DOI: https://doi.org/10.46632/rne/1/1/5

Renewable and Nonrenewable Energy
Vol: 1(1), 2022
REST Publisher; ISBN: 10978-81-948459-2-8
Website: http://restpublisher.com/book-series/renewable-and-nonrenewable-energy/

Investigation of Various Solar Photovoltaic Cells and its limitation

[1]*Shatjit yadav, [2]M. Ramachandran, [2]Chinnasami Sivaji, [2]Vidhya Prasanth, [2]Manjula Selvam
RMIT University Melbourne, Australia.
[2]REST Labs, Kaveripattinam, Krishnagiri, Tamil Nadu, India.
*Corresponding author Email: shatjityadav@gmail.com

Abstract. Solar cells generate Electric Uses sunlight Semiconductor devices. They are like processing computer memory chips. Solar cells primarily Silicon so; it is caused by the sun's rays Absorbs exposed photons. A photovoltaic cell, commonly referred to as the solar cell, it is exposed to direct sunlight a non-mechanical device that converts electricity. Some PV cells Converts artificial light into electricity. Solar cells are cell-based cells and are classified into two types as thin film based cell. What are the disadvantages of Quantitative solar cell? It has a low absorption coefficient, high cost and high temperature and reduces the efficiency of the cell in Low light conditions. To overcome these shortcomings Perovskite, high absorption coefficient, Flexible, light weight The thin film consists of a solar cell and increased performance at high temperatures. The main objectives of this chapter are origin of the Perovskite solar cell; it is a brief discussion of the features, applications, challenges and future trends.
Keywords: Solar cells, Photovoltaic (PV), Photovoltaic-thermal (PV/T), Cooling photovoltaic cell, Perovskite solar cells.

1. Introduction

Photovoltaic solar cells are exposed to sunlight Converts directly into solar energy. They are charged differently between the upper and lower layers Use thin layers of semiconductor materials. The semi-conductive material can be bonded between a glass sheet and the polymer adhesive. A photovoltaic cell, commonly referred to as the solar cell, it converts sunlight directly into electricity Convertible non-mechanical device. The solar cell is important device in the conversion of photovoltaic energy into light energy. Energy conversion involves by in a semiconductor and charge carrier separator Electron-hole pairs Absorption of light energy. Also called photovoltaic cells Solar cells convert sunlight directly into electricity. Light voltage converts light into electricity Derived its name from the conversion process. This is called the photovoltaic effect. Photovoltaic's is the use of semiconductor materials Converting light into electricity that express photovoltaic effects, these are physics and light chemistry and electrochemistry. The photovoltaic effect is used commercially for power generation and photosynthesis. Photovoltaic is the expression of a photovoltaic effect Converting light into electricity using semiconductor materials, It is studied in physics, photochemistry and electrochemistry. The photovoltaic effect is used commercially for power generation and photosynthesis. PV conversion capacity is the percentage of solar energy converted into electricity. Although most commercial panels have an efficiency of 15% to 20%, researchers have developed PV cells that are approaching 50% efficiency. Absorb photons emitted by the sun Creates the flow of electrons a photovoltaic battery made of semiconductor materials. Photons at speeds of 300,000 kilometres per second Elemental particles carrying solar radiation. In the 1920s, Albert Einstein referred to them as "light grains". Perovskite is a solar cell is a type of perovskite-structured compound; usually a hybrid organic-mineral lead or tin halide based material, Light is the active layer of the harvest. Perovskite products, methylamonium lead highlights and all mineral cesium lead highlights, Inexpensive to manufacture and easy to make. Will use these items Solar battery for laboratory level devices performance has increased from 3.8% in 2009 to 25.7% in 2021. 29.8% of silicon-based tandem cells, Exceeds the maximum performance achieved at a meeting. So Perovskite solar cells will be advancing rapidly until 2016 is solar technology. With the ability to achieve higher efficiency and lower production costs, Perovskite solar cells have become commercially attractive. In major issues and research subjects including their short- and long-term sustainability.

2. Solar Cells

Bilateral Photons from the event of solar cells simultaneously collect albito radiation reaches both before and after a solar system. Of the monophasic solar cells device collect only the photons that reach the front. Bilateral solar cells since the 1960s have been studied. Its photovoltaic systems Is a new concept for improving energy output. It has been shown that a 50% increase in electrical output Roofing around a block using alveolar magnification and Direct from the surroundings, Albedo radiation can be achieved by collecting simultaneously. As a result, binary solar cells are compared to Monophonic cells can increase the energy density of PV cells, at the same time area related costs for PV systems can be reduced. [1] The other type is Traditional solid-state PV solar cells in development a similar situation has occurred. Based on thin films Imageless Si, CdTe and CIGS products Analysis of PV devices, DP parameter varies from 5 to 10%, and it signifies a bad

forecast for the future. On the development of PV solar cells our analysis is GaAs-based PV can be used systematically for solar cells. GaAs hetero structures, however, are fully functional under high concentrations of solar radiation Indicates a special event of PV devices. Recently, these cells with an enrichment of 500-suns gave a performance value of almost 40%. This value will reach 50% in the future. Higher values of the DP parameter in the inset Conventional PV is higher than the values suitable for solar cells. Organic PV Technology at Johannes Kepler University, Austria including plastic solar design panels informed reviews of the current status are currently available at the Linz Institute of Organic Found in the latest issue of Serdar Sariciftci, director of Solar Cells. [2] Plasmon is a free electron oscillation in a conductor; they allow nanoscale light to be manipulated. To direct and control light at sub-wavelengths the potential of Plasmon is opening up new design possibilities for solar cells. For the past two years, photovoltaic's using solar cells to convert sunlight into electricity has progressed faster than most reliable predictions. Localized Plasmon already has proven the ability of solar cells to increase efficiency. In cases where the traditional system is not feasible. To propagate Plasmon, parasitic optical absorption in metal is a significant challenge for both structural and robust optical absorption near high-resilience metal-semiconductor interfaces. Nevertheless, Plasmonics opens up a whole new world of optics at the sub-wavelength level, which is often not explored. High-code, non-absorbent conductivity and meta-material plasmonics Both may offer new photovoltaic possibilities The possible minimum cell thickness by plasmonics not only provides the expected material storage, But like the hot carrier cell Allows successful implementation of advanced high performance ideas. [3] Most solar cells currently on the market are based on silicon scales. Also known as first generation technology. As this technology matures, the material costs, mostly silicon flakes, reinforced low-iron glass sheet And other coatings are increasingly dominated by costs. When the photovoltaic industry matures This trend is expected to continue. The cost of production increased sharply in 1997 to 500 MW = y, suggesting that the material costs of such modules would exceed 70% of the total production cost. Without unnecessary complex cell processing this would be advantageous if fabricated, High performance processing lines producing Solar cells with high energy conversion capacity. Many who work Photovoltaic field, The first generation of silicon-sized solar panels is coming soon Or later hope that the low cost will be replaced by the 'second generation' of thin-film technology, This includes different semiconductors. [4] In short, Understanding NW / NPL Solar Cells and There has been significant progress in development. Geometry of NPLs, Tuneable optical absorption and with carrier collection properties Provides unique opportunity to create new device configurations. For example, light absorption and carrier collection processes Orthogonalization is achieved by examining radial junctions. This will increase the carrier collection efficiency. In addition, 3-D geometric structure of NPLs Low optical reflection, so on results in improved absorption. However, with a large surface / interface area the geometry of NPL cells presents major barriers. Importantly, the choice of material structure is important. When the surface remodeling ratios are lower than the total remodeling ratios Only NPL cells provide an advantage. This suggests that Si and GaA are material systems with higher surface restoration speeds. Only when the surface remodeling ratios are lower than the total remodeling ratios NPL cells provide an advantage. [5] Photovoltaic is radiation Converting directly to electricity. In photovoltaic systems there are cells that convert sunlight into electricity. Inside each cell there is a layer of semiconductor material. Light falling on the cell, it creates an electric field across the layers and conducts electricity.The intensity of the light produced by each cell determines the amount of electrical energy. Research on semiconductor-based solar cells has been ongoing since the 1960s. Si (pc-Si) of polycrystalline at that time and thin-film new technology for solar cells means expensive and established to reduce energy input, but increase productivity. PV is currently the most technologically and commercially advanced technology; It uses solar energy Can generate and supply short / interim electricity. However, Current PV installations are even smaller and supply Total of the world only 0.1% of power generation, but according to some market reports PV installations average are growing at an annual rate of 40%. PV technology existed 5 years ago Halves the unit price. And continuous technological advancement and through research for performance improvement, the PV course will continue grow at a rapid pace and eventually become the world's leading energy supplier. According to a report on global enhanced solar photovoltaic power, PV is projected to provide about 345 GW at 4% by 2020 and 1081 GW by 2030. [6] For practical use, not only the switching capacity but also the life of Photovoltaic device is important. Stability of organic solar cells mainly active affects the photosynthesis of materials. However, Organic light-emitting Used in diodes bonding techniques against antioxidants can provide a useful label, But still requires intrinsic photosynthesis of organic matter. Total heterotrosion solar cells, Organic or hybrid molecular structure, Nanometric morphology and device properties Are closely related. Therefore, this closely interconnected parameter for Design of Advanced Organic Solar Cells should is improved simultaneously.

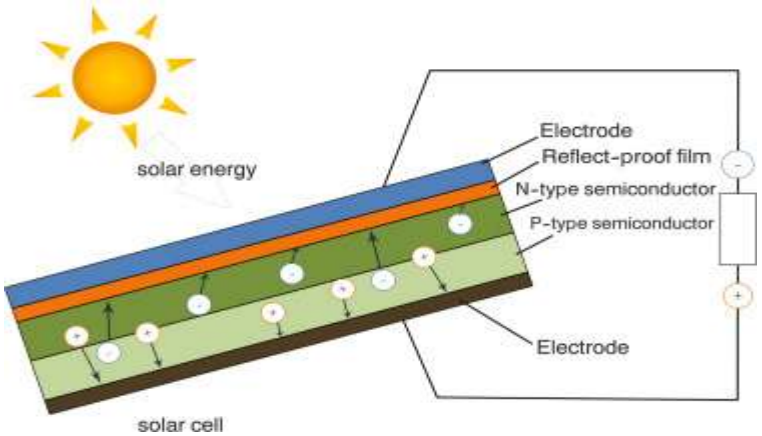

FIGURE .1 Si solar cell productions

[7] In recent years, in thin-film silicon solar cells we have seen renewed interest around the world. With layer thickness running in the range of 10-50 Suitable for thin film silicon solar cells being with a light-trap is something everyone knows they are capable of achieving about 20% efficiency. Also, the thin-film approach reduces material consumption and Provides major cost benefits based on less stringent requirements for material quality. In many ways, thin-film silicone technology is a great choice, Because of its single crystal or thick cell analog of polycrystalline Benefit greatly from well-established technology. The validity of this approach is that it is highly topped; the single-crystal substrate-enhanced epitaxial thin film has already been demonstrated to achieve an efficiency of more than 16%. This endeavour is in low-cost substrates Device-quality thin-film silicon fabrication and is directed towards designing and implementing an effective light-engine scheme. By DOE funded project under PVMT project by Astro Power Corporation Significant progress has been made in this direction. [8]

3. Photovoltaic (PV)

One of the most widespread technologies in renewable energy production the use of sunlight is the use of photovoltaic systems that convert electrical energy. This kind of renewable energy technology Eliminates contamination during operation and reduces the problems of global warming. Operating costs in comparison and reduces maintenance costs to other renewable energy technologies and provides high energy density, which highlights the benefits of solar photovoltaic (PV) energy. Proven by PV technology In addition to the many benefits, this alternative system is similar to hail, dust and surface operating temperatures Has some common problems, this is the performance of the alternative system badly affected. [9] The biggest incentive for renewable energy is given to solar photovoltaic (PV) systems, which greatly enhances the installation of this system. Since annual isolation and Ambient temperature does not vary greatly across the country, Areas suitable for solar power plants have some restrictions based on environmental conditions. However, between urban and rural the price of land varies greatly and the urban cost index is very high. Therefore, many large factories were built in the countryside, especially in the waste salt fields of the Yellow Sea and the west-south sea of the peninsula. Apart from hydropower and some bio fuels, solar power (PV) Wind power is also being commercialized as a renewable energy source. [10] Photovoltaic generation has increased overseas over the past decade and has become one of the major contributors to the current energy shift, with solar cells providing about 1.7% of world electricity. Improvements in materials and production processes play an important role in this development. Nevertheless, photovoltaic are clean; there are many challenges before providing abundant and cheap energy. To convert organic photovoltaic's into mature technology, high performance must be consistent over time. This created static devices in the air and allowed the fictional process to take place in the air. Combustion at organic photovoltaics is a major problem because it can lead to a 20-60% loss in initial performance. [11] Possible solution to reduce global warming, Based on renewable energy sources Establishing a new energy infrastructure. Of the various renewable sources, solar energy is the largest and very practically indescribable. The earth receives 10,000 times more energy from the sun. Currently commercially available Solar battery technologies, crystal-Si, thin-film Si, CdTe, among other promising technologies and CuIn1xGaxSe2 (CIGS), dye-sensitive, organic and GaAs. [12]

4. Photovoltaic-Thermal (PV/T)

Different types of There are solar families and all absorb the sun's energy in different ways. These technologies include photovoltaic, solar voltage (PV / T) and concentrated solar panels. PV panels are mainly used to generate electricity directly from solar energy, Solar heating technologies use solar energy to generate heat. Electricity is a combination of two or more PV / T solar panels it uses solar energy to generate both heat and heat. On the other hand, solar panels generate a large amount of heat Accumulate by capturing and concentrating solar radiation at one point. To generate electricity for these energy machine jobs, eventually electricity is used more efficiently. [13] Concentration of photovoltaic-thermal technology, using optical concentrations uses solar energy to increase solar density in cells. CPVT systems for achieving the highest performance for power utilization and utilization are at the center of continuous research and development. For higher energy production Increases the concentration ratio in the CPVT format raises many improvements and limitations. Single / multi-junction semiconductor products, Primary and secondary optical concentrators, CPVT components in the heat receiver design dipole Shows the effect of temperature on the concentration ratio. To achieve this, single and multiple encounters there is a theory of the properties of solar cells to understand the dependence of temperature and concentration ratio. [14] Depending on the operating fluid, PV / T systems can be divided into two types: Air based and liquid based. Liquid based devices are more efficient than air conditioned PV / T devices and their performance is often comparable to that of conventional solar heat collectors. On the other hand, air-based PV / T devices show lower installation and maintenance costs compared to liquid models reduce the risk of leakage and frost. Innovative systems and products have been integrated and industrialized over the past decades; at the same time theoretical models were developed primarily by academics to assess their energy potential. A survey of the latest developments and Trends in PV / T technologies, there is research and development. Although BIPV / T technology has been extensively explored, Impact on the active and passive effects of building integration, Therefore, there is still a lack of analysis in building energy efficiency. As mentioned in the above studies, To provide guidelines for conducting comprehensive building performance analyzes aimed at enhancing the attractiveness of such a system Further BIPV / T system research is required. In fact, in most of the numerical studies available in the literature, many key features that integrate PV / T devices or are incorporated into the building envelope are overlooked. Therefore, due to the building integration of PV / T devices in the overall building performance, Researchers are

encouraged to focus on the analysis of passive effects. For this purpose, the use of appropriate number and predictive models is also important. [15]

5. Cooling Photovoltaic Cell

PV systems are commercially available, have been widely operated for many years and there are some barriers to the widespread use of this particular technology. Problems such as limited conversion capacity, high temperature and dust accumulation are considered important, because they have a significant impact on the performance of PV cells, especially in areas with hot, humid climates. A wide range of cooling techniques for thermal regulation of PV systems has been explored. Among the proposed systems, the air of PV systems and Liquid-based cooling is considered a mature technology and has been extensively tested in practice. In contrast, heat pipe to cool PV cells, phase converters and the use of thermoelectric devices is still under research and development. [16] Various methods can be used to achieve cooling of PV systems. However, the optimal cooling solution, PV technology used, Depending on many factors such as the geometric types of capacitors and the weather in which the computer is installed. The challenges are mainly in hot and humid climates; there the cells may experience short and long term decay due to high temperature. Cooling systems for PV panels are mainly of two types namely passive and active cooling. The most commonly used cooling medium for passive and active cooling systems is air and water. Depending on many factors such as the geometric types of capacitors and the weather in which the computer is installed. However, the thermal properties of air make it less efficient as a cooling medium. Therefore, in hot areas from PV absorbers Air conditioning is not exactly suitable for extracting thermal energy. This limits the potential for heat-waste recovery and indicates that more parasitic power is required to operate the fans to achieve the same cooling capacity of the water. However, in some situations where water is scarce, air may still be the right choice. Water cooling, on the other hand, allows it to operate at higher temperatures and allows waste heat recovery to be used more efficiently. Therefore, air conditioning is in many cases a less favorable option. Many active cooling systems work in conjunction with passive cooling components. Therefore, the choice of cooling medium depends on the design requirements of the PV system and the operating conditions of the system. [17] **Heat pipe cooling system**: A heat pipe is a metal tube with an inner porous surface that contains a compressible and volatile hot liquid. Furthermore, as a cooling technique, heat pipe cooling is a passive cooling technique in which the working fluid absorbs heat energy from the cells and transfers it to the water tank (compressed area), which is a technique for applying heat to the cells. Evaporates the working liquid. The use of heat pipe for cooling PV cells is very suitable in terms of temperature uniformity, high thermal conductivity and optimal efficiency of variable heat flux. In general, the heat pipe is made up of three main parts. I. The evaporative part of any tube is located behind the cells. II. Fins used to increase cooling and improve heat transfer in dense areas. III. Capacitor area connected to Environmental air by natural convection. [18] Applying sunlight to photovoltaic cells and replacing the resulting expensive photovoltaic component with low-cost magnifying glasses or lenses is considered a way to reduce the cost of solar power. As the solar absorption area decreases, more expensive, but more efficient PV cells can be used. However, only a portion of the sunlight coming into the cell is converted into electrical energy (the typical efficiency value of the concentrating cells is 25%). The remainder of the absorbed energy is converted into thermal energy in the cell and the junction temperature may rise if the heat is not efficiently dissipated. [19] Based on the cone-shaped air collection tunnel A laboratory-sized cooling device was designed and then fabricated to cool a photovoltaic (PV) cell. The air collected from the conical tunnel was used with two targets; at first, it was considered the cooling fluid for the PV cell. Second, it was used to generate electrical energy through a designed turbine. The great potential of the proposed cooling device in the performance of the PV cell is central to this study. The results obtained are of both PV cell and turbine power generation shows that the total output power has increased by 36%. [20]

6. Perovskite Solar Cells

Perovskite solar cells based on organometallic halides represent the emerging photovoltaic technology. Perovskite solar cells are made from dye sensitive solar cells. In a liquid-based dye-sensitive solar cell system, the absorption of methylamonium lead halide perovskite on the surface of the nanocrystalline TiO2, first discovered in 2009, produces approximately 3-4% (PCE) of light current. PCE Perovskite doubled after 2 years by improving coating conditions. However, the liquid-based Perovskite solar cell receives little attention due to its stability issues, including the instantaneous dissolution of Perovskite as a liquid electrolyte. In 2012, a long-lasting, stable and high-performance (10%) Perovskite solar cell was developed by replacing a solid whole conductor with a liquid electrolyte. In 2 years the efficiency has increased rapidly to 18%. Perovskite solar cells are a promising photovoltaic technology because PCO values of more than 20% are realistically expected using inexpensive organometallic halide Perovskite materials. In this review, the opto-electronic properties of Perovskite materials and recent developments in Perovskite solar cells are described. In addition, comments on issues for current and future challenges are mentioned. [21] Organic-mineral halide perovskite solar cells are the most significant breed in the photovoltaic field in the current decade and are the best breed to meet the high performance requirement while allowing low cost solution based production. The first reports of standard solid state solar panels based on CH3NH3PbI3 perovskite in mid-2012 showed that PCEs of solar cells already exceeded 15%, which is higher than other solution-enabled solar cell technology. The wide range of structures of efficient Perovskite solar cell device structures led to remarkable semiconductor materials with excellent electrical and optical properties. [21] The recent arrival of organometallic lead halide perovskite solar cells has led to the most rapid development in the cell performance of any material in photovoltaic history. The unique properties of these absorbent layers offer many advantages over optoelectronic applications, which in many ways are derived from the nature of perovskite lattice. The exclusive use of widely available elements and the ability to shoot through solution or vacuum-based methods indicate the enormous potential of these compounds to completely redefine materials designed and

selected for electronic applications. The purpose of this review is to summarize the notable achievements in hybrid Perovskite filmmaking: 1) film production methods, 2) techniques for changing film properties and 3) cell structure, performance and development. [22] Metal halide perovskite solar cells are rapidly approaching the ability to compete with crystal silicon. After 5 years of intensive research, the efficiency of the registered certified Perovskite research solar cell is 22.1% 1, while the silicon cells of the registered certified multi-layer crystal are 21.9%, which is the most commonly used PV technology. % 3 is approaching and the final performance gains are pressing. Although improvements in Perovskite solar cell performance can be expected in the next few years, single-junction Perovskite solar cells will always be limited to c-Si-like performance. Mainstream PV module production costs have been declining rapidly over the past decade, and now the cost of the module is less than half of the total solar PV installation in utility scale projects. Most non-modular costs referred to as system balance are the PV area used instead of power generation. Therefore, increasing the overall power output of the module per unit area, i.e. performance, is the definitive way to reduce the overall cost of electricity generated by the installed PV. Therefore, we need to develop a strategy and roadmap for making Perovskite solar cells more efficient than c-Si. [23] Unlike 3D Perovskite devices, 2D layer Perovskite devices are more stable in light soaking and long-term operation and promote the use of design techniques such as adding metal oxide layers to 3D perovskites and attaching layer 2D perovskite devices for long-term durability. [25] Perovskite solar cells are our ultimate goal of high efficiency, Low cost, high stability, non-toxic Character and reproduction. The rapid improvement in performance shows that PSCs have more Power over conventional silicon solar cells. Their high performance and relative despite the low price, Perovskite products exhibit random characteristics that have become a major problem that urgently Study and find a solution. Chemical instability can be dramatic restrict business growth in the future. To understand and address the underlying cause of PSCs decay, three factors were explored: Air stability, photo stability, thermal stability. For PSC with high stability all of these factors need to be considered. [26] Perovskite products use earth-heavy components, Have low built-up energies to sediment, Roll-to-roll and other high volume production Are compatible with the techniques. These features Borovsky solar panels make at a very affordable price. low terawatt power generation. Comparable to other thin-film photovoltaic's Improvements in performance and laboratory-level cell sustainability recently they have transformed the scale of this PV technology into an integral part of the research center. [27]

7. Conclusion

Photovoltaic is radiation is to convert directly into electricity. In photovoltaic systems inside each cell are layers of semiconductor material. Light falling on the cell, across the layers creates an electric field and conducts electricity. Concentration of photovoltaic-thermal technology, Utilizes solar energy to increase solar density in cells using optical concentrations. The dual functions of PV/T Rather than single Photovoltaic modules Or the use of solar water heaters Increase the overall solar energy conversion rate. Following that, various researches were conducted to improve its general performance in the hybrid solar PV / T system. Perovskite solar cells are our ultimate goal of high efficiency, Low cost, high stability, Non-toxicity and reproduction. Rapid improvement in performance compared to traditional silicon solar panels Shows that PSCs have high potency.

Reference

[1]. Guerrero-Lemus, R. V. T. K. A. K. L. S. R., R. Vega, Taehyeon Kim, Amy Kimm, and L. E. Shephard. "Bifacial solar photovoltaics–A technology review." *Renewable and sustainable energy reviews* 60 (2016): 1533-1549.

[2]. Shevaleevskiy, Oleg. "The future of solar photovoltaics: A new challenge for chemical physics." *Pure and Applied Chemistry* 80, no. 10 (2008): 2079-2089.

[3]. Green, Martin A., and Supriya Pillai. "Harnessing plasmonics for solar cells." *Nature photonics* 6, no. 3 (2012): 130-132.

[4]. Green, Martin A. "Third generation photovoltaics: solar cells for 2020 and beyond." *Physica E: Low-dimensional Systems and Nanostructures* 14, no. 1-2 (2002): 65-70.

[5]. Shukla, Piyush Kumar, Vandana Roy, Prashant Kumar Shukla, Anoop Kumar Chaturvedi, Aumreesh Kumar Saxena, Manish Maheshwari, and Parashu Ram Pal. "An Advanced EEG Motion Artifacts Eradication Algorithm." The Computer Journal (2021).

[6]. Zuo, Chuantian, Henk J. Bolink, Hongwei Han, Jinsong Huang, David Cahen, and Liming Ding. "Advances in perovskite solar cells." *Advanced Science* 3, no. 7 (2016): 1500324.

[7]. Shukla, Niraj Kumar, Shashi Kant Pandey, and Rajeev Srivastava. "Efficiency and Cost Optimization of Three-ϕ Induction Motor Using Soft Computing Techniques." In Computing Algorithms with Applications in Engineering, pp. 305-318. Springer, Singapore, 2020.

[8]. Sum, Tze Chien, and Nripan Mathews. "Advancements in perovskite solar cells: photophysics behind the photovoltaics." *Energy & Environmental Science* 7, no. 8 (2014): 2518-2534.

[9]. Hörantner, Maximilian T., Tomas Leijtens, Mark E. Ziffer, Giles E. Eperon, M. Greyson Christoforo, Michael D. McGehee, and Henry J. Snaith. "The potential of multijunction perovskite solar cells." *ACS Energy Letters* 2, no. 10 (2017): 2506-2513.

[10]. R. Kurinjimalar, S. Vimala, M. Silambarasan, S. Chinnasami. "A Review on Coir fibre Reinforced Composites with Different Matrix", REST Journal on Emerging trends in Modelling and Manufacturing, 7(2), (2021):25-32.

[11]. Li, Zhen, Talysa R. Klein, Dong Hoe Kim, Mengjin Yang, Joseph J. Berry, Maikel FAM Van Hest, and Kai Zhu. "Scalable fabrication of perovskite solar cells." *Nature Reviews Materials* 3, no. 4 (2018): 1-20.

[12]. Sathish, E., G. Manikandan, and G. Bhuvaneswari. "Design and development of multi controlled smart bike." Materials Today: Proceedings (2021).

[13]. Fan, Zhiyong, Daniel J. Ruebusch, Asghar A. Rathore, Rehan Kapadia, Onur Ergen, Paul W. Leu, and Ali Javey. "Challenges and prospects of nanopillar-based solar cells." *Nano Research* 2, no. 11 (2009): 829-843.

[14]. Lu, Yanjing, Mudassir Khan, and Mohd Dilshad Ansari. "Face recognition algorithm based on stack denoising and self-encoding LBP." Journal of Intelligent Systems 31, no. 1 (2022): 501-510.

[15]. M. Amudha; M. Ramachandran; Vimala Saravanan; P. Anusuya; R. Gayathri " A Study on TOPSIS MCDM Techniques and Its Application" Data Analytics and Artificial Intelligence, 1(1), (2021): 09-14.

[16]. Roy, Rita. "Predicting User's Web Navigation behaviour using AMD and HMM Approaches." In IOP Conference Series: Materials Science and Engineering, vol. 1074, no. 1, p. 012031. IOP Publishing, 2021.

[17]. Zhao, Xing, and Nam-Gyu Park. "Stability issues on perovskite solar cells." In *Photonics*, vol. 2, no. 4, pp. 1139-1151. Multidisciplinary Digital Publishing Institute, 2015.

[18]. Udgata, Siba K., Alefiah Mubeen, and Samrat L. Sabat. "Wireless sensor network security model using zero knowledge protocol." In 2011 IEEE international conference on communications (ICC), pp. 1-5. IEEE, 2011.

[19]. Tyagi, V. V., Nurul AA Rahim, N. A. Rahim, A. Jeyraj, and L. Selvaraj. "Progress in solar PV technology: Research and achievement." *Renewable and sustainable energy reviews* 20 (2013): 443-461.

[20]. Alalmai, Ali, and Dr Gulnaz Fatma. "A., Arun & Aarif, Mohd.(2022). Significance and Challenges of Online Education during and After Covid-19. Türk Fizyoterapi ve Rehabilitasyon Dergisi." Turkish Journal of Physiotherapy and Rehabilitation 32: 6509-6520.

[21]. Tsai, Hsinhan, Wanyi Nie, Jean-Christophe Blancon, Constantinos C. Stoumpos, Reza Asadpour, Boris Harutyunyan, Amanda J. Neukirch et al. "High-efficiency two-dimensional Ruddlesden–Popper perovskite solar cells." *Nature* 536, no. 7616 (2016): 312-316.

[22]. P. K. Chidambaram, Amol Lokhande, M. Ramachandran, Vimala Saravanan, Vidhya Prasanth, "A Review on Biodiesel Properties and Fatty acid composites", REST Journal on Emerging trends in Modelling and Manufacturing, 7(3), 2021:87-93.

[23]. Fegade, Vishal, Krishnakumar Gupta, M. Ramachandran, S. Madhu, C. Sathiyaraj, R. Kurinji< alar, and M. Amudha. "A study on various fire retardant additives used for fire reinforced polymeric composites." In AIP Conference Proceedings, vol. 2393, no. 1, p. 020107. AIP Publishing LLC, 2022.

[24]. Khambra, Geetanjli, and Prashant Shukla. "Novel machine learning applications on fly ash based concrete: an overview." Materials Today: Proceedings (2021).

[25]. Hoppe, Harald, and Niyazi Serdar Sariciftci. "Organic solar cells: An overview." *Journal of materials research* 19, no. 7 (2004): 1924-1945.

[26]. Shukla, Niraj Kumar, Rajeev Srivastava, and Seyedali Mirjalili. "A Hybrid Dragonfly Algorithm for Efficiency Optimization of Induction Motors." Sensors 22, no. 7 (2022): 2594.

[27]. Song, Tze-Bin, Qi Chen, Huanping Zhou, Chengyang Jiang, Hsin-Hua Wang, Yang Michael Yang, Yongsheng Liu, Jingbi You, and Yang Yang. "Perovskite solar cells: film formation and properties." *Journal of Materials Chemistry A* 3, no. 17 (2015): 9032-9050.

[28]. Vimala Saravanan; M. Ramachandran; T. Vennila; G. Mathivanan "A Study on Multi-Objective Optimization on the basis of Ratio Analysis", Recent trends in Management and Commerce, 2(3), (2021):16-22

[29]. Geetha, D., V. Kavitha, G. Manikandan, and D. Karunkuzhali. "Enhancement and Development of Next Generation Data Mining Photolithographic Mechanism." In Journal of Physics: Conference Series, vol. 1964, no. 4, p. 042092. IOP Publishing, 2021.

[30]. Ghadikolaei, Saeed Siah Chehreh. "Solar photovoltaic cells performance improvement by cooling technology: An overall review." *International Journal of Hydrogen Energy* 46, no. 18 (2021): 10939-10972.

[31]. Khan, Mudassir, and Aadarsh Malviya. "Big data approach for sentiment analysis of twitter data using Hadoop framework and deep learning." In 2020 International Conference on Emerging Trends in Information Technology and Engineering (ic-ETITE), pp. 1-5. IEEE, 2020.

[32]. Chopra, K. L., P. D. Paulson, and V. Dutta. "Thin-film solar cells: an overview." *Progress in Photovoltaics: Research and applications* 12, no. 2-3 (2004): 69-92.

[33]. C. Venkateswaran; M. Ramachandran; Vimala saravanan; T. Vennila " A Study on Artificial intelligence with Machine learning and Deep Learning Techniques", Data Analytics and Artificial Intelligence, 1(1), (2021):32-37.

[34]. Deepa, N., Asmat Parveen, Anjum Khurshid, M. Ramachandran, C. Sathiyaraj, and C. Vimala. "A study on issues and preventive measures taken to control Covid-19." In AIP Conference Proceedings, vol. 2393, no. 1, p. 020226. AIP Publishing LLC, 2022.

[35]. Rahimi, Masoud, Peyvand Valeh-e-Sheyda, Mohammad Amin Parsamoghadam, Mohammad Moein Masahi, and Ammar Abdulaziz Alsairafi. "Design of a self-adjusted jet impingement system for cooling of photovoltaic cells." *Energy conversion and management* 83 (2014): 48-57.

[36]. Stalin, Shalini, Vandana Roy, Prashant Kumar Shukla, Atef Zaguia, Mohammad Monirujjaman Khan, Piyush Kumar Shukla, and Anurag Jain. "A machine learning-based big EEG data artifact detection and wavelet-based removal: an empirical approach." Mathematical Problems in Engineering 2021 (2021).

[37]. Vikrant Sharma; M. Ramachandran; Sathiyaraj Chinnasamy; Vimala Saravanan, " A Review on Structural Equation Modeling and Its Classification" REST Journal on Emerging trends in Modelling and Manufacturing, 7(4), (2022): 135-142

[38]. Bhuvaneswari, G., and G. Manikandan. "A novel machine learning framework for diagnosing the type 2 diabetics using temporal fuzzy ant miner decision tree classifier with temporal weighted genetic algorithm." Computing 100, no. 8 (2018): 759-772.

[39]. Siecker, J., K. Kusakana, and et BP Numbi. "A review of solar photovoltaic systems cooling technologies." *Renewable and Sustainable Energy Reviews* 79 (2017): 192-203.

[40]. Fatima, Gulnaz. "Identity, Homelessness and Isolation in "The Room on the Roof"."

[41]. Khan, Mudassir, Aadarsh Malviya, and Surya Kant Yadav. "Big Data and Social Media Analytics-A Challenging Approach in Processing of Big Data." In ICCCE 2020, pp. 611-622. Springer, Singapore, 2021.

[42]. C. Venkateswaran, D R Pallavi, M. Ramachandran, Vimala Saravanan, Vidhya Prasanth, "A Review on Promethee and Analytic Hierarchy Process with Its Application", Data Analytics and Artificial Intelligence, 2(1), (2022):34-39

[43]. Pandit, Shraddha, Piyush Kumar Shukla, Akhilesh Tiwari, Prashant Kumar Shukla, Manish Maheshwari, and Rachana Dubey. "Review of video compression techniques based on fractal transform function and swarm intelligence." International Journal of Modern Physics B 34, no. 08 (2020): 2050061.

[44]. Bhuvaneswari, G., and G. Manikandan. "An intelligent intrusion detection system for secure wireless communication using IPSO and negative selection classifier." Cluster Computing 22, no. 5 (2019): 12429-12441.

[45]. Wee, Jung-Ho, Jae Hyung Roh, and Jeongin Kim. "A comparison of solar photovoltaics and molten carbonate fuel cells as commercial power plants." *Renewable and Sustainable Energy Reviews* 15, no. 1 (2011): 697-704.

[46]. Shahdad, Syed Yasmeen, Mudassir Khan, Habeeba Sultana, Mohammad Ashfaq Hussain, and Syeda Meraj Bilfaqih. "Routing Protocols for Constraint Devices Internet of Things Network." In 2019 International Conference on Communication and Signal Processing (ICCSP), pp. 0114-0117. IEEE, 2019.

[47]. Gupta, Krishnakumar, Vishal Fegade, Jeevan Kittur, M. Ramachandran, S. Madhu, S. Chinnasami, and M. Amudha. "A review on effect of cooling rate in fiber reinforced polymeric composites." In AIP Conference Proceedings, vol. 2393, no. 1, p. 020106. AIP Publishing LLC, 2022.

[48]. Bhatt, Ruby, Priti Maheshwary, Piyush Shukla, Prashant Shukla, Manish Shrivastava, and Soni Changlani. "Implementation of fruit fly optimization algorithm (FFOA) to escalate the attacking efficiency of node capture attack in wireless sensor networks (WSN)." Computer Communications 149 (2020): 134-145.

[49]. Manikandan, G., and S. Srinivasan. "Traffic control by bluetooth enabled mobile phone." International Journal of Computer and Communication Engineering 1, no. 1 (2012): 66.

[50]. Almosni, Samy, Amaury Delamarre, Zacharie Jehl, Daniel Suchet, Ludmila Cojocaru, Maxime Giteau, Benoit Behaghel et al. "Material challenges for solar cells in the twenty-first century: directions in emerging technologies." *Science and Technology of advanced MaTerialS* 19, no. 1 (2018): 336-369.

[51]. Fatima, Gulnaz. "Political Dominance and Wrecked Identity: Reading Margret Atwood's The Handmaid's Tale in a Changing World."

[52]. Khan, Mudassir, Aadarsh Malviya, and Mahtab Alam. "Map Reduce clustering in Incremental Big Data processing." International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN (2019): 2278-3075.

[53]. Ataur rahman farooqi, D R pallavi, M. Ramachandran, S. Sowmiya, Manjula Selvam, "A Brief Study On Recent Trends in Financial Literacy", Recent trends in Management and Commerce, 3(1), (2022):40-45.

[54]. Rathore, Neeraj Kumar, Neelesh Kumar Jain, Prashant Kumar Shukla, UmaShankar Rawat, and Rachana Dubey. "Image forgery detection using singular value decomposition with some attacks." National Academy Science Letters 44, no. 4 (2021): 331-338.

[55]. Manikandan, G., and S. Srinivasan. "An efficient algorithm for mining spatially co-located moving objects." American Journal of Applied Sciences 10, no. 3 (2013): 195-208.

[56]. Tao, Coby S., Jiechao Jiang, and Meng Tao. "Natural resource limitations to terawatt-scale solar cells." *Solar Energy Materials and Solar Cells* 95, no. 12 (2011): 3176-3180.

[57]. Khan, Mudassir, and Shakila Basheer. "Using Web Log Files the Comparative Study of Big Data with Map Reduce Technique." In 2020 International Conference on Intelligent Engineering and Management (ICIEM), pp. 97-103. IEEE, 2020.

[58]. Shukla, Prashant Kumar, Jasminder Kaur Sandhu, Anamika Ahirwar, Deepika Ghai, Priti Maheshwary, and Piyush Kumar Shukla. "Multiobjective genetic algorithm and convolutional neural network based COVID-19 identification in chest X-ray images." Mathematical Problems in Engineering 2021 (2021).

[59]. Kurinjimalar Ramu; M. Ramachandran; M. Nathiya; M. Manjula " Green Supply Chain Management; with Dematel MCDM Analysis", Recent trends in Management and Commerce, 2(3),(2021): 8-15.

[60]. Suhasini, S., J. M. SheelaLavanya, M. Parameswari, G. Manikandan, and S. Gracia Nissi. "Input Based Resource Allocation in Motion Estimation using Re-configurable Architecture." In 2021 Fifth International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud)(I-SMAC), pp. 1091-1095. IEEE, 2021.

[61]. Jamshed, Mohammad, Gulnaz Fatma, and Sujan Mondal. "Deconstructing the Weaponization of Faith and Nationalism with A Special Reference to Bankim Chandra Chatterjee's Anandamath." Review of International Geographical Education Online 11, no. 7 (2021).

[62]. Ahmad, Lujean, Navid Khordehgah, Jurgita Malinauskaite, and Hussam Jouhara. "Recent advances and applications of solar photovoltaics and thermal technologies." *Energy* 207 (2020): 118254.

[63]. Rashid, Ekbal, Mohd Dilshad Ansari, Vinit Kumar Gunjan, and Mudassir Khan. "Enhancement in teaching quality methodology by predicting attendance using machine learning technique." In Modern approaches in machine learning and cognitive science: a walkthrough, pp. 227-235. Springer, Cham, 2020.

[64]. Shukla, Prashant Kumar, Piyush Kumar Shukla, Poonam Sharma, Paresh Rawat, Jashwant Samar, Rahul Moriwal, and Manjit Kaur. "Efficient prediction of drug–drug interaction using deep learning models." IET Systems Biology 14, no. 4 (2020): 211-216.

[65]. Alzahrani, Mussad, Katie Shanks, and Tapas K. Mallick. "Advances and limitations of increasing solar irradiance for concentrating photovoltaics thermal system." *Renewable and Sustainable Energy Reviews* 138 (2021): 110517.

[66]. Modjinou, Mawufemo, Jie Ji, Jing Li, Weiqi Yuan, and Fan Zhou. "A numerical and experimental study of micro-channel heat pipe solar photovoltaics thermal system." *Applied energy* 206 (2017): 708-722.

[67]. Pathak, Yadunath, Prashant Kumar Shukla, Akhilesh Tiwari, Shalini Stalin, and Saurabh Singh. "Deep transfer learning based classification model for COVID-19 disease." Irbm (2020).

[68]. Fatma, Gulnaz, Nahla Pirzada, and Sameena Begum. "Problems, Illusions and Challenges Faced by a non-Arabic Speaker in Understanding Quran: A Sub-Continental Study." Journal of Positive School Psychology 6, no. 2 (2022): 5422-5426.

[69]. Roy, Vandana, Prashant Kumar Shukla, Amit Kumar Gupta, Vikas Goel, Piyush Kumar Shukla, and Shailja Shukla. "Taxonomy on EEG artifacts removal methods, issues, and healthcare applications." Journal of Organizational and End User Computing (JOEUC) 33, no. 1 (2021): 19-46.

[70]. Khan, Mudassir, and Mohd Dilshad Ansari. "Multi-criteria software quality model selection based on divergence measure and score function." Journal of Intelligent & Fuzzy Systems 38, no. 3 (2020): 3179-3188.

[71]. Athienitis, Andreas K., Giovanni Barone, Annamaria Buonomano, and Adolfo Palombo. "Assessing active and passive effects of façade building integrated photovoltaics/thermal systems: Dynamic modelling and simulation." *Applied Energy* 209 (2018): 355-382.

[72]. Makki, Adham, Siddig Omer, and Hisham Sabir. "Advancements in hybrid photovoltaic systems for enhanced solar cells performance." *Renewable and sustainable energy reviews* 41 (2015): 658-684.

[73]. Royne, Anja, Christopher J. Dey, and David R. Mills. "Cooling of photovoltaic cells under concentrated illumination: a critical review." *Solar energy materials and solar cells* 86, no. 4 (2005): 451-483.

[74]. Park, Nam-Gyu. "Perovskite solar cells: an emerging photovoltaic technology." *Materials today* 18, no. 2 (2015): 65-72.

