Potential of Roof Top Solar Power Generation in India

Bharat Raj Singh[*1], Onkar Singh[2], Raghuvir Kumar[3] and Dharmendra Singh[4]

ABSTRACT

World's about 80% of the energy consumption is sustained by the extraction of fossil fuels, which consists of oil, coal and gas. Another non-renewable resource that is exploited by humans is subsoil minerals such as precious metals that are mainly used in the production of industrial commodities. It is only because of the increasing population and subsequent growth of materialistic attitude in human's behavior that has lead our planet to an exhaustible measure and subsequent release of harmful carbon particulate from the vehicles' exhaust pipes also cannot be overlooked as it contains many harmful Green House Gases like: Carbon-dioxide, Carbon-monoxide, Methane etc. emerging out of Thermal Power Houses and Industries. This is also causing environmental damage and changes in the and atmosphere around earth's surface. Unfortunately, our future generation may face awful challenges for their survival due to these changes. Although, scientists and environmentalists, are seriously focusing to research an alternative energy to be helpful for the development of society and curbing the challenging climatic conditions. India being a geographically very rich pasture and has more than 10 months sun-shine (i.e. 300 days against 365 days) in a year. Thus, Solar Energy can be a better alternative in India to be exploited as a major source of Electric Power Deficit. Currently in India, Installed capacity of Power is 302087.87 MW and Generation is 104867.30 MW against Peak demand of 148166 MW (a deficit of around 45,000MW).

As an experiment in Lucknow, if an average house-hold installs 2 kWh Roof Top Solar Power Generation, it will help to generate around 2-2.50 million units (2,000-2,500MW) in a year by approx. 10 lacks existing houses in Lucknow and light additionally more than 100-150 villages with current installed capacity of power generation under Solar Green Energy Potential and without damaging Environment. Thus, Solar Roof Top Power Generation can create almost surplus power in India by the year 2020 even if 50% of houses of countrymen decide to place Solar Roof Top Panels in their houses under major awareness programme.

Keywords : Roof top solar power, Climate change, Thermal power, Green house gases.

1[*]. Director-IET, School of Management Sciences, Lucknow, (U.P.) India. e-mail : brsinghlko@yahoo.com

2. Professor and Vice Chancellor, Madan Mohan Malviya University of Technology, Gorakhpur, (U.P.) India.

3. Professor and Head, Department of Civil & Mechanical Engineering, School of Management Sciences, Lucknow-226501, (U.P.) India.

4. Professor & Dean, School of Management Sciences, Lucknow, (U.P.) India.

1. INTRODUCTION

India's per capita power consumption is among the lowest in the world. Around 280 million people in the country do not have access to electricity. In comparison, China has a per capita consumption of 4,000kWh, with developed nations averaging around 15,000kWh per capita. Interestingly, while the peak shortage in the country was at 2.3% in May, many believe that the demand still looks artificially suppressed as State Electricity Boards (SEBs) are not buying power. SEBs have been unwilling to procure electricity because of their weak financials due to low tariffs, slow progress in reducing losses, higher power purchase costs and crippling debt. India has an installed power generation capacity of 272,503MW as shown in Annexure-I.

Growing appetite for electricity in India, the country's per capita electricity consumption has reached 1010 kilowatt-hour (kWh) in 2014-15, compared with 957 kWh in 2013-14 and 914.41 kWh in 2012-13, according to the Central Electricity Authority (CEA), India's apex power sector planning body. The per capita electricity consumption reached 1010 kWh some time back, said a senior government official, requesting anonymity. But experts are far from enthused from the increasing consumption figure. "Per capita electricity consumption crossing 1,000 units a year is certainly a milestone, but without much significance. One-fourth of the households in the country still have no access to electricity, with some states in East and North East having less than even 30% households with (electricity) access. Most significant milestone that the nation must achieve is 100% households having 24x7 quality supply of electricity, said Debasish Mishra, senior director, consulting, Deloitte Touche Tohmatsu India Pvt. Ltd.

Of our installed capacity, only around 145,000MW is operational. Electricity generation was the 'Silver Lining' in the May index of industrial production data. Electricity output, which contracted 0.5% in April, recovered to grow 6% in May, 2015. The Government of India had made energy security and launched a scheme aimed at ensuring about eight hours of quality power supply to agricultural consumers and 24-hour electricity to households in April-May 2014. India needs to invest much as 13417 billion (kharab) Indian Rupees to meet its target of installing 100,000MW (100 GWatt) of solar power capacity and around 60,000MW of wind power capacity by the year 2022.

2. INDIA'S SOLAR POWER POTENTIAL

India's plan to become of the largest solar power markets in the world has received a massive boost as the latest estimated of its solar power potential.

Fig.1: Future of Solar Energy in India

Fig.2: Solar Generation Unit

The National Institute of Solar Energy in India has determined the country's solar power potential at about 750 GW, a recently released document by the Ministry of New & Renewable Energy (MNRE) shows. The solar power potential has been estimated using the wasteland availability data in every state and jurisdiction of India. The estimate is based on the assumption that only 3% of the total wasteland available in a state is used for development of solar power projects.

3. WHY SOLAR POWER GENERATION

Solar energy is a genesis for all forms of energy. This energy can be made use of in two ways-

(i) Thermal route i.e. using heat for drying, heating, cooking or generation of electricity.

(ii) Photovoltaic route which converts solar energy into electricity that can be used for myriad purposes such as-lighting, pumping and generation of electricity. With its pollution free nature, virtually inexhaustible supply and global distribution - solar energy is very attractive energy resource.

Solar Energy can be utilized for varied applications. So, the answer to the question, "Why Solar" can be sought from two different perspectives:

(i) Utilizing solar energy for grid-interactive and

(ii) Off-grid (including captive) power generation.

3.1. Solar for Grid Connected Electricity

Grid interactive solar energy is derived from Solar Photovoltaic Cells and CSP Plants on a large scale. The grid connection is chosen due to the following reasons:

- Solar Energy is available throughout the day which is the peak load demand time.
- Solar energy conversion equipments have longer life and need lesser maintenance and hence provide higher energy infrastructure security.
- Low running costs & grid tie-up capital returns (Net Metering).
- Unlike conventional thermal power generation from coal, they do not cause pollution and generate clean power.

- Abundance of free solar energy from all parts of the world (although gradually decreasing from equatorial, tropical, sub-tropical and polar regions), can be utilized almost everywhere.

3.2. Solar for Off-Grid Solutions

While, the areas with easier grid access are utilizing grid connectivity, the places where utility power is scant or too expensive to bring, have no choice but to opt for their own generation. They generate power from a diverse range of small local generators using both fossil fuels (diesel, gas) and locally available renewable energy technologies (solar PV, wind, small hydro, biomass, etc.) with or without its own storage (batteries). This is known as Off-Grid Electricity. Remote power systems are installed for the following reasons:

- Desire to use renewable - Environmentally safe and Pollution free.
- Combining various generating options available through Hybrid Power Generation.
- Desire for independence from the unreliable, fault prone and interrupted grid connection.
- Available storage and back-up options.
- No overhead wires and No transmission loss.
- Varied applications and products: Lighting, Communication Systems, Cooking, Heating, Pumping, Small scale industry utilization etc.
- Captive power generation is done mainly considering the replacement of diesel with solar.

4. ROOF TOP SOLAR PLANT

Electricity generated through Coal Plants is becoming expensive every day. Power cuts and increasing dependence on DG sets is causing a lot of damage to the environment. The demand-supply gap for electricity is increasing in country which makes it very important for the people to start thinking of other ways of realizing their energy needs. Keeping this in mind, Ministry of New and Renewable Energy (MNRE), Government of India is promoting Off-Grid and On-Grid Solar PV systems under Jawaharlal Nehru National Solar Mission in the country. In Uttar Pradesh like those of Gujarat and Rajasthan, net metered Solar Roof Top Policy was announced in the year 2015. Many people in the country have started feeling the need of installing Solar PV system for their homes, apartments complexs and offices. Through this article we would try to provide some information which can be a good starting point for a Roof-Top Solar PV system project.

4.1 Solar PV Cell and Module

Solar PV cell is the basic building block of a PV system. It consists of semi-conductor material that absorbs sunlight

to generate electricity through a phenomenon called "Photoelectric Effect". Only sunlight of a certain wavelength can effectively generate electricity. Although, a Solar PV can generate electricity on a cloudy day too, but it is not as effective as it is on sunny days.

A basic PV cell produces a very small amount of electricity and multiple of them are connected together to form a Solar PV module that can generate 10W to 300W output. If more electricity is required, then multiple such PV modules have to be installed in an array.

Multiple kind of materials are used to create a solar cell and the efficiency of solar cell depends on the same. The efficiency of a solar cell is defined as its capability to convert a certain amount of sunlight into electricity. Solar cells available in the market are of various efficiencies: 4%, 8%, 12%, 14% and 16%. The size of a Solar PV module required will depend on output and efficiencies as listed below.

Table-1: Roof Area Required in Sq. Ft.

PV Module Efficiency (%)	PV Capacity Rating (Watts)						
	100	250	500	1,000	2,000	4,000	10,000
4	30	75	150	300	600	1,200	3,000
8	15	38	75	150	300	600	1,500
12	10	25	50	100	200	400	1,000
16	8	20	40	80	160	320	800

(Source: solar PV sizing information on energy savers.gov)

For example, to generate 2000 watts from a 12% efficient system, you need a 200 sq ft of roof area. Solar home lighting systems approved under NSM (National Solar Mission) are required to have a certain level of efficiency. The CFL based solar systems are required to have module efficiency of 14% and above and a LED based solar system is required to have module efficiency of 12% and above. Please note that such systems will have a serial number starting with NSM engraved on the frame.

4.2 Sizing a Solar System

Before you buy a system, it is very important to size your solar system properly. Sizing will depend on the load requirements in your setup. It is important to note that a Solar system is good for operating low wattage appliances like Lights, Fans, TV, etc. High wattage appliances like Air Conditioners and Water Heaters cannot be operated using solar PV system (in fact Solar Water Heaters and Solar Air Conditioners are available separately). It is very important to make sure that your system is energy efficient so that, you do need a bigger sized solar system. The connected load of your setup will help you to determine the size of a system that you need and that in turn will drive the cost of the system.

4.3 Other Considerations for Installing a Solar System

Although a Solar PV system can generate electricity through direct or scattered sunlight, but it is very important to assess the amount of sunlight available at a location where a Solar PV system is being installed. To collect maximum sunlight, the ideal orientation of a Solar Panel is towards the South. However, a 45-degree east or west of south can also work. The system should be placed in such a place so that there is no obstruction of trees or adjoining buildings. In case these requirements are not getting fulfilled, an expert should be hired to do a detailed analysis on the amount of sunlight available. Solar Panel structure typically weight 15kg per sq meter and the roof should be able to handle the load.

Tilt at which the solar panel is installed, is also an important consideration. It is important that the tilt of the solar panel is the same as the latitude of your location.

4.4 System Output or Electricity Units Generated from A Solar System

Although we talked about wattage capacity of a Solar PV system, but that does not mean that the wattage will be available 24 hours a day and all throughout the year. The units or kWH output of a solar panel will depend on the panel efficiency and availability of sunlight in a location. The factor that defines this output is called CUF (or Capacity Utility Factor). For India, it is typically taken as 19% and the calculation of units goes as:

Units Generated Annually (in Kwh) = System Size in Kw * CUF * 365 * 24

So typically a 1kW capacity solar system will generate 1600-1700 kWH of electricity per year (please note that this is just a thumb rule as the CUF will vary in different cities in India).

4.5 Components of a Roof Top PV system

A typical Roof Top PV system also contains a set of batteries and inverter along with the modules of Solar PV cells. The overall efficiency of the system will also depend on the type of battery and inverter used in the system. It is important to choose the right components for most effective use of Solar PV systems.

"Deep Cycle" batteries (generally lead-acid) are the best suited for a solar PV system. They last for 5 to 10 years and are 80% efficient (can reclaim 80% of energy stored in it). These batteries are also designed to provide electricity for long periods and can discharge up to 80% of their capacity repeatedly. Automotive batteries that are shallow cycle should not be used. Sealed maintenance free or tubular positive plate batteries are good for Solar PV systems. It is important to size the batteries properly so that, they can store sufficient power based on your

needs during cloudy weather. Batteries should be located in a space that is easy to reach (for maintenance), well-ventilated and protected from extreme weather.

Even inverters are not 100% efficient and it is important to choose the right inverter that is at least 85% efficient (If a system is purchased under National Solar Mission then these standards are guaranteed). A modified sine wave or a pure sine wave inverter is better suited for a solar PV system. Modified sine wave inverters are cheap but less efficient. They waste some electricity in form of heat. They create a buzz sound with appliances and thus should be used only with low-end appliances. Pure sine wave inverters are most efficient but are expensive. They are good for all kinds of appliances.

4.6 Warranties and Maintenance Requirements for a Solar PV System

If purchased under NSM, a Solar PV module comes with a warranty of 25 years from the date of supply. A solar home lighting system (with inverter) comes with a warranty of 5 years and the batteries if sealed maintenance free come with 2 years warranty and lead acid flooded type battery comes with 5 year warranty.

It is important that the manufacturers provide an operation, instruction and maintenance manual in English and local language along with the system. As with all electrical and mechanical system, Solar PV system also needs regular maintenance. An efficient long lasting system is one that is maintained properly and regularly. A Solar PV system does not require a lot of maintenance but, it is good to clean the system of dust and bird droppings regularly to maintain its efficiency. Since system does not need any battery, thus, one should not worry about the maintenance of battery. If you choose battery in rural area, then the battery will need regular maintenance. Make sure that the system is getting adequate sunlight and is not getting shaded by nearby trees, etc.

4.7 Costs of Solar PV Systems and Incentives from MNRE

As per our resources from the Solar PV industry, cost of a PV module (just the panel) costs anywhere between Rs 30 to Rs 50 per watt of power generated. A good imported module will cost around Rs 40 per watt. Good ones manufactured in India would come as low as Rs 30-32 per watt. Please note that this is the cost for the panel and in case you are looking for inverter and batteries, the cost would be additional. A good 5 kW system for a home would cost around Rs 3-4 lakhs to setup, which can provide electricity for 25 years. The additional operating cost will include the cost of replacing the batteries.

Fig.3: First 5-Kw Solar Roof Top on-grid Plant at 5/323, Viram Khand, Gomti Nagar

Fig.4: 5-Kw Roof Top Solar PV Plates Installed at Gomati Nagar, Lucknow

4.8 Where Can You Buy Solar PV Syste

The list of authorizes suppliers/ manufacturers is available at MNRE. Few of them are shown in Table 2. (appended annexure-1)

4.9 Has any Initiative Taken in Uttar-Pradesh

MNRE is providing all kind of facilities through their registered vendors, but few social activist or environmentalist started provoking about the benefits of Roof Top Solar Plant and in UP State a Professor of self financed Institute SMS, Lucknow affiliated to AKTU got First 5-Kw Roof Top Solar Plant installed in the month of November / December 2015 at his Gomati Nagar residence and gave a boost to the government departmental buildings as well private residential buildings to install Solar On-Grid System in the urban areas. Now more than 1 Mw electric power is being fed into grid through Roof Top Plant in Lucknow City.

The Professor is of firm opinion that if in Lucknow city and its adjoining areas (approx. 4 lac houses) Solar PV Roof Top Plant is installed with an average 2 Kw Roof Top Solar On-grid System, it can feed 2000 Mw power generation through public leaving, apart government buildings. It will not only help or enhance power generation but also help 30 % people of India, those who have yet to get electric connection in their houses. Thus, we the people of India should utilize the nature's gift, God has showered upon us that will help in reducing carbon generation in the atmosphere through burning of Coal Fired Power Plant and will also help in curbing the disasters due to climatic imbalances.

(Here is a quick video that can help and guide you on Rooftop Solar PV buying in India: https://www.youtube.com/watch? v= WA6PLwATIfI)

5. CONCLUSION

India is endowed with vast solar energy potential. About 5,000 trillion

kWh per year energy is evident over India's land with most parts receiving 4-7 kWh per sq. m per day. Hence, both technology routes for conversion of solar radiation into heat and electricity, namely, Solar Thermal and Solar Photovoltaic, can effectively be harnessed providing huge scalability for solar in India. Solar power also provides the ability to generate power on a distributed basis and enables rapid capacity addition with short lead times. Off-Grid decentralized and low-temperature applications will be advantageous from rural electrification perspective and meeting other energy needs for power, heating and cooling in both rural and urban areas. From an energy security perspective, solar is the most secure of all sources, since it is abundantly available. Theoretically, a small fraction of the total incident solar energy (if captured effectively) can meet the entire country's power requirements.

In Lucknow and its adjoining areas (approx. 4 lac houses) if an average 2 Kw Roof Top Solar On-grid System is installed then, it can feed 2000 Mw power generation through public leaving, apart government buildings. It will not only help or enhance power generation but will also help 30% people of India, those who have yet to get Electric connection in their houses. It is also clear that given the large proportion of poor and un-served population in the country, every effort needs to be made to exploit the relatively abundant sources of energy available in the country. While, today, domestic coal based power generation is the cheapest electricity source, future scenarios suggest that this could well change.

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