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A Review on Solar Photovoltaics and Roof Top Application of It.

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Abstract - *'Energy crisis' and 'Energy security' has been continuously in news since the first oil crisis in 1973. The worries for environmental impacts due to fossil fuel based power generation also are a matter of concern now for quite some time [1]. In spite of endeavors to promote renewable sources of energy, the fossil fuel based power generation continues to dominate the market. Since power generated from coal is more affordable and available to consumers than any other fossil fuel new power plants are being built to perform at "supercritical" and "ultra-supercritical" conditions of temperature and pressure, increasing electricity generation efficiency from average 30% to 50% or higher. These new coal technologies are encouraging a continuous use of coal for electricity generation and other purposes, making it difficult for renewable energies to become a significant component of energy mix. To keep pace with the growing energy demands and as a National Action Plan for Climate Change (NAPCC), there is a need to switch from conventional to non-conventional source of energy. And solar energy is the most abundant permanent energy source available to use in direct form. In this paper the focus is laid on the solar photovoltaic technology of power generation and review of the roof top application of it.*

Keywords- *Solar Photo Voltaic, renewable energy, roof top SPV, non-conventional sources of energy, solar energy*

I. INTRODUCTION

Solar energy intercepted by earth from sun is approximately $1.8X10^{11}$ MW which is much more than the present consumption rate [1]. So the solar energy can meet all the present and future demands of energy on a continuing basis thus proving it to be one of the most reliable energy sources. It is also a clean source of energy. Solar energy has enormous potential in India. The country has on an average three hundred sunny days per year and receives an average hourly radiation of 200 MW/km ^{2}.[2] The Jawaharlal Nehru National Solar Mission (JNNSM) has given a significant boost to the industry by setting up a feed-in-tariff regime and drafting clear regulation [3]. The Mission has set an objective of building 20GW of solar PV and CSP power capacity in the next decade. Various state governments, such as Gujarat or Rajasthan also offer policies to boost solar energy production in the coming decade.

A broad classification of various methods of solar energy utilization is given in fig. 1

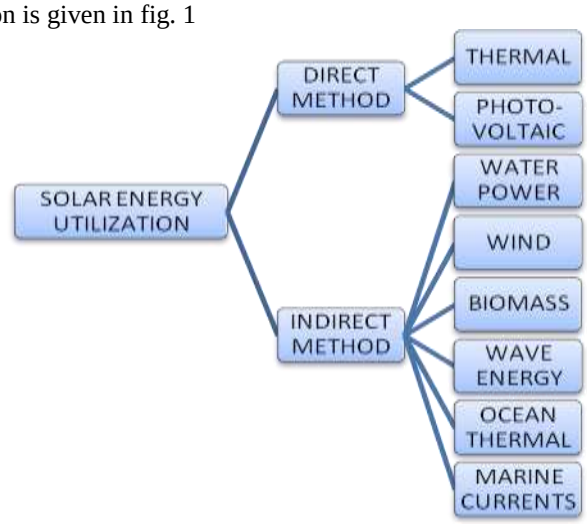

Fig. 1. Classification of methods of solar energy utilization

II. PHOTO VOLTAIC TECHNOLOGY

Photovoltaic (PV) cells also called as solar cells are made of special materials called semiconductors like silicon, which is currently the most commonly used. Basically, when light shines on the solar cell a percentage of this solar energy is absorbed into the semiconductor material. This energy now inside the semiconductor knocks electrons loose allowing them to flow freely. This flow of electrons is an electrical current. This current, combined with the cell's voltage (which is a result of its built-in electric field or fields), determines the power (or wattage) that the solar cell can produce [4]. In fig. 2 the classification of PV technologies is shown.

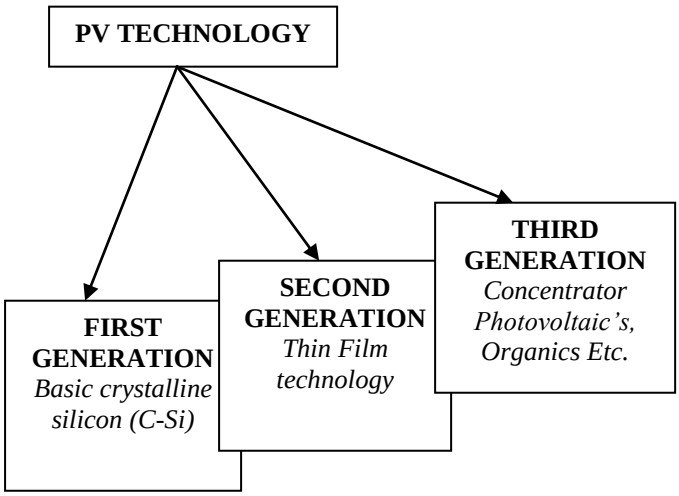

Fig. 2. Classification of PV technologies

2.1. Crystalline silicon

First Generation Solar Cells is the oldest and the mostly common used technology type due to high efficiencies. First generation solar cells are produced on wafers. Each wafer

can supply 2-3 watt power. To increase power, solar modules, which consist of many cells, are used. As seen in the list, generally there are two types of first generation solar cells. They differ by their crystallization levels. If the whole wafer is only one crystal, it is called single crystal solar cell. If wafer consist of crystal grains, it is called multicrystal solar cell. Anyone can see the boundaries between grains on the solar cell. Although efficiency of mono crystal solar cells is higher than multicrystal solar cells, production of multicrystal wafer is easier and cheaper. So they are competitive with monocrystals [5].

2.2. Thin film

Second Generation Solar Cells are thin film solar cells. Despite their efficiencies are less than 1st generation, their costs are also less than 1st generation. In addition they have an advantage in visual aesthetic. Since there is no fingers in front of the thin film solar cells for metallization, they are much more applicable on windows, cars, building integrations etc. These thin films can also be grown on flexible substrates. So second generation solar cells are applicable on textile products or on foldable devices. As an advantage of thin film solar cells, they can be growth on large areas up to 6 m2. However wafer based solar cell can be only produced on wafer dimensions. The second generation solar cells include amorphous Si (a-Si) based thin films solar cells, Cadmium Telluride/Cadmium Sulfide (CdTe/CdS) solar cells and Copper Indium Gallium Selenide (CIGS) solar cells [5].

2.3. Concentrator PV

Third Generation Solar Cells are novel technologies which are promising but not commercially proven yet. Most developed 3rd generation solar cell types are dye sensitized and concentrated solar cell. Dye sensitized solar cells are based on dye molecules between electrodes. Electron hole pairs occur in dye molecules and transported through TiO2 nanoparticles. Although their efficiency is very low, their cost is also very low. Their production is easy with respect to other technologies. Dye sensitized solar cells can have variable colors. Concentrated PV solar cell is another promising technology. Main principle of concentrated cells is to concentrate large amount of solar radiation on to a small region where the PV cell is located. The amount of semiconductor material, which might be very expensive, is reduced in this way. In this system a perfect optical system should be integrated. Concentration levels starts from 10 sun to thousands suns. So, total cost can be lower than conventional systems. CPV s are promising technologies for near future [5].

III. SALIENT FEATURES SPV

The solar photo voltaic cells posses the following salient features:

1. No fuel is involved to generate power.
2. Solar radiation is available in abundant and is free.
3. It is environmental friendly.
4. It can be installed in dry areas.
5. Solar panels or modules are silent, without any moving parts
6. A solar module should last for at least 20–30 years.
7. Solar modules can be integrated into the building in the form of windows, walls, roof tiles or pergolas
8. Solar electricity can be fed into the grid
9. Additional solar modules can be added later as demand or budget grows.

IV. ROOF TOP SPV SYSTEM

A Rooftop photovoltaic is a system which uses one or more photovoltaic panels, installed on rooftops of residential or commercial buildings, to convert sunlight into electricity. The various components in a rooftop photovoltaic power station include photovoltaic modules, mounting systems, cables, solar inverters and other electrical accessories.

The urban environment provides a large amount of empty rooftop spaces and can inherently avoid the potential land use and environmental concerns. Estimating rooftop solar insolation is a multi-faceted process, as insolation values in rooftops are impacted by the following:

1. Time of the year
2. Weather conditions
3. Shading from adjacent buildings
4. Shading from overhanging vegetation
5. Roof slope and aspect
6. Shading from adjacent buildings and trees

An average home has more than enough roof area for the necessary number of solar panels to produce enough solar electricity to supply all of its power needs. Solar panel arrays can be sized to meet the domestic electrical loads by converting DC current generated by solar panels into AC currents by using suitable inverters. For obtaining high power, multiple panels can be arranged in series and parallel circuits on a panel (module) area of several square feet. The solar array is defined as a group of several modules electrically connected in series- parallel combinations to generate the required current and voltage.

With the downward trend in the cost of solar energy and appreciation for the need for development of solar power, many solar power projects have recently been implemented. A significant part of the large potential of solar energy in the country could be developed by promoting grid connected solar photovoltaic power systems of varying sizes as per the need and affordability coupled with ensuring adequate return on investment.

There are two types of roof top SPV systems: stand-alone system and grid connected system [6].

4.1. Stand-alone roof top solar photovoltaic systems

Stand-alone roof top solar photovoltaic systems do not have a connection to an electricity grid. They can have capacity ranging from milliwatts to several kilowatts. The main components of this system are: solar modules, charge controller, battery and inverter. The solar modules are mounted on a mount structure and the DC power they

produce is channeled through a charge controller to charge the battery where it is stored. The two main functions of a charge controller are to prevent the battery from being overcharged and eliminate any reverse current flow from the batteries back to the solar modules at night. The battery bank stores the energy produced by the solar array during the day for use at anytime of the day or night. The inverter takes the DC energy stored in the battery bank and inverts it to 120 or 240 VAC to run your AC appliances.

4.2. Grid-connected solar photo voltaic systems

Grid-connected solar photo voltaic systems are connected to the public electricity grid via a suitable inverter because a PV module delivers only dc power. Normally there are almost no effects of the PV systems on the grid affecting power quality, load-on lines, and transformers, etc. However, for a larger share of PV in low- voltage grids, as in solar settlements, these aspects need to be taken into account. From a technical point of view, there will be no difficulty in integrating as much PV into low- voltage grids as the peak load of the respective segment decentralized grid-connected PV systems, central grid-connected PV systems .Decentralized grid-connected PV systems have mostly a small power range and are installed on the roof of buildings (flat-roof installation) or integrated into building facades Central grid-connected PV systems have an installed power up to the MW range. With such central photovoltaic power stations it is possible to feed directly into the medium or high voltage grid [7].

4.3. Benefits Comparison

Pros and cons of Stand-alone roof top solar photovoltaic systems:

Pros:

1. Ideal for remote places where power is expensive to bring in.
2. No power bills.
3. No power outages.
4. Self sufficiency on a clean, renewable energy source.

Cons:

1. Batteries and generator are expensive and require maintenance.
2. Lifetime for the batteries and generator (10 – 15 years) is less than for the solar array (35+ years).
3. Batteries can only store power for a few days and have a maximum capacity. When they are full, the rest of the power is wasted unless you can find an immediate use for it.
4. Power use must be carefully planned

Pros and Cons of Grid-connected solar photo voltaic systems:

Pros:

1. Easy backup from grid power.
2. Eliminates need for expensive batteries and generator (which also requires fuel).
3. Provides seasonal storage if a net metering or Feed-in Tariff program is available.
4. Maintenance free for a solar power system.
5. Internet monitoring available with inverters designed to be used for individual solar panels**.**
6. You are providing clean energy to the grid.

Cons:

1. Power outages when utility power goes out your system also goes out unless you invest in a battery bank. This is a requirement by the utility company and is for the safety of those repairing the system.
2. You still have to pay the basic utility bill, just not for whatever power you've produced.
3. You are still using non-renewable resources when there is no solar.

V. COMPARISON BETWEEN ROOFTOP SOLAR AND LARGE GROUND MOUNTED SOLAR PLANTS

Advantages

1. Large Solar Farms have to go through a myriad of regulations and clearances which the roof top systems don't have to face.
2. Grid Connection leads to additional costs for solar farms while rooftop solar can use existing transmission infrastructure
3. A Large Part of roof top Solar is consumed locally while Farms supply 100% to the grid. That makes managing the grid difficult when solar penetration increases

Disadvantages

1. The greater scale of these plants allows lower installation costs compared to smaller installations. The costs are reduced in permitting, maintenance as well.
2. Solar Farms can be built on waste lands like in Germany where they have been built on former airbases.
3. Large Solar Farms are controlled by utilities or IPPs while rooftop solar is generally in the ownership of residential owners or commercial owners. This results in less pushback from utilities which generally control transmission and allow easier acceptance of solar energy.

VI. TECHNICAL ISSUES

1. The efficiency constraint: 4% to 12% (for thin film) and under 22% (for crystalline) in the current market.
2. Performance limitations of BOS components such as batteries, inverters and other power conditioning equipments.
3. Silicon supply: strong demand for PV outpaced the supply and partly stalled the growth of solar sector.

4. Cadmium and tellurium supply for certain thin film cells: these two components are by-products from respectively the zinc mining and copper processing and their availability depends on the evolution of these industries.

VII. CONCLUSION

To promote solar rooftop for household use government need to provide economic help to the consumers. Promotion of solar rooftop by the government of India can be done by two ways:

1) Subsidy in Capital cost
2) Generation based Incentive

Solar power enhances the renewable energy in the country, so for its promotion government should provide some incentive to promote use of solar power in urban areas. This promotion will also help in reducing green house gases emission.

Capital cost of solar rooftop is currently high enough to be opted by a normal household. A household will go for solar rooftop only if they have been given certain advantages. It can be promoted as Government of India provide certain subsidy for a fixed capacity say 5KW and Excess power generated can be send to grid against which a fixed amount will be given.

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