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Eco-Friendly Power Power Production, Understanding BIPV Systems and their Efficient Developments

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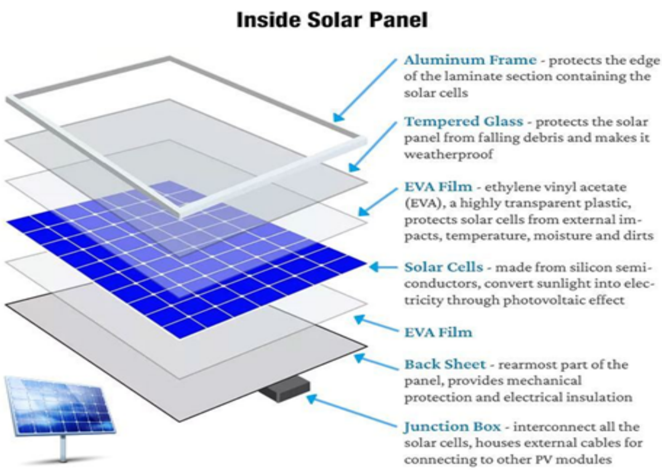
Abstract

In the world of over-used fossil-fuel energy resources, the rise of Renewable energy generation resources became more essential. Environmental pollution, green house effects, global warming etc. have created the urgent need of eco-friendly and energy-efficient energy sources. Solar energy, the most abundant form of renewable energy, is going to be the need for sustainable future. PV modules have electrical efficiency varies from 4% to 47%, depending on their operating temperature. BIPV systems are the one and only one efficient form to develop energy efficient building. It protects the façade and also increases the overall energy generation. By understanding the working of BIPV systems, the efficiency controlling parameters like, temperature, angle of installation, fog, dust etc. are taken care of. The most important factor is

Temperature, which reduces the overall efficiency as well as the life-span of the panels. Cooling techniques are researched to control the heat gain by the PV modules. The more efficient the cooling technique, the more productive will be the energy output. The overall growth of the nation depends on the efficient power generation, which can be easily achieved through BIPV systems.

Introduction of Bipv

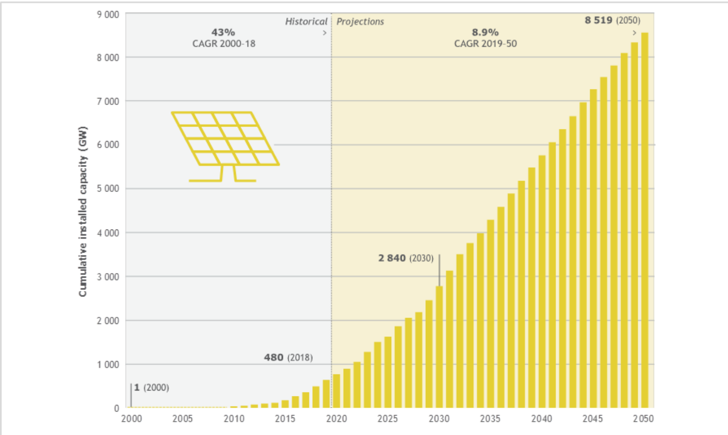


Solar energy may give the Earth with enough energy for a year's worth of use per hour [1]. Solar energy collecting and use via photovoltaic (PV) systems is one of the most promising ways for exploitation of renewable resources now in use. PV systems are one of the most promising renewable energy technologies for converting solar radiation to electricity, and their use is quickly growing. The integration of PV devices into façade systems as an exterior layer continues

to gain traction in the construction industry. BIPV systems have evolved into a functional and architectural component of the building envelope, altering its heat resistance and optical properties in the process. Active solar PV components, which are viewed as both a local power producer and a construction material in one, are replacing traditional building materials. Photovoltaic (PV) panels put on rooftops may generate power from solar energy without releasing greenhouse gases or taking up more space while in use. The system of integrating PV panels into the building exterior is known as BIPV (Building Integrated Photovoltaic Panels). BIPV applications were thoroughly vetted in the early stages of development, prior to 1996.BIPV applications were divided into 10 categories, including Facades, windows, skylights, and shading systems are all examples of rooftop uses. PV cells based on polycrystalline and amorphous silicon were primarily employed in these applications. [2].The components of PV module can be shown in Fig.1

Need of BIPV

Because of society's general development, economic expansion, automation, and modernization, energy demand has risen dramatically over the world [3,4]. The massive usage of fossil fuels is meeting the world's increasing electrical demand (the primary source of electricity generation). It triggered bioclimatic changes such ice melting at the north and south poles, ozone depletion, and global warming [5,6]. The rapid consumption of fossil fuels has restricted their availability from the earth's crust, igniting a global movement toward renewable energy sources. Solar energy has a significant advantage over other traditional power producers in that sunlight can be directly converted into solar energy using small and tiny photovoltaic (PV) solar cells. Photovoltaic technology is used to address issues such as greenhouse gas emissions and climate change. Solar energy is also safe, environmentally friendly, and appropriate. Energy scarcity and pollution have become more major issues, causing a surge in interest in solar photovoltaic energy throughout the world [7].



Above figure shows the prediction by the IRENA, for the cumulative installed capacity of PV panels by 2050

As a result, the Indian government is concentrating its efforts on improving access to the power grid and ensuring that electricity is available 24 hours a day, seven days a week. In India, rising incomes, new infrastructure and services, and changing lifestyles are all helping to boost per capita electrical energy consumption. [**8**]. Over the last decade, India has seen consistent economic growth. The electricity industry is one of the fastest-growing sectors. [**9**]. India will need to increase its installed solar PV capacity to fulfil its present and future energy needs.

BIPVs are photovoltaic modules that may be utilized as coverings, peaks, and other architectural components in

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addition to generating power. As a result, two notions must be differentiated:

1. BIPV (Building Integrated Photovoltaics) are photovoltaic modules that can be thought of as additions to a home's construction. They are put together after a building's erection is complete, and they provide the fundamental and exclusive function of generating electricity by converting solar energy. They may be disassembled at any time, and there will be no loss of integrity or building reliability. Roof solar power stations, which are constructed over the primary roof covering, are the simplest and most common type of BIPV.
2. BIPV (Building-Integrated Photovoltaics): solar modules are integrated into a building and perform the same functions as those elements into which panels are built-in; BIPV-elements protect a house from moisture, wind, and improve thermal and acoustic proofing while also acting as solar panels, generating electricity. Their installation is planned at the architectural design stage, and their removal is only conceivable if similar construction materials are substituted.

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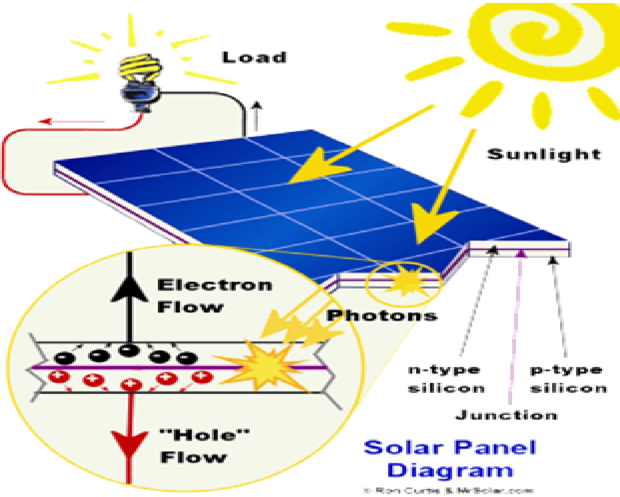
Working of PV module



Photovoltaic solar cells, as previously defined, are thin silicon wafers that convert sunlight energy into electrical Energy. The idea of electron hole production in each cell made of two separate layers (p-type and n-type materials) of a semiconductor material underpins contemporary photovoltaic technology. When a photon with sufficient energy strikes the p-type and n-type junction in this structure, an electron is released and goes from one layer to the next by acquiring energy from the impacting photon. This generates electrical power by generating an electron and a hole in the process.

Fig.2 represents the working of PV module

Types of PV module

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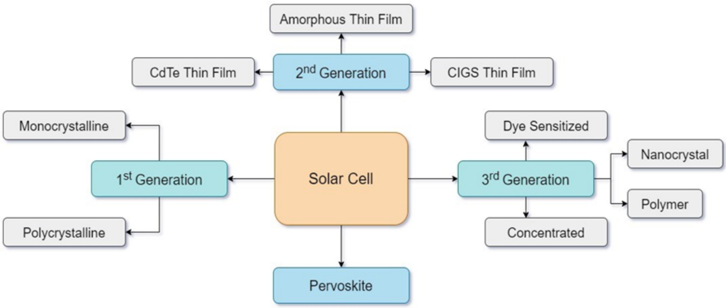

1. First generation of PV panels: Due to their great power efficiency, it is the most common and oldest technology. In terms of technology and fabrication method, these generations of cells are well-developed. Crystallized silicon (c-Si) or GaAs wafers are commonly used. Classification: crystalline mono and poly.
2. Second generation of PV panels: When compared to earlier first generation silicon wafer solar cells, thin-film cells are the most cost-effective. A-Si, CdTe, and CIGS are the three classifications.
3. Third generation of PV panels: These are photovoltaic modules that are still being studied. These are cutting-edge technologies that aren't yet on the market. Solar cells based on nanocrystals, polymers, dye sensitized solar cells, and concentrated solar cells are divided into four categories.
4. Perovskite: ABX3 (A & B are cations of various sizes) defines a compound class. (Halogen is denoted by the letter X.) The most up-to-date PV research material. Solar cells made on perovskite can achieve a 31 percent efficiency.

Efficiency of PV module

Despite its many benefits, this energy is not without its drawbacks. Solar energy does not radiate at night, for starters. Second, the amount of solar energy available is nearly never consistent. Furthermore, in addition to daily variations in the strength of radiant radiation, solar energy is hampered from reaching the earth during severe weather. Solar energy must be stored somewhere else at night to avoid these drawbacks of this technology, and extremely efficient solar cells and modules must be produced.

The efficiency of solar PV modules is referred to as photovoltaic conversion efficiency, which is defined as the proportion of the Sun's energy that can be transformed into electricity. Solar panels are made up of a large number of microscopic solar cells that are placed in a specific geometrical pattern to produce a specific quantity of power. Solar energy storage is still a work in progress. Solar panels now have a radiation efficiency of up to 22%.

In the current circumstance, however, a select group of materials may be arbitrarily classified into several efficiency regimes:

1. Multijunction tandem cells employing semiconductors such as GaAs and GaInP2 are commonly used to create ultrahigh-efficiency devices (>30 percent).
2. High-efficiency cells (>20 percent) are often made with high-quality single-crystal silicon materials in innovative device designs that take use of microelectronic technology advancements.
3. Polycrystalline silicon,amorphous and microcrystalline silicon, copper gallium indium selenide (CIGS), and cadmium telluride are examples of polycrystalline and amorphous thin-film semiconductor materials that have high efficiency (=12 percent to 20 percent)

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(CdTe)

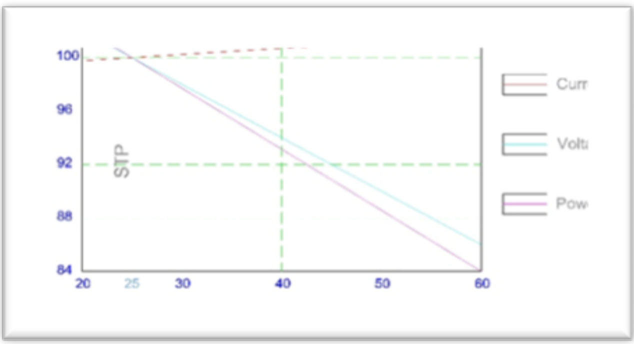
4. Cells with a moderate efficiency (12%), such as dye-sensitized nanostructures TiO2 solar cells, are indicative of several of the newer materials.

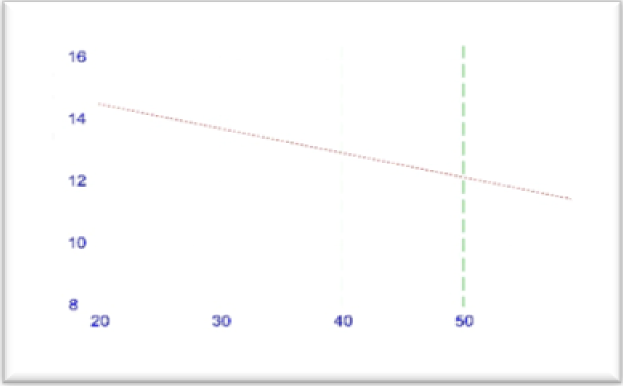
Factors affecting the efficiency of PV module

The main factors affecting the overall efficiency of the Photovoltaic modules are :

1. Accumulation of dust on photovoltaic (PV) modules.
2. Even in deserts, high humidity can cause capillary adhesion between particles and surfaces, resulting in particle-surface capillary adhesion.
3. Soiling - Debris that collects on the surface of PV panels can prevent light from reaching the solar cells, limiting the amount of energy generated.
4. Shading - As previously stated, shading is the blocking of irradiance by trees, buildings, topography, and other objects in the environment. Inverter efficiency and age of the panel also contributes a lot to decrease the efficiency of the PV cells.
5. The most important factor that affects the performance of the Photovoltaic cells is Temperature.

Temperature





Basic phenomena of PV modules is based on the displacement of an electron present in the lattice structure of a PC module's atom. As the photon from solar radiation strikes the surface of PV panels, the energy of that proton should be equal to the Bandgap Energy. Electrons gain this energy to jump out of the lattice producing an electric charge. These minute charges contribute to the overall current generation.

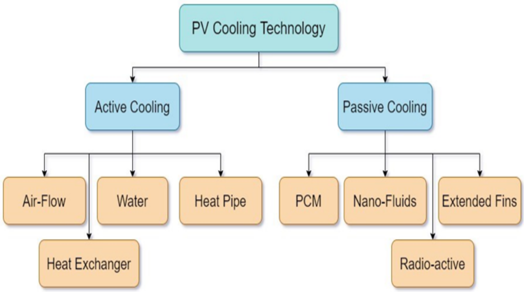
But as the radiation increases, the photons strike in large numbers on the surface of the panel, increasing its surface temperature. As photons create more holes but the quantity of electrons is limited. So the efficiency decreases. And if this remains continued for a longer period of time, the life-span also suffers adversely.

The electrical performance of PV panels diminishes as the temperature rises, as shown in the two graphs below. With increasing temperature, electrical performance measures such as open-circuit voltage, PV panel power, and fill factor decrease.

The high temperature of PV panels degrades their lifespan and efficiency.

Relation of temperature with Power of the panel

Cooling Techniques



PV cells capture 80% of incoming solar light but do not convert it completely to electricity. The PV cell technology employed determines the conversion efficiency. The remaining solar energy raises the temperature of solar cells to up to 40 degrees Celsius above ambient.

Under optimum working circumstances, the conversion efficiency of single junction solar cells ranges from 6% to 25%, depending on the semiconductor material used in the solar cell's production

Air cooling, water cooling, heat pipe utilisation, phase change materials, and thermoelectric cooling are all options for regulating the temperature of solar panels.

Active Cooling Techniques:

1. **Air-Flow:** Vent pipe is passed behind the PV panel to direct the flow of air . As cool air passes into the pipe, it

cools down the PV module.

2. **Water:** Tube is run through-out the panel at the back-side, and cold water is pressurized from one end to the other, to cool down the temperature of the panel.
3. **Heat-Exchanger**: At the rear side of the panel, a coil is placed, which allows the coolant to flow the coil and reduces the overall temperature.

Passive Cooling Techniques

PCM: Phase change materials are used to place behind the panel. As the temperature rises, the PCM changes its phase and absorbs the heat from the module and reduces the temperature of the overall panel.

Nano-Fluids: fluids containing engineered colloidal suspensions of nano-particles. Very effective to cool down the PV panels

Conclusion

In today's polluted and degrading world, there is a need for sustainable and clean energy. Out of all renewable energy sources, Solar energy is the most appropriate, as Sunlight is most abundant and accessible to each part of the world.

PV panels are discussed, their innovative methods to integrate themselves with the building envelope, their benefits and limitations, their types and efficiencies are reviewed. BIPV systems are the need of the sustainable future, as it provides dual benefits, protects the façade, building amenities as well as increases the energy generation output for the building unit.

The factors affecting BIPV performances and the methods to resolve them are studied.

There is the scope for development in BIPV systems as new and innovative PV panels are under research, their functions are more advanced than these primitive cells, their efficiency, conversion factor, life-span etc. factors are also being upgraded.

Innovative methodologies for cooling the PV panels have been introduced, but mostly are in the research phase.

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