Solar Energy – The Solution of Energy Crisis

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***Abstract*- At present the use of fossil fuel: Coal, oil and gas, the conventional energy sources is increasing rapidly and are limited to quantity. If they will be used at present rate, they will be exhausted in near future and will lead to its shortage. During its different types of uses, greenhouse gases are emitted in the atmospheres that cause greenhouse effect which will lead to global warming and climate change. Due to shortage of fossil fuel, its price rises and so it is difficult to maintain economical growth. So it is an immediate need to switch over a better, cheap and eco-friendly energy resource.**

Solar energy is a clean, climate friendly and abundant energy resource for mankind. The cost for solar energy production is falling rapidly which helps in fulfilling increasing demands. It helps to keep environment clean and safe. It is available at local level which reduces the loss due to transmission. So solar energy is a good alternative for conventional energy sources.

INTRODUCTION

Energy is a basic need for mankind. The demand for energy increased enormously in the recent years due to growing population and industrial development. Today major part of energy is obtained from conventional sources: coal, oil and gas. These fossil fuels are obtained from earth and are limited in quantity and are available at particular areas. Due to increased demand and limited stock it results energy crisis. So prices of coal, oil and gas increases and that threaten the economical and national security.

Shortage of fossil fuel supply, land acquisition and environmental clearance problem, radiation hazards due to nuclear power plants, all above reasons lead to a energy source which will be easy to install, cheap, clean and non polluted. Renewable energy sources have huge potential to provide energy crisis and to overcome above mentioned issues. The renewable resources are Solar - wind – water. Due to limited applicability, expensive installation, manufacturing and maintaining cost for wind energy and hydro energy, solar energy is a best alternative resource in renewable energy in our country. Solar energy the energy from sunlight has been used in many different ways for thousands of years by people all over the world. Besides its traditional uses in heating, cooking, and drying, it is also used today to generate electricity where other power sources are absent, such as in remote places and in space. Sunlight is available at major part of our country and input of solar radiation has much more energy than total energy consumption of the world. The cost for solar energy production have been falling rapidly and solar thermal energy and solar photovoltaic energy are becoming competitive with generation of conventional energy. Solar photovoltaic energy generated by rooftop in urban as well as in rural area can competitive with increasing prices of conventional energy.

Solar radiation reaches the Earth's upper atmosphere with the power of 1366 watts per square meter (W/m2). Due to curvature of Earth surface, the surface nearer its poles receives much less solar energy than the surface nearer the equator. After passing through the Earth's atmosphere, most of the Solar energy is in the form of visible light and infrared light radiation. Plants convert the energy from sunlight into chemical energy through photosynthesis process. Living beings are regularly using this energy in various ways, like burning of wood or fossil fuels, or while taking vegetarian or non-vegetarian food.

SOLAR ENERGY EARLIER DEVELOPMENT

The early development of solar technologies starting in the 1860s, it was believed that the mass of coal in the surface of earth is very less it would be expected that coal would soon become scarce. In 1884 Charles Fritts installed the world's first rooftop photovoltaic solar array, using 1%-efficient selenium cells on a roof of New York City. In the early 20th century development of solar technologies stagnated in the face of the increasing availability, economy, and utility of coal and petroleum. The 1973 oil embargo and 1979 energy crisis lead to reorganization of energy policies around the world and brought

attention to develop solar technologies. Deployment strategies focused on incentive programs such as the Federal Photovoltaic Utilization Program in the US and the Sunshine Program in Japan. Other efforts included the formation of research facilities in the United States (NREL), Japan (NEDO), and Germany (Fraunhofer–ISE). Installations of Photovoltaic systems grew rapidly between 1970 and 1983, but falling oil prices in the early 1980s moderated the growth of photovoltaic from 1984 to 1996.

Due to supply issues of oil and natural gas, global warming concerns and the improving economic position of PV relative to other energy technologies, In the middle 0f 1990s development of residential and commercial rooftop solar as well as utility-scale photovoltaic power stations began to accelerate again. In the early 2000s, the adoption of feed-in tariffs and a policy mechanism gives renewable priority on the grid and defines a fixed price for the generated electricity—lead to a high level of investment security and to a soaring number of PV deployments in Europe.

For several years, worldwide growth of solar PV was driven by European deployment but it has been shifted to Asia, especially China and Japan and also to a growing number of countries and regions all over the world. The average growth of photovoltaic has been 40% per year from 2000 to 2013 and total installed capacity reached to 303 GW at the end of 2016 with China having the most cumulative installations (78 GW). The largest manufacturers are located in China.

Concentrated solar power (CSP) also started to grow rapidly, increasing its capacity nearly tenfold at the end of 2013; worldwide cumulative CSP-capacity reached 3,425 MW.

Types of technologies

Many technologies have been developed to make use of solar radiation. Some of these technologies make direct use of the solar energy (e.g. to provide light, heat, etc.), while others produce electricity. Solar cell panels convert, at best, about 15% of sunlight hitting them into electricity.

SOLAR POWER

Solar power is the conversion of energy from sunlight into electricity, either directly using photovoltaic (PV), indirectly using concentrated solar power, or a combination. Concentrated solar power systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam.

Solar cells – Photovoltaic cells :

Solar cells can be used to generate electricity from sunlight. It is a device that converts light energy into electrical energy. Sometimes the term solar cell is reserved for devices intended specifically to capture energy from sunlight, while the term photovoltaic cell is used when the light source is unspecified.

Solar cells have many applications. They have long been used in situations where electrical power from the grid is unavailable, such as in remote area power systems, Earth-orbiting satellites and space probes, consumer systems, e.g. handheld calculators or wrist watches, remote radiotelephones and water pumping applications. A large no. of solar cells are combined in an arrangement called solar cell panel that can deliver enough electricity for practical use.

Photovoltaic cells convert light into an electric current using the photoelectric effect. Photovoltaic's were initially solely used as a source of electricity for small and medium-sized applications, from the calculator powered by a single solar cell to remote homes powered by an off-grid rooftop PV system. Commercial concentrated solar power plants were first developed in the 1980s. The 392 MW Ivanpah installation is the largest concentrating solar power plant in the world, located in the Mojave Desert of California.

As the cost of solar electricity has fallen, the number of grid-connected solar PV systems has grown into the millions and utility-scale solar power stations with hundreds of megawatts are being built. Solar PV is rapidly becoming an inexpensive, low-carbon technology to harness renewable energy from the Sun. The current largest photovoltaic power station in the world is the 850 MW Longyangxia Dam Solar Park, in Qinghai, China.

The International Energy Agency projected in 2014 that under its "high renewable" scenario, by 2050, solar photovoltaic and concentrated solar power would contribute about 16 and 11 percent, respectively of the worldwide electricity consumption and solar energy would be the world's largest source

of electricity. Most solar installations would be in China and India. Currently, as of 2016, solar power provides just 1% of total worldwide electricity production but growing 33% per annum.

Photovoltaics :

A solar cell, or photovoltaic cell (PV) is a device that converts light into electric current using the photoelectric effect. The first solar cell was constructed by Charles Fritts in the 1880s. The German industrialist Ernst Werner von Siemens was among those who recognized the importance of this discovery. In 1931, the German engineer Bruno Lange developed a photo cell using silver selenide in place of copper oxide, although the prototype selenium cells converted less than 1% of incident light into electricity. Following the work of Russell Ohl in the 1940s, researchers Gerald Pearson, Calvin Fuller and Daryl Chapin created the silicon solar cell in 1954. These early solar cells cost 286 USD/watt and reached efficiencies of 4.5–6%.

Concentrated solar power

Concentrating Solar Power (CSP) systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam. The concentrated heat is then used as a heat source for a conventional power plant. A wide range of concentrating technologies exists; the most developed are the parabolic trough, the concentrating linear Fresnel reflector, the Stirling dish and the solar power tower. Various techniques are used to track the Sun and focus light. In all of these systems a working fluid is heated by the concentrated sunlight, and is then used for power generation or energy storage.

CONVENTIONAL PV SYSTEMS

The array of a photovoltaic power system, or PV system, produces direct current (DC) power which fluctuates with the sunlight's intensity. For practical use this usually requires conversion to certain desired voltages or alternating current (AC), through the use of inverters. Multiple solar cells are connected inside modules. Modules are wired together to form arrays, then tied to an inverter, which produces power at the desired voltage and for AC, the desired phase and frequency.

Many residential PV systems are connected to the grid wherever available, especially in developed countries with large markets. In these grid-connected PV systems, use of energy storage is optional. In certain applications such as satellites, lighthouses or in developing countries, batteries or additional power generators are often added as back-ups. Such stand-alone power systems permit operations at night and at other times of limited sunlight.

be used by humans each year that took into account factors such as insolation, cloud cover, and the land that is usable by humans. The estimate found that solar energy has a global

Solar cooker :

Solar cooking uses the Sun as the source of energy instead of standard cooking fuels such as charcoal, coal or gas. Solar cookers are an inexpensive and environmentally sound alternative to traditional ovens. They are becoming widely used in areas of the developing world where deforestation is an issue, financial resources to purchase fuel are limited, and where open flames would pose a serious risk to people and the environment. Solar cookers are covered with a glass plate. They achieve a higher temperature by using mirrors to focus the rays of the sun.

Solar heater :

The Sun may be used to heat water instead of electricity or gas. There are two basic types of active solar heating systems based on the type of fluid — either liquid or air — that is heated in the solar energy collectors. (The collector is the device in which a fluid is heated by the Sun.)

Liquid-based systems heat water or an antifreeze solution in a "hydronic" collector, whereas air-based systems heat air in an "air collector."[28] Both air and liquid systems can supplement forced air systems.

SOLAR RENEWABLE ENERGY CREDITS

Alternatively, SRECs allow for a market mechanism to set the price of the solar generated electricity subsidy. In this mechanism, a renewable energy production or consumption target is set, and the utility (more technically the Load Serving Entity) is obliged to purchase renewable energy or face a fine (Alternative Compliance Payment or ACP). The producer is credited for an SREC for every 1,000 kWh of electricity produced. If the utility buys this SREC and retires it, they avoid paying the ACP. In principle this system delivers the cheapest renewable energy, since the all solar facilities are eligible and can be installed in the most economic locations. Uncertainties about the future value of SRECs have led to long-term SREC contract markets to give

clarity to their prices and allow solar developers to pre-sell and hedge their credits.

Financial incentives for photovoltaic's differ across countries, including Australia, China, Germany, Israel, Japan, and the United States and even across states within the US.

GRID INTEGRATION

Construction of the Salt Tanks which provide efficient thermal energy storage so that output can be provided after the sunset and output can be scheduled to meet demand requirements. The 280 MW Solana Generating Station is designed to provide six hours of energy storage. This allows the plant to generate about 38 percent of its rated capacity over the course of a year.

THERMAL ENERGY STORAGE

The Andasol CSP plant uses tanks of molten salt to store solar energy. Pumped-storage hydroelectricity (PSH). This facility in Geesthacht, Germany, also includes a solar array. The overwhelming majority of electricity produced worldwide is used immediately, since storage is usually more expensive and because traditional generators can adapt to demand. However both solar power and wind power are variable renewable energy, meaning that all available output must be taken whenever it is available by moving through transmission lines to where it can be used now. Since solar energy is not available at night, storing its energy is potentially an important issue particularly in off-grid and for future 100% renewable energy scenarios to have continuous electricity availability.

Solar electricity is inherently variable and predictable by time of day, location, and seasons. In addition solar is intermittent due to day/night cycles and unpredictable weather. How much of a special challenge solar power is in any given electric utility varies significantly. In a peak utility, solar is well matched to daytime cooling demands. In winter peak utilities, solar displaces other forms of generation, reducing their capacity factors.

Conventional hydroelectricity works very well in conjunction with solar power, water can be held back or released from a reservoir behind a dam as required. Where a suitable river is not available, pumped-storage hydroelectricity uses solar power to pump water to a high reservoir on sunny days then the energy is recovered at night and in bad weather by releasing water via a hydroelectric plant to a low reservoir where the cycle can begin again.[89] However, this cycle can lose 20% of the energy to round trip inefficiencies, this plus the construction costs add to the expense of implementing high levels of solar power.

Concentrated solar power plants may use thermal storage to store solar energy, such as in high-temperature molten salts. These salts are an effective storage medium because they are low-cost, have a high specific heat capacity, and can deliver heat at temperatures compatible with conventional power systems. This method of energy storage is used, for example, by the Solar Two power station, allowing it to store 1.44 TJ in its 68 m³ storage tank, enough to provide full output for close to 39 hours, with an efficiency of about 99%. stand alone PV systems batteries are traditionally used to store excess electricity. With grid-connected photovoltaic power system, excess electricity can be sent to the electrical grid.

Environmental impacts

Part of the Senftenberg Solar park, a solar photovoltaic power plant located on former open-pit mining areas close to the city of Senftenberg, in Eastern Germany. The 78 MW Phases 1 of the plant was completed within three months. Unlike fossil fuel based technologies, solar power does not lead to any harmful emissions during operation, but the production of the panels leads to some amount of pollution.

Greenhouse gases

The life-cycle greenhouse-gas emissions of solar power are in the range of 22 to 46 gram (g) per kilowatt-hour (kWh) depending on if solar thermal or solar PV is being analyzed, respectively. With this potentially being decreased to 15 g/kWh in the future. For comparison (of weighted averages), a combined cycle gas-fired power plant emits some 400–599 g/kWh, an oil-fired power plant 893 g/kWh, a coal-fired power plant 915–994 g/kWhor with carbon capture and storage some 200 g/kWh, and a geothermal high-temp. power plant 91–122 g/kWh.] The life cycle emission intensity of hydro, wind and nuclear power are lower than solar's as of 2011 as published by the IPCC, and discussed in the article Life-cycle greenhouse-gas emissions of energy sources. Similar to all energy sources were their total life cycle emissions primarily lay in the construction and transportation phase, the switch to low carbon

power in the manufacturing and transportation of solar devices would further reduce carbon emissions. BP Solar owns two factories built by Solarex (one in Maryland, the other in Virginia) in which all of the energy used to manufacture solar panels is produced by solar panels. A 1-kilowatt system eliminates the burning of approximately 170 pounds of coal, 300 pounds of carbon dioxide from being released into the atmosphere, and saves up to 105 gallons of water consumption monthly.

OTHER ISSUES

One issue that has often raised concerns is the use of cadmium (Cd), a toxic heavy metal that has the tendency to accumulate in ecological food chains. It is used as semiconductor component in CdTe solar cells and as buffer layer for certain CIGS cells in the form of CdS. The amount of cadmium used in thin-film PV modules is relatively small (5–10 g/m²) and with proper recycling and emission control techniques in place the cadmium emissions from module production can be almost zero. Current PV technologies lead to cadmium emissions of 0.3–0.9 microgram/kWh over the whole life-cycle. Most of these emissions arise through the use of coal power for the manufacturing of the modules, and coal and lignite combustion leads to much higher emissions of cadmium. Life-cycle cadmium emissions from coal is 3.1 microgram/kWh, lignite 6.2, and natural gas 0.2 microgram/kWh.

In a life-cycle analysis it has been noted, that if electricity produced by photovoltaic panels were used to manufacture the modules instead of electricity from burning coal, cadmium emissions from coal power usage in the manufacturing process could be entirely eliminated.[115]

In the case of crystalline silicon modules, the solder material, that joins together the copper strings of the cells, contains about 36 percent of lead (Pb). Moreover, the paste used for screen printing front and back contacts contains traces of Pb and sometimes Cd as well. It is estimated that about 1,000 metric tonnes of Pb have been used for 100 gigawatts of c-Si solar modules. However, there is no fundamental need for lead in the solder alloy.

REFERENCES

[1] "Physical Progress (Achievements)". Ministry of New and Renewable Energy, Govt. of India. Retrieved 2017-09-15.

[2] . Economic Times. Retrieved 2017-04-06.

[3] McGrath, Matt (2017-06-01). "Five effects of a US pull-out from Paris climate deal". BBC. Retrieved 2017-06-01.

[4] Krishna N. Das (2015-01-02). "India's Modi raises solar investment target to $100 bln by 2022". Reuters. Retrieved 2015-01-02.

[5] "Solar Energy to Power India of the Future". The World Bank. 2016-06-30. Retrieved 2017-04-05.

[6] Neslen, Arthur (2015-12-04). "India Unveils Global Solar Alliance of 120 Countries at Paris Climate Summit". AlterNet. Retrieved 2016-08-06.

[7] Muneer, T.; Asif, M.; Munawwar, S. (2005). "Sustainable production of solar electricity with particular reference to the Indian economy". Renewable and Sustainable Energy Reviews.

[8] Jaishankar, C. (2010-12-23). "Solar farm launched in Sivaganga district".