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A SHORT REVIEW ON DEVELOPMENT AND WORKING OF SOLAR PV CELL

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Abstract:

The population of the world is increasing rapidly and also facing massive energy and pollution problems. Solar energy is the most desirable renewable energy resource to fight with the energy and pollution problem in the world simultaneously. The solar photovoltaic (PV) is way of utilising solar radiation to produce electricity without carbon dioxide emission. Monocrystalline silicon, thin-film technology, polycrystalline silicon, and nanomaterials are the most often utilised materials in the manufacture of solar cells. These materials were chosen because they are all in production or will be in production within the next few years. Effective photovoltaic implementation is examined, with an emphasis on semiconductor attributes and total solar system layout.

Introduction:

A clean method of producing electricity directly from solar radiation is solar photovoltaic (PV) technology. Less than 23% conversion efficiencies characterise the currently available PV technologies, highlighting the need for future advancements to maintain improved competitiveness [4]. PV system efficiency are affected by a number of factors, and certain conditions must be followed in order to run as efficiently as possible. The most significant influencing factors in weather are solar radiation, ambient temperature, dust storms, and wind speed. Increased cell temperatures lower the power output of PV panels. Temperature augmentation, specifically, impacts the open-circuit voltage, leading in decreased efficiency at higher temperatures [2]. Solar cell is composed of semiconductor materials like silicon. A typical silicon PV cell is composed of a thin wafer consisting of an ultra-thin layer of phosphorus-dope silicon on top of a thicker layer of boron-doped silicon. Solar radiation consists of range of particles, classified based on wavelength(frequency).

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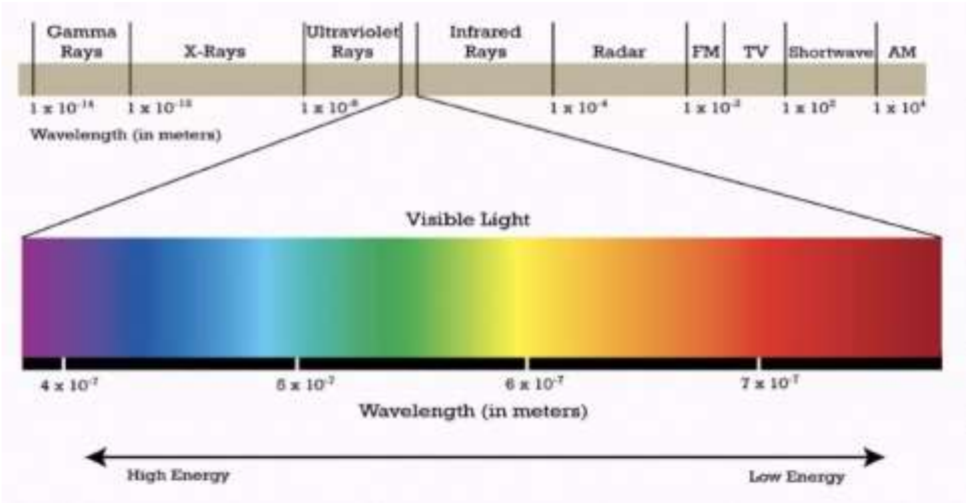

Fig. 1. Wavelength of different rays [4]

Working of PV cell:

When sunlight shines on the cell, photons bombarded the upper surface then photons give up their energy down through the cell. These photons give up their energy to electrons in the lower p-type layer. The electrons use this energy to jump across the barrier into the upper, n-type layer and escape out into the circuit. Then finally flowing around the circuit, the electrons make the lamp light up.

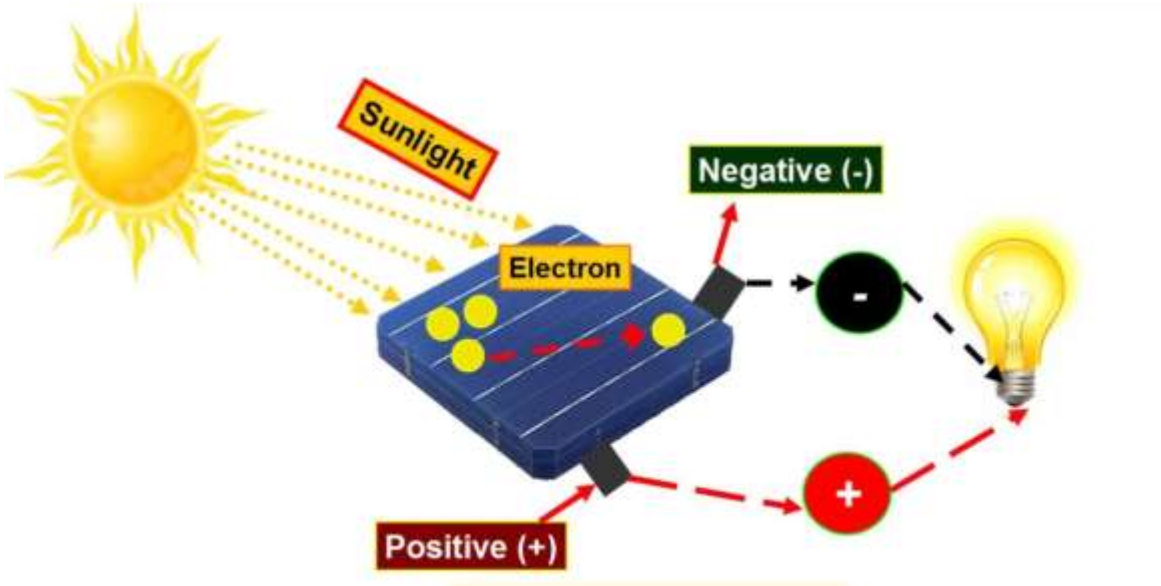

Fig. 2. Working process of solar PV cell [2]

Review on solar PV cell:

Many research and development projects have been conducted. Making a Silicon thin film solar cells for a parabolic trough hybrid solar PV-T collector. Thermal and photovoltaic automations are combined to create a photovoltaic hybrid technology. Photovoltaic hybrid automations may be expanded by design spontaneity, design zone expansion, and structure exergy outcome expansion. The electrical efficiency of the PV-T hybrid system experiment was determined to be 14.93%, and the average thermal temperature difference detected was 11.40F[1]. Photovoltaic (PV) solar applications, Challenges, possibilities, and future views. Rural electricity, communication repeaters, oil pipeline cathodic protection, and water pumping are commonly used areas of solar PV cell. Soil deposition, environment temperature, population growth in the country will increase power consumption, resulting in the activation of industrial, building, and agricultural expansion projects and Electricity losses during transport using wires. The incremental adoption of smart meters to motivate households to use green energy system. Solar energy is the ideal choice for future power generation due to its constant access to sunshine, silent operation, cheap maintenance costs, independence from fuel sources, ecologically favourable working conditions, and contribution to reducing carbon emissions [2]. Examining the effects of solar temperature and insolation on PV cell properties. As solar radiation increases, photon current rises, increasing output power and therefore efficiency. Temperature increases reduce output voltage by 2.2 mV, useable power by 0.45, and efficiency by 0.06[3]. Important considerations for employing PV cells in solar-powered aircrafts. To achieve a high endurance flight, an effective and lightweight MPPT (maximum power point tracker) device must be designed to combine voltage and current for maximum power [4].

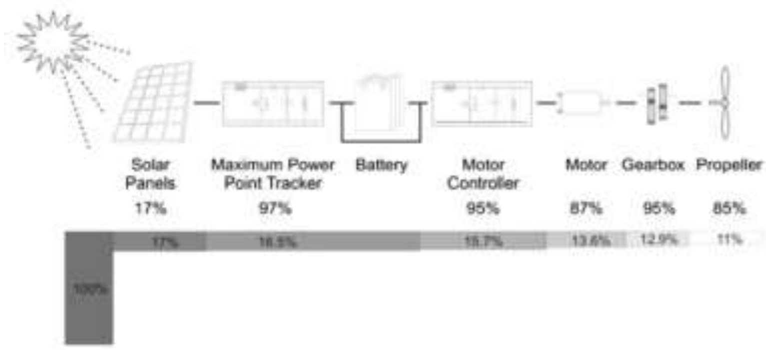

Fig. 3. Energy conversion process in solar-powered aircrafts [4]

Research and development in solar PV technology and materials. Research for making PV cells with different materials like polycrystalline, GaAs (Gallium arsenide), Amorphous silicon, graphene and etc and developing of existing PV technology with nanotechnology is the present status of PV technology. The Carbon Nanotubes (CNT), Quantum dots and Hot carries solar cell are also implementing new technologies for making solar PV panels for more efficiency with less cost [5][6]. The influence of improved technology advancements on the value chain of solar PV. Advanced material manufacturing technologies like Passivated emitter and rear cell (PERC), Hybrid solar cells, Perovskite solar cells and advanced module manufacturing technologies like Bifacial solar cell modules, solar shingle modules, Modules with Multi-busbars are focused to develop for high efficiency of solar PV cell with less emissions [7]. PEM hydrogen fuel cell and solar PV cell hybrid model analysis. Proton Exchange Membrane Fuel Cells (PEMFC) employs hydrogen and air to supply electricity and water through electro chemical reactions. On the other hand, solar photovoltaic cells are playing significant role in energy production with its dominating and eco-friendly characteristics. The solar photovoltaic cell and Fuel cell model were first simulated separately and combined analysis were carried out using MATLAB Simulink. The developed hybrid model was validated and its power output was more efficient than individuals with continuous energy production [8]. Using power production data to determine solar cell characteristics and degradation rates. A variety of heuristic techniques, including as particle swarm optimization, genetic algorithms, and teaching-learning-based optimization, have been used to extract solar cell characteristics and model IV curves to understand PV deterioration [9]. Dust influence on on-grid linked PV system performance: An energy nexus perspective. Software called Monitoring-Solar Edge was used to measure the power production for the PV panel and the production difference between the automated cleaned panels and the uncleaned modules was compared. Due to leaving the solar panels for weeks, months, years without cleaning leads to reduction of power drop by 9.9% and average of 2.33% per month. The panels were cleaned with water by activating the automated cleaning system on the specified panels [10]. Grid-connected solar PV system based on carbon-based DYE sensitised solar cells. The primary advantage of employing carbon-based DSSC is lower material and production costs, which increases ultimate efficiency. MATLAB is used for modelling the DSSC [11].

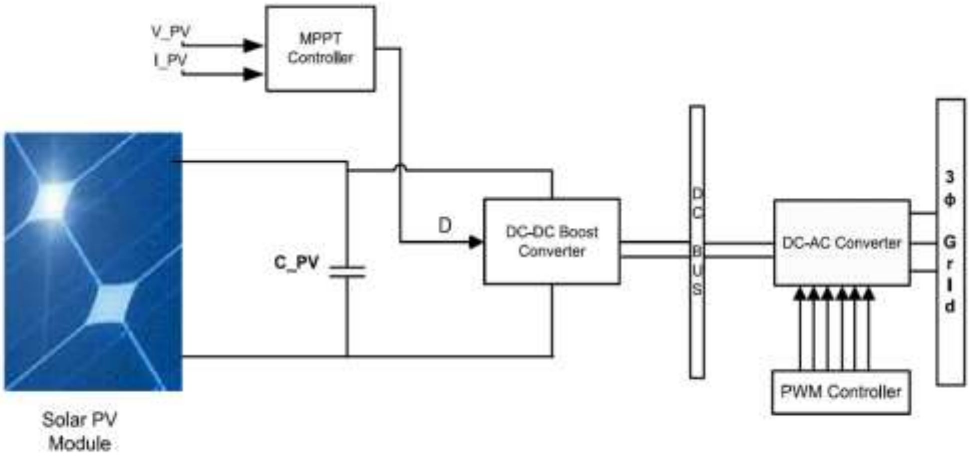

Fig.4. System configuration of Electricity generation from Solar PV cell [11].

Strategies for the circular economy as catalysts for the use of solar power in organisational market sectors. Lower energy costs, independence, and assured availability to energy are more crucial factors for organisational market segments for investing in circular solar PV than its renewable or green aspects. The PSS (product service system) model is seen as a fundamental prerequisite for opting for PV reuse since it includes aspects such as lowering the risk of maintenance and repair, as well as incentives to improve PV system size, performance, and end-of-life processing [12]. Choosing the best sites for solar PV installations by combining data envelopment analysis with Random Forest. First, the technical efficiencies of solar PV plants are calculated using the Data Envelopment Analysis (DEA). The impacts of environmental factors on the projected efficiencies are then calculated using a truncated regression model. Finally, the extremely adaptable Random Forest is utilised to estimate the effectiveness of new locations to choose the best place to implant the plant [13]. Analysing the environmental effect of monocrystalline silicon solar photovoltaic cell manufacture. The life cycle assessment (LCA) method is an efficient method that is used for analysing the environmental impact of a product by detecting and measuring the effect of utilised material and energy flows, as well as pollutants discharged into the environment by the monocrystalline silicon solar PV [14]. The usage of a hybrid photovoltaic/thermal (PV/T) collector system as a sustainable energy-harvesting instrument in urban technology. Increase in temperature reduces the efficiency of PV cells. In order to reduce temperature PVT cooling method is used which ultimately absorbs heat of fluid resulting increase in efficiency of PV cell in urban. All this modelling was carried out firstly in ANSYS software for better simulation [15]. Standards for solar PV network installation and cost calculation for smart cities. IEC TC82 has five working committees and almost 80 photovoltaic standards. For required safety standards, 'Quality and Standards' must be technologically improved and updated, to educate stakeholders about standards for more dependable PV system design by conforming to the standards [16]. Placement and size of solar PV and wind installations in trolleybus networks. Six distinct approaches were simulated and evaluated based on direct RES (Renewable Energy Sources) consumption and direct load coverage of their proposed RES systems for solar PV and wind placement and size. Finally, scenario VI's Centralized (Aggregated) Energy-Neutral Wind and PV Approach produces the best results, with a hybrid solution of 53% PV and 47% Wind [17]. Thermal management strategies are being tested in order to improve the efficiencies and levelized cost of energy of solar PV modules. The phase change material (PCM) serves as a thermal management medium as well as a heat capturing mechanism for meaningful heat gains that may be used to boost power production. Along with PCM, the ducted fin forced convection (DFFC) technology is employed for stable thermal management, which aids in maintaining stable temperatures and, as a result, increases the life of the PV panel. Apart from thermal management, it is very inexpensive [18]. Solar PV cleaning procedures that use multi-criteria decision-making (MCDM) help to achieve the Sustainable Development Goals (SDGs). To choose the optimum cleaning method, the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) was employed. The results indicated that hand cleaning is the best method, followed by automatic cleaning. The cleaning approaches had the greatest impact on SDGs relating to water and energy usage [19]. The effect of load coordination on the appropriate size of standalone PV systems with solar energy potential. There were four categories of loads considered: street lighting, residential, industrial, and irrigation. MATLAB software was used to simulate the study. The street-lighting load is a non-coordinated load. So, it had 19 kW and 41 batteries. Residential load is a sort of partial coordinated load (50 %). As a result, it had 18 kW and 30 batteries. A percentage of 65% is used to coordinate industrial load. As a result, it had 18 kW and 28 batteries. Because the irrigation load is 100% synchronised, it had 18 kW and 25 batteries [20]. A comparative study using an artificial neural network to evaluate PV/T solar energy generation. PV and PV/T system design and evaluation work is done using ANN. They tested three different ANN FFBP for estimating GSR. The first model used the maximum temperature as an input variable and used 24 hidden layers, which obtained an MSE of 0.0002823 and a MAPE of 10.3%. The second model used the mean temperature as an input variable and used 32 hidden layers, which obtained an MSE of 0.0052 and a MAPE of 111.8%. The third model used the mean temperature and mean relative humidity as an input variable and used 24 hidden layers, which obtained an MSE of 0.00003 and a MAPE of 4.49% [21]. Phase change materials' cooling properties for solar photovoltaic panels. The phase change material (PCM) may lower the average temperature of the centre point of the top surface of the PV panel by 33.94 °C and lower surface by 36.51 °C in less than 300 minutes under conditions of no wind, light irradiance of 1000 W/m^2, and beginning ambient temperature of 7.3 °C. The average maximum output power of the PV panel is improved by 1.35 W for 12 W PV panels due to the cooling effect of PCM, and the average maximum efficiency is enhanced by 1.63%. By lowering the solar PV panels' exposure to thermal stress, increases the lifetime of the devices [22]. Performance evaluation of a stand-alone integrated solar hydrogen energy system for zero-energy buildings. PV panels, a proton exchange membrane (PEM) electrolyser, a storage tank, a hydrogen gas tank, and a PEM fuel cell stack make up a stand-alone hybrid energy system that can provide all of the home's ongoing energy needs without tying into the grid [23].

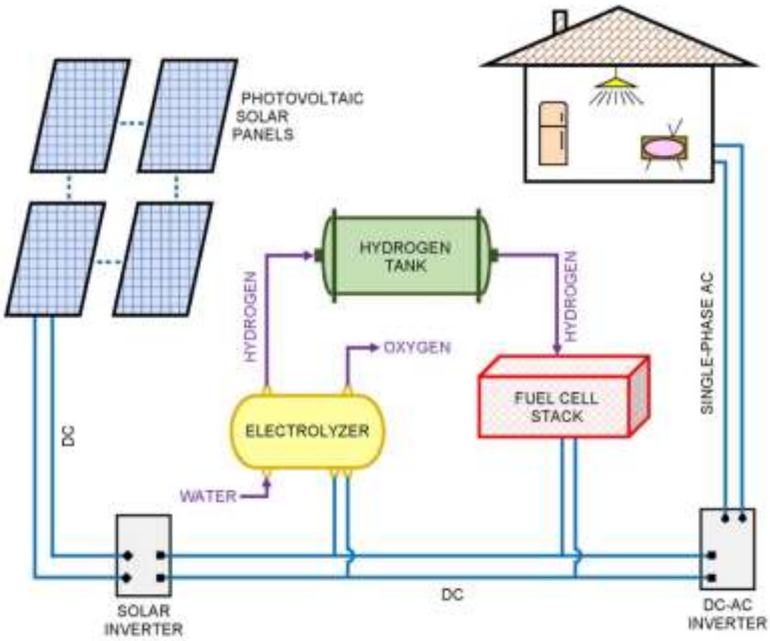

Fig.5. Schematic of solar hydrogen hybrid energy system [23].

Identification of the triple diode model's optimal parameters for solar photovoltaic cells and panels. Effective triple diode modelling will be done using a marine predator's algorithm (MPA) (TDM). The calculation of nine unnamed factors shows that the MPA achieves lower RMSE (root mean square error) than its competitors [24]. A water-based PV/T system design for cooling solar panels. The thermal behaviour of the photovoltaic module and the specified cooling box flow are connected to accomplish the water-based PV/T system's thermal and electrical conversion efficiency. The system's input temperature has a considerable effect on thermal efficiency since it leads to improved cooling. For different flow rates, the thermal efficiency climbs to roughly 7.5% [25]. Exergy analysis is used to conduct a techno-economic study of solar photovoltaic (PV) and solar photovoltaic thermal (PVT) systems. PVT technologies combine the functions of a traditional PV system with a solar thermal system into a single module, making them more efficient than traditional systems. Because of the incorporated thermal unit, PVT systems are more expensive than normal PV modules, necessitating a cost/benefit study to determine the limits of their practicability. The PV and PVT systems have total energy efficiency of 9.6% and 42.5%, respectively [26]. Performance evaluation of a solar PV module for various climatic classifications based on energy, exergy, economic, and environmental aspects. Photovoltaic systems will surely be considered as suitable, clean, safe, and cost-effective alternatives to fossil fuels. As the temperature rises in the summer, exergy and energy efficiency decrease. As a result, lowering the temperature leads to an improvement in photovoltaic module efficiency [27]. The influence of optical filters on the performance of a solar photovoltaic system was investigated experimentally. A Plexiglas sheet was attached to the top surface of the PV panel, along with a box filled with air and water. By including optical filters, the temperature of the module is reduced, hence increasing its efficiency. A reference PV module's average efficiency, a plexiglass-sheet-covered PV module's average efficiency, and a plexiglass-air-box-covered PV module's average efficiency are 7.02%, 7.5%, and 8.12%, respectively. In compared to the 6.66% average efficiency of the reference module, the covered PV module with plexiglass water box averages 6.74% [28]. Opportunities and difficulties for compound parabolic concentrators (CPC) in solar photovoltaic applications. 2D CPC troughs were most suited for ground and/or rooftop applications, whilst ACPCs and 3D CCPCs were better suited for building faced integration applications. However, the actual findings were found to be lower than predicted values due to various losses happening within the systems, such as optical losses, series resistance of linked cell losses, higher cell temperatures, and non-uniform illumination phenomena [29]. Rooftop solar Photovoltaic (PV) plant performance after one year. The PV system was placed on an inclined surface of 12^{o}. The energy generated by a 30kWp PV SPP (solar photovoltaic plant) was calculated to be 45,591.99 kWh. The PV plant's yearly average module, inverter, and system efficiency values were calculated to be 13.59%, 97.88%, and 13.29%, respectively. Furthermore, the system's performance ratio was determined to be 83.61%, with a capacity factor of 17.35% [30].

Conclusion:

Solar photovoltaic (PV) cells are an important energy-generation technology. Solar PV is getting more popular as the globe recognises the need to shift away from fossil fuels and towards sustainable energy sources. Solar PV has a huge potential. Solar PV is expected to become an ever more dominant source of energy as technology improves and costs fall. Advances in energy storage technologies will also enable solar PV to offer dependable, continuous electricity even when the sun isn't shining. As nations throughout the world try to reduce carbon emissions, solar PV is likely to play an increasingly crucial part in accomplishing these goals. Perovskite solar cells are a novel form of solar cell that uses perovskite materials to absorb sunlight and create power. Perovskite cells have demonstrated excellent efficiency in the lab, however they are still being researched and may have stability and durability challenges.

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