordinary amount of research that has been conducted in solar energy production, PV/T collectors, solar heaters, design enhancements, and materials for effective light absorption in order to advance the technology of solar panel. We discussed about the solar technologies that are now the most widely used, analyze the many different ways solar electricity may be put to use.

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