A Study of Solar Thermal Power and Its Uses In Different Forms In India At Present and Future Scope

Dr. P.T. Bharathi
Associate Professor, Dept of Geography
Maharaja's College, University of Mysore, Mysuru – 570 005

Abstract- *Earth has enough resources to meet people's needs, but will never have enough to satisfy people's greed. (Mahatma Gandhi).The effects of global warming and ever-rising pollution have brought an increased environmental consciousness among people globally. Various attempts have been made by governmental and non-governmental bodies to spread awareness about climate change and to control pollution. In India, use of fossil fuel-based energy resources, including in power generation, is one of the major reasons for pollution. On 2 October 2016, India ratified the Paris climate accord and committed to reduce its emission intensity to 35% below 2005 levels by 2030 and achieve a 40% cumulative electricity power capacity from non-fossil fuel-based energy resources by 2030.This shows India's twin focus on using renewable energy to meet its power requirements while simultaneously addressing the problem of pollution.*

Among the various renewable energy resources such as solar, wind, small hydro and biomass, India, being a tropical country, has a high potential for solar energy. Most parts of India witness 300 sunny days a year, which translates into an incidence of 5,000 trillion kWh per year of energy over India's land mass (with most parts receiving 4–7 kWh per sq m each day). India can capitalize on this huge potential by using the latest advanced solar PV and thermal technologies and fulfil its commitment under the Paris climate accord India: Solar Power - A Practical Handbook, 18 June 2018 by Abhishek Saxena

So this Article is intended to analyse the overview of key developments of the solar thermal power sector in India and its uses in different forms in the present situation in Indian context.

Keywords- greed, global warming, rising pollution, environmental consciousness, sunny days.

I. INTRODUCTION

Less than a decade ago, solar projects were struggling to gain popularity and were required to be heavily subsidized by the Indian central government. The government's focus was on coal-fired power generation to support the unprecedented economic growth being witnessed during that period. Indeed, the Indian government had planned to set up ultra-mega power projects, each having a capacity of about 4,000 MW. In contrast to this earlier emphasis, the Gujarat state government recently dropped a plan to build a 4,000 MW imported coal-based ultra-mega power project because it believes that upcoming renewable energy units could meet its power requirements. This may be explained partly by the historic low tariffs offered by private bidders in the recently concluded competitive reverse auction for solar power projects in India which, surprisingly, were lower than conventional (coal-based) sources. The government received a low tariff of Rs 2.44/kWh (i.e., US$ 0.037/kWh) for 500 MW of capacity in one of India's largest solar parks. To put this into perspective, in 2010 the tariff hovered around Rs 12.16/kWh (i.e., US$ 0.17/kWh). This change augurs well for the prospects of solar power plants in India.

The installed capacity of commercial solar thermal power plants (non storage type) in India is 227.5 MW with 50 MW in Andhra Pradesh and 177.5 MW in Rajasthan. The existing solar thermal power plants (non-storage type) in India, which are generating costly intermittent power on a daily basis, can be converted into storage type solar thermal plants to generate 3 to 4 times more base load power at cheaper cost and not depend on government subsidies. In March 2020, SECI called for 5000 MW tenders which can be combination of solar PV with battery storage, solar thermal with thermal energy storage (including biomass firing as supplementary fuel) and coal based power (minimum 51% from renewable sources) to supply round the clock power at minimum 80% yearly availability.

II. OBJECTIVES

- To study the various forms of solar energy used in India.
- To analyze the spatial distribution and production of various forms of solar energy used in India

III. METHODOLOGY

The study is conducted on the various forms of solar energy in India analysis based on the data gathered from secondary sources. Secondary data has been collected from the records, books, journals and websites. The relevant information and data have been organized, classified and tabulated using simple statistical methods.

HYBRID SOLAR PLANTS

Solar power, generated mainly during the daytime in the non-monsoon period, complements wind which generates power during the monsoon months in India. Solar panels can be located in the space between the towers of wind-power plants. It also complements hydroelectricity, generated primarily during India's monsoon months. Solar-power plants can be installed near existing hydropower and pumped-storage hydroelectricity, utilizing the existing power transmission infrastructure and storing the surplus secondary power generated by the solar PV plants. Floating solar plants on the reservoirs of pumped-storage hydroelectric plants are complementary to each other. Solar PV plants clubbed with pumped-storage hydroelectric plants are also under construction to supply peaking power.

During the daytime, the additional auxiliary power consumption of a solar thermal storage power plant is nearly 10% of its rated capacity for the process of extracting solar energy in the form of thermal energy. This auxiliary power requirement can be made available from cheaper solar PV plant by envisaging hybrid solar plant with a mix of solar thermal and solar PV plants at a site.

SOLAR HEATING

Array of parabolic troughs

Generating hot water or air or steam using concentrated solar reflectors, is increasing rapidly. Presently concentrated solar thermal installation base for heating applications is about 20 MW in India and expected to grow rapidly. Cogeneration of steam and power round the clock is also feasible with solar thermal CHP plants with thermal storage capacity.

Bengaluru has the largest deployment of roof-top solar water heaters in India, generating an energy equivalent of 200 MW. It is India's first city to provide a rebate of ₹50 on monthly electricity bills for residents using roof-top thermal systems, which are now mandatory in all new structures. Pune has also made solar water heaters mandatory in new buildings.

RURAL ELECTRIFICATION

The lack of electricity infrastructure is a hurdle to rural India's development. India's power grid is under-developed. In 2004, about 80,000 of the nation's villages still did not have electricity, 18,000 out of them could not be electrified by extending the conventional grid due to inconvenience. A target of electrifying 5,000 such villages was set for the 2002–2007 Five-Year Plan. By 2004 more than 2,700 villages and hamlets were electrified, primarily with solar photovoltaic systems. The development of inexpensive solar technology is considered a potential alternative, providing an electricity infrastructure consisting of a network of local-grid clusters with distributed electricity generation. It could bypass (or relieve) expensive, long-distance, centralized power-delivery systems, bringing inexpensive electricity to large groups of people. In Rajasthan during Financial Year 2016–17, 91 villages have been electrified with a solar standalone system and over 6,200 households have received a 100W solar home-lighting system. India has sold or distributed about 1.2 million solar home-lighting systems and 3.2 million solar lanterns, and has been ranked the top Asian market for solar off-grid products.

LAMPS AND LIGHTING

By 2012, a total of 4,600,000 solar lanterns and 861,654 solar-powered home lights were installed. Typically replacing kerosene lamps, they can be purchased for the cost of a few months worth of kerosene with a small loan. The Ministry of New and Renewable Energy is offering a 30 to 40 percent subsidy of the cost of lanterns, home lights and small systems (up to 210 W). Twenty million solar lamps are expected by 2022.

AGRICULTURAL SUPPORT

Solar photovoltaic water-pumping systems are used for irrigation and drinking water. Most pumps are fitted with a

200–3,000 W (0.27–4.02 hp) motor powered with a 1,800 W_p PV array which can deliver about 140,000 litres (37,000 US gal) of water per day from a total hydraulic head of 10 m (33 ft). By 31 October 2019 a total of 181,521 solar photovoltaic water pumping systems were installed and total solar photovoltaic water pumping systems would reach 3.5 million by the year 2022 under PM KUSUM scheme. During hot sunny daytime when the water needs are more for watering the fields, solar pumps performance can be improved by maintaining pumped water flowing/sliding over the solar panels to keep them cooler and clean. Agro photo voltaic is the electricity generation without losing agriculture production by using the same land. Solar driers are used to dry harvests for storage. Low cost solar powered bicycles are also available to ply between fields and village for agricultural activity, etc.

RAINWATER HARVESTING

In addition to solar energy, rainwater is a major renewable resource of any area. In India, large areas are being covered by solar PV panels every year. Solar panels can also be used for harvesting most of the rainwater falling on them and drinking or breweries water quality, free from bacteria and suspended matter can be generated by simple filtration and disinfection processes, as rainwater is very low in salinity. Good quality water resources, closer to populated areas, are becoming a scarcity and increasingly costly for consumers. Exploitation of rainwater for value-added products like bottled drinking water makes solar PV power plants profitable even in high rainfall and cloudy areas by the increased income from drinking water generation.

REFRIGERATION AND AIR CONDITIONING

4 MW horizontal single-axis tracker in Vellakoil, Tamil Nadu

Thin-film solar cell panels offer better performance than crystalline silica solar panels in tropical hot and dusty places like India; there is less deterioration in conversion efficiency with increased ambient temperature, and no partial shading effect. These factors enhance the performance and reliability (fire safety) of thin-film panels. Maximum solar-electricity generation during the hot hours of the day can be used for meeting residential air-conditioning requirements regardless of other load requirements, such as refrigeration, lighting, cooking and water pumping. Power generation of photovoltaic modules can be increased by 17 to 20 percent by equipping them with a tracking system.

The maximum power generation of solar panels during the sunny daytime is complementary with the enhanced residential electricity consumption during the hot/summer days due to higher use of cooling appliances such as fans, refrigerators, air conditioners, desert coolers, etc. It would discourage the Discoms to extract higher electricity charges selectively from its consumers. There is no need of any permission from Discoms similar to DG power sets installation. Cheaper discarded batteries of electric vehicle can also be used economically to store the excess solar power generated in the daylight.

GRID STABILISATION

Solar-power plants equipped with battery storage systems where net energy metering is used can feed stored electricity into the power grid when its frequency is below the rated parameter (50 Hz) and draw excess power from the grid when its frequency is above the rated parameter. Excursions above and below the rated grid frequency occur about 100 times daily. The solar-plant owner would receive nearly double the price for electricity sent into the grid compared to that consumed from the grid if a frequency-based tariff is offered to rooftop solar plants or plants dedicated to a distribution substation. A power-purchase agreement (PPA) is not needed for solar plants with a battery storage systems to serve ancillary-service operations and transmit generated electricity for captive consumption using an open-access facility. Battery storage is popular in India, with more than 10 million households using battery backup during load shedding. Battery storage systems are also used to improve the power factor. Solar PV or wind paired with four-hour battery storage systems is already cost competitive, without subsidy and power purchase agreement by selling peak power in Indian Energy Exchange, as a source of dispatchable generation compared with new coal and new gas plants in India.

SOLAR INVERTERS

An inverter is one of the most important pieces of equipment in a solar energy system. It's a device that converts direct current (DC) electricity, which is what a solar panel generates, to alternating current (AC) electricity, which

the electrical grid uses. As a result, a DC input becomes an AC output.

The basic function of an inverter is to convert the direct current (DC) power that solar panels create to alternating current (AC) power that is usable in homes and businesses or fed directly into the grid in front-of-the-meter projects (utility-scale solar arrays).

There are three types of inverters that are currently available to you for your solar energy system: string (also known as centralized) inverters, power optimizer systems (also known as string inverters + power optimizers), and micro inverters. The top ten solar inverter companies in India in 2019 are Huawei, MEIC, ABB, TBEA, Sineng, Kehua, Delta, Talaricheruvu, Charanka and Sungrow.

SOLAR PHOTOVOLTAICS (PV)

A photovoltaic system, or solar PV system is a power system designed to supply usable solar power by means of photovoltaics. It consists of an arrangement of several components, including solar panels to absorb and directly convert sunlight into electricity, a solar inverter to change the electric current from DC to AC, as well as mounting, cabling and other electrical accessories. The global solar PV capacity was only 50 GW in 2010, and in 2000 it was a meager 4 GW. In 2016 alone, the global solar PV capacity rose by 50% due to new installations in China and the US. The PV industry is a $100 billion industry that is expected to continue to grow. By 2030, the total global PV capacity could reach 10 TW, generating about 5% of the anticipated global consumption of energy in 2030.

SOLAR PANELS

These are the traditional types of solar panels made of monocrystalline silicon or polysilicon and are most commonly used in conventional surroundings. Monocrystalline Solar Panels (Mono-SI), Polycrystalline Solar Panels (Poly-SI), ThinFilm Solar Cells (TFSC), Amorphous Silicon Solar Cell (A-Si) and Biohybrid Solar Cell are important panels used in India.

SOLAR PHOTOVOLTAICS (PV) GLOBAL DEVELOPMENT FIGURES

Top 10 countries by added solar PV capacity in 2019	Top 10 countries by cumulative solar PVcapacity in 2019
China: 30,100 MW (26.2%)	China: 204,700 MW (32.6%)
United States: 13,300 MW (11.6%)	United States: 75,900 MW (12.
India: 9,900 MW (8.6%)	Japan: 63,000 MW (10.0%)
Japan: 7,000 MW (6.1%)	Germany: 49,200 MW (7.8%)
Vietnam: 4,800 MW (4.2%)	India: 42,800 MW (6.8%)
Spain: 4,400 MW (3.8%)	Italy: 20,800 MW (3.3%)
Germany: 3,900 MW (3.4%)	Australia: 14,600 MW (2.3%)
Australia: 3,700 MW (3.2%)	United Kingdom: 13,300 MW (2.1%)
Ukraine: 3,500 MW (3.0%)	South Korea: 11,200 MW (1.8%)
South Korea: 3,100 MW (2.7%)	France: 9,900 MW (1.6%)
All others: 31,200 MW (27.2%)	All others: 121,600 MW (19.4%)

CONVERSION OF SOLAR ENERGY

The solar energy is the energy obtained by capturing heat and light from the Sun. The method of obtaining electricity from sunlight is referred to as the Photovoltaic method. This is achieved using a semiconductor material.

The other form of obtaining solar energy is through thermal technologies, which give two forms of energy tapping methods. The first is solar concentration, which focuses solar energy to drive thermal turbines. The second method is heating and cooling systems used in solar water heating and air conditioning respectively.

The process of converting solar energy into electricity so as to utilize its energy in day-to-day activities is made by absorption of energy carrying particles in Sun's rays called photons, photovoltaic conversion, inside the solar cells and combination of current from several cells. This step is necessary since a single cell has a voltage of less than 0.5 V, then conversion of the resultant DC to AC.

IV. FUTURE SCOPE

With reduced costs and improved technologies, the solar energy ensures the reduced electricity bills, increases countries energy security through reliance on an indigenous, inexhaustible resources, enhanced sustainability, reduced pollution, lower the costs of mitigating global warming, and keeps fossil fuel prices lower than otherwise. It is environment friendly and any one can use it. The advantages are global. Hence the additional costs of the incentives for early deployment should be considered learning investments; they must be wisely spent and need to be widely shared energy (STE) is a form of energy and a technology for harnessing solar energy to generate thermal energy for use in industry and in the residential and commercial sectors.

V. CONCLUTION

In the developing countries like India, solar and power energy is a growing need for the progress of the country. As power shortfalls continue, peak shortage is a critical problem that has stifled industrial growth and back-up generation is becoming increasingly expensive. Effective measures have been taken and now solar energy in India has become the fast growing industry. International equipment suppliers are paying more attention to the Indian market and are developing specific pricing and product strategies for India.

India is ranked number one in solar electricity production per watt installed, with an insolation of 1700 to 1900 kilowatt hours per kilowatt peak (kWh/KWp). India's first solar power project (with a capacity of 5 MW) was registered under the Clean Development Mechanism. The project is in Sivagangai Village, Sivaganga district, Tamil Nadu. India saw a sudden rise in use of solar electricity. Recent growth has been over 3,000 MW per year and is set to increase yet further.

The Charanka Solar Park, at 214 MW the largest in the world, along with a total of 605 MW in Gujarat, representing 2/3 of India's installed photovoltaics. Large solar parks have also been announced in the state of Rajasthan. The rapid growth in deployment of solar power is recorded and updated monthly on the Indian Government's Ministry of New and Renewable Energy website. Being a tropical country, India has about 300 clear and sunny days in a year. The solar energy available in a year exceeds the possible energy output of all fossil fuel energy reserves in India.

In addition to the large-scale grid connected solar PV initiative, India is continuing to develop the use of off-grid solar power for localized energy needs. India has a poor electrification rate in rural areas. Reports say that the installed price of solar energy has declined significantly in recent years as policy and market forces have driven more and more solar installations. Perhaps the most interesting piece of data to come out in the latest Lawrence Berkeley National Lab reports is the trend in the price of solar power purchase agreements or PPAs. These prices reflect the price paid for long-term contracts for the bulk purchase of solar electricity.

In an attempt to boost its image as a global leader in the solar power market, India is planning to propose collaboration among nations to promote research and development with an aim to reduce costs. In January 2016, the Prime Minister of India, Narendra Modi and the President of France, Mr. François Hollande laid the foundation stone for the headquarters of the International Solar Alliance (ISA) in Gwalpahari, Gurgaon. The ISA will focus on promoting and developing solar energy and solar products for countries lying wholly or partially between the Tropic of Cancer and the Tropic of Capricorn.

REFERENCES

[1] http://unfccc.int/files/essential_background/convention/application/pdf/english_paris_agreement.
[2] India's Intended Nationally Determined Contribution, www4.unfccc.int/submissions.
[3] The Ministry of New and Renewable Energy's Annual Report for year 2016–17
[4] The Jawaharlal Nehru National Solar Mission, see www.mnre.gov.in/file-manager/UserFiles/mission_document_JNNSM.
[5] www.financialexpress.com/industry/yogi-adityanath-cancels-bids-for-3800-mw-power-in-uttarpradesh.
[6] www.qz.com/984656.
[7] www.cleantechnica.com/2017/04/17/solar-bid-prices-india-fallen-73-since-2010.
[8] www.moef.nic.in/sites/default/files/Pg01-52.
[9] http://pib.nic.in/newsite/PrintRelease.
[10] www.thehindu.com/opinion/op-ed/On-paper-electrified-villages.

.